NOTICE

CERTAIN DATA CONTAINED IN THIS DOCUMENT MAY BE DIFFICULT TO READ IN MICROFICHE PRODUCTS.

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EXECUTIVE SUMMARY

SYMAGERY has developed a patented process to manufacture clothing without direct human labor. This **CLOTHING CREATOR**™, will have the ability to produce two (2) perfect garments every 45 seconds or one (1) every 30 seconds. The process will combine Computer Integrated Manufacturing (CIM) technology with heat molding and ultrasonic bonding/cutting techniques. This system for garment production, will have the capacity to produce garments of higher quality and at lower productions costs than convention cut and sew methods.

ADVANTAGES

- Greatly reduced production costs
- Increased quality of garments
- Reduction in lead time
- Capacity to make new class of garments

ACCOMPLISHMENTS

- Patent on process
- Engineering of machine design
- Located vendors of components
- Costs to produce garment from process
- Cost/benefit analysis comparing cut and sew methods to our process
- Selected target markets where technology could be applied to
- Produced prototype garments
- Industry awareness and identification of product

This technology will accommodate a variety of knit, woven and nonwoven materials containing a majority of synthetic fibers. Among the many style of garments that could be manufactured by this process are: work clothing, career apparel, athletic garments medical disposables, health care products, activewear, haz/mat garments, military clothing, cleanroom clothing, outdoor wear, upholstery, and highly contoured stuffed toy shells.

SYMAGERY is seeking $1.3 million dollars in start-up capital for the building and testing of a full-scale prototype machine. Our goals are to:

- **Build and test equipment**
- **Set-up pilot plant facility**
- **Develop joint venture with existing company in apparel/textile industry**
- **License patent and related information**

SYMAGERY is currently under the aegis of the U.S. Department of Energy, Energy Related Inventions Program and New York State Energy Research and Development Authority research grants to help supplement this current phase of work. Funding of $140,000 has been awarded to compliment SYMAGERY'S own investment of $150K in the project. An additional $70K has been provided by the National Science Foundation and New York State Science and Technology Foundation.

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(Copyrighted pages and costs removed)

DISCLAIMER

SYMAGERY

Brett Stern
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PRESIDENT'S NOTE

Man differentiates himself from the animal kingdom by erecting shelter, cultivating food and adorning his body with cloth to protect himself from the harsh environment. This business plan concentrates of this later nuance. Clothing has changed radically from the first fig leaf of Adam to the use of sophisticated synthetic fabrics for todays spacesuits. Apparel not only offers function, but addresses our culture from a social, economic and political standpoint. As styles of clothes has changed so to has the forces of production to manufacture them. From the use of animal skins, to the spinning of yarn, to the industrial revolution and the invention of the sewing machine, society has begrudging accepted these technical changes.

SYMAGERY is now proposing the next step. The automation of the apparel production process. I realize that for this new technology to be successful it has to attract the attention of both the manufacturer and consumer. Presently, the machine is just starting to define its niche in the marketplace and answering all the financial inquiries. But all neoteric ideas and methods require a longer time period for acceptance and financial commitment to demonstrate their potential.

The **CLOTHING CREATOR**™ will never replace cutting and sewing, but rather co-exist, just as the fine art of hand tailoring still endures. SYMAGERY now seeks a partner for this next industrial revolution.

Brett Stern
President
October 1, 1990

PLAN FOR COMMERCIALIZATION

SYMAGERY has developed a patented process to manufacture clothing without direct human labor. This **CLOTHING CREATOR™**, will have the ability to produce two (2) perfect garments every 45 seconds or one (1) every 30 seconds. The process will combine Computer Integrated Manufacturing (CIM) technology with heat molding and ultrasonic bonding/cutting techniques. This system for garment production, will have the capacity to produce garments of higher quality and at lower productions costs than convention cut and sew methods.

SYMAGERY is seeking to raise $1.3 million dollars in start-up capital for the building and testing of a full-scale prototype machine. We will consider creating a joint venture or limited partnership with a machine, apparel and/or textile manufacture to assist in producing and marketing the machinery to the apparel industry.

ACOMPLISHMENTS

- **Patent on process**
- **Engineering of machine design**
- **Located vendors of components**
- **Costs to produce garment from process**
- **Cost benefit analysis comparing cut and sew methods to our process**
- **Selected target markets where technology could be applied to**
- **Produced prototype garments**
- **Industry awareness and identification of product**

OBJECTIVE

- **Build and test equipment** - Complete engineering and build prototype.

- **Set-up pilot plant facility** - Have working machine to demonstrate to industry.

- **Develop joint venture** - Find partner to commercialize technology.

- **License patent and related information** - Distribute process to industry.

To prove the technology, the first products to be produced from the machinery will be disposable medical scrubs, operating gowns or related medical products from nonwoven materials. According to Nonwoven Industry (trade publication), the current dollar amount of medical disposable clothing purchased in the US is $200 million plus annually, with an anticipated growth of over 15% a year. This positive growth comes from the fact that nonwoven garments, compared with launderable garments, offer a more secure barrier when in contact with infectious material. Currently, over 95% of this production is in Mexico or Caribbean basin nations.

A medical garment has been selected for the first product because of it's simple shape and construction. The market for these garments puts a premium on function and cost. Nonwoven materials have also demonstrated to be highly adaptable to our process.

TECHNOLOGY

SYMAGERY has developed an automated process for garment manufacturing that has the capability to produce two (2) garments without direct human labor in 45 seconds or one (1) garment in 30 seconds. The process, which is patented, will combine Computer Integrated Manufacturing (CIM) technology with heat molding and ultrasonic bonding/cutting techniques. This system for manufacturing has the capacity to produce a garment of higher quality and at lower production costs than conventional cut and sew garments.

Fabric molding is accomplished by bringing the fabric, which is thermoplastic (plastic that is formed by the introduction of heat) by fiber specified content, up to its heat transition temperature (Tg) (molding temperature) and placing it in-between a male and female mold for a set-period of time. The fabric is then allowed to cool, which sets the material into it's three-dimensional shape. This shape is permanently in the material, although the cloth is completely soft and flexible and not affected by washing or drying.

Ultrasonics is high frequency vibration that "welds" the two pieces of fabric together, cuts off the excess and finishes the edges simultaneously.

Both of these technologies have been used in the apparel industry before, but not in the format that we are suggesting. The computers to run the machinery are standard machine control systems. The ultrasonics, computers, machine controls and related hardware are off-the-shelf components and available from numerous suppliers.

INNOVATIVE FEATURES

The process is capable of taking fabric from a bolt of cloth, manipulating the material into a three-dimensional shape, joining the pieces of fabric together and producing a finished garment. This is accomplished by keeping the fabric stationary while it is being processed. Conventional cut and sew methods required a great deal of material handling of the fabric which is limp and non-uniform in nature. It has been proven to be quite difficult to transfer the material with any type of robotic measures. Our method, on the other hand, looks at the process as a complete system for manufacturing. We accomplish our positioning by moving the machinery, which has defined parameters, around the stationary fabric, which is held in a pin tenter frame.

Our technology should not be considered revolutionary, but rather, evolutionary. The basic technologies, fabric molding and ultrasonics are inherent to the types of materials that are being employed. Most of the components exist from other industries, such as plastics, paper and web processing. Our machine design will use off-the-shelf parts, with limited custom fabrication.

SYMAGERY has completed the design of the machine, speed of production and has located potential vendors of the equipment. We have also simulated the process by fabricating numerous prototype garments that people have worn and given positive feedback on. This technology will accommodate a variety of knit, woven and nonwoven materials containing a majority of synthetic fibers, such as polyester, nylon, spandex and polypropylene. Among the many styles of garments that could be manufactured by this process are: work clothing, career apparel, athletic garments, medical disposables, health care products, activewear, haz/mat garments, military clothing, cleanroom clothing, outdoor wear, upholstery, doll clothing and highly contoured stuffed toy shells.

BENEFITS

The advantages to the manufacturer that adopts our technology are:

- **Greatly reduced production costs** - Since the process is highly automated, the inherent advantages now being enjoyed by the the low-labor-rate countries would be eliminated. Expenses that are directly related to labor, such as, production, inspection and maintenance would be reduced. Overhead costs and time for running the business and factory would also be decreased. Because of the integrated and compact nature of our equipment the amount of floor space would be lessen compared to conventional methods.
  - **30% of a garments cost is overhead expenses**
  - **25% of a garment cost is direct labor**

  Our process will focus on over 55% of the costs associated in garment production. While we do have slightly higher material consumption, our process is a complete system and costs must be evaluated on a finished garment, not on a particular part of it.

- **Increased quality of garments** - The elimination of the many stages of hand manipulation of the fabric required in the cut and sew procedure would greatly enhance the quality of the garments produced. Since the process involves only heat molding and ultrasonic bonding, it is capable of producing perfect clones every time. The problem of "seconds", which have always plagued the garment manufacturer would be eliminated. Problems of size variation due to different operator skill level would not occur. Moreover, thread breakage along the seams would not arise since there are no threads.

- **Reduction in lead time** - Since the total time of production of a garment by our process would be 30 seconds, a garment facility could be operated without loss of product quality around the clock. Garment makers could respond rapidly to changing market demands. The economy of dealing with smaller inventories, but at the same time being able to get additional deliveries of fast moving lines on short notice, is a crucial factor in competing with imports.

- **Capacity to make new class of garments** - Present product lines are limited both by technological and economic restraints imposed by cutting and sewing. Our technology will lead to the development of a whole new class of garments that are not feasible at present. Also, the fashion industry would be provided with options that are not available to other manufacturers.

PATENTS AND TRADE SECRETS

SYMAGERY currently holds a US patent on the process, # 4,645,629 [1] issued in 1987. We are actively perusing further patents on current developments in the US and abroad. The term **CLOTHING CREATOR**™ has a trademark application pending.

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[1] U.S. Patent #4,645,629

PROPRIETARY PROTECTION

Our current patent will last until the year 2004. We anticipate future patents, trademarks and copyrights to be secured once the equipment is fully engineered and prototyped. Because we have been developing this process for ten years, we will assume a direct leadership position in the industry. This has already been established by marketing and press coverage throughout the years.

EFFICIENCY

This system will combine textile processing equipment with Computer Integrated Manufacturing (CIM) techniques to produce clothing in a method that is simpler and more cost effective than the conventional cut and sew procedures that have been around for over 135 years with limited and incremental improvements. While, current methods produce a very finished product, one that our system cannot match yet, they have great difficulty in retaining product quality, speed of operation and cost control. Our technology will eliminate these production problems, control inventories and create garments that are not available with current technologies.

ENERGY RELATEDNESS

Since this process is a radical change from conventional cut and sew methodologies, we envision be numerous avenues through which the process will prove its energy efficiency. For example, the machinery is physically compact in size (approximately 5ft. x 20ft.) and a complete system to produce a two garments in one 45 second cycle. The amount of floor space would be reduced, HVAC (which is almost nonexistent in most garment factories) would not be required and electricity to run equipment and lighting would also be greatly reduced. We estimate the machine to require only 18 kilowatts of electricity per hour (aprox. $1.48/hour). With the small size and flexibility associated with the machinery, it is anticipated that manufacturing could be decentralized to geographic areas that need the production, such as, outside larger cities for the production of disposable medical clothing (hospitals) or cleanroom garments (electrical/food manufacturing) to smaller towns to assist in creating jobs and economic revitalization. Suppliers and end-users could respond to immediate market demands, which would lower inventory, decrease space requirements and reduce transportation costs. [2]

ENVIRONMENTAL EFFECTS

All fabric waste will be vacuumed from machinery and processed through a "rag-tear" machine which breaks down the material back into fiber for reprocessing. Because all of our fabrics are thermoplastic in structure, they are capable of being recycled back into fiber or fabric. We will also be investigating the usage of existing recycled material (polyester, polypropylene, etc) to be converted into fabric for our process.

2 National Institute of Standards and Technology and Dr Howard Olson, Georgia Institute of Technology technical reviews for Department of Energy grant.

JOB RETENTION

The cut and sew jobs that were lost over the past ten years will never be replaced. The apparel industry is described as the most labor intensive industry and has the most hours of direct labor or number of direct employees per wholesale dollars of all industries. It requires more people to add a dollar of value to the material than any other manufacturing industry. It is an industry of individual manual skills, supervision and training.

JOB CREATION

There will be jobs created to operate the machinery (computer controlled), and to build and service the machinery. More fabric will be needed, which will benefit the textile mill operators and all the allied jobs in running a factory. While the actual machinery to make the garment operates without direct human intervention, no factory or shop floor can operate without people giving instructions or making decisions.

CURRENT STAGE OF DEVELOPMENT

An engineering firm, VAUGHN PRECISION, Thomasville, N.C., that specializes in automation equipment design has been retained to design, engineer and produce cost estimates of the prototype machine. These tasks have been completed which demonstrate the machine motions, flow of material, speed and cost of production. Vendors of the machinery and allied components have been located, with interest from those companies to supply equipment and assist in our development when necessary.

VAUGHN PRECISION will oversee the final engineering, building and testing of the machine. They have ample facilities to set-up and demonstrate the equipment. Serial production of the equipment could also be produced from Vaughn's shop if need be.

Drawings have been created to exhibit the design and control systems of the machinery. Because of the proprietary nature of the drawings a review of the documents will be made available through Brett Stern. A summary of tasks to engineer, time schedule and costs for prototype and serial production are listed in the appendix.

METHODS FOR COMPLETION

SYMAGERY is open to a variety of arrangements to complete the project. The options are:

- SYMAGERY - working by self with just a capital investment from outside company.
- SYMAGERY + COMPANY - jointly develop technology using a combination of capital, personnel and facilities of investing company.
- COMPANY + SYMAGERY - investing company would license technology and build machine with its own personnel and facilities. Brett Stern and SYMAGERY would serve as consultants on the project.

MARKET ANALYSIS

CURRENT MARKET

Currently, in the U.S. we import over 55% of our clothing. This has more than doubled since 1975. Recent U.S. Department of Commerce figures indicate that garment imports now account for at least 17% of our national deficit. This can solely be attributed to cheaper labor and production costs overseas. The technology (sewing machines) is the same everywhere, but to be competitive in the retail marketplace, domestic manufacturers have had to set-up shop in the Orient or other low wage countries. The quality of the garments are the same, but the costs are less. Americans have demonstrated that the Crafted With Pride or Buy American, Because It Matters To Me campaigns, are irrelevant and that price is the major factor in purchasing similar garments.

Clothing production in the U.S. has continued to decline and imports are increasing annually at an accelerated rate. According to the Office of Technology Assessment, "if penetration of the US markets were to continue at the pace of the past decade (measured in terms of volume), domestic sales of US apparel firms would approach zero by the year 2000".

American apparel manufacturers have become apparel marketers. Their solution has been to continually locate a cheaper source of labor overseas.This will continue until there are fewer countries to exploit. As we become closer to a world economy, this search will eventually become arduous and working condition for the apparel worker will become more dehumanizing, resembling those of sweatshops.

MARKET IDENTIFICATION

INDUSTRY - CONSUMER GROUP

The industry is divided into two groups:

Consumer - all retail clothing for men, women and children, including outerwear, undergarments, athletic apparel, sportswear, etc.

Industrial - all garments used in a work environment, such as, medical, chemical, career apparel, military uniforms, work clothing, etc.

This technology relates to:

- Apparel manufacturers
- Apparel retailers
- Fabric and secondary suppliers
- Fashion designers

MARKET DEFINITION

- Anyone who wears clothes
- Any product constructed out of fabric

MARKET SEGMENTATION

The apparel manufacturing industry is extremely segmented, with product categories divided between women, men and children clothes. This diversity continues to breakdown to types of garments, such as, outerwear, sportswear, underwear, etc. Though this segmented system may seem complex, it could be used to our marketing advantage. Since there are numerous product categories, we would be able to give exclusives to numerous apparel manufacturers without conflict. This would enable our technology to be applied to a variety of products, create a multitude of retail and wholesale outlets and quickly establish a market demand and consumer awareness.

VOLUME OF UNITS - FIVE YEARS

Because of the radical change in production that we are advocating, it would not be prudent for us to suggest the number of machines to be sold. However, the garments that we anticipate to be manufactured are of the high-volume type and would require numerous machines to meet the market demands.

MARKET DIFFERENTIATION

Our machine will be the only machine on the market that can manufacture clothing without direct human intervention. The garments will be three-dimensional in structure and fit the human body more comfortably. SYMAGERY is the only company doing research that uses molding and ultrasonic as an alternative to current production methods. Our method constitutes a complete system for manufacturing a garment, with a continuous flow of material on one end and a completed garment on the other. The competition, whether industrial or academic, in this country or abroad, has all focused on automating single operations or making only incremental improvements on existing machinery.

ADVANTAGES OVER COMPETITION

To obtain a realistic and unbiased opinion of the apparel machinery industry, we have included a copy of a report sponsored by a MIT Commission on Industrial Productivity, MADE IN THE USA, which evaluated the American apparel industry.[3]

DISPLACEMENT OF TECHNOLOGY

SYMAGERY is currently the only company doing work in the described area of research. The only present competition comes from the Japanese MITI project, though this has focused on automating traditional technology and producing conventional clothing.

3 MIT Commission on Industrial Productivity, "Made In America", 1989

MARKET NICHE

The American consumer currently purchases over $70 billion dollars worth of clothing annually. In terms of location of that production, over 55% of that volume is from imports. It is however, unrealistic to predict the volume that our machine could capture. But it is already a fact that clothing consumed in our country uses over 65% synthetic or blended fabrics. Also, this figure does not include industrial clothing or products, such as our disposable medical garment. Since our process offers the manufacturer an opportunity to decentralize production, it is conceivable that garment production can and will return to the U.S.

EXISTING AND FUTURE MARKETS

Because of the speed of operation and the start-up costs associated with the process, only the larger apparel producers will accept the machinery. We would have the option to sell, lease or license the equipment to apparel manufacturers.

The apparel manufacturing industry has always taken a "lets see it run" and "how much does it cost" attitude. Since we are not currently marketing any product, we understand that we must physically, through a working prototype demonstrate to companies that this technology works and is financially feasible.

% OF MARKET TO CAPTURE

SYMAGERY would be as aggressive in marketing the technology as we have been in developing the machinery. A dollar figure would only be speculative. There is currently nothing out in the market similar to our machine or product.

We will be active in seeking opportunities throughout the process for technology transfer of the machinery by licensing the patent . We envision giving exclusives to garment manufacturers for particular types of garments, such as medical, industrial, or athletic clothing.

MANAGEMENT

- **Brett Stern**, president developed the technology in 1980 as part of his senior thesis for a degree in Industrial Design at the University of Cincinnati. He has been the principal investigator, as well as, running SYMAGERY in an entrepreneurial fashion. Mr. Stern and SYMAGERY have supported the project financially over the years through outside consulting work, government grants and personal investment. Brett Stern's role has involved technical expertise and hands-on research to define the process and secure the required financing, while serving as the project organizer delegating only those responsibilities that require greater expertise in specific areas, like engineering, marketing, or law. Brett Stern has invested over ten years in the project and has committed himself to seeing the project to fruition.

  His knowledge includes a thorough understanding of the technology, its economic and social implications and probably most importantly what will work in a real manufacturing environment. Brett Stern has also presented research papers in the US, Canada and Europe. Mr.Stern also teaches "Inventions and Entrepreneurship" at Parsons School of Design, NYC.

Currently all staff are retained as consultants. They include:

- **Cam Tibbels**, Vaughn Precision, Thomasville, NC. President, registered mechanical engineer. Mr Tibbels was retained for the original engineering phase and will oversee the final engineering, building of the prototype and testing of the equipment.

- **Jim Alterbaum**, Parker Chapin, NY, NY. Attorney. Mr Alterbaum and firm handles all legal and contractoral arrangements for the company.

- **Jeff Bass**, Jeff Bass Associates, Lake Success, NY. Mr Bass is a business consultant and advises on financial, licensing and related matters.

- **Stanley Berger**. Berger, Sudran, Dizenhaus and Associates, NY, NY. Certified public accountants. Mr Berger has been handling accounting and tax matters since 1984.

FIRM

SYMAGERY'S lead time in developing this technology will surely be advantageous when other companies try to copy the technology. This know-how will ensure SYMAGERY'S position in being the vanguard in the industry . The project has already attracted a considerable amount of press coverage all over the world identifying SYMAGERY as the developer of the technology.[4]

BUSINESS STRUCTURE

SYMAGERY is an Industrial Design firm located in New York City. It is a New York State corporation established in 1980. Their primary work is high-tech research, specializing in new product development. All stock has been issued to Mr. Stern.

DIFFICULTIES IN NEW VENTURE

To date, the difficulties have been in demonstrating to the apparel industry, whether machine or garment maker, that this technology works and how much it will cost. Added to this, the industry has been using the same technology, the sewing machine which dates back to the 1850's. It is an industry that is not known for capital expenditures or developing new process technology. The trade-off will be that companies would have to sacrifice short-term profits to purchase new equipment.

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4 Press

FINANCIAL PROJECTIONS

COST/BENEFIT ANALYSIS

We selected an operating room scrub blouse as a sample garment for the cost/benefit analysis. The garment would be produced from a polyester or polypropylene nonwoven material with annual production of 1million + garments. The operating room garment was selected because of its simple form and construction.

VAUGHN PRECISION provided operating costs for the **CLOTHING CREATROR**(TM) and Professor Irwin Kahn from Fashion Institute of Technology provided the costs for a comparable style garment that would be cut and sewn. SYMAGERY has been assisted by the Department of Commerce, Office of Productivity, Technology and Innovation to provide financial projections of our process compared with conventional cut and sew methods[5]. John Hiezer, a computer scientist, has run a financial computer model that they have developed for automation in manufacturing.

To summarize the results:

- Cost for the **CLOTHING CREATOR**(TM) - **$0.48** per garment with **3** employees
- Cost for conventional cut and sew - **$0.57** per garment with **17** employees

The complete model is presented in the appendix.

The process reduced labor costs by 73% and the amount of workers by 15 people. In comparing the costs, we used similar figures for the indirect overhead charges. We anticipate these charges to be lowered once production starts and true costs can be determined in a factory environment.

PRICING AND PROFITABILITY

We have estimated that serial production of the machinery will cost us $132K to produce. This would include the basic machine and computer . Molds would be additional (a set of aluminum cast molds for a medical scrub top would be approximately $12K). This could then be sold to an apparel manufacture for $350K - $400K There would also be a continuous demand for different size and styles of molds and for service contracts. We would have the option to sell, lease or license the equipment to apparel manufacturers. We also anticipate charging a <u>royalty</u> on production. With every garment produced, SYMAGERY and its investors will receive financial restitution.

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5 Department of Commerce computer model cost/benefit analysis

CAPITAL

REQUIRED FUNDING

AMOUNT - $1.3 million dollars.

TIME - 18 months to build and test machine. [6]

Monies will be used to cover the following expenses:

• Building machine	$995,000
• Salaries	106,000
• SYMAGERY overhead	196,000
TOTAL	$1,300,000 [7]

Management will raise the required financing through the private placement of Symagery's common equity.

CURRENT FUNDING

To assist SYMAGERY'S efforts, we are currently under the aegis of the U.S. Department of Energy (DoE), Energy Related Inventions Program (ERIP) to help supplement this present phase of work. A grant for $70,750 was awarded in September 1989. To procure this grant, the technology received a positive technical review from the government's testing labs, National Institute of Standards and Technology (NIST) and Dr. Howard Olson, a professor at Georgia Institute of Technology, Textile Engineering Department. Brett Stern, SYMAGERY'S president and principal investigator, has also participated in the DoE commercialization workshop.

In July 1990, a proposal was approved for funding by the New York State Department of Energy Research and Development Authority (NYSERDA) for a grant in the amount of $70K. As of October 1, 1990, this contract is being negotiated for funding and we expect monies by December 1990. This program can provide up to $500K, by way of a $ for $ match from private sources. Repayment of these funds are required and we are currently negotiating with NYSERDA these arrangements.

6 Tasks and time schedule

7 Salary, overhead and machine costs

PAST FUNDING

SYMAGERY has received funding from the National Science Foundation, Phase 1 SBIR grant, 1984 ($35K) and New York State Science and Technology Foundation, matching SBIR grant, 1985 ($35K).

SYMAGERY having started this project in 1980, has also invested over $150K for research to date. Brett Stern has provided an equal amount through sweat equity investment during that same time period.

REFERENCES

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Fashion Institute of Technology
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APPENDIX

1 - US Patent #4,645,626

2 - Department of Energy technical reviews. National Institute of Standards and Technology and Dr Howard Olson, Georgia Institute of Technology.

3 - MIT Commission on Industrial Productivity, "Made in America", 1989

4 - Press

5 - Department of Commerce, Office of Productivity - computer model on cost/benefit analysis

6 - Time and task schedule

7 - Salary, overhead and machine costs

United States Patent [19]

Stern

[11] **Patent Number: 4,645,629**

[45] **Date of Patent: Feb. 24, 1987**

[54] **METHOD OF MANUFACTURING HEAT MOLDING GARMENTS**

[76] Inventor: **Brett Stern**, 111 W. 28th St., New York, N.Y. 10001

[21] Appl. No.: **745,011**

[22] Filed: **Jun. 14, 1985**

[51] **Int. Cl.**[4] **B06B 3/00**

[52] **U.S. Cl.** **264/23**; 2/169; 156/73.3; 156/228; 156/245; 156/251; 264/25; 264/153; 264/163; 264/248; 425/174.2

[58] **Field of Search** 264/248, 23, 25, 292, 264/231, 324, 153, 163; 425/174.2; 156/73.1, 73.3, 245, 251, 228, 292, 272.2; 128/463, 504, 506; 2/169, D7

[56] **References Cited**

U.S. PATENT DOCUMENTS

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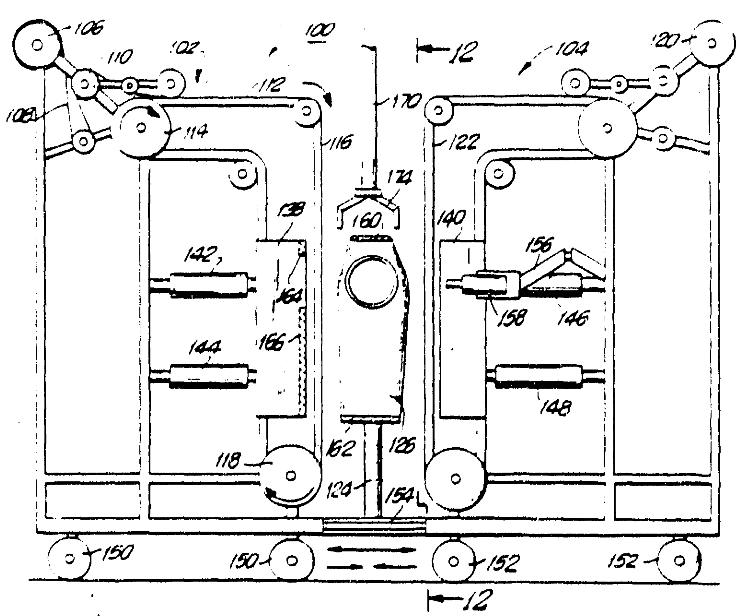
4,034,853	7/1977	Smith	2/169 X
4,392,257	7/1983	Furga	156/251
4,459,704	7/1984	Sears et al.	264/292

Primary Examiner—Jan Silbaugh
Assistant Examiner—Harold Pyon
Attorney, Agent, or Firm—Helfgott & Karas

[57] **ABSTRACT**

A method and apparatus for manufacturing a garment which is three dimensionally molded. The garment in the form of opposing sheets of fabric are fed from bolts of fabric to a molding station wherein a male mold section is provided in the shape of the three dimensional garment desired. A pair of opposing female mold sections close onto the male mold section sandwiching the sheets of fabric into the mold cavities. Heat is applied to mold the fabric sheets into the three dimensional garment. Simultaneously, an ultrasonic seamer cuts and bonds the periphery of the material around the mold. The mold cavity is then opened, portions of the mold are separated and the garment is then lifted off the male mold section.

11 Claims, 12 Drawing Figures



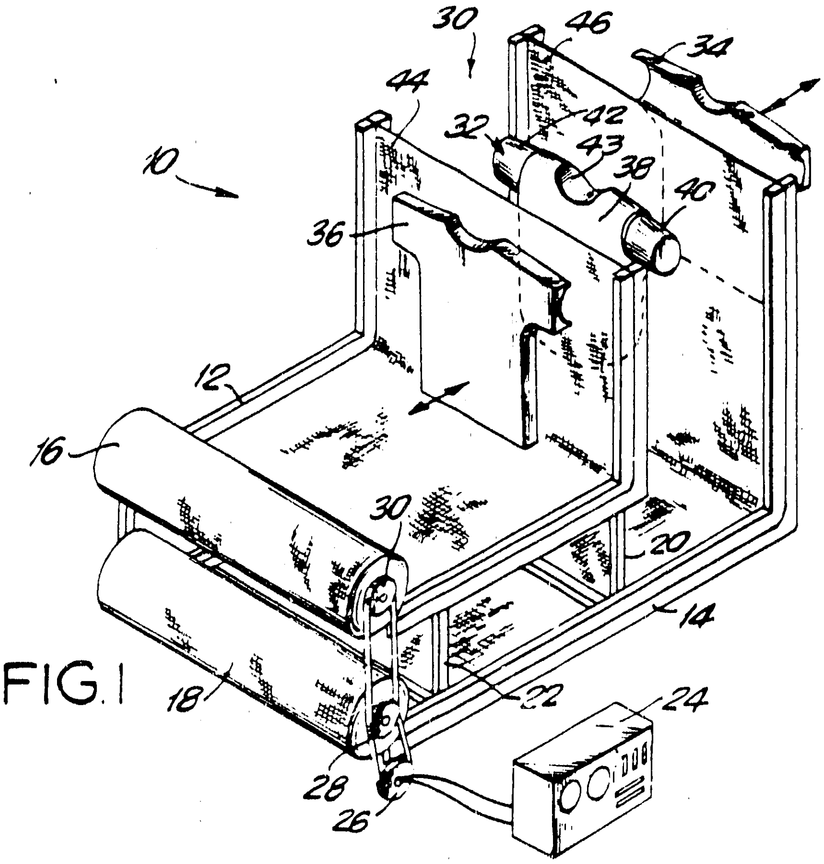


FIG. 1

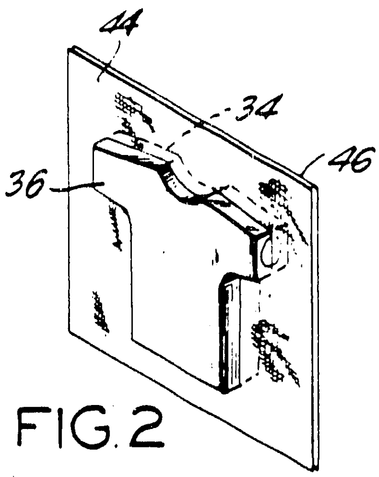


FIG. 2

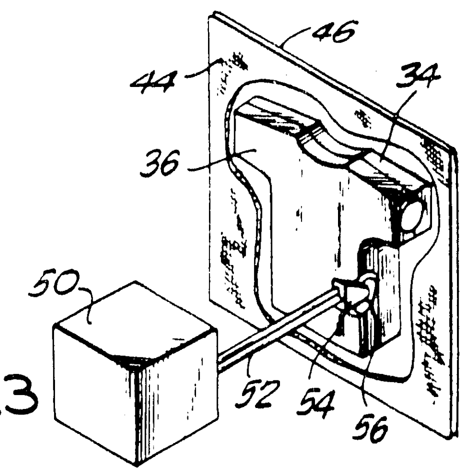


FIG. 3

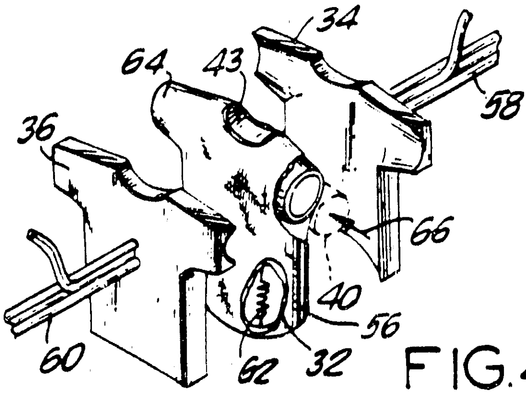


FIG. 4

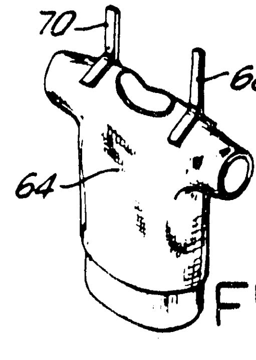


FIG. 5

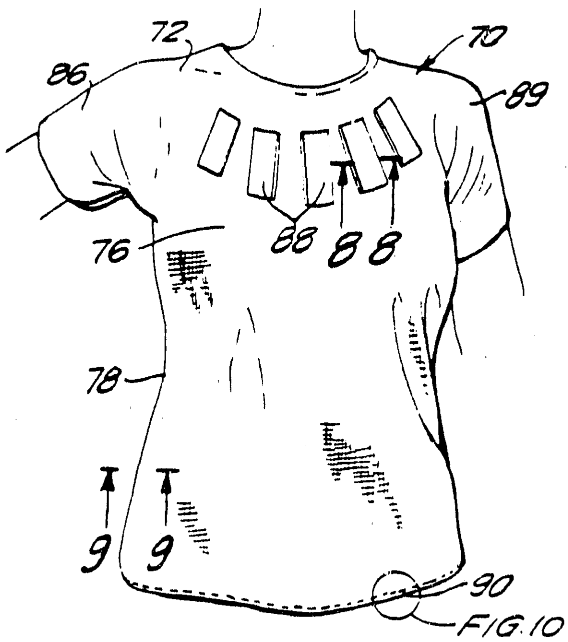


FIG.6

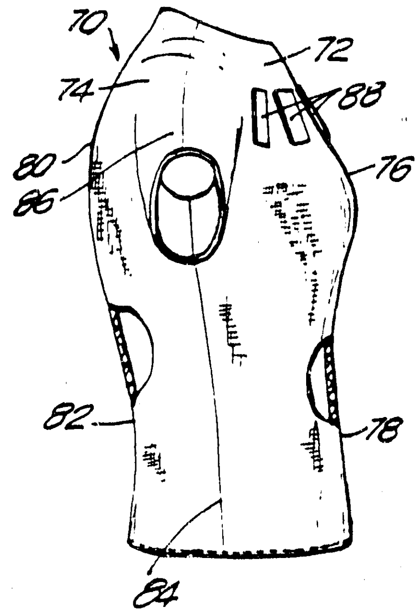


FIG.7

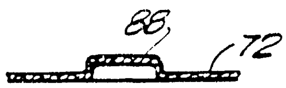


FIG.8

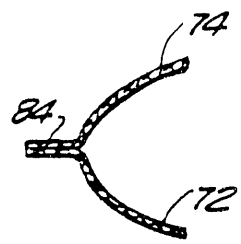


FIG.9

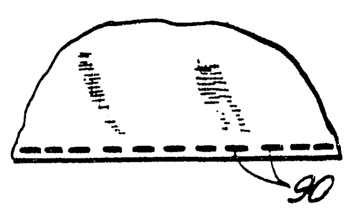


FIG.10

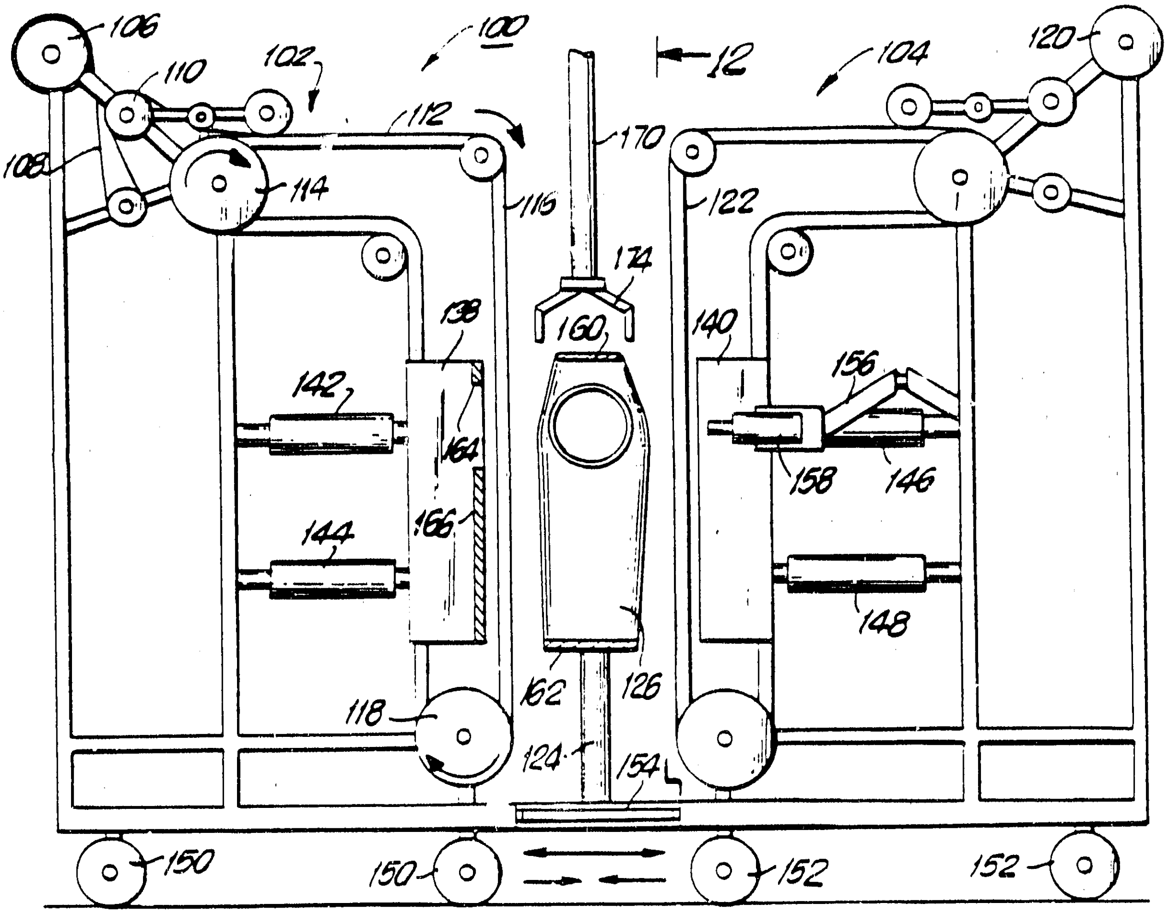

106
110
102
100
112
12
104
120
108
114
116
170
122
174
138
160
140
142
164
156
158
146
144
166
148
162
126
118
124
154
150
150
152
152
12

FIG.11

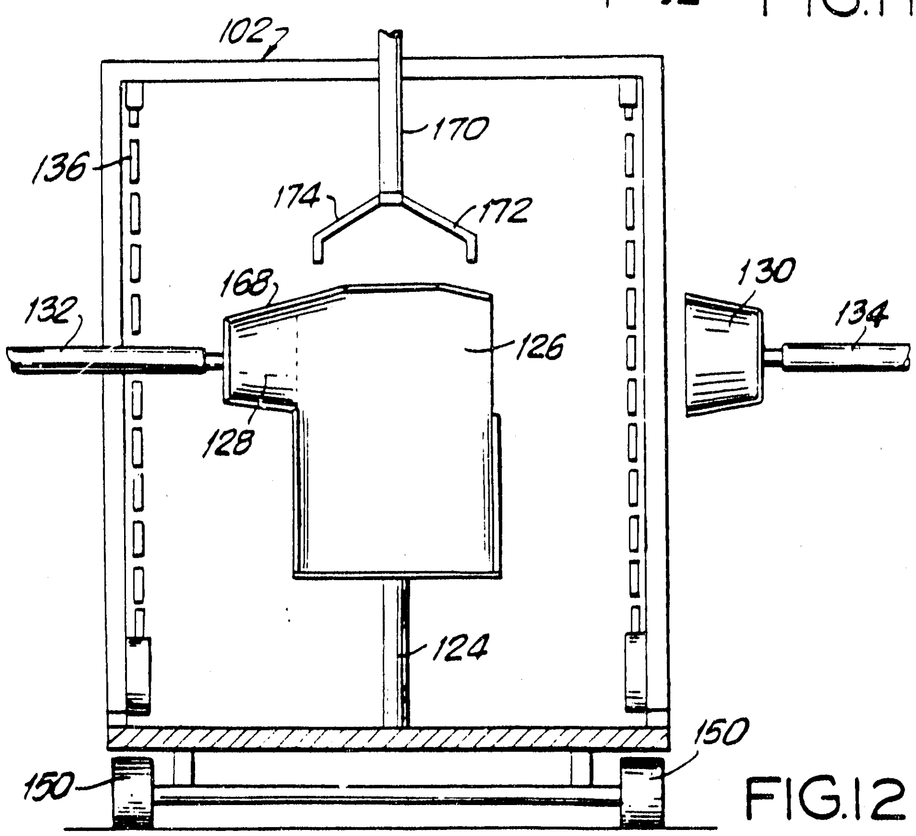

102
170
136
174
172
168
130
132
134
126
128
124
150
150

FIG.12

METHOD OF MANUFACTURING HEAT MOLDING GARMENTS

BACKGROUND OF THE INVENTION

This invention relates to heat molded garments, as well as to a method and apparatus for the manufacture of such garments, using the combination of heat molding techniques and ultra sound bonding techniques.

Historically, the garment manufacturing industry has utilized well known cut-and-sew procedures in the manufacture and production of garments. Typically, a pattern is created and fabric material is cut in accordance with the garment pattern. The various sections cut are then sewn together to form the particular garment.

Clothing production is an extremely labor intensive process. There are approximately forty separate steps involved in the manufacture of a single garment, such as a dress. Although there has been a significant modernization of the individual steps involved in garment manufacture, it still remains basically the same cut-and-sew operation that has been in existence for over a hundred years. Even with the introduction of newly developed laser cutting and automatic sewing machines, the manufacture of the garment still requires much hand manipulation of the fabric. Not only does this make the process highly labor intensive, but also causes many quality control problems because of the impossibility of achieving precise replication of manual manipulations.

An additional problem with the existing cutting and sewing techniques is that the resulting garment is one that is substantially two dimensional. Beginning from a pattern and cutting designs and sections and ultimately piecing them together results only in a flat garment having front and back portions. Since the garment is to be worn by a three dimensional human form, numerous techniques have been introduced to permit the two dimensional fabric to achieve a proper shape on the human form. Darts, ruffles, pleats, and similar gathering of material is formed at various portions of the fabric design in order to simulate a three dimensional form.

Nevertheless, because of the standard techniques, great imposition is placed upon designers who must restrict their capabilities to two dimensional patterns. In addition, the garments themselves frequently do not lie properly on the human form and unsightly bulges appear, or sections may stretch greater than their capabilities.

In order to permit actual three dimensional formation of garments, various techniques have been introduced in the past. For example, after the introduction of knitted fabics, the inclusion of additional stitches in the fabric design permitted a three dimensional shape in such knitted garments. Utilizing complex knitting machines, such additional stitching could be achieved. However, this approach was limited to knitted fabrics and also required extremely complicated design and control of the knitting machines.

A more recent development is the ability to actually mold garments into three dimensional form. Although garment molding machines were introduced in the early 1900's, they were not utilized to great extents until the invention of appropriate fabrics which accommodate thermo-setting techniques. The introduction of man made fibers and synthetic thermoplastic continuous yarn such as nylon or polyesters, gave greater feasibility to the molding of garments. However the capabilities were little utilized in garment production. The use of

such molding techniques has generally been limited to the formation of specialized items such as brassieres and bra cups for swimwear, and the like. By way of example, U.S. Pat. No. 3,077,196 was one of the first to introduce a one piece molded plastic brassiere fitted with a non molded elastic band on the back. Likewise, "seamless" garments were also introduced utilizing molding techniques. In fact, in many cases the "seamless" bra has become the common terminology of molded brassiere cups.

Little, however, was done to utilize the molding technique for overgarments such as dresses, shirts, and the like. Nevertheless, U.S. Pat. No. 3,819,638 did introduce a method of making molded ladies dresses from knitted fabrics. That patent, however, utilized a cylindrical fabric and stretched the fabric in its cylindrical form over a mold in order to make an appropriate tubular dress. Sleeves, and other portions were molded in tubular fashion and sewn onto the main body portion.

While certain of these molding techniques have been known and developed, they have been essentially limited to experimental use mainly because the techniques introduced failed to lend themselves to automated continuous formation of garments. Additionally, they failed to provide for the ability of simulating the production of the garment with that of standard cut and sew techniques. As a result, thus far the garment industry still depends upon the standard cut and sew methods and the use of molded garment techniques have failed to achieve inroads in the garment industry.

SUMMARY OF THE INVENTION

It is accordingly an object of the present invention to provide a method of manufacturing a garment which avoids the aforementioned problems of prior art devices.

Another object of the present invention is to provide a method of manufacturing a garment utilizing heat molding techniques which can be applied to an automated sequence of operations.

Yet a further object of the present invention is to provide a method of manufacturing a garment utilizing the combination of heat molding techniques and ultrasonic bonding techniques.

An additonal object of the present invention is to provide a method of manufacturing a garment utilizing an automated process involving heat molding of the garment and simultaneous ultrasound bonding of the seams of the garment being molded.

Another object of the present invention is to provide an apparatus or the automated manufacturing of garments using heat molding and ultrasonic bonding techniques.

Yet a further object of the present invention is to provide a garment having a three dimensional form produced by heat molding and including ultrasonically bonded seams.

Yet a further object of the present invention is to provide molds for use in connection with automated processes for forming garments through heat molding techniques.

Briefly, the present invention provides for a method of manufacturing garments which lends itself to automated processes. The method includes feeding opposing sections of fabric material along a conveyer system leading to a molding section. The molding section includes a male mold conforming to the particular three dimensional body configuration of the garment to be molded. For example, it can conform to the upper torso portion when molding a shirt, blouse, or the like. There are also provided an opposing pair of female mating mold sections for closing onto the male mold and defining opposing mold cavities on either side of the male mold section. The opposing sections of fabric material are positioned on either side of the male mold within the mold cavity. The female mold sections are closed onto the male mold with heat applied, to thereby mold the garment into the shape desired. While the molding is taking place, an ultrasonic device carries out bonding and cutting whereby the garment is cut around the periphery of the mold an at the same time the opposing sections are bonded together. In this manner the garment is finished on the mold form. After suitable cooling, the mold cavity is opened and the garment is removed.

In removing the garment, the mold itself is formed with separable portions to facilitate the removal of the garment. For example, in the formation of a blouse, the arm sections of the mold can be removed or retracted with respect to the body portion of the mold to permit release of the garment. The garment is then lifted up by means of a robotic lifter.

The invention also contemplates apparatus for carrying out the above mentioned manufacture process. Also, the invention contemplates the mold required for utilization within such apparatus.

Also included within the invention is a garment itself molded into a three dimensional configuration including a three dimensional front portion and a three dimensional back portion with ultrasonically bonded seams joining the front and back portions.

The aforementioned objects, features and advantages of the invention will, in part, be pointed out with particularity and will, in part, become obvious from the following more detailed description of the invention, taken in conjunction with the accompanying drawings, which form an integral part thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a schematic representation of the apparatus for manufacturing a three-dimensional garment, including the feeding of the fabric as opposing sections on either side of the male mold portion using a system controlled conveyer;

FIG. 2 is a schematic drawing showing a further step in the manufacture with the closing of the female mold portions onto the opposing sections of the fabric;

FIG. 3 is a schematic representation of the ultrasonic cutting and seaming of the edges of the opposing sheets of fabric while still in the mold;

FIG. 4 shows a further step in the manufacturing process and specifically the opening of the mold cavity and the removing of a section of the mold.

FIG. 5 shows yet another step in the manufacture including the removal of the completed garment from the male mold portion;

FIG. 6 is a front view of a molded garment manufactured in accordance with the steps previously described;

FIG. 7 is a side view of the garment shown in FIG. 6 and specifically showing the three dimensioned molding of both the front and rear fabric sections as well as the molding of the sleeve portion;

FIG. 8 is a cross sectional view taken along lines 8—8 of FIG. 6 and showing the molding of a three dimensional graphic design directly in the garment simultaneous with the formation of the garment;

FIG. 9 is a cross sectional view taken along lines 9—9 of FIG. 6 and showing the ultrasonically bonded seams between the opposing front and rear sections of the garment;

FIG. 10 is an exploded view of the lower edge of the garment and showing an ultrasonically bonded stitching arrangement simulating a sewn stitch;

FIG. 11 is a detailed schematic view of an apparatus for forming the three dimensional garment of the present invention, and

FIG. 12 is a side view looking in at 12—12 of FIG. 11.

In the various figures of the drawings, like reference characters designate like parts.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, there is generally shown an apparatus **10** including an upper conveyer system **12** and a lower conveyer system **14**. A bolt of fabric **16** is connected to the upper conveyer **12** and a second bolt of fabric **18** is connected to the lower conveyer **14**. The conveyer system can typically include a pin frame which serves to fix and stabilize the fabric as it is fed along the conveyer system. The conveyers are shown spaced apart by means of separating supports **20**, **22**.

The conveyer is driven by means of a system controlled unit schematically shown at **24**, electrically connected to the appropriate belt drive mechanism **26** coupling to the drive **28** associated with the bolt of fabric **18** and the drive **30** associated with the bolt of fabric **16**. The system control **24** is appropriately arranged so that it simultaneously moves the upper and lower fabric material along their conveyers until the material is properly fed into the mold section. Appropriate synchronisation will be used to drive the fabric and the conveyer system in order to coordinate smooth flow. A motor drive will serve to unwind the fabric from the bolts and properly feed them onto the pin frames.

The mold serves, shown generally at **30**, comprises a male mold **32** and spaced apart a pair of mating female molds **34**, **36**. The particular molds are of a form to make a shirt and therefore the male mold portion **32** is in the form of a upper torso including a body portion **38** with a pair of opposing arm portions **40**, **42** laterally positioned thereof, and a cut out neck portion **43**. The female mold portions likewise have corresponding sections to close onto the male mold portion. Together, a pair of opposing mold cavities are formed between each of the female mold sections and the male mold sections.

The conveyer belt feeds a first section of fabric material **44** between the female mold portion **36** and the male mold section **32**, and a second opposing sheet of fabric material **46** between the female mold portion **34** and the male mold **32**. As soon as the two sheets of fabric **44**, **46** have been fed into the mold cavities, a suitable timer contained within the control system **24** will stop the conveyer. The mold, which is maintained at a predetermined temperature will then close for a preselected length of time. As shown in FIG. 2, the opposing sections of fabric **44**, **46** are then heat molded within the mold cavities. The heater for the molding operation can be implanted within the mold itself or can be from an external source.

Simultaneously with the molding operation, an ultrasonic seamer, shown at 50 in FIG. 3 will make a complete transverse around the perimeter of the mold in order to bond together the opposing sheets of fabric material 44, 46. At the same time, it will serve to cut away the surrounding fabric around the mold. The ultrasonic seamer is shown in include a robotic arm 52 with an appropriate cutting edge 54 which simultaneously serves to seal the sheet of fabric. An appropriate bond 56 will be formed between the front and back sheets of fabric.

As shown in FIG. 4, the mold will remain closed for a short interval of time after the heating operation in order to appropriately cool the garment. Cooling can also occur after the mold reopens with the garment remaining upon the mold, as shown in FIG. 4. The opening and closing of the mold can be achieved by means of a pneumatic device 58, 60 for retracting and compressing the mold sections. The appropriate tubes with compressed air would operate the pneumatic device. As is shown in FIG. 4, heating can take place by means of electrical heaters such as the resistance wire 62 embedded directly within the mold. However, it should also be appreciated, that other type of heating arrangements could also be used, wherein the heating can be in the female mold portions, or exteriorly. Appropriate temperature control sensing devices would be included. These can be implanted in the various portions of the mold such as the exterior portions thereof.

The garment 64 is shown as being completely formed onto the male mold with appropriate ultrasonically bonded seams. In order to remove the garment, the molds are made with separating portions. Specifically, as shown in FIG. 4, the arms 40 of the male dye are shown as being retractable internally of the body portion as shown by the arrow 66. Appropriate spring mechanisms, pneumatic control, etc., can be embedded within the mold itself in order to retract the projecting portions of the mold. Alternately, portions can be removable, as by a pneumatic arm.

Once the garment is free from restriction, a suitable robotic lifter whose arms 68, 70 are shown in FIG. 5, can be used to pinch the fabric so as not to damage it. The fabric can then be lifted up from the mold as a finished garment and delivered to a secondary system for suitable labeling, packaging, etc.

As soon as the lifter has cleared the garment from the mold, the drive mechanism reactivates the conveyer belt and the entire cycle is completed.

The apparatus required to carry out the device can be a composite of various equipment much of which is readily available. For example, the ultrasonic seamer and cutter can be of the type available from BRANSON SONICS INC. The lifter can of a type manufactured by CLUETT who supply a line of "Clupicker" products. Other parts of the equipment, such as an adjustable electric clock mechanism to start and stop the drive motors, are also well known. The master control system itself can be an appropriate driving mechanism which starts and stop the conveyer belt.

The molds themselves can be contructed in various manners. By way of example, two half-body molds of the upper torso of a body portion can be constructed using standard garment industry dress forms. For example, separate negative casts of the front and back halves of the torso can be constructd from the dress form using hydrostone or other gypsum type of material. These negative hydrostone casts can then be used to construct

two aluminum working molds for use in the processing system. The aluminum casting can then be provided with the electrical heating elements together with temperature sensor controllers and watt meters for measuring power consumption. The molds can be made with retracting or removable portions such as the arm portions, which will permit separation of these parts to facilitate removal of the garment.

Using cad-cam software techniques, the mold itself can also be constructed in accordance with the actual configuration of a wearer. A suitable "mouse" or other sensor can be used to plot the various three dimensional characteristics of the actual wearer using standard cad-cam techniques. A computer can generate the appropriate dimensions for the manufacture of the mold. In this manner, each wearer can actually have a mold in accordance with his actual dimensions and garments can then be manufactured to fit each particular wearer where the garment itself is three dimensions in accordance with the actual dimensions of the wearer.

Referring now to FIGS. 6 and 7, an actual garment 70 has been constructed in accordance with the previously mentioned techniques. The garment itself is formed of a front fabric section 72 and a rear fabric section 74 and forms the shape of a t-shirt or blouse. It should be noted that the front section 72 is three dimensioned so as to actually include a projecting chest portion 76 and an indented waist portion 78. Similary, the back portion 74 is contoured to have a rounded back portion 80 and an indented waist portion 82. The front and back sections are interconnected along an ultrasonically boned seam 84.

As is noted, the sleeves 86 88 are actually formed of front and rear sections integrally with the rest of the body portion. This is quite contrary to standard cut and sew techniques where the sleeve portions would be formed independently and sewn onto the body portion. Since the front and back sections are each molded from a respective single sheet each can actually include a half of a sleeve portion with the two sleeve halves being ultrasonically bonded together along the same seam line 84.

In addition to molding the garment into a configuration to fit the wearer and have an appropriate shape of the body portion, three dimensional graphic designs can also be included. By way of example, the rectangular three dimensional projections 88 are molded directly into the upper front portion 72. As best shown in FIG. 8, these projections are actual three dimensional portions molded out of the fabric front sheet 72. Other type of graphics can also be molded into the design. In fact, appropriate creases, pleats, etc. can be molded into the design along with ruffles and other three dimensional forms.

The ultrasonic bond 84 which forms a seam between the front and rear fabric sheets 72, 74, is best shown in FIG. 9. However, as shown in FIG. 10, the ultrasonic bonding can provide an effect similar to that of stitiching. Specifically, the lower edging is shown to include a plurality of individual bonded intervals 90 spaced from each other in order to simulate a stitching. The use of simulated stitching permits the fabric to stretch. In addition to the ultrasonic bonding, the same operartion can also provide graphic designs by using ultrasonic bonds at various locations in order to produce the design itself.

The type of material which is best suited for such molding techniques is typically a thermosetting material, and especially materials including synthetic man made materials. Types of fabrics used for such molding techniques includes polyester, nylon, acrylic, any blends of these materials with natural fibers such as cotton and wool, as well as a variety of knit materials. However, almost all garments can have thermosetting properties depending upon the temperature, time and pressure involved.

Referring now to FIGS. 11 and 12, thre is shown a specific structure constituting an automated apparatus for manufacture of a garment in accordance with the present invention. The apparatus includes a tenter frame 100 having substantially similar left portions 102 and right portions 104. On the section 102, there is provided a bolt of fabric 106 which feeds the fabric 108 along a series of tensioning belts 110 from which the fabric extends onto the conveyer 112 driven by the drive wheel 114. The fabric passes downward along the vertical section of the belt 116 and is held in a taut position by means of the lower control wheel 118.

A similar arrangement occurs on the right side with another bolt of fabric 120 feeding the fabric along the vertical conveyer section 122.

Supported on a post 124 in between the two tenter frame sections 102, 104, is a male mold form 126 in the form of a body torso having a pair of opposing arm portions 128, 130. The arm portions are connected to pistons 132, 134 in order to remove the arm portions 128, 130 so as to permit lifting of the garment off the mold.

The tenter frame 102 and 104 includes side pin plates 136 to support the fabric on each side and maintain it in a taut condition on opposing sides of the male mold 126. Spaced behind each of the vertical fabric sections 116, 122 are respective female mold sections 138, 140 for mating with the male mold section 126. The female mold sections are supported by means of pistons 142, 144 and 146, 148 to move the female sections onto the mold section thereby closing the mold cavity. The left tenter frame 102 is supported on wheels 150 and likewise the right section is supported wheels 152. By means of the telescoping arrangement along the rod 154, the two tenter frame sections can be respectively moved toward each other to open and close the tenter frame around the male mold 126.

In opearation, the fabric is fed respectively from the bolts 106, 120 to position them in the vertical sections 116, 122 on either side of the male mold 126. The left and right halves of the machine roll on the wheels to open and close the tenter frame around the positive mold. The piston arms 142-148 then move together to close the mold cavity and heat is applied to mold the fabric into the desired shape. A robotic arm 156 carrying an ultrasonic welder 158 would then be rotated around the mold cavity. Appropriate perforated anvil sections 160, 162, 164 and 166 would form the stitching arrangement around the periphery of the garment, the neck portion, the hems, and around the sides. A solid anvil portion 168, around the outer periphery of the garment would serve as the mating portion for the cutting of the garment.

After the garment has been molded and properly ultrasonically bonded and cut, the garment would be permitted to cool. The left and right halves would open and the pneumatic arms controlling the female mold sections would be retracted. The arm portions 128, 130 of the mold would be removed. A garment lifter 170 having a pair of opposing pinching arms 172, 174 would be lowered to grab the garment and lift it off the male mold section, the process would then again repeat for a next garment.

By having both the tenter frame and the mold sections each moveable, it is possible to obtain a better tension on the fabric prior to heat molding of the fabric.

As a result of the present method, the garment can be manufactured in an automated process with minimal amount of labor. All of the operations can be automated and mass produced without any labor intensive requirements. Furthermore, designers can now have an opportunity to expand their design abilities since they are no longer limited to two dimensional fabrics but can produce three dimensional effects using either the molding, bonding, or the combination of both techniques.

There has been disclosed heretofore the best embodiment of the invention presently contemplated. However, it is to be understood that various changes and modifications may be made thereto without departing from the spirit of the invention.

DISCLOSURE DOCUMENT PROGRAM

A brief description of the above invention has been submitted as part of the "Disclosure Document Program" and has been assigned Disclosure Document #132372. The document was dated Nov. 7, 1984.

What I claim is:

1. A method of manufacturing a garment, comprising the steps of:
   (a) feeding opposing sections of flat uncut thermosetting fabric material, in full, from bolts of such fabric material, to a heat molding section;
   (b) positioning the opposing sections of said flat uncut thermosettiong fabric material, in full, on either side of a male mold of the garment shape to be formed;
   (c) closing a pair of female mold sections onto the male mold to sandwich the fabric in the mold cavity formed between the male mold and the female mold section;
   (d) heat molding the opposing sections to form a three dimensional garment shape including heat molded three dimensional body contours; and
   (e) simultaneously with the heat molding, ultrasonically bonding and cutting about the periphery of the female sections to form the desired garment.
2. A method as in claim 1, and further comprising the step of opening the mold cavity and removing the garment.
3. A method as in claim 1, wherein only one unitary section of fabric is utilized for forming the front of the garment and another unitary section of fabric is utilized for forming the back of the garment.
4. A method as in claim 1, and further comprising removing parts of the mold after completing the garment to facilitate removal of the garment.
5. A method as in claim 2, and further comprising retracting parts of the male mold after completing the garment to facilitate removal of the garment.
6. A method as in claim 2, and further comprising the step of allowing the garment to cool after the cavity is opened and prior to removal of the garment.
7. A method as in claim 1, and further comprising the step of indexing the opposing sections of fabric material on a pin frame as it is fed along a conveyer system.
8. A method as in claim 2, and wherein said removal of the garment comprises the steps of pinching the garment using a robotic lifter and lifting the garment off the mold.

9. A method as in claim 1. and further comprising heat molding a three dimensional ornamental design into the garment.

10. A method as in claim 9. wherein the three dimensional contour and the three dimensional ornamental design are simultaneously molded into the garment.

11. A method as in claim 1. and further comprising ultrasonically forming designs into the garment simultaneously with the bonding.

* * * * *

FINAL TECHNICAL REVIEW
An Automated Process for Garment Manufacture
OERI No. 012302

INTRODUCTION

The invention, "An Automated Process for Garment Manufacture," was submitted for evaluation to the Office of Energy-Related Inventions by Mr. Brett Stern of the Symagery Company, New York, New York, on July 20, 1987, under Section 14 of the Federal Nonnuclear Energy Research and Development Act of 1974.

It was entered into first-stage evaluation on August 4, 1987, and after one consultant review, it was entered into second-stage evaluation on September 30, 1987, resulting in this recommendation.

The invention has been developed to the prototype stage. The technology is covered by U.S. Patent No. 4,645,629.

DESCRIPTION

The invention is an automated process for manufacturing garments. Cloth is fed from opposite sides of the production hardware toward the center, where the cloth is clamped by female molds over a mannequin-like torso to give a three dimensional drape to the cloth. Computer-controlled ultrasonic horns pass along the edge of the clamped molds, cutting the cloth from the bolt and welding the seams in place. The molds then open, the arms retract into the torso portion, and another arm reaches down and lifts the garment off the torso portion of the mold. The cycle then repeats itself. A simple garment can be produced about every 45 seconds. This production rate would be about 5 times faster than could be done with conventional sewing machines making the same garment. It is estimated that this process would replace a required battery of about 72 sewing machines working in parallel. About 72 machines working in parallel are required to make the various sub-assemblies of garments that are then sewn together into five garments. These five garments would be made up from the various sub-assemblies in the same amount of time required for the inventor's process to make twenty-five garments.

The process can be used only with high synthetic fiber content textiles, over 50 percent synthetic being required for the ultrasonic welding process. A low natural fiber content is required to be able to hot-deep-draw the material without breaking the natural fibers in the non-synthetic fiber portion of the cloth. For non-deep-draw applications, the 50/50 synthetic-to natural-fiber content could be used.

DISCUSSION

Background

The story of the immense inroads made by foreign textiles and garments into the domestic markets, and the resulting large number of jobs lost in this country, is well known. As foreign textiles flooded into the country, the textile industry was able to automate and did so to the extent possible at the current state-of-the-art of automation. Consequently, the textile industry has been able to partially stem the tide of imports of raw cloth. However, the advanced automation developed by the automobile and aerospace industries is not suitable for translating to the production of such flexible and highly varied articles as garments. As a consequence, foreign garments have continued to pour into this country in increasing numbers. These garments naturally use foreign-produced textiles. Thus, the domestic textile industry cannot be expected to regain its former market share, no matter how much it automates, until garment production is fully automated. At that point, domestically-produced garments would use mainly domestically-produced textiles. For the foregoing reasons, the future of both industrial segments are heavily dependent on the development of automated manufacturing processes and equipment for the domestic garment industry. This is emphasized by a projection (see reference 8, page 8, Tab B) by the garment industry, in 1985, that indicated that about half of the domestic garment manufacturers that were in business in 1985 would have been squeezed out of business by foreign imports by 1990. This naturally would have a large impact on domestic textile manufacturers.

Research and development on automated garment production is carried out mainly by the larger garment companies and at a few universities. Most of the work on automation in other industries cannot be directly translated to garment manufacture. Garment manufacture is unique in that it involves the assembly of a flexible material into a three-dimensional structure requiring exact registering of textures and patterns on all of the parts, which are then joined together by thread.

As far as we know, after our doing an extensive national and international patent file search, the automation of garment production has centered primarily on the automation of subassemblies instead of making complete garments. Subassemblies include sleeves, collars, lapels, and registering and sewing on pockets on shirts, blouses and jeans. Each subassembly operation normally requires a single-purpose, complex, processing station. The various subassembly parts are normally sewn together by conventional means to make the completed garment. The sewing machines themselves have been partially automated with respect to being able to be set for making a given type seam, with a given type stitch, at a given sewing speed. In contrast, the inventor's process makes the entire garment in one operation.

Technical Questions

At the current state of development, the inventor's process has a number of limitations that make it unsatisfactory for the manufacture of most garments. Use would currently be limited to the manufacture of very simple garments, e.g. clean-room type disposable uniforms such as used by hospitals, industry, and the military. With further development, most if not all of the current limitations can be overcome.

One major limiting factor is that if cloth is cut by laser or ultrasonic horns, the edges of the cut will melt and resolidify to become sharp and stiff. This results in seams that are uncomfortable to the user. Fabric cut with scissors or high pressure water jets does not have this problem. It may be possible to modify the seam characteristics by using a welding horn that folds the sharp edge under and then makes small dot or diamond connections instead of a solid seam. However, a mechanical or water-jet cut may be required for the more upscale garments.

Another problem is the large amount of wasted material. With the present state of technology, large amounts of material are wasted when each garment is cut from a separate rectangle of two-ply material. In the garment industry, the material is cut so that the waste is very small. This has been pushed to the point that an increase or decrease of one percent in the wastage is quite significant. As it now stands, the inventor's process will likely result in a wastage of well over twenty percent. The wastage can, however, be substantially reduced with further development.

As noted above, only very simple garments can be made with the invention at present. It is not possible to include elaborate pleats, tucks, insets, and other garment design features possible with conventional technology. With further development of the inventor's technology, this limitation is likely to be overcome. It is also likely that garment design features will change to take advantage of new possibilities offered by the inventor's technology.

There is little question about the technical validity of the invention per se; it has been demonstrated on the laboratory scale. The major remaining problems that must be overcome at this point are those discussed above: the limits on deep-draw hot-forming textiles with high natural-fiber content; the sharp seam problem; the wastage; and the complexity of garment styles that can be handled. These problems can be solved by use of standard engineering techniques; no new technical breakthroughs are required. It is likely that in several years these problems and many others will have been solved, and the manufacturing speed will have been greatly increased.

Economics and Energy Savings

Energy savings come about largely from eliminating the electrical energy required for lighting and materials handling, and for operating the sewing stations and machines used in conventional practice. A typical sewing station consumes the equivalent of from 1/2 to 1 horsepower of energy. Even when the machines are not actually sewing, the motors still run. The energy savings are partially offset by the energy required to operate the inventor's system.

At the present state of development of the new technology, about 80 percent of both the labor and energy per garment would be eliminated. Savings are further, at least temporarily, offset by the large amount of material wastage. Further development is expected to greatly reduce or eliminate this material wastage, and result in even greater energy and labor savings.

The energy savings cannot be accurately quantified at this time, but should easily run into the equivalent of several millions of barrels of crude oil per year. The total amount will depend on how much of the garment manufacturing industry can be automated and to what extent. There is no basis for estimating this at present.

Business Attractiveness

With the total dollar volume involved and the current state of the supporting technologies, it is inevitable that garment manufacture will be automated rapidly on a global scale. For any development, competitor reaction will be swift, both domestically and internationally. It is unlikely that a strong enough patent position can be established in any given country to gain a significant amount of control over garment manufacturing in any given sector of the garment industry. In all probability, short life-cycle automated production equipment will be sold to the trade by many competing firms.

We would expect developments in the field to be constant and rapid and to continuously make existing equipment and manufacturing techniques obsolete. Such progress will undoubtedly restructure the entire textile and garment industry in the next one or two decades.

No new regulatory or other special factors are foreseen at this time, although developments will probably bring some to the surface over the next few years. At the present state of development, and for the next few years, capital intensity to enter the hardware part of this business will be small. The main limitation will be technological know-how. Once the main thrust of development becomes apparent, it is likely that there will be a global flood of equipment manufacturers and garment manufacturers entering this field. Within a few years, the capital-intensity to remain in the garment manufacturing business, at least in the commodity portion, will likely increase rapidly.

CONCLUSIONS

1. The invention is technically valid.

2. The eventual energy savings impact will be significant. Once the waste problem is solved in the cloth utilization part of the process, energy savings could be on the order of several millions of barrels of crude oil equivalent per year.

3. The Symagery automated garment production process is commercially feasible; the market is well defined. Automation of garment manufacturing should be welcomed by the domestic garment industry as a means of improving competitiveness.

4. The basic system design is essentially complete. Under a NSF/SBIR Phase One grant for $35,000 that was completed in 1984, the feasibility of molding the fabric and ultrasonically welding the seams, while cutting the garment from the cloth web, was successfully established. The next stage in research and development should include:

   a. Detailed design of a pilot system for test and demonstration purposes. The principal focus here should be to solve the problems noted earlier; that is of cloth wastage and sharp seams, broader application in styles and garment types, and of the need to define usable deep-draw, hot-forming textiles.

   b. Installation and test operation of the pilot system. The test program should be designed to establish operating performance characteristics, capital and production costs, and maximum production rates, so as to provide the basis for system design improvements.

Feb 26, 1988
DATE

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Evaluation of an Automated Process for Garment Manufacture

for the Office of Energy Related Inventions
(OERI No. 12302)

by

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Summary

The apparel industry represents a multi-billion dollar business that is labor intensive at this time. As such it is sensitive to labor costs. The textile industry which represents producers of fabric rather than producers of garments was in a similar position until recently. Due to the marketplace becoming international as opposed to national, competitive forces favor the developing nations with lower labor costs. The U.S. textile industry has placed large investments in automated, high speed machinery and in cost cutting management strategies in order to remain competitive.

The textile industry deals with a primarily linear or planar structures. Automation of these processes occurred rather quickly and within reasonable cost bounds over the last several years. The apparel industry deals with three dimensional product formation which adds another degree of difficulty to the task of automating processing. Secondly, the automation equipment developed for aerospace and automotive industries has proved quite inadequate in dealing with a highly flexible component, i.e. fabric, which additionally requires pattern matching. To date, automation of apparel manufacturing has consisted of automation of subassembly processing, relying on manual intervention between processes and in joining subassemblies.

A fully automated apparel assembly process of the type proposed by Symagery offers savings in space, reduction of labor by an estimated 80%, and energy savings from reduction of environmental control system capacity and number of batch sewing stations by about 80% as well.

The development and testing of the Symagery automated apparel process represents an important contribution to the apparel industry.

I. Introduction

The automated garment manufacturing process proposed by Symagery has several features, no single one of which is of itself unique. The following attempts to explain this statement. The primary operations at a traditional garment assembly process are fabric cutting, transportation of fabric parts to the sewing station, alignment and registration of pattern parts, joining the parts, and collection of finished subassemblies for transportation to further processing. A traditional garment assembly consists of from five to fifty parts and subassemblies requiring batch processing through these operations. The three dimensional geometry needed to fit the human form has been met to date by design of flat parts and seam lines which configured the garment to appropriate shapes.

Symagery has looked at technologies for fabric handling, shaping and joining and has selected means for doing each which represent advanced technology. The following section on historical background discusses these technologies. These then are combined in a automated station which offers complete fabrication of a garment - this being a unique concept. Symagery estimates direct cost savings of $1.5 million annually.

II. Historical Background

This background section will discuss respectively developments in apparel manufacturing automation, fabric handling, fabric shaping, and joining fabric parts. The purpose is to offer a better understanding of what the Symagery invention is attempting to do and the extent to which it is based upon untried versus well understood technology.

A.) Apparel Manufacturing Automation

The Bobbin Show presented annually by the American Apparel Manufacturers Association is the showcase for new technology in the apparel industry. The nature of change reflected by opinions of the author and in discussion with Prof. Larry Haddock* has been a gradual and steady progression. Firstly, the sewing machine was automated with respect to programmed speed, seam distance, seam direction, and change of stitch formation characteristics. Then fabric cutting equipment adopted numerical control positioning methods

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* Prof. Larry Haddock, Director, Apparel Engineering Technology, Southern College of Technology, Marietta, GA

packing and automatic controls are part of this.(1) Finally, complicated, automatic subassembly processing stations have been developed. The first of these were pocket setters for shirts and jeans. Then the advancements have proceeded through collars, sleeves, etc. Each process generally is a single purpose station.

Discussion was held with Merrill Caldwell regarding a patent(2) for an automatic garment position loader. The process does several important operations on precut parts such as a pants leg or sleeve including smoothing and orientation of the part. Mr. Caldwell directs R & D efforts at a large apparel manufacturer in Alabama and is very aware of and designs or purchases equipment representing the state of the art in apparel automation. My opinion of our discussion is that automation exists through manufacture of subassemblies and not beyond. Also, all considerations were devoted to sewing of flat parts and no mention was made of unusual seaming and shaping processes.

Approximately two years ago the Textile Clothing Technology Corp. transferred technology for manufacturing subassemblies of a man's jacket to Singer Corp. according to a news wire report at that time. TCTC encountered numerous difficulties but were successful with automating production of some complicated subassemblies, e.g. lapel and sleeve. Further support of the point that automation is at the subassembly level currently is found in a review of technology which appeared in Women's Wear Daily(3).

Research toward completely automated garment production is ongoing in a few of the larger private firms and at the university level. My opinion of those of which I have knowledge is that each is aimed at handling a specific garment, e.g. sweat suit and military fatigues jacket. The Japanese and one patent(4) refer to making an apparel article using bonding of chopped fibers on a form much as fiberglass boat hulls are made.
Because fiber bonding restricts the degrees of freedom of "fabric" motion, the garments so produced are stiff.

B. Fabric Handling

The current state of the art of robotics, particularly end effectors, is that there is no cost justifiable means of reliably picking up single layers of fabric from a stack and positioning the part without stretching or wrinkling the parts to be joined. This limits the ability to design a general purpose automated station. One effort has been to develop garments with fewer parts by use of unusual geometric cuts of fabric(5). This does not ease the positioning problem. Fabric handling problems are probably the reason that a fully automated garment assembly process has not been developed.

C. Fabric Shaping

The alternative to sewing many flat parts into a three dimensional form is fabric molding. A conference held at Georgia Tech in 1974 reported that several companies were actively pursuing fabric molding to improve garment esthetics or to bypass one or more sewing operations. The author has pursued research with NASA on seamless, molded fabric parts for the space suit over the past eight years. This research and discussion with the Lovable Company in Buford, Georgia, who mold seamless brassiere cups, has made several determinations.

Firstly, polyester is the fiber of choice for molding. Polyester does not yellow or degrade at a molding temperature of 395 F. Nylon will yellow unless protected by an oxygen-free atmosphere, e.g. saturated steam. Natural fibers such as cotton or wool are not thermoplastic and are not suitable for molding. Dimensional changes requiring elongation of the fabric or changes to dimensions less than 10-15% of the original require use of a two part,male-female, mold. Complex molded parts require design of a means of finished part removal. This may not be a simple task.

D. Joining Fabric Parts

Federal Standard 151 lists approximately twenty major classes of stitch type, which refers to how one or more threads are to be placed in a seam, and similarly classes of seams, which refer to placement of fabric parts and stitch location. The popularity of sewn seams arises from the fact that no other joining process leaves the components as flexible in bending and shear. The needle and thread sewn seam is reasonably reliable and efficient.

An alternative to traditional sewing is ultrasonic bonding. The first ultrasonic fabric bonding machines shown at the Bobbin Show essentially sealed the two parts continuously. The edge thus produced was stiff and if pointed inward was also uncomfortable. The newest machines have especially designed anvils against which the ultrasonic horn works which produce a pattern such as dots, allowing for greatly increased seam flexibility and some improvement in shear response.

III. Symagery°s Invention

A. Workability

The process developed by Symagery avoids the complications of parts assembly by forming the fabric from two separate fabric sheets. Pattern registration involves only initial setting of the pattern and quality checks during operation. Molding assures that shape is achieved uniformly and per the garment designer's intent. Their patent(7) shows a reasonable means of disassembling the mold and removing a finished part. There are some drawbacks to be considered. These are considered under III c acceptance...

Technically, the process can be developed into a workable step-wise continuous manufacturing concept. Economically, based upon elements of the design, once developed, the machine should have reasonable cost.

B. Desirability

Among the responsible individuals who have commented upon garment manufacture and automation, there has been consensus that totally automated garment manufacture is critically important. In that this represents an initial proposal to this end, it will merit the attention of manufacturing concerns. Beyond consideration as a process, the device also affords unique opportunities for the garment designer.

Aesthetic qualities were not researched in preparing this report, but Symagery is probably correct in stating that new concepts in fit and appearance of clothing will arise from the molding technology. This applies more directly to industrial, medical, and military applications than to consumer products.

C. Acceptance in the trade

From the point of view of automation, Symagery's invention has the benefits of being not overly complicated and understandable. The apparel industry acquires high technology from outside vendors rather than from within, generally. Those few apparel manufacturers doing internal R & D on automation are buying promising technology at least on a mill trial basis as well. Thus, broad acceptance must rely upon acceptance of ultrasonic seaming, which has had an unfavorable past, and acceptance of molding, which replaces their traditional business of operating parts assembly plants. The process will have to prove itself before general acceptance will be found.

Perhaps more difficult to deal with is the potential for inefficient use of fabric. The value of waste fabric from the cutting room exceeds a billion dollars in this country. One percent savings due to better marker lay out (the parts cutting pattern) is considered a remarkable achievement. Reviewing the Symagery patent, there appears a loss of fabric equivalent to twice the reach of an arm and the length of the fabric body. This waste must be assessed and a means found to limit it to current levels or less.

Ultrasonic seaming and edge cutting fuses fibers together. An ultrasonic cut edge as well as a laser cut edge can be uncomfortable. The patent does not suggest a means, but turning under these edges or covering them will be a strong element in industry and consumer acceptance of these garments. This comment applies to the welt (waistband) and cuffs as well.

Manmade thermoplastic fibers can be molded to shape and welded or cut by ultrasonic devices due to their plastic behavior at elevated temperature. Cotton and wool cannot because they do not exhibit this plasticity. Symagery claimed that the process is applicable to blends, but a 50-50 cotton-polyester blend fabric would be a very poor choice for a molding operation. The cotton component will not elongate in a rubber-like fashion as the thermoplastic will. During deep draw operations on the mold above the few percent elastic elongation of the cotton, the cotton can match the plastic deformation of the polyester only by breaking. Thus, the range of fabrics to which this process is applicable does have limitations.

To achieve some perspective on this fiber limitation, note that polyester is the leading fiber in the U.S. in terms of pounds consumed annually. Thus, an automated process requiring polyester fabrics can have significant application in the trade.

Finally, the traditional textured surface of a polyester fabric can be altered, and perhaps in a nonuniform fashion, by the heat and pressure exerted upon the fabric by the opposing mold faces. Attention to mold surface texture may prevent this. Nevertheless, this may affect acceptance by the consumer.

IV. Energy Conservation

The Symagery invention does offer the potential for energy conservation. Assuming that molding will be carried out in an insulated environmental cabinet, the opportunity exists to reduce garment manufacturing direct energy input on a per garment basis to 20-30% of current levels. Symagery suggests that one machine will replace seventy-two parts assembly stations. Each of these has an energy consumption from sewing machine motor, electronics, lighting and materials handling equivalent to 1/2-1 horsepower. The 72 stations consume on the order of magnitude of 50kw. The automated process should operate on an input of 10-15kw in contrast.

Sewing machine motors operate 100% of the time, although they are performing useful work 60-80% of the time. The ultrasonic seaming operates on demand only. Thus, there is some efficiency gained by the change in mode of utilizing some efficiency gained by the change in mode of utilizing energy for seaming.

V. Conclusion

The Symagery invention clearly has areas needing R & D effort, but is based upon established, workable concepts. There is no reason to believe that a totally automated garment production facility cannot be realized. By the nature of thermal molding and seam fusion used in this concept, the machine will not be universally adaptable to all garments nor will it be universally applicable in all garment markets. Despite this, there is potential for significant acceptance of the process in the broad spectrum of consumer and non-consumer products.

An article(8) remarked that 50% of all U.S. clothing manufacturers will go out of business by 1990, and that the key to success in apparel manufacturing lies in new technology. In my opinion, this is an appropriate and reasonable step in bringing about new technology for apparel manufacture.

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