University of Alberta

Design Synectics: Machine Knitwear

by

Wendy Evelyn Bakgaard ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of MASTER OF ARTS.

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **DESIGN SYNECTICS: MACHINE KNITWEAR** submitted by **WENDY EVELYN BAKGAARD** in partial fulfillment of the requirements for the degree of **MASTER OF ARTS** in **CLOTHING AND TEXTILES.**

Marlene Cox-Bishop

Marlene Cox-Bishop

Linda Capjack

Linda Capjack

Jorge Frascara

DATE: August 3, 1995

DEDICATION

To my grandparents,
Thomas F. Rieger, tailor and
Christine (nee Jensen) Rieger, tailor's seamstress.

What's bred in the bone...

ABSTRACT

This investigation documented the application of synectic trigger mechanisms to the designing of a small collection of machine knitwear. Documentation of the designing process took the form of computer files and printouts, samples, sketches, and photographs. Stitch Painter™ computer software assisted the designer in the application of the synectic triggers at the motif level. Inspiration for the motifs was derived from the designer's photographs of mountains taken during backcountry travels.

The design and production of seven machine knit sweaters with coordinating hats formed the corpus of this investigation. A Brother 910 Electronic™ knitting machine was used to knit the wool and rayon garments. Synectic triggers were applied from the micro through to the macro levels of both design and production. The synectic pinball machine paradigm proved to be useful for research in designing because it assisted in limiting the number of plastic variables upon which the synectic triggers could act.

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For her continued nurturing and for always being there, ready to help in any way -- I thank my mother, Evelyn M. Bakgaard.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF PLATES

CHAPTER 1

Introduction

Few designers have written about the design process as it relates to creative activities. This may be because the designer is often so implicitly and intensely engrossed in the work of designing that she/he is not cognizant of the thinking processes involved. Furthermore, the intensity of the designing process does not lend itself to the documentation and the study of designing activities while these are in progress. The design process remains a mysterious and magical process to those without familiarity with the design field and even to those actively practising in the field. The lack of research documentation has perpetuated the mystery surrounding the nature of designing and how designers work. Designers are deemed to be makers of objects, rather than planners of concepts when, in fact, they are usually both.

The writings of Plato and Aristotle delineated the separation of the intellectual and the manual (Dilnot, 1992). The stereotype persists - - that those who think, generally write; while those who make, generally do. This implies a hierarchy which sets a priority of writing over doing or making (Dilnot, 1992). Research into the nature of designing has been hindered by this separation and has resulted in a lack of understanding by both designers and society of "what it is that we do when we make objects and images" (Dilnot, 1992, p. 32). For designers thinking, planning and making occur in a synchronous process. Coyne and Snodgrass (1991) have argued "against the view that designing involves a special kind of knowledge that is fundamentally difficult to grasp and therefore mysterious." (p. 124). These authors suggest that design does not make use of a special kind of reasoning; rather, the tempos, materials, and settings differentiate designing from other types of work (Coyne & Snodgrass, 1991). Furthermore, these authors propose that logical, analytical and rational thinking is not the polarized opposite of subjective, idiosyncratic and irrational thinking and that the process of design involves both ways of thinking.

One designing method that capitalizes on these different modes of conceptualizing is synectics, which synergizes thinking styles in order to foster creativity in the designing process. Combining design theory with a theory of creativity such as synectics provides a method to stimulate creative designing (Roukes, 1982, 1988). Design synectics can promote an integration of thought and action by providing a manageable method for synthesizing objects, images, ideas and technologies. Such a synthesis is needed if individuals and communities are to constructively care for society and the environment

(Dilnot, 1992; Papanek, 1988). Apparel and textile designers have much in common with designers from other fields in terms of this need for a constructive synthesis because they share common problems and goals. Design synectics can be applied by any designer to meet this need for a more creative approach to problem solving.

The textual literature review prepared for this investigation provides textile and apparel designers with an overview of the current dialogue about designing issues in other areas of design. In addition, the textual information surveyed in this literature review summarizes the current research in computer aided design within the textile and apparel designing context.

This study contributes to the study of the creative designing processes in the field of textiles and apparel through documentation of the application of the synectic design method and computer aided design (CAD) tools to the designing and production of a collection of one-of-a-kind machine knitwear. The efficient, logical processes characteristic of computer software were used in conjunction with the synectic trigger mechanisms prescribed by Roukes (1982, 1988) to enhance the creative designing process.

Knitwear design synthesizes apparel designing with textile designing and, thus, challenges the designer to simultaneously determine the form of both the garment and the fabric. Computer software provides the knitwear designer with the potential to efficiently manipulate the elements of design by using the principles of design when designing apparel. The computerized knitting machine provides the designer with a wide range of structural, patterning, and silhouette possibilities. Yarn, the raw material of knitted textiles, offers the designer a vast choice for manipulating the elements of design, especially colour and texture.

CHAPTER 2

Literature Review

The literature review is presented prior to focusing on the statement of the problem, purpose and objectives, significance of the study, and its parameters in order to provide a context for the reader.

The textual and visual literature collected for review in preparation for this study are related to three areas; design theory and methodology in general and in textiles and apparel in particular; computer aided design (CAD) in textiles and apparel; and the history and development of machine knitting and contemporary knitwear designing. The textual and visual data used in my investigation were limited to sources available in English at the University of Alberta Library, in the Clothing and Textiles Collection at the University of Alberta, through interlibrary loan, the Calgary Public Library, and in the researcher's personal library. Textual sources included journals such as: Design Issues, Journal of Design History, Design Studies, Surface Design Journal, and magazines such as Fiberarts, Threads, Piecework, and Vogue Knitting. Books related to the theoretical, historical, and technical aspects of designing, knitting, and computer aided design were also consulted.

Theory Related to Designing

The etymology of 'design' is derived from the Latin 'de + signare' meaning to make something, giving it significance, and designating its relation to other things, "design is making sense of things." (Krippendorff, 1989, p. 9). Throughout this study, the term 'design' is used as a verb to describe a process: "planning, organizing, to meet a goal, carrying out according to a particular purpose, creating." (Davis, 1980, p. 3). "Design" can also be used as a noun to refer to a product, "the end result, an intended plan or arrangement that is the outcome of a plan." (Davis, 1980, p. 3). "Designing" in this study refers to the mental and physical processes of "to design," the verb.

It is a fundamental human trait to desire a sense of order and understanding about our environment. According to Willem, (1991, p. 133) "designing is to conceive and plan out in the mind." This statement defines the process of designing in the broadest and most general of terms and makes everyone a designer. The conception and planning of manmade things refers to all products; be they material objects, verbal or visual communications, organized activities and services, or complex systems or environments (Willem, 1991). Bevlin describes design with direct reference to material objects, such as apparel, and states that design "is the organization of materials and forms in such a way as to fulfill a specific purpose." (1984, p. 9). Designing performs physical, communicative, symbolic, and aesthetic functions or some or all of these functions in combination. Coyne and Snodgrass (1991) characterize designing as a project that "translates human culture, technology and aspiration into form." (p. 130). These authors remind us that "even a designer working alone is working within a social, historical and technological context". (1991, p. 130).

Schmitt and Chen (1991) distinguish and describe three classes of designing: routine, innovative, and creative (see Figure 1). Routine designing refers to problems that are well defined and in which client requirements are well understood from the onset. In routine designing, the end products are the goals and the functional requirements of the products are known from the start. Routine designing has very few variables present and much of the designing work is simply the refining of previous products. Innovative designing is the process used when designers have a priori ideas of the desired end products and can adapt existing prototypes to fit the required needs or can combine two or more prototypes. Once the prototype is successful, the process becomes routine designing. Creative designing involves the designer in development of new solutions that may only be partially known at the beginning since neither the total functional requirements nor the product's properties are completely defined. Creative design often results in the designer redefining the original problem once the end product has been developed or, in extreme cases, rendering the original problem irrelevant. Creative designing usually warrants extensive prototype creation and may be the most influential activity in the field of design. It is also the least understood by those who are not designers, because attempts to formalize the creative designing process have been unsuccessful to date. This lack of formalization has helped to surround the designing process with magic and mystery. However, research shows that designing is neither magical nor mysterious when the process is examined closely.

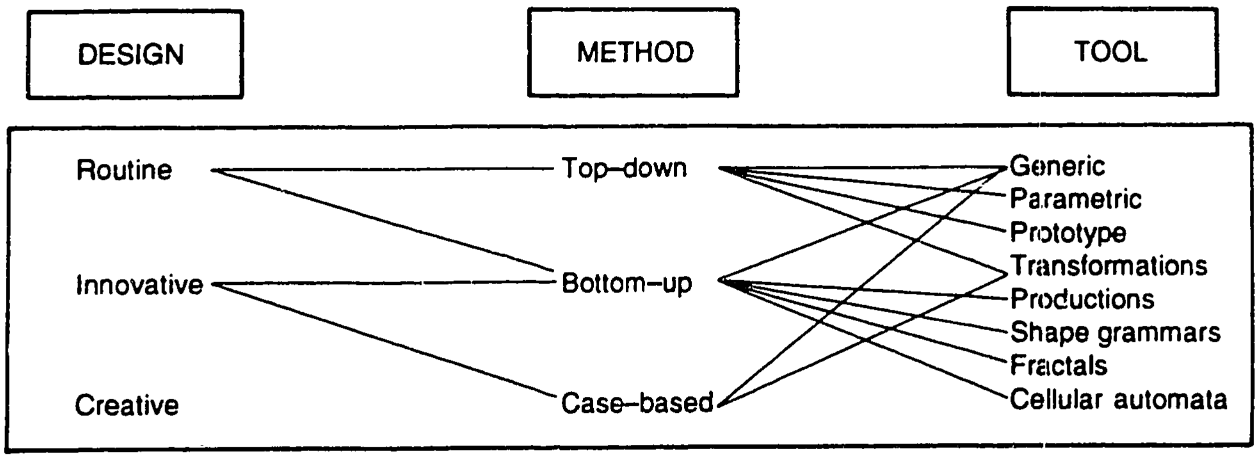


Figure 1. The mapping between the classes of design, design methods and design tools depicts how the various classes of design relate to one another (Schmitt & Chen, 1991, p. 250). Paint type computer software programs such as Stitch Painter™ are classified as generic design tools. Computer aided design programs such as KeyCAD™ are classified as parametric design tools.

The Process of Designing

Researchers have identified designing as a process involving a number of phases -- as few as three and as many as nine. These phases should not be seen as linear stages but as stages that recur and interact with each other throughout the designing process regardless of how many phases are involved. Zeisel's 'design development spiral' best demonstrates the ways in which these components relate to one another (see Figure 2). The spiral metaphor reflects the following characteristics of design: backtracking, repeating activities with shifting focus, and multi-directional movement (Zeisel, 1984). The design development spiral further illustrates how the conceptual shifts occur during the cyclical, reiterative designing process which is comprised of three constituent activities: imaging, presenting and testing (Zeisel, 1984). Koberg and Bagnall (1981) conclude that the ultimate model of the design process is the spiral, a continuum that includes their seven designing stages: accept situation, analyze, define, ideate, select, implement, and evaluate.

When commencing the designing process, generally a designer first identifies the problem. Often this is the most difficult part of the process because it requires a thorough, in-depth analysis of the problem as presented. Criteria must be established to define and set the goal that is to be reached in order to arrive at a solution. Research and data collection are undertaken to ensure that external factors are considered and that as much information is known about the problem as is possible.

The second phase of the design process is the concept stage, "when the imagination soars" (Bevlin, 1984, p. 24). It is this component of the creative process that mystifies those who do not have a working knowledge of the designing process. At the concept stage, the creative process is used to develop preliminary ideas and images which may be set down in textual, or visual forms. Utilizing the elements and principles of design, the designer may employ either brainstorming or synectics as methods to create new forms, and ideation and planning may be used to produce the first rough ideas. In apparel design, particularly, it is this aspect of the designing process which is seen as "nebulous, spontaneous, chaotic and imaginative." (Lawson, 1980, p. 1). Whereas, in engineering design, ideation and planning are considered to be "precise, predetermined, systematic, and mathematical." (Lawson, 1980, p. 1). Perhaps this falsely dichotomous view is due to a lack of understanding of the creative designing process used by apparel designers, which is fostered by the paucity of published research conducted by apparel designers themselves.

Analysis and evaluation of the ideas and images gathered during the second phase (concept stage) comprise the third component of the designing process. This process involves testing, evaluating, and selecting ideas that show promise. Presenting these ideas in more finished form such as in working drawings, prototypes, and mock-ups allows the designer to synthesize the information and to better communicate these ideas to clients and peers. In consultation with the clients and peers the designer is able to select the most suitable ideas for continued development.

Production and implementation of the selected ideas are the fourth components of the design process. Development and construction of the product(s) usually requires supervision by the designer in order to ensure quality and integrity of the finished product. These characteristics may, for example, be based on the criteria set by the client or by production factors.

The fifth component of the design process is the evaluation of the product to establish whether or not the end product conforms to the criteria defined in the first phase of the design process. If the product outcome is not satisfactorily completed or does not successfully meet the set criteria, some or all of the designing process may be revisited and reworked as visualized in the design development spiral (see Figure 2). Often, it is not until this last evaluation stage that new or missed facets of the problem are discovered and the problem revisited. Buchanan (1992) has observed that "the design problem can never be completely described in advance. It is never truly finished and therefore the problem is never really solved. This is the 'wicked problem' of design." (p. 15). Designers, given the chance, would always tackle the same problem differently the next time, armed with the knowledge and experience of hindsight. "Design is series of choices." (Bevlin, 1984, p. 24). By trial and elimination, the designer chooses the best solution available at the time. Technology has given designers complex alternatives from which to select materials, equipment, and techniques for production. Today, designers are responsible for making decisions that were previously limited by the available resources of the past (Archer, 1984). These newly available parameters require that designers increase their efficiency and effectiveness in all aspects of the design process with training, practice, and experience. The design synectics method can stimulate the creative capabilities of designers and provide a useful methodology for designing.

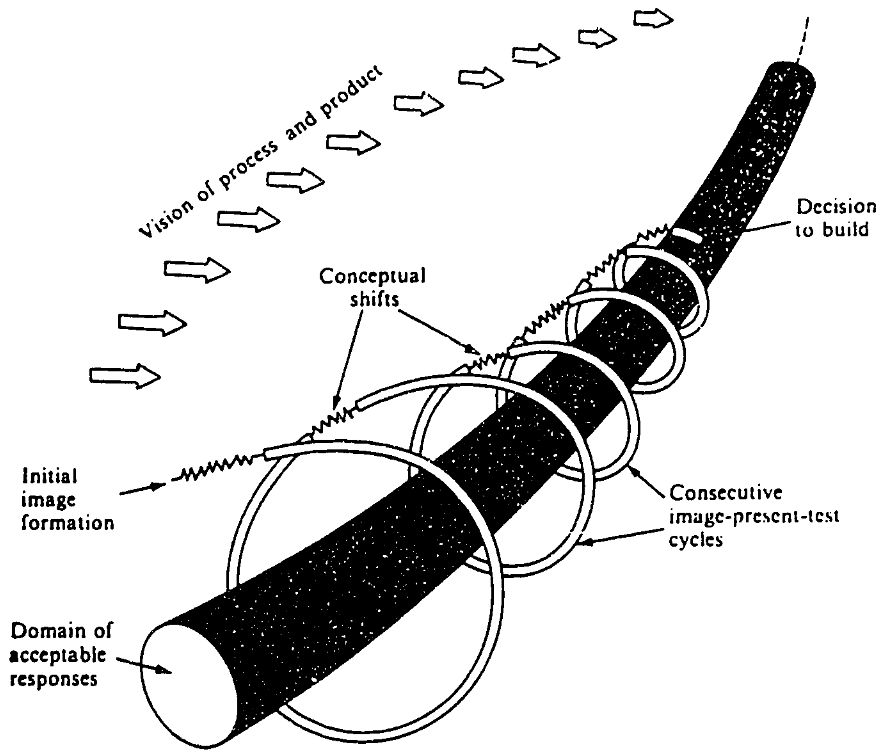


Figure 2. The design development spiral metaphor illustrates how the various phases of designing fit together. The design development spiral also reflects the characteristics of design within the context of the reiterative and elaborative nature of the designing process (Zeisel, 1984, p. 14).

Research in Designing

Research in designing differs from investigations in other fields because designing expresses itself in terms of complex objects, products and systems. Research in other fields concerns itself with discovering knowledge through investigation of the phenomenon and its context and communicating this knowledge through unambiguous text. Designed objects embody extensive knowledge on the part of the designer but usually the design does not explicitly communicate this knowledge (Agnew, 1993).

Study of the designing process is hampered because, being a process, it is in motion. If the process is halted, there is only the product to observe and evaluate and, too often, formal evaluation of this end product is also neglected. Research in design is further hindered by the lack of any fundamental documentation of the design process during the designing of the product (Gordon, 1961; Agnew, 1993).

Zeisel (1984) states that, "although outsiders can directly observe behavioral and representational parts of designing, they cannot directly observe cognitive processes taking place inside someone's head." Only in the event that video cables or virtual reality, plugged into the designer's brain, could project images for others to observe would it become possible to discover how designers think. In the meantime, research into the designing process will continue to be observed indirectly and will utilize "personal experience, participant observation, stream-of-consciousness reports by designers designing, and analysis of successive design drawings." (Zeisel, 1984, p. 5). Conclusions drawn by these non-designing observers will be inferential. In order to understand the process of designing, design theorists are looking to disciplines such as linguistics, artificial intelligence, and biological evolution for analogies about the designing process in order to understand the process of designing (Zeisel, 1984). This research has sought parallels in terms of systems of thinking, organizing information and behaviors between designing and other skills. One area of research into creativity that has illuminated how the designing process works has involved synectics theory.

Synectics Theory

Studies in synectics theory were begun in 1944 with the goal of developing an operational description of the creative process. Since 1944, investigations into synectic theory have continued to investigate the creative process in order to determine the underlying psychological mechanisms integral to creative activity. Gordon (1961), one of the first researchers to write about synectics, asserts that "the only way to learn about the creative process is to try to gain insight into the underlying, non-rational, free-associative concepts which flow under the articulated surface phenomenon." (p. 3). In order to accomplish this, his 1944 study involved a longitudinal research project using the Cambridge Synectics Group in cooperation with various types of industry. Industry presented problems and designers from a variety of backgrounds were observed as they went about solving the problems. For example, in 1961, the Cambridge Synectics Group was comprised of six problem-solvers of differing backgrounds: physics, mechanics, biology, geology, marketing, and chemistry. Discussion of their designing processes was conducted with the use of tape recorders. They tackled two types of problems: invention and implementation. Solutions to the invention problems were analyzed in order to determine how they were developed. Solutions to the implementation problems took the form of working models, experiments, and market evaluations. The resulting products were also discussed and analyzed in order to learn more about the invention processes. These studies led to the development of an operational concept of human creativity termed synectics.

According to Gordon (1961), synectics research is based on the following assumptions. First, "that the creative process in human beings can be completely described and, further, that sound description should be usable in teaching methodology to increase the creative output of both individuals and groups." (p. 5). Second, "that the cultural phenomena of invention in the arts and in science are analogous and are characterized by the same fundamental psychic processes." Third, "that individual process in the creative enterprise enjoys a direct analogy in group process." (Gordon, 1961, p. 5).

Furthermore, synectics theory argues three principles. First, "creative efficiency in people can be markedly increased if they understand the psychological process by which they operate." Second, "in creative process the emotional component is more important than the intellectual, the irrational more important than the rational." Third, "it is these emotional, irrational elements which can and must be understood in order to increase the probability of success in a problem-solving situation." (Gordon, 1961, p. 6).

Research in Textiles and Apparel Designing

Only a few researchers have published articles in the area of design theory as it applies specifically to the designing of textiles and apparel. Brent (1991) reviewed paradigms and theoretical orientations. Watkins (1984, 1988) applied the design process to teach functional apparel design. Lamb and Kallal (1992) developed a conceptual framework for apparel design. Davis (1980) and Cooklin (1991) wrote textbooks with chapters devoted to apparel designing. Cox-Bishop (1989) argued for a place for research in art and design in home economics. These researchers included little information regarding the creative designing aspects of the apparel designing process.

The majority of the literature reviewed in the area of knitwear is of a technical nature. However, one notable exception is D. Newton's **Knitwear Design** (1992), which provides technical advice and instructions regarding the designing and making of hand knitted garments. D. Newton's work differs from that of other descriptions of knit apparel designing in that she devotes a chapter to "learning to see" in which she describes her own designing process which she identifies as having four phases: "inspiration, swatching, capturing the design on paper, and keeping records." (D. Newton, 1992, p. 9).

For D. Newton (1992), the inspiration phase is when the idea is conceived, and she admits to a certain confusion about how to proceed during this phase of the design process. Swatching involves experimenting with a variety of needles, yarns, colours, stitches, and patterns until she has a combination she thinks reflects her initial idea. During the third phase, capturing the design on paper, D. Newton sketches possible combinations and variations of the fabric just invented and applies these to a specific garment shape and construction. The last phase of D. Newton's design process requires recording how she has created the fabric and garment so that it may be reproduced by others.

D. Newton's work is also remarkable in that she provides some visual and textual examples of objects she consciously utilized for inspiration and she offers suggestions for how the reader can also gain inspiration. D. Newton's approach is useful because it demystifies parts of her creative designing process for the reader. However, her work is less accessible to those designers with different aesthetic needs and values because she does not put her examples in generic design terms. Had D. Newton used the terminology of the elements and principles of design, her work would have been more easily transferred to designers in other mediums. Furthermore, much of D. Newton's creative method could be described using the synectic trigger terminology, especially the more structural, logical trigger mechanisms which closely correspond to traditional textile designing methods. While D. Newton does not yet use computer software programs or knitting machines for her creative designing process, her approach to designing does not preclude the application of such technology to each phase of the process.

Nabney, in **Designing Garments on the Knitting Machine** (1991), encourages the machine knitter to spend time on the creative designing process in order to produce garments that are unique. She directly addresses the fact that "most knitters seem afraid to experiment with shape, colour, or design." (p. 7). Nabney attributes this reluctance to a fear of making mistakes and thereby wasting time and materials. She distinguishes two constituents to designing knitwear: first, the designer who uses elements and principles of design and second, the technician who operates the knitting machine. Nabney challenges the machine knitter to bridge the gap between the designing and the knitting processes in order to make them a coherent whole. She identifies three elements which must be considered when designing knitted garments: fabric, garment shape, and construction of the garment (Nabney, 1991). Because other works have focused on fabric and construction, Nabney concentrates primarily on garment shaping and she demonstrates how historical and ethnic clothing can be used for inspiration.

Lang (1988) distinguished three types of aesthetics: sensory, formal, and symbolic. Sensory aesthetics is concerned with the pleasurableness of the sensations, colours, sounds, and textures which are perceived in the environment. The second describes formal aesthetics, which is concerned with the appreciation of the shapes, rhythms, complexities, and sequences of the visual and haptic world. The third type is symbolic aesthetics which is the appreciation of the associational meanings of the environment. (Lang, 1988). The designing of apparel and accessories purposefully exploits sensory, formal, and symbolic aesthetics.

Brent (1991) was influenced by Lang's work and uses Lang's terminology when she reviewed paradigms and theoretical orientations in order to understand systematic inquiry in the design field. She observed that "design research and creative endeavors embrace multiple paradigms." (p. 161). These paradigms are: social facts, social definition, and social behavior. According to the case studies reviewed by Brent, aesthetics theory, a sub category of the social definition paradigm, best addresses the designing of apparel and textiles. Brent contends that an integration of the aesthetic and social science paradigms could be useful to solving problems in art, design, and social science. Brent also reminds us that "although aesthetics plays a vital role in the design curriculum...it does not fit neatly in a social/psychological taxonomy. That is, it is intuitively based rather than empirically based." (Brent, 1991, p. 168). This general inability to quantify the subjective and intuitive aspects of textiles and apparel may explain why very few studies have been undertaken which focus on the creative designing process of textiles and on apparel design in particular.

This neglect of the study of the qualitative and intuitive in design is mentioned by Cox-Bishop (1989) in arguing for a place for research in the art and aesthetics of clothing and textiles design. She grounds her argument in the functions of art as summarized by Eisner (1972). Eisner contends that "art provides a sense of the visionary in human experience by giving visual form to dreams, hopes, values, feelings and aspirations so that others may also share these views and so articulate their own." In addition, he holds that "art activates the senses causing the creator and the viewer to become aware of the real, the ordinary, and the mundane of all that we have encountered but never before seen." Finally, he considers that "art reveals dimensions of social context through visual metaphor and therefore enhances appreciation of the cultural context of ourselves and that of others." (Eisner, 1972, p. 9-16).

Watkins (1984, 1988) refined and presented a design process framework for functional clothing design as well as fashion design (see Figure 3) based on the problem solving design process conceived by Koberg and Bagnall (1981) in the **Universal Traveler**. This model has seven phases: acceptance, analysis, definition, ideation, ideas selection, implementation, and evaluation (see Figure 4). Lamb and Kallal (1992) expanded on the functional clothing design process developed by Watkins and proposed an integrated apparel design framework (see Figure 5). They posit that the functional designing process is equally applicable to fashion design practice and education, but they do not focus on the creative aspects of the designing process. Lamb and Kallal's conceptual framework includes functional, expressive, and aesthetic concerns but it does not specifically include feasibility relative to budget, materials, and equipment factors. The four functional, utilitarian considerations of apparel designing relate to physical needs: environmental protection, thermal comfort, fit, and ease of movement. The expressive, psychological considerations of apparel designing relate to the cultural environment: communicative, and symbolic aspects of dress. The aesthetic considerations of apparel designing relate to the aesthetic environment: the subjective human desire for beauty. The last consideration leads to the designing of wearable art. The apparel design framework requires the designer to integrate and balance the aesthetic, expressive, and functional considerations during the design process.

Lamb and Kallal (1992) describe a six stage creative problem solving designing process based on Koberg and Bagnall's seven stage problem solving process (see Figure 4). Their first stage, problem identification, requires the designer to perceive, accept, and seek resolution to the problem. For apparel designers, this might be the development of a seasonal collection of garments for a specific target market. Stage two generates and documents preliminary ideas using sketching and brainstorming, as well as research, survey, and question and answer sessions. During the brainstorming phase, emphasis is on nonjudgemental, freewheeling thinking so as to foster the formation of a multitude of solutions (Lamb and Kallal, 1992). This brief description of brainstorming is the extent of the information presented by Lamb and Kallal regarding the creative aspects of the designing process. Their third stage of the apparel design framework is design refinement which scrutinizes the preliminary ideation. The fourth stage as conceived by Lamb and Kallal, prototype development, includes patternmaking and construction of sample garments. In the fifth stage, evaluation, the designer assesses the prototypes "according to criteria established in the problem identification stage." (Lamb and Kallal, 1992, p. 45). The culmination of the apparel designing process is the implementation stage, when the garment is put into production. Lamb and Kallal (1992) suggest "this stage may not be reached until previous stages have been repeated to refine a final design. The designing process might be endless if closure is not required to meet client, course, or industry deadlines." (p. 45).

Cooklin (1991) very briefly describes the work of the apparel designer and does not discuss the designing process itself. According to Cooklin, the designer working for factory production begins the apparel designing process by sketching ideas and selecting fabrics and trims. This author also enumerates seven stages of product development which are common to the apparel factory process: forecasting, designing, collection planning, patternmaking, technology, production of sample garments, and pattern grading. Each of these phases are also usually undertaken by the one-of-a-kind apparel designer.

Davis (1980) does describe the designing process, and states that "the creative person is often regarded as someone who is good at getting new ideas." She continues, "getting ideas, however is not so often a matter of inventing something new, but of using old things in new ways, of seeing the familiar in a new light." (p. 7). This description is similar to the synectic design method, but it is not identified as such. Davis does suggest cross-sensory interpretation as a way of seeking inspiration for new ideas. She describes the cross-sensory method as being a translating of experiences or designs perceived through one sense organ and interpreted through another. The example she gives is "if you were a clothing designer, what would Chanel No. 5 perfume look like?" (Davis, 1980, p. 7). This description of the cross-sensory method parallels that of the 'transfer' synectic trigger mechanism described by Roukes (1988).

FUNCTIONAL CLOTHING DESIGN PROCESS AND STRATEGY SELECTION

	2 Design situation explored	3 Problem structure perceived	4 Specifications described	5 Design criteria established	6 Prototype developed	7 Design evaluation
1 Request made	1.2 State general objective Brainstorming User interview and observation Visual inconsistency Literature search					
2 Design situation explored		2.3 Brainstorming Observation analysis Market analysis Literature search Identification of critical factors Definition of problem				
3 Problem structure perceived	3.2 Brainstorming Visual inconsistency Reassess critical factors		3.4 Activity assessment Movement assessment Impact assessment Thermal assessment Social-psychological assessment			
4 Specifications described	4.2 State objectives Check specifications against objectives	4.3 Reassess critical factors		4.5 Charting Ranking and weighing Prioritizing		
5 Design criteria established	5.2 State objectives Check criteria against objective	5.3 Identify critical factors	5.4 Literature review of assessment areas to check specifications		5.6 Materials testing Technique evaluation Brainstorming Creative integration Solutions weighed against criteria	
6 Prototype developed	6.2 Visual inconsistency Identify objective User interview	6.3 Identify critical factors	6.4 Literature review of assessment areas	6.5 Rank order specifications		6.7 Specification testing User satisfaction

Figure 3. The functional clothing design process and strategy selection diagram juxtaposes the seven steps of the designing process with the problem-solving strategies available to the designer (Watkins, 1984, p. VIII).

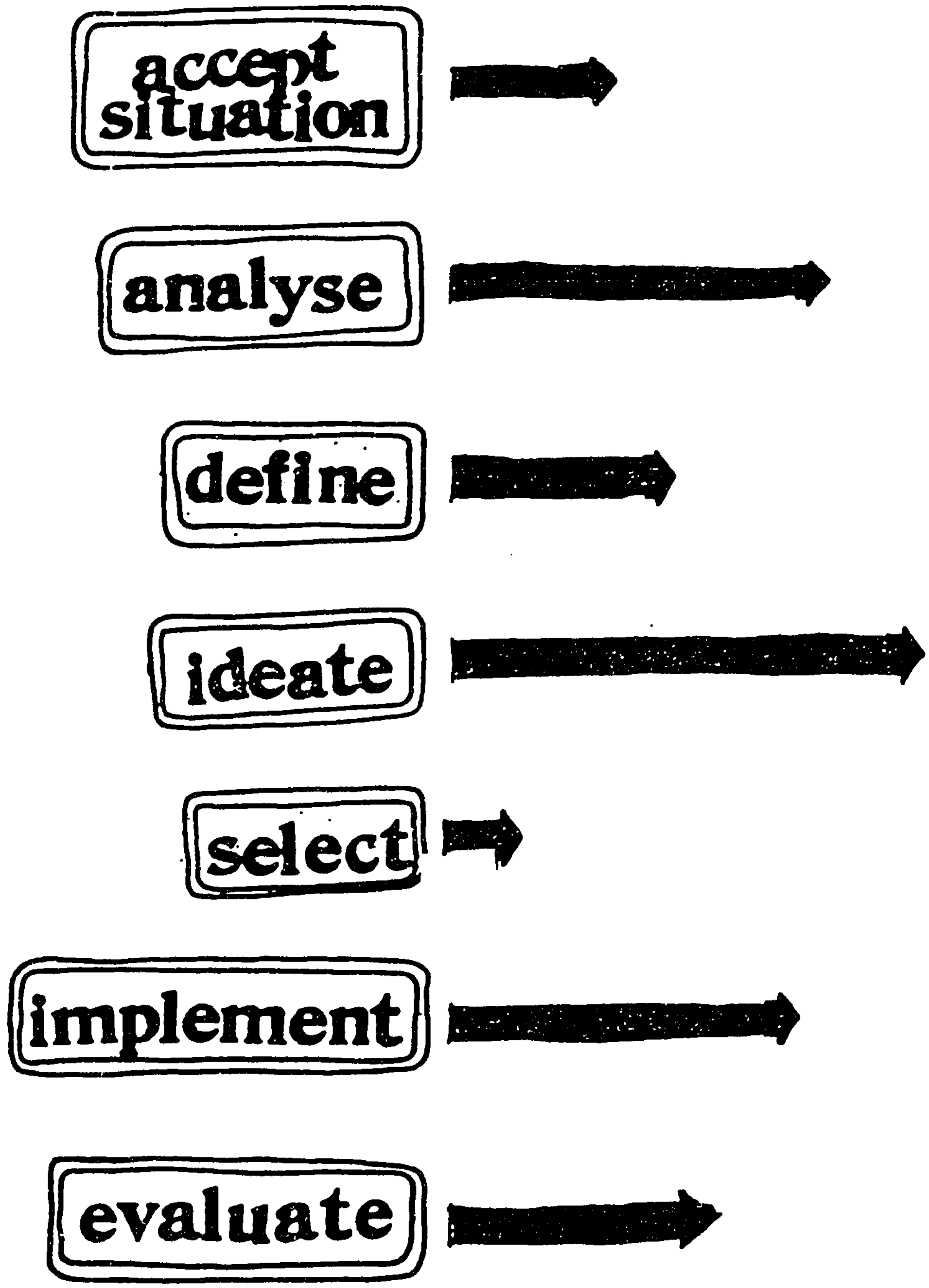


Figure 4. Horse race model of the design process emphasizes that the different phases of the design process progress concurrently. Even though some stages may take precedence occasionally, all of the phases must function as part of the whole designing process (Koberg & Bagnall, 1988, p. 21).

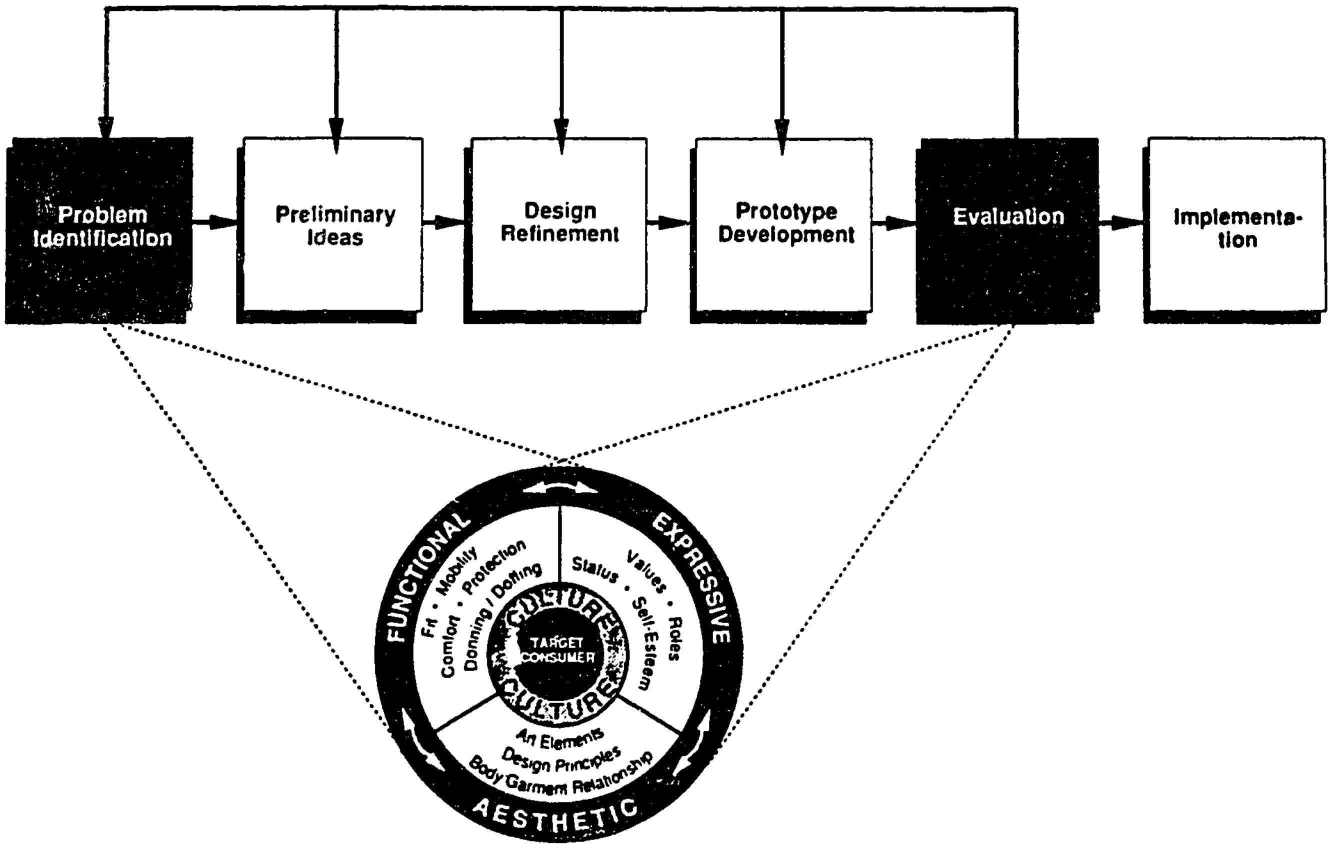


Figure 5. The apparel design framework incorporating the functional, expressive and aesthetic consumer needs model. This model presents a framework for applying the designing process to aid in developing design criteria for a variety of customers. This problem-solving approach does not distinguish between functional apparel design or fashion design (Lamb & Kallal, 1992, p. 44).

The Methodology of Designers

Schmitt and Chen (1991) distinguish three classes of design methods: top-down refinement, bottom-up refinement, and case-based reasoning (see Figure 1). The top-down refinement designing method, best suited for routine designing, refines prototypes with a specific end product in mind. Computers have been effective in top-down refinement because the computer can produce prototypes of every permutation and combination of solution possible. The bottom-up refinement designing method is a data-driven approach to problem solving. It is best suited for innovative design because it allows the flexibility for experimentation. The case-based reasoning designing method relies on the designer's experience and her/his memory of similar, previously solved problems. Computers are most deficient in this method of designing because it is almost impossible to develop a set of parameters large enough to represent the body of knowledge that human experience brings to the design process.

Jones (1970) enumerated thirty-five different designing methods. Of these thirty-five only two methods can be characterized as being innovative and creative. These innovative design methods are brainstorming and synectics. The brainstorming method aims to stimulate groups of individuals to quickly generate many ideas in order to solve problems. The brainstorming method has four requirements. The first requirement is deferring judgment; there will be time for criticism later. The second requirement is free-wheeling or uninhibited disclosure, and the third requirement is tag-on, when work from ideas already generated is continued. The fourth requirement is quantity; work quickly because more is more (Koberg & Bagnall, 1981, p. 68). Brainstorming is most productive when it is employed by groups of individuals.

The second innovative and creative design method identified by Jones (1970) uses synectics to direct the "spontaneous activity of the brain and nervous system towards the exploration and transformation of design problems." Synectics has been productively used by both individuals working alone and by those working in groups.

Design Synectics Methodology

'Synergy' is derived from the Latin 'sun + ergos' meaning that "the combined effect of drugs, organs, or the like exceeds the sum of their individual effects." (Allen, 1990). R. Buckminster Fuller (1975) wrote two volumes on synergetics, and he defined synergy as the behavior of whole systems unpredicted by the behavior of their parts taken separately.

Gordon (1961) was one of the first researchers to document synergy as a creative tool for use in the designing process. He stated that "synectics defines creative process as the mental activity in problem-stating, problem-solving situations where artistic or technical inventions are the result." (p. 33). However, the problem must be clearly defined, understood, and stated, before the designer can solve the problem. According to Gordon, the synectic process requires that the individuals involved in the designing process become informed of, and responsible for, understanding the problem. In addition, synectics requires that designers approach the problem in a new way, in order to implement an innovative perspective towards the everyday world, people, ideas, feelings, and objects.

Both Gordon (1961) and Lawson (1980) enumerate four mechanisms that foster the development of a different perspective: personal analogy, direct analogy, symbolic analogy, and fantasy analogy. When the designer uses personal analogy, he/she identifies personally with a part of the problem or solution which thus may enable the designer to act out the situation. Direct analogy allows the designer to use parallel facts or systems to help understand an abstract problem by enabling the problem to be visualized and made concrete. In order to use symbolic analogy the designer must identify not her/himself but some other object with some part of the problem. Fantasy analogy depends on the designer temporarily suspending her/his critical judgments made on the basis of past experience (Lawson, 1980).

The value of using analogies in the creative process is pointed out by Arieti (1976), writing about fostering creativity in individuals. Arieti equates synectics with "a state of readiness for catching similarities" (p. 376). This ability to recognize similarities is only one of ten conditions that Arietti says promotes creativity.

"All things regardless of their dissimilarity, can somehow be linked together, either in a physical, psychological or symbolic way." (R. Buckminster Fuller in Roukes, 1988, p. 11). Roukes (1988), in his book, **Design Synectics**, states that "synectic thinking is the process of discovering the links that unite seemingly disconnected elements. It is a way of mentally taking things apart and putting them together to furnish new insight for the solution of problems in both art and industry." (p. 11). Synectic trigger mechanisms work to catalyze new thoughts, ideas and inventions. Roukes distinguishes twenty-three triggering mechanisms applicable to the creative design process (see Figure 6). He sets the trigger mechanisms in a pinball machine model in order to illustrate the randomness that can be applied to the creative process to facilitate new ways of approaching the problem.

In describing the 'synectic attitude', Roukes (1988) states that "synectics encourages the ability to live with complexity and apparent contradiction", and furthermore "synectics stimulates creative thinking." (p. 12). The synectic process mobilizes both sides of the brain; the right or dreamer side and the left or reasoning side in order to provide a free-thinking state of consciousness (see Figure 7). Creativity is nurtured by the interaction of left and right brain thinking. The rational left, makes concrete the dreams and intuitions from the right brain, turning them into objective perceptions and tangible constructions (Roukes, 1988).

There are three thinking modes used in the synectic design method: referring, reflecting, and reconstructing (see Figure 8). Referring is the initial stage of awareness. At this stage the designer poses the problem, sets the question, and identifies the subject to be acted upon. Reflecting involves the designer in imaginative interplay about the subject, contemplation, incubation of ideas and fantasizing. Reconstructing is the process of reinventing or transforming, and the designer examines information to discover new integrations (Roukes, 1988). This circular configuration of the synectic process is somewhat similar to Ziesel's design spiral (see Figure 2).

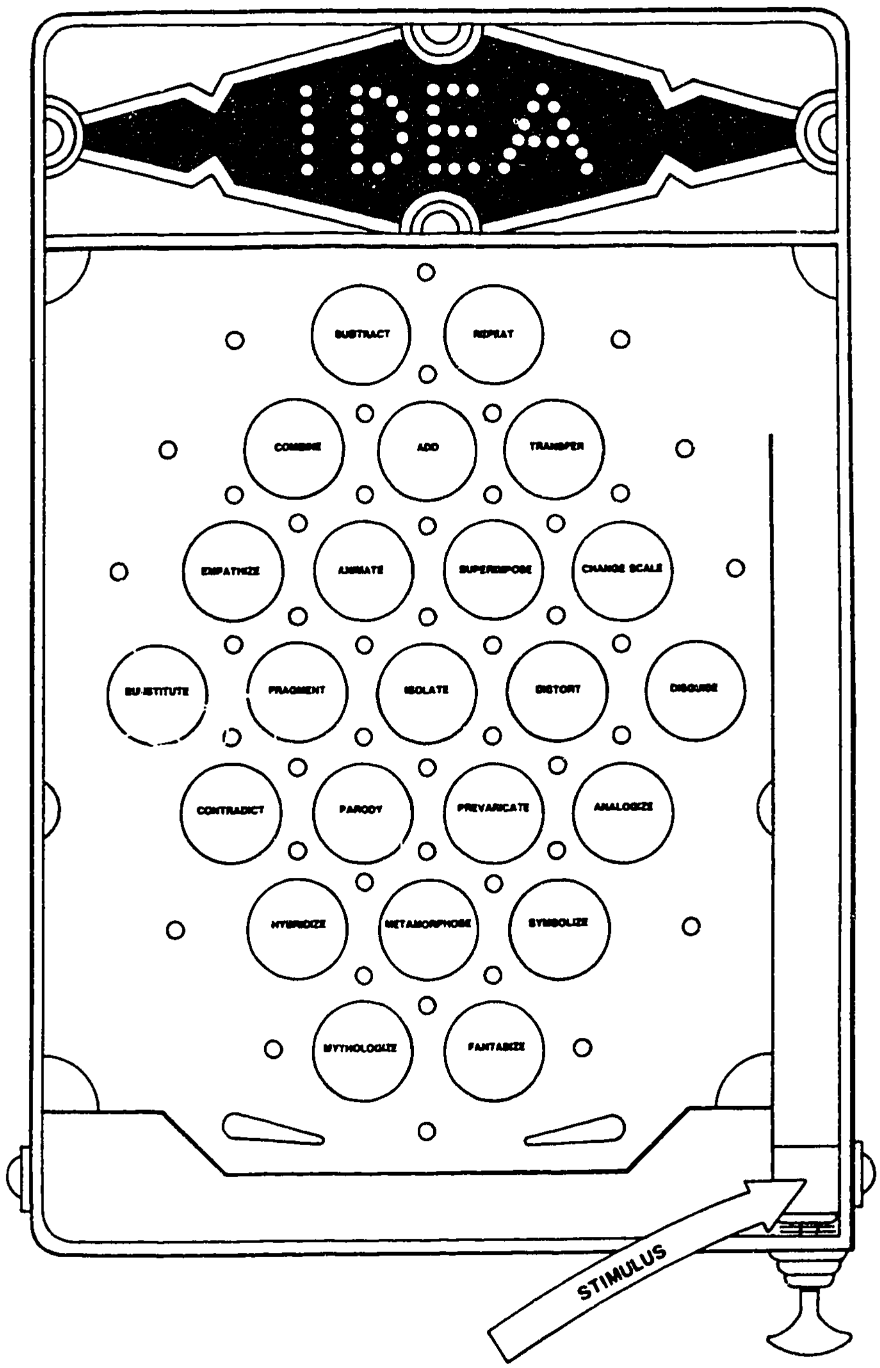
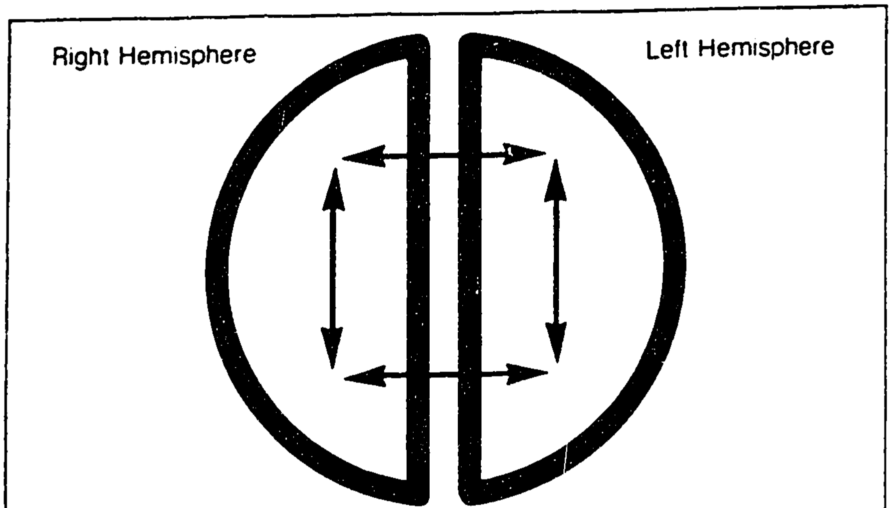


Figure 6. The synectic pinball machine paradigm helps visualize how the synectic triggers can act upon a stimulus in order to transform the original concept into a creative idea for design or art Any one or more of the twenty-three synectic trigger mechanisms can affect the out-coming idea (Roukes, 1988, p. 13).



Right/Left Brain Functions

Right Brain
- Intuitive
- Perceptual
- Creative
- Experiential
- "Felt-Thought"
- Spatial
- Associative (pattern recognition)
- Simultaneous mental processing
- Diffuse mental processing
- Holistic associations
- Visceral-nervous control
- Active during dream state
- Emotional

Left Brain
- Intellectual
- Rational
- Analytical
- Verbal (language skills)
- Computational (mathematics, detail, codification)
- Sequential mental processing (linear thinking)
- Routinization
- Musculoskeletal control
- Orthodox
- Quiet during dream state
- Reason

Figure 7. The creative designing process combines right and left brain thinking styles together to synergize the strengths of each of the left/right brain functions (Roukes, 1988, p. 13).

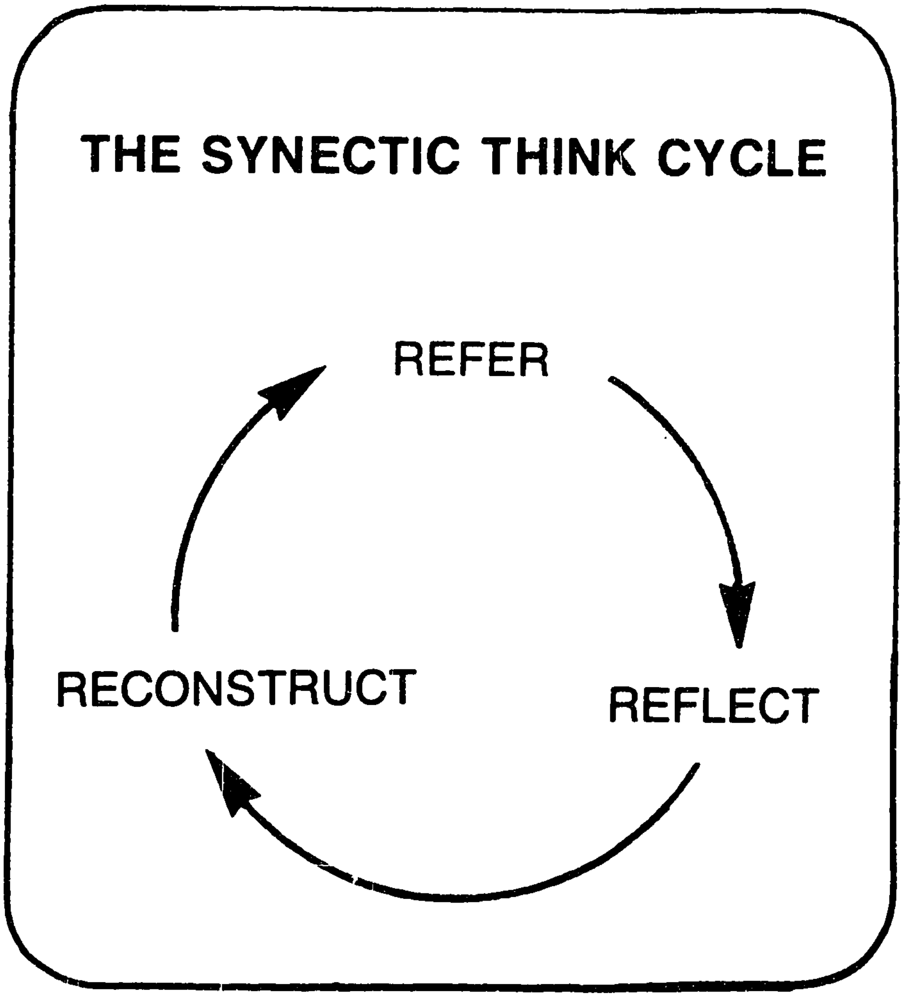


Figure 8. The synectic think cycle illustrates the three R's of the synectic design method; reflecting, referring, and reconstructing (Roukes, 1988, p. 22). This circular model also reflects the reiterative characteristic of designing.

The Tools of Designers

Schmitt and Chen (1991) distinguish seven classes of designing tools: generic, parameter, prototype, transformation, knowledge, grammar, and cellular automata (see Figure 1). Generic tools include computer programs that support painting, drafting, and three-dimensional modeling. These programs are particularly useful in representing objects, rather than the qualitative or functional properties and requirements of these objects. Parametric tools include computer programs that allow variation of known parameters in 2 or 3-D space. CAD packages include the capability of storing and manipulating parametric objects such as building components, constraints are handled and maintained by the system. Prototype tools include tools to establish, manipulate and combine prototypes through interactive input or forms of machine learning. These design tools easily support tasks related to routine design. Transformation tools have mechanisms for symbol replacement, substitution, and instantiation. These tools encourage the study of alternatives in a given context and the development of various levels of detail of a simple type. Knowledge tools include a list of knowledge acquisition and representation tools (see Figure 1). Grammar tools include tools to interactively define and edit shape and structure. An example of shape grammars is fractals, in which the number of rules are small, the number of recursions is high and self similarity is guaranteed. Cellular automata tools control a network of cells in which each cell acts as a computer, taking the state of its neighbours as input and transforming itself into a new state according to the input of the neighbour. The style transformation occurs concurrently in all cells.

Schmitt and Chen (1991) concluded that "present commercial CAD programs and tools developed in CAD labs best support the routine design process." (p. 250). The parameters implicit in using CAD today can place constraints on truly innovative and creative designing. These drawbacks have to be weighed against the speed and efficiency benefits offered by CAD. The increased proficiency during routine designing should relieve the designer of the mundane tasks and allow the designer more time to focus on the truly creative facets of the designing work.

Computer Aided Design in Textiles and Apparel Designing

Walker (1992) addresses the impact of computer software on the apparel design process and emphasizes the iterative nature of designing. He suggests that computers have increased the efficiency of the designing process. Colour and pattern sequences are easily modified during the design process, and the software allows the designer to return to a previous stage of the design at any time. "The scope of CAD has been extended to include the whole spectrum from design initiation and decision making through to technical design with the subsequent link to production plant and machinery." (p. 84).

Danin (1989) included CAD in her textile design classes at California State University in Northridge, California. She reports that students learned about design, spacing and color much faster by using computers. Immediate results, and easy colour and image changes allowed freedom to explore, create and make mistakes because the students' design products were no longer precious objects of laboured effort. With respect to the designing process itself, Danin states "the computer offers the user the clear advantage of quick idea development, instant ability to alter a design without losing the original, and the ability to generate a finished design in an hour or two. Most programs allow you to repeat, mirror, rotate, reduce and enlarge motifs instantly. This frees the designer to invent unlimited variations and explore many more new ideas." (1989, p. 34).

Phillips and Bunce (1993) note that the ability to visualize designs in repeat has been emphasized as one of the benefits of CAD. The pattern created when a motif is put into repeat can often be a strong diagonal which can effectively and inexpensively be avoided by putting the motif into repeat on the computer screen instead of waiting to detect this fault at the production stage. Furthermore, Phillips and Bunce also point out that CAD provides control over the exact percentage of drop in a repeating structure as well as in obtaining precise mirror images.

Trevett (1991) explains in her interview with British fashion designer, McGuirk, that the benefits of computers to designers are numerous and multifaceted. For example, computer software programs that allow digitizing, sketching, scanning, and colourway separations needed for designing can be run on the same computers that are used for the accounting and business applications of design work. This enables designers to be more responsive to customer demand by showing them alternatives immediately thus saving on sampling costs and time. The biggest payoff is the 'kickstart' to creativity, because there is no inherent preciousness about the designing process and its products. If the design doesn't work it can be changed quickly and easily. If the modification doesn't work, the first version is still in the computer's memory, and is easily retrieved and edited until it works.

Cronk and Dacey (1992) view computers as labour saving devices that lack innovative value. They discuss the benefits of the computer software which permits the designing of textiles in conjunction with apparel design. Computers facilitate printed textile designing by allowing easy motif and pattern changes, duplication, and preparation of silk-screen positives. Software programs offer automatic repeats, fast colourway development and previewing and colour matching of proposed textiles. The use of scanners to input existing patterns, motifs, fabrics, and photographs, allows for endless modification and perfection. Cronk and Dacey (1995) at the University of Idaho are currently developing interactive software for textile design. This tutorial software will address traditional approaches to the development of styles, motifs and repeats. Expedient exploration of a variety of repeat structures is the goal of this software. Cronk and Dacey have also found that teaching the principles of colour interaction in print design is facilitated by the use of computer software. In addition, the software easily conveys the concept of positive and negative space.

Tovey (1989) describes designing and the integration of the computer into the process. He reminds the reader of the importance of drawing to the creative designing process and suggests that the computer may not be a substitute for free, open, and easily visible sketches. Although he is skeptical of the computer's use at the ideation stage for generating new, radical designs, he sees the computer being well suited for fine tuning of final designs, and for evolutionary design.

S. Newton (1989) describes a number of philosophies regarding the effects of CAD on the designing process. He affirms that the process of designing is as valuable as the product and calls for the development of computer software programs which have a qualitative rather than quantitative focus. S. Newton suggests that more qualitative computer programs would better reflect the analysis, synthesis and appraisal processes involved in designing since designing is an elaborative and iterative process as opposed to a linear process leading toward a specific end. Contemporary computer technology has been developed for methodical, scientific and technical approaches to problem solving. S. Newton argues that designers must be free to conceptualize information during their designing process in their own way with the support of more qualitative computers. Because intuition cannot be reproduced by any device other than the human mind, S. Newton calls for a new approach to research into the designing of the computers and their programs. He warns of the dangers to the creative process when it is limited by the linear thinking imposed by the computer.

The role of computers in the creative process is also discussed by Sokolove (1990). She explains how and why the artist must experiment with a new computer and its software just as if it was a new brush or new type of paint. In the same way, the designer must discover what marks can be made with the new tool. She suggests that this experimentation often becomes so fascinating that the process itself becomes the sole content of the product. This may happen even if the computer is initially intended for use as a design tool for another medium. Light and colour are very strong elements of design. The computer offers light and colour in direct form, and this visual luminosity can become a fascinating new medium in itself The textile designer can become caught up in using the computer to design textiles whose content is the computer itself. The designer must come to terms with the computer technology and then determine how to use it in designing the finished product. These decisions are not easily made, because these new tools allow for the creation of new forms and new meanings. This forces the designer to revisit and reassess the functions of their products and how the products will manifest themselves in physical form.

Truckenbrod (1988, 1992) examines the effects of computer technology on the artist, on the creative process, and on the nature of the artwork. These are issues parallel to those affecting the designer. She emphasizes the importance of understanding the issues raised by the use of computers in the creative process. Perhaps most importantly, she reminds the reader that having an idea does not constitute art until it is made manifest. By extrapolation, an idea formulated using the computer is not a design product until it has found a vehicle for public expression. Absorption in the creative process is especially hypnotic when tackled using a computer and must be tempered by thinking about the end result and expression. The computer offers a number of variations and modifications and therefore, the designer must learn more than just how to use the computer. The designer must continue to think and work creatively because the computer cannot replace the designer's experiences. Truckenbrod (1988) cites Gordon's book **Synectics** (1961) in her brief discussion of four varieties of creative thinking paths in discussing computer use among artists and designers. Truckenbrod specifically refers to Gordon's discussion of "the process of making associations between unlike things or systems, attributing the characteristics or behavior of one to the other." (Truckenbrod, 1988, p. 166). She posits that using Gordon's approach can suggest new ideas for designing.

As a design educator, Racine (1992) calls for de-emphasizing the routine, technical aspects of CAD; and encourages maximizing the conceptual and interpretive aspects of CAD in order to improve the quality of the design process. She suggests that the apparel design curriculum should integrate traditional designing methods with computer technology to increase the students' competencies with respect to designing.

The possibilities for the use of CAD in the design studio are largely uncharted according to Tolukas (1995). However, some of the benefits to introducing CAD into a design school setting have been documented at Rhode Island School of Art and Design. These benefits include an increase in the designer's visual vocabulary resulting from scanning images onto the computer which allows for the incorporation of photographic images, textures and fine details. A second benefit from CAD is the ease with which repeat patterns may be varied. A third benefit is the computer's capacity to permit immediate changes. These, in addition to the computer's inherent accuracy and speed, have all profoundly affected the designing process.

The above cited CAD researchers agree that more research must be done with respect to the effects of CAD on the process of textile and apparel designing. These investigators also call for further investigations into new applications for CAD in textiles and apparel.

Technical Description of Knitting

The philology of the word "knit" is derived from the Old English "cnyttan" from the West Germanic "knot" (Allen, 1990). Emery defines "knitting" as "vertical interlooping of stitches with a yarn of unlimited length." (Emery, 1980, p. 40). Knitting, she states, consists of "successive rows of running open loops, each loop engaging the corresponding one in the previous row and being in turn engaged by the corresponding one in the following row. The alignment of loops and the interconnection is vertical." (Emery, 1980, p. 40). The term "knitting" refers to the construction process itself or to the textile structure. For the purposes of this study, "knitwear" refers to knitted outer garments for the upper body or head (Brackenbury, 1992).

There are many factors which affect the complexity, appearance, and properties of knitted fabrics. The most elemental of these factors are the types, sizes, colours, lustres, and cross-sectional shapes of the fibres themselves. The nature of the knitted fabric produced is further characterized by the types, size, colour, surface nature, and contrived irregularities of the yarn. The needle size, gauge and tension determine the size of loop, another contribution to the properties of the finished knitted fabric. Also, the constructional details can generate colour or structural patterns in the knit fabric which are produced thereby determining the appearance and texture of the knitted fabric. Furthermore, specific properties such as weight, insulation, abrasion resistance, and washability can be controlled by the method of stitch construction. Finishing treatments applied to the knitted fabric also affect the performance and aesthetics of the end product (Brackenbury, 1992).

There are three basic types of weft knitting stitches produced by domestic knitting machines: plain, purl and rib. The most basic stitch is plain stitch which is also called "Jersey", after the Channel Island. The structure of plain stitch knitting can be modified with tuck stitches, miss stitches and transferred loops. Another variation of plain knitting is achieved by colour patterning using different yarns and fairisle patterning which is also known as "single bed jacquard". Purl stitch, or "links-links" which is derived from the German "leftward", yields fabric that is the same on both sides much like the fabric produced by hand knitting. Rib stitch is characterized by lengthwise ribs that are formed by wales which alternate from the front to the back of the fabric.

Rib knit jacquard fabrics are a specific type of weft knitted ribbed fabric, also known as multi-coloured 1/1 rib. Rib knit jacquards are produced using a V-bed knitting machine or, in the case of the Brother 910 Electronic™ knitting machine with a ribber attachment which is added to allow for V-bed knitting. One common type of rib jacquard knitting uses miss stitches to produce a fabric with a pattern on the face and a striping or bird's eye pattern on the reverse. The patterning is determined by needle selection which is controlled manually or by punchcards, mylar grid sheets, or by directly downloading the data from a computer file to the knitting machine.

Weft knitted textiles are characterized by properties such as stretch, elasticity, ease, drapability, and cover. These qualities allow an "easy fit" and facilitate "one size fits all" apparel which simplifies sizing in a mass production market. Knitted textiles are more flexible than woven textiles when compared in terms of colour and pattern changes which results in easier adaptation to the vagaries of fashion (Pizzuto, 1981). In addition, knits are relatively inexpensive and are easily adaptable to many different types of apparel which explains their continuing popularity in today's competitive market. Weft knits are produced on flat or circular machines, using latch or springbeard needles (Brackenbury, 1992). All domestic knitting machines produce weft knits.

Knitwear garments are classified according to neck opening style and sleeve attachment method. Examples of the various neck openings are round neck, v-neck, turtle neck, polo neck, shirt collar, and cardigans with ribbing, stolling, or rolled revers collars. Sleeve attachment may be raglan, set in, or drop and this is important to the shape of the knitted blanks in terms of the utilization of raw material (Brackenbury, 1992).

Brackenbury (1992) distinguishes four methods which can be used to produce a similar garment: fully cut, cut stitch shaped, fully-fashioned, and integral garments. Fully cut garments are garments that are cut-and-sewn from piecegoods of either single jersey (plain) or double jersey (rib), much like woven fabrics. Cut stitch shaped garments use knit rectangles which are known as 'blanks' that are knitted to the approximate size and shape of the separate garment components such as bodies and sleeves. The fully-fashioned method knits portions of the garment with shaping at the selvages which is achieved by increasing or decreasing stitches. This method results in little cutting waste and, because the edges are finished as they are knit, there is no fraying and no bulk at the seam area. Integral garments are knitted in the round in one piece with few or no seams. Examples of apparel typically knitted using the integral method are berets, toques, socks, and gloves. Integrally knitted apparel eliminates all waste and therefore Brackenbury identifies this method of production as a timely challenge for garment designers (Brackenbury, 1992).

Origins and Development of Machine Knitting

Knitting can be traced to prehistory and some researchers have even argued that it is an older textile technique than weaving (Kiewe, 1971; Henson, 1831; Grass, 1956; Kinder, 1979). Historically, the interlooped textile structure of knitting has been found throughout much of the world, although curiously not in Eastern Asia (Rutt, 1987; Norbury, 1973). There are techniques similar to and easily confused with knitting such as "knotless netting" that is also known as "Nalbinding" or "single needle knitting". "Cross-knit looping" and "Peruvian needle knitting" have also been mistakenly called knitting (Rutt, 1987; Emery, 1980). Although all of these structures are comprised of interlooping elements, they do not meet the exact criteria of true knitting.

Of all textile construction techniques, knitting most closely connects production with consumption because it is used for producing ready-made clothing (Turnau, 1991). The structure of knitting owes its very origins to the need for close-fitting and elasticized covering for the body; especially for the head, hands, and feet. This use as working apparel is the reason that there are relatively few artifacts extant for study -- they were simply worn out (Turnau, 1991).

A machine for knitting hosiery was invented in 1589 by William Lee of Calverton, Nottinghamshire (Brackenbury, 1992; Harte, 1989). Lee's application for Letters Patent was denied by Elizabeth I on the basis of the Queen's concern that her faithful subjects who relied on hand knitting for their incomes would be put out of work (Felkin, 1967; Brackenbury, 1992). Lee and his workers persevered, and, despite the uncertain beginning (mechanized knitting was a major irritant to the Luddites), technical improvements have continued. According to Brackenbury, Lee's knitting machine was remarkable in many ways. "It was the product of lateral thinking in that it used an entirely different method to produce a familiar product; it employed complex interacting notions unlike any other machine in existence; and it was arguably the first machine to concentrate on increasing the productivity of a process for its own sake (i.e., the start of the industrial revolution)." (Brackenbury, 1992, p. 3).

The Framework Knitters Company which was chartered by Cromwell in 1656 was a powerful organization in Britain (Grass, 1956). Frame knitting became an important cottage industry in the Midlands of England during the seventeenth century. The framework knitter either owned his frame or rented it and while he worked the frame, his family wound the yarn and finished the hose or other apparel items. "A hosier would supply the materials and buy the finished product, which was then taken to a warehouse to be made ready for sale" (Levitt, 1986, p. 115).

One of the biggest advantages of the use of the knitting machine was speed. An expert hand knitter could knit 100 stitches per minute. Lee's first machine could knit, albeit inconsistently, 500 - 600 stitches per minute. By the late 1800's, rotary knitting machines could produce 144 million knitted stitches per minute (Turnau, 1991).

In 1758, Jedediah Strutt invented the Derby Rib machine, an attachment to the hand knitting frame that allowed the invention of the double knit technique. Matthew Townsend obtained a patent for his invention of the latch needle in 1847. This needle simplified the knitting mechanism, increased production speeds and reduced costs. (Iyer, Mammel, & Schach, 1992).

In 1963, at the International Textile Machinery Exhibition in Hanover, Germany the era of electronic knitting began with the demonstration of the first electronic needle selection knitting machine by the firm, Moratronik (Iyer et al, 1992). By the early 1970's, electronics and computers controlled needle selection for patterning, and machine control of stitch structure and transferring (Nutting, 1989). These developments revolutionized the knitwear manufacturing process (Gartshore, 1983).

Domestic knitting machines were first introduced in Europe in the 1950's, followed by the introduction of Japanese push-button knitting machines in the 1960's. The Japanese punchcard and electronic machines of the 1970's and 1980's were designed to encourage creativity and more personalized designing by the operator (Kinder, 1989). Today domestic or studio knitting machines are computer programmed with either internal or external software, and therefore, the use of CAD/CAM/CIM is now feasible even for the one-of-a-kind knitwear designer (Holmes, 1992). The studio designer can create designs using computer software and then transfer this information to the knitting machine. This allows immediate sampling, evaluation, and modification and changes the nature of the designing process itself. The basic domestic knitting machine is manufactured with a single bed that produces plain stitches and plain stitch variations such as miss, tuck, intarsia, fairisle, and weaving. Adding a ribbing bed to the knitting machine enables the production of rib stitches and jacquard knitting, and additional carriages may be used to create purl stitches and lace-like textiles.

Contemporary Knitwear Designing

The visual literature reviewed provides a selective survey of what other knitwear designers are doing. An on-going task for a designer is staying aware of what other knitwear designers are producing; keeping up-to-date with developments in fields other than knitwear aids the designer in being cognizant of aesthetic themes and stylistic trends. Much of the visual information collected is not available in the more formal textual literature. Magazine articles and advertisements provide important visual information and stimuli, but usually lack descriptive textual information. The visual materials referred to in this study reflect the aesthetic biases and values of the designer which are inherent in any creative work.

The decorative design of knitted textiles is integral, rather than applied, because it is the configuration of the interlooping yarns which determines the appearance of the fabric. Knitwear designers are therefore primarily structural, rather than decorative designers. In addition to controlling the configuration of the textile, knitwear designers also determine the silhouette of the garment. Thus, their work truly synthesizes the many components of textile and apparel designing into a single product.

According to Brackenbury (1989), couture fashion designers and other fashion industry designers do not, as a rule, design knitwear. Knitwear design is considered a specialized field, perhaps due to the specific equipment and materials required. The manufacturing process for knitted apparel differs from that of other types of apparel production because knitted items may be fully-fashioned and structurally decorative, thus requiring different methods of pattern designing and construction. Some of the influential British knitwear designers include Patricia Roberts, Vanessa Keegan, Sandy Black and Kaffe Fassett. In addition to designing knitwear, these designers produce books of their designs as well as yarn kits complete with pattern instructions. Fassett's books are unique in that in addition to presenting colour photographs of his sweater designs, his books include visual materials which illustrate where his inspirations for his sweater designs are derived from (Fassett, 1985).

In the United States, the wearable art movement began in the 1970's as a fringe art form and its influence continues to be felt in the one-of-a-kind knitwear market today. Many of the American designers who used machine knitting as a medium during the 1970's and 1980's are still active today. These knitwear designers include Susanna Lewis, Linda Mendelson, Nicki Hitz Edson, Marika Contompasis, Janet Lipkin, and Jacquelyn Roesch-Sanchez (Dale, 1986). Their work ranges from the excessively decorated, narrative coats of Lewis, Mendelson and Lipkin to the simple silhouettes of Roesch-Sanchez which feature spectrum-dyed rayon yarns. Susan Lazear, another American knitwear designer, developed Stitch Painter™ in 1992. This paint-type computer software program is grid-based in order to facilitate her work as a designer of machine knitwear, which is also largely narrative. Alicia Niles designing for her company "A.A.N. Designs" in Toronto also uses Stitch Painter™ to design her collection of knitwear and knitting patterns. The Missoni company leads the Italian fashion knitwear industry in state-of-the-art knitwear characterized by rich saturated colours. Japanese fashion designer, Issey Miyake has included innovative knitted garments in a number of collections. An Australian knitwear company "Coogi" (also spelt "Cuggi") is renowned for its distinctive designer knitwear with riotous colour and texture combinations.

The textual as well as the visual literature which focuses on the work of these knitwear designers reveals that they share a common fascination and love of the design elements colour and texture. However, as with textile and apparel designing, very little documentation has been focused on the knitwear designer's creative designing process.

Reviewing the work of these knitwear designers provided me with a visual context within which to work. Although direct design inspiration was not consciously taken, studying a sampling of the designs produced by other designers did provide the inspiration that perhaps I, too, could design knitwear. This visual review also confirmed and rekindled my desire to work with knitwear as a designing medium because knitwear presents the challenge to work with all of the elements and principles of design at once.

CHAPTER 3

The Designing Process

Statement of the Problem

As a result of the preceding literature review I have found that little research regarding theory in the area of textiles and apparel design theory has been published. There is even less research focusing on the creative process aspects of the apparel designing process, and fewer investigations still have been conducted directly relating to the creative processes of knitwear design using computer software. Furthermore, apparel design continues to be taught as a series of explicit technical skills which include drafting, draping, and construction. The designing process, in general, and the creative designing process, in particular, are implied but not prescribed. This scarcity of description has led to a lack of understanding of the designing process on the part of non-designers. Furthermore, this paucity of research in the area of textiles and apparel designing has fostered a lack of awareness by designers in other fields. Documentation and examination of the application of synectic design methods using computer software in the knitwear designing process will enhance my understanding of the creative designing process. This will assist me towards my goal of becoming a better designer and design educator. Zeisel (1984) noted that "describing the design process may help designers and teachers of design understand their own behavior and thereby improve their design ability." (p. 5).

Furthermore, it is important for textile and apparel designers to be aware of, and to participate in, discussions of contemporary design issues. There is a need to examine current philosophical, theoretical, and ethical issues related to designing and to focus on these issues within textiles and apparel contexts. Although much of the contemporary discussion about design theory has been written by architects, engineers, and graphic designers, there is a paucity of investigations related to design theory in the field of textile and apparel design. This study contributes to the dialogue about design and designing within a textile and apparel design context.

Purpose and Objectives

The purpose of this investigation was to utilize design synectics theory and computer technology in order to stimulate my creativity in designing a collection of machine knitwear. Specifically, the objectives of this study were:

1. to apply design synectic trigger mechanisms to stimulate my creativity;
2. to document the application processes of the synectic trigger mechanisms to my creativity; and
3. to create a collection of one-of-a-kind machine knitwear suitable for exhibition on a fashion runway, by applying design synectic trigger mechanisms.

The ultimate aim of this investigation was to contribute to the dialogue about the designing process within a textiles and apparel context and to increase my understanding of my designing process and, thence, to become a better and cognizant designer and design educator.

A supplementary contribution of this study was to provide an overview of the current literature regarding design theory in fields other than textiles and apparel. In addition, the literature reviewed for this investigation included a survey of contemporary research in CAD in textiles and apparel.

Significance of the Study

Because the literature review revealed that there is a paucity of investigations related to design theory within the field of textiles and apparel, therefore, there is room to examine the philosophical and theoretical issues related to the use and descriptions of design processes. Furthermore, very little research addressing the creative design process as it is applied to knitwear designed with computer software has been published in Canada and the United States. Therefore literature addressing computers and creative designing in the surface design and apparel areas was examined.

Watkins (1984, 1988) investigated the functional apparel design processes but did not focus on methods for stimulating creativity in designing apparel. She states that, "the development of the 'process' orientation is, over the long run, more important to design education than a 'product' orientation." (Watkins, 1988, p. 10). However, apparel patternmaking and construction continues to be taught solely focused on the evaluation of the product, ignoring the designing process. This has led to a lack of understanding by apparel design students of the creative process of designing, leaving most of these students to reiterate previous designs. In order to impart a clearer understanding of the process of designing to students, it is important for apparel designers and apparel design educators to document their own creative designing process while it is in progress if they and others are to explicitly understand it (Zeisel, 1984). Designers themselves have a vested interest and have the most to gain by having an increased understanding of the creative designing process. By being more cognizant of their own designing processes, designers would be able to foster their own creativity. Design synectics provides a method to stimulate the creative designing process. Computer software can be a tool for this creative process, and can become integral to the designing process. Advances in computer technology are affecting not only how we live and interact with the near environment but also are affecting the processes and materials of designers. The computer has revolutionized how designing is practiced; however, very little research has studied the effects of computer aided design (CAD) as a tool of the apparel designer on the designing of textiles and apparel.

Parameters for the Study

The commencement of the designing process is always a daunting task for me because I am faced with both an exciting and overwhelming array of choices. In order to limit the number of design possibilities for this study, I made arbitrary decisions to designate non-plastic some of the variables or choices. "Plastic" in this study refers to those constituents of a design that can be shaped and that are changeable (Zelanski & Fisher, 1987). "Non-plastic", therefore, refers to those components of designs that remain constant and unchanging. The non-plastic variables for the development of this collection were: mountain-inspired imagery, casual sportswear, one-of-a-kind market, knitted fabric structure, and boxy silhouette. These non-plastic variables were not completely rigid but they assisted the decision making process by reducing the number of variables that I had to think about all at once and they remained constant throughout the production of the collection. The non-plastic variables remained unaffected by the synectic triggers. Further limitations were developed during the preliminary designing process.

The plastic variables established were those that I permitted the synectic trigger mechanisms to affect: the development of the motifs, the repeat structures, the pattern blockings, the use of colours, and the construction techniques. The synectic pinball machine (see Figure 6) was used as a paradigm to assist in the application of the synectic triggers to the plastic variables.

Designer's Statement

My intention in this study was to apply design synectics to my design process to stimulate my creativity during the design and production of a small collection of knitwear. By documenting the application of the synectic trigger mechanisms to my creative designing process, my goal was to gain a better understanding of the creative process of designing. The preceding literature review had informed me about the existing dialogue about the designing process: by documenting my creative designing process I hoped to contribute to the dialogue about designing from within a textiles and apparel context in addition to becoming a better designer and design educator.

As a designer of textiles and apparel, I have developed a set of aesthetic values and beliefs which influence the techniques that I use and feel most comfortable with. Moreover, I have amassed a bank of imagery from which I can draw upon in addition to past experiences. These experiences are the tools that Schmidt and Chen (1991) refer to as the case-based method (see Figure 1). Application of the case-based method is the one method that a computer hasn't been programmed for yet. Most often my designing work has progressed intuitively, on a problem solving basis, without my being conscious of my creative process.

A continuing aspect of my work is my respect for fabric, and showcasing the fabric itself is usually the focus of my garments. The research conducted by Burnham (1973) and Tilke (1990) has been influential in the development of my preferred boxy silhouette which is composed of rectangular pattern pieces. Both Burnham and Tilke present information about how early makers of clothing conserved materials so that very little, if any, fabric was wasted. Another consequence of my respect for textiles is that the quality and integrity of the design and construction of my garments must be of a very high standard.

Inspiration for the Imagery

I need a focus for my creative designing processes as well as a source of inspiration in conjunction with the elements and principles of design. This is because, as a designer, I produce visual or textural forms which the wearer/viewer perceives as content whether it be as a subject, theme, or design motif (Proctor & Lew, 1984). In order to be perceived as a unified collection, the content should be related thematically. Some previous studies in contemporary textiles have drawn inspiration from a variety of cross-cultural sources and these have included: Subsaharan African textiles (Maguire, 1995); Shibori (Weir, 1994); Miao textiles (Cao, 1994). However, natural or manmade objects from the near environment can serve as design sources for inspiration as well (Bevlin, 1984).

The inspiration for the knitwear collection that forms the corpus of this study was derived from photographic imagery of mountains taken during my backcountry travels in the mountains of Alberta and British Columbia (see Plates 1-4). Mountains offer me aesthetic and athletic experiences unrivaled by other environs. Travel on foot, telemark skis, or mountain bike in the mountains offers me a chance to get away from life in the city and the freedom to think. Arietti states that "excessive routine stifles mental activity and creativity" (1976, p. 374). Giving myself permission to 'do nothing' works to give my brain a rest from conscious problem-solving while my body exerts itself. Furthermore, travel in the mountains often imposes rather long stretches of aloneness while one traverses the geography involved and this fosters the introspection which Arietti (1976) has determined to have significant value in fostering creativity in the individual.

Mountains are a metaphor for the challenges of my life. Scrambling to the top of a mountain peak under my own power offers challenges and rewards seldom paralleled in my daily life. The vistas offered by the mountain top are always spectacular to me as a designer and provide ample inspiration for my creative endeavors. On days when the clouds roll in, my visual attention shifts to the nearer environment; the flora and fauna offer a focus which is different in scale to the encompassing landscape, not to mention subject matter for continuing design studies. Design synectics can assist me in the exploitation of these mountain experiences for application to my designing processes.

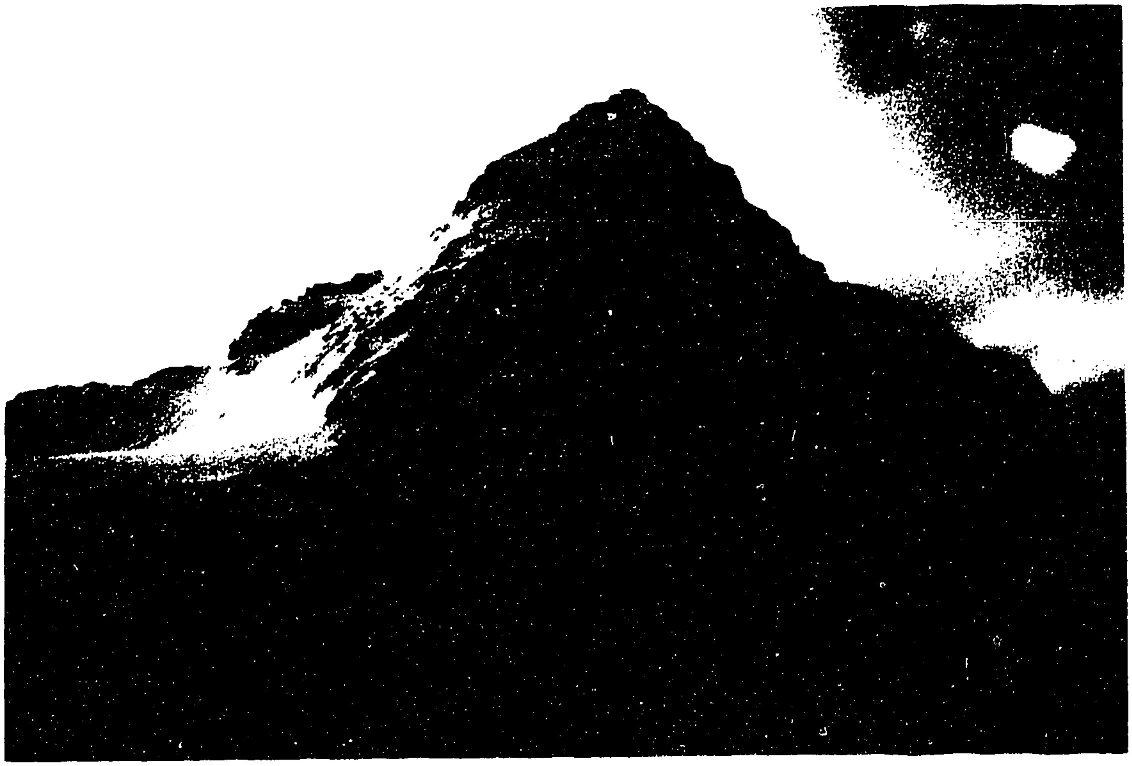


Plate 1. Mount Assiniboine, British Columbia; September, 1980.

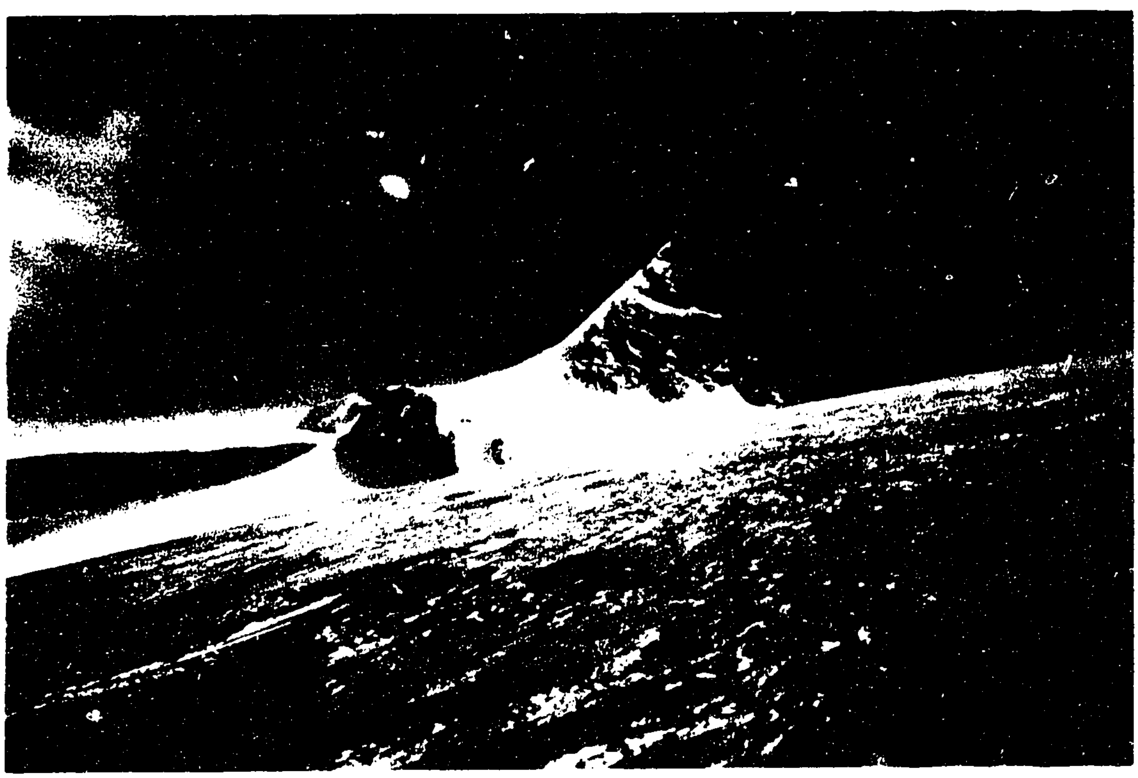


Plate 2. St. Nicholas Peak, Wapta Icefield, Alberta; March, 1982.

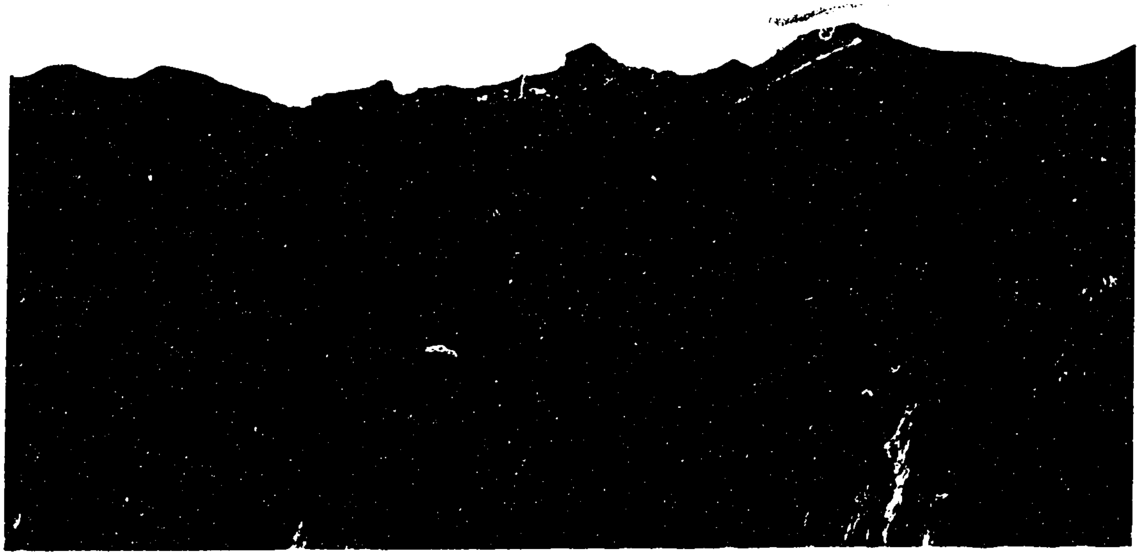


Plate 3. View to the west from Mount Waconda, Alberta; September 1979.

Plate 4. View to the north from Mount St. Mary, British Columbia; July 1992.

Preliminary Design Studies

I undertook preliminary design studies using the design synectics method in order to explore the possibilities offered by the synectic trigger mechanisms when they were applied to the mountain inspiration. The Stitch Painter™ computer program was used to develop the mountain motifs and the Brother 910 Electronic™ knitting machine was used to experiment with various knitting structures and yarns. During this preparation phase, I experimented with the Brother 910 Electronic™ knitting machine, using a variety of knitted stitches utilizing both the single bed of needles and the double bed, which is formed when the ribber is attached. I also tried a variety of yarns, in differing fibre contents, styles, and colours. In addition to knitting these samples, I was also using the Stitch Painter™ program to investigate motif development and repeat structures. I did some preliminary sketches of garment silhouettes to somewhat determine the overall look of the collection. During these exercises I used the synectic pinball machine model (see Figure 6) to the explore the possibilities posed by those variables that were deemed to be plastic and the limitations imposed by those variables designated to be non-plastic.

Stitch Painter™ Computer Software

The Stitch Painter™ software computer program was developed by American machine knitwear designer Susan Lazear in 1992 as a design tool for textile designers. This paint type program presents a grid layout on which to work and its stitch-oriented system can be programmed for different gauges of knitting. The colour, texture, and pattern palettes can be customized according to specific yarns, techniques and media. Repeat, rotate, flip, copy, size, and tile repeats are some of the textile design manipulations easily performed with this software. The software's strongest feature is the accuracy and speed of repetition; however this slows when the motif (Stitch Painter™ calls it a brush) becomes very large and/or very detailed.

The Stitch Painter™ program facilitates viewing the repeated motif on the computer screen; this works to somewhat eliminate surprises after the knitted fabric is removed from the knitting machine. Ehrenzweig (1967) has pointed out that the importance of the subjugation of the motif into the overall pattern is a characteristic prevalent in textile design. He observed that textile designers often fail to take into account the visual effect rendered once the motif is put into repeat. Ehrenzweig further acknowledges that textile designers are prone to taking great care with the development of the initial motif but these designers generally pay less attention to the overall effects created by the repeating structure. Utilizing the Stitch Painter™ program to test the repeat structures allowed me to efficiently check for the strong horizontal, vertical, or diagonal patterns that emerge in most repeats and which may completely overwhelm the individual motif itself. However, the computer screen cannot yet provide sufficient textural rendering to totally simulate the actual finished fabric. In the case of my knitwear designing, I was eager to see and feel the actual knitted fabric as it was being produced; because until this 'real' material was examined, fully informed design decisions could not be made. Furthermore, although small knitted swatches can assist in the visualization process, samples may not read and behave the same way as the full size knitted fabrics. Thus, the knitted garments became in fact, prototypes and not finished products.

Brother 910 Electronic™ Knitting Machine

The Brother 910 Electronic™ knitting machine is limited to a pattern repeat size of 60 stitches in width by 150 stitches in length. Tucking, miss stitch, weaving, plaiting, knitted lace, single bed fairisle and double bed jacquard knits are some of the knitting structures that the Brother 910 Electronic™ can be programmed to produce. This knitting machine, like many other makes and models of knitting machines, offers the following computerized pattern variations: flip, mirror image, double width, double length, negative, and combine. These motif modifications closely parallel some of the synectic trigger mechanisms: flip - 'transfer'; mirror image - 'transfer'; double width or double length - 'distort'; double width and length - 'change scale'; negative - 'contradict'; single motif - 'isolate'; and combine pattern - 'combine'.

The knitting machine's computer is configured to support only block repeats. This limits the patterning once the knitting machine is programmed with the motif and challenges the designer to design a motif that works well in block repeat.

Machine knitwear design is usually structural rather than decorative design, because the needle selection determines which colour of yarn is to be knit on the face of the fabric. This structural construction lends depth and richness to knitted fabric. The pattern is not superficial; rather it is an integral quality of the knitted textile.

Development of the Mountain Motifs

A motif is defined by Phillips and Bunce (1993) as a simple, unit or figure that is easily repeatable at regular intervals over a surface. In the Stitch Painter™ program, this repeating unit is called a "brush". By multiplying and arranging a motif or series of motifs in an orderly sequence, a pattern is developed (see Figure 9). The organization of the motifs determines the types of patterns designed; Proctor and Lew (1984) identified eight basic pattern networks: block, brick (slide), half-drop, diamond, triangle, ogee, hexagon and scale. One limitation of Stitch Painter™ is that it is programmed to produce block repeat patterns. Some of the Stitch Painter™ commands are similar to some of the synectic triggers (see Figure 6), and this similarity made it easy to apply the logical, structural triggers, for example: repeat - 'repeat'; rotate - 'transfer'; flip - 'transfer'; size - 'change scale'; and size - 'distort'. The application of the intuitive, more personal triggers, for example, 'metamorphose' and 'mythologize' demanded that I do the conceptualizing.

Stitch Painter™ was used to develop the mountain motif (see Figure 9) as well as its patterning variations (see Figures 10-13). Both of the mountain landscape motifs (see Figures 14&15) were also developed by utilizing the Stitch Painter™ software. I did not directly reproduce specific images; instead I designed stylized motifs that were derived from the overall impressions imparted by the collected imagery (see Plates 1-4). The synectic triggers which I used to develop the mountain motif included 'symbolize' in order to develop a motif that would symbolize my mountain experiences and memories. A small, single mountain motif was developed to allow design exploration using a small motif which would also reflect the mountain as a singular entity (see Plates 1&2). In addition, a larger, more detailed mountain landscape was created which would foster experimentation with superimposing detailed textures as well as offering a more literal interpretation of an alpine environment (see Plates 3&4). During the development of both the single mountain motif and the mountain landscape I tried to evoke the visual and physical effects that the geological strata imparts to the mountainous environment. These linear striations provide visual interest and establish the very contours of the mountains themselves. The geological layering determines the deposition of vegetation and snow pack which in turn provides the visual texturing and surface interest.

To me, an isosceles triangle can symbolize a mountain when the synectic triggers 'subtract', 'simplify' and 'hybridized' are applied to a detailed mountain image. This triangle (see Figure 9, top) was further transformed by applying the synectic trigger 'metamorphose' into a more complicated motif in anticipation of the nature of the plain knit structure: when motifs are plain knit with patterning needle selection, floats are created on the back of the fabric. These floats can cause snagging problems if fingers catch on the floats which in turn results in pulling and puckering. In order to eliminate this problem, the motif was fragmented to shorten the length of the floats. Another solution would have been to knit solely using jacquard double knit structure but this would have limited the variety of knitted fabrics possible. Jacquard double bed knits are by nature heavier and thicker and stiffer than single bed knits and these qualities are not always suitable for garments designed to be worn indoors or against the skin. By designing a motif with short floats, I left myself flexibility in terms of choosing a knitted structure. Stitch Painter™ grid studies and knitted samples were undertaken using the solid triangle motif in repeat but these were eventually set aside in favor of the more complex and personal mountain motif.

Once the triangular mountain motif had been developed (see Figure 9, middle) further work was necessary to eliminate the long floats in the background. By fragmenting the background, the triangle motif was metamorphosed into the basic mountain motif (see Figure 9, bottom). This disguised the motif somewhat and further mythologized its meaning for me. If the mountain is not pointed out, the viewer is free to make their own interpretations of the motif.

When the mountain motif had been resolved to my satisfaction, the next phase was to experiment with putting the mountain motif into various repeats. Of these variations, four repeat patterns were selected for use in the collection (see Figures 10-13). The first repeat pattern was developed by putting the mountain motif into block repeat (see Figure 10) by applying the synectic trigger 'repeat'. The Stitch Painter™ command 'Design in Repeat' is ideally suited for applying this trigger. The second patterning structure was accomplished by mirroring the mountain motif over a horizontal axis -- the synectic trigger 'transfer' -- and then repeating in a block repeat (see Figure 11). The third pattern was created by repeating the mountain motif in a brick network with a six unit slide to the right -- the synectic trigger 'transfer' (see Figure 12). In the fourth repeat pattern, I rotated the mountain motif 180 degrees using the synectic trigger 'transfer' and then repeated it in a brick network (see Figure 13). I performed these modifications by utilizing varying sequences of Stitch Painter™ commands.

In order to design the mountain landscape (see Figure 14), I began by overlapping -- synectic trigger 'superimpose'-- three triangle outlines and then developed infill patterns -- synectic trigger 'fragment'-- which would give the suggestion of geological strata found in mountain landscapes. I tested numerous permutations of this motif using the Stitch Painter™ software and applied the synectic triggers 'repeat, combine, add, transpose, substitute, fragment, and metamorphose'. My experimentation included printing out multiple copies of the motif to check for problems when the motif was put into block repeat. I developed the abstracted mountain landscape (see Figure 15) from the mountain landscape by applying the synectic trigger 'change scale'. This change of scale was achieved by using the 'Change Scale' command on the Stitch Painter™ program. The 60 percent change of scale abstracted the motif somewhat and increased the visual strength of the im[illegible].

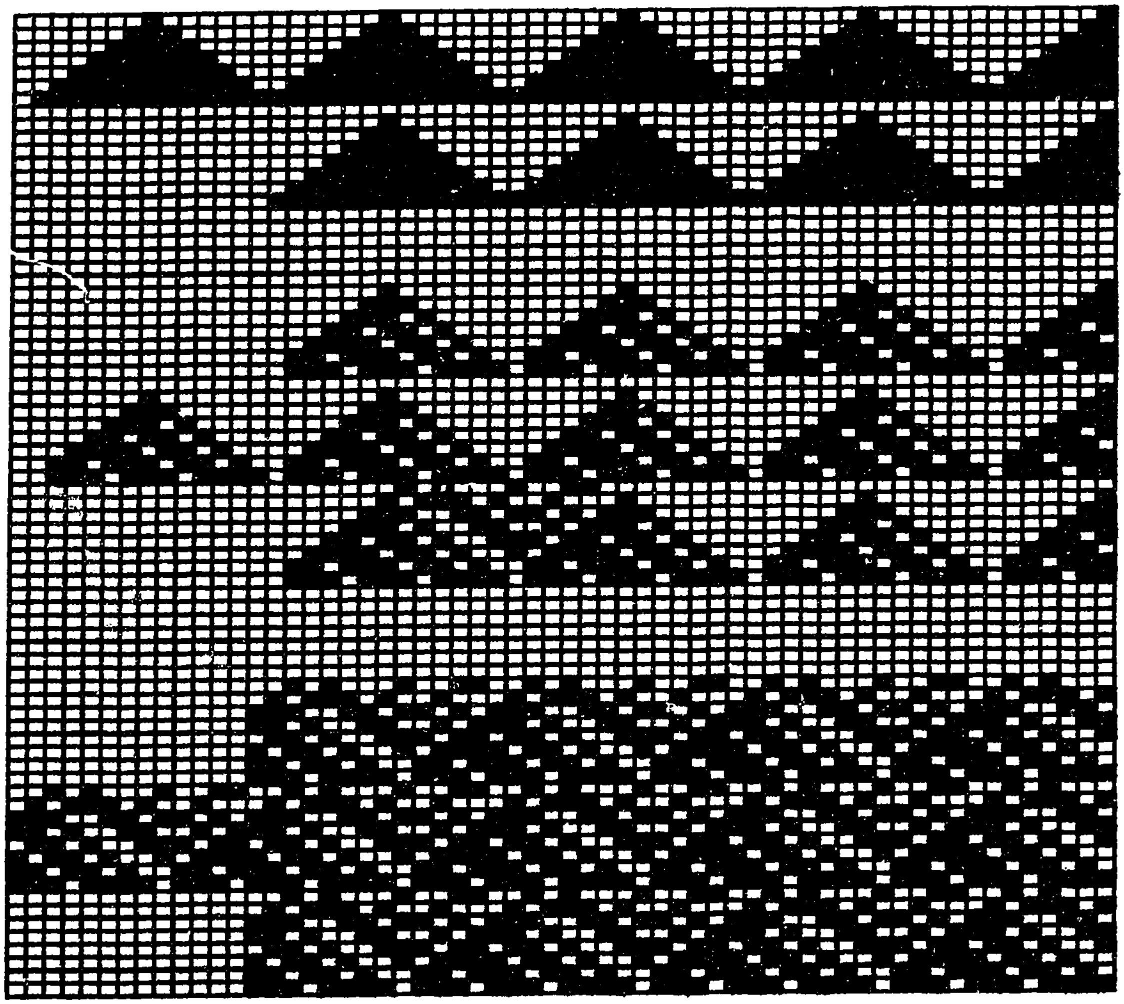


Figure 9. Development of the mountain motif using Stitch Painter™ software. Synectic triggers were used to develop the mountain motif from the extremely simplified triangle (top). This triangle had problematic long floats on the reverse of the fabric, when put into repeat in a fairisle patterning in plain knit stitch. The second version (middle) of the mountain motif has added interior detail yet maintains the stylized silhouette. This single motif, when put into repeat also had long floats between motifs. In order to eliminate this problem, I developed a third version (bottom) which has floats no longer than four needles when the motif is in block repeat. The synectic triggers used were repeat, add, and fragment.

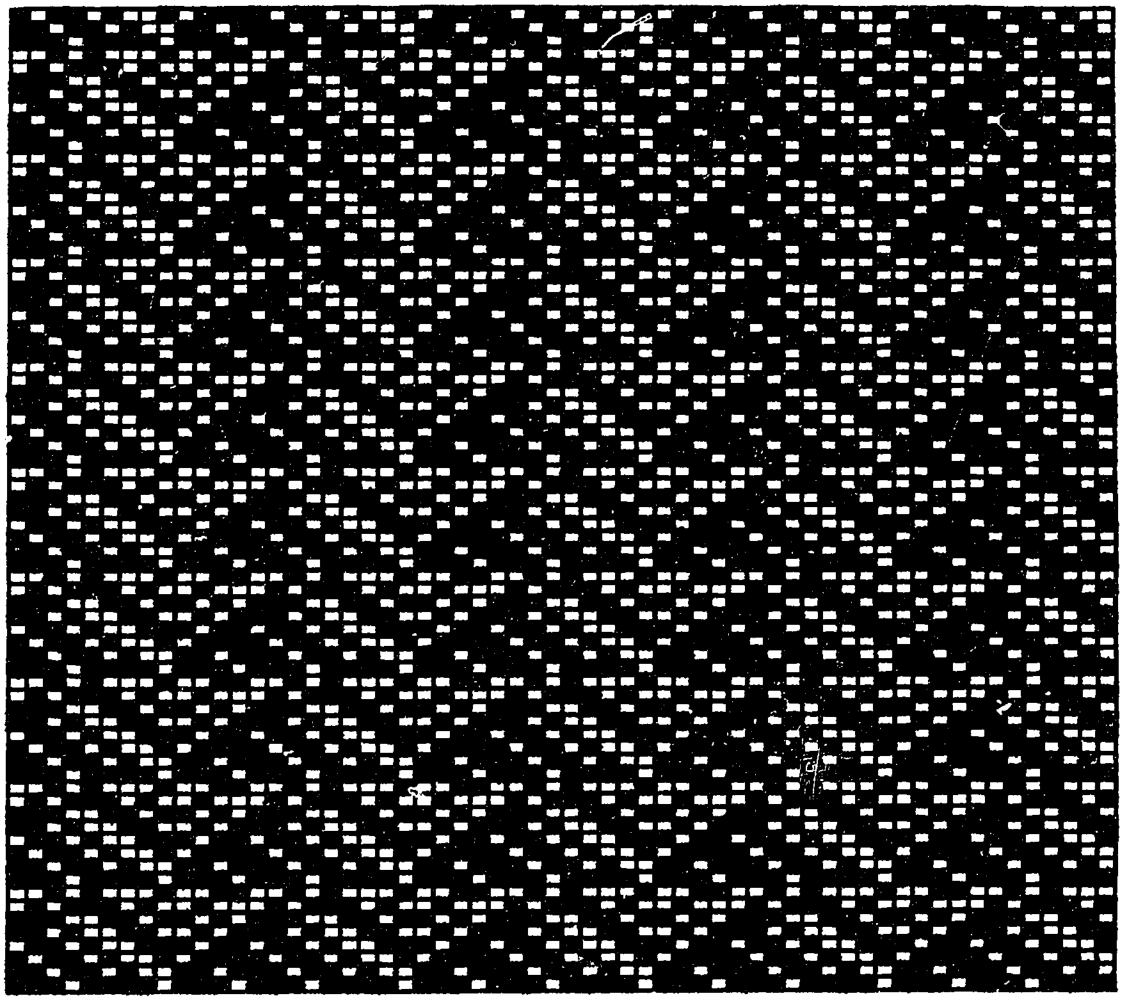


Figure 10. The mountain motif in block repeat was used on the sleeves of the sweater with red (see Plates 5&6). The background yarns of the right and left sleeves were reversed: black in place of off-white. This version of the mountain motif was also used doubled lengthwise for the front panel of the felted coat (see Plates 17&18). This doubled-in-length mountain motif was also used in the black-on-black centre back, and underarm panels of the vest (see Plates 11&12). The synectic triggers used were repeat and contrast.

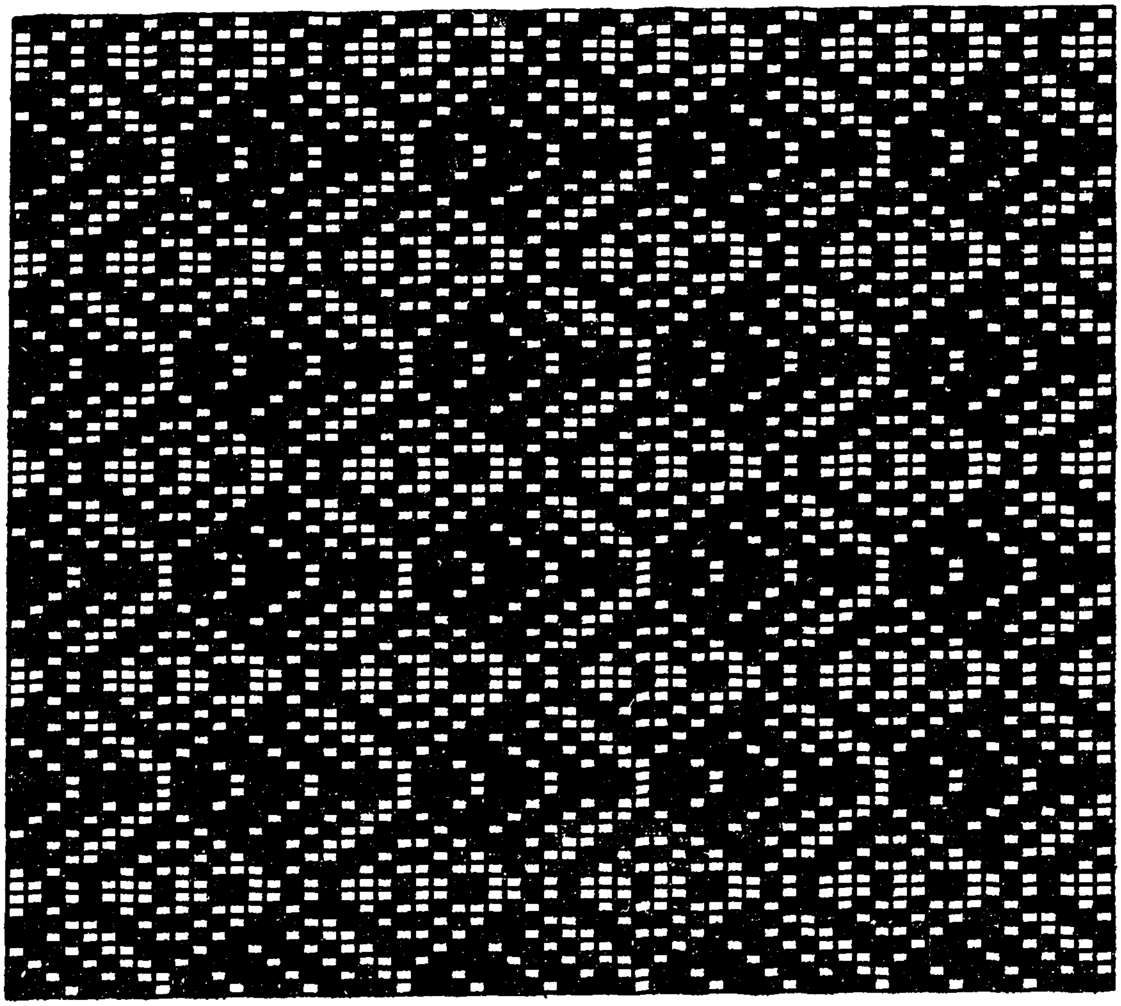


Figure 11. This version of the mountain motif is mirrored on a horizontal axis and then put into block repeat and this pattern was used on the sweater with red (see Plates 5&6). The side panels of the vest and the hat to accompany the vest also use this version of the motif, which was doubled in length (see Plates 11-13). The synectic triggers used were repeat and contradict.

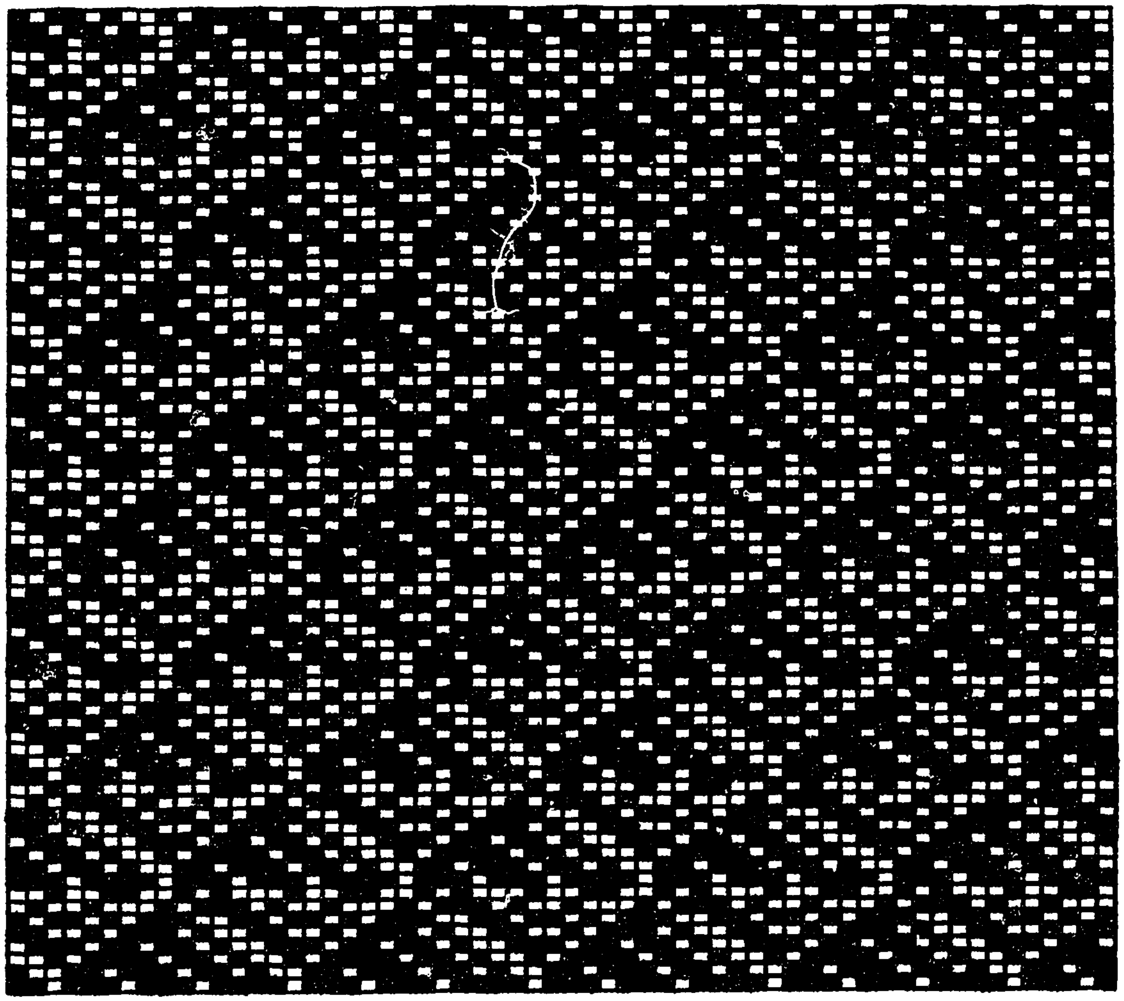


Figure 12. The mountain motif in brick repeat with a six unit slide to the right. This version of the motif was used on the sweater with red (see Plates 5&6). It was also used on the black and off-white jacket, doubled lengthwise (see Plates 14&15). The synectic triggers used were repeat, transfer, and distort.

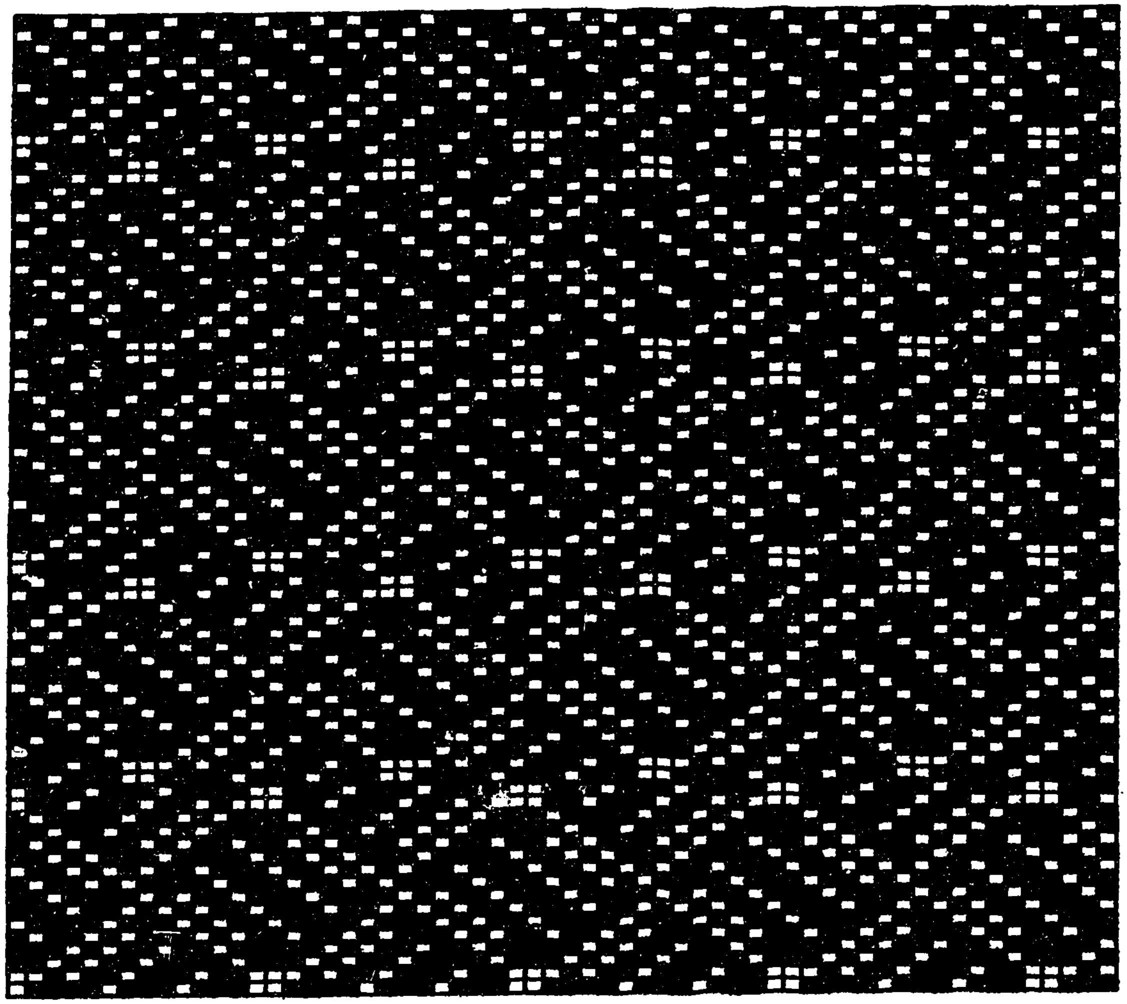


Figure 13. In this variation, the mountain motif was repeated across the bottom row. I rotated the mountain motif in the second row 180 degrees, and put it into a brick repeat with a six unit slide to the right. The synectic triggers used were: repeat, transfer, and contradict. This version of the mountain motif is used on the sweater with red (see Plates 5&6). This motif became fragmented when the knitting machine didn't read the mylar grid sheet correctly. The synectic trigger used to describe this accident is fragment. This motif was used on the sleeves of the sweater with blue as well as in a fragmented state for the body of the sweater with blue, doubled in length, and reversed black for off-white across centre front and back (see Plates 8&9). The synectic triggers used were distort and contradict.

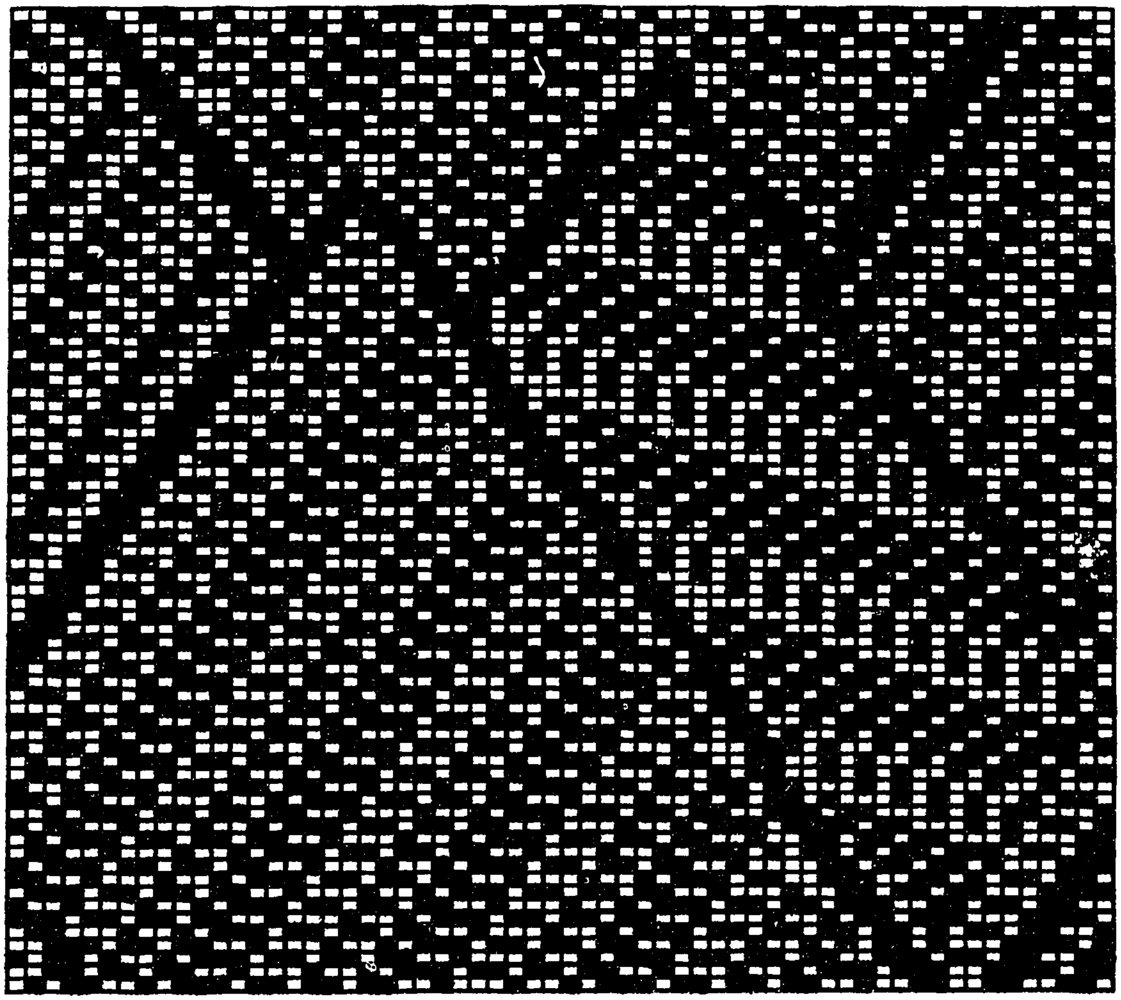


Figure 14. This is the mountain landscape motif used for the black-on-black opera jacket (see Plates 20&21). The Brother 910's™ switch number four was used to double the length of the motif. The synectic triggers used were: repeat, combine, superimpose, distort, and disguise. This motif was scaled down by 60 percent in both the vertical and horizontal axes to develop the abstracted mountain landscape (see Figure 15). The synectic trigger used was change scale.

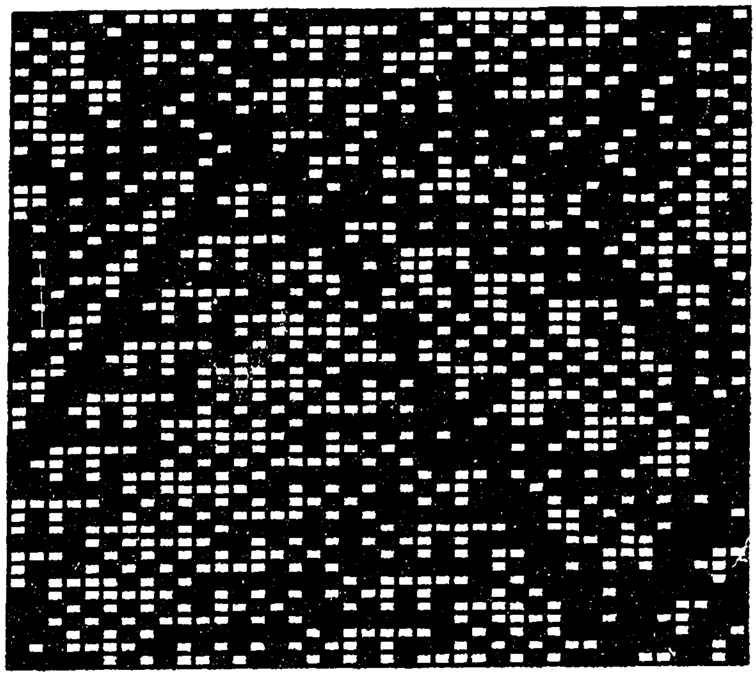


Figure 15. The abstracted mountain landscape motif which was developed by reducing the scale of the mountain landscape motif (see Figure 14) by 60 percent with Stitch Painter™ software. The synectic trigger used was change scale. This motif is 40 units wide and 60 units in length. This version of the abstracted mountain landscape motif was used on the black and off-white jacket (see Plates 14&15). The felted coat and hat (see Plates 17-19) used this motif doubled lengthwise which shrank during the felting process. The sweater and hat for Tim (see Plates 23-25) also utilized this motif doubled lengthwise and widthwise using the Brother 910 Electronic™ knitting machine's computer. The synectic triggers used were distort and change scale.

Designing the Collection

During the preliminary design studies using the mountain motifs, developed by utilizing the Stitch Painter™ software, I had experimented with various knitted structures produced by the Brother 910 Electronic™ knitting machine. I tried tucking, miss stitch, weaving, plaiting, knitted lace, single bed fairisle and double bed jacquard knits using a variety of yarn types and styles. I also experimented with wool, rayon, and blends of wool and rayon, as well as space-dyed acrylic in two ply or three ply yarns of differing qualities. I undertook this exploration to determine the possibilities for patterning offered by these structures and yarns as well as their appropriateness for use in garments.

In the designing of the collection, I continued with the application of design synectics to my creative process while I worked on designing the individual pieces that would make up the collection. The results of the textural experimentation using yarns with similar tonal values proved to be very subtle in contrast value. Because I had decided to limit motifs to those mountain motifs developed with the Stitch Painter™ program, some patterning restrictions were in place. One of the criteria which I had set for the development of this collection was that the collection would initially be viewed from a distance, such as on a fashion runway. Therefore, I deemed subtle textural and colour palettes with similar tonal values to be not suitable for the garments because they would not be visible from a distance of more than one meter. In order to ensure maximum visibility for the mountain motifs, I chose black yarns and off-white yarns to emphasize the patterning structure of the motif with opposing tonal values. To ensure the quality and integrity of the finished garments, I selected wool yarns because the knitting process requires a relatively fine, smooth, strong yarn with good elastic recovery properties. (Spencer, 1989). The primary yarn which I used for the development of this collection was a three ply, superwash wool, was selected because it is easy to wash and more comfortable to wear than other wools. I chose off-white coloured yarn over a 'real' white because truly 'white' whites are not readily available in yarns with 100% wool fibre content.

I determined that single bed fairisle patterning and double bed jacquard patterning to be the knit structures which would best exploit the motifs developed using the mountain motifs and the Stitch Painter™ software. The plain stitch fairisle knitted fabrics provided a medium weight fabric while the jacquard double knits were float-free, somewhat heavier, and more stable.

I selected construction techniques that conserved materials and saved labour, while maintaining a high level of quality and integrity. The assembly of the garments is essentially a hybrid of cut-and-sew and fully-fashioned knitting techniques. The construction techniques utilized in the production of the knitwear all serve to reduce the amount of material wasted as well as to reduce the labour time. The overall silhouette of the garments in the collection is boxy (see Figures 16-22), which allows for the knitting of rectangular body panels and eliminates waste material as well as the need for overcast seaming. All of the sleeves taper from the flat shoulderline to the cuff; on the plain stitch knit sleeves this tapering is achieved by decreasing the stitches. On the double knit sleeves decreasing stitches is technically very difficult, so I knit the fabric as a rectangle and cut it to the desired shape after blocking. The resulting raw edges were stabilized with serging.

I developed the jersey rolls to exploit the natural tendency of plain knitting to roll. These rolls are constructed [illegible] the knitted panels on the back bed needles of the knitting machine and knitting [illegible] of plain stitch. I then cast off the plain knitting using the linking attachment, [illegible] a finished cast off edge. Due to the inherently unstable nature of the plain stitch [illegible] fabric rolls towards the face of the fabric, and when it is steamed into place the resulting roll holds its shape without supplementary stitching.

Description of the Garments

Sweater with Red

The synectic triggers which I applied were: repeat, combine, substitute, fragment, contradict, symbolize, and mythologize. I was excited by the diversity of variations developed using Stitch Painter™ and therefore I was eager to use them all in this sweater. This is a rather typical beginning designer's habit -- the kitchen sink approach to designing -- so this first sweater has a large number of synectic triggers working.

For the patterning of the sweater with red (see Plates 5&6), I utilized the mountain motif in block repeat (see Figure 10) for the sleeves. In the body of this sweater, I introduced three modifications of this mountain motif, each of which was further modified by reversing the black and off-white backgrounds. The modifications were the mirrored mountain motif (see Figure 11), the mountain motif in brick repeat with a six unit slide to the right (see Figure 12), and the mountain motif rotated 180 degrees in brick repeat (see Figure 13). Each of these modifications was put into block repeat when they were programmed into the knitting machine using the mylar grid sheet. I substituted and moved around the pattern blocks within the sweater and black backgrounds were contradicted with off-white.

The yarns that I used to knit the body of this sweater were black three ply superwash wool and off-white three ply superwash wool. I used red three ply superwash to knit the centre front and centre back rolls and trim.

The structure of the sweater with red is plain stitch with miss stitch structure, which leaves short floats on the back of the fabric where the yarn is not knitting on the face of the fabric. In this sweater, these floats were short enough to not catch on the wearer's fingers and rings. The rectangular silhouette is emphasized by the grid structure and pattern blocking. Further emphasis is achieved with the black bands at the sleeve heading, shoulders and hems.

While I was knitting this first sweater, the knitting machine failed to read the mylar sheet correctly -- or I may not have taken enough care to fill in the mylar grid exactly enough -- instead of knitting the pattern, the motif became fragmented during the electronic needle selection. The mylar sheet has a grid printed on it which is filled in with a special felt pen; this determines the knitting machine's needle selection. This unexpected synectic trigger, 'fragment', was initially a disappointment, but upon reflection I determined that this serendipitous disaster had yielded a fragmentation that I would not have designed consciously. I decided not to unravel the knitted panel but to retain it as an exclamation point and focus for emphasis, as well as a relief from the usual and expected perfection of the machine knitting.

The red roll on the sweater with red and its accompanying hat draws attention to the centre front and centre back structural joins. The red horizontal bands emphasize the break up of space and isolate the pattern structures from each other. The interior space is divided into six equal sized patterning areas. The patterning blocks exchange places across the centre front and centre back mirror line, as well as vertically.

The silhouette of this first sweater (see Figure 16) is boxy, and with the hem roll it is designed to extend to just below hip level. The wrist-length sleeves were knit to shape by casting off stitches at both sides of the underarm seam.

Hat for Sweater with Red

The hat (see Plate 7) to accompany the sweater with red echoes the mountain motif (see Figure 13) with a black background used on the middle back side panel. The red roll echoes those on the sweater and serves to emphasize the join of the patterned band into a cylinder, as well as working as an exclamation point. The red bands of colour isolate the mountain motif patterning around the crown of the hat. The silhouette is cylindrical with a gathered black plain stitch crown.

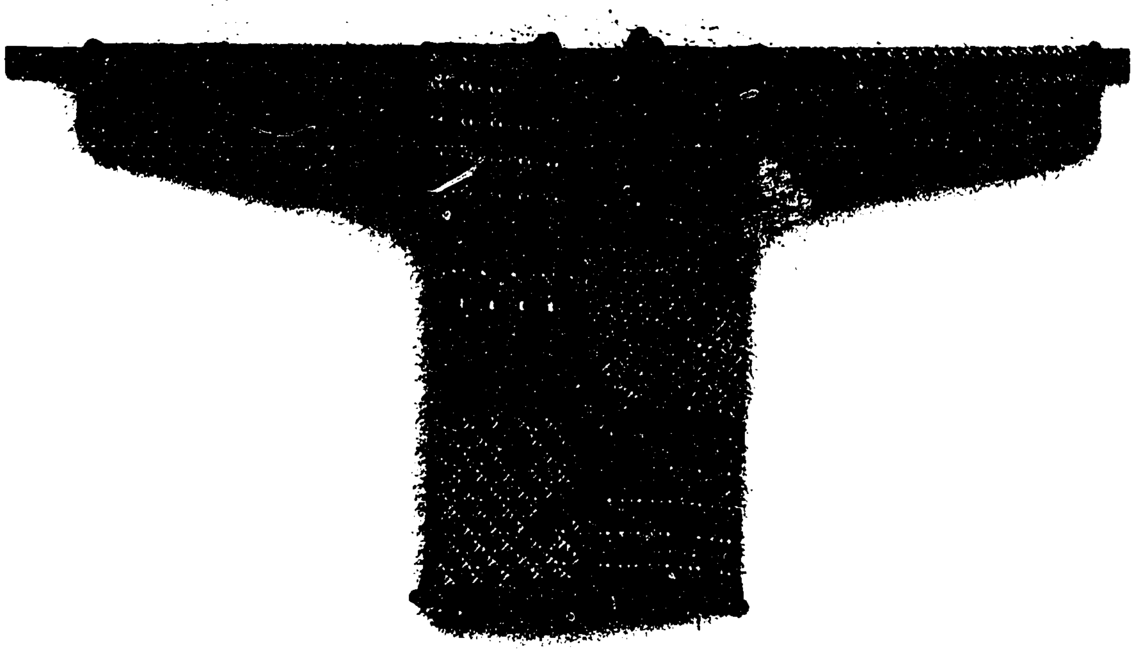


Plate 5. Sweater with red, front view.

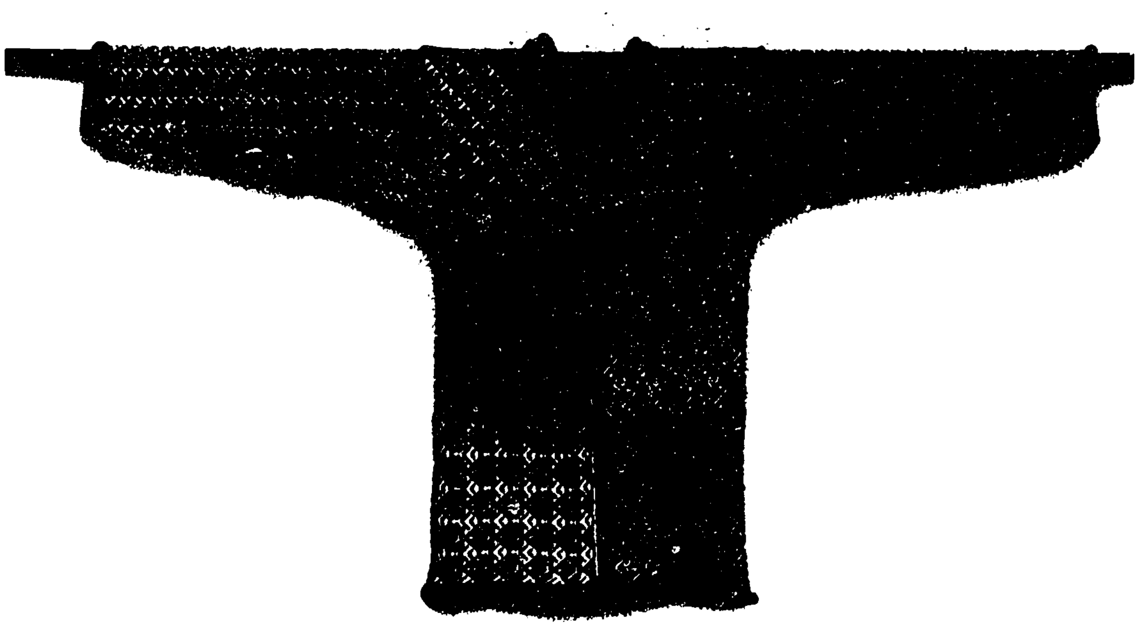


Plate 6. Sweater with red, back view.

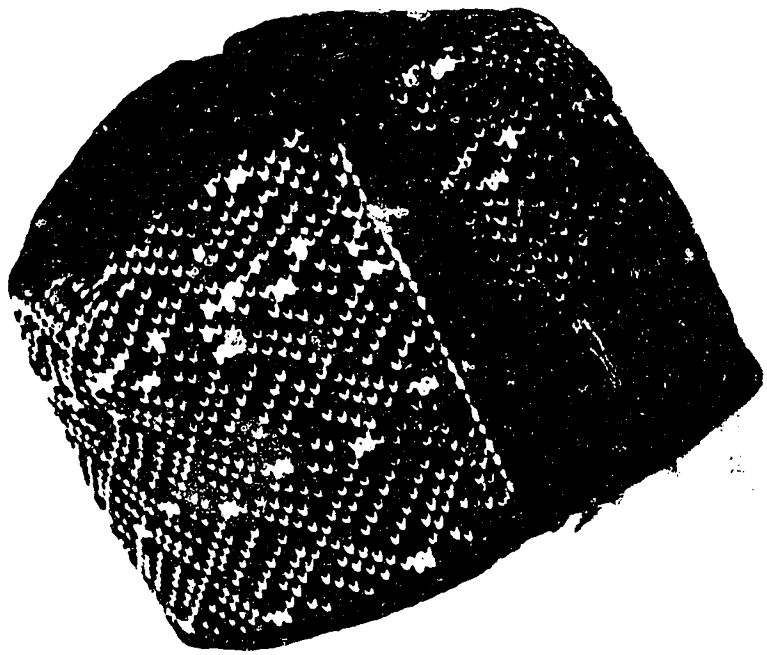


Plate 7. Hat to accompany sweater with red.

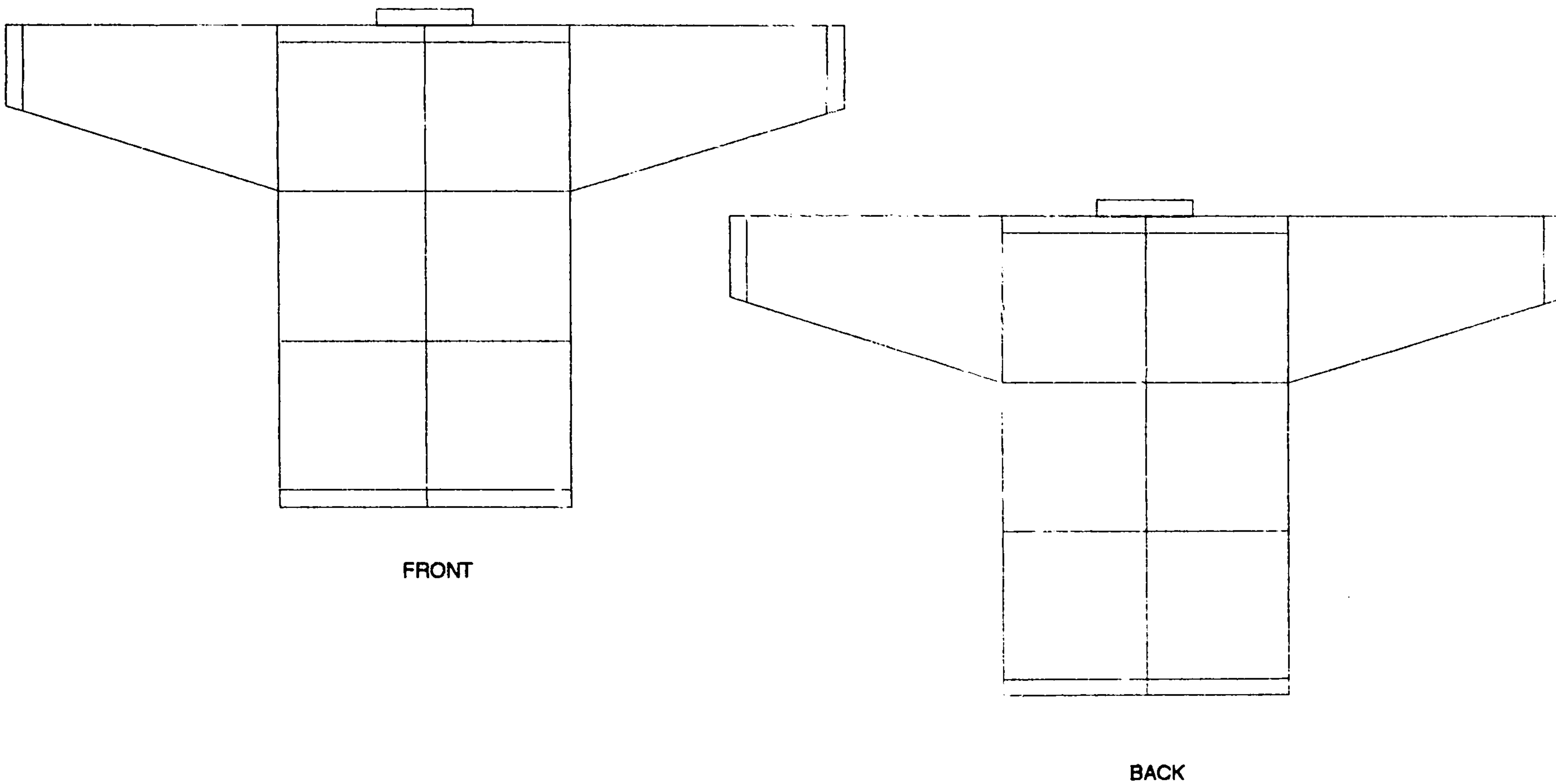


Figure 16. Schematics of Sweater with Red.

Sweater with Blue

The synectic triggers which I applied were: subtract, repeat, distort, fragment, contradict, and symbolize.

In the patterning on the body of the sweater with blue (see Plates 8&9), I reiterate the use of the fragmented mountain motif from the sweater with red (see Plates 5&6). In this sweater, the fragmented mirrored mountain motif is vertically distorted to twice the original length that was used on the sweater with red. This elongation was accomplished by using the knitting machine's double length capability. The sleeves of the sweater with blue use the unfragmented mirrored mountain motif (see Figure 11), which is also doubled lengthwise. I contradicted the black and off-white backgrounds across the centre front and centre back mirror line. The sweater silhouette and patterning are symmetrical across the centre front and centre back axis.

The red roll from the sweater with red is echoed with the blue rolls in this sweater. The hem roll and colour bands of the sweater with red are also restated in this sweater. The blue rolls emphasize and celebrate the structurally necessary seams at centre front and centre back. This blue colour is repeated in the stripe at the cuffs, hems and neckroll.

This sweater is simpler than the sweater with red in that it uses just one configuration of the motif. The black and off-white grounds are reversed by using the contrast switch on the knitting machine. The mirror line is at center front and back and this mirror line is emphasized with a blue roll. The blue roll functions as both an exclamation point as well as structurally joining the left and right panels. The form of the blue roll at the centre front and back is echoed in the black rolled hem, cuffs, and neck roll. The blue colour of the blue roll is restated in the blue band at the hem, cuffs, and neck.

The yarns used in this sweater and hat are black three ply superwash wool and off-white three ply superwash wool. The blue yarn is Velveen™, a 70% wool and 30% rayon blend which provides a lustrous texture with a cool hand.

The structure is plain stitch with miss stitches which generate the patterning on the face of the fabric and leave floats on the reverse. These floats are short enough not to cause problems of snagging if worn with care.

The silhouette of this sweater (see Figure 17) is two-thirds the proportion of the length of the sweater with red. The body of the sweater is rectangular and the hem roll is designed to fall at waist level. I knitted the wrist-length sleeves to shape at the underarm seams by casting off stitches.

Hat for Sweater with Blue

The hat (see Plate 10) repeats the unfragmented, black background mountain motif used on the right sleeve of the sweater (see Plates 8&9). This mountain motif is mirrored (see Figure 11) and doubled in length. The blue roll and band echo that of the sweater. The blue roll functions to join the knitted band to create a cylindrical silhouette with a gathered crown. The black, plain stitch roll forms a brim on the hat, further echoing the hem and cuffs of the sweater with blue.

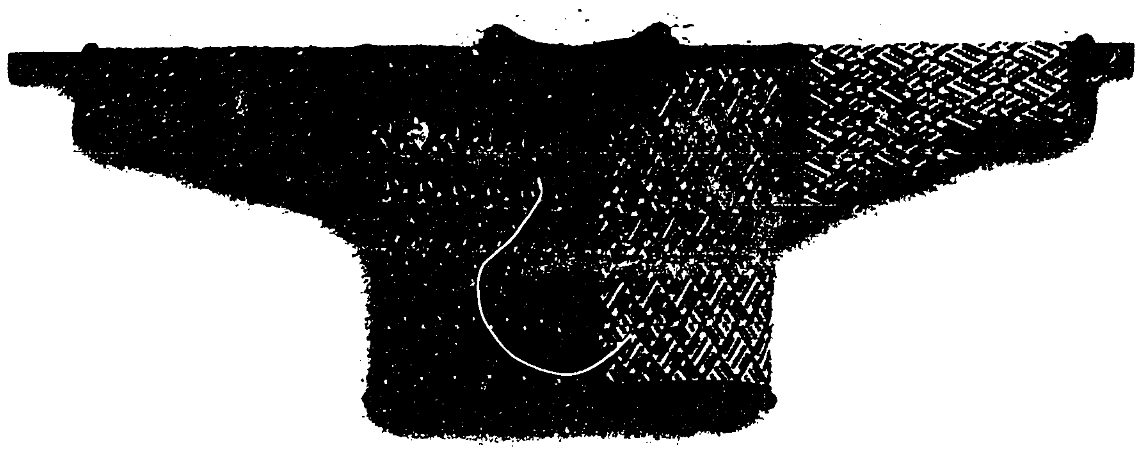


Plate 8. Sweater with blue, front view.

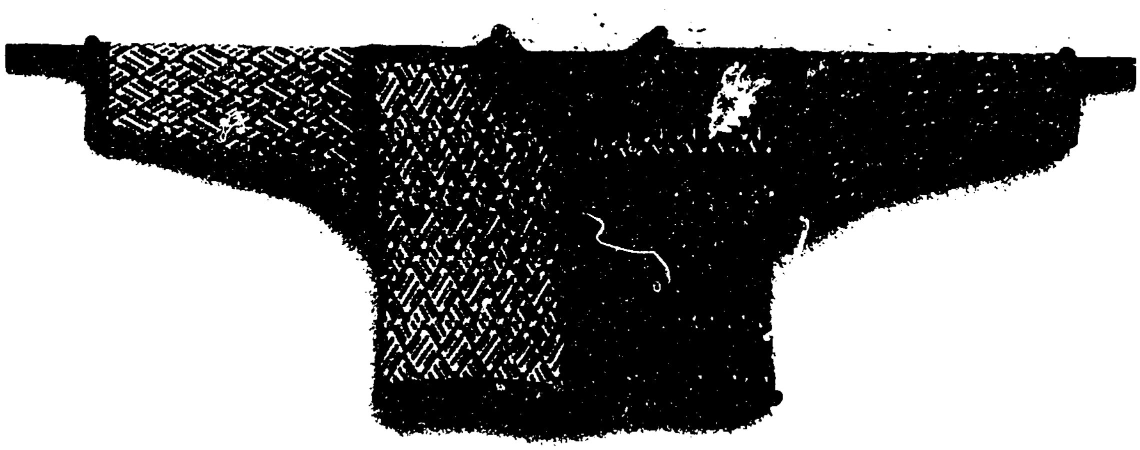


Plate 9. Sweater with blue, back view.

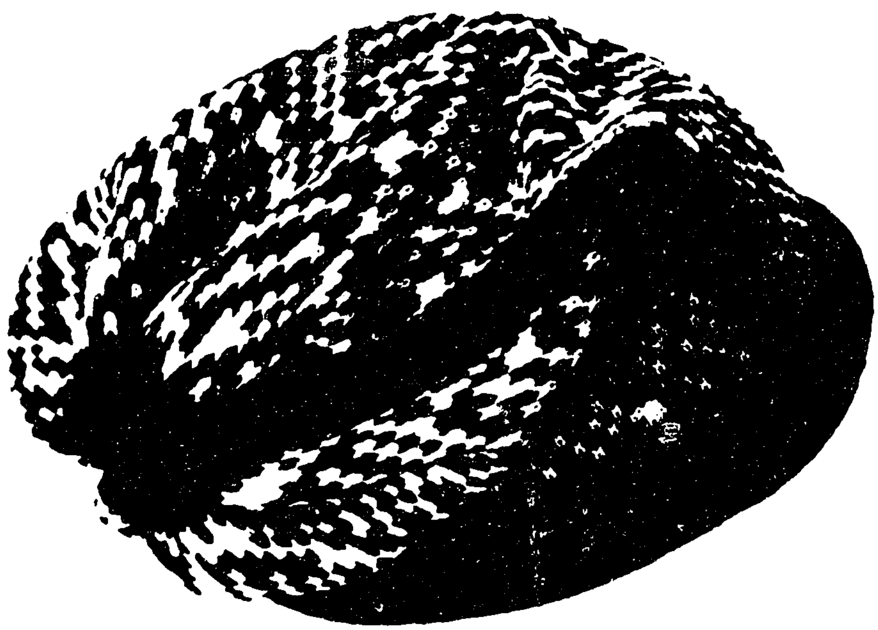


Plate 10. Hat to accompany sweater with blue.

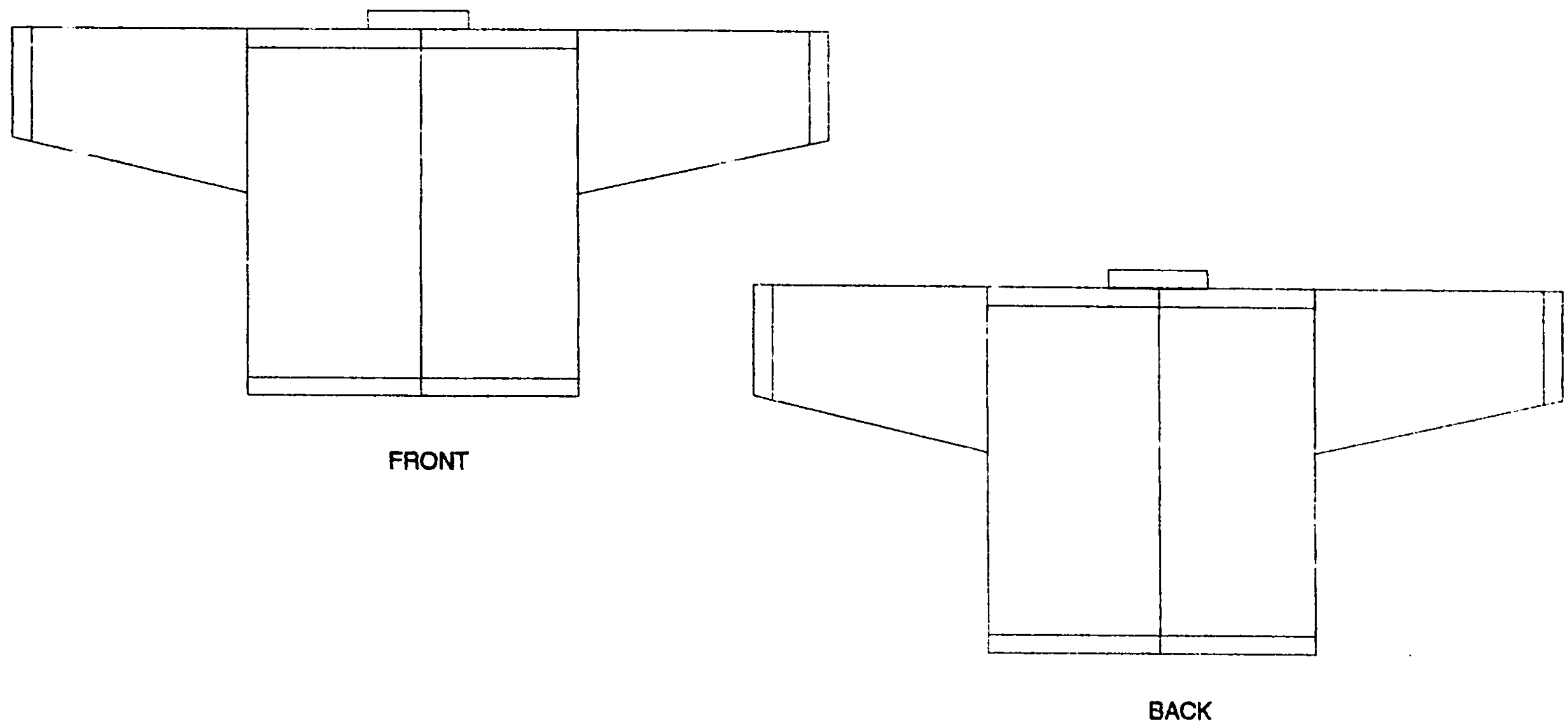


Figure 17. Schematics of Sweater with Blue.

Vest

The synectic triggers which I applied were: simplify, repeat, add, combine, superimpose, distort, and disguise.

The patterning for the vest (see Plates 11&12) is the mountain motif mirrored (see Figure 11) on black and off-white side panels which are mirrored on a horizontal axis and then doubled lengthwise. These mirrored motifs on the side panels are further mirrored across the centre front and back; each of the side panels is a mirror image of the other. The shoulder seam has been eliminated to further restate this mirrored effect front to back.

The yarns for both of the side panels of the vest were knit with black Velveen™ and off-white superwash three ply wool. The centre back and underarm panels of the vest were knit with black Velveen™ and black superwash wool.

The structure of the vest panels is jacquard double knit. This black-on-black structure introduced textural interest to the collection in addition to disguising the mountain motif which is the original motif in block repeat (see Figure 10), doubled in length. The blue rolls recall those of the second sweater and emphasize the seaming. The rolls were used to knit together the seams and place emphasis on these technically necessary structural lines. The blue rolls are knitted using a plain knit structure with Velveen™, a two ply yarn with a high twist.

The silhouette of the vest (see Figure 18) is based on a simplified box, symmetrical across the centre front and centre back. The rectangular body echoes the bodies of the other pieces in the collection and the vest does not meet at centre front. To add interest and an element of surprise, the symmetry was distorted by elongating the right front side panel. This distortion is reiterated on the side front panel of the black and off-white jacket. The hemline of the vest falls at the low hipline.

Hat for Vest

The hat (see Plate 13) restates both the mirrored, elongated mountain motif on the side panels of the vest (see Plates 11&12) as well as the blue roll. The blue roll emphasizes the seaming that joins the band into a cylindrical form. The plain stitch, black Velveen™ crown of the hat echoes the black of the centre back and underarm panels of the vest, and is gathered at the top.

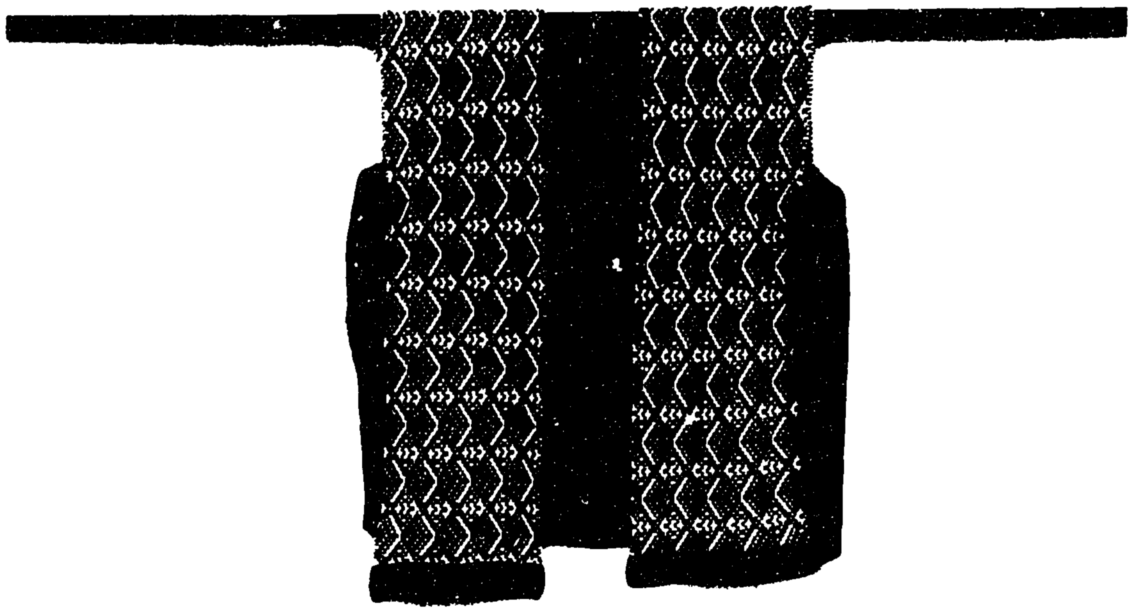


Plate 11. Vest, front view.

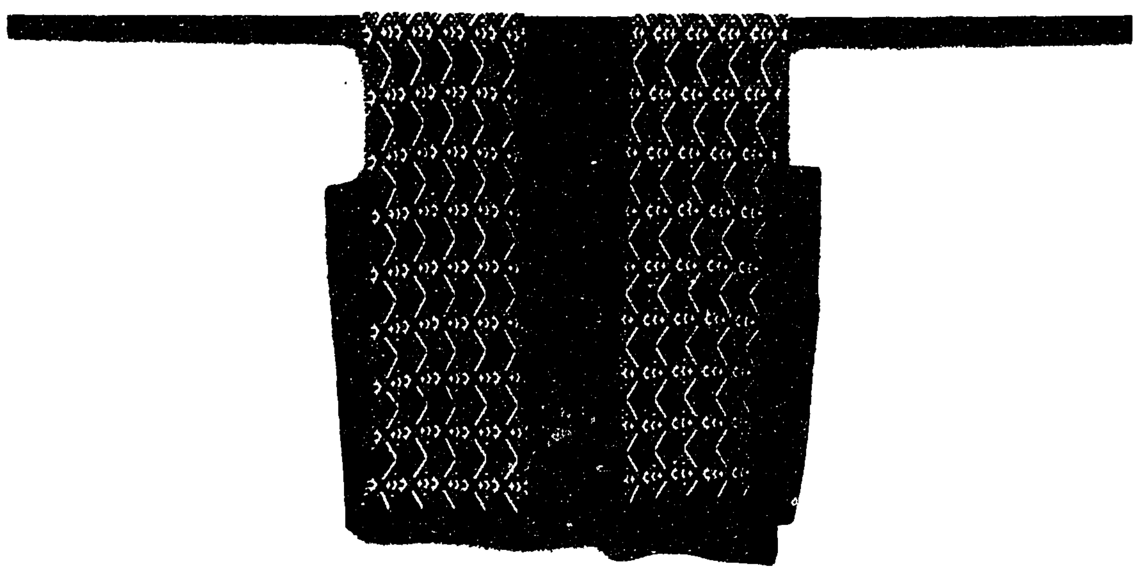


Plate 12. Vest, back view.

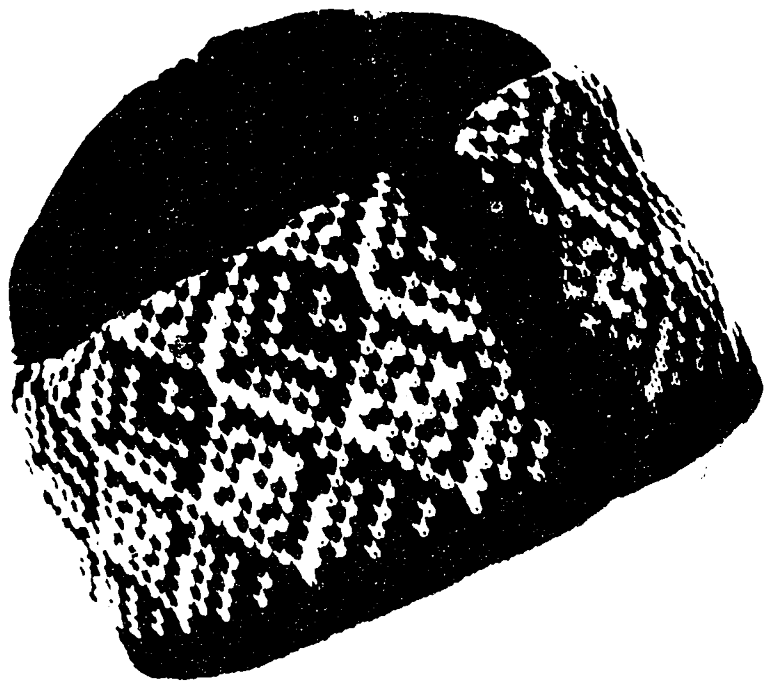


Plate 13. Hat to accompany the vest.

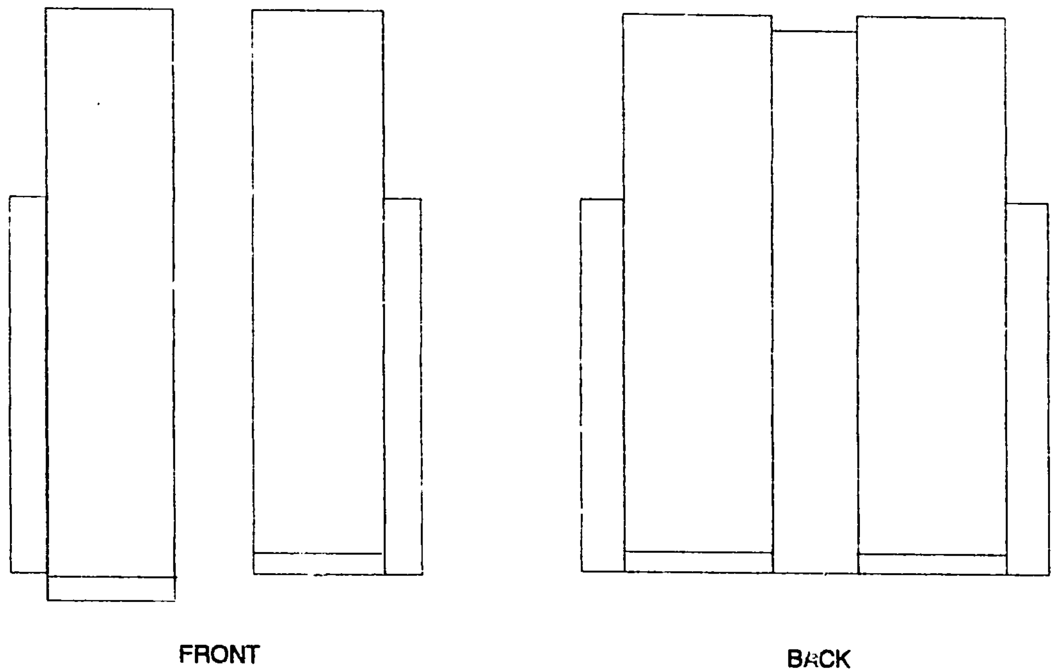


Figure 18. Schematics of Vest.

Black and Off-White Jacket

The synectic triggers which I applied were: repeat, combine, add, isolate, disguise, and contradict.

The patterning on the sleeves and narrow front panel of the black and off-white jacket (see Plates 14&15) utilized the elongated mountain motif in brick repeat with six unit slide, with an off-white background (see Figure 12). The wide front and back panels introduced the abstracted mountain landscape motif (see Figure 15) into the collection. By combining these two motifs, I sought a bridge between the first three pieces in the collection which use the mountain motif and the following three pieces which use both of the mountain landscape motifs. The wide front panel with the abstracted mountain landscape motif uses an off-white background and these panels are contrasted black in place of off-white, from front to back. This reversal of grounds provides an element of surprise for the viewer/wearer and distinguishes the back from the front.

The yarns used were off-white superwash three ply wool and black Velveen™. This combination of yarns provides the warmth of wool with the lustre of rayon.

The knitted structure of the vest is jacquard double knit with striping backing. This fabric is without floats and is of medium weight.

The silhouette of the black and off-white jacket (see Figure 19) is boxy with asymmetrical side panels reiterating the asymmetrical side panel on the vest (see Figure 18). This side panel was knit in one piece front to back, thus eliminating a shoulder seam, and restating the vest construction. In addition, by having this side panel all one piece, the mountain motif is turned upside down when viewed from the back.

Black plain knitted rolls emphasize and celebrate the shoulder seams and neckline of the jacket. The asymmetrical front closure of the jacket is accented by the double black rolls. Further emphasis of the roll theme is achieved by using the knitted tubes which each loop around one of the three black buttons. This tubing is integrated into the front opening roll, disguising their technically necessary attachment. Black bands integral to the sleeve headings echo similar bands on the sweater with red as well as on the sweater with blue. These bands have two functions; firstly to stabilize the knitted fabric and the shoulder seam, and secondly, to visually draw attention to the shoulder area. By delineating the shoulder area, the eye forms a box around the body panels, thus isolating the internal patterning.

The silhouette of this jacket reiterates the boxy silhouette of the other pieces in the collection. The hip length body panels are rectangular in shape, while the sleeves are tapered to the wrist.

Hat for Black and Off-White Jacket

The hat to accompany the black and off-white jacket (see Plate 16) repeats the elongated mountain motif in brick repeat (see Figure 12) used for the narrow side panel and sleeves of the jacket. The black roll is knitted together with the side band and emphasizes this seam and echoes the rolls on the jacket. The silhouette is cylindrical, restating the shape of the other hats in the collection. The crown is knit with plain stitch, black Velveen™ and is gathered at the top of the crown.

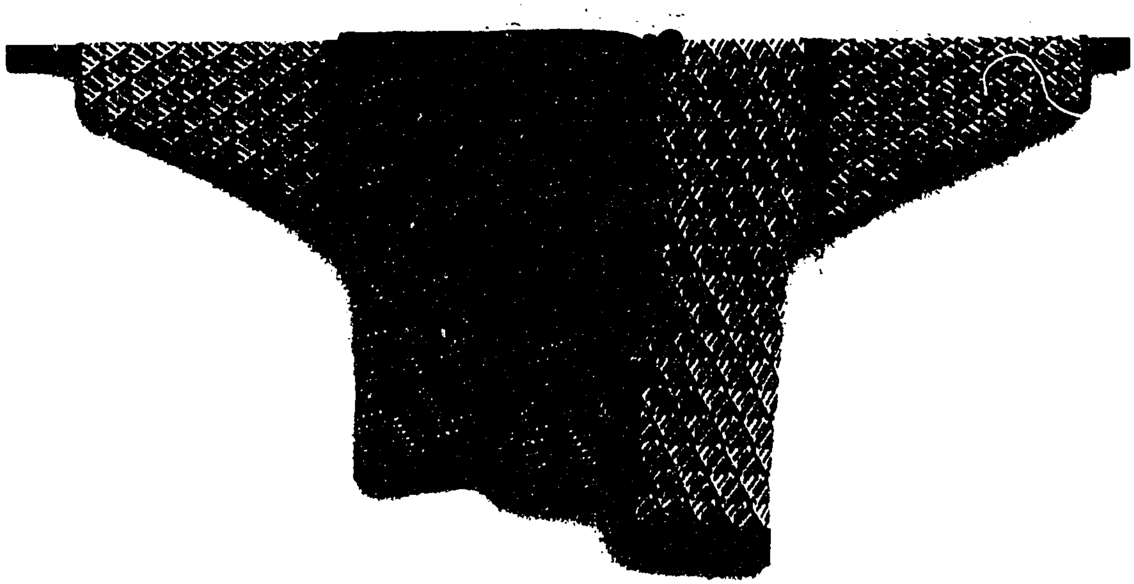


Plate 14. Black and Off-White Jacket, front view.

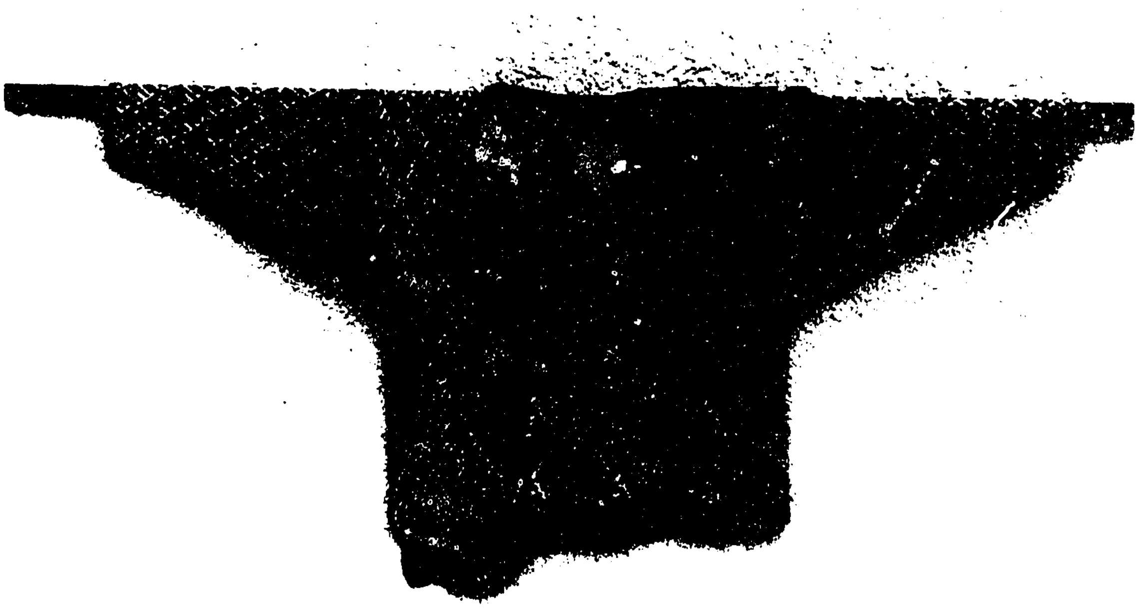


Plate 15. Black and Off-White Jacket, back view.

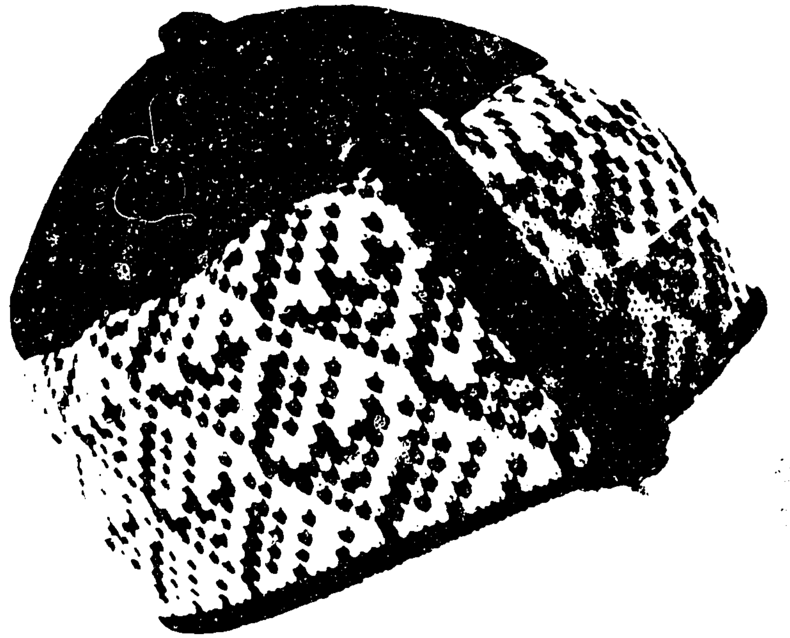


Plate 16. Hat to accompany the black and off-white jacket.

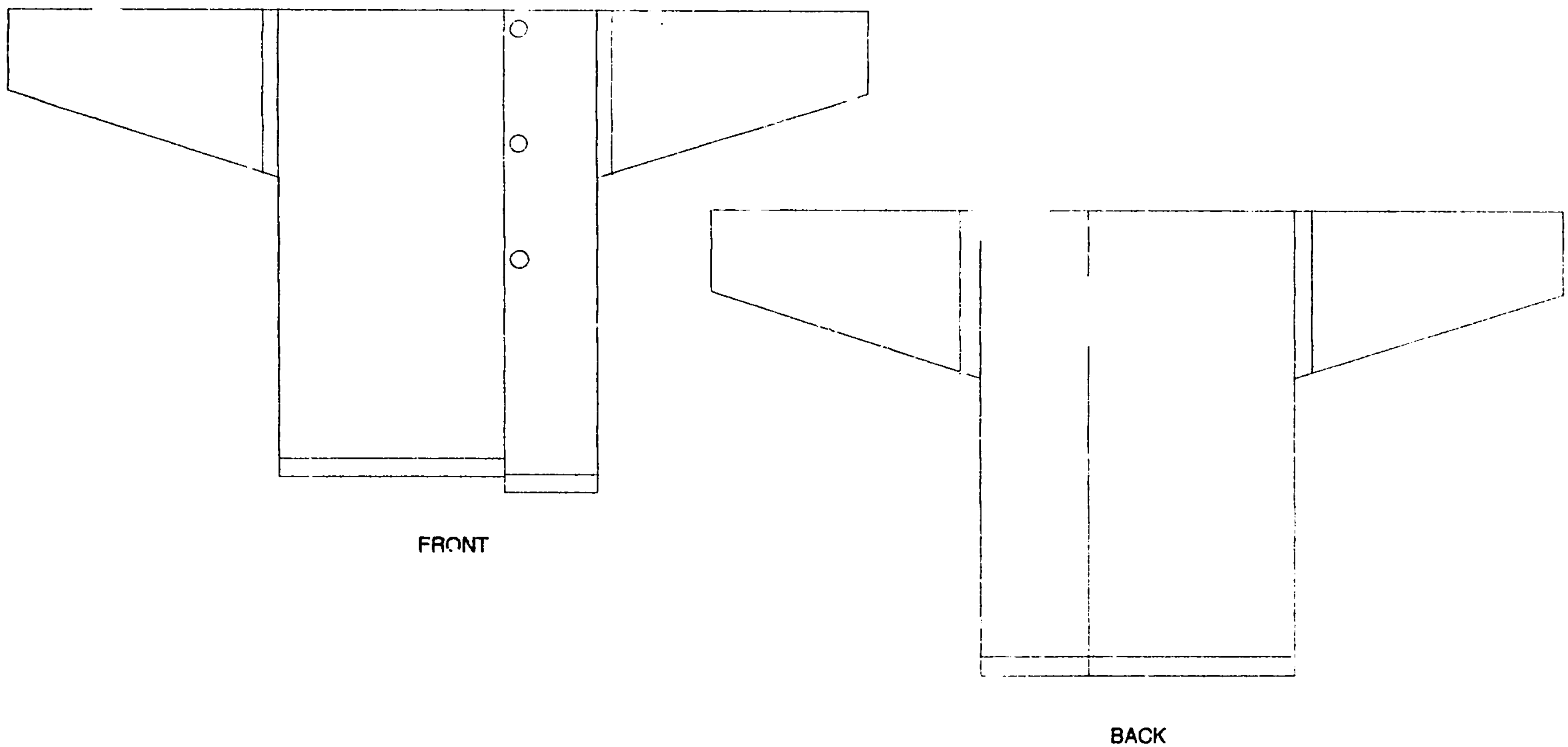


Figure 19. Schematics of Black and Off-White Jacket.

Felted Coat

The synectic triggers which I applied were: repeat, combine, add, distort, and mythologize.

The patterning used to knit the felted coat (see Plates 17 & 18) was affected by the synectic trigger "distort" which manifested itself in at least two ways in this garment; both with the visual imagery having been doubled in length, and the fabric itself having been distorted by felting. The abstracted mountain landscape (see Figure 15) covers the body of the coat. This abstracted mountain landscape was knitted with the motif doubled vertically which compensated for the lengthwise shrinkage that occurred during felting. The felting process shortened the lengthwise measurement of the fabric by 22% of its unfelted length. This particular knitted fabric also shrank 6% widthwise. Careful calculations were necessary to ensure that the pieces fit together after being felted.

After the panels were knitted and removed from the knitting machine, all seven of the knitted panels were washed in a domestic washing machine using household detergent and hot water which is usually strictly avoided when caring for wool. The felting process took advantage of the tendency of wool fibres to interlock scales when subjected to heat, moisture and friction. I decided to felt this coat to obtain three technical benefits. The first benefit was to increase the wind resistance which resulted from the matting over of the holes inherent to knitted textiles. The second benefit derived from the felting process was a reduction in the knitted fabric's propensity to snag. The third benefit of felting was that the increased fuzziness reduces the itch factor which is due to the inferior quality of this particular wool. In addition to the tactile fuzziness, the visual fuzziness distorts and blurs the motif. This blurring asks the viewer to examine more closely just what the patterning is.

Felting is one of the oldest forms of nonwoven fabric, owing its origins to Asiatic nomads who used felted wool fleeces for garments and housing. Wool has the unique property of being able to migrate under mechanical action in moist conditions to form dense entanglements of the fibres. The knitters in the Basque country of south-west France and northern Spain felt their loosely knit caps to make berets (Nabney, 1992). Contemporary knitters can felt most fabrics containing wool yarns in a domestic washing machine. Friction caused during the wash, rinse, and spin cycles is assisted by hot water to result in a felted fabric. The wash cycle can be repeated until the desired density is achieved. Careful blocking is required to obtain a rectangular fabric without rippling and distortion.

The front band and standing collar of the felted coat echo the mountain motif (see Figure 10) on the sleeves of the sweater with red (see Plates 5&6). This mountain motif was doubled in length before being felted to anticipate the lengthwise shrinkage. The red roll on the felted coat and hat echoes that of the sweater with red, and draws attention to the superimposition of the small mountain motif on the vertical band to the abstracted mountain landscape motif. In addition, this emphasis works to celebrate the technically necessary seam.

The structure of the knit is jacquard double knit with striping backing. This knitted structure provides a stable fabric which will shrink equally throughout.

The yarns used to knit the felted coat were black 2/20's wool and off-white Maine 2/20's wool plyed twice. Utilizing two two-ply yarns side by side proved a technical challenge because the yarns had a tendency to get caught in the machine's workings, and thus cause puckering and missed stitches. The black wool was very fragile and inferior because it had been overdyed during manufacturing. This oversaturation of the black dye caused the yarn not to felt to the same degree as yarns of other colours may have. It is primarily the off-white yarn that provides the fuzzy texture. Another result of the overdyeing is the propensity to bleed black while it was being felted and blocked.

The silhouette of the coat (see Figure 20) is boxy, in keeping with the shape of the other pieces, but it is somewhat narrow around the body due to being limited by the width of the double bed of the knitting machine. A centre back seam would facilitate a wider silhouette on future garments as well as allow for larger sizes. The long sleeves are tapered to the wrist. The mid-calf length hems should all have been knit at the same tight tension to eliminate puckering and fluting. Two solutions to this problem would be to either exaggerate this fluting or use a cut-and-sew method to completely eliminate it.

Hat for Felted Coat

The hat (see Plate 19) to accompany the felted coat echoes the felting and the motifs used on the coat. The abstracted mountain landscape (see Figure 15) forms the crown of the hat, and the mountain motif (see Figure 10) from the narrow centre front panel forms the cylinder of the hat. The red roll on the centre front of the coat is restated in the joining of the side band into a cylindrical shape. The black binding restates the black trim found at the shoulder and cuffs and hem of the coat.

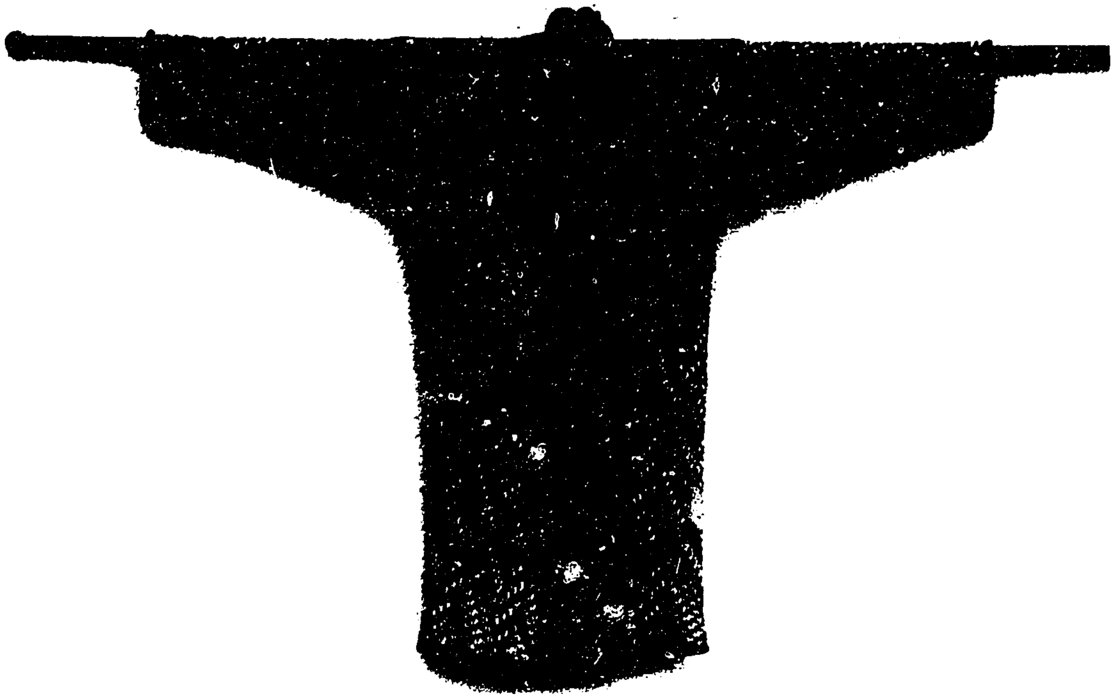


Plate 17. Felted coat, front view.

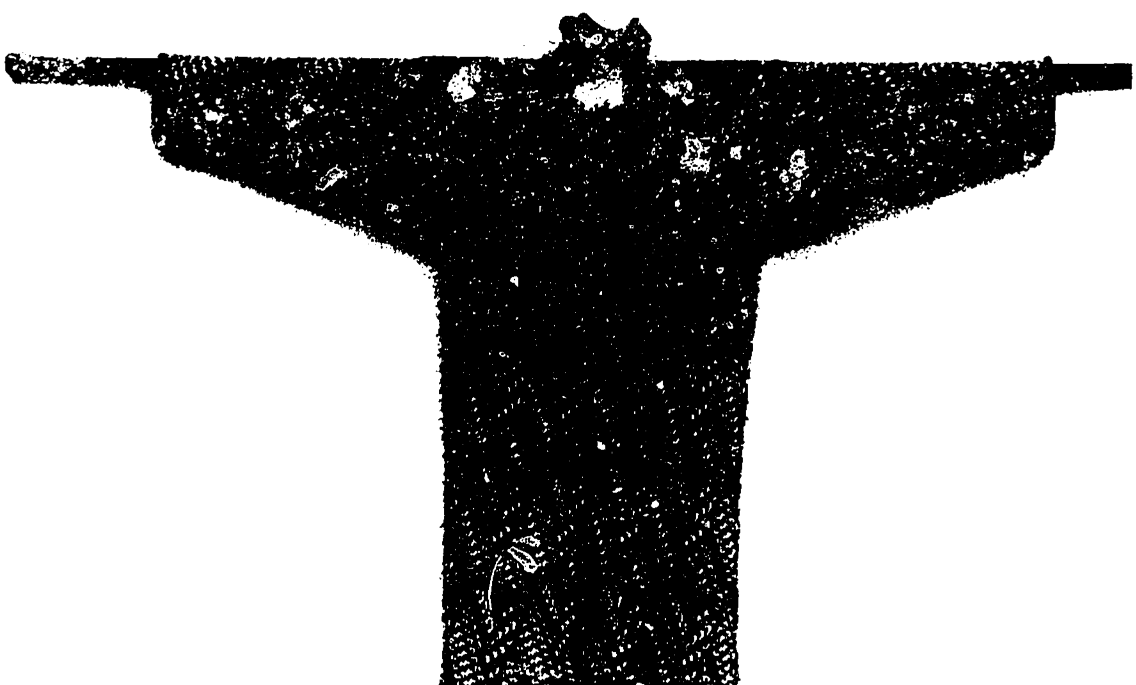


Plate 18. Felted coat, back view.

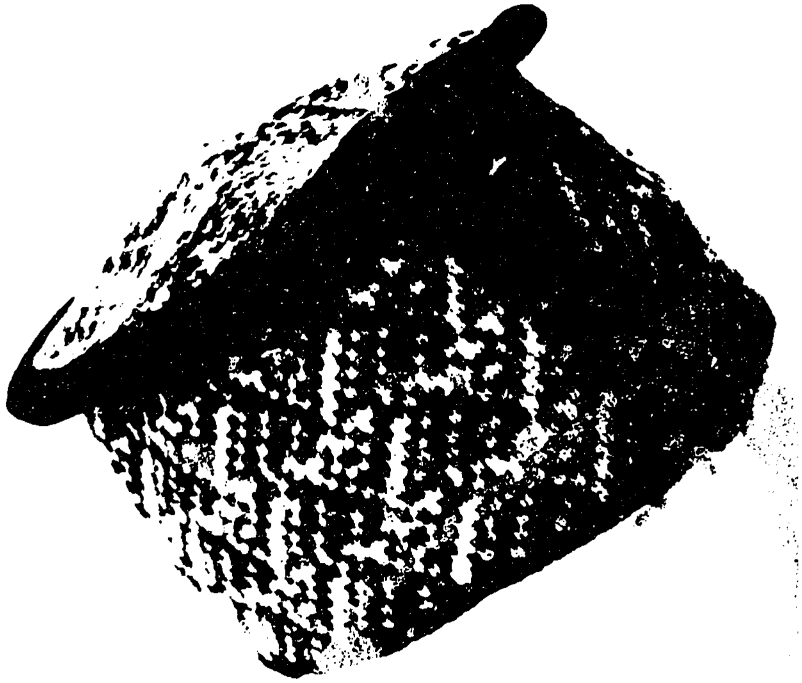


Plate 19. Hat to accompany the felted coat.

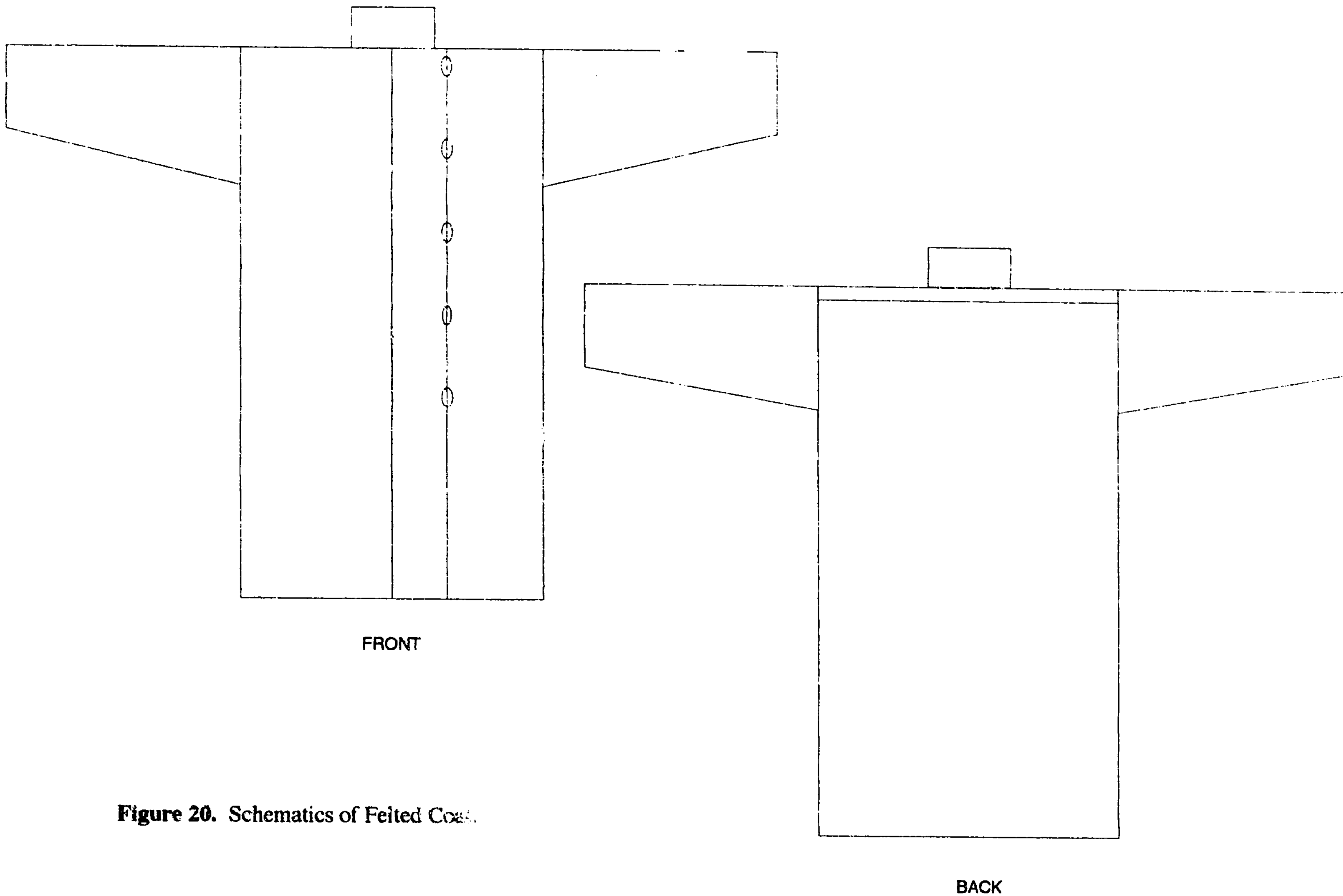


Figure 20. Schematics of Felted Coa[illegible]

Opera Jacket

The synectic triggers which I applied were: repeat, change scale, disguise, and fantasize.

The patterning for the opera jacket (see Plates 20&21) is the mountain landscape motif (see Figure 14) repeated throughout the knitted fabric. Changing the scale by doubling lengthwise the mountain landscape motif optimized the visibility of the imagery. At the same time, the black-on-black texture disguised the mountain landscape motif. The primary design element working in this piece is texture. The black-on-black tonality echoes the black-on-black panels introduced in the centre back and underarm panels of the vest.

The yarns utilized to knit the opera jacket were two plys of black 2/20's wool. This repeated use of black maintained continuity with the black in the other pieces in the collection. To add textural interest, black three ply rayon was used because of its lustre. The black-on-black begs requires attention from the viewer if the motif is to be discerned.

The structure of the opera jacket was the plain stitch fairisle knit which was used to ensure a high degree of drapability. This jacket was designed as an evening wear piece, therefore it is expected that care will be taken by the wearer in order to reduce the likelihood of snagging the long floats on the inside. Lining this jacket would prevent snagging from the inside but lining would also change the drape and feel of the garment. The continuous knitted band that finishes the centre front and neckline is the same width as the non-patterned hems.

The jacket's silhouette is boxy with a v-neck front. The sleeves were tapered slightly towards the wrist (see Figure 21) by casting off stitches at the underarm seam.

Hat for Opera Jacket

The hat to accompany the opera jacket (see Plate 22) echoes the mountain landscape motif (see Figure 14) used on the jacket. This mountain landscape was again doubled in length on the knitting machine. The band at the brim of the hat is the same scale as the band on the jacket opening, cuffs and hem. The form of the hat is simplified to eliminate visual competition with the jacket and the surface interest. Furthermore, technical difficulties arising from shaping such loose, delicate fabric were avoided by keeping the form simple.

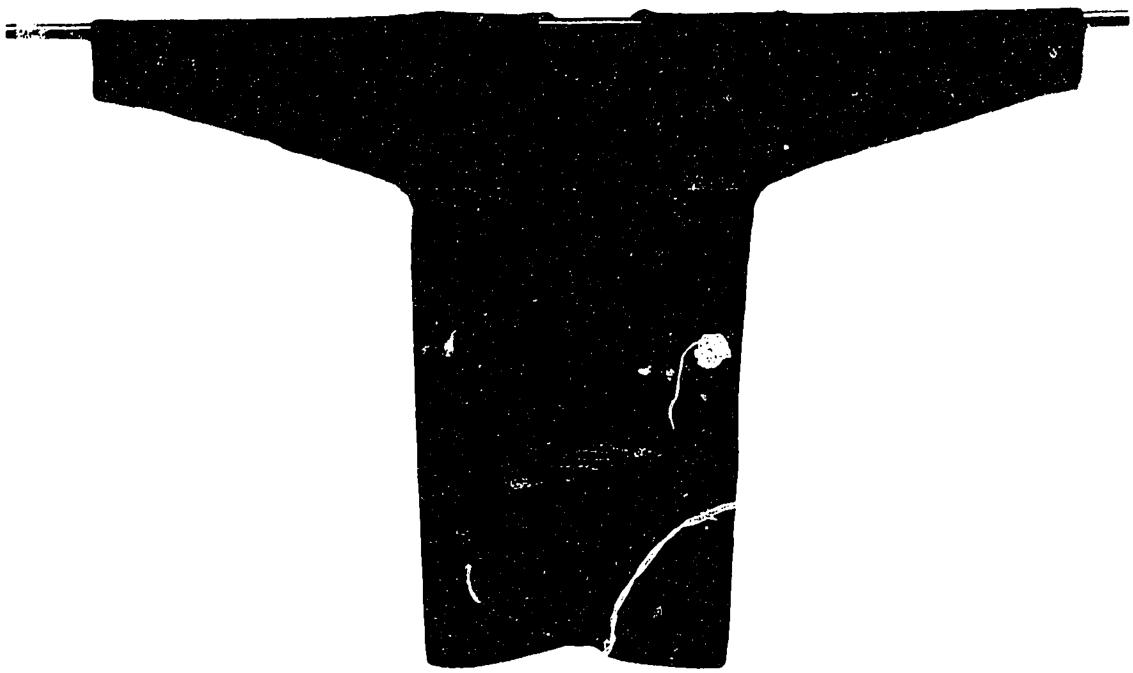


Plate 20. Opera jacket, front view.

Plate 21. Opera jacket, back view.

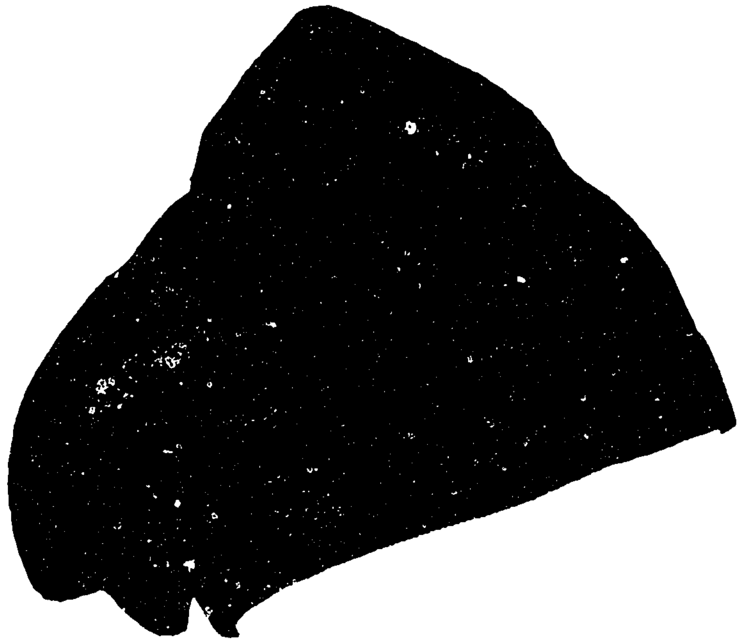


Plate 22. Hat to accompany opera jacket.

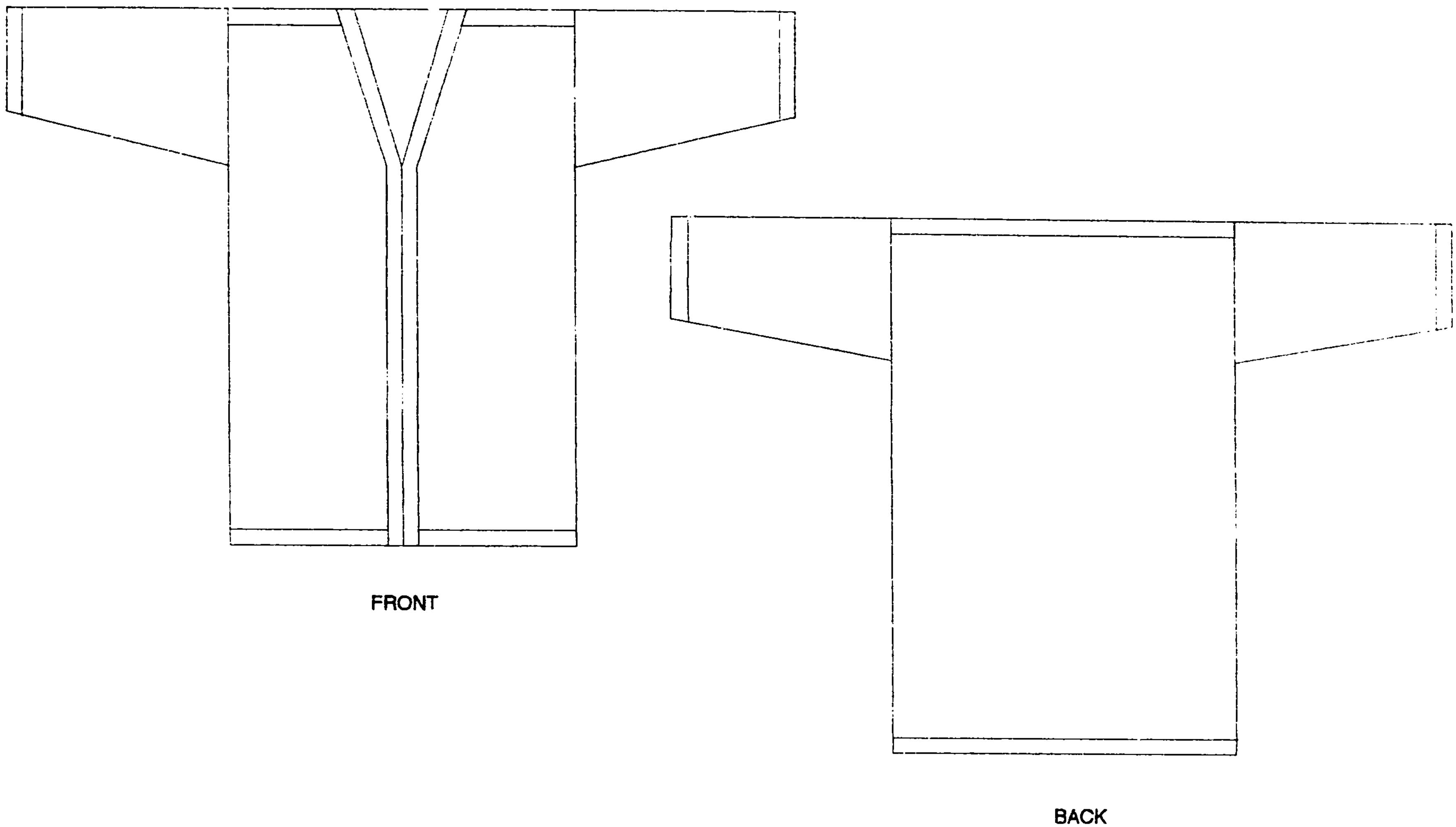


Figure 21. Schematics of Opera Jacket.

Sweater for Tim

The synectic triggers which I applied were: repeat, add, superimpose, change scale, distort, disguise, and metamorphose.

The patterning for the 'sweater for Tim' (see Plates 23&24) was created with the abstracted mountain landscape motif (see Figure 15). The scale of the abstracted mountain landscape motif was changed by doubling the motif both vertically and horizontally. A two ply acrylic yarn with space-dyed black, green, and blue was introduced to lend variety and textural interest. By superimposing the bands of colour created by the variegated yarn over the abstracted mountain landscape motif, the motif becomes disguised and metamorphosed.

The yarns used to knit the body of the sweater for Tim were three ply black superwash wool and space-dyed acrylic. The ribbed cuffs at the wrists and the hem were knit with the black superwash wool as was the folded neckband.

The structure utilized to knit this sweater was double bed jacquard knit on the face of the fabric with striping backing. The neckband, cuffs, and hem were knit with a 2X2 rib.

The silhouette of the sweater for Tim repeated the rectangular body, dropped shoulder, and tapered sleeves of the other pieces (see Figure 22). The neckline was cut-and-sewn to provide for a good fit of the 2X2 rib neck band. The cuffs were knit with 2X2 rib which produced a close fit at the wrist. The hemline falls at hip level and fits around the body closely.

Hat for Sweater for Tim

The hat (see Plate 25) to accompany the sweater for Tim echoes the abstracted mountain landscape motif (see Figure 15) as well as the 2X2 ribbing on the sweater. The shape of the hat was kept simple to allow the patterning and colour changes to dominate the hat, a cylinder with crimped ends.

Plate 23. Sweater for Tim, front view.

Plate 24. Sweater for Tim, back view.

Plate 25. Hat to accompany sweater for Tim.

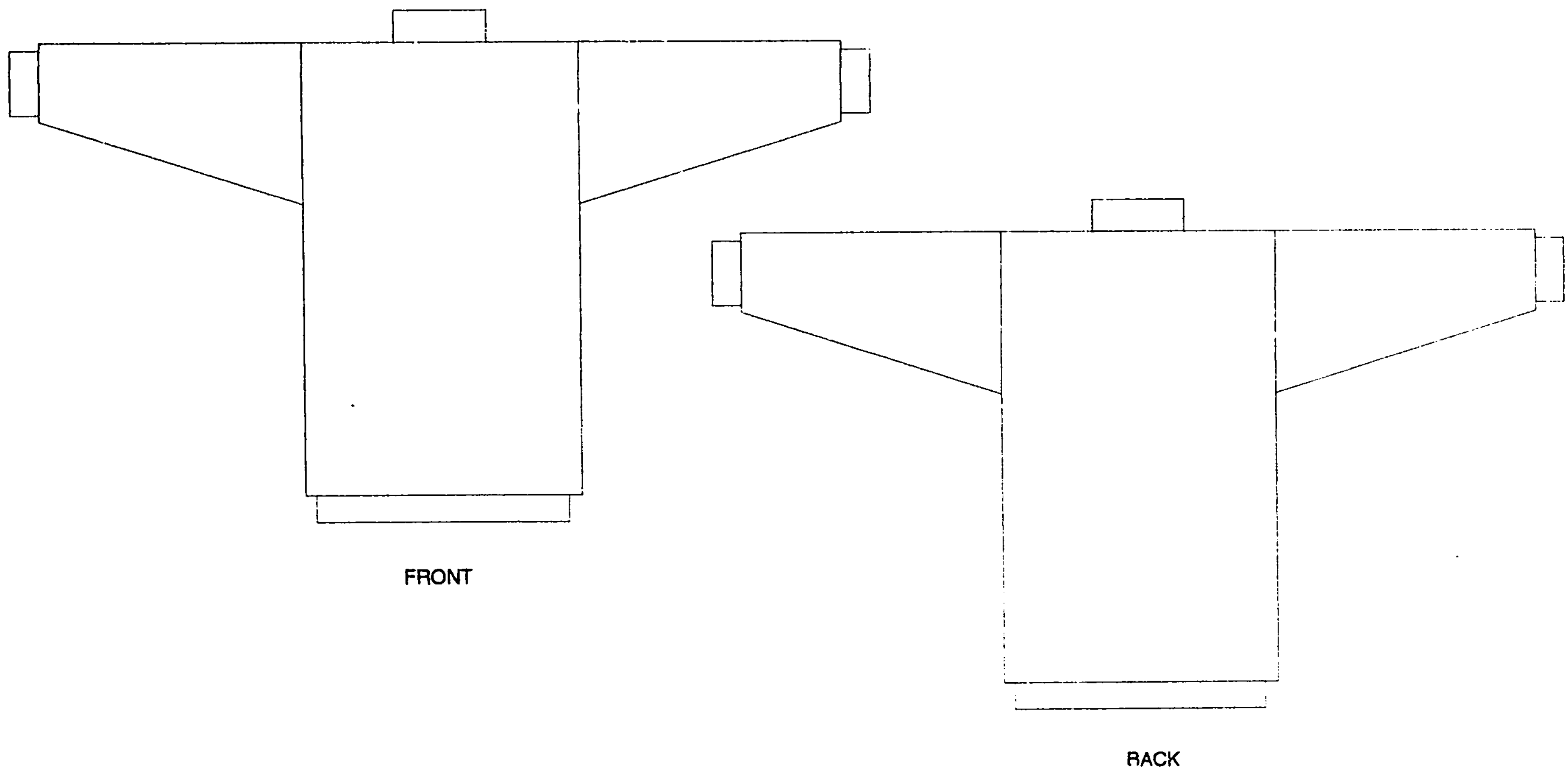


Figure 22. Schematics of Sweater for Tim.

Critique

Evaluation is an important phase of the creative designing process. Evaluating the products of the designing process involves reviewing what has been accomplished and planning improvements (Koberg & Bagnall, 1981). Although evaluation is sometimes considered as a final stage of the design process, I have been making decisions throughout the designing of this collection. From the type of yarn fibres to knit with, through how to exhibit the collection, the designing process is a series of choices (Bevlin, 1984).

Evaluation is not necessarily an end but a beginning, and in reflecting on Buchanan's "wicked problem of design" (1992, p. 15), if I could continue with this particular creative designing process, my work would be informed by what I have learned thus far, and the collection would continue to evolve. Furthermore, given the opportunity to begin the designing work for this collection all over again, I would approach it differently and, if I did so, a completely different set of apparel products would emerge. This is the exciting attribute of design work.

This collection should be considered as a prototype because this was the first time each of these pieces was knitted and completely finished. If garments such as these were to be offered in the marketplace, further designing work would be undertaken to improve the aesthetic considerations. In addition, continued technical work on the production and manufacturing aspects would be required to improve the construction quality and to streamline production techniques. Ideally I would employ the services of a knitting technician to perform the actual knitting, thereby leaving me free to tackle the essential design problems. This would free me to focus on the creative aspects of the designing process without heed to the technical constraints of feasibility and practicality. However, these technical difficulties did present me with unforeseen opportunities for creativity. In this critique I will address some of the problems that I encountered during the designing of the pieces in the collection and propose some solutions to these difficulties.

This group of knitted garments can be perceived as a collection because the design principle 'unity' is maintained throughout with the following elements: stylized mountain imagery, maintaining a boxy silhouette, black wool yarns, and similar knitted structures. The five garments and hats with black and off-white are most closely related at first glance because of their shared tonality and because each of these pieces has the roll detailing. The opera jacket and sweater for Tim are rather different in mood and styling from the black and off-white pieces. I included them with this collection in order to add variety and interest to the collection in terms of texture and colour contrast. Emphasis was employed to provide exclamation points throughout the collection, primarily with the use of the red and blue rolls.

The sweater with red is very busy, demanding a great deal of visual attention from the viewer/wearer. The red bands in the hems could be wider and would therefore have a stronger visual presence. The construction techniques used to attach the collar should be fine tuned to clean finish the raw edges of the cut-to-shape neckline.

The black cuff and hem rolls on the sweater with blue are a bit skimpy, they could be thicker, more visually weighted. The technical attachment of the collar to this sweater should also be improved upon by utilizing a cleaner finish on the neckline. This sweater may be the most successful piece in the collection, perhaps because of its simplicity.

The black and off-white motif patterning used on the vest is visually strong and symmetrically balanced, but the front opening of the vest is visually rather weak. Perhaps this could be remedied with the addition of blue rolls or by adding a black centre front panel to provide a closed front. The asymmetry of the length of the front hem of the vest should be either increased to draw attention to this asymmetry or eliminated. The black underarm and centre back panels are rather long; they were eased onto the side panels and are therefore puckering and sagging. The black rolls which delineate the shoulder line and neckline are flimsy visually and structurally; they should be thickened. The mountain landscape on the front of this jacket reads as mountain imagery clearer than any other of its permutations on the other garments. The off-white colour outlines serve to refer to snow-capped mountain peaks.

The felted coat is narrow through the body's silhouette, and the sleeves are proportionally too wide at the wrist. The off-center, narrow front band would be technically simpler if this band were positioned evenly over centre front. Repositioning the band would also allow the buttons to take more prominence. The flaring of the hem, which was caused by trying to hem the panels during the felting process, distracts from the desired boxy, straight silhouette. This flaring is a technical fault that would be eliminated by knitting yardages longer and wider than the finished dimensions, felting the panels and then using cut-and-sew methods to construct the coat.

The opera jacket utilized black wool of an inferior quality which contradicts the high-end mood that this piece is trying to accomplish. The fairisle patterned plain stitch structure is prone to snagging and puckering of the long floats on the inside of the jacket so special care is required of the wearer. This problem could be eliminated by lining the jacket with a lightweight silk or rayon lining fabric; however, lining would alter the drape of the knitted fabric. Although the mountain landscape is well disguised in the black-on-black texture, under some lighting conditions it becomes quite apparent.

The sweater for Tim stylistically departs from the other pieces in the collection in two ways; the silhouette and the coloured yarns. This sweater was designed in this way to add variety and contrast as well as an element of unpredictability, as if to suggest what next? and, indeed, this sweater does suggest future directions for this designer to explore.

CHAPTER 4

Summary

Directions for Continued Design Study

Further study stemming from this research points to two directions: theoretical application and technical experimentation. Applying design synectics theory to the creative process of designing presents opportunities for continued study. For example, the synectic trigger mechanisms could be applied and tested in apparel design and textile design classrooms or the synectic trigger mechanisms could be used for other creative designing in textiles and apparel, particularly in surface design.

Research could also be undertaken to develop a computer program to implement the synectic triggers on command. For example, instead of selecting the repeat or change scale commands intrinsic to the Stitch Painter™ program, the designer could select 'fragment' or 'analogize' trigger mechanisms. Synectic trigger software would facilitate design education by expediting the application of the synectic triggers to the students design work.

Continued research by this designer could introduce the elements of colour and texture to the motifs developed during this study; colour could be explored using both pre-dyed yarns and yarns dyed in process; texture in terms of both textured, novelty yarns and textures constructed by manipulating the knitted structure itself. Future studies could apply the synectic triggers not used extensively in this study, for example: 'prevaricate, mythologize, symbolize, and metamorphose'. In addition, the synectic triggers could be applied to other subject material which is inspirational to me such as motifs derived from flowers and beaches.

During the preliminary studies, this designer used a very simplified, stylized mountain motif in the shape of an isosceles triangle. Many different cultural groups have used the triangle as a decorative motif. Further studies using the synectic triggers applied to the triangle motif could prove interesting, as would a content analysis of the use of the triangle in other cultures' textiles as well as in other material objects.

Technical improvements in future studies would include the use of a large colour monitor. This would facilitate easier manipulation of the motifs (Stitch Painter™ brushes) on the screen, and thereby allow the designer to see more of the effect of the repeat at one time. Using the newest model of knitting machine which allows for direct downloading of the work developed using Stitch Painter™ to the knitting machine would eliminate problems with the scanning of the mylar grid sheet by the knitting machine. Furthermore, this direct downloading would eliminate the human error factor made possible when filling in the mylar grid sheet by hand. The newer model Brother 965™ knitting machines can support stitch repeats of 200 needle by 1000 rows, much larger than the Brother 910 Electronic's™ 60 needle by 150 row limits which were used in this study. This increased pattern repeat would facilitate larger, more detailed motifs.

Another area of further research is the exploration of the new technological processes, for example: cloqué, devoré, and coupure (Edmiston, 1995). Applying these industrial techniques to knitted fabrics and knitwear would increase the technology and materials available to the knitwear designer. These new processes would add to the repertoire of post-knitting techniques which include the felting process which was used in this study.

Conclusion

This study contributes to the dialogue about design and designing within a textile and apparel design context. In this investigation, I have attempted to articulate and document my creative processes while designing a collection of one-of-a-kind knitwear. It is important for designers and design educators in textiles and apparel to articulate their creative methods for designing (Zeisel, 1984). This is because an integration of the creative designing process with the technical skills of textile and apparel design will strengthen not only the products produced but also, what is more important, the competency of the students' abilities and her/his understanding of the processes of designing.

This thesis provides documentation of my application of the synectic trigger mechanisms to the designing of a small collection of machine knitwear using computer aided design. I used computer files and printouts, samples, sketches, and photographs to record the designing process as it progressed.

The Stitch Painter™ computer software program expedited the exploration of the synectic triggers at the motif level and proved an efficient tool for testing the effects of the pattern created by the motif when put into repeat. The design and production of seven sweaters, each with a coordinating hat, formed the corpus of my investigation. A selection of synectic triggers were applied from the micro -- the selection of the fibre content -- through to the macro -- exhibition of the collection -- levels of design and production. The synectic pinball machine model (see Figure 6) proved to be a useful research paradigm in that it assisted me in limiting the number of variables upon which the synectic triggers could act. Design synectics proved valuable in both prescribing and describing the designing process as it progressed. The structural synectic triggers, for example; repeat, add, and combine were found to be the easiest to apply because they most closely correspond to traditional textile and apparel designing methods. The more intuitive synectic trigger mechanisms such as; analogize, metamorphose, and fantasize pose a greater creative challenge to use due to the personal, introspective nature of these triggers. Future studies with design synectics will continue to utilize the pinball model in order to select and limit the number of the synectic triggers used and the plastic variables they can affect.

Application of the synectic triggers to my creative process was synergized with the influence of the technical obstacles invariably encountered during the production of one-of-a-kind machine knitwear. All of these variables had an impact on my designing process and therefore on the designed products. Often these technical problems imposed limitations; yet at other times they offered solutions and alternatives. This synthesis of the theoretical and practical reinforces the notion, proposed at the beginning of this thesis, that those who do should also think and write.

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