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Rochester Institute of Technology

INshade

The Structure of a Synergistic Approach to Product Design

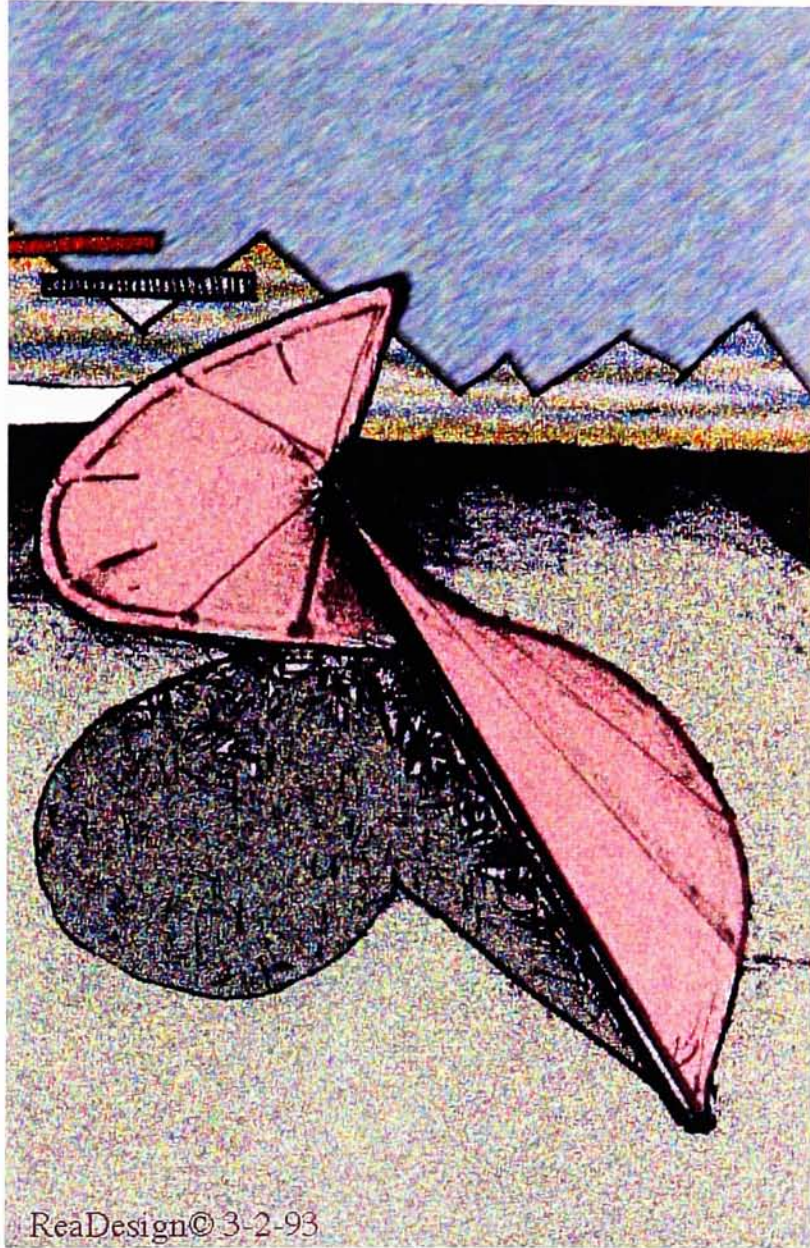
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By

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I would like to thank my friend and wife Dori Farrar Read, for without her editing, support and faith in me, this thesis could not have been possible.

-James Morley Read
September 27, 1993

PREFACE

This project started as the development of a design method loosely based on the principles of synergism. The results have not been a formula or a matrix. The findings should bring insight into the design decision making process, a window into the creative experience.

Although the design process documentation was central for this project the specification statement was also salient. The specification statement played a pivotal role in product design and in understanding the design process. Words provide us with an economical organization of what can be seen through the mind's eye. The words used - depending on their organization - can lead to new understanding, or have the potential of stopping one cold.

“Most men spend their lives in futile rebellion against things they cannot change, in passive resignation to things they can, and - never attempting to learn the difference - in chronic guilt and self-doubt on both counts.”
(Rand, 1984, 24)

Introspection has been a major factor in data collection for this project. The documentation of the design process has been gathered as a chronicle of 5 inch by 7 inch pencil sketches from the winter of 1992 into the spring of 1993. These sketches illustrate the design process within the evolution of this project. The design process has also been documented with a series of study models.

These models range from simple wire and soap film studies to a number of full scale polystyrene and fabric models.

The objective of this Thesis has been to demonstrate a synergistic approach to product design. The intention was to demonstrate the structure of this synergistic method through the example of development of a consumer product.

This product, INshade, has been identified throughout the design process by a specification statement. This pro-active statement is the result of collating a series of identified problems into one sentence. The specification statement is intended to embody the essence of the product without transferring a preconceived icon identification to the designer about the desired outcome.

The problem-solving process, fueled by the specification statement, explored two distinct avenues. These paths are identified as designing with natural forms and designing with parallel forms. The design process led to the development of a number of innovative and contextual forms which are intended to satisfy the stated problems. The final product INshade, derived from this exploration, has moved to its new state as a result of these activities working in combined action.

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CHAPTER I

SYNERGISTIC PRODUCT DEVELOPMENT

Currently there are two product development models which are actively in use. These two different models are the sequential and the parallel development strategies. There is a third model which is emerging as an ideal development strategy. This strategy is referred to as a helical development model.

Sequential Model

Data within the sequential or “handshake” development model originates in the sales and marketing departments. This data or potential product proceeds linearly throughout the development process. It is literally handed off from one department to the next in an orderly, straight line fashion.

The product evolves from marketing to appearance design, from appearance design to engineering, from engineering to manufacturing, then from manufacturing to quality control, and quality control hands it off to service. The results of this sequence of events tends to let small problems that are left unchecked develop into big problems. Decisions are often made as reactions to problems, not as solutions to them. An oversight from a preceding department is often hard to remedy down the road.

Over time this type of development system can lead to mistrust and cynicism towards the other departments. There is potential for general devaluing of the roles which the other groups play in the development cycle.

An additional drawback to this linear “handshake model” is the time it takes to execute. This development strategy is very time consuming. While one department in the front of the line is completing its part, the department following it must wait to start. At this time first-to-market often means better market share. Waiting to start or processing change orders can mean the difference between success and failure for a new product.

Parallel Model

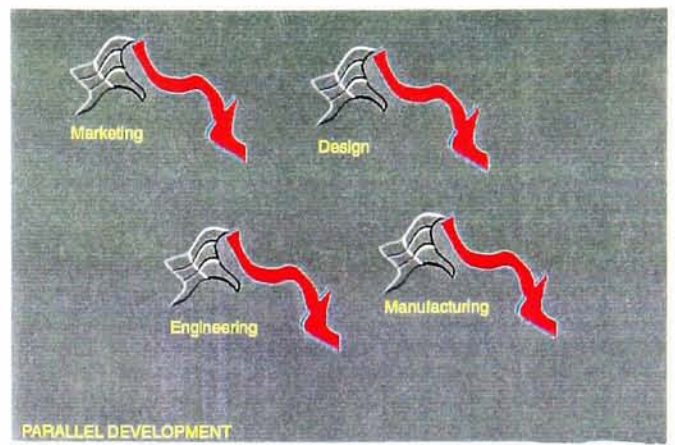
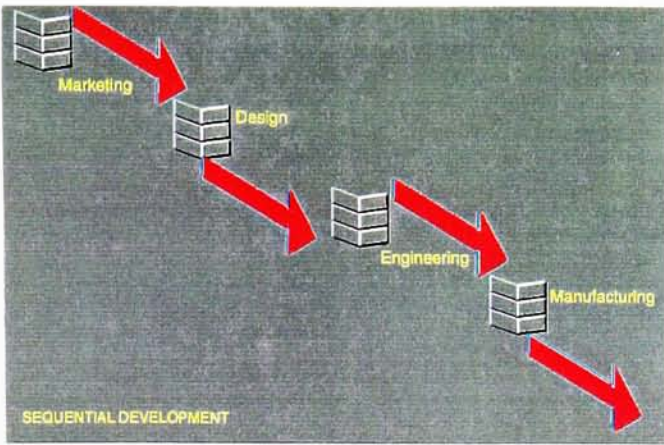
The parallel model is now a widely used product development model. This parallel, or overlapping model, provides better interaction among neighboring groups. The exchange of information occurs in a timely fashion. This model is based on the successful Japanese kan ban system. This development system has the groups working in an overlapping style that allows for more communication between groups.

There has been a need for a “design guru” within this model, an individual who has been through the entire development process a number of times. This person would be a disseminator of knowledge, one who is able to share his/her knowledge about the discipline of the other groups. This role of

“design guru” now is slowly being replaced by the computer data base. A computer data base can allow access and update all information to the entire group at the same time. Access to this computer data base disseminates information in a timely manner, shortening the time to market.

Simultaneous Model

The simultaneous or helical development model is an extremely synergistic approach to the development cycle. In this model the members are clustered. These members are able to interact among all parties simultaneously. This differs from the overlapping model in which the members can only interact with the nearest neighbor. In the simultaneous model all members work concurrently, sharing and exchanging all decisions and information (Albert 1991, 9). The ideal form of this synergistic system would allow for the process to be design driven, ultimately producing a superior product which is functional, economic and relevant (fig. 1).



DESIGN

HELICAL DEVELOPMENT
 Ideal synergistic team model. Product development is design driven and all members are involved from concept to completion.

MARKETING Find out what's important to the group. *SPEAK THEIR LANGUAGE*

Example: Increased Market Share

GROSS MARGIN ENHANCEMENT
 The primary means to analyze the gross profit of producing a product is relative to the price that can be charged for it and varies with the volume produced.
 This is calculated by subtracting from 1: the ratio of the sum of all product, labor, and materials costs divided by sales.

SALES
 Any reduction to costs of product labor or materials will be an enhancement to the Manufacturer's Gross Margin (MGM).
 Decreasing the labor component of the product cost through assembly simplification will enhance (MGM).

Key words:
 Operation Margin Enhancement
 Return on investment
 Output
 Opportunity Cost

Stress the need for communication among all groups.

ENGINEERING Find out what's important to the group. *SPEAK THEIR LANGUAGE*

Coordinated Product and Process Design

INTERACTION
 Existing process
 New processes and their limitations

Reverse Engineering
 Design Axioms
 (DFM) Design for Manufacturing

Exchange information from the start
 Share in the decision making
 Reinforce communications with marketing

MANUFACTURING Find out what's important to the group. *SPEAK THEIR LANGUAGE*

Identify Current Trends and Processes

Example: **INTERACTION**
 Cell and System design
 Controls and System Transfer
 Information Transfer
 Group Technology
 CAD/CAM
 JIT Inventory Control

JIT Inventory Control

Special efforts should be made to knock down barriers with this group.

Where they are
 What direction they are heading
 Where they want to be

Stress the need for communication among all groups.

SERVICE Find out what's important to the group. *SPEAK THEIR LANGUAGE*

Define:
 the group.

Example:
 the group.

Stress the need for communication among all groups.

Stress the need for communication among all groups.

Establish the limitations of the existing or similar products
 Define potential maintenance problems and concerns
 Establish existing service processing and identify possible improvements

LEGISLATION Find out what's important to the group. *SPEAK THEIR LANGUAGE*

Define potential liabilities.
 Establish trends and forecasts of legislation which may impact on the product

Example:
 Cigarette smoking in public spaces
 New German law requires that up to one-quarter of an automobile's components must be made from recyclable materials by 1994.
 Establish existing service processing and identify possible improvements

Stress the need for communication among all groups.

CHAPTER II

UNDERSTANDING AND COMMUNICATION WITHIN THE DESIGN-DRIVEN SYNERGISTIC MODEL

The industrial designer has emerged with a new role in the project development cycle. The responsibility of the industrial designer is no longer limited to the "package," leaving the product to the engineers. The designer was previously seen as a necessary evil, one who brought only intangible arts to the package or the skin of a product. It is incumbent upon the designer to add functionality, bring humanity (the soul) to the product. The designer's role is not just as some fashion-driven shape shifter.

The new role for the designer is that of the facilitator. This new role requires the designer to become familiar with, and continuously develop a better understanding of the needs of all the disciplines. With a better understanding of all the team members, the flow of the project from start to finish is smoother. The process becomes much more efficient with the team acting as one entity. It also allows each player to contribute concurrently and potentially without seams.

In the helical, or simultaneous development model, the project is design-driven. This requires the designer to facilitate communication amongst the whole team. The product and the client are best served when each team

member is able to contribute from the start, understanding the needs and expectations of the other team players (Albert 1991, 9). It has become the facilitating role of the designer to help each member of the group make his or her needs known.

Communication with Marketing

In communicating with marketing, the project should be addressed in terms which can be identified by the marketing players. The designer should be familiar with their terminology. The designer should speak their language. From the start there is a need to identify what is important to the group.

Increased market share could be identified as an element that is important to this group. This element might be defined as, "How will the new product out-perform the existing one?" This in turn might be addressed as "What reductions to costs of product labor or materials will be an enhancement to the manufacturer's gross margin?" This statement is referred to as the gross margin enhancement.

Examination of the gross margin enhancement is the primary means to analyze the gross profit of producing a product relative to the price that can be charged for it. The gross profit varies with volume produced. This is calculated by subtracting from 1 the ratio of the sum of all products, labor, and materials costs, divided by sales (Rae 1992, 61).

$$1 - \frac{(\text{product} + \text{labor} + \text{materials costs})}{\text{SALES}} = \text{Gross Margin Enhancement}$$

Fig. 2. Formula for Calculating Gross Margin Enhancement

In this formula any reduction to costs of product, labor, or materials will be an enhancement to the manufacturer's Gross Margin. For example, decreasing the labor component of the product cost through assembly simplification will enhance the manufacturer's gross margin.

As it is with marketing, it is important to communicate with manufacturing, engineering, service, and legislation from the start of the project. For example, with the manufacturing group it is important to identify current trends and processes. As with the engineering group, it is important to coordinate product and process design. With service, reviewing the limitations of the existing or similar products is vital; and with legislative group, defining potential liabilities is necessary. The final component is stressing the need for communication among all groups.

CHAPTER III

IDENTIFICATION OF THE PROBLEM

The Development of the Specification Statement

The Development of the Specification Statement has a very deliberate goal. The goal is to describe the outcome for the designing that has yet to be performed (Jones 1992, 383). This description can be accomplished through a three-step process: identifying, selecting, and defining. First, identify a range of possible outcomes. Then select the lowest level of generality. Finally, define the expected design outcome (Jones 1992, 384). It is this careful selection of words, through a process of inclusion and deliberate omission, which can be critical to the overall success of a project.

Selecting the Project

To illustrate the thesis described here, a product was selected. The essence of this product was to be extracted through the development of the specification statement, which then should facilitate an innovative outcome.

The selection process for this product was somewhat arbitrary. The consensus of the thesis committee was that the product could be almost anything (outside of simply shrouding a widget in a plastic box).

It was strongly argued that the product should be one which had a strong

recognized appearance and use. Through much lively debate and prolonged discourse, a product was reluctantly agreed upon. After the development of the specification statement clearly defined and identified the problem, the word(s) used to originally identify this product were never spoken again. These words, if used to define the product, could have limited the design by creating a design fixation, a preconceived resolution to the design problem.

Defining and Identifying the Problem

There has been a replacement of the Victorian ideal of the Camille. The snow white skin has been replaced by a bronzed god look. This bronzed look now signifies that the possessor has the leisure time to play in the sun, while previously the fair complexion signified for all to see that the possessor did not labor in the sun for a living. With this change has come a rise in incidence of skin cancer in both the U.S. and in Europe. The most lethal form, malignant melanoma, which is less directly linked to sunshine, has jumped ten-fold in the past twenty years (Wallis 1983, 46).

Skin cancer is the most common type of cancer in the United States. According to current estimates, 40 to 50 percent of Americans who live to age 65 will have skin cancer at least once.

Several *risk factors* increase the chance of getting skin cancer. *Ultraviolet (UV) radiation* from the sun is the main cause of skin cancer (National Cancer Institute 1992, 4).

Ultraviolet radiation (UV) from the sun produces changes in the human skin. The most dangerous and insidious ultraviolet radiations are the short wave-lengths (UV b's) which are most prevalent between 11 am and 3 pm. There is also a danger from longer wave length radiation (UV a's) from the sun all day long. 80 percent of skin cancers caused by the sun are basal-cell carcinoma. This form of skin cancer is the most common and is also the most preventable and treatable (Wallis 1983, 46).

The preventive measures are simply to stay out of the sun's rays and use sun screen lotions. Playing in the sun has become part of the idyllic unobtainable image promoted by Madison Avenue. It is still viewed by most as healthy and sexy. Many activities take place in association with the sun and tanning. The weekend getaway vacation or the two week family trip are often planned around the beach and ocean, whether it is the New Jersey Shore, Baja California, a Club Med, or a deserted beach in the Dry Tortugas.

When considering exposure to ultraviolet radiation at the beach, avoiding it seems difficult because of a lack of any natural shade protection. Because of the natural reaction of the two environments, the beach and ocean, there is very little natural protection from the sun's direct or reflected rays in this setting. When spending long amounts of time at the beach, there is also a more immediate effect to over-exposure to the sun: fatigue and dehydration which can lead to sunstroke.

The first pass at identifying the problem was summed up with three brief statements and a two word simplification. Those statements were:

- UV a and UV b radiation from the sun cause skin cancer in humans.
- There is very little natural shade at the beach.
- Over exposure to the sun can cause fatigue and dehydration.

At this stage in the specification statement development, a two word simplification of the problem was stated: BEACH SHADE.

Brainstorming Activity

Armed with the simplified statement, "beach shade", and the three identified problems, a brainstorming activity was undertaken. This exercise listed for each statement possible features, alternatives, and existing types of similar products and objects.

- **Possible features**

Opaque / translucent / transparent / block the sun / block UV b and UV a rays but not light / blocks light but not vision / blocks vision / stops the wind / lets the breeze pass through / blocks the rain / does not need to stop rain / portable / permanent / transportable how? -on a bicycle - on foot - in a car - on a car - on a boat - from where to where?- dwelling to beach / portable why? how portable? - moving 200 yards, moving 10 feet / opens and closes / fixed in one position / light weight / fashion accessory / obelisk / landmark / gnomon / shadow clock / sundial.

- **Existing types of similar products, object, etc.**

UV protection : lotions / hats / visors / sunbonnets / the atmosphere / clothing / blankets / shade / shadows / sunglasses | Shade at the beach : umbrellas / hats / visors / sunbonnets / under the sand / palm trees / mangroves / other trees / sand dunes / rocks / blankets / kites | Fatigue and dehydration : drink water / salt tablets /sleep / eat food / avoid sun

- **Alternatives**

UV Protection - Parasols / awnings / canopies / buildings | Shade at the Beach - Buildings / houses / roofs / cars / tents / sundials / fur / feathers / eyelashes / eye lids / tinted glass

This brainstorming activity developed the final Specification Statement which was used to design the product "INshade". The Specification Statement reads: **Create a portable means of shade at the beach.**

The importance of this simple statement should not be undervalued. The choice of words has been very deliberate. There has been a conscious effort not to use a word like parasol or umbrella, which through concept labeling would suggest a preconceived outcome. At the same time there has been an effort to convey information about potential characteristics of the product. Economy and information are balanced against one another.

The world is categorized in part for reasons of economy. To remember and treat everything in one's environment as unique would require tremendous cognitive capacity (Anderson, 1991a). . . .

.....
Thus, economy and informativeness trade off against each other: If categories are very general, there will be relatively few categories (increased economy), but there will be few characteristics that one can assume different members of a category share (decreasing informativeness) and few occasions on which members of the category can be treated as identical. If categories are very specific, there will be relatively many categories (decreasing economy), but there will be many characteristics that one can assume different members of a category share (increasing informativeness) and many occasions on which members can be treated as identical (Komatsu 1992, 501).

The intent of the specification statement was to impart with brevity an

intended outcome, without relying upon someone else's symbol to impair the solution. A well-written specification statement can help avoid the potential for design fixation. This specification statement could potentially lead the designer to whole new solution which results in actual designing, not styling.

CHAPTER IV

DESIGN ACTIVITY

The Problem-Solving Process

With the problem identified and the specification statement developed, the stage for the activity of designing was set to begin. There are three basic mental activities in which a designer is involved at this point in the project development. The first is the way in which the designer organizes his or her actions. The second includes the main strategies that are adopted; and the third is the problem-solving processes that are used to execute the design. The organization of the designer's actions have been reviewed and the main strategies have been adopted. A method of reporting the problem-solving process was needed.

Selecting the Data Collection Method

In the search for models of researching and gathering data on the design process, a number of existing methods were reviewed. An interesting fact surfaced: It seems that very few designers are looking at the design process as a means to create better designs or better designers. There is, however, a great amount of research being done by cognitive scientists in conjunction with computer programmers in an effort to understand the creative decision-making

process.

Through this search for a data collecting method, it became clear that simple reporting of the tasks would be inadequate; the actual activities of problem solving would be most relevant. This would entail examination of the cognitive activity with which the designer realizes his or her tasks, the information sources, the use of them, the reasoning processes from start to completion. Industrial design being a visual discipline, some pictorial means would be a logical method for recording the events.

There were two promising choices for developing and reporting the design activities for this thesis. These were verbalization and introspection. The method of reporting on this thesis became a hybrid between the two. Verbalization, as a data collection method, requires the designer to think out loud, reporting all mental activities. This includes verbalizing the choices that a designer confronts, the decisions that are made, and the reasoning behind them. The designer is to report hesitations and second-guessing of past decisions. Introspection is the main data-collection method for reporting on the design process; it consists of commenting on one's own mental activity and reflection upon the events which lead to the outcome of a design (Visser 1992, 94).

The data collection method undertaken for this thesis was a pictorial log of the design process. A journal of 5"x 7" pencil sketches, along with 3D soap bubble models, wood and paper models, and models of wire and cloth were created and logged to document the process of the design decision-making

activity. The sketches were made to refine the design as it developed, but more importantly the sketches provided an ongoing record of the thought process that occurred while designing. The intent was that the sketches would act as the pictorial equivalent of an ongoing verbalization of the design process, one that could record and be reflected upon after the completion of the exercise.

Identifying the Paths in the Problem-Solving Process

There are three basic activities of the design process. The first is to organize the dissemination of information within the group (see Chapter II). The second, is to identify the strategies that are used to achieve the goals and the processes which develop the specification statement (see Chapter III). The final event is that of the actual problem-solving process, the creation of the product. The problem-solving process could explore unlimited avenues of discovery. For this project four paths were identified and two were followed.

The four identified paths were: 1) design a better mousetrap, 2) rename the "mousetrap" and define "better," 3) designing with parallel forms, and 4) designing with natural forms.

Designing a better mousetrap refers to developing the existing form and exploration of the history of the object to be designed. This process involves evolutionary design. One major drawback to this approach is the potential for

design fixation. A designer presented with a picture or a predetermined idea of the product will reproduce a number of characteristics of the original design, including the inappropriate design attributes. Existing knowledge about a design may result in fixations. Also, with this evolutionary design approach there is often a reluctance to do something that has never been done before.

The approach of renaming the “mousetrap” and defining the word “better” takes the evolutionary design farther. It attempts to redefine the problem and uses analogies to stimulate spontaneous thinking. This spontaneous thinking is encouraged by the uses of personal, symbolic, direct, and fantasy analogies to stimulate the design.

The approach of designing with *parallel forms* refers to the use of contextual elements and the forces that may impact on, or perform the same function as required by the specification statement.

Designing with *natural forms* uses the building blocks which comprise all natural elements. These are the branch, the circle, the helix, the meander, the spiral, and the polygon.

CHAPTER V

PROBLEM-SOLVING PROCESS

Use of Computers and Study Models

One of the first interests of exploration was the way in which three-dimensional spaces were being expressed in the two-dimensional environment of the computer monitor. Representing three-dimensional objects in a computer environment is a daunting task. Defining ways in which to represent mathematically the physical world in the space of 0's and 1's is not a job for the faint-hearted. This is a task being tackled by some of the most daring minds of the computer science world.

These computer scientists have devised a number of methods of creating three-dimensional objects in the computer environment. These methods include extrusion, section rotation, B-splines, and least square method of surface coverage. All of these methods require the manipulation of two-dimensional geometry. The use of B-splines and least square method of surface coverage were of particular interest for this thesis. These methods of creating three-dimensional objects were studied as both physical models and computer-generated models. The computer models were constructed in the three dimensional program from Intergraph called *MicroStation*. The first physical models were constructed of wire and soap film.

Soap film study models

With the examination of simple soap film models as a beginning point, natural forms and their structures were explored. Soap film surfaces are surfaces of least area, and are referred to by mathematicians as minimal surfaces. The soap bubble model described the surface areas by a contour of a single closed wire. These closed wires bound at least one soap film. A number of different forms were constructed this way. The geometry which constructed the forms was then entered into the computer.

The soap film models were duplicated in the computer with the use of a 3-d format in MicroStation and the 3-d B-splines palette . This palette has four parts: the derived surfaces commands, surfaces, space curves, and the change surfaces command.

The first soap film models were constructed using soft, light-weight copper wire. The forms generated mimic the gentle helixes in the structure of shells found at the beach. These designs were then studied in pencil sketches and some were then formalized and brought into the mathematical world of the computer. The forms were refined, giving them size and proportions appropriate for casting a shadow for the 50th percentile male.

The shade cast by these forms was studied both in the computer and by building physical models. The physical models were constructed of fabric, wood, and polystyrene, along with models of paper and wood. These models were more formal in appearance than the original soap film models and were needed to help refine the geometry and predict the shadows that would be cast.

The shadows were also studied in the computer environment by first defining the geometric information in relationship to the x, y, and z Cartesian planes of the software program. The *ModelView* software provided a means of predicting the shadows cast by these different forms. This program allows for the placement of the object relative to the degrees of the compass, in relationship to its position of latitude and longitude. Lighting controls were set to natural light conditions, which were selected for time of day and year. With this information the computer was able to accurately calculate the shadows that would be cast (fig. 9. & 12.).

CHAPTER VI

EMBODIMENT OF THE PRODUCT

Use of Materials and Methods

The product "INshade" was designed to produce Beach Shade specifically: a portable means of shade at the beach. In creating a product to satisfy this statement, a diary of sketches and models was developed using parallel forms and natural forms as inspiration. As different concepts developed, strategies for manufacturing were explored. Ease of manufacturing was identified as important to the overall product for the purpose of cost control. This would potentially enhance the gross margin. By use of the computer, the manufacturing process could also be streamlined.

The overall design of the product, INshade, was based on a helix similar to those found within a shell's structure. The pattern of the fabric is based on a spiral of Archimedes. The proportions were constrained to provide maximum shade with minimal use of materials. The design maximized the use of a standard 60 inch piece of fabric without the need of stitching two widths of material together. The design, based on this 60 inch standard, was then plotted full scale from the *MicroStation* 3-d file. This pattern was then used as the template for the cutting of the fabric.

The spiral pattern of the fabric has a line, tangent from the center to the outermost point of the curve. This line, used as the lead, provided the measurement for the distance traversed parallel to the center staff. This distance provided a base point to establish the overall length for the staff. The lead measurement and the length of the spiral's curve were then used to establish the length of the pultrusion rod.

The fabric was chosen for its resistance to material degradation from exposure to UVA and UVB radiation. The fabric is to be, or the equivalent to Burlington's: Trigger 60 Poplin, which is 65 percent Fortrel polyester and 35 percent cotton. The design of this shape reduces labor costs by eliminating potential steps in material handling. The design also reduces product and material costs by maximizing standard material sizing. The choice of materials will help in the longevity of the product and will help increase the perception of quality.

The design of the center staff is based on the mast of a sailboat, and would to be manufactured as an extrusion. By using a simple extrusion die section, tooling costs for this part could be kept low relative to other processes available. The material to be extruded for this part is to be a mineral-filled PBT resin. This thermoplastic polyester has been chosen for its stiffness and resistance to warping.

The top part of INshade has been designed to be injection molded thermoplastic polyester. This hinging part, which has been designed as a simple piece-work assembly, provides an added flexibility between the center

staff and the shade-casting fabric. This hinging mechanism also allows for the collapsing of the shade for ease of storage and portability.

The final part of the INshade is a pultruded glass fiber-reinforced polyester resin rod with a hollow core. This rod is used as the outer rib, which gives the fabric its shape when assembled. This pultrusion rod was cut into sections, and through the core an elastic cord was stretched. This provides for a consistent and easy breakdown and assembly.

When assembled this portable shade satisfies the identified problems with a new and unique form. This inventive form was facilitated by a pro-active statement which embodied the essence of the product. The final solution developed from many activities working together. This project should provide insight and inspiration for designer's interested in the changing role of design and the design decision making process.

GLOSSARY

Synergism. (sin 'ər jiz'm) N. [<Gr. SYN-, Together + ERGON, Work] Phases working in combined action, greater in total effect than the sum of their effects (Websters New World Dictionary, 1979 ed. s.v. "Synergism"). Syn'er •gis'tic adj. Based on the Greek term SYNERGOS - literally to work together - Greek theory that the universe is made up of and maintained by vast collection of cooperating parts. In the twentieth century the process has led to the discovery of superconductivity, laser light, and is used in computer programming. The basic principles that govern the cooperative behavior of elements within a system moving toward a state change. (Daniels and Mara 1989, 16).

FOUR DISTINCT PHASES for change:

1. Energy event : Identification of the problem
2. Phase Transition : Specification Statement
3. Order Parameter Event : Design process
4. Entry into a New State: The Product (Result of the preceding actions)

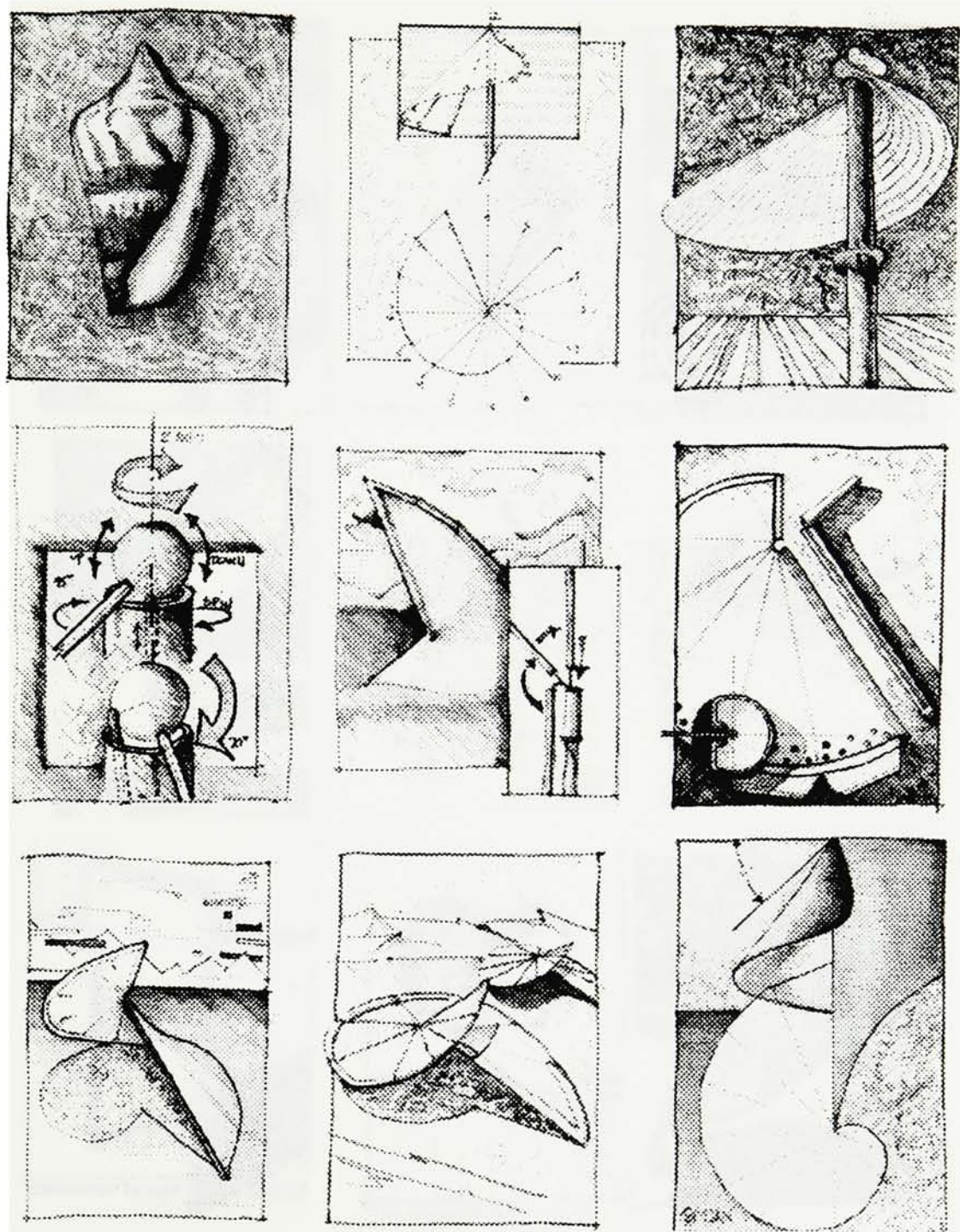


Fig. 3. Sketch Book

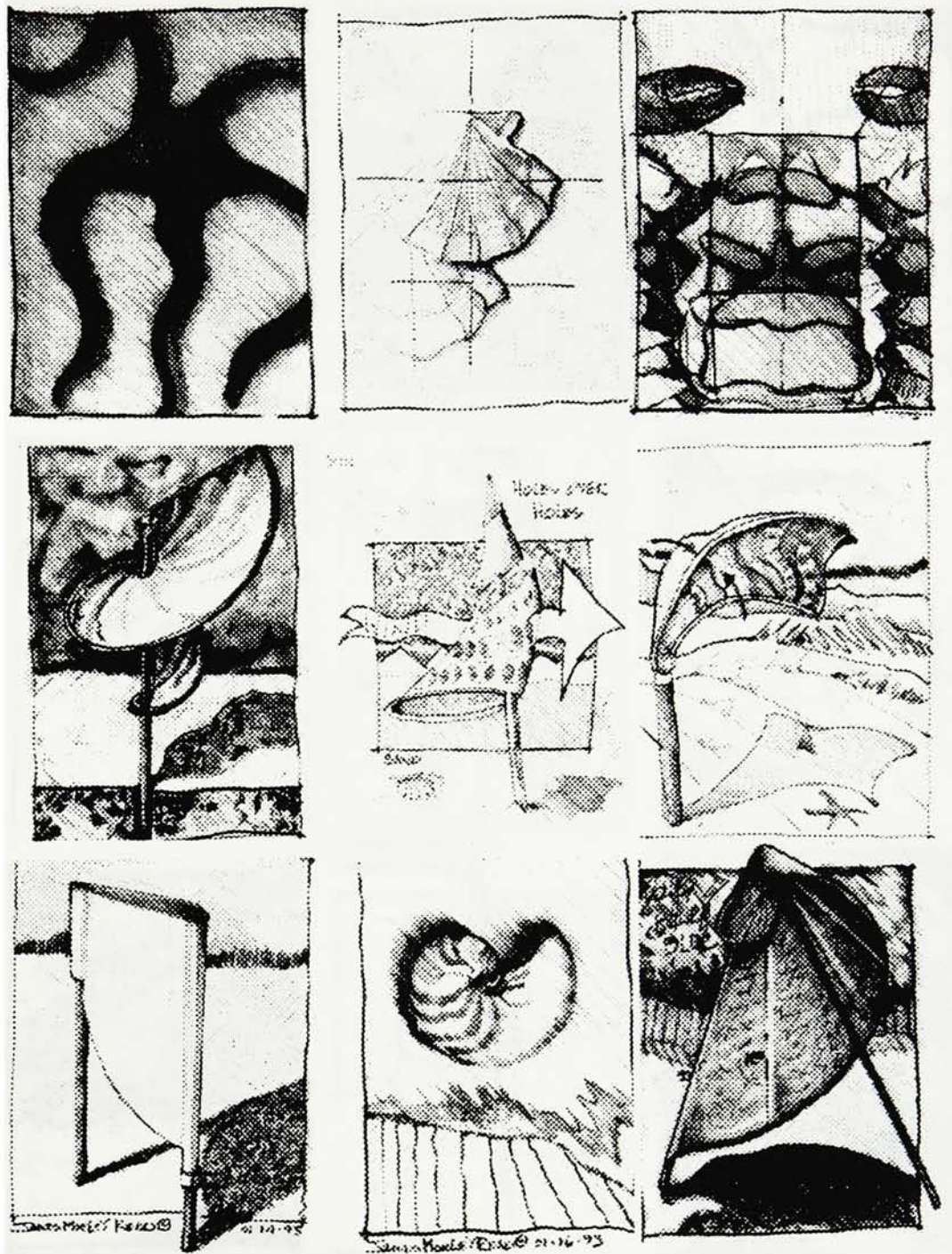


Fig. 4. Sketch Book

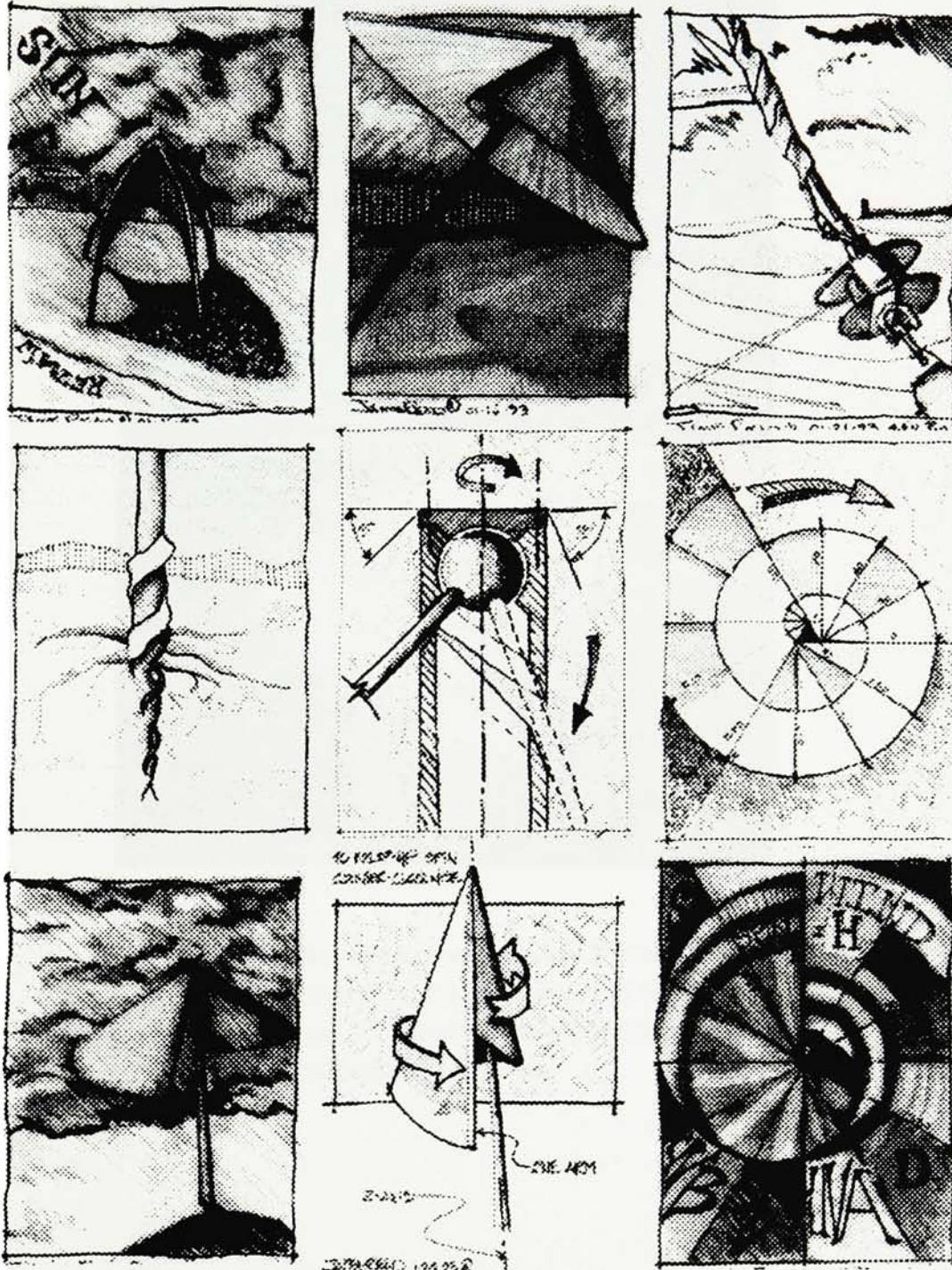


Fig. 5. Sketch Book

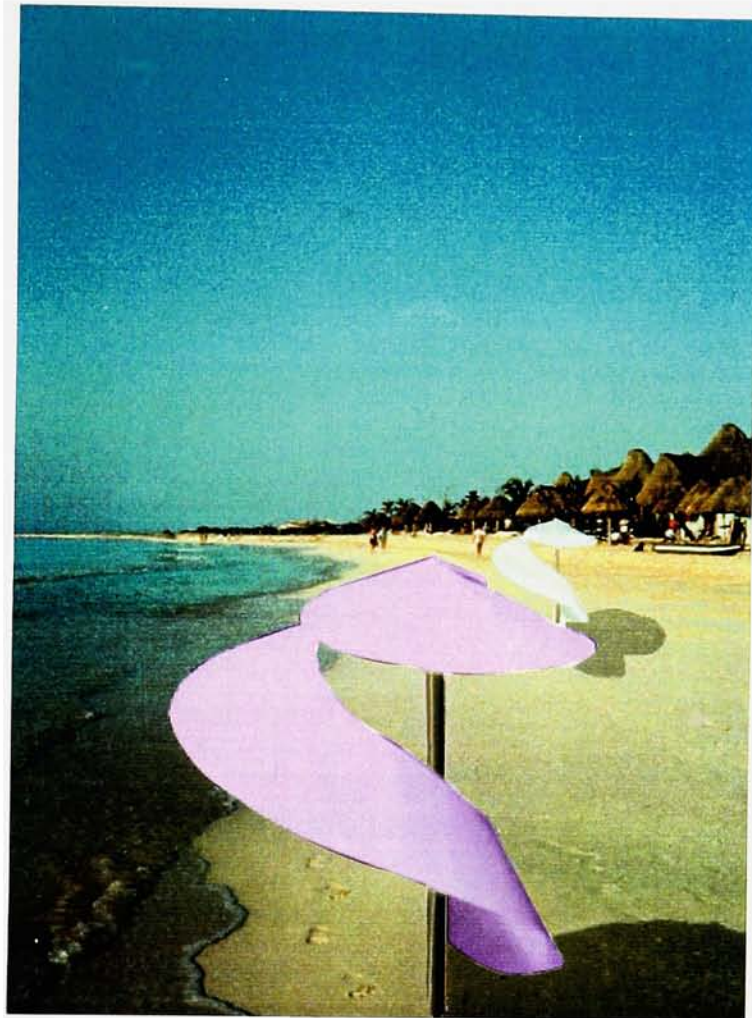


Fig. 6. Computer Photograph: Vertical study models with shadows on the beach. Original photograph by Elizabeth A. Read, Computer rendering/composite of models and photograph by Author.

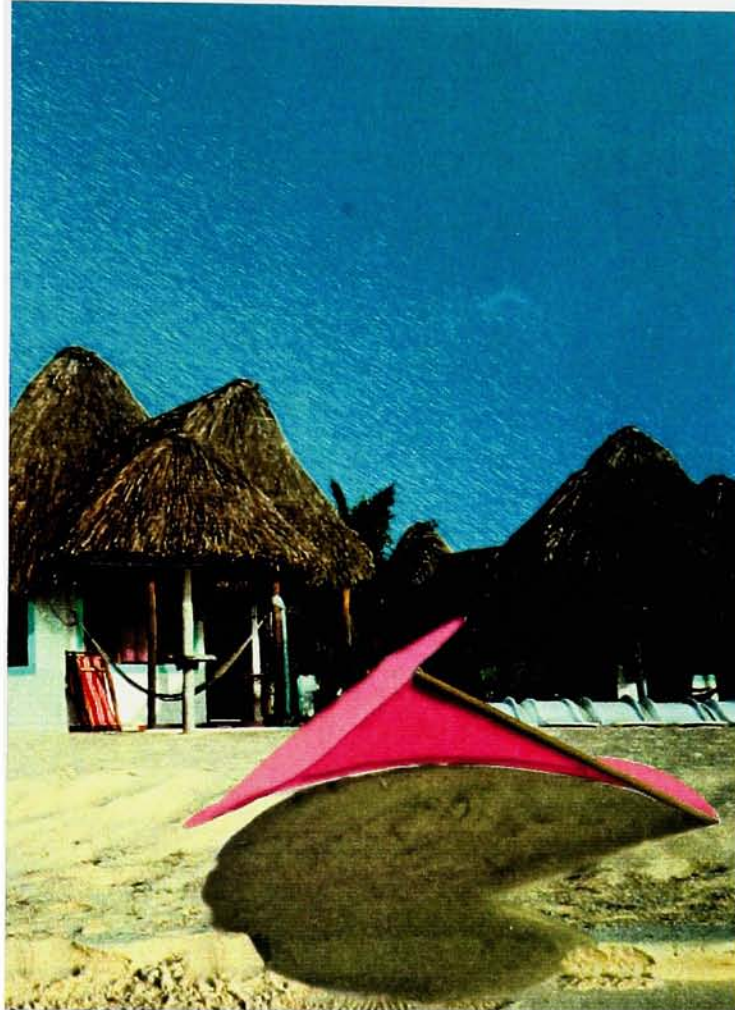


Fig. 7. Computer Photograph: Horizontal study model with shadow on the beach. Original photograph by Elizabeth A. Read, Computer rendering/composite of models and photograph by Author.

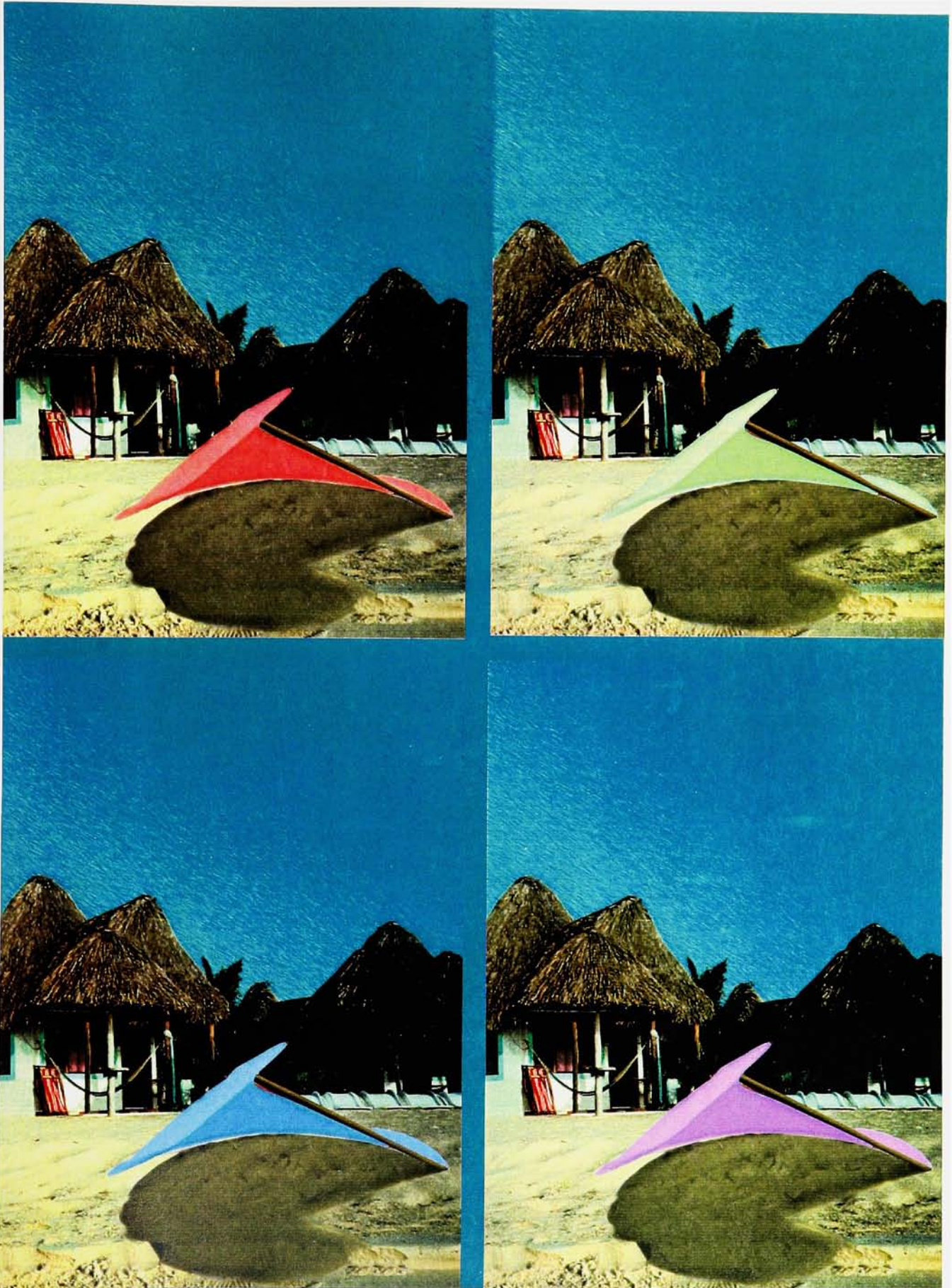


Fig. 8. Computer Photograph: Color studys of Horizontal model with shadow on the beach. Original photograph by Elizabeth A. Read, Computer rendering/composite of models and photograph by Author.



Fig. 9. Computer Rendering: Computer study model of shadows on the beach. Computer rendering by Author.



Fig. 10. Scale Model: Polystyrene and fabric model. Photograph by Author.



Fig. 11. Scale Model: Polystyrene and fabric model. Photograph by Author.

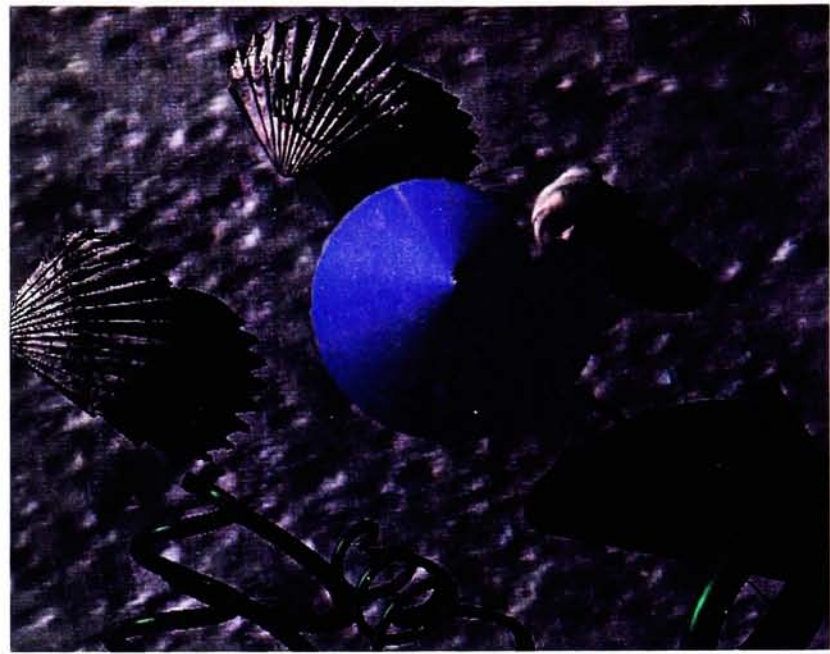


Fig. 12. Computer Models : Computer generated contextual forms and models. Computer Rendering by Author.

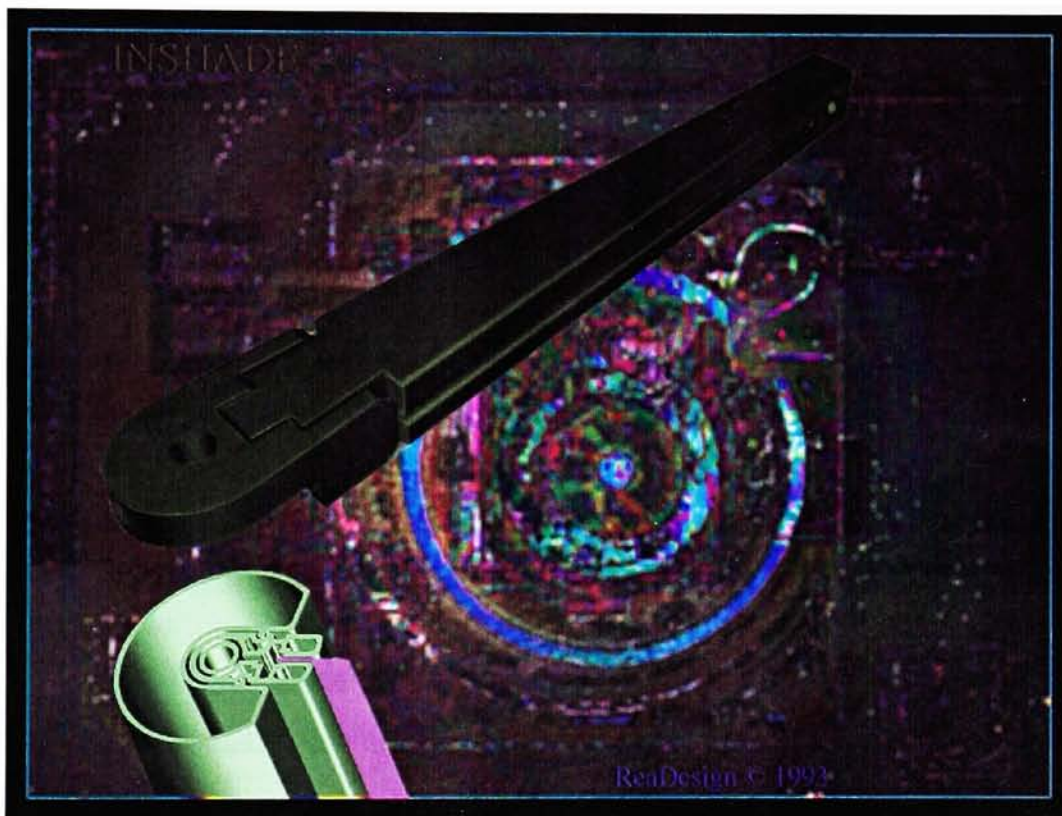


Fig. 13. Computer Rendering: Parts for Inshade; a) Center staff - extruded, mineral filled PBT resin and, b) The top - injection molded, thermoplastic polyester. Computer rendering by Author.

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