THE UNIVERSITY OF CALGARY

FACULTY OF ENVIRONMENTAL DESIGN

The undersigned certify that they have read, and recommend to the Faculty of Environmental Design for acceptance, a Master's Degree Project entitled Design Proposal for a Birthing Chair submitted by Ykje Piera in partial fulfillment of the requirements for the degree of Master of Environmental Design.

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Abstract

"Design Proposal for a Birthing Chair"

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June, 1992

Prepared in partial fulfillment of the requirements of the M.E.Des. (Industrial Design) degree in the Faculty of Environmental Design, University of Calgary, Alberta, Canada.

Birthing chairs used in contemporary North American hospitals are typically modeled after hospital beds and are limited by a predisposition towards injury-preventive medical practices. The purpose of this study has been to develop a proposal for a three dimensional form for a birthing chair that is intended for the birthing population who requires no medical assistance during any stage of the birth experience; to explore the psychological, physiological and anthropometric factors influencing childbirth; and to develop a model based on emphasizing the positive aspects of childbirth without disregard for perceived pain.

The study includes documentation of historical birth products and practices to provide a temporal context for the design proposal. Also included as a foundation tool are facts regarding the contemporary medical management of childbirth.

The form proposed in this study consists of a 'chair' that may be manipulated into three distinct configurations permitting a minimum of four postural options. Two additional postural alternatives and potential product design modifications for future studies are also discussed.

The speculation is that the proposed birthing chair may provide new possibilities in the birth environment in terms of providing a philosophy and product form that enables women to control their birth experiences while they are able and desirous of doing so, and to be assisted when necessary. This may potentially provide a more personally satisfying experience for all persons involved.

The results of the study indicate that there is a potential market for this type of childbirth product, however product testing and refinement are required before any conclusive findings are possible.

Keywords: birthing apparatus, chair, childbirth, hospital chair, furniture, labor and delivery, midwifery, obstetrics, parturition, natural childbirth

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1.0 INTRODUCTION

Parturition, the act of giving birth to a child, has always been a part of everyday life as a means for the procreation of the species. For human beings, childbirth has also been connected with the supernatural. Attention, throughout history, has always been given more to the result than the process, and childbirth was treated as a normal bodily function. As far back as records exist, during the Middle Ages, and until the early developments of modern medicine, childbirth had been managed by a village or community midwife, the birthing woman, and usually a female assistant.

In the footsteps of the great developments in medieval science, physicians invaded the delivery room in the nineteenth century. Soon they laid down their own rules regarding the management of childbirth, although ideas varied from country to country. By the "early 1900's, physicians had seized, without legal right or authority, control over childbirth by virtue of being authorities on medical issues."[1]

During the nineteen-seventies and eighties activities surrounding childbirth were evaluated by concerned psychologists and medical personnel. After safety guidelines for mother and child had been established, attention was focused on the area of perceived pain experienced during the labor and delivery of birthing women. Medical personnel advocated that through the practice of alternative birth postures pain experienced during childbirth could be reduced. Psychologists, on the other, promoted the use of massage, distraction methods, and positive thoughts as a means for reducing perceived pain. Consequently, a number of theories regarding birthing aids and environments have recently been examined. As a result, a number of models of birthing beds were designed and promoted in developed countries.

Birthing beds have been designed to address all four stages of labor and delivery as they are currently defined within the North American medical community. In addition to the four stages, consideration has been given to the Trendelenburg Position, a posture necessary in case of excessive blood loss during stages two through four. In general, birthing bed designs, to a certain extent, have sought to address alternative birth postures of laboring women while simultaneously fulfilling the needs of medical personnel in upholding an injury-preventive environment.

Three of the alternative postures advocated were the reclined sitting position, forward leaning squat, and left-lateral side lying. It was concluded that through the use of gravity, an upright

posture during labor and delivery could reduce pain. That is, "...by exerting an equal pressure on the cervix, the pituitary gland is stimulated to release oxytocin which in turn increases uterine effectiveness and contractions."[2] "Research has shown that women in the upright position during labor and birth have stronger and more effective contractions which result in shorter labor duration and increased comfort."[3] Furthermore, because the vena cava; the main artery circulating blood from the fetus to the right atrium of the heart, is in most cases located along the right side of the mother's body, a left lateral birth posture facilitates both oxygen flow to the fetus and comfort for the mother.

Although the birthing beds of the nineteen seventies address these alternative postures, there are several shortcomings in terms of appearance and functionalism. Most importantly, they do not adequately accommodate the range of physical characteristics, such as height and weight, of North American women. The manner in which these products address alternative postures could be improved. Moreover, existing products have the appearance of hospital sickbeds, a factor that is considered undesirable given the biological nature of childbirth.

The objective of undertaking this study has been to determine an improved birth chair form that addresses the physiological and physchological needs of women, and does not resemble a sickbed. The proposed design is intended to improve user comfort and promote an emotionally satisfying experience within an aesthetically pleasing and injury-preventive context, while recognizing the standards required by birthing women and their assistants.

This objective has been carried out according to the following methodology. The birth process has remained unchanged since it first occurred and therefore it is considered valid and relevant to examine the history of childbirth practices and their tools. Research and analysis of birthing ceremonies practiced by traditional and primitive societies before the transition of childbirth from a female dominated ritual to a medically regulated practice provide insight into natural childbirth postures and primitive birth aids; one of which is still used today (see figure 18). This information has been obtained from the knowledge of midwives.

An examination of contemporary North American obstetric procedure has offered an understanding of the complications commonly experienced during labor and delivery. Based on the idea that the ideologies of midwives and obstetricians should be complementary, the design proposal takes into consideration the

needs, as perceived by both groups, within a conceptual framework. "Midwifery is indispensable and an essential part of good obstetrical organization, since midwifery means: protection of health and normality, whereas obstetrics, as part of medicine, belongs to the department of knowledge and practice, dealing with disease and its treatment"[4]

This historical and contemporary information has then been combined to form an understanding of the constraints and criteria defining the parameters for the proposed conceptual framework. In Industrial Design, the conceptual framework is a body of knowledge considered to be a scientific base from which to draw information regarding product design. In this case, it includes an identification and discussion of the traditional or primitive and contemporary medical issues related to childbirth. The issues are selected on the basis of their relevance to the *design* of a labor and delivery chair, and not according to popular debate surrounding the birthing activity.

Several conceptual ideas were generated and evaluated in terms of the identified objectives. Although crucial to the design has been the premise that a vertical posture during labor and delivery increases comfort, product adjustability to postures of side-lying, rest and recovery were also explored. These conceptual proposals culminate in a single design concept that is presented in the final three chapters of this document.

The final consideration was in the use of materials and manufacturing methods. A preference for 'off-the-shelf' or existing parts was adopted as a mean for minimizing overall cost.

The design sketches and proposals are conceptual in nature. Comprehensive technical drawings and a cost analysis are speculative and considered to be beyond the scope of the project. Conjecture regarding the functionalism, appearance and cost of the proposed design is unverifiable and subject to prototyping, user testing, data analysis and potential redesign. Background research and the final design proposal provide the groundwork for prototyping and user testing. If this project were to be further pursued the first stage would include detail design, production drawings and prototyping.

2.0 REVIEW OF LITERATURE

2.1 Overview

The review of literature is comprised of two main sections. In the first section similar products are reviewed with respect to their functionalism in promoting childbirth with increased comfort. These models are collected from historical and contemporary contexts. In the second section, studies dealing with the anthropometric requirements of childbirth are reviewed.

These approaches do not include the actual formulation of a design proposal. They are intended to offer an understanding of birth aids employed throughout history; their shortcomings and assets. In addition, these studies make obvious modifications that are necessary for fulfilling the objectives. Both sections conclude with a summary of constraints and criteria, and the implications of the respective findings to the design proposal developed in the study.

2.2 Review of Existing Equipment: Historical

2.2.1 General Comments

Figure 0: The Birth of Bachus: mixture of realism and fantasy in birth scene[5]

Since the beginning of time, birth assistants have sought to ease the process of childbirth. Midwives, men or women, and doctors have concentrated their attention on reducing or eliminating the maternal and infant mortality rates and alleviating pain during labor and birth. This has led to the development of a wide variety of birth aids and obstetric chairs. These objects reflect the level of technological sophistication and medical knowledge of their times. Some products were intended for use during difficult labor, while others were derived from goals of promoting comfort and effective uterine contractions.

Research in the field of obstetrics as a science can be traced to the lifetimes of Hypocrites and Soranus in the years 460 B.C. to 200 A.D. Although papyrus writings dating as early as 2200 B.C. dealt with the issue of childbirth, much of the knowledge from this time period was incorrect.[6] The writings of Greek scholar Soranus of Epheus, 200 A.D., echoed the thoughts of Hypocrites. In fact, Hypocrites, known as the father of medicine, was the first recorded person to take a scientific approach into the relationship between cause and effect in obstetrics. Prior to this, superstition, magic, and the use of charms were the only treatments for failing health of birthing women.[7]

At the time of Hypocrites, in the fifth century B.C., the first developments of medical science occurred. Hypocrites made the first attempts to transform medicine from pagan rituals and witchcraft into a legitimate practice of cause and effect or illness and cure. He listed over 400 herbs that could be used to treat common ailments.[8] Before his time, fairy midwives were believed responsible for exchanging babies for grotesque changelings, and causing illness or death in mother or infant.[9] Although the writings of Hypocrites were preserved and practiced for the eighteen centuries that followed his lifetime, paganism also survived and experienced a significant resurgence during the Dark Ages (5-th and 6-th centuries A.D.). "Ignorance and superstition combined to pile magical attributes on to plants, sometimes with minimal reason, and to preserve the mystery of herbalism the 'herb wife' took to elaborate rituals, such as the need to gather plants at night, preferably by moonlight ... so as not to offend the Earth Mother."[10]

This initial investigation into the physiological aspects of childbirth was followed by a period of "little encouragement in the field of medicine. This is attributed to the breakdown of the Roman Empire in 400 A.D. For the next 1300 years [200 A.D.-1500 A.D] these writings were considered as the final authority."[11]

Parallel to the developments of alchemy and witchcraft as explanations for problems in pregnancy and childbirth was scientific reasoning. It was not until the late fifteenth and early sixteenth centuries, while childbed fever, also known as puerperal fever, was taking its toll in childbirth, that significant changes occurred in obstetrics. The early works were revived in the western world and translated into German in 1513 by physician E. Roeslin. In addition, Roeslin produced wood engravings to add illustrations to the translated works (see figure 18).[12] He also added a more accurate description of the physiology of childbirth to medical knowledge. Dr. E. Roeslin initiated a renewed investigation into obstetrics from a medical viewpoint. Continuing developments in the field of obstetrics can be seen up to the present day.

Louis XIV (1638-1715) of France, due to an overwhelming curiosity about where babies came from, has been given credit for a lithotomy position or horizontal posture in childbirth. During the next two hundred years this posture was popularized and accepted in both North America and Europe

In 1847, Hungarian physician I. P. Semmelweis determined that sterilization and cleanliness were necessary in the treatment of birthing women. Although not widely accepted until the turn of the century, this discovery marked an important transition in the field of obstetrics. In 1913, the first classes in childbirth were offered to women as a result of an understanding of the relationship between hygiene and the infant mortality rates. With the implementation of cleaner birthing environments, the maternal and infant mortality rate was drastically reduced. However, the perception of women as 'healthy in childbirth' to women as 'sick in childbirth' was well embedded in the attitudes of the general population due to the many years during which women were often brought to the cemetery after the delivery.

By the turn of the twentieth century, North American childbearing women were inclined to deliver in hospitals for reasons of sanitation and safety. Public opinion had developed, either as direct response to high mortality rates or as a result of fear of pain during labor and delivery, to the extent that childbirth was perceived as a medical condition requiring hospitalization. As a result hospitalization during childbirth became legally sanctioned.

During the nineteen fifties it was common for women to undergo a general anesthetic to avoid pain in childbirth. However, by the 1970's it was discovered that this could temporarily adversely effect the baby. To avoid potentially harmful side-effects of anesthetic, alternative birth postures and distraction techniques

were developed as a method for tolerating pain. The nineteen eighties produced the latest generation of birthing beds.

This section comprises a summary of some of the devices that were invented in response to goals of easing or improving the birthing environment. They range from the most primitive to the most advanced design. Although it is difficult to accurately date some of these devices, they can be identified according to their choice of materials and manner of use. This information is intended to offer insights into birth aids used for natural childbirth for the last three thousand years. It is proposed that because the birth process has remained consistent, it is valid to examine historical design solutions and adopt those design aspects of obstetric chairs that are functionally consistent throughout the centuries. Since it does not follow that because these products were used in the past, they must be correct, it is proposed that if a product, or variation of it, has been used successfully for past millenniums, it is possible to claim that there must be certain valuable aspects of the product and its variations that are still valid today.

This information has been divided into three categories according to the use of materials and degree of sophistication in design. They are presented as follows:

1. products constructed of found objects
2. products developed prior to the occurrence of modern medicine
3. products developed in conjunction with modern medicine

The factors or design aspects, which are consistent throughout most products and are intended to facilitate comfort during childbirth, promote the following (see sections 2.2.2 - 2.2.6):

a. change maternal posture every twenty to thirty minutes during labor
b. use gravity by adopting a vertical posture
c. elevate the mother's perineal area
d. provide free and unrestrained movement of the legs
e. provide back support and massage

2.2.2 Primitive Birth Aids

Many of the earliest birth aids were primitive and archaic in nature. They appear to have been assembled when needed, and apparently depended on available materials of wooden poles or tree branches, ropes either suspended or woven into slings or hammocks,

and piled bricks. Drawn from North and South American, Mexican, African, and Persian cultures, it is possible that the products were constructed of found materials due to the nomadic nature of these (primitive) peoples. These products are included in the study and are of interest only because of how they were used and the postures of their users.

2.2.2.1 Wooden Poles

Wooden poles were employed in two ways. They were placed either vertically or horizontally. In both cases, the parturient woman grasped the pole as a mean of supporting herself, or pulling herself forward during contractions.

Vertically placed, birth stakes were used by North American Indian women as a component of the childbirth ritual. Approximately five feet in height, three wooden poles were placed twenty paces apart just outside a birthing teepee. With the onset of labor, the birthing women walked from pole to pole pausing to cling to one or another during contractions. Holding onto the pole at shoulder height, she supported herself in a kneeling or standing squat (see figures 1-3). Occasionally, effleurage (abdominal massage) was performed by a female assistant. As labor continued, and delivery was immanent, the mother was admitted to the birth teepee where she squatted over a sunken pit of hot coals. Heat from the coals softened the perineum thereby decreasing the possibility of tearing of the skin.

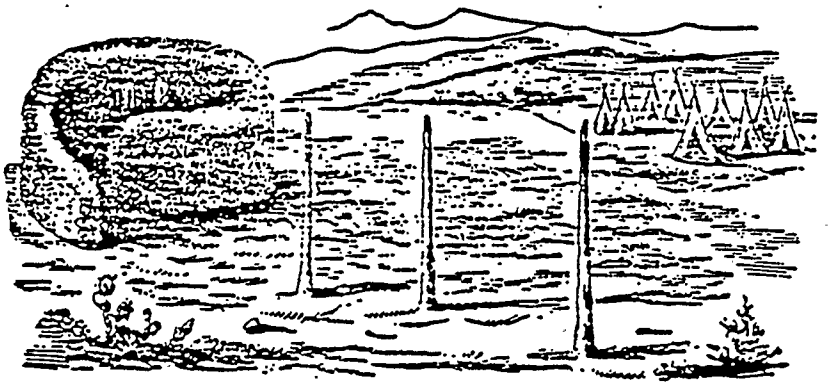


Figure1: Comanche lying-in shelter with birth stakes[13]

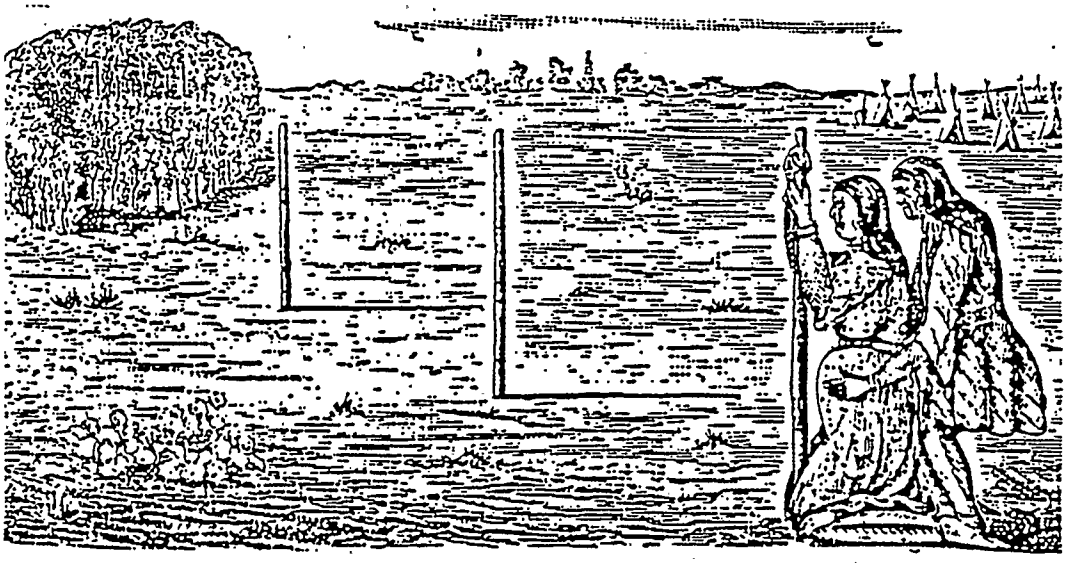


Figure 2: Comanche labor[14]

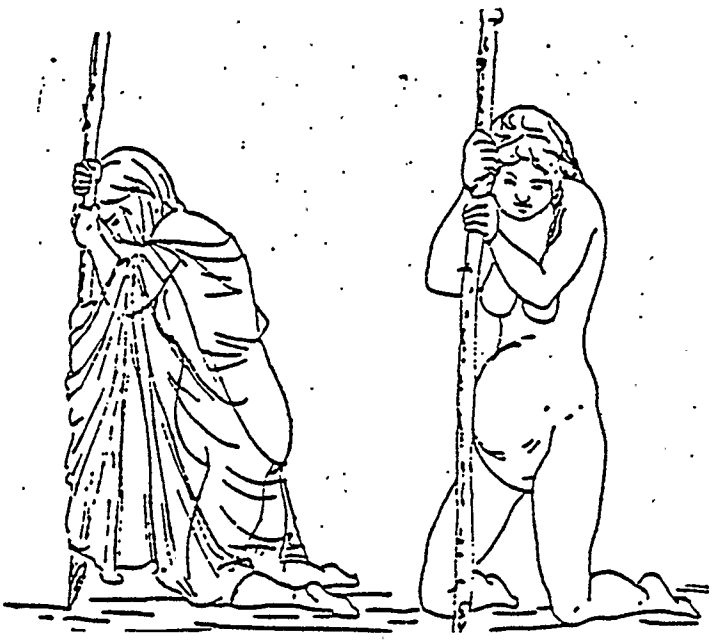


Figure 3: Blackfoot Squaw[15]

Wooden poles or beams arranged horizontally had two uses. In the first instance, the beam was used as a leaning pole for a kneeling or squatting woman (see figure 4). Placed at shoulder height, it was used as a bar to pull herself forward by during contractions.

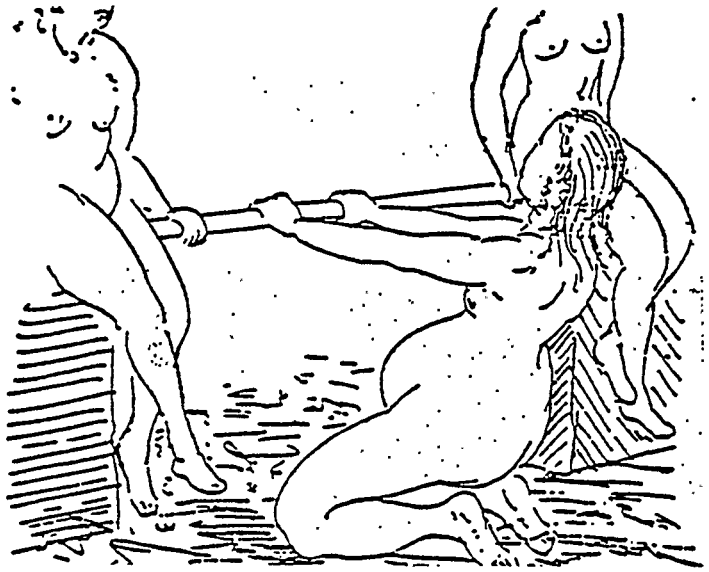


Figure 4: kneeling inclined backwards Chippiwa labor[16]

In the second instance, the rafters, structural ceiling beams (see figure 5), or tree branches (see figure 6) were used in the same manner. In a standing position, the woman hoisted herself during contractions. The parturient woman received effleurage and additional physical support from tribal women. It is interesting that this birthing posture is still used in Papua, New Guinea today.[17]

Figure 5: Primipara during stage of dilation, Papua, New Guinea[18]

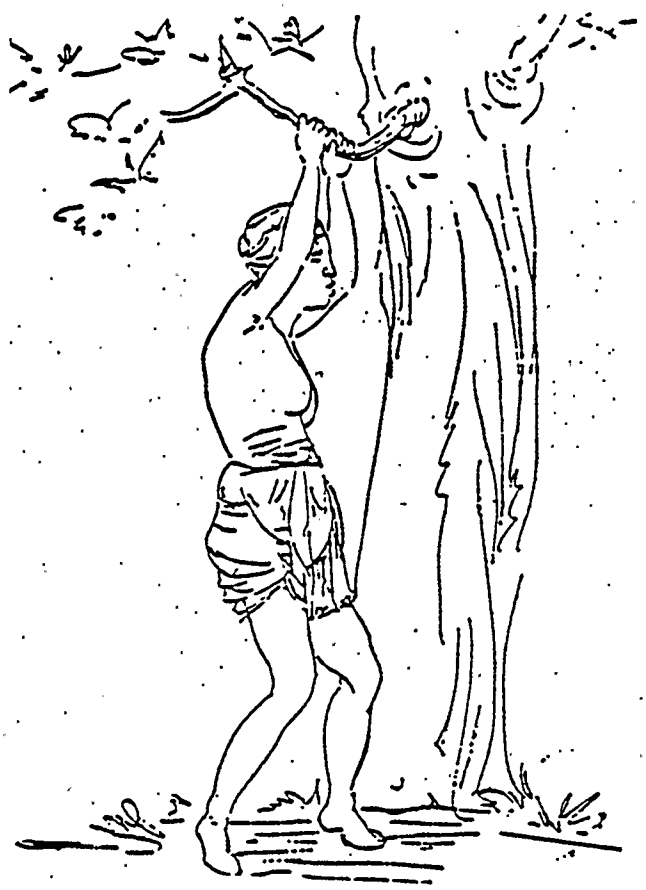


Figure 6: Southern Negroes, suspended[19]

The posture of arms raised above the head is repeated in the use of ropes as a birth aid.

2.2.2.2 Rope

There are also several variations in the use of ropes in birthing. Rope has been used either as a lariat, as a sling, woven into a hammock, or hanging with knots tied at different heights.

As a lariat, it was "tied around the woman's chest and beneath her arms"[20] and was used to hoist her during difficult labor (see figures 7,8). The woman's feet were often barely touching the ground.

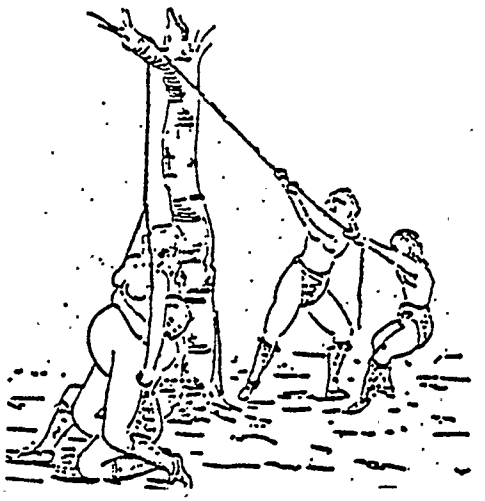


Figure 7: Coyotero Apaches, difficult labor[21]

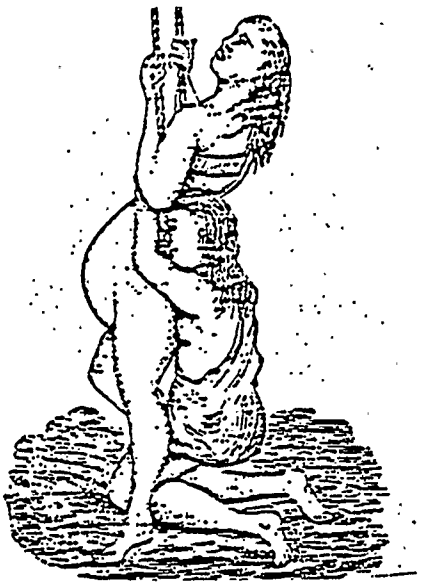


Figure 8: management of difficult labor in Siam[22]

In a rather extreme example of the use of a lariat, the woman is bound to the tree with her arms raised above her head while in a standing posture (see figure 9).

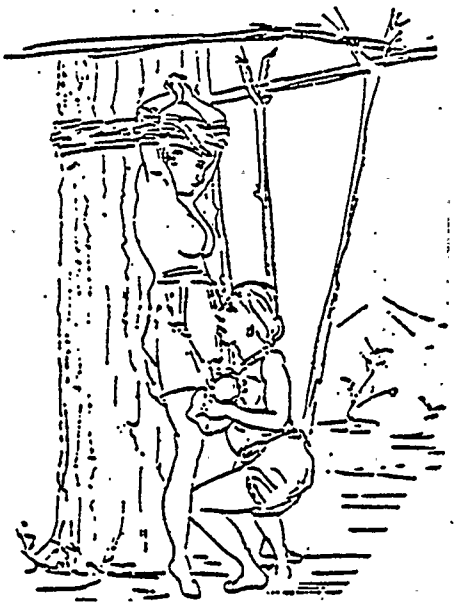


Figure 9: Ceram, standing, semi-suspended[23]

Used as a sling, or woven into a hammock, the rope is transformed into a soft chair-bed. The Oronoko Indian and Mexican women are known to prefer this posture (see figure 10). Mexican women used a full hammock as a birth aid. Sitting with legs on the hammock, knees apart, and feet bottoms together, the baby was delivered into the hammock with the assistance of a midwife and a head-supporter (see figure 11).

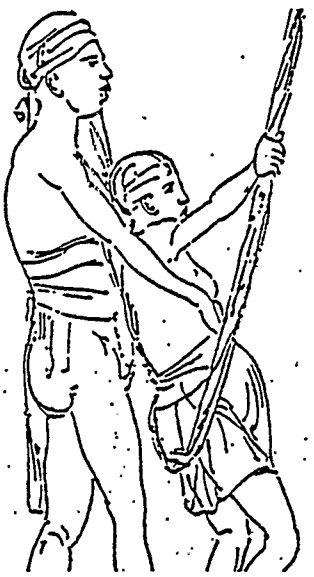


Figure 10: Oronoko Indians, Seated semi-recumbent in sling[24]

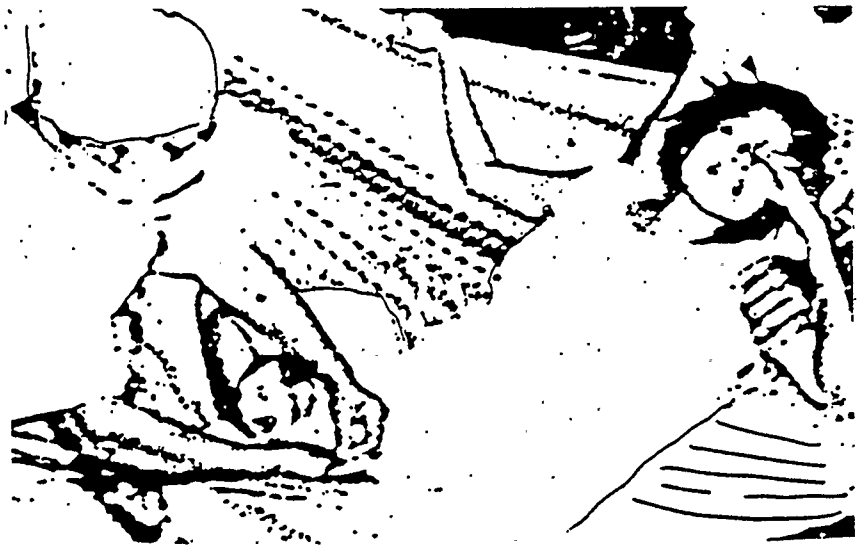


Figure 11: contemporary Mexican labor posture[25]

In its simplest form, the rope was knotted, or wrapped with a cloth for cushioning the hands, and suspended from an angled pole or tree branch (see figures 12-15).

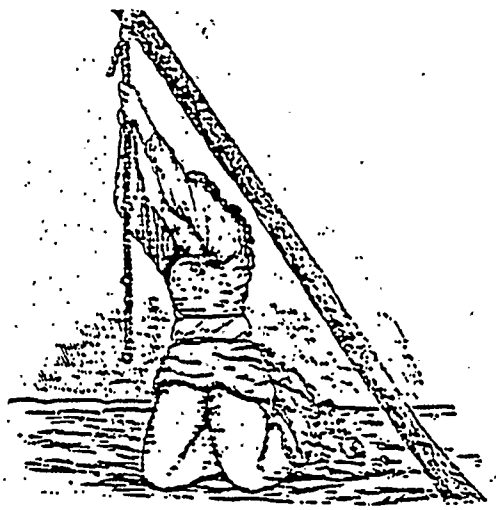


Figure 12: kneeling clinging to knotted rope[26]

Figure 13: massage and expression as practiced in Mexico[27]

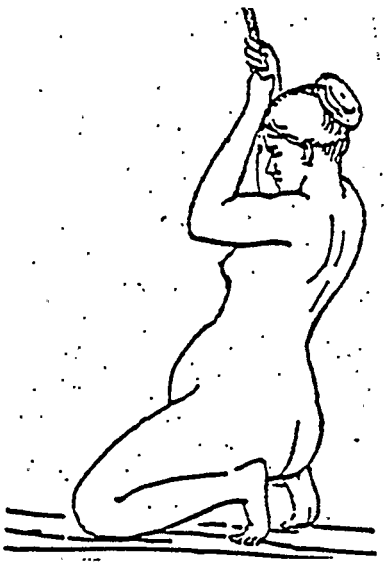


Figure 14: kneeling clinging to rope[28]

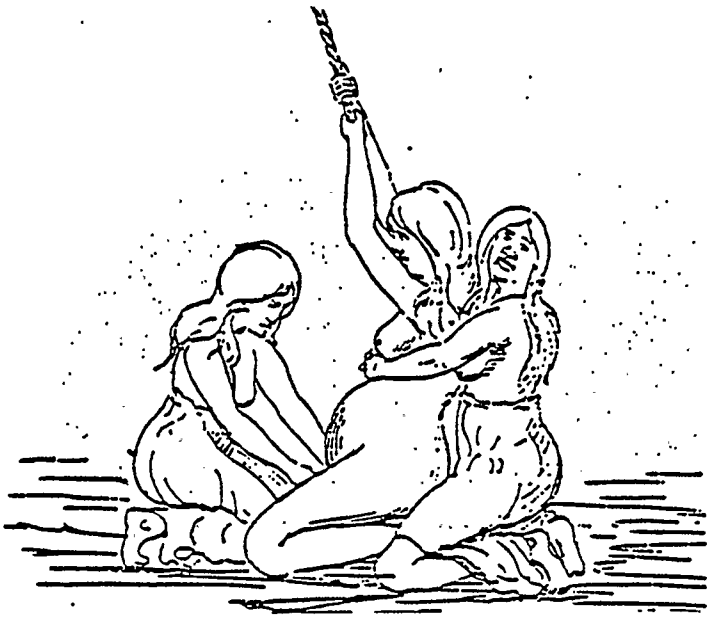


Figure 15: Northern Mexico, kneeling with assistants[29]

In general, the postures most frequently adopted were those of kneeling or standing with arms raised above the head. Other than in the kneeling posture, the torso and legs were either supported as in the use of the hammock, or positioned such that the balls of the feet are barely touching the ground.

2.2.2.3 Bricks

Even more primitive, and considered to be one of the earliest recorded form of a birthing aid, is an arrangement of piled bricks. In a papyrus writing dated 1700 B.C., the birth chair "... in its simplest form consisted of two stones, one to support each buttock of the bearing down [during contractions] woman."[30] Another reference to the use of bricks describes Persian woman placing each knee on a pile of three bricks.[31] The former suggests a seated posture, the latter a forward leaning squat (see figure 16)

Figure 16: Obstetric position of the Persians[32]

2.2.2.4 Observations on the Use of Primitive Birthing Devices

Postural arrangements that are echoed throughout the use of these primitive materials of wooden poles, ropes and bricks are:

a. arms pull body forward during contractions grasping onto something which is placed either in front of the woman or raised above her head (see figure 17);

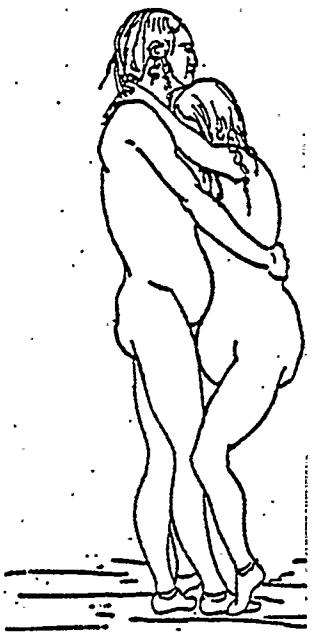


Figure 17: Brule Sioux in a standing posture[33]

b. women assumed a supported standing, squatting, kneeling, or reclined sitting posture.

The positioning of the arms is of interest in the design proposal. What will be abstracted from this information is that women desire something to grasp onto with their hands during contractions, and that whatever they grasp onto should be placed directly in front of them. Although this will potentially conflict with the unimpaired access the doctor may require to safely assist in the delivery of the child, a compromise will be made.

Of importance to note is that the squatting posture, which was quite common in primitive times, is not really a viable position for contemporary North American woman. The reason for this is that primitive peoples, who were in general agrarian, performed the majority of their tasks (e.g.: washing, food preparation) low to the ground and in a squatting position thereby developing strong thigh muscles. Twentieth century women are unable to maintain this posture for the duration of labor and delivery because they lack the muscle strength in their legs to independently assume this posture for extended time periods. Therefore the squatting position, which is physiologically desirable, requires knee support, buttock support or both.

2.2.3 Origin of the Birth Stool

Evidently the birth stool was already commonly used 3300 years ago.

> "And the King of Egypt spake to the Hebrew midwives, of which the name of one was Shiphrah, and the name of the other Pu'ah; and he said, when ye do the office of a midwife to the Hebrew women, and see them upon the stools, if it be a son, then ye shall kill him; but if it be a daughter, then she shall live."[34]

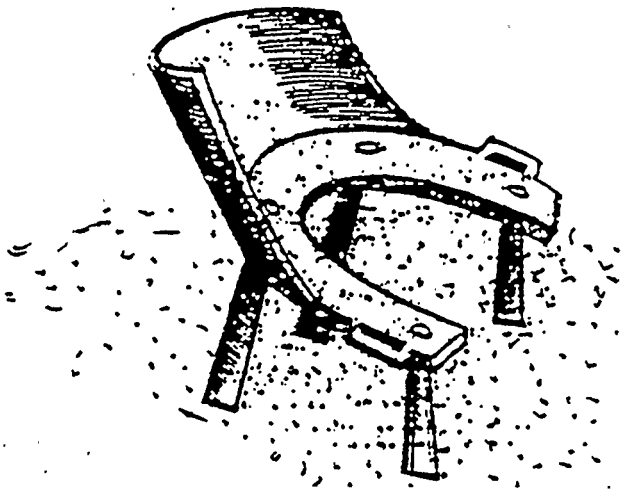


Figure 18: Birth Stool: woodcut, Strassburg, 1513[35]

This section documents the evolution of the birthing stool from a four legged horse-shoe shaped seating device to a wooden throne-like chair with stirrups. The significance in presenting this work is in providing an understanding of obstetric tools in use before the medical developments of the late nineteenth century, the attitude of 'childbirth as illness' and some of the foundations for contemporary medical practices. It covers the period from the early biblical reference to approximately 1850 A.D. It is important to note that the birthing stool, in its most primitive form, can still be found amongst the tools of twentieth century midwives.

The birth stool can be compared to a toilet seat with the front half missing. This was the basic concept for the first birthing stool. Variations on this theme involve:

a. the seat shape;
b. number and placement of chair legs;
c. an extension to the rear of the stool for an assistant's seat;
d. draping around the base of the stool;
e. the eventual inclusion of foot stirrups.

This information is considered to be relevant to the design of a contemporary birthing chair for the following reasons:

a. the act of birthing has not evolved;
b. although medical developments have provided a better understanding of the physiological considerations in childbirth, a better way for removing the fetus from the uterus has not been

discovered excepting in cases of difficult labor (e.g.: cesarean section);

c. although presented as an inductive rather than a deductive argument, it is proposed that if a vertical birth posture on a horse-shoe shaped seat sufficed in 1300 B.C., 400 B.C., 200 A.D., 1500 A.D. and 1800 A.D., it is likely that it could work in 2000 A.D. as well;

d. it is proposed that those aspects of similar antiquated similar products, which are physiologically correct, may be worthy of further investigation in contemporary product design.

2.2.3.1 Birth Stool of Soranus

The stool of the Hebrew midwives in the biblical reference is most likely very close to the birthing stool that is attributed to Eucharius Rodeus in 1544,[36] E. Roeslin in 1513,[37] and described by Soranus in 200 A.D (see figure 18). This description, translated to German by E. Roeslin, follows:

> "In der Mitte des Stuhles und dort, wo die Genitalien ruhen, soll ein kleiner halbmondfoermiger Raum ausgeschnitten sein. Dieser darf nicht zu gross, damit die Frau nicht bis zu den Hueften einsinke, noch zu klein sein, da sonst die weibliche Scham gepresst wird, was noch laestiger ist. Denn eine Hoehlung die zu weit ist, kann man mit Leinwand zustopfen, Die Stuhlplatte sei derartig, dass auch recht starke Weiber darin Platz haben, die Hoehe im Varhaeltnis dazu. Kleineren Personen kann eine Fussbank nachhelfen. Der unter dem Sitze befindliche Teil des Stuhles soll an den Seiten mit Brettern beschalen, vorne und hinten dagegen offen sein zur Verwendung beim Geburtsakt. Ueber dem Sitze sollen an beiden Seiten zwei Querhoelzer ... eingefuegt sein, damit man in diesen bei den Anstrengungen die Haende der Gebaerenden stuetzen kann, im Ruecken befinde sich eine Lehne, welche den Hueften and dem Becken das Zurueckweichen unmoeglich mache."[38]

Translated into English by the author, the description is as follows:

> In the center of the chair and in that place where the genitalia rest a small half-moon shaped space should be cut out. It should not be too large so that the woman does not sink into it up to her hips, nor too small for otherwise the female genitalia will be pressed, which will be more of a nuisance since a caved space that is too wide can be stuffed or filled with canvas. The height of the chair platform should be such that fairly sturdy, large or strong women can also take their place in it, and smaller persons can be assisted by a footstool. The part of the chair found under the seat should be covered with wood on the sides, but should be open in the front and back side for utilization in the act of birth. Across the seat, on both sides, there should be placed two pieces of wood so that one can support one's hands on them during contractions, and in the back there should be a backrest that makes it impossible for the hips and pelvis to recede or slide backwards.

This description of a crude wooden form was likely functional, but not very comfortable. The contemporary version of this stool used by North American midwives similarly lacks a back rest of any sort. Interviews with doctors who have observed the use of this product claim that it is occasionally placed against the wall to provide back support for the user. The modern version of this ancient birth aid is manufactured with a cushioned seat.

2.2.3.2 Ancient Greek Birth Stool

It is also possible, based on the description of the birth stool in the translation, that Roeslin modified the description offered by Soranus. It is possible that Soranus was referring to the chair used in "Cyprus during the Greek period[39] and the "labor scene from ancient Greece"[40] (see figures 19, 20).

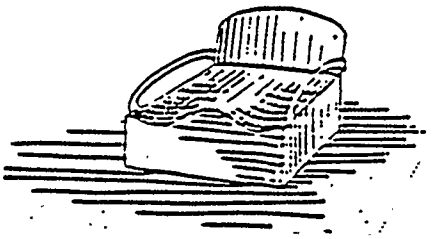


Figure 19: Cypriot midwife's chair[41]

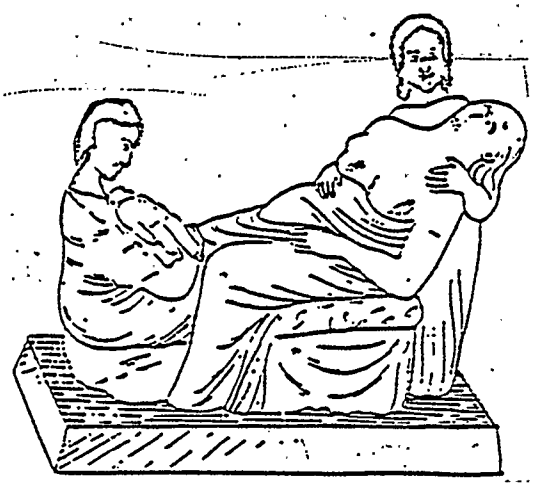


Figure 20: labor scene in ancient Greece[42]

2.2.3.3 The Birth of the Virgin

Figure 21: woodcut engraving of birth scene by Albrecht Durer[43]

This 1505 woodcut engraving by German painter Albrecht Durer (1471-1528) is presented to provide an understanding of the contextual framework (see figure 21) in which the birth stool was used during the lifetime of E. Roeslin. This illustration details the Birth Scene of Mary with a mixture of fantasy with reality. Although there is no birthing stool to be seen, the parturient woman recovers in bed with the exhausted midwife seated nearby while assistants celebrate the event.

2.2.3.4 Sixteenth Century Delivery Scene

Figure 22: Delivery scene 1513[44]

Figure 23: Delivery scene using birthing stool 1554[45]

These sixteenth century maternity scenes illustrate the use of the birthing stool. With the parturient seated between the midwife and the assistant or masseuse, she grasps the handles during contractions. Figure 23 is attributed to J. Ruff of Zurich.

2.2.2.5 Birth Stool With Sides

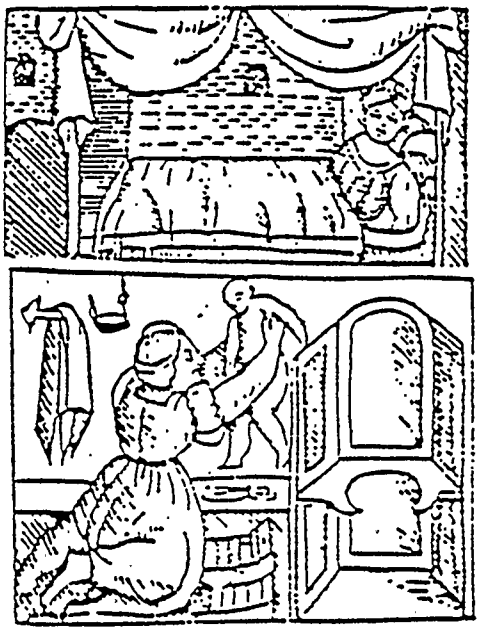


Figure 24: 1536 version of the birthing stool[46]

This 1536 version of the birthing stool by Pederzani includes a high back and sides. It was intended that the stool be used for delivery, and the bed be used for the recovery. Contemporary designs of similar products aim to satisfy the needs of labor and delivery, delivery of the placenta, and rest and recovery with one product.

2.2.3.6 Three-legged Birth Stool

Figure 25: Birth stool dated 1547[47]

This "scientific posture advocated in the sixteenth century"[48] comes from a wood engraving by J. Savonarola. This three legged stool was intended for use by two persons. Figure 25 depicts both the chair on its own (see figure 26), and in use. The extension in the back of the stool provides a seat for the assistant.

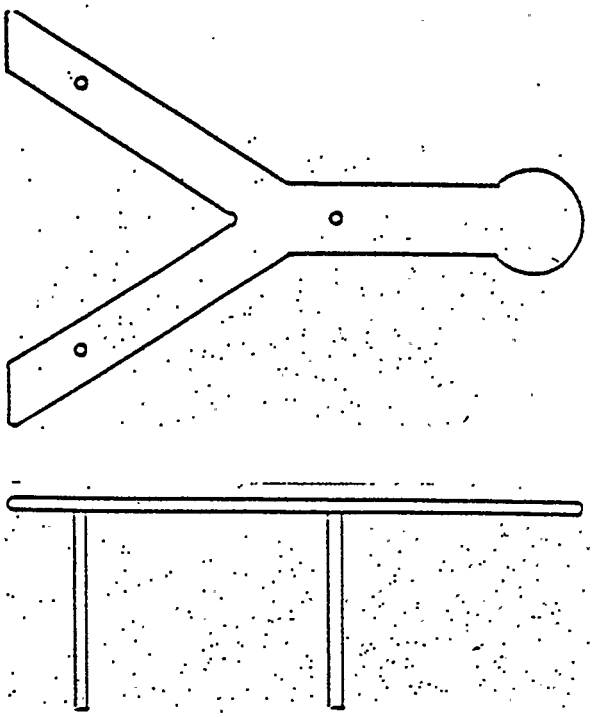


Figure 26: Top view, side view of 1547 version of birthing stool

2.2.3.7 Birth Stool with Draping

On the basis of the 1513 model, the bottom of the 1554 version of the chair was draped with black cloth. It was believed that this modification provided better access to the perineum than a solid wooden base and reduced the chance of injury to the baby. It is possible that this design modification prevented draft and confined the body warmth for the mother.

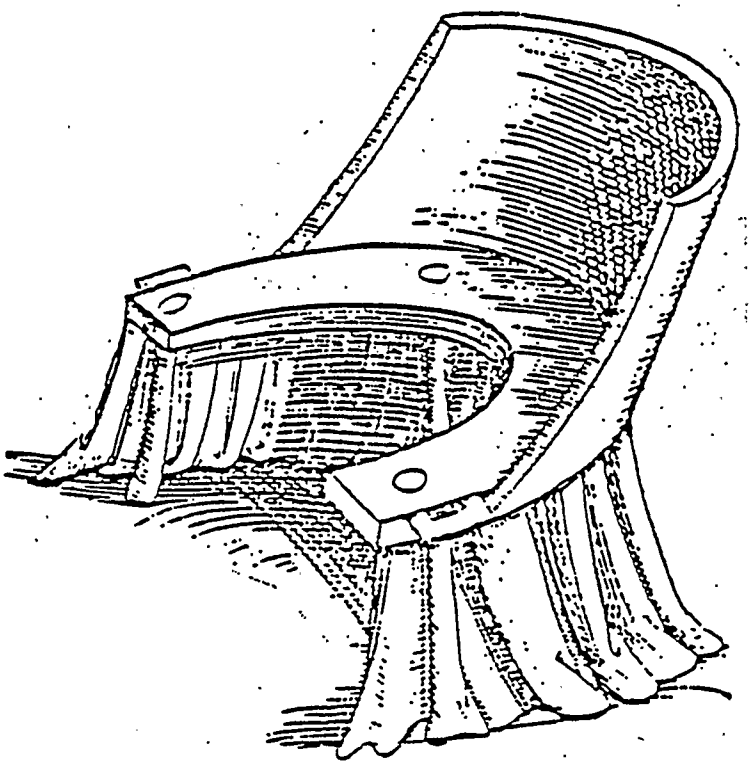


Figure 27: Draped birthing stool[49]

2.2.3.8 Birth Stool with Solid Wooden Base

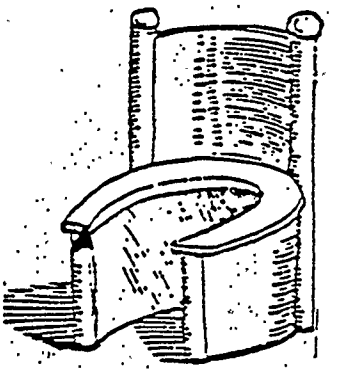


Figure 28: Birthing stool with solid wooden base

In this 1556 version of the birthing stool, the cloth draping is replaced by a solid wooden base. This, in contrast to the 1554 model, is more likely to impair access to the perineal area and potentially injure the infant. This product development appears to be a step backwards in terms of functionalism.

2.2.3.9 Birthing Throne With Arm Rests

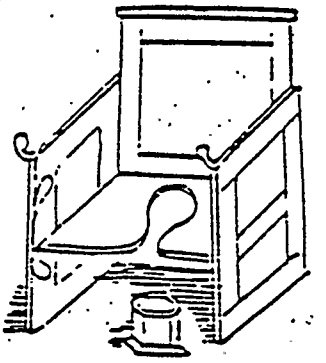


Figure 29: Eighteenth century birth chair[50]

Deventer's 1701 model of the birthing chair includes arm rests with more conveniently located hand grips (rather than along the seat edge) and a pail for collecting the placenta. This model reflects a greater understanding of childbirth as it appears more solid and offers more protection and privacy although it is more than offset by the limitations of access.

2.2.3.10 Syrian Rocking Chair

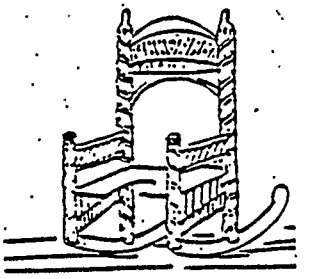


Figure 30: Obstetric chair with rockers[51]

> "... the absence of the rocking chair from foreign homes may be accounted for by the fact that the only rocking chair of which they had cognizance was the chair which the midwife carried from house to house ... for the relief of the childbearing woman; this chair was then so intimately associated with the idea of suffering, of labor, and childbirth, that it did not appear as a desirable piece of furniture for parlor or sitting room; it would have seemed improper and out of place ... it is only within late years [1882] that the American rocking chair has found its way across the ocean."[52]

Not only is this version of the birth stool ornately decorated, but it is also the first to consider the dynamic movement required during labor and birth.

> "The chair ... is different from any other I have seen described, and appears to be a most practical contrivance, enabling the woman to assume various inclinations of the body; it is like a rocking chair with comfortable arms, the seat about two feet above the rockers and cut out in a semi-circle, so as to permit the expulsion of the child."[53]

For its time of the mid-nineteenth century, this product may have seemed practical and comfortable. However, from a late twentieth century viewpoint, this contrivance appears rigid, with narrow armrests, no hand grips, and unstable.

2.2.3.11 Birth Chair with Stirrups

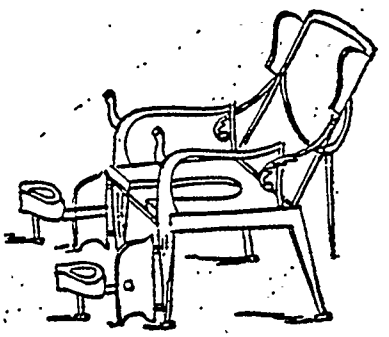


Figure 31: Birth chair cum electric chair[54]

The first chair that bears some of the accouterments of the 1950's delivery table, such as the stirrups, is the 1805 birth chair by Stein. This version resembles an electric chair because of its rigid appearance, straps and leg guards.

2.2.3.12 Make Shift Birthing Aids

The following illustrations (figures 32-39) are intended to speak for themselves. They provide an understanding of make-shift birth chairs that have been used in the absence of the real thing.

Also included are crude manifestations of techniques used during difficult labor. These methods all date from the nineteenth century.

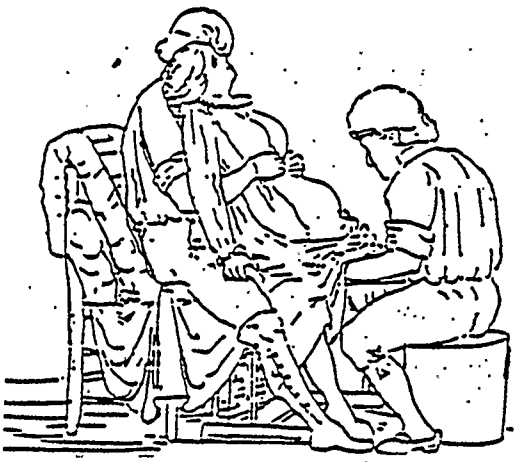


Figure 32: Semi-recumbent in the husband's lap[55]

Figure 33: Placental expression, Mexico[56]

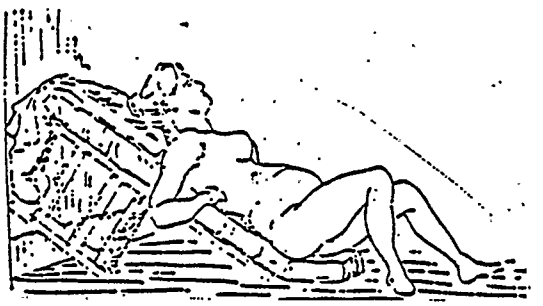


Figure 34: Favorite posture of the French Canadians[57]

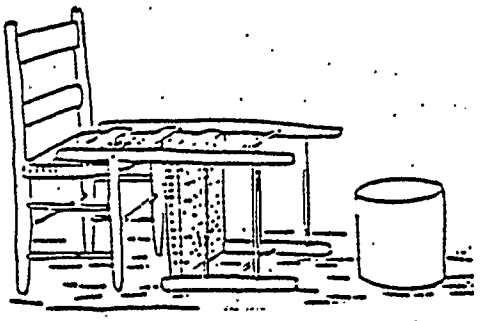


Figure 35: Obstetric couch[58]

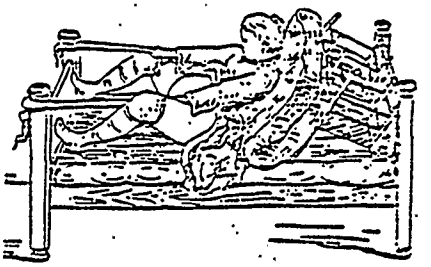


Figure 36: Semi-recumbent in bed, difficult labor

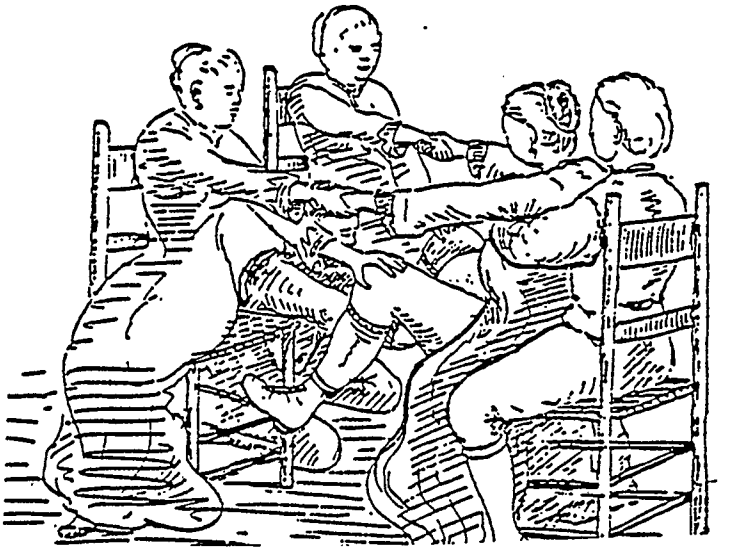


Figure 37: Semi-recumbent in lap, Virginia[59]

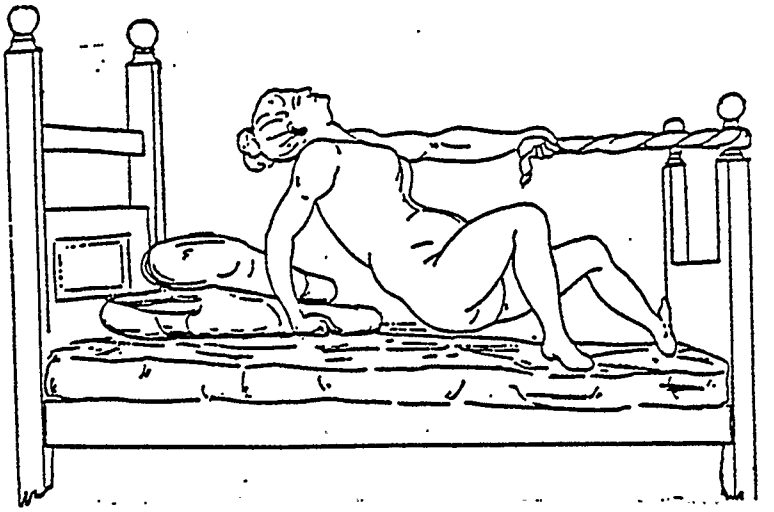


Figure 38: Semi-recumbent, in the agony of the expulsive effort[60]

Figure 39: Japanese labor, instrumental delivery[61]

2.2.3.13 Observations on the use of the Birthing Stool

Evidently, certain design aspects remained consistent throughout the evolution of the birth stool from the times of Hypocrites to the middle of the nineteenth century. These aspects are considered to be:

a. a sitting position
b. the half moon cut out in the seat
c. back support
d. hand grips for use during contractions

e. reasonable space below the mother for safe reception of the child

The seat configuration is one of the elements from antiquated similar designs that, through inductive reasoning, will be included in the design proposal. Not only does it provide an opening in the chair for the infant to pass through, but it also permits easy access by the doctor or birth assistant to the perineal area.

Back support is considered mandatory due to the dynamic nature of birthing. Between contractions, the birthing woman needs to rest.

Hand grips gravitated from their location directly in front of the woman to either side of her. This is likely done to facilitate access to the area. The location of hand grips will be explored further in the design proposal..

2.2.4 The Lithotomy Position

"Lithotomy position: the posture assumed by the patient lying supine (on the back) with the hips and knees flexed and the thighs abducted and rotated externally"[62]

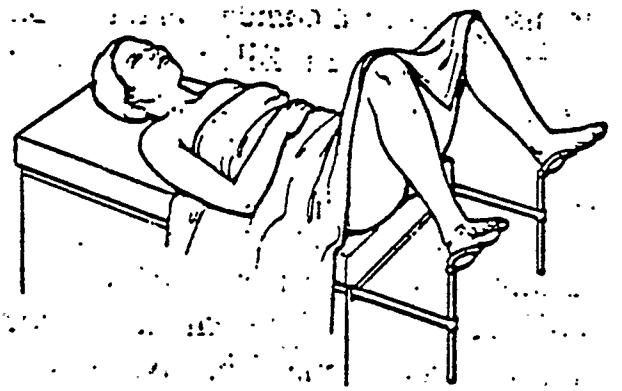


Figure 40: Lithotomy position[63]

2.2.4.1 Lithotomy Position in Childbirth

To provide an understanding of the reasons for the transition in childbirth postures from sitting to lying; the transition in the choice of tools from chairs to beds, and the shift of childbirth caregivers from midwives to doctors, a discussion of the origins of the lithotomy position is necessary. This information is offered to clarify the postural change from the practices of primitive women "who knew all about posture as an aid to easy delivery and

automatically assumed the sitting, squatting, or kneeling position"[64] to posture of contemporary women who assumed the lithotomy position. This discussion is intended to provide support for the hypothesis that a vertical birthing posture, although abandoned in the late nineteenth century North American society, remains a valid alternative.

Although the lithotomy was first proposed by Louis XIV of France (1638-1715) during his marriage to Maria Teresa as a result of his curiosity about childbirth, it was not widespread until two centuries later. French obstetrician Marcel Mauriceau (1637-1709) gladly obliged to his Majesty's request to place women on their backs during childbirth, and eventually advocated this posture to his contemporaries on both sides of the Atlantic Ocean.[65]

This postural transition was confirmed by the existence of the high infant and maternal mortality rates during the last half of the nineteenth century. Records show that between 1850 and 1900 puerperal fever, also known as childbed fever, claimed 29.3 percent of mothers and infants in some months. It was not uncommon for one out of every six women to be carried from the maternity ward to the mortuary.[66] This death rate gave support to the intervention of medical doctors as purveyors of health and well being. Unfortunately, medical care was also responsible for this illness due to an ignorance on behalf of doctors for the need for hygienic birthing conditions.

Curiosity may have been the original cause for a lithotomy birth posture, but it was not the sole reason for placing a woman on her back during labor and delivery. In fact, this posture became necessary as a result of the high mortality rates of birthing women. Childbed fever, usually fatal for mother and child, describes the symptoms of delirium and fever that developed after women were admitted to the maternity wards. Hungarian physician P. Semmelweis (1818-1865) first determined the cause of these symptoms in 1847 and attributed them to the lack of sterilization methods used in hospital rooms. Doctors moved from performing autopsies on cadavers, infected with illnesses such as typhoid fever, to performing internal or gynecological examinations on laboring women.[67] It was not until after the death of Semmelweis, surprisingly by puerperal fever contracted through a finger wound, that Louis Pasteur formalized the relationship between transferred germs and puerperal fever in 1879. By this time, childbearing women in sickbeds were a familiar sight and the lithotomy position was well established as a normal childbearing posture. Although puerperal fever was not a global phenomena, it was a familiar sight

in countries where medical care was common for birthing women. The lithotomy position, used in conjunction with general anesthesia, was common until well into the 1950's in North America.

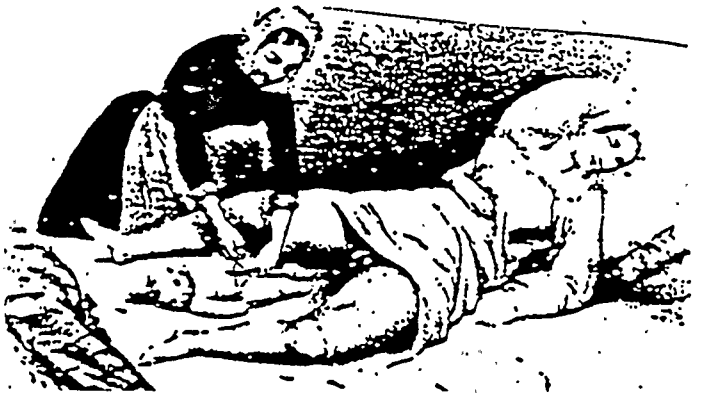


Figure 41: 1850 birth scene[68]

Figure 42: women's ward in a hospital[69]

Figure 43: medical attention 1860's[70]

During the 1960's, psychologists explored the nature of pain in childbirth and sought methods for alleviating perceived pain through distraction techniques and the use of massage, also known as effleurage. It was not until the 1970's that alternative birth postures, instead of the predominant supine position, were explored. This decade led to the development of the contemporary birthing chair or bed.

2.2.4.2 Conclusions

The merits of the lithotomy position in childbirth are well known in addressing the needs of women experiencing difficulties in labor and delivery. However, for women in excellent physical condition who are interested in an active participation in natural childbirth, the lithotomy position has little to offer. It is important to note that of all women who elect natural childbirth, approximately ten percent have a cesarean section, fifteen percent have forceps delivery and the remaining seventy-five percent are natural.[71]

2.2.5 Competitive Products: Birth Aids Developed in Conjunction with Modern Medicine

2.2.5.1 General Comments

The reason for examining competitive products, or products that provide a similar service to a woman in labor, is to assess which aspects of current products are reasonably satisfactory or unsatisfactory in terms of user needs. By determining advantages

and disadvantages of these products, either in terms of anthropometry, production technologies, or functionalism, the possibilities of a solution for an alternative improved design will be better defined. Products that were examined are the Birthing Stool, Beanbag Chair, Delivery Table, Borning Bed, Genesis Bed, and Adel Bed. The Borning, Genesis, and Adel Beds are similar to the extent that they address the four stages of labor and delivery. These products are typical of high-end hospital equipment. The approximate retail cost for these beds is $20,000.

2.2.5.2 Birthing Stool

Birthing Stools have been documented throughout the centuries, and have traditionally offered an interactive birth experience between assistants and parturient. The Birthing Stool resembles a leather covered, cushioned half toilet seat supported by three or four wooden legs. It stands thirty-five or forty centimeters above the ground. This product, used by midwives in many western societies, provides little more than buttock support in a sitting or squatting position. Due to the lack of back support, an additional person is required to provide back support during labor. Midwife and support person work together to provide both physical and emotional support to the mother. The midwife crouches on the ground to receive the baby. Occasionally the chair is placed against a wall to offer back support. The criticisms of the product are that although the product is somewhat satisfactory for contractions during labor and delivery, it does not address the possibility of resting between contractions. The main advantage of this product is that it promotes the healthy posture of squatting which results in a shorter labor duration and does not increase pressure on the vena cava.

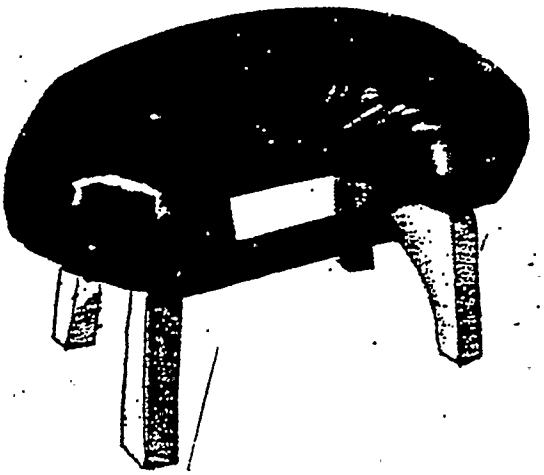


Figure 44: Contemporary Birth Stool[72]

2.2.5.3 Beanbag Chair

An oversized Beanbag Chair has been used for labor and delivery of child and placenta. These chairs conform to the parturient's elected posture regardless of postion. They are of particular value for mothers who seek an active involvement in the birth process. "The chairs are covered in washable, fire-retardant material and filled with nonflammable styrofoam beads."[73] The only known criticism of this product is that the shell of the product is not porous, and therefore if a woman is too warm from the efforts of labor, she must be moved while the product is wiped down or recovered. Also, the placental stage is not adequately addressed in this product, and moving the mother between the delivery of the child, and delivery of the placenta is not in the best interests of the mother. Finally, the product does not address the Trendelenburg posture nor the stage of recovery.

2.2.5.4 Delivery Table

The Delivery Table precedes birthing beds, and although still preferred by some medical doctors, was far more commonly used before the development of the birthing beds of the 1970's. In some cases, it is still used today in cases where there is a shortage of birthing beds, or an incompatibility in dimensional requirements. The delivery table is little more than a horizontal platform with stirrups for aiding the woman into the lithotomy position. This product is not unlike a hospital operating table. It is not particularly useful in the time leading up the actual delivery as it does not provide for the type of dynamic movement that is best for a laboring

woman. It is also unsuitable for the post-delivery recovery because of the narrow width of the table.

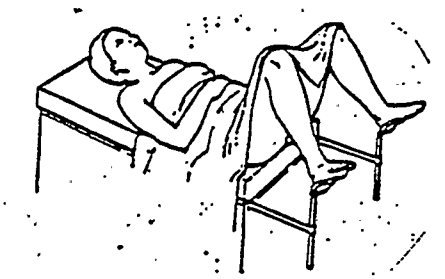


Figure 45: Delivery Table

2.2.5.5 Borning Bed

The major criticism of the Borning Bed is that it does not adjust to the Trendelenburg posture. For high-end hospital equipment, this is a major criticism of the product. Adjustment to the Trendelenburg position is crucial in the design of hospital beds as this "position, in which the head is low and the body and legs are on an inclined plane, [is particularly advantageous in cases where excessive bleeding occurs]. It is sometimes used in pelvic surgery to displace the abdominal organs upward, out of the pelvis, or to increase the flow of blood to the brain in case of hypotension and shock."[74] The loss of greater than 500 cc's of blood in a birthing woman technically constitutes hemorrhaging. Therefore, if she is manipulated into the Trendelenburg position, blood flow to the brain is improved thereby reducing chances of fainting. (This procedure is currently considered to be controversial.[75])

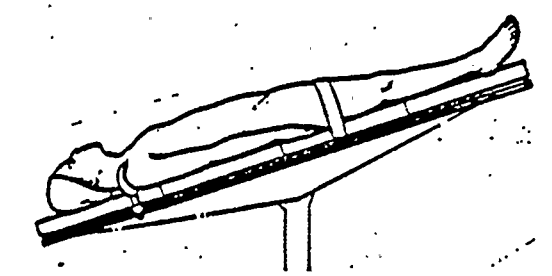


Figure 46: Trendelenburg Position[76]

Additional criticisms of this product are that there are too many adjustments and removable parts such as stirrups, arm supports, and the lower end of the bed. Adjustments require both valuable time for altering the product, and sufficient space within

the hospital room for storing the parts when they are not used. The removable lower end of the bed is both large and heavy and consequently difficult to lift, move and store.

The Borning Bed does not provide integral lumbar support. This problem is usually remedied by the nurse placing a folded sheet or pillows behind the woman's back in the lumbar area. These modifications are bandaid solutions for the seat length that is too long for most women.

Cleaning of the product is difficult because blood and other body fluids are frequently trapped in the edge piping of the seat, thus making sterilization of the product time consuming.

The final criticism of this product is in the area of handles and hand grips. Stirrup slots have been incorrectly used as hand grip slots. The removable metal bar, which is intended for the woman to grasp during contractions while in a squatting position, is dimensionally incorrect for a full spectrum of users. It is out of reach of smaller framed women[77], and therefore is rarely used.

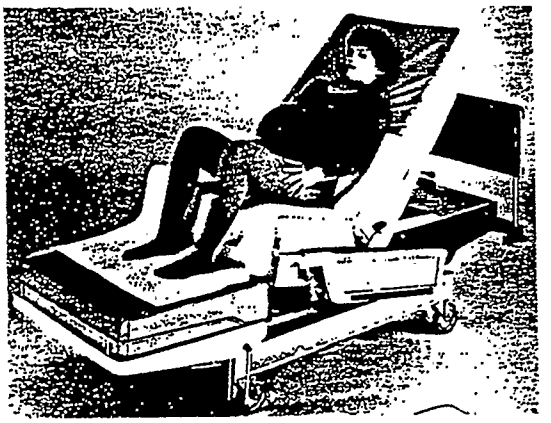


Figure 47: Borning Bed[78]

2.2.5.6 Adel Bed

The Adel Bed, aside from having problems similar to the Borning Bed, has reportedly had a foot plate snap off during severe labor contractions.[79]

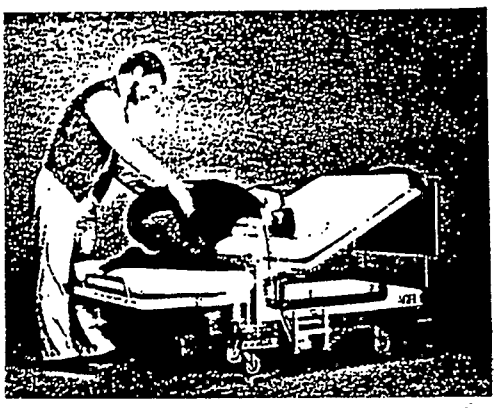


Figure 48: Adel Bed[80]

2.2.5.7 Genesis Bed

Since there are no products of this type in the hospitals that were interviewed, the only available information on this product comes from journals. In general, the product is similar to the Borning and Adel Beds. Criticisms are similar to other existing products.

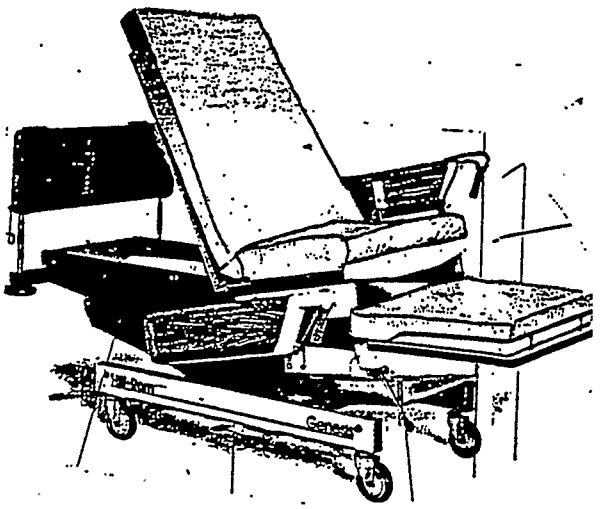


Figure 49: Genesis Bed

2.2.5.8 Conclusions

In summary, competitive products have been identified as suffering from the following three shortcomings:

a. they do not adequately address the postures of forward leaning and squatting (except the Birth Stool);
b. transition time in adjustment from the reclined sitting position to the Trendelenburg Position relies on an electrical system which not only introduces hazardous wires which are strung across the floor, but has a slow response time;
c. product dimension are inadequate in terms of addressing a full spectrum of potential users, notwithstanding the beanbag chair.

2.2.5.9 Possible Modifications of Existing Products

It is highly unlikely that existing products could undergo modifications that would overcome these shortcomings without major redesign and changes such as:

a. redesign in terms of the material selection and dimensional requirements for the removable tubular steel bar which is used as hand grip in the forward leaning squat position;
b. simplification of attachments in terms of weight, sterilization and storage;
c. reconsideration and redesign of details such as stirrup slots to prevent misuse of the product;
d. seat length suitable for larger user group to eliminate the need for pillows in lumbar area;
e. forces re-evaluated to prevent breakage.

These observations help to define the limits of existing products and also ensure that the proposed design does not imitate flaws in existing equipment. The design proposal will attempt to address these shortcomings thereby fulfilling an identified market need. The Birthing Stool and Beanbag Chair were developed out of natural childbirth postures and although they fulfill a market need, there are alternative forms for serving the same purpose. The Delivery Table is intended for medical convenience, and it fulfills that function. A Birthing Bed that adapts to all four stages of labor and delivery as well as the Trendelenburg Position is considered to be adequate for the purpose it is intended for: a hospital bed that can easily adapt from use for women participating in natural childbirth to use for women who develop into high risk patients. Although these products are satisfactory in many respects, there are sufficient shortcomings in the designs to warrant a new approach to,

and interpretation of, childbirth postures in the hopes of developing a product that not only accurately reflects the achievements of modern technology and medicine, but values traditional childbirth practices as well.

2.2.6 Summary and Conclusions of the Review of the Literature Related to Existing Obstetric Chairs

Western women generally delivered their infants in a vertical posture or in chairs throughout documented history. The only anomaly, the lithotomy position, can be attributed to the need for medical attention by birthing women, and not a natural inclination of laboring women to deliver on their backs. Although contemporary equipment addresses all four stages of labor and delivery: from the onset of labor to the post-delivery recovery period, this is not considered to be a high priority in the design proposal. The concentration in this project is on the labor and delivery stages, with a standard bed recommended for stage four: rest and recovery.

On the basis of the findings in the literature review of obstetric chairs used in the past, the following design parameters in the design proposal for an alternative birthing chair have been determined:

a. there should be hand grips or handles for use during contractions;
b. the seat base should be formed appropriately in depth, width, and height to permit safe passage of the infant;
c. back rest should be available for rest between contractions;
d. the surface of the chair, and all parts contacting body fluids to be easily sterilized;
e. the chair must be not too large or small so as to eliminate a percentage of the user population;
f. all adjustable parts should be easy to manipulate.

2.3 Literature Review of Human Factors Considerations

2.3.1 General Overview

> "It is important to appreciate that clinical entities such as fetal presentations or mechanisms of labor may be helped or hindered by maternal posture"[81]

This section deals primarily with the ergonomic and anthropometric considerations in childbirth. To familiarize the reader with the conceptual framework for this discussion, some background information is provided.

A discussion of the four stages of labor and delivery, as they are currently defined within the North American medical community, is provided to offer an understanding of the contemporary birth experience from a medical perspective. An examination of the childbirth experience on three levels: personal, familial and cultural offers insight into the relationship between product design, perceived pain and relaxation from the parturient's viewpoint. Current medical considerations such as the use of stirrups, lumbar support, anesthetic and the sterilization of equipment are discussed in view of their significance in the proposed design form. This section concludes with a discussion and analysis of the anthropometric considerations and ergonomic requirements that are considered relevant to the design of a birthing chair.

The main reason for including this information is to offer insight into the relationship between the product users and the proposed design's overall form and function. This section is an exploration of the birth experience from both the medical and parturient's viewpoint.

2.3.2 Four Stages of Labor and Delivery

2.3.2.1 Stage I: Stage of Dilatation

Stage one, the stage of dilatation, "begins with the onset of regular contractions and ends with the complete dilatation of the cervix." The cervix expands from a zero to ten centimeter diameter. This stage is divided into two phases. Early labor, dilatation of the cervix from a zero to three centimeter diameter, is characterized by gentle contractions during which hospitalization is neither necessary nor recommended. This is followed by active labor, cervical dilatation from a four to ten centimeter diameter, during which the uterine contractions are more regular and strongly felt by the mother. The contractions increase not only in frequency but also in duration as cervical dilation progresses. Activity of the mother is

generally highest during this stage and postural shifts are recommended every twenty to thirty minutes.

During the early labor stage, the woman is generally alert, excited, apprehensive, and anticipatory. Her thoughts are directed inwards, concentrating on herself, her labor, the baby and minimizing discomfort. Pain can usually be managed by massage, controlled breathing techniques, and walking between brief periods of rest. This phase normally lasts eight to ten hours.

Phase two is divided into two parts: four to seven centimeters dilation with a duration of approximately three hours, and eight to ten centimeters dilation with a duration of between one and two hours. During this final stage of dilation the woman's activity significantly decreases as the contractions are usually minutes apart, thus making activities such as walking undesirable. The woman usually becomes more serious, exhibits signs of fatigue and stress, becomes uncertain about managing pain and is increasingly apprehensive. Occasionally, due to a focused concentration on contractions, there is difficulty in following directions.[82]

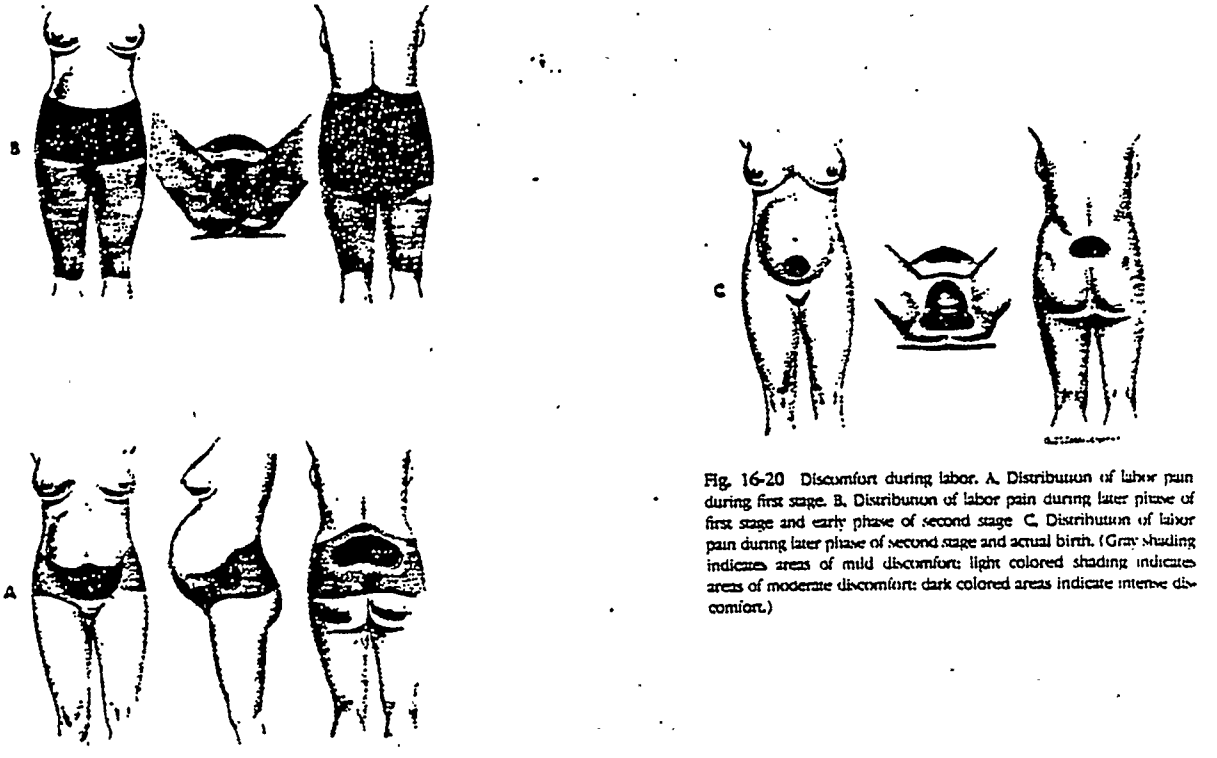


Fig. 16-20 Discomfort during labor. A. Distribution of labor pain during first stage. B. Distribution of labor pain during later phase of first stage and early phase of second stage C. Distribution of labor pain during later phase of second stage and actual birth. (Gray shading indicates areas of mild discomfort; light colored shading indicates areas of moderate discomfort; dark colored areas indicate intense discomfort.)

Figure 50: Areas of pain during Stages One and Two[83]

The perception of pain during childbirth varies greatly in intensity, duration and extension to other areas. Early labor is sometimes characterized by mild pains in the lower back. This can be followed by feelings of frustration, a lack of controland irritability. Women become gradually more incommunicative and can suffer from amnesia between contractions. Normal reactions are writhing in pain, nausea, vomiting, hyperventilating, perspiring, leg tremors, and the feeling of a need to defecate. During this final phase the parturient woman may become introverted, in a trance like state during contractions, and unconcerned with the surroundings.[84]

2.3.2.2 Stage II: Stage of Expulsion

The second stage of labor is the stage of expulsion of the fetus. "It extends from full cervical dilation (ten centimeters) through to the birth of the baby."[85, 86] The woman will have selected a birthing posture such as side lying or sitting. Physical mobility is no longer considered to be beneficial in facilitating delivery although position changes are sometimes necessary. The woman's activity, if seated, is often confined to actions such as grasping under the thighs with the lower arms during contractions as a mean of expelling the infant. A 'hands and knees' position or supported stand are also options during this stage. In optimum fetal presentations, the head appears first. In other fetal presentations, medical assistance is more likely to be required.

2.3.2.3 Stage III: Placental Stage

The placental stage is characterized by the expulsion of the placenta. Placenta is the tissue interlocking the infant, through the umbilical cord, with the maternal circulation. "The third stage of labor extends from the birth of the baby until the delivery of the placenta. The goal in the management of the third stage is the prompt separation and expulsion of the placenta, achieved in the easiest, fastest manner"[87] This tissue is expelled by uterine contractions during the first hour following stage two. In some instances parts of the tissue remain in the uterus thus requiring medical assistance.

2.3.2.4 Stage IV: Immediate Postpartum Period

The immediate postpartum period is characterized by the close observation of the woman for the first twenty-four hours after

the expulsion of the placenta. "The fourth stage of labor, the stage of recovery, is a critical period for the mother and newborn, who are not only recovering from the physical process of birth, but are also initiating new relationships."[88] Medical concerns are related to the parturient's emotional and physical reactions to the birth. Medical assistants ensure that the woman is warm, restful, and not likely to hemorrhage. Excessive bleeding which in some cases leads to hemorrhaging, can be caused by an episiotomy, tearing of the perineum, or a part of the placenta remaining in the uterus. It is during this stage that the Trendelenburg Position may be required. This stage is typically a period of rest and low patient activity.

2.3.2.5 Summary

As previously stated, chair designs that address all four stages of labor and delivery have been explored in the concept development chapter. Since requirements for the Trendelenburg position and Stage Four have been accommodated in existing birthing equipment and standard hospital beds, these factors are not given further consideration in the design proposal. Design parameters arising from the Four Stages of Labor and Delivery are submitted with this restriction in mind. The parameters for the design of a birthing chair are proposed as follows:

a. the chair should adjust to several different laboring postures allowing for the frequent postural changes desirable during stage one;
b. massage and aural contact with the woman be made easy so as to comfort and reassure the birthing woman during the final stages of delivery.

2.3.3 Childbirth as an Authentic Experience

2.3.3.1 General Overview

This discussion is an examination of perceived pain and emotional responses during childbirth. "In our culture, fear and anxiety dominate childbirth."[89] This fear and anxiety can be controlled or managed through adequate preparation for childbirth, internal meditation, and external assistance in the form of massage and controlled breathing. In addition to these documented relaxation techniques, it is proposed the birthing chair's form and function can facilitate a more personally satisfying birth experience.

In the 1960's, anthropologist Sheila Kitzinger described the birth experience as a personal, sexual and cultural event in which the mother's psychological and physiological stress is displayed in a public forum. Her work proposes that birth is a "normal physiological process in which the woman works in harmony with her own body."[90] This section is a discussion of the birthing chair as a meaningful object within contemporary North American society. It addresses the mother's emotional state and how pain is perceived. One objective is to present an alternate attitude towards pain in childbirth through associating significant meaning with the product. It is further proposed that through alternative associations with, and uses for the product, such as a household leisure product, perceived pain in childbirth may be reduced. Finally, the product's form, given that it is significantly different in appearance from standard hospital equipment, could reduce experienced fear.

"Pregnancy is an altered state of consciousness largely because it plunges the individual's awareness from its secular pursuits into profound involvement in universal processes."[91] A laboring woman can associate significant personal meaning with the experience of childbirth as an authentic experience from three viewpoints:

1. as an private and unique individual or personal experience;
2. as a shared family experience
3. as a cultural event shared by all women.

This distinction was made for the purpose of generating preliminary design sketches responding to the identified needs of the experience from each perspective. These ideas are then combined and integrated into a single design proposal (see Appendix A).

2.3.3.2 Childbirth as Unique and Personal

On an individual level, childbirth is interpreted an a unique experience. Not even two birth experiences by one woman are the same. In this sense birth is not a shared experience. Childbirth is a personal event whereby the person experiencing it has the need to feel not that she is in control, but rather that she is not being controlled.

Childbirth, as a personal experience, is a concept based on the woman who was once isolated while in labor and whose family is now welcome in the delivery room. This transition reintroduces the family as a physically and emotionally supportive element into the birthing environment.

The first concept arising from this type of experience is the hospital chair. This concept deals with the subject of a design solution relating the constraints and criteria derived from medical considerations with a consideration of a philosophy for contemporary and future lifestyles that proposes that the quality of the birth experience may be improved by increasing the parturient's personal freedom during the experience. By shifting away from existing birthing bed designs, perceived as modified hospital beds that rely heavily on modern technology and predispose the birthing woman to medical assistance and invasive medical techniques, and towards modified historical birthing chair forms that depend more on the efforts of the laboring woman to exert herself to expel the infant, this objective may be achieved.

A safe birthing environment, offered by modern technologies, is not only advisable, but advocated. To address birthing women as healthy until there is an indication to the contrary would provide a psychologically and physiologically healthy environment which is consistent with these goals. This leads one to the conclusion that the hospital birth environment requires two types of products: the modified hospital bed for potential high risk persons, and the birthing bed for low risk persons delivering in hospitals. Existing products adequately address the needs of women who are either high risk or become high risk patients during the labor and delivery. Not adequately addressed are the needs of women who are not high risk either before or during labor and delivery. It is proposed that the treatment of healthy women as ill could adversely affect their responses to childbirth and in some occasions interfere with the birth process. It is to help and comfort women that this product is intended.

The major consideration in the design of a hospital birthing chair for the present and immediate future is the critical aim that women are permitted, encouraged and enabled to do as much as they are capable of in terms of delivering a child while at the same time employing modern injury preventive techniques to support mother and child in the birth experience.

By examining the products of traditional times and modernizing them, it appears possible to improve the birth experience through promoting greater freedom and higher expectations on the part of the mother to exert more effort, rather than rely on medical techniques. For example, given modern medicine, a woman may be more inclined to request medication during strong contractions rather than shift her posture or redirect her thoughts to alleviate or reduce perceived pain.

The fear-tension-pain syndrome was introduced by Grantly Dick-Read, a British physician, in the 1920's.[92] His theory describes pain in childbirth as a circular and escalating phenomenon that can be controlled. Childbearing women, especially primiparas (women who have not delivered a viable baby), are generally somewhat apprehensive about giving birth due to the many risks and unknown factors. This apprehension is often manifested as fear. Fear leads to a physiological muscle tensioning. Muscle exertion (as in contractions) with tense muscles can be painful, thus leading to increased fear. More specifically, if a contraction is preceded by fear, the muscles will be tense, and the contraction will be perceived as more painful. The resulting pain leads to renewed fear, and the syndrome escalates.

Grantly Dick-Read and his followers Dr. Fernand Lamaze, Dr. Robert Bradley and Sheila Kitzinger argued that through a woman's understanding of a her physiology and the use of calming relaxation techniques of massage and breathing, the fear-tension-pain syndrome could be interrupted.

During the 1950's, Dr. Fernand Lamaze of France proposed "accouchement sans douleur" (childbirth without pain). This method advocates a form of mind control whereby the woman concentrates her thoughts on pleasurable images, music, or regular breathing. This is supplemented by massage of the lower abdomen and back region.

In the 1970's a greater understanding between the physiological and psychological responses in the user was achieved. Several recommendations integrating the two ideas were proposed as follows:

a. promotion of voluntary movement of the birthing woman during Stage One;
b. upright birth posture facilitates oxygen flow to the fetus;
c. abdominal muscle control exercised during contractions can be achieved through controlled breathing and abdominal and back massage;
d. encouraging the user to adopt learned skills to suit the individual needs improves the woman's sense of control;
e. the use of an internal or external focal point serves as distraction from pain;
f. a change in maternal posture every twenty to thirty minutes improves maternal state of mind.[93]

Posturally, these findings indicate the need for the birth assistant's access to the mother's abdomen and lower back for massage, and the parturient's independent access in and out of the chair. A chair that is raised above a normal sitting height combined with a foot stool is not considered an alternative to a chair at normal sitting height because pregnant women are generally unable to see their feet. An unsuitable height for entering and leaving the chair could interfere with the parturient's independence and sense of control in the situation.

2.3.3.3 Childbirth as a Familial Experience

The second concept, the birthing chair, considers the product from the viewpoint of its' multiple users. Childbirth is an interactive interpersonal relationship in which the mother relies on assistants, support persons and other family members to support her. The responsibilities of the family are to:

a. offer physical support;
b. offer psychological support and encouragement;
c. acquire educational experience, as with children.

In the 1950's, it was Dr. Robert Bradley's "major contribution ... was to encourage husbands to participate as coaches"[94] in childbirth. During the 1950's, a time when the family was banished to the waiting room, some women claimed that because they were drugged at the time they were unaware of a birth experience. "Today most medical staff see the father as an important contributor to the mother's well-being."[95]

Perhaps the best example for the family as a physically supportive element during childbirth can be found in contemporary midwifery practices. In the Netherlands and Great Britain, countries that have had an uninterrupted history of practicing midwifery, the 'two-person' birthing position is similar to that practiced in Europe in the sixteenth century. The three-legged birth stool (see figure 26) has an extension in the rear for the support person. Today, this posture is practiced whereby the woman is seated at the edge of the bed, and the support person sits directly behind her with knees raised. The birthing woman uses her assistant's legs to pull herself forward during contractions.

The advantages of this position are that it provides for intimate physical contact as well as the application of various back and abdominal massage techniques. The father can also help to push the baby out during contractions through the use of massage techniques.

Family as psychological support and encouragement can be accommodated much more easily in this position. "Childbearing is a partnership" and support can be provided either nonverbally "such as kissing, holding the mother's hand, and smiling" or verbally such as "coaching breathing techniques, complimenting" and encouraging.[96] Unimpaired aural, tactile and visual contact is necessary for achieving these relaxation goals.

As an educational tool, the benefits are twofold. First, the presence of existing children during the birth promotes an environment where "... the children [are not as likely] to develop separation anxiety ...." which occurs in children who do not understand the process in which the mother leaves them to give birth. Second, in some primitive cultures, female children over the age of nine are permitted to attend the births of tribal women as an educational experience. This practice familiarizes prospective mothers with the labor and delivery process. This practice potentially reduces the effects of the fear-tension-pain syndrome through a dissolution of a fear of the unknown. The implications in the design are that the chair should not appear overwhelming, nor elevate the mother out of view of the child.

2.3.3.4 Childbirth as a Cultural Experience

The third concept examines the birthing chair as an object which may instill a natural sense of relaxation through association with a significant experience such as a previous birth using the same object. Within the category of interpersonal relationships, an object, such as a family heirloom, has meaning because it represents a relationship with a significant other person or event.

As a cultural experience, a person perceives objective relationships between the self and wider patterns of order including the community and species. Cultural experiences range from the mother having a shared experience with multiparas (women who have delivered a viable baby) to practicing traditional cultural values and customs associated with the experience.

In the Sicilian culture, there is a story of 'matrimonial birth beds' which helps clarify what is meant by an object obtaining meaning through a wider pattern of order. Children are born at home in the matrimonial bed. The first born son receives the bed as part of his dowry during the wedding ceremony and it serves as the nuptial bed. In turn, his first son receives the same bed, and so on. The intimation is that the bed achieves significant meaning through association. Similarly, a childbirth chair could achieve significant

meaning if it were handed from mother to daughter to niece, or from midwife to midwife.

2.3.3.5 Summary

Certain aspects of these concepts were explored in design sketches and ultimately combined in the final design proposal. In summary, design considerations for the chair for all three levels of personal significance are as follows:

a. allow for unimpaired aural, tactile and visual contact
b. provide access for abdominal and back massage
c. comfortable height permitting easy access for mother
d. durability
e. aesthetically pleasing so as not to require storage when not in use

2.3.4 Selected Medical Considerations

2.3.4.1 Use of Stirrups

One of the most frequent complaints regarding existing birthing chair designs is the dimensional limitations of the product. Hand grips are found to be so far apart that they cannot be effectively nor efficiently used. Therefore, a delivering woman is inclined to grasp her own thighs and hold her legs apart with her arms while pulling herself forward during contractions. One argument that supports this posture justifies it by claiming that by internalizing the forces, energy is preserved. This posture is adequate for women who are reasonably physically fit. However, women who are obese, or not athletically inclined, are generally unable to comfortably adopt this posture. Thus, the use of stirrups, or a mechanism that provides a similar function, is necessary. Foot supports should provide support, thus permitting relaxation of the leg muscles and resulting in a relaxed perineum.

2.3.4.2 Lumbar Support

With the high incidence of back pain experienced during childbirth, lumbar support is a crucial consideration. As the uterine contractions push the infant into the birth canal, the spinal cord is forced from a natural 'S' curve into a 'C' shape. This places stress on

the lumbar region resulting in lower back pain. The 'C' curve is advantageous over the 'S' curve in that the distance the fetus travels is shorter, thus resulting in a shorter labor duration. A flat surface with 10 centimeters cushioning thickness prevents the spinal cord from excessive deformation. A seat length that does not exceed a woman's femur length will permit her to support her lumbar area with the backrest.

2.3.4.3 Use of Anesthetic During Childbirth

There are two common forms of anesthetic used in North American hospitals today. They are:

a. a local anesthetic in the perineal area to alleviate pain in the event that there is perineal tearing and the need for sutures;
b. an epidural, or spinal, anesthetic used to freeze the area below the diaphragm;

The application of a local anesthetic requires access to the perineal area. This injection does not effect labor.

An epidural injection, on the other hand, has in some cases impaired labor. This can lead to further complications such as arrested labor resulting in the need for medical assistance. This medical assistance is in the form of access to the woman's perineal area, in case of forceps delivery, or abdomen, in case of cesarean section. The application of this injection is into the epidural space around the spinal cord. Medical assistance in this case requires access to the spinal column. A general anesthetic is used in emergency cases.

As the scope of the project tends towards women interested in an active participation in *natural* childbirth, design restrictions based on the use of anesthetic are given a low priority.

2.3.4.4 Sterilization of Equipment

Since the baby must be received into a clean area, sterilization of the birthing area during labor and delivery and between use by different patients should be easy, quick and safe. The reasons for this are as follows:

a. during childbirth various fluids are expelled before, during, and after the expulsion of the infant;
b. cleaning staff contacting blood run the risk of contracting hepatitis and other contagious diseases such as AIDS, while sterilizing hospital equipment.

There are several considerations in the design that may expedite this process. They are as follows:

a. non-porous and sealed removable covers which are either disposable or washable;
b. various components of the chair should have no ridges or piping in which blood can collect;
c. all cushion seams must be sealed;
d. structural parts constructed of plastic or metal which does not deteriorate as a result of solvent sterilization;
e. materials chosen in light colors so as to easily expose blood, whether fresh or dried;
f. the chair should be easily disassembled and reassembled for the sterilization of individual parts to maximize utility;
g. the components of the chair should be light weight to minimize muscle strain by cleaning staff and nurses.

2.3.4.5 Summary

The following is a summary of the design parameters that should be considered to satisfy medical requirements in the design of a birthing chair:

a. provide adequate space for the safe reception of the infant;
b. provide adequate space for the placement of a waste fluids container for use during the placental stage;
c. provide unimpaired access to the perineum in case of suturing required as a result of an episiotomy or perineal tearing;
d. appropriate seat length to minimize the need for additional lumbar support;
e. non-porous and sealed removable covers which are either disposable or washable;
f. various components of the chair possess no ridges or piping in which blood can collect;
g. all cushion seams are sealed;
h. structural parts to be constructed of sterilizable material;
i. use of light colors;
j. the chair is easily disassembled and reassembled;

k. the components of the chair are light weight.

It is important to note that there are design considerations that are not included in this investigation. For example, in some cases it is desirable to place the woman at a height such that it is convenient for standing medical personnel to examine her. These considerations are not included in this study because the emphasis in this study is on improving the physical and psychological environment for the birthing woman. In the example provided, it may not be a psychologically optimum situation for the woman to be placed at a comfortable standing work height for the average man and tall woman[97] (81 centimeters or 32 inches above the ground) as this may cause her to feel somewhat unstable, isolated, or helpless. The focus of the study remains on the well-being of the birthing woman.

2.3.5 Dimensional Data Pertaining to the Parturient Woman as User

2.3.5.1 General Comments

Dimensional data for the physical characteristics of North American women in the 2.5-th to 97.5-th percentile user group have been collected to determine the specific dimensions of the birthing chair. The majority of data has been abstracted from Humanscale 1-9. These standards are based on United States army statistics, and although they may not be an accurate representation of the general population in all aspects, dimensional data such as arm length, leg length, and most effective work postures are applicable. This range of users was chosen to accommodate the largest possible user group without making the product so adjustable that it becomes complicated. "In civilian work it is desirable to include more than 90 percent; 98 percent would be ideal but it can impose excessive requirements on some designs, making them impractical, complicated, or too expensive."[98] This target group excludes five percent of the population: the smallest 2.5 percent, and the largest 2.5 percent of women.

> "Designing for people means accommodating people for comfort, for content, for freedom from disability, and for maximum productivity."[99]

In the design of a birthing chair comfort equates to a feasible physiological posture, content equates to an emotionally satisfying experience, freedom from disability equates to injury

prevention for mother and child, and maximum productivity equates to a product that best serves the purpose for which it is intended.

This product is intended for use by North American women in above average physical condition who are interested in an active participation in natural childbirth.

> "natural childbirth: labor and parturition accomplished by a mother with little or no medical intervention. It is generally considered the optimal way of giving birth and most satisfying for the mother. Prerequisites include normal gestation, an adequate birth canal, strong maternal motivation, physical and emotional preparation, and constant and intensive support for the mother during labor and birth."[100]

The product is also intended to facilitate the process of birth for all women should it be both safe and desirable for a broader population base. Because the user group is targeted as women interested in natural childbirth, extraneous characteristics such as hemorrhaging and the use of an epidural anesthetic, which can on occasion be necessary for the target user group, are not given priority in design considerations. Persons who require medical assistance of this nature must be transferred to a conventional birthing bed that has been designed to address a broader range of uses. It is considered that the degrees of product adjustability necessary to accommodate all users would complicate this product. It is further intended that the product be enticing, inviting, seductive and simple in its presentation.

2.3.5.2 Ergonomic Data for Hand Grip Location

The evaluation of historical information led to the conclusion that a woman should have hand grips placed directly in front of her. The evolution of the obstetric chair indicated that women should grasp something either on the sides of their chair seat or at the end of armrests. This ergonomic projection is based on the most efficient work posture.

> "Maximum push and pull forces occur with arm extended forward and elbow near locking position when seated with back support for the lumbar area"[101]

The conclusion is that in order for the arms to have maximum strength potential, hand grips should be placed directly in front of the woman and at a distance such that her arms are almost fully extended (see Table 1). This location for hand grips must not impair the medical assistant's ability to provide injury preventive care. During contractions, the arm action is pulling the body forward at progressively more frequent and longer intervals until the delivery of the infant. The primary and secondary choices for the hand grip locations are:

a. directly in front of the extended arm
b. on the armrest just forward of the shoulder

Table 1: Sustained Force for Arms With Frequent Intermittent Use Without Discomfort With Feet Braced (1 minute duration)

arm position	weak woman	strong woman
arm extended: pull action	6.25 lbf	29.75 lbf
arm extended: push action	5.5 lbf	36.5 lbf
arm bent 90 degrees at elbow: pull	4.25 lbf	22.5 lbf
arm bent 90 degrees at elbow: push	5.5 lbf	25.75 lbf
arm vertically extended: pull	5.75 lbf	29.5 lbf
arm vertically extended: push	5.0 lbf	22.75 lbf

2.3.5.3 Anthropometric Data for Hand Grip Location

Ergonomic data relate to work performed, while anthropometric data relate to "the science of measuring the human body as to height, weight, and size of component parts..."[102]. The

optimum height for hand grips is in the range between the top of the shoulder and the bottom of the elbow.[103]

Table 2: Dimensional Data for Arms (centimeters)

body segment	2.5-th percentile	50-th percentile	97.5-th percentile
shoulder joint to elbow joint length	24.9	26.4	28.2
elbow joint to wrist joint length	21.8	23.4	25.4
wrist joint to grip line length	6.4	7.1	8.4
shoulder joint width	28.4	31.5	34.8
shoulder joint to seat height	53.9	49.6	46.0
shoulder joint to finger tip length	72.6	67.3	62.7
elbow base to seat height	22.6	20.6	18.5
hand circumference	17.0	18.8	20.3

2.3.5.4 Ergonomic Data for Foot Anchor

Of utmost importance regarding the feet is the free and unimpaired movement of the legs.[104] Primitive women were in some instances put in positions such that only the balls of their feet touched the ground. Women, throughout the middle ages and well into the mid-nineteenth century, placed their feet on the ground while laboring in a sitting position. Contemporary women have their

feet approximately 32 inches above the ground if they use contemporary birthing chairs. Considering the dynamic nature of childbirth, it would be desirable for the laboring woman to easily enter and leave the birthing chair. This leads to the conclusion that a comfortable sitting height, with the woman's feet properly supported, would be desirable. This also leaves the assistants free to perform other tasks as they would not be required to aid the birthing woman in and out of the chair.

The optimum work position for the legs while in a sitting position with the knee angle between 35 and 55 degrees from horizontal (see Table 3).

Table 3: Sustained Force for Legs With Frequent Intermittent Use Without Discomfort (1 minute duration)

leg position	weak women	strong women
35-55 degrees from horizontal	29.25 lbf	73.0 lbf
60 degrees from horizontal	28.25 lbf	68.25 lbf
70-75 degrees from horizontal	21.5 lbf	54.5 lbf

2.3.5.5 Anthropometric Data for Foot Anchor Location

Table 4: Dimensional Data for Legs (centimeters)

body segment	2.5-th percentile	50-th percentile	97.5-th percentile
back of knee to seat back length	40.1	45	50.3
popliteal height with bare foot	34.5	37.8	40.6
thigh width	14.7	17.5	20.0

ischia width	16.3	18.0	19.6
foot length	22.6	24.6	26.4
ankle joint to foot base	7.6	8.1	8.9
knee width	8.9	9.4	10.2
leg length	92.0	84.6	77.2

2.3.5.6 Anthropometric Data for Seat Design

The chair seat should provide adequate support for the birthing woman during stage one, and access to the baby during stage two. Seat length should be among 33 and 40.6 centimeters deep to satisfy the needs of women in chair design[105]. In birthing chair design, this distance suffices for stage one. However, during stage two the seat form should change to provide the half moon cut out advocated by Soranus in 200 A.D.

"Seat widths have no maximum based on human requirements. ... Seat widths less than 40.6 centimeters do not fully support the buttocks of the large female."[106]

Seat padding should have about 3.8 centimeters of medium foam padding over 1.3 centimeters of firm close celled padding. The maximum seat compression should not exceed 3.8 centimeters for a large woman."[107]

Table 5: Dimensional Data for Seat Design (centimeters)

body segment	2.5-th percentile	50-th percentile	97.5-th percentile
ischia to seat back length	11.4	13.0	14.5
sitting hip width	31.2	37.1	45
floor to seat height	36.3	39.6	42.9

front thigh to seat back standing	17.3	20.8	24.9
maximum seat length	40.1	43.5	48.0
approximate seat length for stage two	25.8	27.5	29.8

2.3.5.7 Anthropometric Data for Backrest

"The center of forward curvature of the lumbar region for most adults is located 22.9-25.4 centimeters above the compressed seat cushion. A padded lumbar support with a 25.4 centimeter radius in the vertical plane accommodates most people. Lumbar supports should measure 15.2-22.9 centimeters from top to bottom. They should be 33 centimeters wide. Backrest-to-seat angles of 95-100 degrees are good for most purposes"[108]

Table 6: Dimensional Data for Backrest Design (centimeters)

body segment	2.5-th percentile	50-th percentile	97.5-th percentile
shoulder width	36.6	40.6	45.0
top of head to seat	78.2	84.1	90.4
head length	20.1	20.3	20.8
seat to center of curvature height for lumbar support	22.9		25.4
lumbar cavity	1.3		2.0
sitting hip width	31.2	37.1	45

2.3.5.8 Squatting Posture

The maximum squatting breadth for a large female is approximately 57.2 centimeters.[109] With the knee width of 10.2 added, a squatting chair seat requires a width of 77.6 centimeters for a large female.

2.3.5.9 Conclusions

Hand grip location should be either on the seat edge or directly in front of the user for optimum strength capabilities. This information combined with the idea that the optimum height for hand grips is in the range between the top of the shoulder and the bottom of the elbow leads to the conclusions that hand grips should be located in front of the user.

The optimum work position for the legs while in a sitting position with the knee angle between 35 and 55 degrees from horizontal This will be combined with a seat angle of between 95 and 100 degrees.

The chair seat should provide adequate support for the birthing woman in the selected postures during stage one, and adequate access for assistants for the delivery of the infant during stage two. This requires a chair adjustment. The adjustment range for the center of curvature for the lumbar region for women from the 2.5-th to the 97.5-th percentile user is 2.5 centimeters. This difference is not considered to be significant and therefore lumbar support height adjustment will not be considered. Although there is no recommended maximum seat width, a seat width generously accommodating large women will be adopted to provide a sense of closure and stability. This dimension will be combined with a maximum squatting breadth.

2.3.6 Dimensional Data for Infants

2.3.6.1 Anthropometric Data for Male Infants

This information is relevant only in ensuring that the space for receiving the infant, the seat cut-out, is adequate. This information is drawn from the data of male infants.

Table 7: Dimensional Data for Infants (centimeters)

body segment	males at birth

body length	50.5
head length	12.7
head width	9.7
head circumference	35.3
shoulder width	15.2
chest circumference	33.3

2.3.6.2 Conclusions

The cavity in the chair seat should be a minimum of 50.5 centimeters above the ground. The diameter of the cavity should be approximately 35 centimeters across.

2.4 Summary of the Human Factors Considerations

The results of this literature review have been formally described in the Design Brief.

3.0 DESIGN BRIEF

3.1 Overview

This chapter specifically outlines the design parameters that have been synthesized from the research into the historical, psychological and physiological factors influencing childbirth. These guidelines are first discussed in a general manner, and then formally defined in the Design Brief.

In this stage the selected concept and associated sketches are matched with the identified requirements specified in the Design Brief. Questions, such as: why or how the posture is physiologically addressed in the product design, which environment the product is intended for, and how the product is manipulated from one posture to another in a safe and simple (elegant) manner, required further analysis during this methodological step. These considerations provide clarity and definition to the sketch designs (see Appendix A).

Because of the design goal of designing a product which inspires, permits and enables a woman to deliver a child with increased comfort, confidence and security, more attention has been given to childbirth postures which were not influenced by the medical developments in childbirth between 1650 and 1950 A.D. Through an understanding of the historical changes in the form of birthing aids and traditionally preferred birth postures a decision was made to address birth postures which were common prior to the medical developments which led to the lithotomy position, and rely on the design of medical equipment to accommodate the posture, rather than the posture adapt to the equipment. Therefore, medical developments which led to the lithotomy position, and postures dictated by the use of equipment such as the fetal monitor have been given low priority. Rather, an attitude has been adopted that medical equipment should be designed to accommodate the naturally selected labor and delivery postures of women rather than the postures accommodating the design of medical equipment.

If one were to ignore the developments of birthing aids used during the time when women suffered from puerperal fever, concentrating only on the treatment of women as healthy individuals, one discovers that there is very little similarity in historical products, and those found in contemporary hospitals. This is not to imply that the same product should be used, but that certain elements and aspects of earlier designs may be appropriate and preferable in the contemporary birthing room.

This led to the specific goal to design furniture for the birth experience which could be used in an injury-preventive environment, rather than medical equipment which could be used in any environment. Equipment, such as fetal heart monitors, should be designed to accommodate the postures selected by the birthing woman. In view of modern technologies, such as the miniaturization of electronic chip circuitry, natural childbirth practices may be re-introduced without compromising the medical advances made through these technologies.

3.2 Objectives

It was determined that if the obstetric chair should transform from a sofa to a chair to a bed it could address most of the identified user needs. This section is a discussion of the three configurations for the product. By combining these products into one, there were several considerations in terms of product image which required attention. They are as follows:

a. as a recliner it is not recognizable as a chair or bed;
b. as a chair it is not recognizable as a recliner or bed;
c. as a bed it is not recognizable as a recliner or chair;
d. the transformation from a recliner to a chair or bed, and vise versa, may be accomplished with one simple movement;
e. it is possible to change the recliner to a chair, or chair to a bed, without removing parts such as cushions;
f. there are no grids, levers or parts of the structural framework which may be felt through the cushions;
g. special consideration is given to ergonomical, psychological and physiological factors;
h. levers and controls are self-describing;
i. the plurality of uses is self-evident, and each use is complete in itself.

Each separate product arrangement is presented in chapters 4 and 5.

3.3 User

Women in excellent physical condition who are interested in an active participation in natural childbirth will be interested in this product. Given that approximately 15 percent of birthing women

require major assistance, such as a cesarean section, and approximately an additional 35 percent prefer an epidural or other medical relief, this product is suitable for approximately 50 percent of the mothers to be.

The user will continue with the use of this product until it becomes evident that there are pending physical complications requiring medical assistance, at which point the user will be transferred to a surgical table, or alternative birthing bed that provides options such as manipulation into the Trendelenburg Position.

Due to the advanced monitoring systems of both unborn child and mother available in modern birthing centers and hospitals, there is usually sufficient warning time for this transfer between products without endangering lives or risking health.

Integral to the concept is the necessary requirement for the coherent interaction between the woman as a dynamic body and the chair as a static yet adjustable product, and the understanding that the product is used by an individual for approximately ten hours a few times during a lifetime in its specialized form.

3.4 Product Identity

Common household furnishings such as the sofa, chesterfield, chesterbed or davenport, recliner and armchair have long been associated with comfort and relaxation. This 'product identity' has been selected as the image for the birthing chair. Although this identity holds for only one configuration of the product, it is the standard form for the product while not in use. Thus establishing beforehand the image of relaxation, it is proposed that the visual image of the easy chair may serve to relax the user and thereby help to diminish the fear-tension-pain cycle. If the user is relaxed, the perceived pain during contractions may be reduced. Furthermore, the sofa, as opposed to the bed, is traditionally associated with rest, and not sleep. This is considered an advantage over existing products.

Since childbirth is a unique experience there has been an attempt to personalize the product by providing several postural alternatives. This is not only consistent with the recommendation that women shift their posture every twenty to thirty minutes during labor and delivery, but it also permits the user to adopt postures that are specific to her needs. Different position of the fetus will result in different postures for comfort. For example, a woman

who is experiencing back pain may wish to bend forward at the waist, while another may wish to sit in a reclined position.

3.5 Environment

The intended environment is injury-preventive, one in which the benefits of modern medicine and technology may be implemented when necessary, but this also means that these benefits be used only when necessary, not as a preclusive measure.

The design proposal is intended for the injury-preventive environment, and not for the home. However, benefits of a home environment which are considered valid have been defined as characteristics which provide comfort and relaxation. These ideas have been expressed through product identity.

The purpose of this study has been to develop a model for a birthing chair that could be for use in currently recognized birthing environments: hospitals and Birthing Centers, as well as alternative environments such as community health offices. These concerns are important in view of the move by some women and midwives to transport childbirth into a non-medical location.

3.6 Design Brief

3.6.1 General Comments

The design brief is provided to offer a detailed description of the parameters of the design project. In a client-designer relationship, the design brief may constitute a legal contract that outlines the tasks that the designer will perform, including a fee and time schedule. This brief is an identification of the parameters, or constraints and criteria, that have been determined as a result of the literature review and expressed as as restricting factors or guidelines in the design process.

3.6.2 Project Title: Birthing Chair

> definition: "A chair used in labor and delivery to promote the comfort of the mother and the efficiency of parturition. The chair may be specifically designed, having many technic features, or it may be a simple three-legged stool with a high, slanted back

and a circular seat with a large central hole in it. The newer birthing chairs allow the woman to sit straight up or to recline. The chair has a lower section that may be removed or folded out of the way. Lights, mirrors, and basins may be attached for the attendant's convenience. The upright position appears to shorten the time in labor, particularly the second or expulsive stage of labor, probably because of gravity and increased participation of the mother. The chair is not suitable for use with anesthesia."[110]

3.6.3 Project Description

The emphasis in this project is to improve user performance through a new perspective on traditional and contemporary birthing methods. There are factors that may be considered which have been overlooked or compromised as a result of the rapid growth of medical technology during the twentieth century. Although technological and medical developments in obstetrics were a necessary response to the high infant and maternal mortality rates of the nineteenth and early twentieth century, the functional aspects of them precluded, in some instances, a generous observance of the birthing woman's emotional needs.

3.6.4 Target User Group

The Target User Group is identified as adult North American women of child bearing age (approximately 18-40) who are physically fit women and interested in an active participation in natural childbirth. It is not intended for women in high risk groups. The study includes women in the range of physical characteristics from 2.5-th to 97.5-th percentiles. The study assumes that women who demonstrate a potential need for medical assistance will be transferred to a hospital bed at any point during the labor and delivery. Consequently, the design will not address concerns such as an attachment for an intravenous bag or epidural anesthesia.

3.6.5 Intended User Environment

Although North American childbirth usually occurs within a hospital or birthing center, current controversy between home and hospital birth, and midwife or doctor attended births may introduce changes to the standard birthing environment. This chair is designed for use within an injury preventive environment for both mother and child.

3.6.6 Task Analysis

In addition to the description of the birth activity in Chapter 2, the task analysis is briefly defined in the Four Stages of Labor and Delivery. This section, provided in point form, is offered to provide an understanding of the chronological sequence of birthing.

a. With the onset of regular contractions the woman goes to a hospital or birthing center.
b. She is cared for or labors in a birthing room.
c. An average of eight to ten hours are spent in active labor.
d. Some postures for this stage are straddling a chair backwards, suspended by the arms and gently rotating the pelvic area, a supported squat, a reclined sitting position, and lying down.
e. Medical personnel routinely perform examinations to determine cervical dilation, and monitor the fetal heart rate.
f. The woman selects a comfortable delivery posture, place her limbs clearly away from the perineal area, and draw her upper torso forward during contractions to facilitate the expulsion of the child (second stage).
g. It is desirable for the woman to draw her body forward using her arms by placing them either under the thighs or around another support structure or person.
h. After the expulsion of the baby, the placenta is delivered without a postural shift.
i. The woman will be cleaned and sutured. if necessary.
j. This is concluded with a period of rest and recovery.

3.6.7 Postures to be Addressed

"The functional relationship between the uterine contractions, the fetus, and the mother's pelvis are altered by maternal positioning. ... The positions commonly chosen by laboring women for comfort may also reduce the length of labor, thus reducing the possibility of dystocia (abnormal labor or birth)"[111]. "Freedom of movement (e.g.: walking, squatting, sitting) offers a greater variety of angles to the presenting part thus increasing the chances of a better fit between fetus and pelvis. Women who are in an upright position in the second stage of labor produce lower levels of stress-related hormones."[112] The upright posture in childbirth has been demonstrated to:

a. optimize the force of gravity;
b. better align the fetus with the pelvic angle;
c. decrease labor duration;
d. reduce pressure on the vena cava.

The postures that have been addressed in the design of this birthing chair are:

a. a reclined sitting position;
b. squatting;
c. left lateral side lying;
d. lying or resting
e. hands and knees;
f. supported squat or two person birthing.

3.6.8 Constraints

Constraints provide a coherent set of premises or guidelines that will be presented as necessary components in the design of a birthing chair for the target user group. They are determined as follows:

a. accommodate 2.5-th to 97.5-th percentile females;
b. adjustments fulfill the requirements of the selected postures;
c. to be functional with medical practices which are routine such as fetal monitoring;
d. hand grips or handles available for use during contractions;
e. hand grips should be placed between the shoulder and elbow height directly in front of the user;
f. the seat base to be formed appropriately in depth, width and height to permit safe passage of the infant;

g. in a sitting position the knee angle is 35-55 degrees from horizontal;
h. inclusion of a backrest for rest between contractions;
i. provide adequate space for the placement of a waste fluids container under the chair for use during the placental stage;
j. enable unimpaired access to the perineum in case of suturing required as a result of an episiotomy or perineal tearing;
k. the surface of the chair and all parts contacting body fluids must be easily sterilized;
l. structural parts are to be constructed of sterilizable material;
m. all cushion seams are sealed;
n. various components of the chair possess no ridges or piping in which blood can collect;
o. non-porous and sealed removable covers that are either disposable or washable for covering the cushions.

3.6.9 Criteria

Criteria provide a list of recommendations that would contribute to the aesthetic composition of the chair. They are determined as follows:

a. low cost;
b. massage and aural contact with the woman should be made easy;
c. all adjustable parts should be self-describing;
d. possible to adjust the chair to several laboring postures allowing for the frequent postural changes desirable during stage one;
e. possibility for postural shifts which allow access to the perineal area;
f. adequate space for an assistant to sit to the rear of the laboring woman;
g. use of light colors;
h. the chair to be easily disassembled and reassembled;
i. the components of the chair to be light weight;

3.7 Summary

The parameters are necessary in limiting the design options. The preliminary sketches explore ideas for manifesting the design guidelines in form. The expression of these parameters is explained in greater detail in the following chapter.

4.0 DESIGN PROPOSAL

4.1 Overview

This section is a discussion of the proposed form as a function of historical precedents, human factors considerations, childbirth as an activity including both of the birth chair users: the woman and her assistant, and the assembly process. These factors are discussed within the scope of the project in terms of their realization and expression within the proposed design for a birthing chair.

This discussion is prefaced by a description of the proposed design and the three configurations:

1. chair;
2. recliner;
3. bed.

4.2 General Form

The three product configurations are presented in terms of their postural adjustments.

4.2.1 Chair

The chair configuration (see figure 51) is intended for reclined sitting with knees lowered, for use during stage one, knees raised, as may be desirable during stages two or three and possibly stage four when a woman may want to hold her newborn baby.

The sitting position permits direct eye contact with persons around her, as well as enables her to enter and leave the chair without struggling. The sitting position also makes use of gravity. Furthermore, the sitting position echoes the postures more commonly adopted until only a few centuries ago.

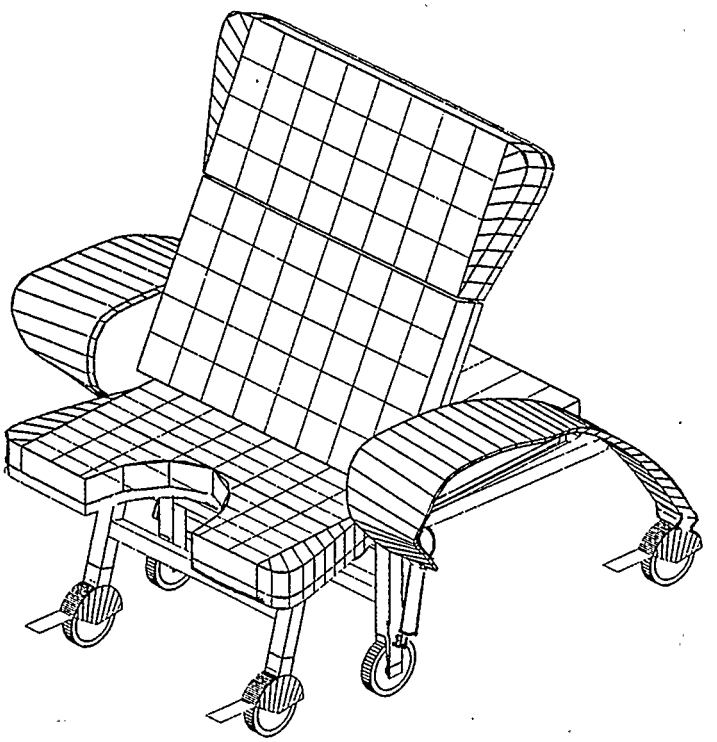


Figure 51: Chair Configuration

4.2.2 Recliner

The recliner configuration (see figure 52) is recommended for squatting and the 'hands and knees' posture.

Squatting has been documented using ropes, poles and trees. The possibility of a squatting position is provided, although the parturient woman is expected to squat on the obstetric chair, rather than over the ground, for reasons of sanitation. This posture is recommended for stages one and two. Again, this posture makes use of gravity, and reduces the pressure on the vena cava.

A posture of 'hands and knees', or leaning forward and taking all weight off of the back, is desirable in cases of back pain during labor. This posture is also useful in stages one and two.

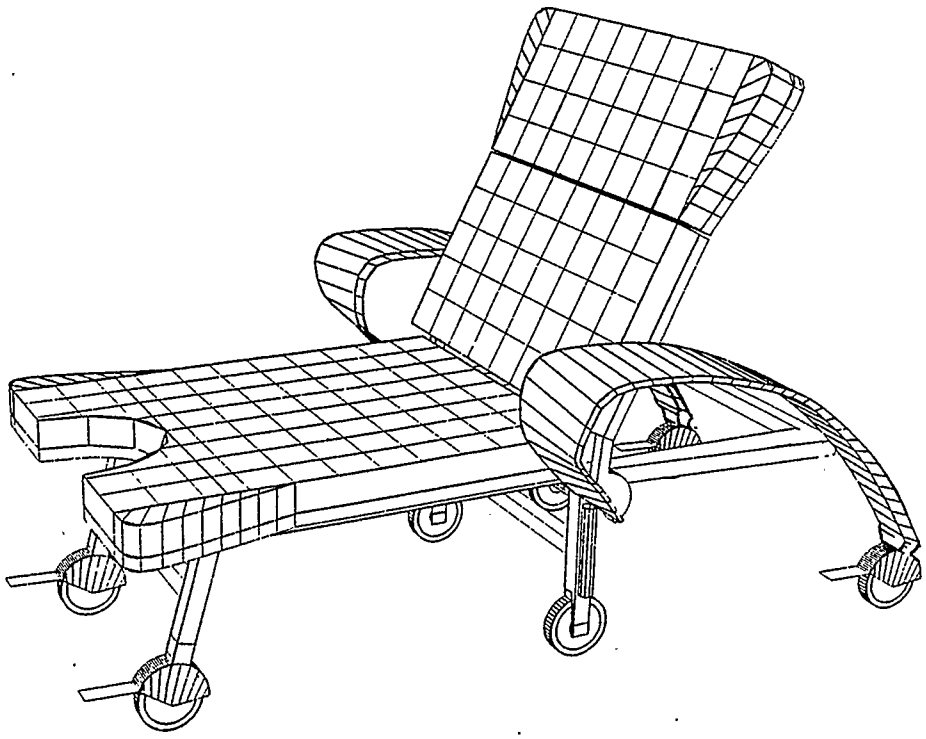


Figure 52: Recliner Configuration

4.2.3 Bed

The bed configuration (see figure 53) is intended for left lateral side-lying, resting, as well as squatting or the hands and knees posture.

Although a left lateral side-lying posture is sometimes used during stage one, it is most often used during stage two. The major benefit in delivering in this posture is that because the vena cava is usually on the right side of the body the unborn baby is less likely to become distressed due to reduced oxygen supply. The major consideration in this posture is to elevate the right lower limb away from the delivery area which is achieved through the positioning of the armrest.

This posture of resting or lying down is recommended during stage four. It is not advised during stages one, two and three as the prone position does not make use of gravity, and the weight of the unborn baby on the vena cava may impair oxygen flow to the placenta thus resulting in potentially distressing the unborn infant.

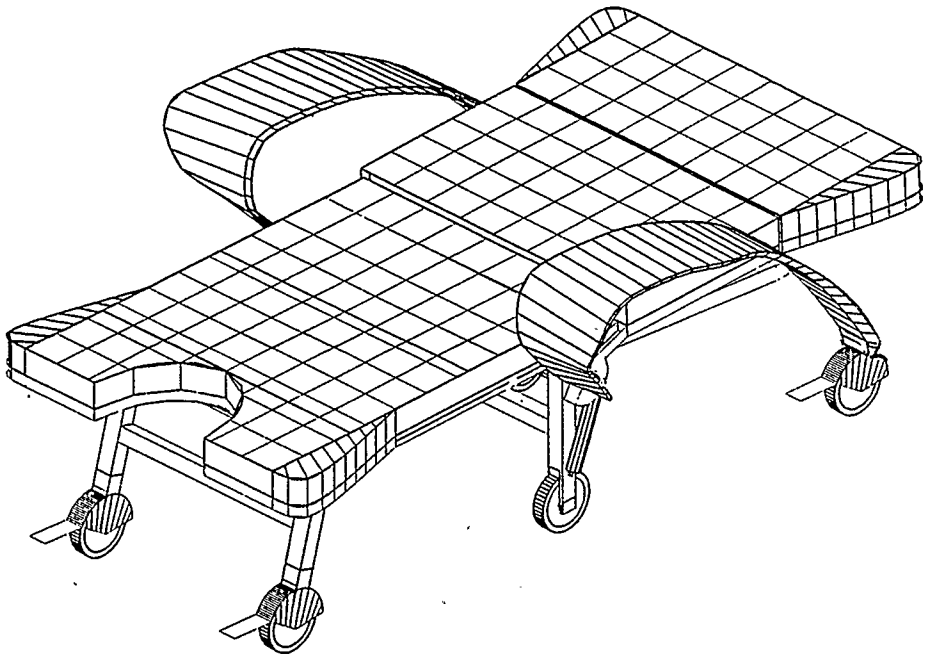


Figure 53: Bed Configuration

4.3 Form as a Function of Historical Precedents

Since the primary reason for researching historical birth postures and methods was to re-evaluate their form for the purpose of re-introducing certain design details into the contemporary birthing environment, this section is a discussion of those aspects of previous designs that have been retained and expressed in the design proposal.

4.3.1 Implementation of Primitive Birth Aids

Two elements which have been taken from primitive birthing practices are:

a. a raised arm support;
b. posture of 'all fours'.

Based on the primitive birthing aids of ropes and poles, a padded bar which swivels about the backrest, with pivot points along the top edge and on either side of the part, can be used in two manners (see Appendix A: figures 5, 8, 11, 13-16).

As a leaning bar that passes under the arms of the user, a supported squatting posture is made possible. The width of the seat reflects the alternative use as a pad on which to place ones' feet and squat. As a handle, the bar assists women in pulling themselves forward during contractions while in a reclined sitting position. The bar, when not in use, swivels to the rear of the product and does not interfere with the birth process or birthing assistants.

Based on the 'piled bricks' birth aid, the seat platform provides adequate space for the user to kneel on hands and knees for delivering in this posture. This detail is not included in drawings.

4.3.2 Borrowed Stool Seat

The 'half moon' cut-out in the seat of the traditional birthing stool is considered to be a crucial addition to modern birthing products. As an aid to the mother as user, the cut-out permits comfort while expelling the infant. As an aid to the assistants, the seat shape facilitates access to the perineum during stages two and three of labor and delivery.

The length of the seat, which adjusts from a 'chaise longue' to a typical chair seat is formed to accommodate the leg length of a 97.5 percentile female and the comfortable seat length for a 2.5 percentile female.

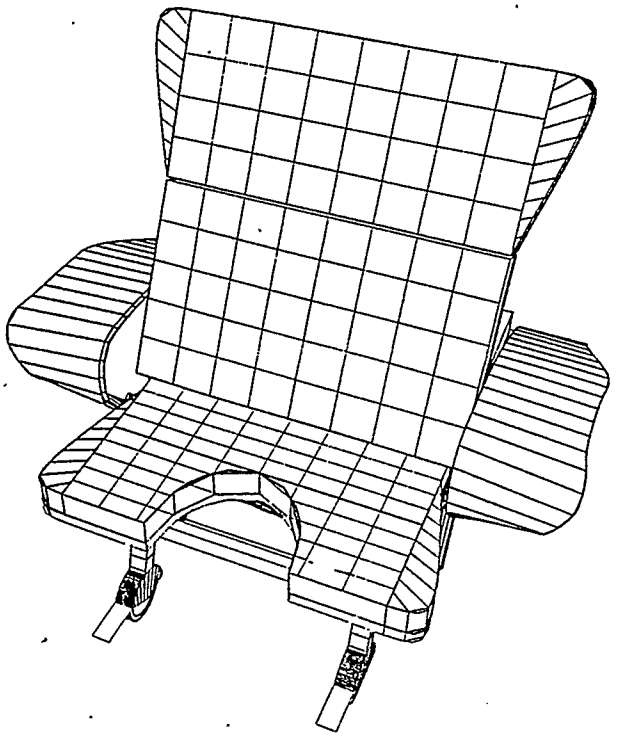


Figure 54: Chair Seat Form

4.3.3 Midwifery Considerations

Another important aspect of historic and contemporary midwifery practices which has been implemented in the design proposal is that of the 'chair for two', whereby the mother's assistant is seated directly behind her. The exaggerated length of the chair seat adequately accommodates the seat length required for two persons to sit comfortably.

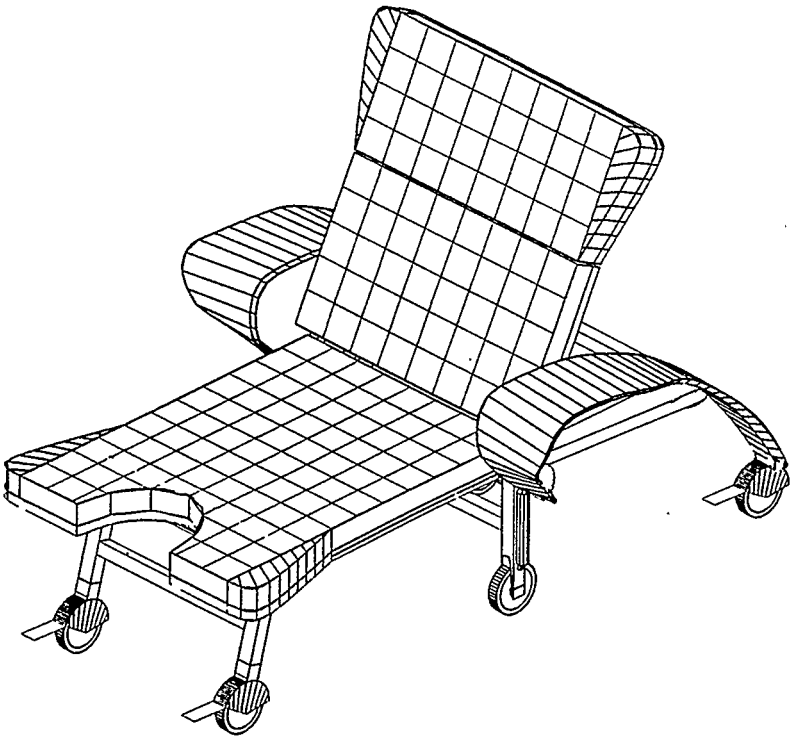


Figure 55: Extended Chair Seat for Two

4.3.4 Lithotomy

Although the lithotomy position has not been remotely considered, the posture of lying down, whether during the early phase of stage one, stage four or as a precautionary measure responding to potential maternal or fetal distress, is deemed desirable.

This posture is possible through reclining the seat back of the chair to its lowest position. The seat must be fully extended before this maneuver is possible.

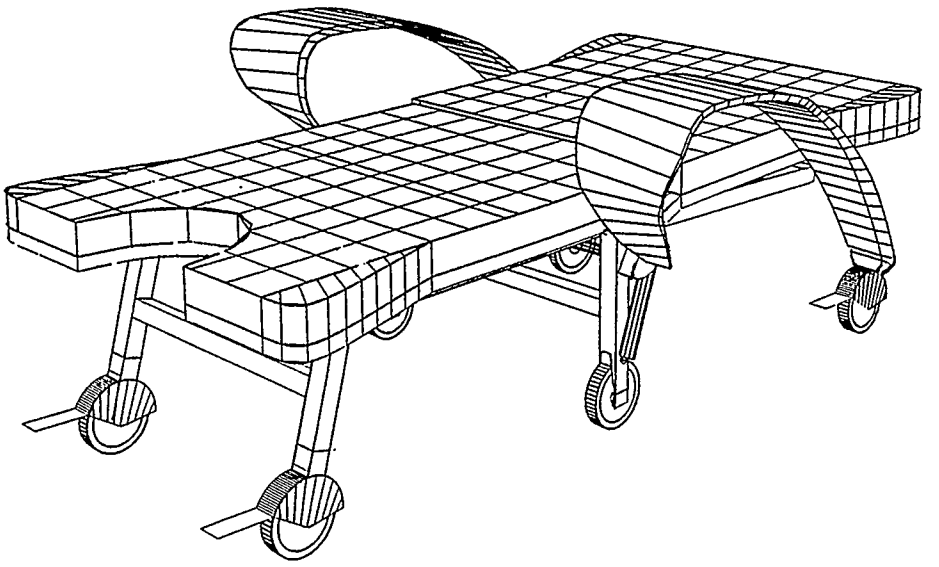


Figure 56: Bed for Resting

4.3.5 Left Lateral Side Lying

With the chair in a bed position, the width of the chair accommodates a woman comfortably lying on her side. Regarding support of the right leg, the arm rests have been designed and contoured with an exaggerated width to permit space for resting the right leg above and away from the perineum during left lateral side lying.

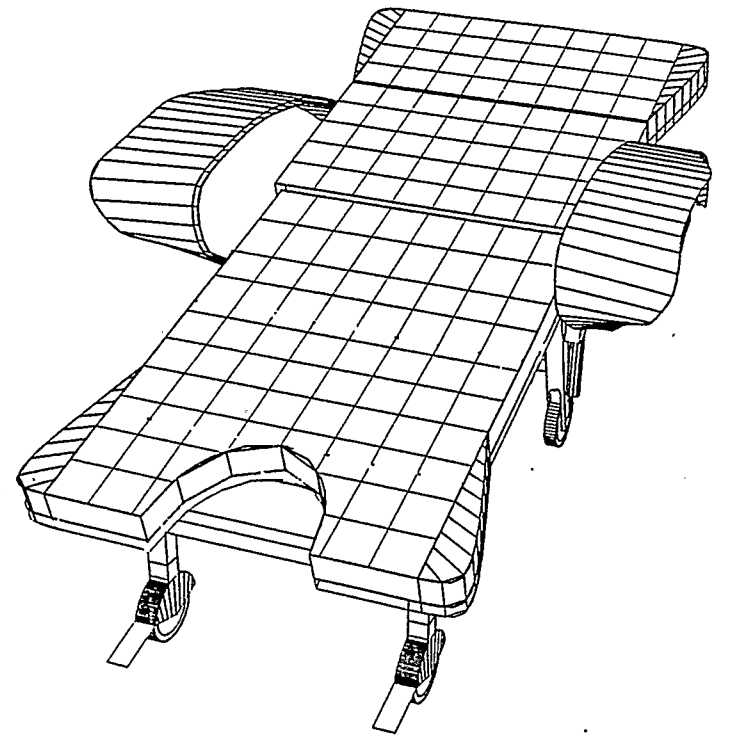


Figure 57: Bed for Left Lateral

4.4 Form as a Function of Human Factors

Human factor considerations are expressed through the determination of the physical dimensions and use of the product. Physiological considerations have been integrated with this information, and only the conclusions are included.

An important consideration again in this discussion is that pregnant women are healthy individuals, unlike most hospital users. Therefore, this product differs significantly from standard hospital equipment because it relies on the normal abilities, agility and sound mind of a healthy person.

All actual dimensions and force requirements are included in the discussion of the materials and manufacturing methods.

4.4.1 Dictating Behavior

The greatest impact of the philosophy of dictating product use through product design in this instance is through the active decision to require the parturient to slide to the front edge of the chair to manipulate it from a bed to a chair.

When adjusting the chair to a bed, which would be natural after the completion of stages one through three, the backrest rolls back, and the woman slides back without leaving the chair. Beyond this specific requirement all adjustments of backrest headrest may be made without any major postural changes.

4.4.2 Seat Design

The seat surface has been made flat to eliminate the possibility of the woman sliding in any direction unintentionally. Furthermore, the seat width has been determined in order to accommodate a sitting posture with the feet bottoms placed together. This posture, often used during traditional childbirth, further assists in providing access to the perineum.

The seat slides forward and backward manually along rollers that are placed beneath the seat. The adjustment range of 700 millimeters reflects the full dimensional differences required by the target user group of 2.5 percentile women in a sitting position and 97.5 percentile women in a resting position.

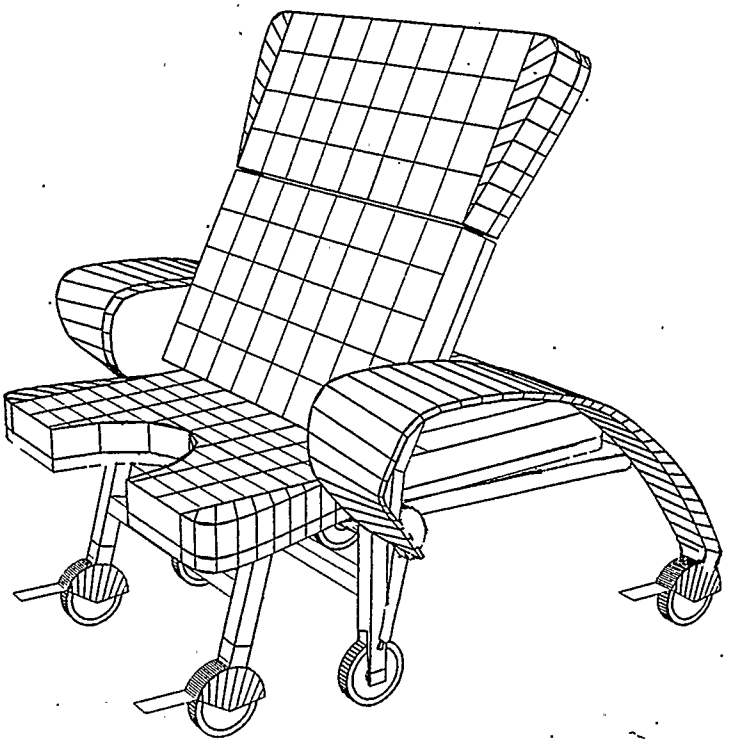


Figure 58: Minimal Seat Length

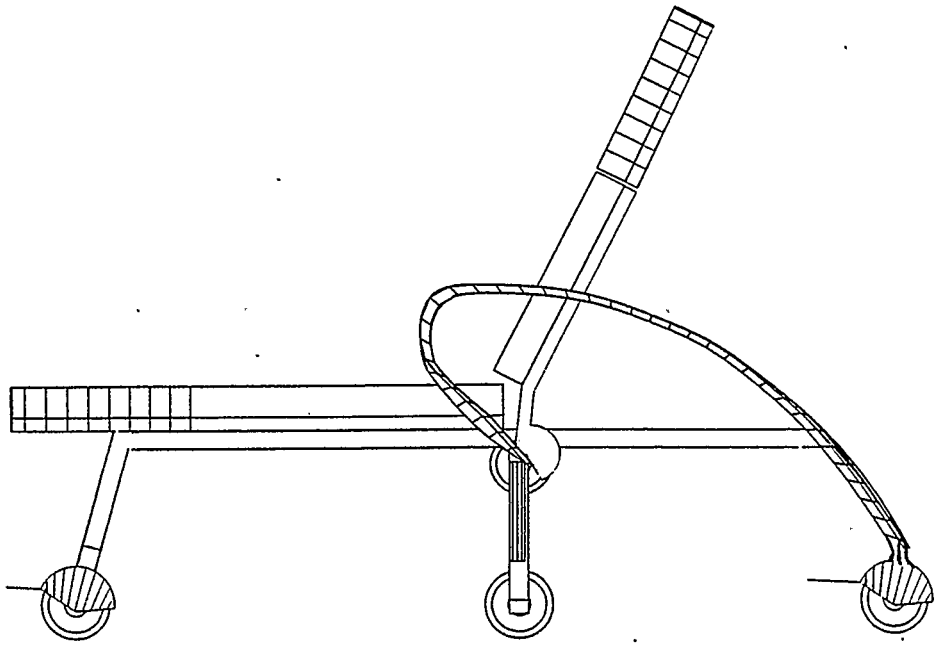


Figure 59: Maximum Seat Length

4.4.3 Headrest Design

The headrest may be raised and lowered manually. The internal ratchet mechanism adjusts through the limited possibilities, and must be pulled completely forward to readjust it to the flat position.

Because this part is intended for the head, and not any additional forces, a ratchet mechanism was considered of adequate strength.

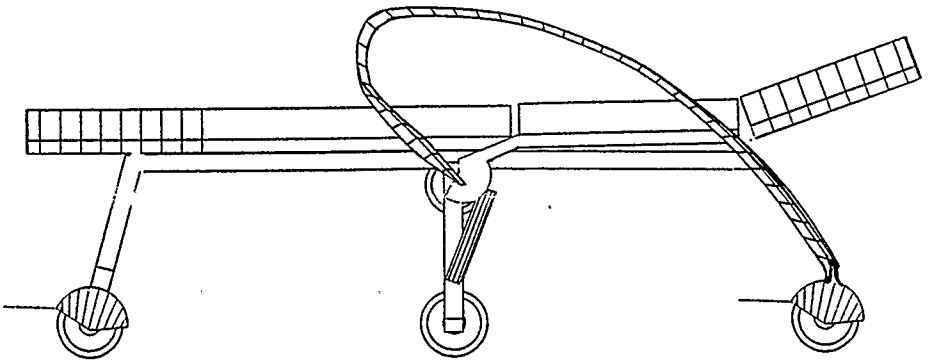


Figure 60: Headrest Raised

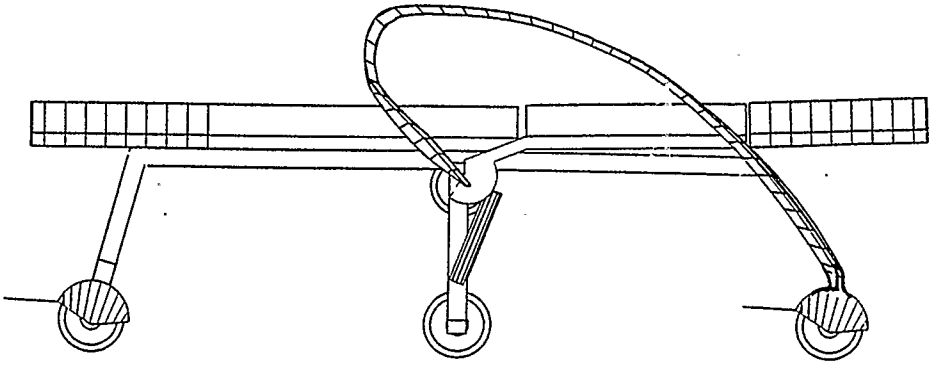


Figure 61: Headrest Lowered

4.5 Form as a Function of User

Although there are two user groups for this product, the priority in terms of design considerations has primarily been given to the parturient group. This decision has been made on the basis of the time each user group is actively involved with the product. A discussion of some examples of these compromises follows.

4.5.1 Product Height

The conflict between a product height comfortable for a pregnant woman in moving on and off as well as comfortable for an assistant for delivery has led to a compromise for both users. The product is used for an average of ten hours by the parturient, and a substantially shorter time by the assistant. However, a sitting height similar a standard bed would make an assistants task difficult and uncomfortable to perform. Thus the compromise has been to place the sitting height higher than a comfortable sitting position. This will hopefully eases the difficulties of entering and leaving the chair with a large belly. The product is lower than a comfortable standing working positionthus relying on assistants to use a stool.

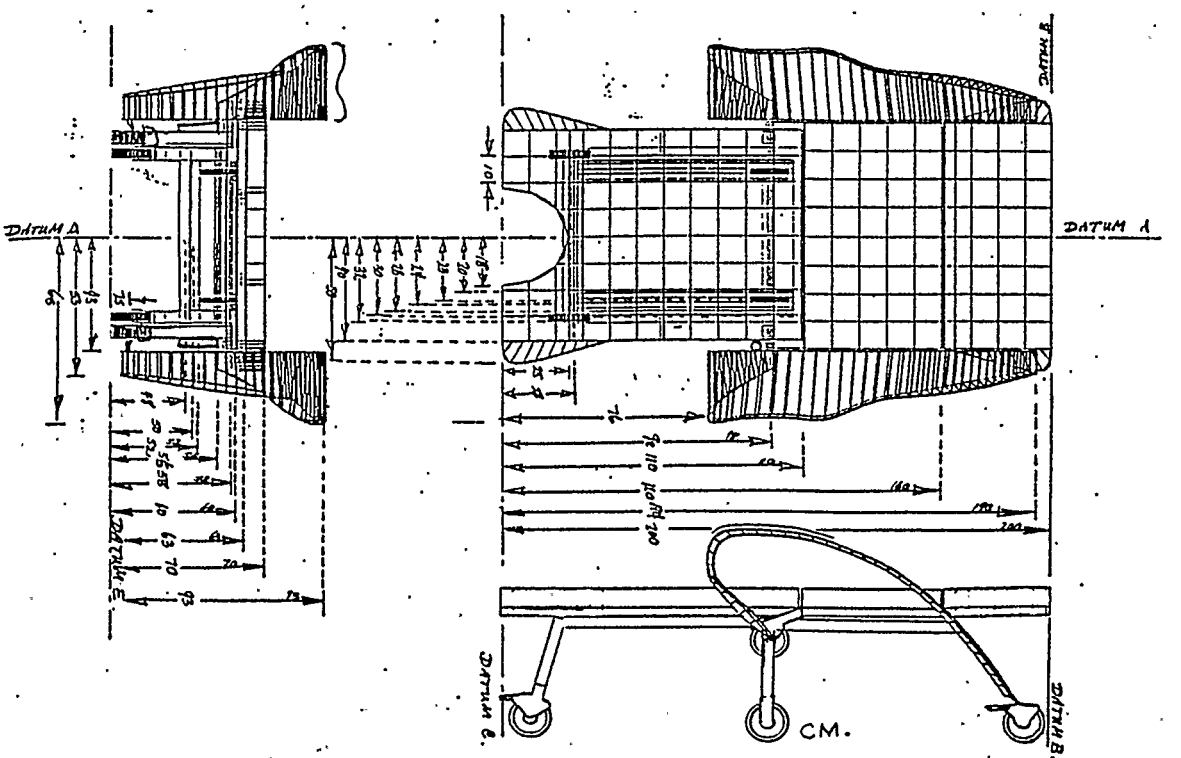


Figure 62: Dimensioned Drawings

4.5.2 Control Design

The only *control* in the product is the pneumatic cylinder that operates the angle of the backrest. The headrest and seat are adjusted manually.

The pneumatic cylinders are controlled by a depression button that is located in two places:

a. along the arm rest for use by the parturient;
b. in the form of a foot pump for use by assistants.

By depressing either unit, the angle of the backrest may be adjusted to any point between 0 and 65 degrees from horizontal.

The reason for providing two controls for the same function is to permit the parturient woman to control the product while she is able and interested in doing so and to permit the assistants to intervene on her behalf when she becomes uninterested, unable to or requires medical assistance, .

The parturient control unit, clips onto the armrest of the chair, and may be removed at any point during any stage of labor and delivery. The assistants' foot pump is located on the floor and can, because it is on wheels, be shifted to any point under and around the product.

4.5.3 Safety

The chair rests on six leg supports with wheels. Cross bars connecting each set of wheel provides lateral support. The cross bar connecting the arm rest adds further support to the head-backrest when it is in the bed configuration.

The pneumatic cylinders and ratchet mechanisms are covered by a draping, thus preventing the possibility of fingers and clothes being caught in the joints. The roller system controlling the seat movement is placed beneath the chair, thereby eliminating personal hazards at this point.

All structural parts of the chair are solvent sterilizable. The draping is machine washable.

There are five factors influencing safety of this product:

a. ratchet mechanism;
b. pneumatic cylinder;
c. roller bar;
d. wheels;
e. overall product stability.

Each component will be discussed in terms of the failure mode analysis proposed in the 26-th annual meeting of the Human Factors Society.[113] All observations are projected consequences that are based on an understanding of the recommended product mechanisms.

4.5.3.1 Safety Considerations: Ratchet Mechanism

Failure Mode:
- clutch locks on a particular setting
- clutch does not lock

Effects on Component:
- headrest inoperable

Effects on Whole System
- system inoperable

Detector Method
- operator vision

Compensating Provisions
- periodic inspection

Effects on User
- clutch locked in reclined position results in use of conventional pillow
- clutch locked in any other position results in transfer of user to alternate product or postural restrictions limited to bed position

4.5.3.2 Safety Considerations: Pneumatic Cylinder

Failure Mode:
- cylinder disconnected at backrest hinge
- cylinder disconnected at valve
- life span of cylinder springs expired
- forces exceed 400 lbf

Effects on Component:
- failure of one cylinder: difficulty in reclining backrest
- failure of both cylinders: backrest reclines to bed position, will not maintain chair backrest position
- cylinder damaged

Effects on Whole System
- product does not adjust to chair position
- backrest dysfunctional

Detector Method
- operator vision of all connector points of controls and cylinder

- failure of one cylinder results in greater forces needed to recline backrest

Compensating Provisions
- dual cylinders
- periodic inspection
- replacement after three years
- replace with longer cylinder

Effects on Users
- disconnected cylinder results in inspection of connection points and service (estimated time: 10 minutes)
- failure to restore function through reconnection requires transfer of user to alternate product
- user restricted in postural options

4.5.3.3 Safety Considerations: Roller Bar

Failure Mode:
- bar deformed
- roller wheels not aligned with tracks on seat bottom
- bar breaks

Effects on Component:
- seat locked in position and seat length adjustment option eliminated

Effects on Whole System
- chair inoperable

Detector Method
- periodic inspection

Compensating Provisions
- support bars along inside of armrests to prevent seat collapse
- crossbar connecting central leg supports, armrests

Effects on User
- user temporarily removed from product to determine cause of failure
- bar deformed or broken results in transfer of user to alternate product
- incorrect alignment results in re-alignment and continued use
- user limited in postural options

4.5.3.4 Safety Considerations: Wheels

Failure Mode:
- lock in position
- lock mechanism failure

Effects on Component:
- lock in position: product adjustment limited in seat length options, product not easily moved for cleaning floors

Effects on Whole System
- lock mechanism failure: seat length extends to recliner position as a result of forces applied to backrest

Detector Method
- periodic inspection

Compensating Provisions
- locking mechanisms on front and back wheels

Effects on User
- user limited in postural options
- transfer to alternate product

4.5.3.5 Safety Considerations: Stability

Failure Mode:
- chair cantilevers at front leg support point

Effects on Component:
- none

Effects on Whole System
- chair tips over

Detector Method
- periodic inspection

Compensating Provisions
- front support legs angled forward

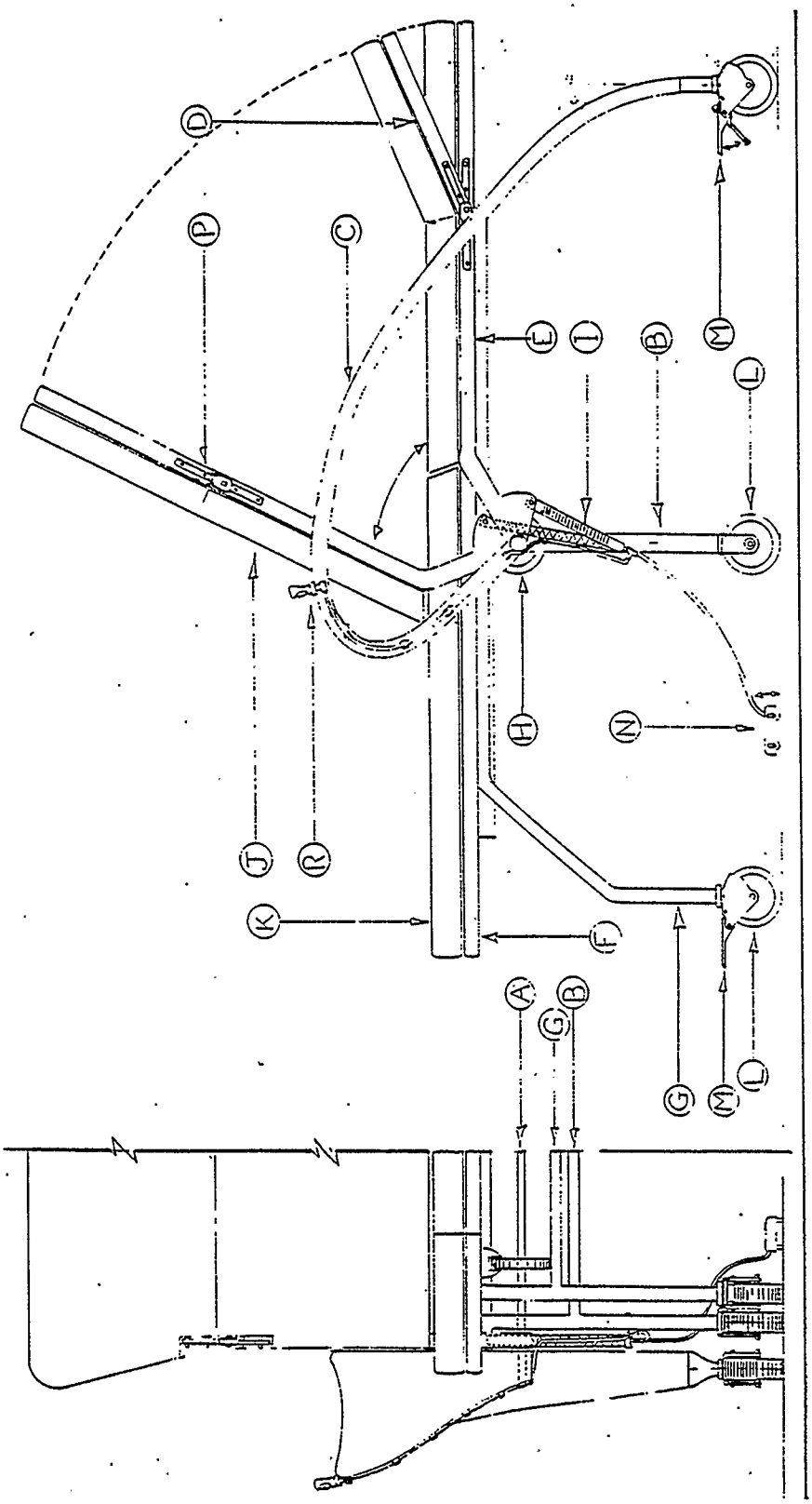
Effects on User
- transfer to alternate product

4.6 Form as a Function of Assembly

Assembly considerations, as form determinants, are included in terms of their relevance in the initial product assembly, cleaning or sterilization of parts, and repair or replacement of individual mechanisms and parts.

The implications in form are that all repairable parts, such as pneumatic cylinders, be easily accessible, and parts requiring frequent sterilization are added and subtracted with relative ease.

4.6.1 Assembly Process



NOTES
G slides into B
F rides on H
I pivots at two endpoints
foot pedal: spring wheels

Figure 63: Assembly

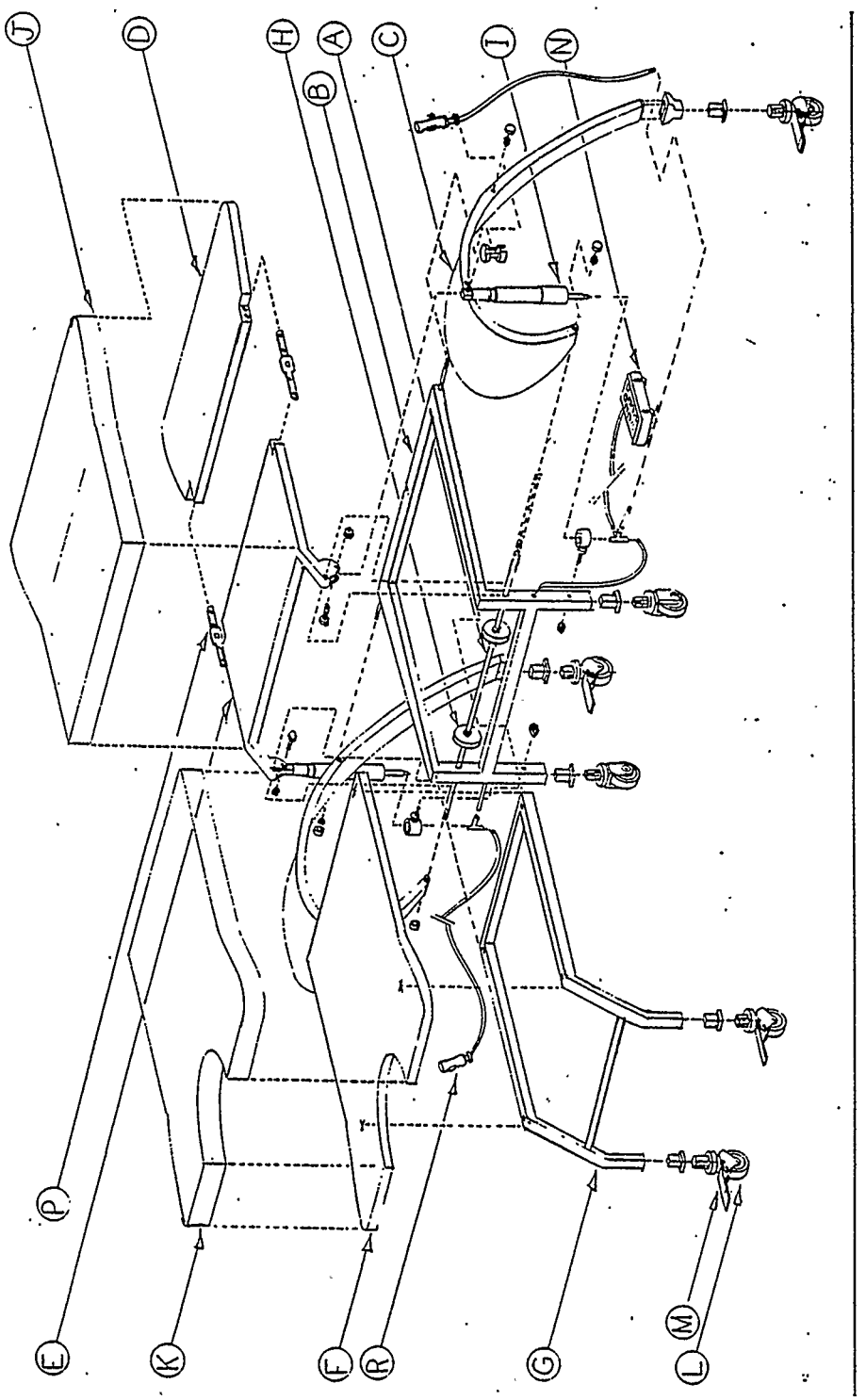


Figure 64: Exploded Pictoral Assembly

The following sequence is a proposal for the assembly of the product:

a. connect the roller bar **A** to the central leg base **B**;
b. attach the armrests **C** to the either end of the roller bar **A**;
c. connect the headrest base **D** to the backrest base **E** on either side using the ratchet connection;
d. attach the seat base **F** to the seat wheel base **G**;
e. place the seat section on the roller bar **A**, centering it on the roller guides **H**;
f. connect the head-backrest section **D-E** to the pneumatic cylinders **I** (attached to the outside of the central leg base);
g. attach the insulation mattress **J** to the head-backrest;
h. attach the insulation mattress **K** to the seat base;
i. place the draping (not shown) on the head-backrest;
j. connect the seat draping to the seat base.

4.6.2 Pneumatic Cylinders

The pneumatic cylinders have been located on either side of the product, under the seat and on the outside of the central leg support. They may be easily removed and repaired in case of faulty air tubes, over-extended springs or damaged cylinders.

4.6.3 Ratchet Mechanism

In case of failure the ratchet mechanisms, located on either outer edge of the connection point between the backrest and the headrest may be easily accessed after removal of the cushion matress.

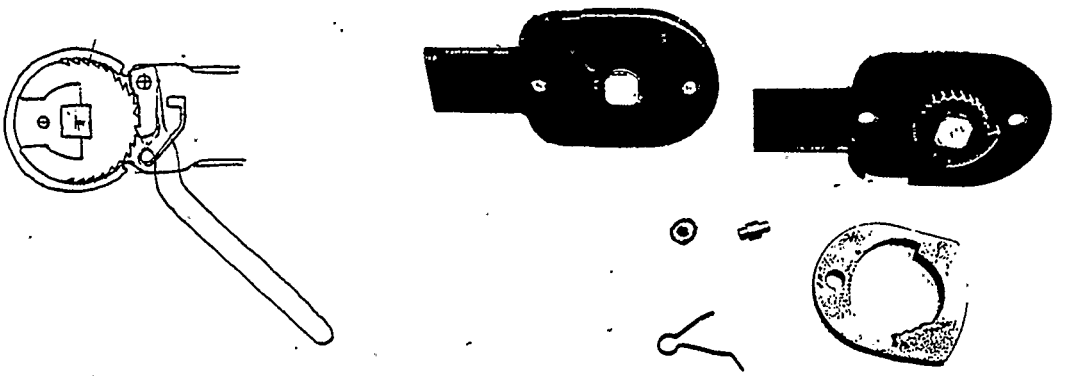


Figure 65: Ratchet Mechanism

4.6.4 Roller Bar

The roller bar, located under the seat, may only be accessed by removing the seat draping, insulation and seat base. Repair of this part would require the main components of the product to be disassembled since it is attached to the backrest and supports partially the seat base and armrests.

4.5.5 Armrests

The armrests have been attached to the outer ends of the roller bar through two points to prevent pivoting. In case of product failure, the cross bar must first be removed, then the armrests removed and repaired or replaced.

4.6 Summary

The form and mode of operation have been determined according to historical and human factors considerations. Before the design proposal can be taken seriously, materials selection, manufacturing method and approximate cost are required.

5.0 PRODUCTION TECHNOLOGY

5.1 Overview

In this section the dynamics of the proposed model are discussed in terms of their mechanical workings, materials, manufacturing methods and cost. An emphasis has been placed on the comparison of materials and manufacturing cost in view of the projected number of products to be manufactured. Discussion of actual components has been limited to those which are not self-evident.

The chair can be reduced to four main sections. The first, the seat, slides horizontally through the second, the vertical backrest plane. The armrests function independently and do not rotate or move. The final section is the draping which camouflages the internal mechanisms. These main components (see figures 64 and 65) will be discussed individually in terms of their construction.

The seat section contains three parts:

a. base **G**;
b. structural seat base **G**;
c. insulation **K**.

The vertical backrest section contains the following:

a. leg base **B**;
b. roller bar **A**;
c. pneumatic cylinders **I**;
d. ratchet connector between headrest and backrest;
e. structural backrest base **I**;
f. structural headrest base **D**;
g. insulation **J**.

The armrests C are complete in themselves.

The draping is formed in two parts:

a. head-backrest;
b. seat.

5.2 Stainless Steel Components

5.2.1 General Comments

Stainless steel has been recommended for the metal inserts, wheel bases, leg bases and mechanical parts, although other metals may be equally acceptable. Parts made from this material are:

a. leg support under seat;
b. 'H' shaped leg support under backrest;

c. cylindrical bar holding roller wheels on which the seat slides back and forth;
d. ratchet mechanism which maintains position of head rest;
e. metal inserts in plastic molds.

5.2.2 Surface Finish

The recommended surface treatment for all exposed or visible parts made of stainless steel is a powder coated matte black. This finish is achieved by using a reverse polarization electrical charge whereby the part is positively charged and heated, the powder is negatively charged. The powder is then welded or melted onto the stainless steel providing a smooth even coat.

5.2.3 Manufacturing Methods

Extruded square steel tube is recommended for the leg support under the seat and 'H' bar under the backrest. The cross bars may be spot welded in place. The roller bar is a piece of bent metal rod.

5.3 Structural Base Support

5.3.1 General Comments

Several possibilities for materials and manufacturing methods were considered for the structural base for the seat, backrest and headrest. The following options were given serious consideration:

a. blow molded polypropylene shell;
b. injection molded polypropylene shell;
c. vacuum formed shell, top and bottom, with gasket seal joining the two halves;
d. square stainless steel tubing:
   i. woven nylon webbing to form a surface;
   ii. 16 - 18 gauge stainless steel plate;
   iii. modular plastic bar arranged to form a surface;
e. fiber glass lay-up.

There are advantages and disadvantages with each method in terms of cost, weight, appearance and production quantities. Only the proposed method will be discussed at any length.

5.3.2 Materials, Manufacturing and Cost

The supportive structure for the seat, backrest and headrest has been manufactured from foamed injection molded polypropylene with metal plate inserts for rigidity. Foamed injection molded polypropylene produces a self skinned plastic part that is relatively light weight, solvent sterilizable and available in many colors including pastels. This material was chosen over metal, for light-weightedness, over woven webbing for cleanliness, and over fiberglass lay-up in anticipation of a production run exceeding 100 units.

Polypropylene is a tough, inexpensive material, with properties comparable to polycarbonate. It is more rigid than polyethylene and not as brittle as acrylic. It is heat resistant to temperatures of 250 degrees Fahrenheit or 116 degrees Celsius. As a thermoplastic, it does not pose environmental risks as a discarded product as the material may be molded for re-use.

A drawback in the use of plastic over metal is the flexibility of the material. Since plastic is generally structurally weak, special consideration is necessary in the quality of the bottom surface of the seat to ensure that the required rigidity is accomplished either by metal inserts, as recommended, or integral ribbing in the mold.

Manufacturing cost has been considered, although in view of the specialty use for the product, has not been considered as a priority. Injection molded parts require extremely high tooling costs, and in view of the flat surfaces proposed for the seat, backrest and headrest, a material which is produced in sheets, such as stainless steel, may be a better material choice for the product while the form is transitional. However, once product changes have been finalized, the advantages of plastic are greater, and larger production runs justify high tooling costs. For example, a seat surface made of stainless steel square tubing with a sheet metal or webbing filling would cost nothing in tooling, and approximately $25 per part. The same part, injection molded, would cost in excess of $100,000 in tooling, but with a production run exceeding 10,000 units, could result in a unit cost of $5.

5.3.3 Backrest

Because the backrest is hinged at the bottom, this load-bearing point requires additional strengthening. This may be achieved through the use of metal inserts at this point.

5.4 Armrests

5.4.1 General Comments

The armrests must be considered as a part which will be influenced by product changes. Flexibility in the design of the armrests is a key issue that will influence manufacturing methods until a conclusive form has been determined. Rigidity and strength are also important considerations, as this part could conceivably be used as a seat by assistants.

With consideration given to these concerns, the initial armrest design should be molded in plastic panels or sections that are then attached to structural metal bars.

5.4.2 Materials, Manufacturing and Cost

Fiberglas lay-up is an effective method for limited production runs of less than 100 units. The tooling cost is a maximum of $1000, however the unit cost, due to the labor intensive method, range between $30 an $50.

Reaction injection molded foamed urethane with metal plate inserts has the advantage of being softer and more flexible, yet is limited to the use of dark colors due to commonly found material flaws. The self skinning shell thickness may be controlled, thus eliminating some of the more evident problems. The metal plates not only add rigidity to the part, but also are used as points for attachment to the structural support bars. Tooling costs for manufacturing this part as one piece, after the form is finalized, are approximately $10,000. A production run of 10,000 would result in a unit cost of $25.

Injection molded polypropylene panels would also require metal inserts for rigidity. Tooling costs exceed $40,000, and unit costs range between $5 and $10 for production runs of 10,000.

For large number production runs, foamed injection molded polypropylene requires a tooling cost of $25,000 to $30,000, with a unit cost of $10 to $15. For smaller production runs of 100 to 1000 units, the unit cost is approximately $50.

Fiberglas lay-up of sectional panels would be recommended in the prototyping stage. However, after the form is no longer undergoing research and development changes, foamed injection molded polypropylene with metal inserts for structural rigidity would be the recommended production method.

5.5 Cushioning: Insulation Mattress

5.5.1 General Comments

Two factors deserve consideration in the cushion design: materials and method for attachment to the frame. In the first instance, materials are important in terms of weight, sterilization and comfort. Attachment to the frame should be integral to the cushion cover, yet not be conspicuous.

5.5.2 Materials, Manufacturing and Cost

Several possibilities were considered for the insulation material of the cushion:

a. extruded flexible polypropylene film with gel-pak insulation heat sealed into pockets;
b. air mattress;
c. flexible polyurethane foam.

From these alternatives, the high tech solution of polypropylene foam has been given the greatest consideration due to the product benefits. The polypropylene film is easily sterilizable, however has low heat resistance. Approximate costs were not available.

5.5.3 Cushion Cover

The recommended fabric for the cushion covers, also referred to as draping, is a polycotton blend Cordura Nylon Plus. This is a light weight material that has been designed for "next to the skin" comfort.[114] Cordura Nylon, a Du Pont registered trade name, has been available since the 1970's. Cordura Nylon Plus has been made with finer and more numerous filaments producing a softer fabric that is available in many colors, styles and weaves. Cordura is a breathable or porous material that is machine washable. It is highly abrasion, and tear, resistant within the normal everyday uses for which it is intended.[115]

It has been designed as a 'sock' in which the insulation is inserted. The opening in the cover is at the rear of the seat or base of the backrest. The cover may be easily removed for washing.

The intent in the method for attaching the cushion to the base surfaces has been to minimize the exterior points of connection to maintain a simplistic aesthetic appearance, and to ensure that the cushion remains securely in place.

There are three points where the seat cushion has been attached to the base:

a. front legs;

b. stainless steel structural supporting plastic shell.

The connection between the backrest cushion and the back-head rest base support is similar to that of the seat. There are two connections points located on either side of the central leg support.
The backrest insulation cover must have a small pocket sewn into the headrest end which slips over the plastic base support and holds the cushion in place.

The covers are attached to the chair via elasticized rope such as bungie cord. Using standard plastic fasteners commonly found in outdoor equipment the cover may be easily added and subtracted from the chair frame.

5.6 Mechanisms and Wheels

5.6.1 General Comments

There are three operational mechanisms in the construction of the chair. The ratchet which controls movement of the headrest, pneumatic cylinder which controls movement of the backrest, and wheels are 'off-the-shelf' pieces. There are important safety considerations that require some explanation.

5.6.2 Wheels

All leg supports, including the armrests, are mounted with cater wheels. The Colson TotalLOCK brake caster, specifically designed for hospital use, is completely suitable for the intended use. The wheel and swivel can be locked and unlocked by pressing a foot pedal. Locking two of six wheels will satisfactorily secure the bed from undesired movement for weights less than 350 pounds.[116]

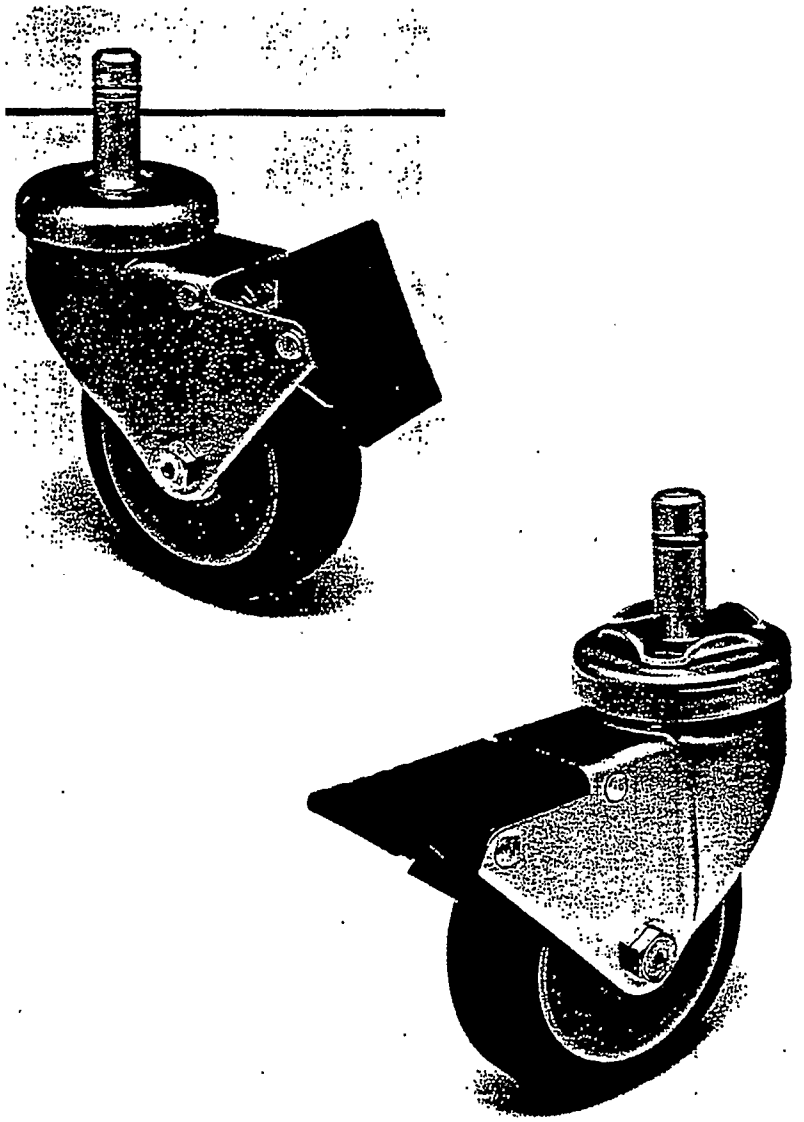


Figure 66: Caster Wheel

5.6.3 Ratchet

The recommended ratchet mechanism controlling angle adjustment of the headrest has been developed by the furniture B & B Italia (see figure 64). The headrest clicks forward using minimal

force and locks at the various angle settings. To release the headrest to a horizontal position, the headrest must be pushed as far forward as possible. This automatically releases the mechanism.

5.6.4 Double-Acting Pneumatic Cylinder

The main reason that the pneumatic system was chosen over the use of an hydraulic system has been to avoid the potential contamination of the birthing environment with hydraulic fluid. Air provides a clean solution, but there is a compromise in the effectiveness of the system. Pneumatic cylinders do not provide as exact a holding position as do hydraulics, and air leaks are not easily detectable as are hydraulic fluid leaks.

In order to compensate for the potential mechanism failure, two pneumatic cylinders have been implemented; one on either of the central leg support. They are simultaneously controlled by one locking mechanism, although the air circuits are completely separate. This results in the situation whereby the potential failure of one cylinder will not result in the failure of the product. In case of significant air loss, a standard bicycle pump may be used to regenerate the pneumatic cylinder.

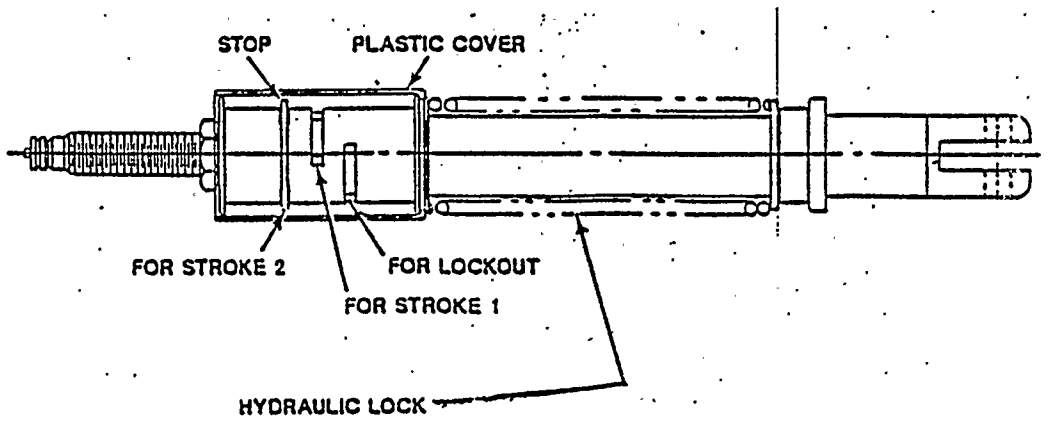


Figure 67: Pneumatic Cylinder

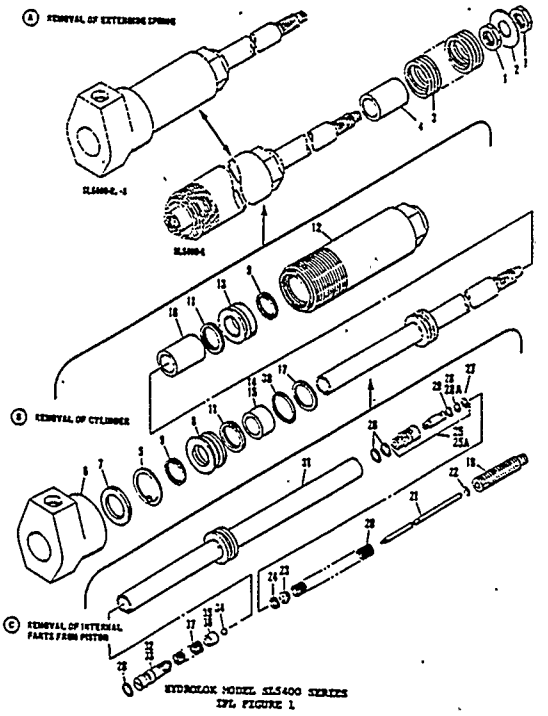


Figure 68: General Assembly Pneumatic Cylinder

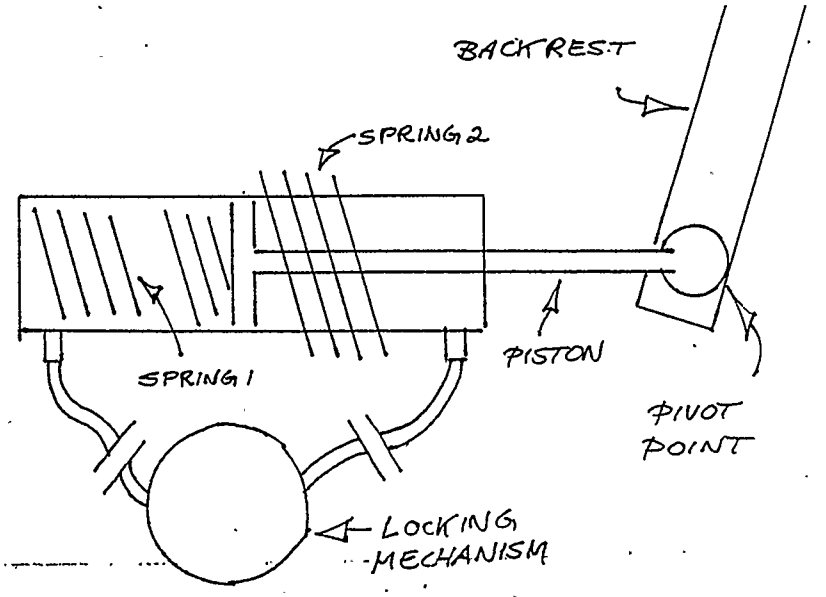


Figure 69: Sketch of Pneumatic Cylinder

5.6.4 How It Works

Double-acting pneumatic cylinders are commonly found in commercial airplane seats. "Double-acting means that the out-stroke as well as the return stroke are produced by compressed air."[117]

The cylinder is comprised of the following parts:

a. aluminum cylinder with end covers;
b. pressure seals: gaskets, O-rings, lip seals to seal against air pressure without regard to direction of force;
c. stainless steel piston rod;
d. Spring 1: internal spring, piston can only move it there is a difference in pressure between the two sides of the piston;
e. Spring 2: external tension spring pulling the backrest into an upright position and limits the chair angle to 0-65 degrees;
f. Valve 1: air release valve (exhaust);
g. Valve 2: air release valve (inlet);
h. air transfer tube;
i. lock mechanism, in form of foot pedal and hand control;
j. universal fork end mount permitting rotation of the backrest.

Suppose the backrest is in an upright sitting position. By releasing the lock, air transfer is permitted resulting in the natural expansion of Spring 1 (see figure 69). The expansion of Spring 1 pushes the piston out of the cylinder thus permitting the backrest to swivel along the pivot point at the end of the piston rod. Air is transferred out of the cylinder along air release Valve 1, along a silicone air tube, and into air release Valve 2. The application of body force to the backrest is now freely permitted and controlled by Spring 2. Once the backrest angle has been selected, the lock is closed, and the pneumatic cylinder holds the backrest in place.

The choice to position the springs such that the backrest automatically returns to the upright position was made with the understanding of the possibility of mechanical failure. If the pneumatic system fails, force applied to the backrest will place it in a bed position. The reverse, however, would lead to a situation where the backrest would have to be forced and held manually in an upright position.

If the cylinder is operated in a dry, clean condition with lubricated air and is not unfavorably loaded (e.g.: improperly installed such that there is damage to the cylinder and piston rod),

then the life span of the part is a minimum of 100, and a maximum of 500-1000, kilometers travel for the piston.[118]

5.7 Summary

Since it is unlikely that a specialty use product such as a birthing chair would be mass produced without an obvious secondary consumer use, such as a chair for incontinent seniors, the manufacturing method, materials and cost are higher than a typical furniture item. The preferred material for the shell is foamed injection molded polypropylene with metal inserts. The cushion should be a gel-pak matress. All other parts are discussed in terms of specific materials. The approximate cost for manufacturing this product in small quantities is $2000 dependent on the mattress cost.

6.0 CONCLUSION

The purpose of this study was to develop a model for a birthing chair. For the proposed application, it has shown its potential. With the formulation of this design proposal it was possible to determine further design modifications that may contribute to a healthier birth environment. Although this information has not been applied at this time, it does offer insights into factors that could contribute to a healthier birth environment in the future.

The form proposed in this study should be seen as the beginning of a process and not as the finished product. This study has hopefully provided a new perspective on the birth experience and demonstrated on which areas the emphasis should be laid in further studies.

Recommended areas of concentration in future product developments are in the implementation of a bar providing a supported standing posture, insulation materials, attachment of insulation cover to the main structure, possible modifications for the Trendelenburg Position, and the addition of pneumatic cylinders to control the movement of the seat.

Although not provided in the drawings, possible product modifications for the Trendelenburg Position are possible through future product developments in the use of hydraulic or pneumatic cylinders in the leg support system.

Consideration was given to a swivel bar which could be attached to the backrest to provide the posture of a supported stand as well as an unassisted supported squat. Future studies should include this design modification.

Manufacturing materials and processes are improving rapidly, and innovative technologies should be implemented where necessary and possible. Environmental factors will make a greater impact on the nature of this product in terms of materials selection in the future.

Future considerations for this project, if consistent with current trends in product design, would be to use modular parts rather than solid forms in the construction of the chair. Some advantages for moving in this direction are to reduce manufacturing cost, reduce packaging size and potentially simplify the repair assembly process. As a special needs product, the scope of the project did not include consideration of mass production techniques such as modular design.

Other considerations that could contribute to the well-being of the birthing mother and improve the birth experience are additions to the birthing environment such as a shower stool and the implementation of a leaning bar that is either suspended from the ceiling or hung from a floor stand. These accessories would provide additional birth postures which were considered in the overall project but could not be elegantly integrated with the birth chair design proposal.

As with the design of most functional furniture and hospital beds, the design process is rarely complete. Through observation of the user-product interaction, the product must evolve. To remain useful in terms of international design, the birthing chair requires constant evaluation in terms of meeting societal requirements. This design proposal should undergo further refinement before it is at a final stage for consumer use. These factors all play an important role in the design of products of this nature. Given the limitations of this project the proposals, although untested, are based on sound reasoning.

Appendix A: Developmental Sketches

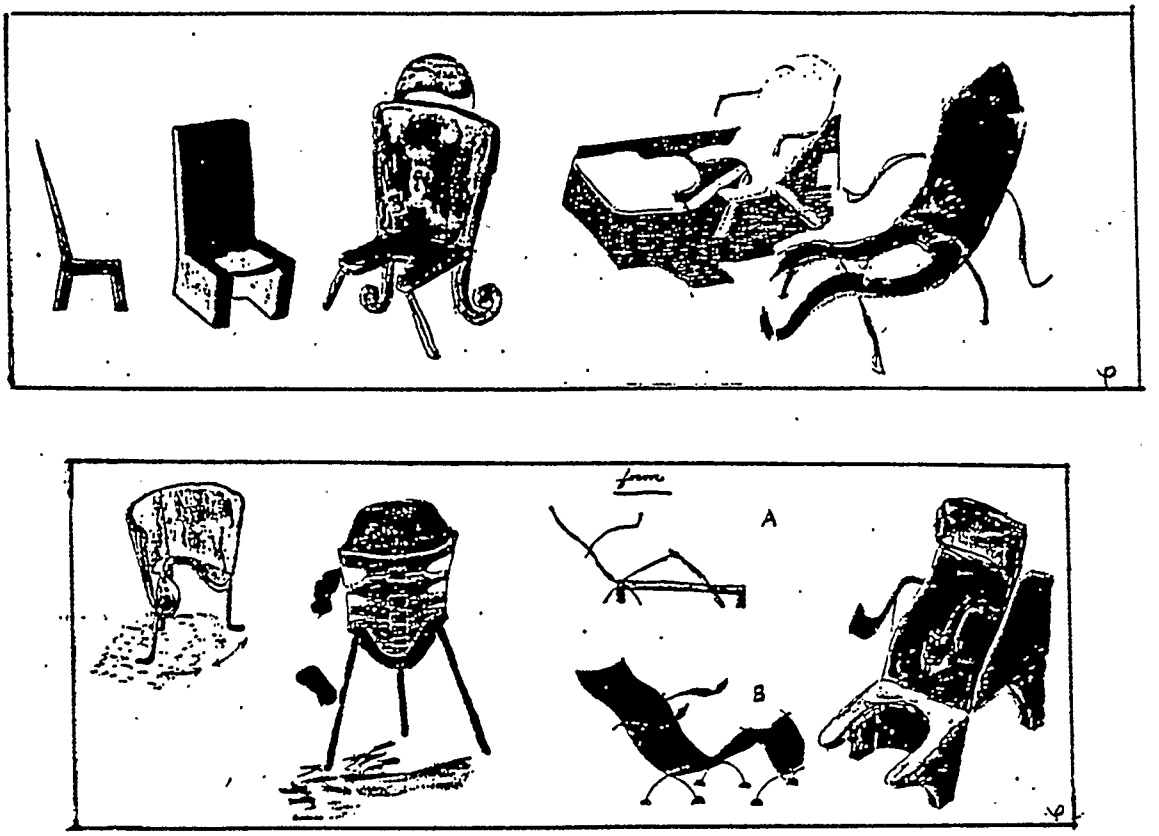


Figure 1: Preliminary sketches for birth chair

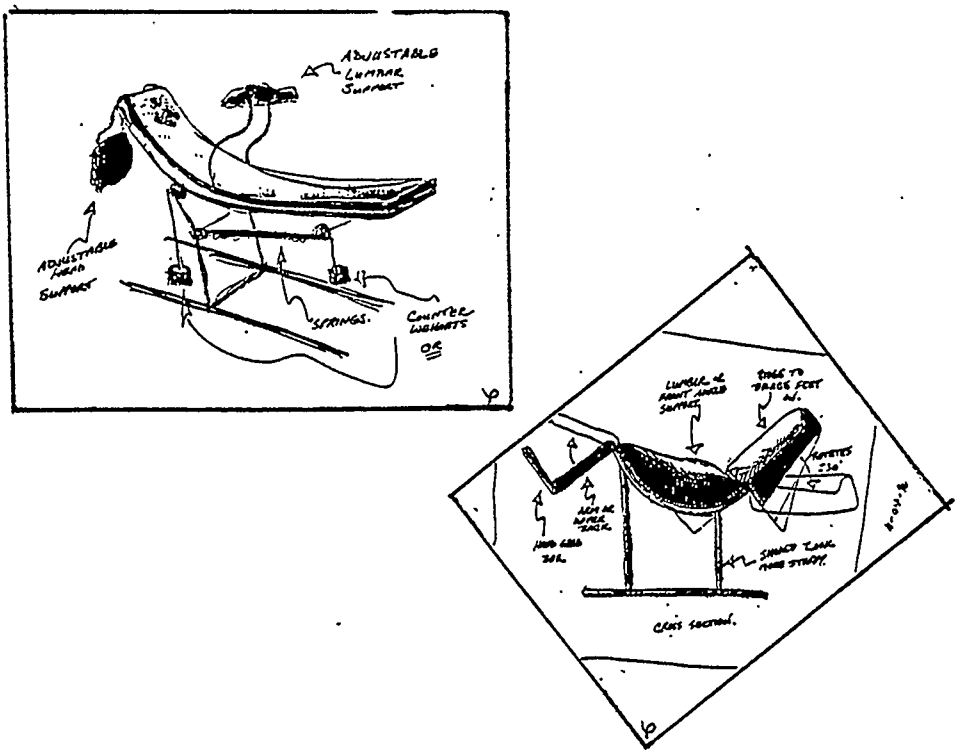


Figure 2: Early sketches for birth bed

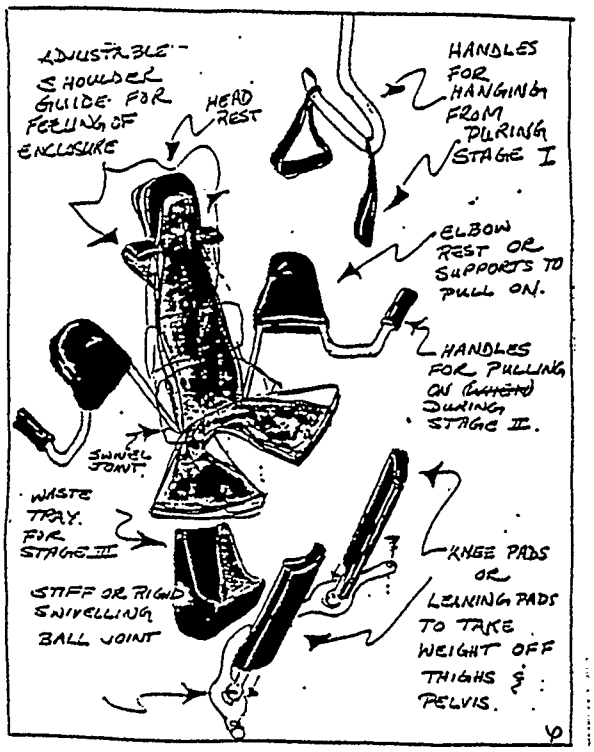


Figure 3: Birth bed with knee pads and arm rests

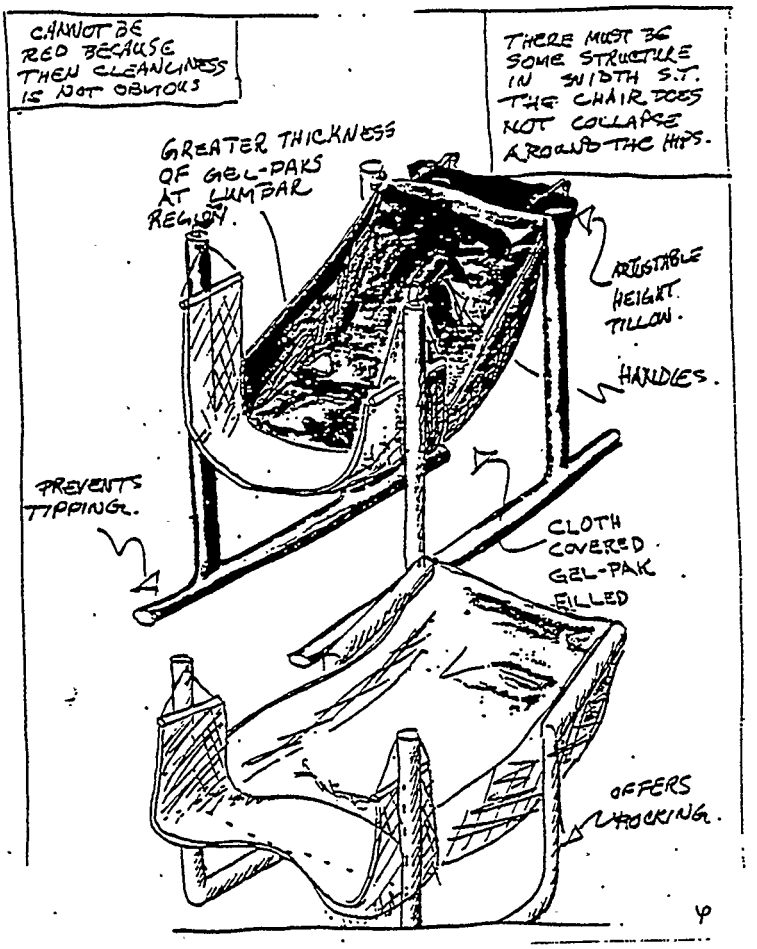


Figure 4: Sling birth bed

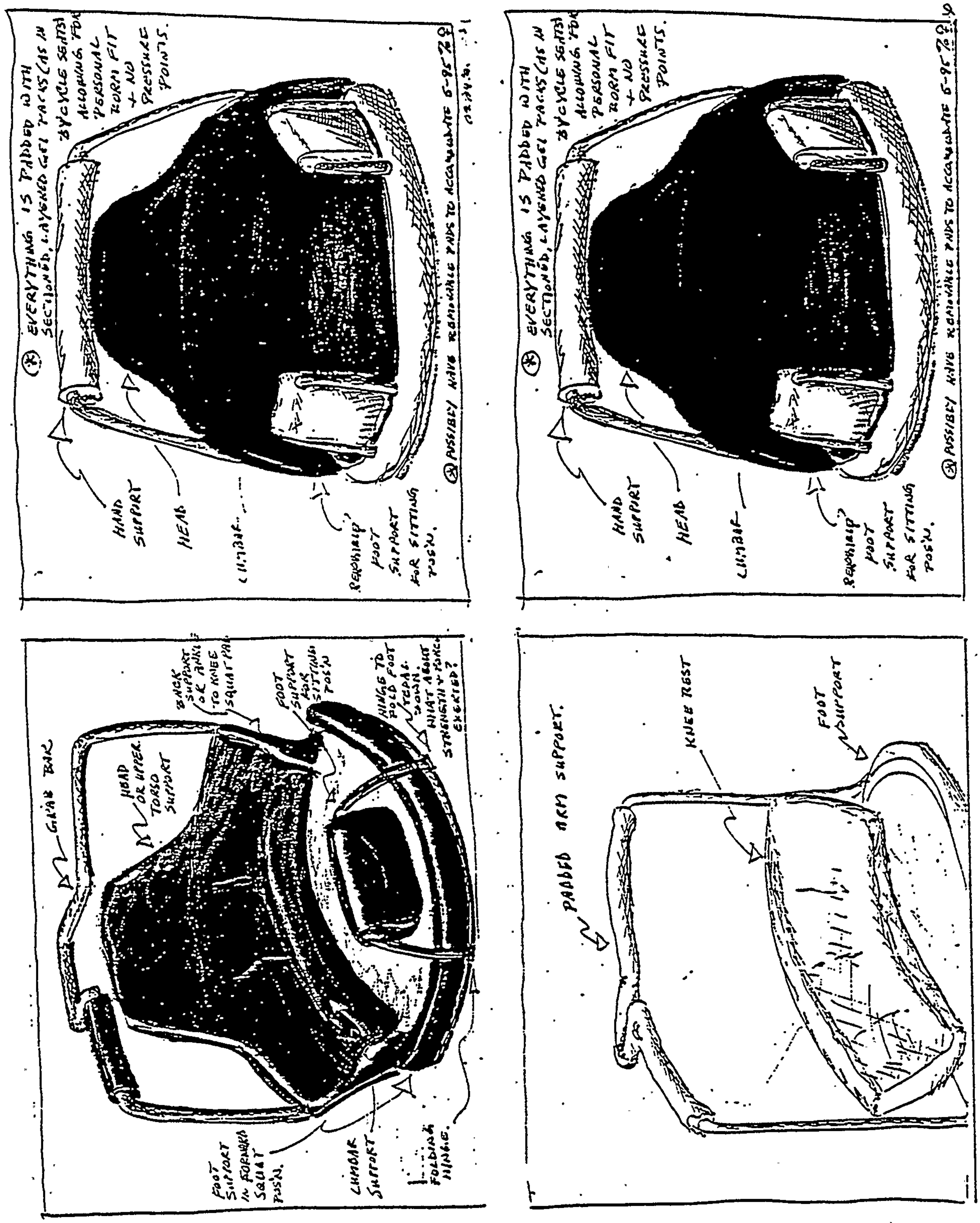


Figure 5: Birth bed: variations on arm and foot rests

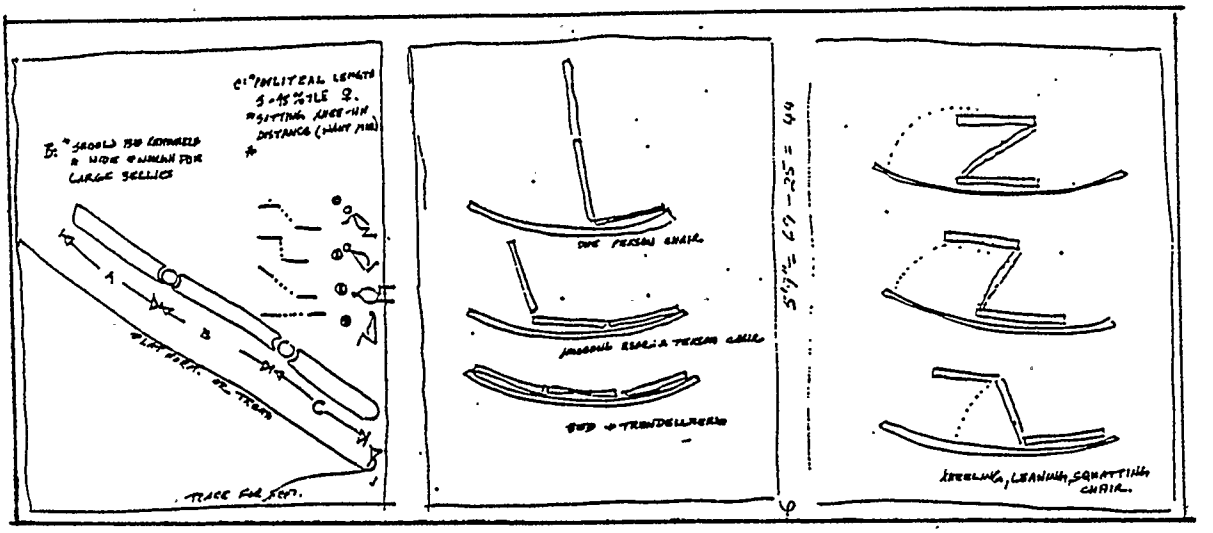
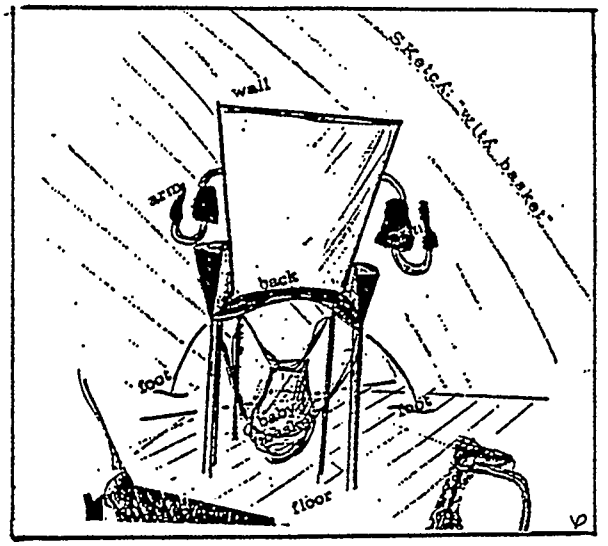


Figure 6: Stool for squatting: shower accessory



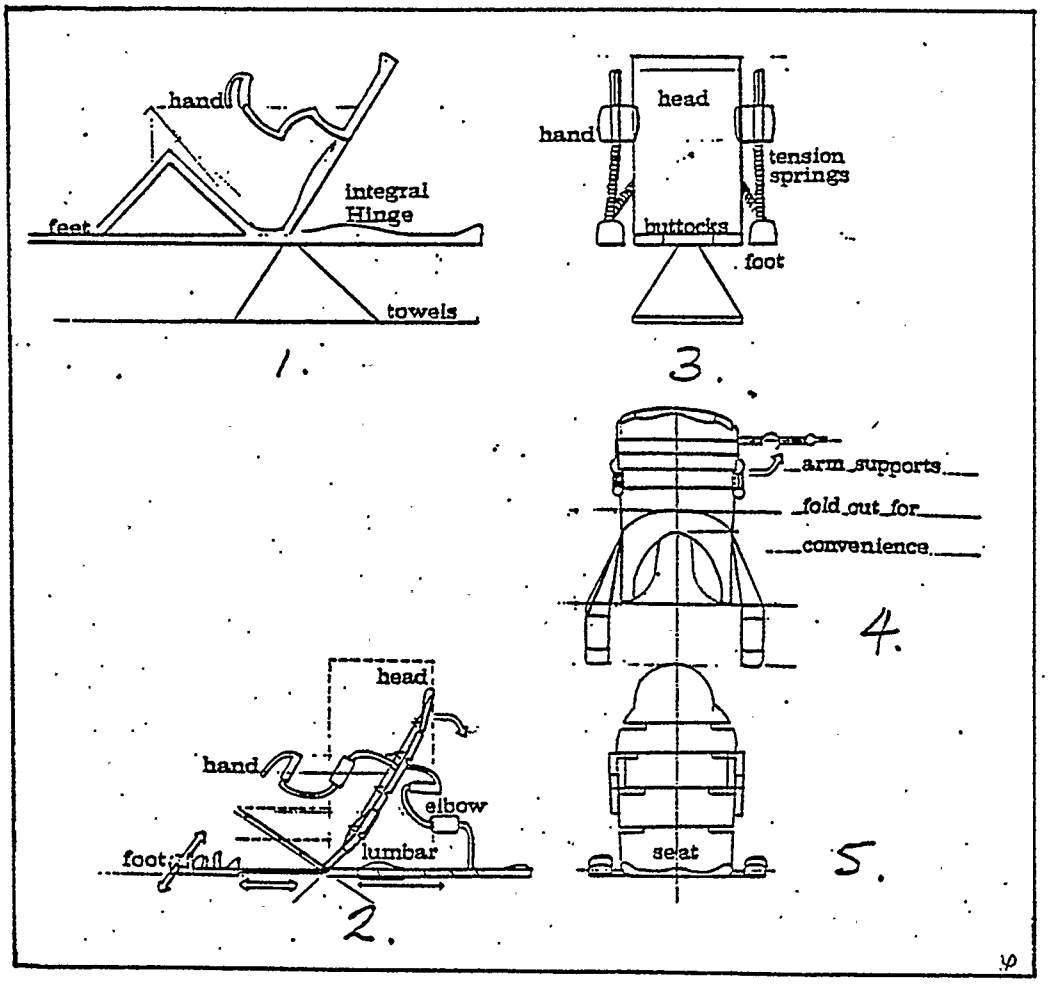


Figure 7: Birth chair which converts to bed

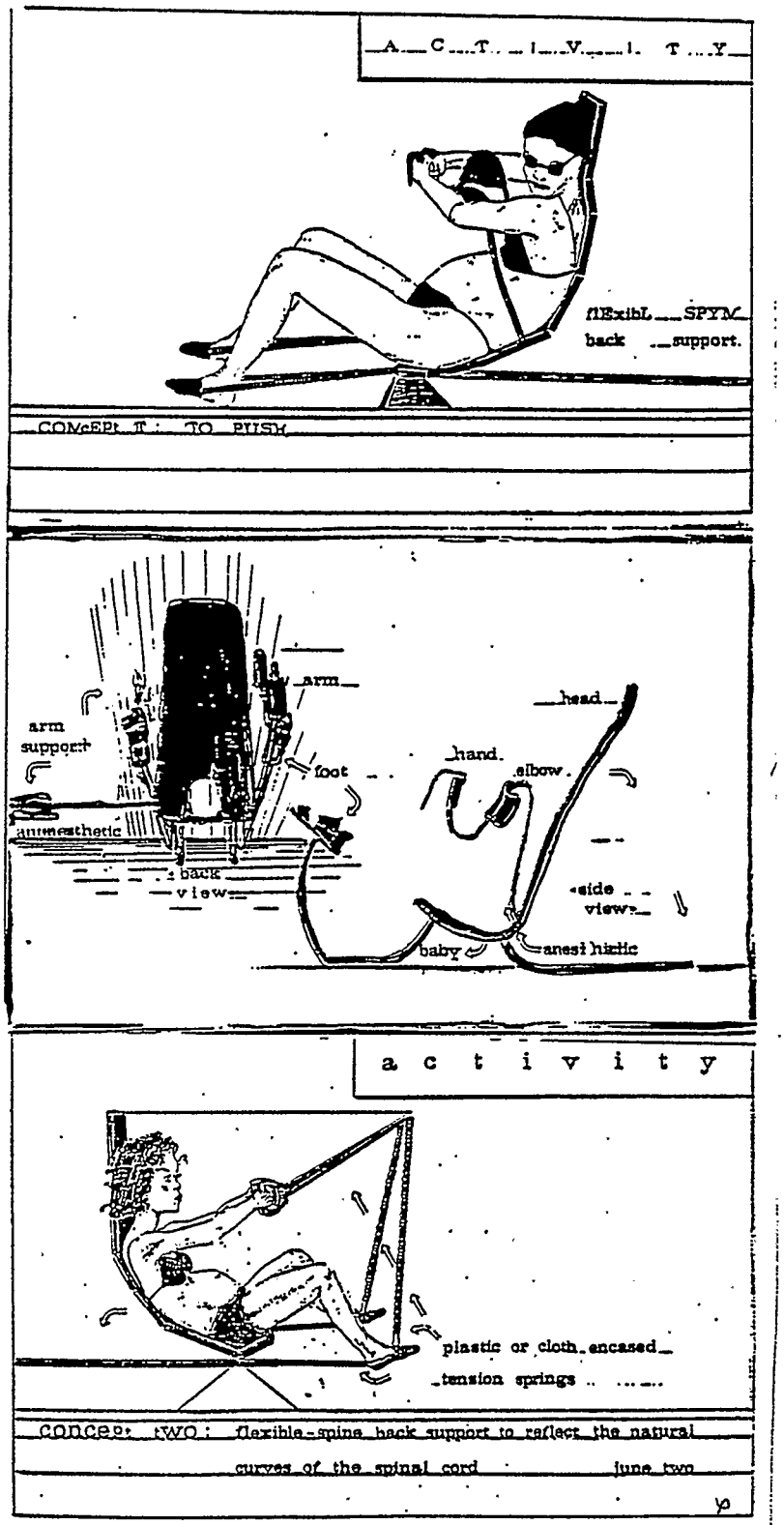


Figure 8: Birth chair with arm and foot rests

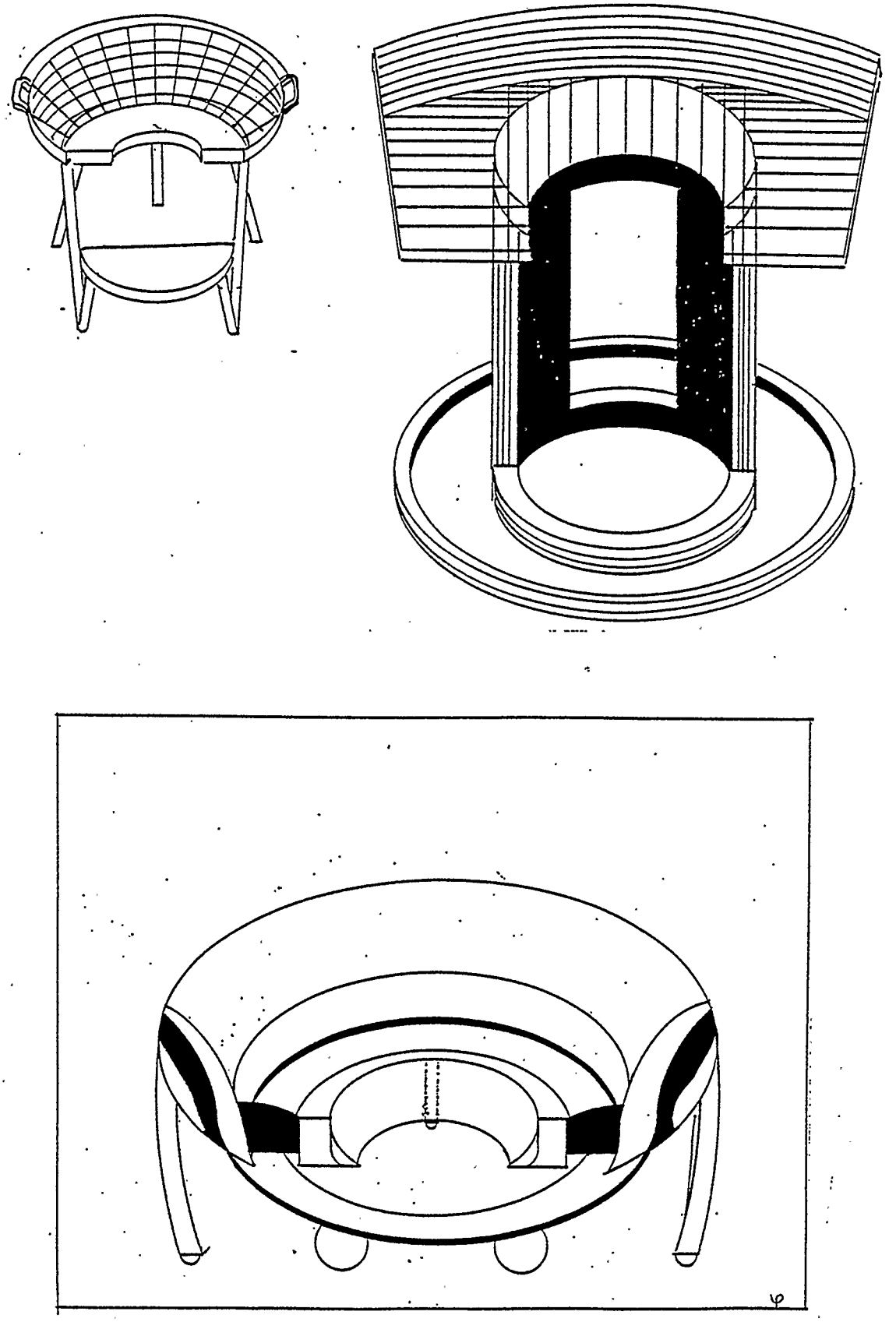


Figure 9: Portable chair sketches

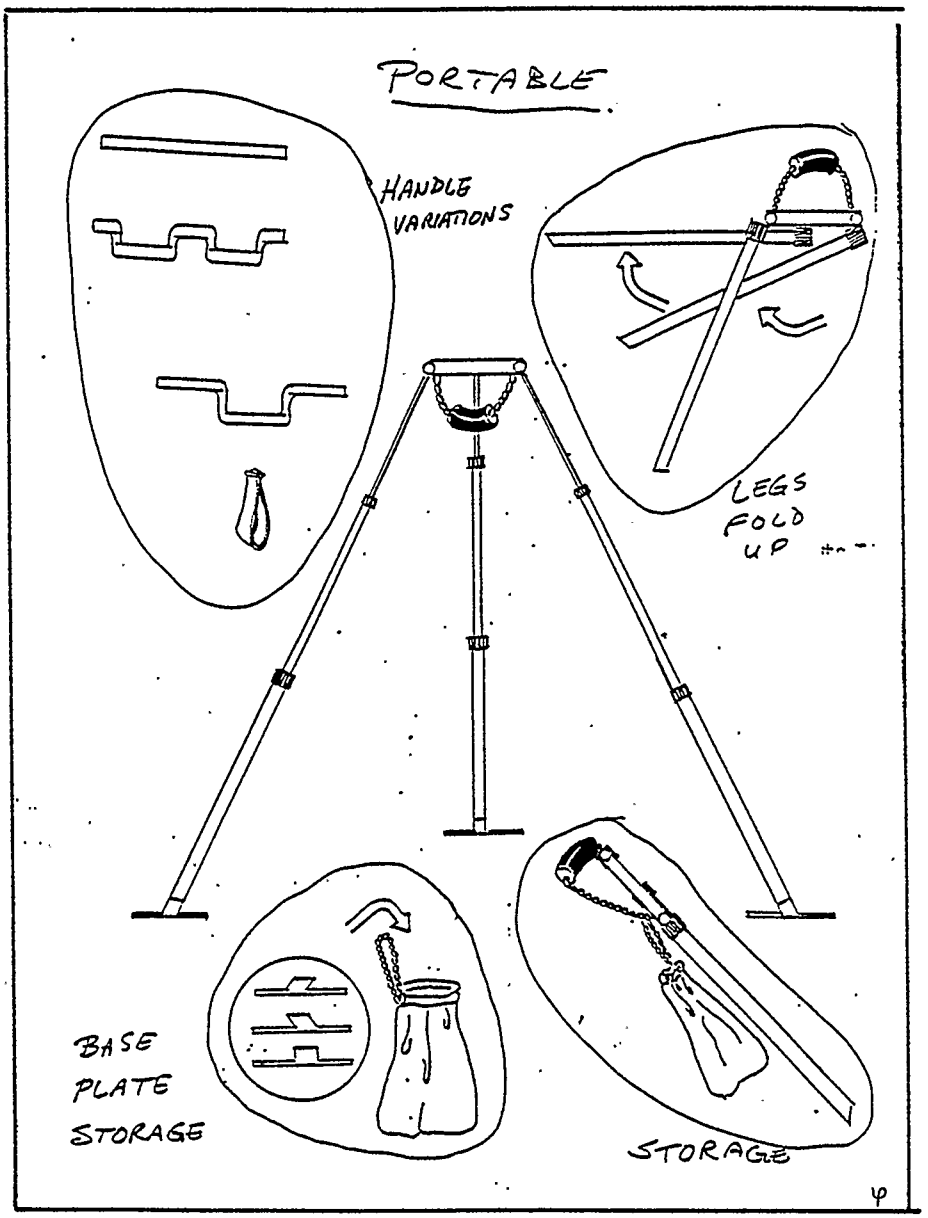


Figure 10: Tripod birth room accessory: supported stand

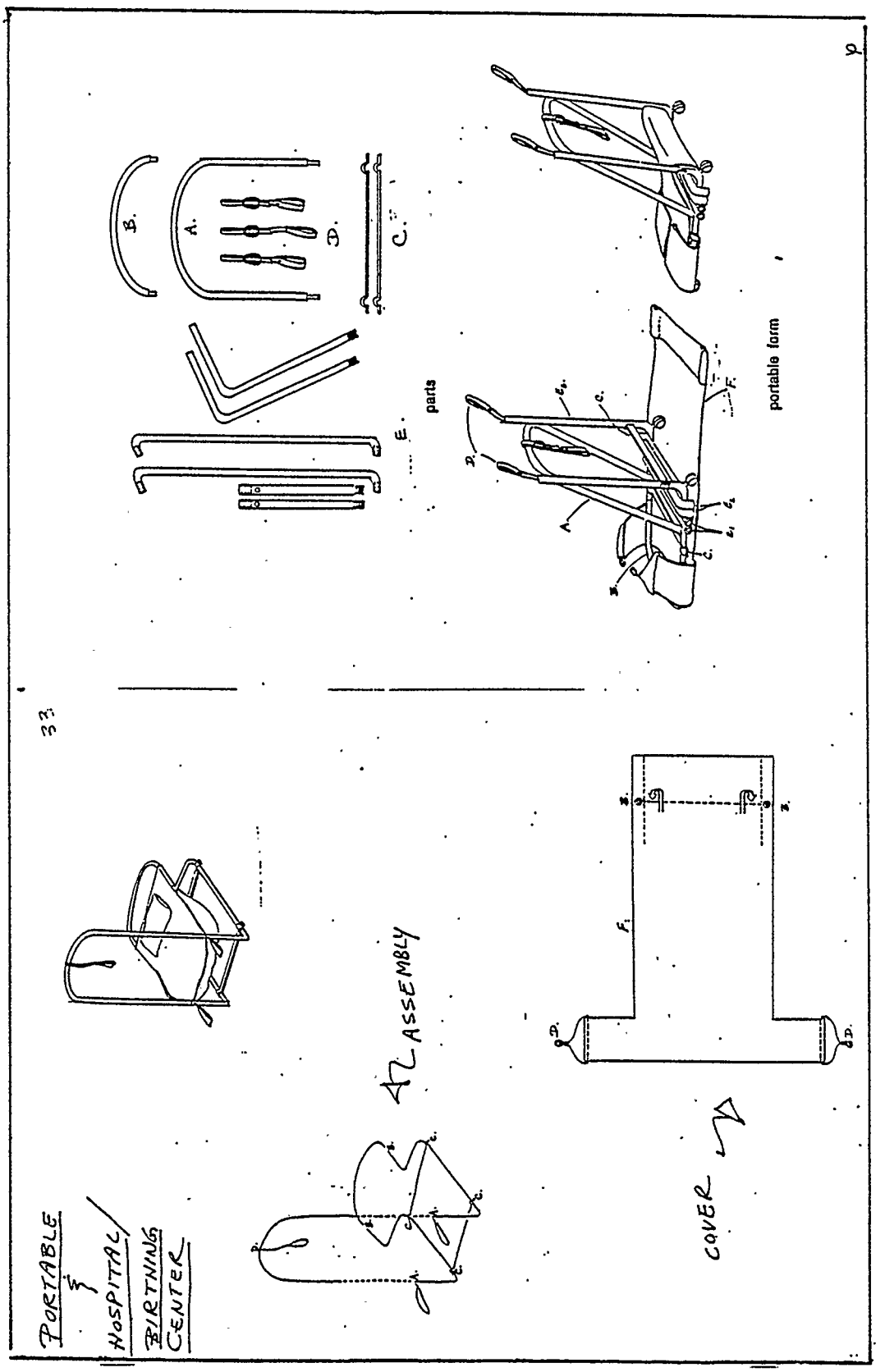


Figure 11: Portable sling chair:

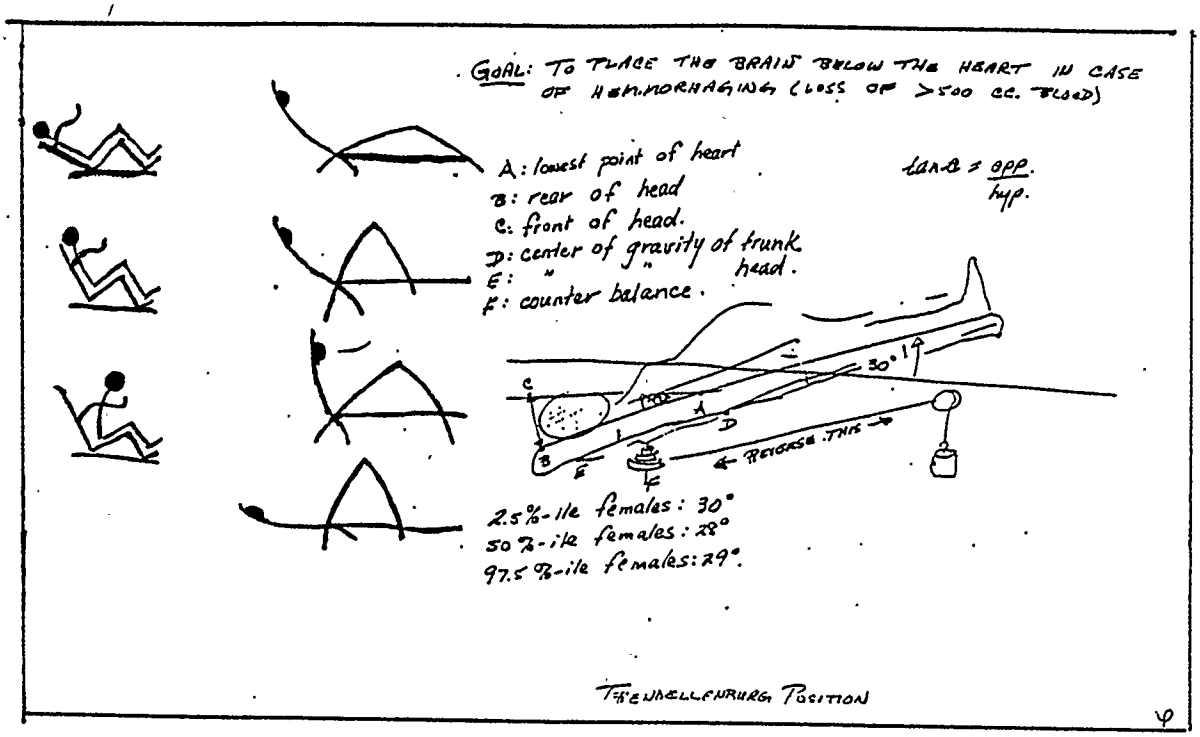


Figure 12: Initial Trendelenburg considerations

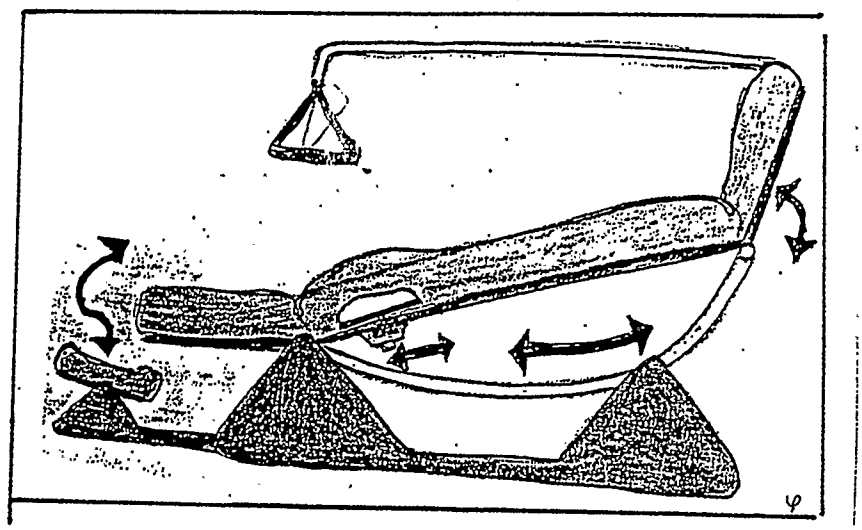
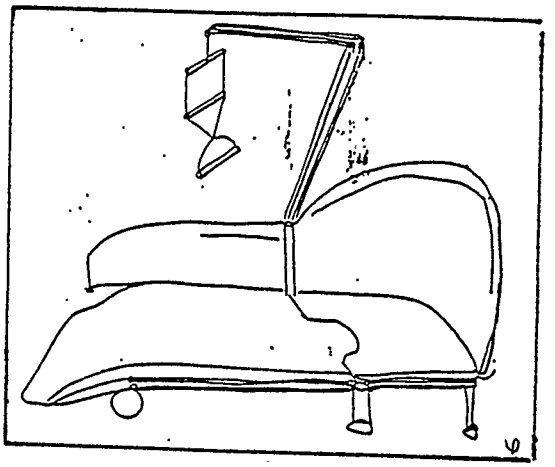


Figure 13: Adjustable recliner sketch



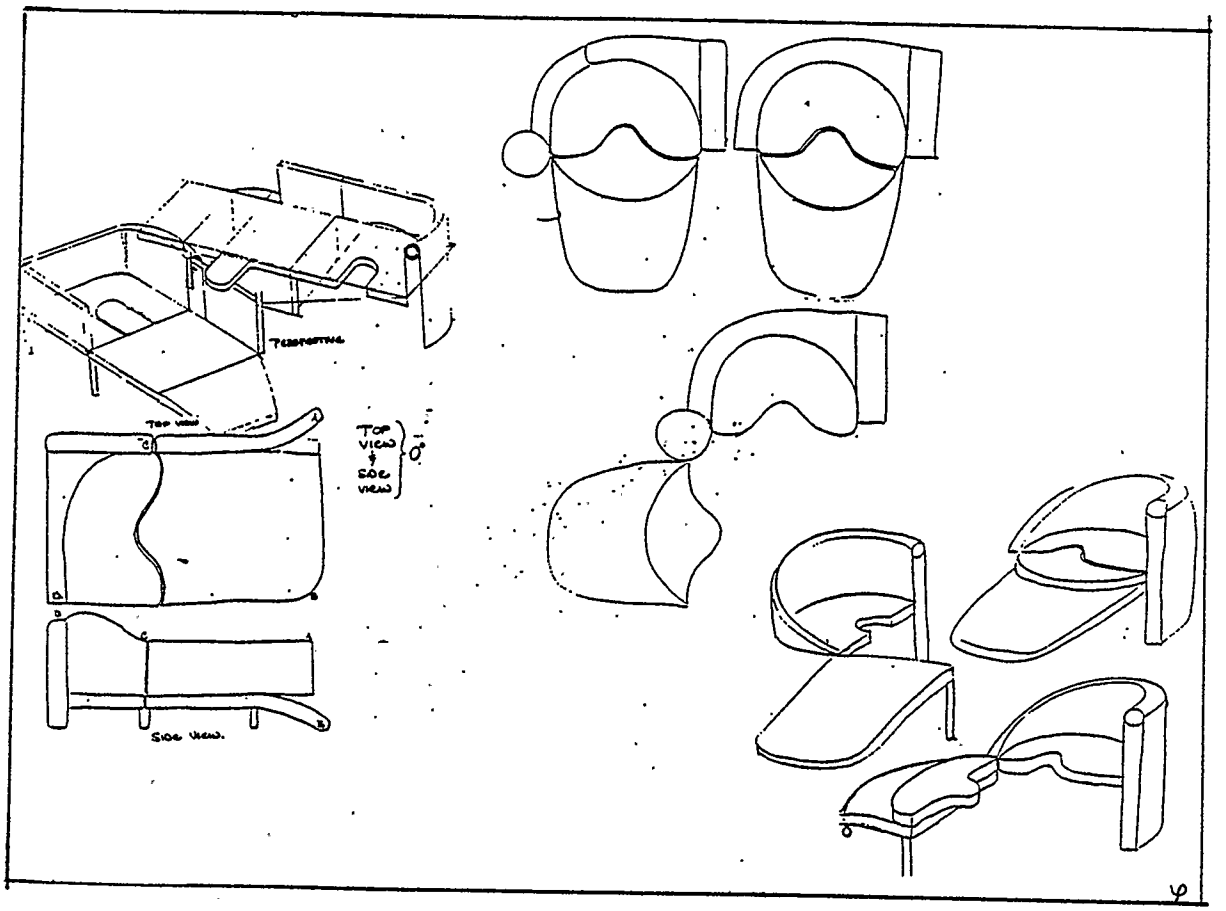


Figure 14: Adjustable sofa bed

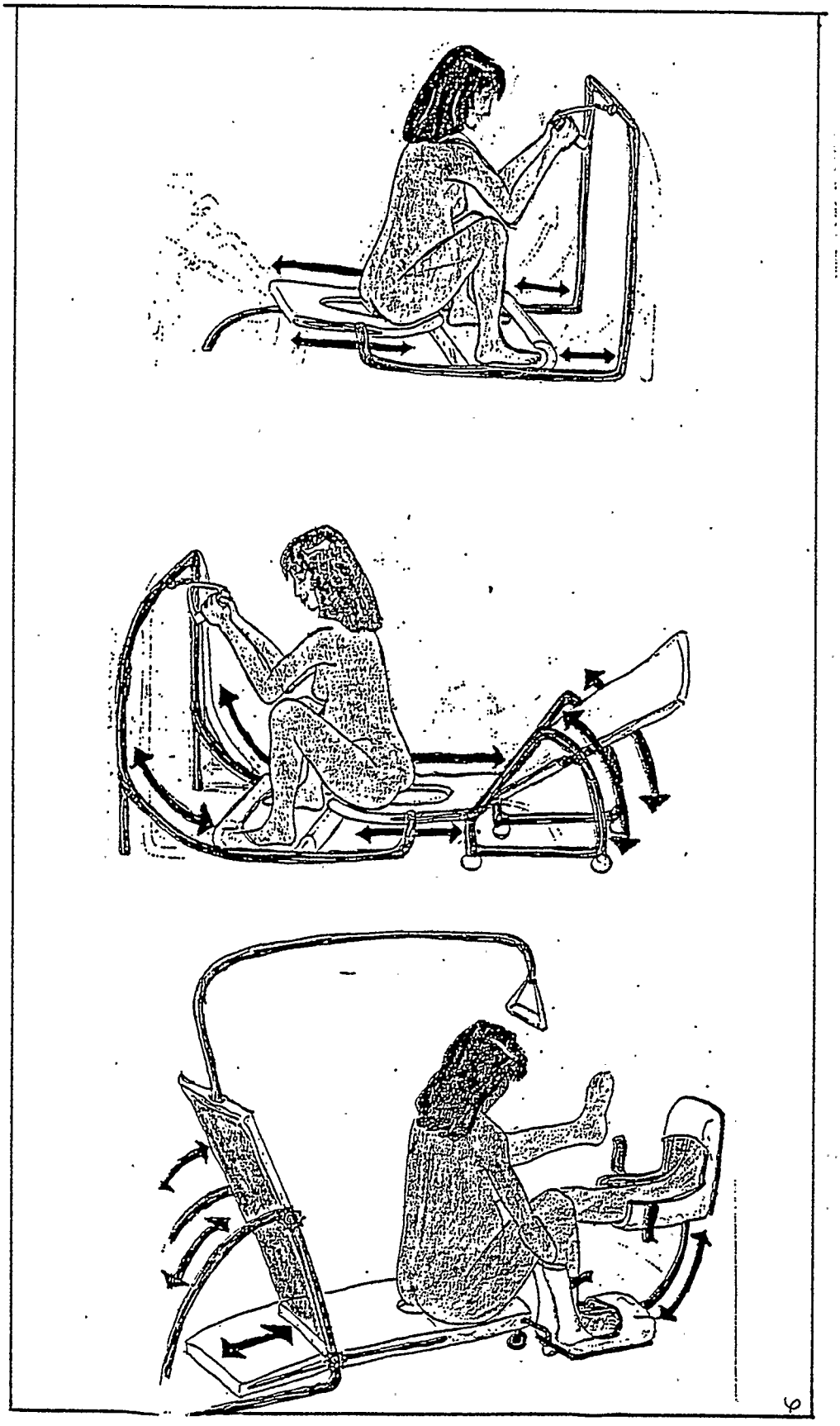
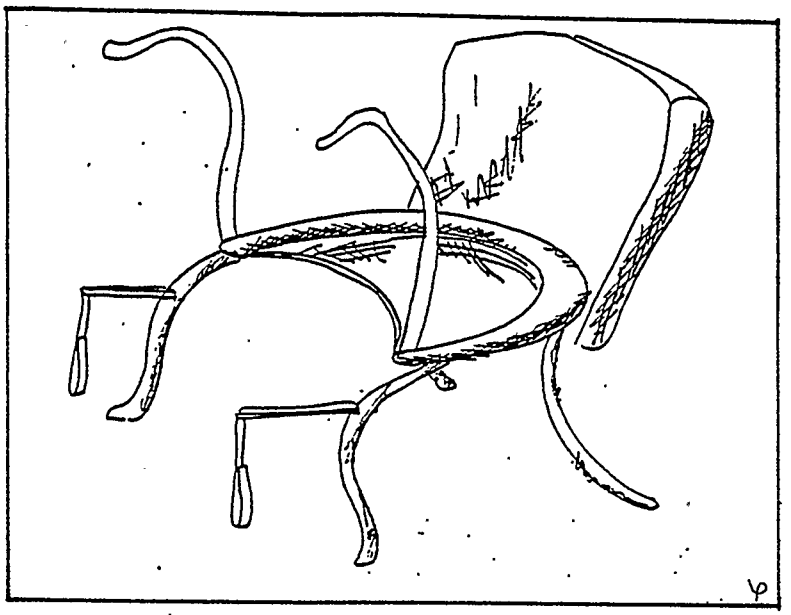


Figure 15: Adjustable chair: variations on arm, leg rests



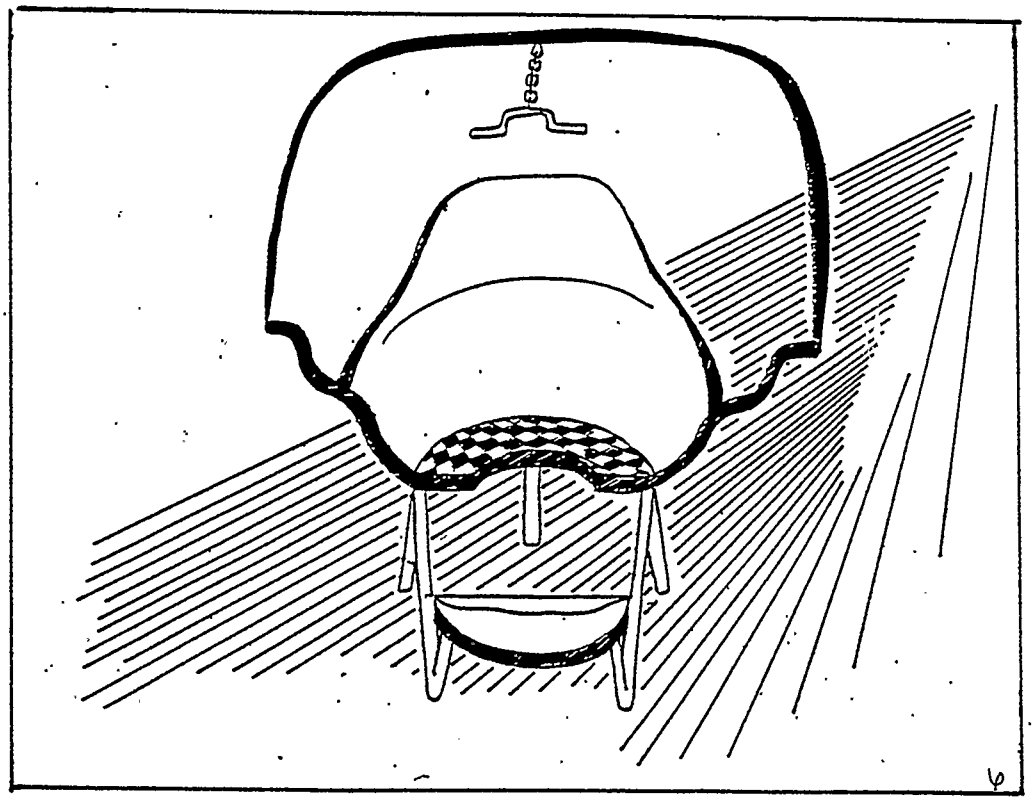
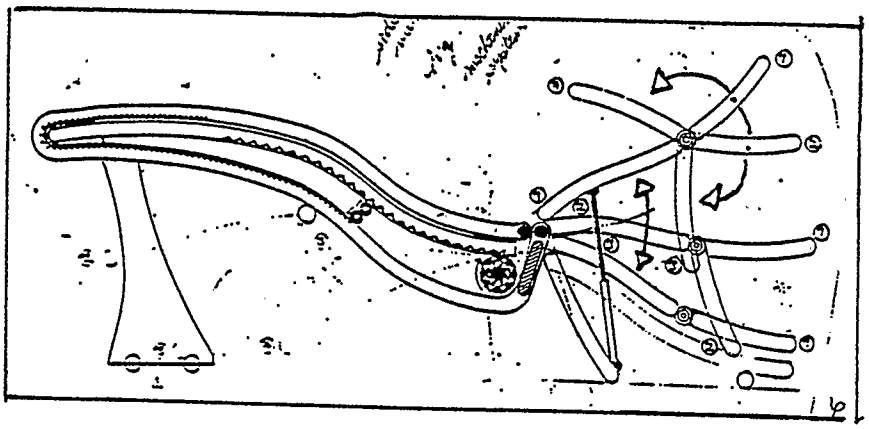


Figure 16: Birth chair with accesories



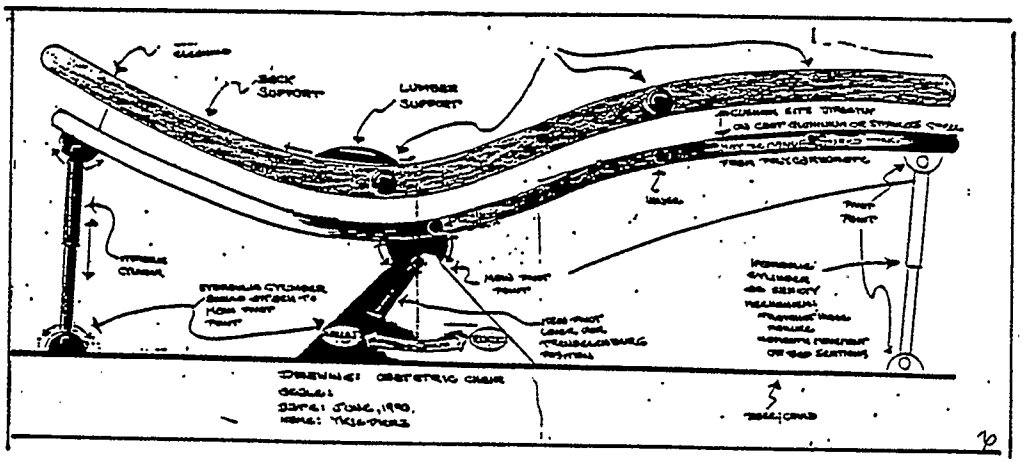


Figure 17: Adjustable birth chair-bed

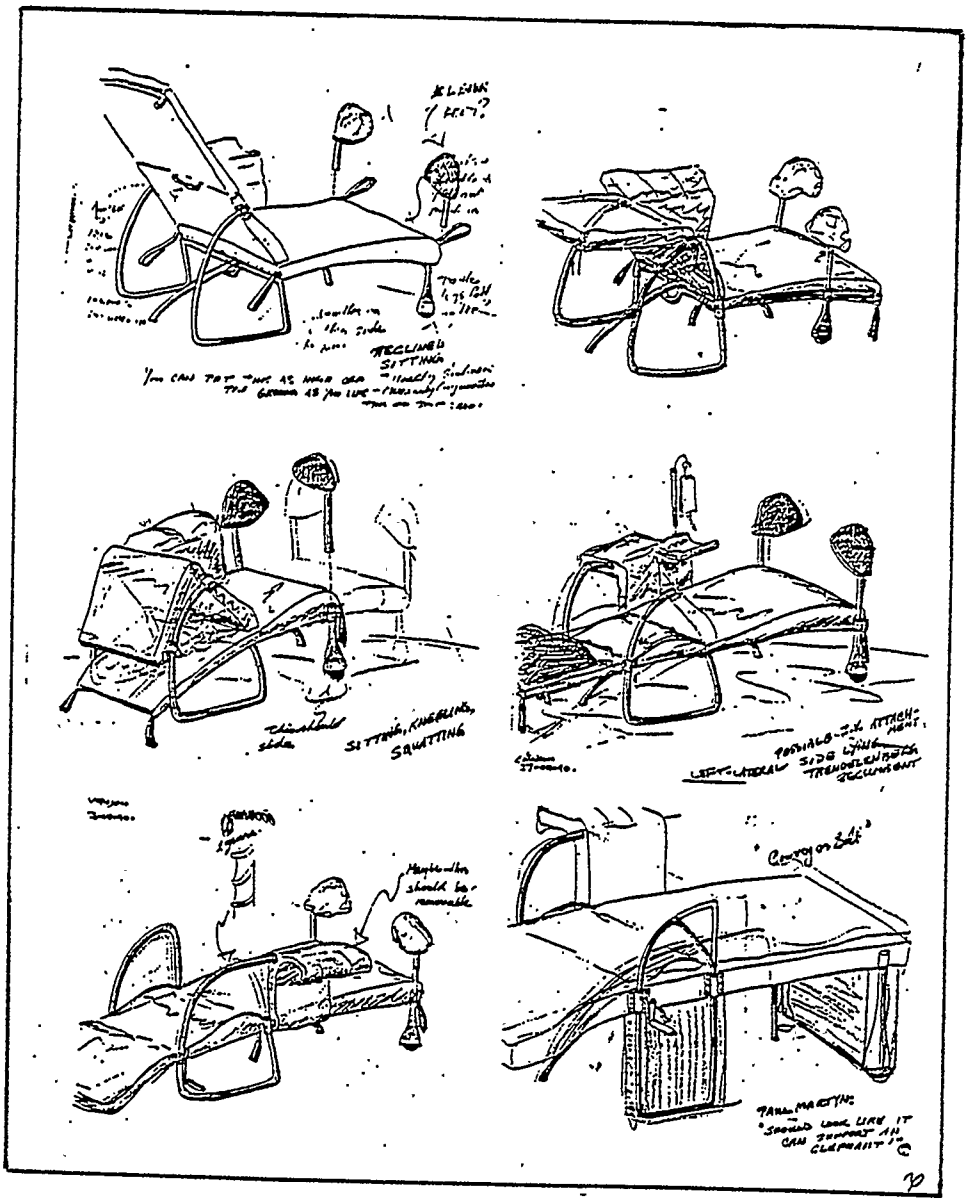


Figure 18: Idea Refinement for adjustable chair-bed

Appendix B: Proposed Design

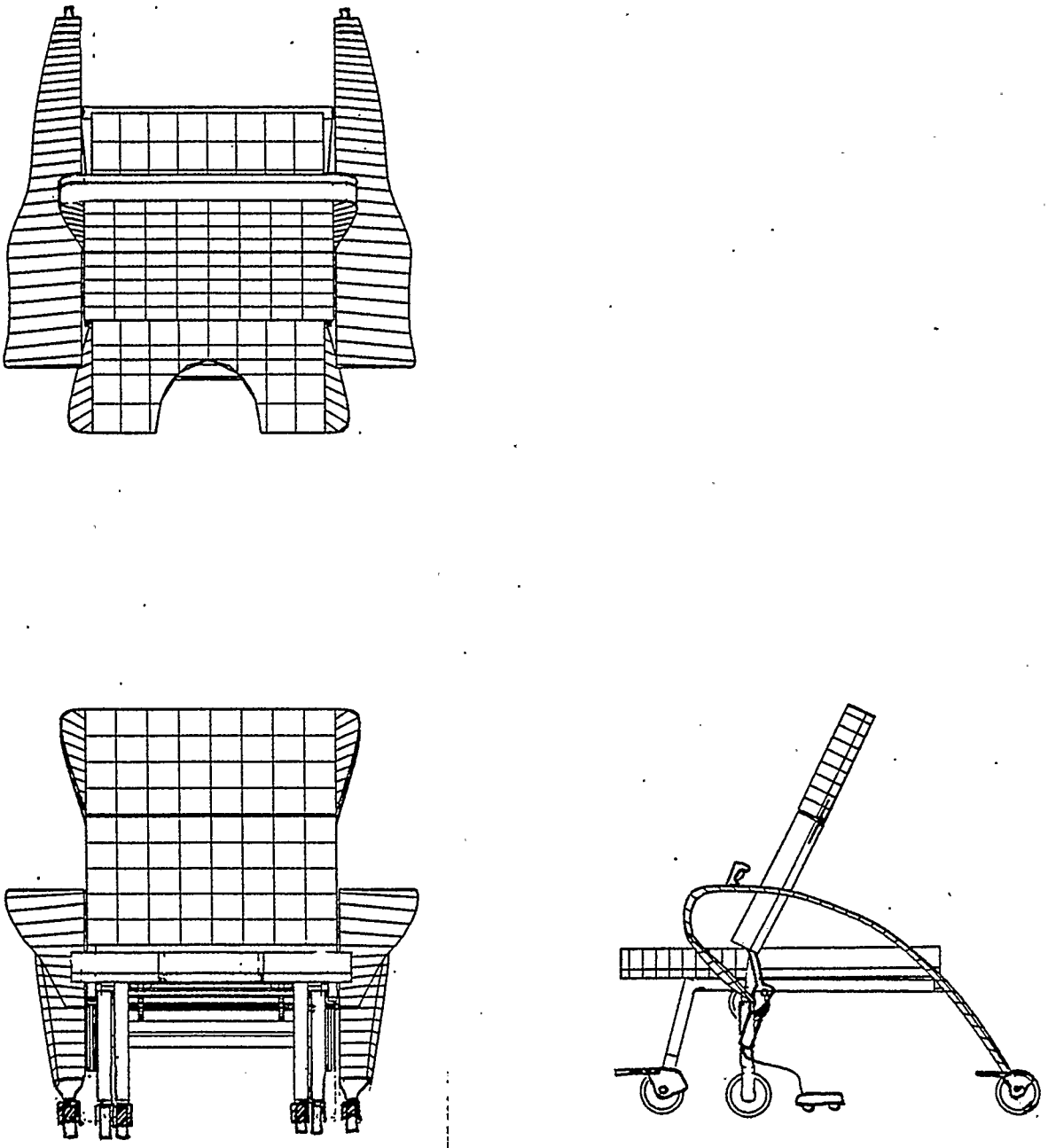


Figure 1: Top, Front, Side View Chair

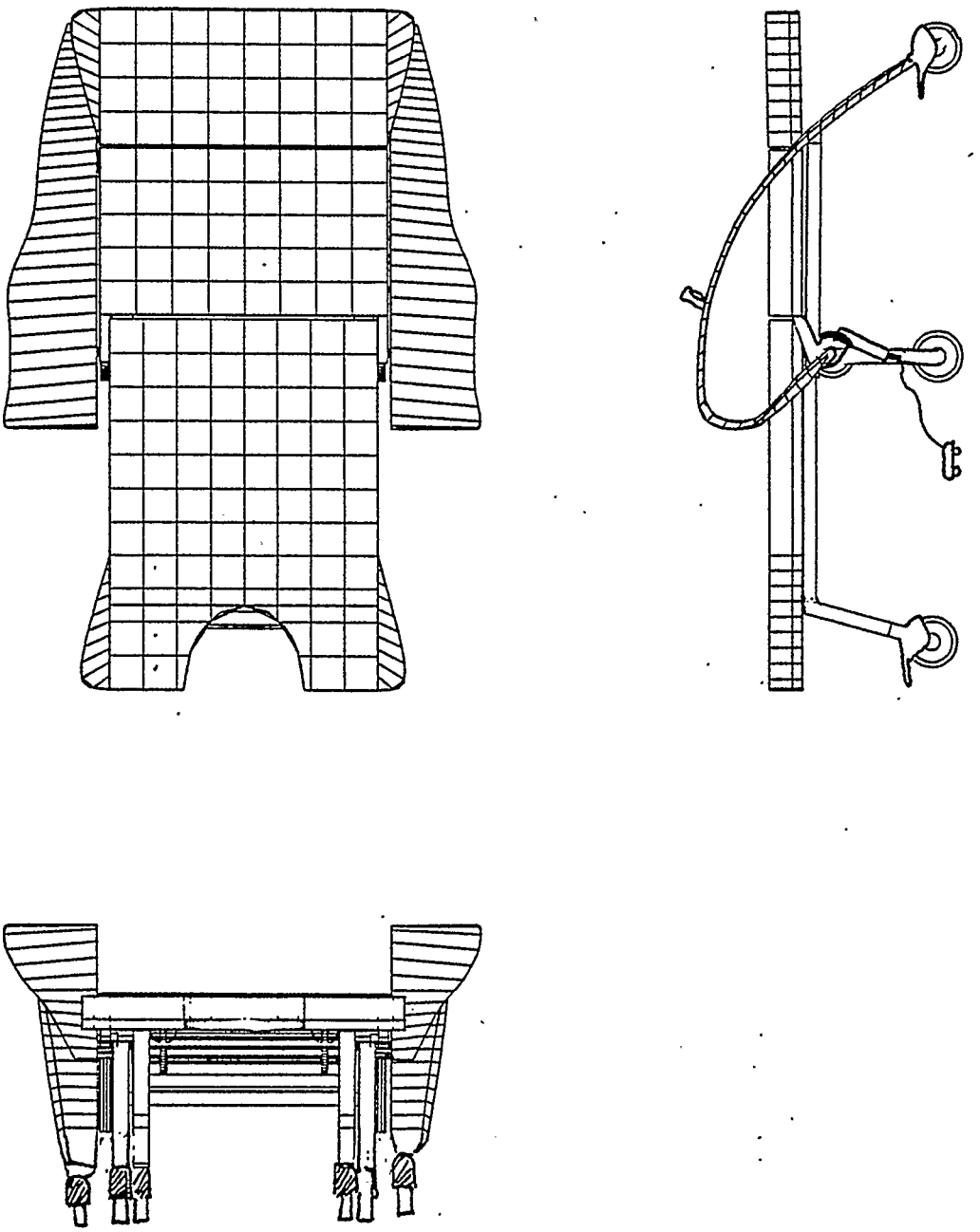


Figure 2: Top, Front, Side View Bed

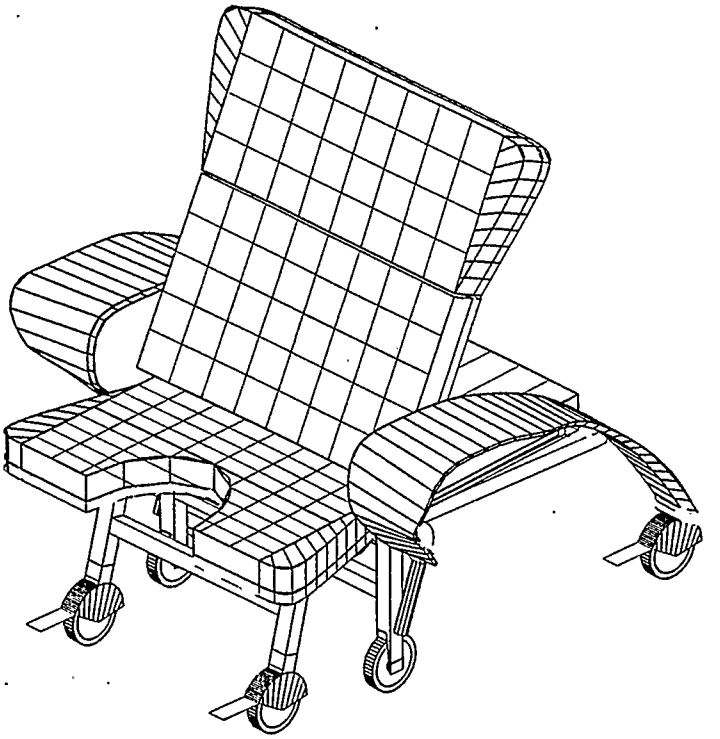


Figure 3: Chair

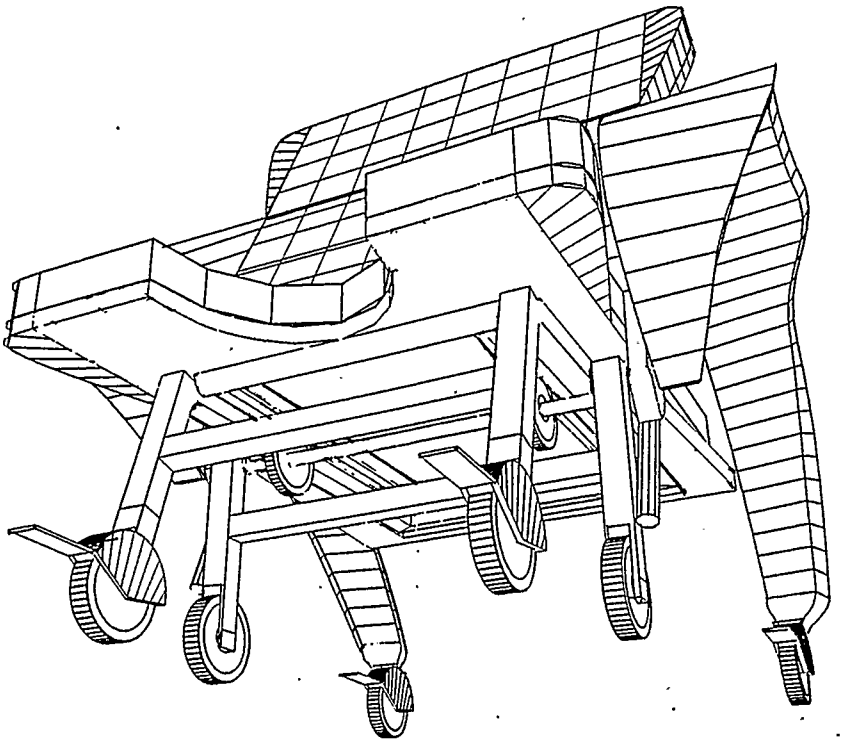


Figure 4: Under-Carriage Chair

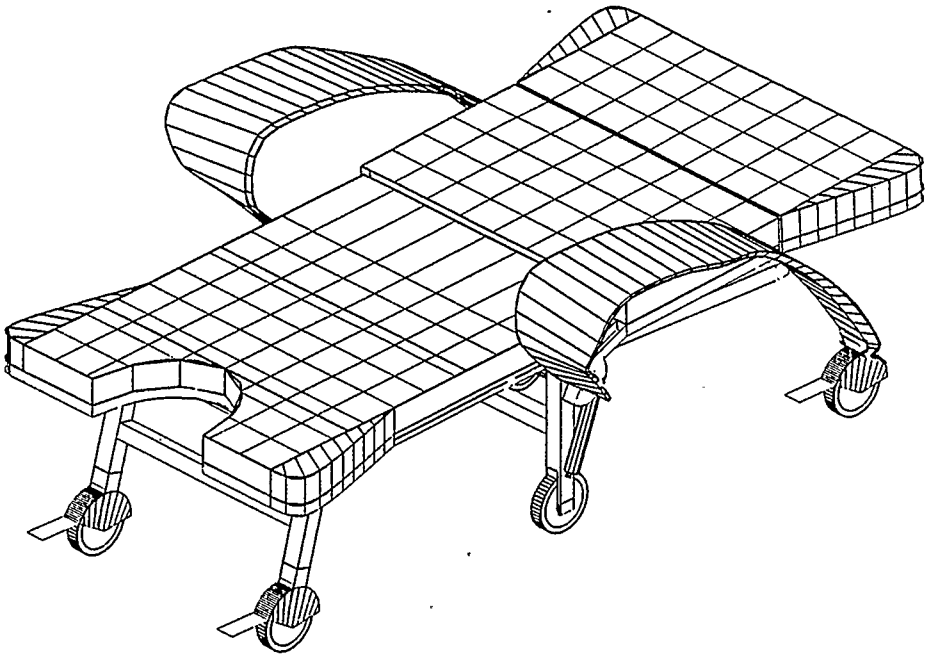


Figure 5:, Bed

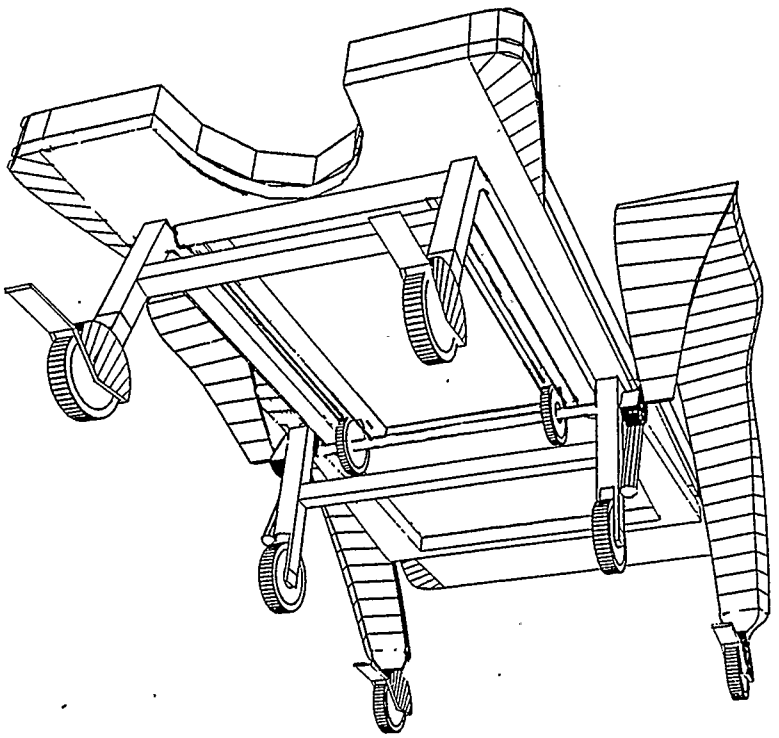


Figure 6: Under-Carriage Bed

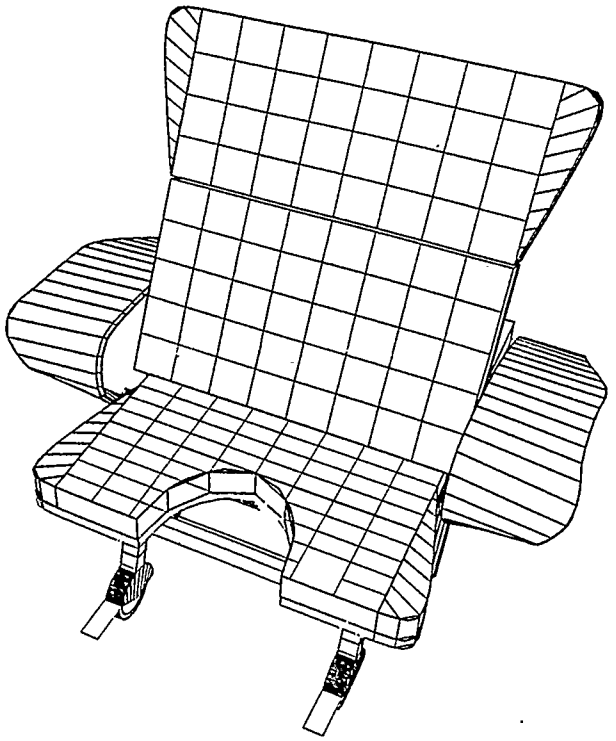


Figure 7: Seat Partially Extended

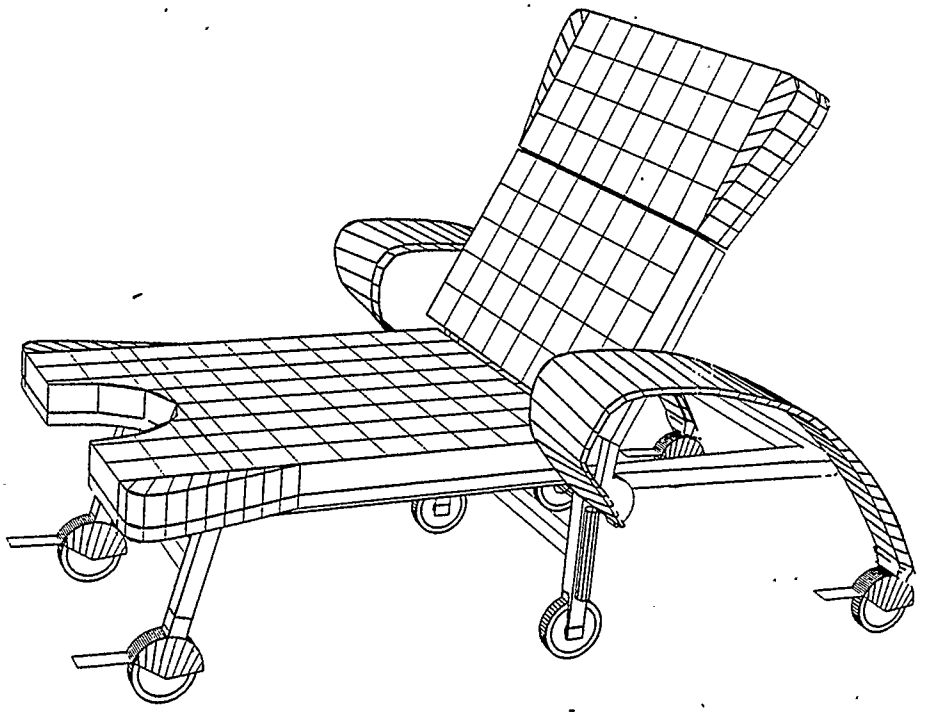


Figure 8: Backrest Partially Reclined

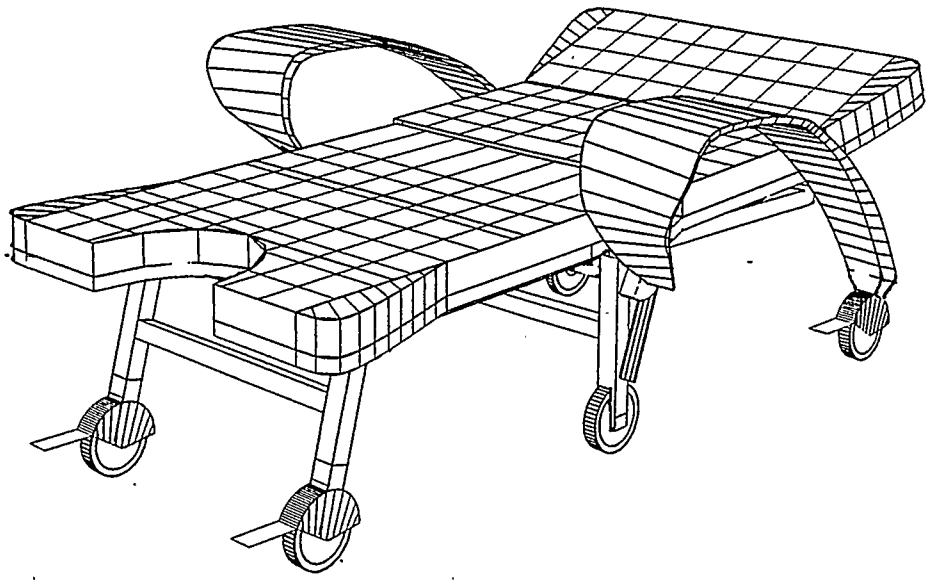


Figure 9: Perspective with Pillow Raised

BIBLIOGRAPHY

Al-Issa Ihsan, The Psychopathology of Women, Prentiss-Hall, Inc., Inglewood Cliffs, New Jersey, 1980.

Baird, Jan Ruby, Birth Companion: A Guide for Support During Labour and Delivery, Childbirth Graphics Ltd., New York, 1982.

Bataille, Georges, Erotism, Death & Sensuality, City Lights Books, San Fransco, California, 1957.

Beck, Ronald D., Plastic Product Design, 2nd. ed., Van Nostrand Reinhold Company, Toronto, 1980.

Beer, Ferdinand P. and Johnston, Jr., E. Russell, Mechanics of Materials, McGraw-Hill Book Company, New York, 1981.

Beer, Ferdinand P. and Johnston, Jr., E. Russell, Mechanics For Engineers: Statics and Dynamics, 3rd ed., McGraw-Hill Book Company, New York, 1976.

Beat, Frank and Lehman, Andrea, Atelier Vorsprung: 32 Mobelobjecte 1986-1988, Kurt Salchi Verlag, Bern, 1988

Billcliffe, Roger, Mackintosh Furniture, E. P. Dutton, New York, 1985.

Bishop, Sharon and Weinzweig, Marjorie, Philosophy and Women, Wadsworth Publishing Co., Inc., Belmont, California, 1979.

Bobak, Irene M., Jensen, Margaret and Zalar, Marianne K., Maternity and Gynecologic Care: The Nurse and the Family, 4th ed., The C. V. Mosby Company, Toronto, 1989.

Bredt, E. W., Die Welt der Kunstler, Verlag Otto Maier, Ravensburg, Germany, 1913.

Britanica Junior Encyclopedia (selected readings), Vol. 7, published by William Benton, Toronto, 1971.

Campbell, Joseph, The Power of Myth (selected readings), Double Day, New York, 1988.

Canadian Airlines International, Service Department, Furnishings Supervisor, personal interview, Calgary, Alberta, 1992.

Castor Town Ltd., # 13, 5935 - 35 St. S.E., Calgary, Canada. T2C 2H1

Chadwick, Whitney, Women, Art and Society, Thames and Hudson, London, England, 1991.

Clark, Ann L. and Alfonso, Dyanne D., Childbearing: A Nursing Perspective, F.A. Davis Company, Philadelphia, 1976.

Crichton, Jennifer, Delivery: A Nurse-Midwife's Story, Warner Books, Inc., New York, 1987.

Daly, Mary, Gyn/Ecology: The Meta-ethics of Radical Feminism, Beacon Press, Boston, Massachusetts, 1990.

Day, Peter and Lewis, Linda, Art in Everyday Life, Summerhill Press, Toronto, 1988.

Denko, Arthur C. and Levy, Jennifer, 397 Chairs, Harry N. Abrams, Inc., Publishers, New York, 1988.

Dick-Read, Grantly, Childbirth Without Fear: The Original Approach to Natural Childbirth, 4th ed., Harper and Row, New York, 1972.

van Dijen, F. S. G., Pneumatic Mechanization, Kemperman Technical Publishers, Culemborg, The Netherlands, 1975.

Diffrient, Niels, Humanscale 1/2/3, Henry Dreyfuss Associates, New York, 1974.

Diffrient, Niels, Tilley, Alvin R. and Harman, David, Humanscale 4/5/6, Henry Dreyfuss Associates, New York, 1974.

Diffrient, Niels, Tilley, Alvin R. and Harman, David, Humanscale 7/8/9, Henry Dreyfuss Associates, New York, 1981.

Du Pont, "Cordura Nylon Brochure", Industrial Fibres Division, Box 2000 Streetsville, Missisauga, Ontario, L5M 2H3. 1992.

Ecker, Gisella, Feminist Aesthetics, The Woman's Press, London, England, 1985.

Ehrenreich, Barbara and English, Deirdre, "Complaints and Disorders: The Sexual Politics of Sickness", Glass Mountain Pamphlet, No. 2, 1973.

Engelmann, Geo J., A.M., M.D., Labour Among Primitive Peoples, J. H. Chambers Co., St. Louis, 1882.

Frederickson, Burton B., The J. Paul Getty Museum: Greek and Roman Antiquities, published by J Paul Getty Museum, 1975.

Goldsmith, Judith, Childbirth Wisdom from the Worlds Oldest Societies, Congdon & Weed, Inc., New York, 1984.

Graham, Harvey, Eternal Eve, published by William Heinemann, Altrincham, England, 1950.

de Hahn, Else and Spanjer, Jetske, Beter Bevollen over Zwangerschap en Bevallen in Nederland, CIP-Gegevens Koninklijke Bibliotheek, Den Haag, Netherlands, 1984.

Hellman, Alfred Myer and Pepper, C. Doris (Hellman), A Collection of Early Obstetric Books, New Haven, 1952.
Hiller, Bavis, The Style of The Century: 1900-1980, E. P. Dutton, Inc., New York, 1983.

Houghton, P. S., Ball and Roller Bearings, Applied Science Publishers Ltd., London, England, 1976.

Jordan, Brigitte, Birth in Four Cultures, Eden Press, Montreal, 1983.

Kloosterman, G. J., "Why Midwifery," *Journal of The Practicing Midwife,* Vol.2, No. 2, Spring, 1985, The Practicing Midwife Publications, Inc., Tennessee.

Lippard, Lucy R., From the Center: Feminist Essays on Women's Art, E. P. Dutton, New York, 1976.

Lucie-Smith, Edward, A History of Industrial Design, van Nostrand Reinhold Company, Toronto, 1983.

Lucie Smith, Edward, Furniture: A Concise History, Thames and Hudson, London, England, 1991.

Luzadder, Warren J., Fundamentals of Engineering Drawing for Design, Product Development, and Numerical Control, 8th ed., Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1981.

Malcolm, Andrew, "Fear of Malpractice Suits Leading Some Doctors to Quit Obstetrics", *Journal of The Practicing Midwife,* Vol.2, No. 2, Spring, 1985, The Practicing Midwife Publications, Inc., Tennessee.

Mastropietro, Mario, An Industry for Design: The Research, Designers and Corporate Image of B & B Italia, Edizioni Lybra Imagine s.n.c., Milano, Italy, 1986.

Mosby, C. V., Mosby's Medical and Nursing Dictionary, 2nd. ed., The C. V. Mosby Company, Toronto, 1986.

Muybricge, Eadweard, The Male and Female Figure in Motion: 60 Classic Photographic Sequences, Dover Publications, Inc., New York, 1984.

Newton, Helmut, Helmut Newton's Illustrated, Number 2, Schirmer/Moser, West Berlin, Germany1987.

Passuth, Krisztina, Moholy-Nagy: selected readings, Thames and Hudson Ltd., London, England, 1985

Pile, John F., Modern Furniture, John Wiley and Sons, New York, 1979.

Pile, John, Furniture: Modern and Postmodern, Design and Technology, 2nd. ed., John Wiley & Sons, Inc., Toronto, 1990.

Poschl, Ulrike, "The Vertical Birthing Position of the Trobrianders, Papua, New Guinea", *The Australian and New Zealand Journal of Obstetrics and Gynaecology*, Vol. 27, No. 2, May, 1987.

Rogers, William, Pumps and Hydraulics, Part Two, Theo. Audel & Company, London, England, 1905.

Rollheiser, "Shock and the Trendelenburg Position", AARN, September 1986.

Sadamatsu, Junko and Sadamatsu, Shuzo, Design Drafting, van Nostrand Reinhold Company, New York, 1985.

Schaef, Anne, Women's Reality: An Emerging Female System in a White Male Society (selected readings), 2nd ed., Harper and Row Publishers Inc., New York, 1985.

Shorten, Geoff, Amptech Corporation, personal interview, Calgary, Alberta, 1992.

Simkin, Penny, Whalley, Janet and Keppler, Ann, Pregnancy, Chidlbirth and the Newborn: A Complete Guide for the Expectant Parents, Simon and Schuster, New York, 1984.

Simon and Schuster, The Way Things Work, Vol 2, Simon and Schuster Publishing, New York, 1971.

Stobbe, Terrence J. and Plummer, Ralph W., "Case Study: Ergonomic and Hazard Evaluation of a New Consumer Product", *Proceedings of the Human Factors Society*, pp. 515-519, 26th Annual Meeting, West Virginia, 1992.

Vance, Carol S., Pleasure and Danger: Exploring Female Sexuality, Routledge & Kegan Paul, London, England, 1984.

Watson, Ted, M. D., personal interview, 1992.

Ziegal, Erna. E. and Cranley, Mecca S., Obstetric Nursing, 7th ed., MacMillan Publishing Company, Inc., New York, 1978.

Footnotes

[1]Irene Bobak, Maternity and Gynecologic Care, (Toronto, C. V. Mosby Co., 1989).p. 195.
[2]Ulrike Poschl, "The Vertical Birthing Position of the Trobrianders, Papua New Guinea", (The Australian and New Zealand Journal of Obstetrics and Gynecology, 1987).p. 120-125.
[3]op. cit. Bobak, p. 402.
[4]G. J. Kloosterman, "Why Midwifery", (Journal of the Practicing Midwife,1985).p. 4-9.
[5]Burton Fredericksen, The J. Paul Getty Museum (J. Paul Getty Musem, 1975).p. 87
[6]Harvey Graham, Eternal Eve (England, William Heinemann, 1950).p. 17-19
[7]"Hippocrates" (Toronto, Britanica Junior Encyclopedia, 1970).p. 136
[8]Author Unknown, Encyclopedia of Magic and Superstition.p. 219
[9]ibid, p.52
[10]ibid, p. 218
[11]ibid, p. 8
[12]Alfred Myer Hellman, Collection of Early Obstetrical Books (New Haven, 1952).p. 8
[13]Geo J. Engelmann, Labour Among Primitive Peoples (New York, Congdon & Weed, Inc., 1984).p. 127
[14]ibid, p. 34
[15]ibid, p. 32
[16]ibid, p 37
[17]Ulrike Poschl, "The Vertical Birthing Position of the Trobrianders, Papua New Guinea", (The Australian and New Zealand Journal of Obstetrics and Gynecology, 1987).p. 120-125.
[18]ibid
[19]Geo J. Engelmann, Labour Among Primitive Peoples (New York, Congdon & Weed, Inc., 1984).p. 122
[20]ibid, p. 48
[21]ibid, p. 48
[22]ibid, p. 164
[23]ibid, p. 16
[24]ibid, p 54
[25]Brigitte Jordan, Birth in Four Cultures (Montreal, Eden Press, 1983).p. 24-25,
[26]op. cit. Engelmann, p. 162
[27]op. cit. Jordan, pp. 167-193
[28]op. cit. Engelmann, p. 90
[29]ibid, p. 47
[30]op. cit. Graham, p. 19
[31]op. cit. Engelmann, p. 27
[32]ibid, p. 27
[33]ibid, p. 15
[34]Exodus I: 15 & 16, King James Version Holy Bible

[35]op. cit. Hellman, p. 29
[36]op. cit. Engelmann, p. 67
[37]op. cit. Hellman, p. 29
[38]op. cit. Hellman, p. 9
[39]op. cit. Engelmann, p. 57
[40]ibid, p. 56
[41]ibid, p. 57
[42]ibid, p. 56
[43]E. W. Bredt, Die Welt der Kunstler (Ravensburg, Germany, Otto Maier, 1913).p. 13
[44]op. cit. Hellman, p. 20
[45]Author Unknown, Anthropology and History. p. 182
[46]op. cit. Hellman, p. 37
[47]op. cit. Engelmann, p. 59
[48]ibid, p. 59
[49]op. cit. Hellman, p. 64
[50]op. cit Engelman, p. 67
[51]ibid, p. 72
[52]ibid, p. 73
[53]ibid, p. 72
[54]ibid, p. 67
[55]ibid, p. 62
[56]ibid, p. 108
[57]ibid, p. 74
[58]ibid, p. 61
[59]ibid, p. 63
[60]ibid, p. 86
[61]ibid, p. 75
[62]C. V. Mosby, Mosby's Medical and Nursing Dictionary (Toronto, The C. V. Mosby Company, 1986). p. 657
[63]ibid, p. 657
[64]Graham, p. 16
[65]op. cit. Goldsmith, p. 153
[66]op. cit. Graham, p. 215
[67] ibid, p. 213
[68]Barbara Erhenreich, Complaints and Disorders (1973)
[69]ibid, p. 73
[70]ibid, p. 36
[71]personal interview with Dr. T. Watson, M. D.
[72]op. cit. Kloosterman, p.4
[73]op. cit. Bobak, p. 424
[74]op. cit. Mosby's Medical and Nursing Dictionary
[75]Elizabeth E. Rollheiser, "Shock and the Trendelenburg Position" (AARN, September 1986)
[76]op. cit. Mosby's Medical and Nursing Dictionary

[77]personal interview with Dr. Ted Watson, M. D.
[78]Jan Ruby Baird, Birth Companion (New York, Childbirth Graphics Ltd., 1982).p. 4
[79]personal interview with Nursing Staff Foothills Hospital (Calgary, Alberta, 1991)
[80]op. cit. Baird, p. 4
[81]op. cit. Bobak, p. 402
[82]op. cit. Bobak, p. 350
[83]ibid, p. 350
[84]ibid
[85]op. cit. Ziegal, p. 258
[86]op. cit. Bobak, p. 420
[87]ibid, p. 430
[88]ibid, p. 447
[89]Penny Simkin, Pregnancy, Childbirth and the Newborn (New York, Simon and Schuster, 1984).p. 264
[90]op. cit. Bobak, p. 296
[91]Ann L. Clark, Childbearing: A Nursing Perspective (Philadelphia, F. A. Davis Co., 1976).p. 250
[92]op. cit. Simkin, p. 91
[93]ibid, p. 107
[94]ibid, p. 92
[95]ibid, p. 263
[96]op. cit. Bobak, p. 414
[97]Henry Dreyfuss Associates, Humanscale 7/8/9, (1981). section 9a
[98]Henry Dreyfuss Associates, Humanscale 4/5/6, (1981).p. 39
[99]ibid
[100]op. cit. Mosby's Medical and Nursing Dictionary
[101]Henry Dreyfuss Associates, Humanscale 4/5/6.p. 10
[102]op. cit. Mosby
[103]Henry Dreyfuss Associates, Humanscale 4/5/6, (1981).p. 29
[104]op. cit. T. Watson.
[105]Henry Dreyfuss Associates, Humanscale 1/2/3, (1974).p 19
[106]ibid
[107]ibid, p. 20
[108]ibid
[109]Henry Dreyfuss Associates, Humanscale 7/8/9, (1981).p. 40
[110]op. cit. Mosby
[111]op. cit. Simkin
[112]op. cit. Bobak, p. 810
[113]T. J. Stobbe, Case Study: Ergonomic and Hazard Evaluation of a New Consumer Product (Proceedings of the Human Factors Society, 26-th Annual Meeting, 1982).p515-519.
[114]Du Pont, Industrial Fibres Division, Ontario, 1992.
[115]ibid

[116]Atten.: Chris, Caster Town Ltd., #13, 5935 - 35 St., S.E., Calgary, Canada. T2C 2H1

[117]F. S. G. van Dijen, Pneumatic Mechanization (Netherlands, Kemperman Technical Publishers, 1975).p. 22

[118]ibid, p. 273