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A study of the apparel industry in the State of Washington was accomplished through the use of a questionnaire which yielded data concerning the types of automated and mechanized equipment used during three time periods. Descriptive information about the apparel industry in this state was gathered in order to analyze the former data.

The apparel industry in the State of Washington produces primarily skiwear, general outerwear and down products. Other types of apparel are also produced, but on a smaller scale. The factors which were related to the increase in mechanization and automation were the size of the firm, the class of products made and whether the plant was part of a multi-plant firm or was a single-plant firm. No appreciable relationship was found between the degree of mechanization and automation and the age of the firm, the age of the plant or

quality level of the product. Automation and mechanization are generally seen by manufacturers as possible "solutions" to many of the problems which plague the apparel industry.

Automation and Mechanization in the Apparel Industry in the State of Washington

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AUTOMATION AND MECHANIZATION IN THE APPAREL INDUSTRY IN THE STATE OF WASHINGTON

I. INTRODUCTION

Statement of the Problem

This study was undertaken to gain needed information concerning the use of mechanized and automated equipment in the apparel industry in the State of Washington, and concurrent with this, changes taking place in the equipment used in the manufacture of apparel. Information which was needed in order to be able to form a picture of the changes taking place in equipment in the apparel industry include the following:

1) What types of equipment are presently owned or leased?

2) Were these types of equipment used five years ago?

3) Are these types of equipment predicted to be in use three years in the future?

Information which was gathered to describe the apparel industry in the State of Washington includes the following:

1) What are their primary products?

2) How long have the firms and plants been in operation?

3) Are the firms multi-plant or single-plant firms?

4) Is the employment in these plants seasonal, multi-seasonal, or non-seasonal?

5) What is the size of the plant?

6) For what type of market are the goods produced?

The data were analyzed in order to draw conclusions regarding:

1) How levels of automated and/or mechanized equipment are changing.

2) What direction these changes are taking.

3) Whether there are types of automated and/or mechanized equipment which are not being used in the State of Washington.

4) Why this might be so.

The data collected in the first portion of the study were analyzed in relationship to the types of equipment held. Correlations were then drawn relating to the product made by the firm, the age of the firm and/or plant, whether the firms were multi-plant or single plant, as well as to the market for which the products were designed. Also, from the second portion of the study, conclusions could be drawn regarding the degree of mechanization or automation which was extant in the apparel industry in the State of Washington. Information on the direction of change could lead to conclusions of what the future may hold for the apparel industry in the State of Washington.

Further, a compilation of the respondents' opinions regarding the future could provide the basis for later studies. The purpose of this study is not to provide equipment dealers with a market research study, but more generally, to attempt to look at the direction and the force with which the garment industry in the State of Washington is moving.

Need for the Study

A limited amount of published research has been found regarding the apparel industry. Griffin, in 1949 (30), surveyed selected regional apparel markets producing women's and misses' apparel. Johnson (39) studied the women's outerwear industry in Texas. Spencer (62) surveyed the textile and allied industries in Virginia to ascertain the need for textile technicians. Mason (42) surveyed the apparel industry in the State of Michigan. Ekenes (20) surveyed the Portland, Oregon apparel market through an investigation of selected apparel manufacturers.

The United States Bureau of Labor Statistics Bulletin 1635 (68) concerns labor in the textiles and apparel industry. The International Labour Office (35) published a paper on the problems arising from fluctuation of employment in the clothing industry. This report resulted from the Tripartite Technical Meeting for the clothing industry, which was held in Geneva in 1969.

It is felt that this study will add to the available knowledge and perhaps provide a basis from which further studies can be launched.

The Scope of the Study

The apparel firms in the State of Washington which were included in the study were primarily those producing skiwear, general outerwear, and down products. Washington manufacturers produce other apparel products in smaller quantities. The choice of the entire state meets two criteria: first a group of manufacturers producing like products has been chosen, secondly a geographic area has been selected.

All questionnaires were distributed and returned by June of 1972.

Firms which were included in the study comprised those in the State of Washington which were defined as manufacturers of garments made primarily from textile materials. Excluded from the study were the manufacturers of furs and speciality items such as wetsuits. The producers of gloves were included in the study even though a portion of their production is made from non-textile materials.

The list of firms to be contacted was obtained from the Department of Commerce in the State of Washington at Olympia. This list was then double checked against a list of firms that were known to the researcher, and also checked by persons who were active in the manufacturers' association within the state.

II. REVIEW OF LITERATURE CONCERNING RECENT DEVELOPMENTS IN CLOTHING MANUFACTURE

Most of the many treatises on the subject of automation begin with a definition of mechanization. "Mechanization means the use of machines to perform work" (8, p. 6) contrasts with a later definition ". . . any technological change which increases output per worker (or per man-hour)" (38, p. 18). Automation is most often found defined as, "automatically controlled operation of an apparatus, process or system by mechanical or electronic devices that take the place of human organs of observation, effort, and decision" (70, p. 148) or a variation of this. A definition which is useful for analysis is ". . . any continuous and integrated operation of a production system that uses electronic or other equipment to regulate and coordinate the quantity and quality of production" (8, p. 6).

The term, automatic factory, has been in use for some time. Diebold (17) states that Oliver Evans designed and built a completely automatic factory in 1784, scarcely after the industrial revolution had begun.

A discussion of specific types of mechanized and automated equipment which have been marketed or introduced to the apparel manufacturing field during the last five years will follow the route by which a garment might come into contact with these pieces of equipment or as they might be used in an average factory.

Pattern Grading

Pattern grading in the past required a skilled employee utilizing a master pattern provided by the designer and a variety of drawing equipment such as rulers or french curves and scissors. Today computer assisted pattern grading is a reality. The first demonstrations were held in 1964 (59). A number of methods can be used to produce a set of patterns in the size range desired. The starting point, however, is the master pattern provided by the designer. This master pattern must include notches, grain lines, darts, drill holes, sew lines, and grade points. Additional input is required before the computer can begin. One method is the use of a grade chart, in which all key points for line segments are located, and the grade rules which state the necessary amount of vertical and/or horizontal shift. The information from the master pattern and the grade rules provides the base for computer-directed grading, just as it would in manual grading.

Advantages which result from computer-directed grading are quite varied. Irish (37) states that it yields "a uniformity that exceeds that which can be obtained by conventional means" (p. 52). Parker's (50) evaluation is that it gives "a significantly superior job on necklines and armholes" (p. 26) (which are judged to be among the most difficult areas to grade manually). Mendel (43) sees merit in receiving "a printed listing of the total parts graded, the perimeter of each pattern and the total area graded by the system" (p. 72). This information is of use to management in determining wages in the cutting room and cloth requirements for any particular design.

Today, most computer-directed grading is done by a firm which contracts to produce graded patterns for many firms. Some of the reasons for this arrangement are the investment in capital equipment which approaches $250,000 (43), the need for skilled personnel, the size of the computer needed to handle such a task (which is normally larger than that to which most firms have access) and the infrequent use of the facility which would result if each firm produced its own graded patterns. Firms which presently do contract pattern grading by computer are Compusize, California Computer Products (Cal Comp.), Graphical Technology Corporation and Graphic Systems of America, Incorporated.

A mechanical device which develops a set of graded patterns at one time is also available from Precision Pattern Company. This device, by the use of interconnected rollers and a number of layers of paper, can produce an entire set of patterns in a very short time. The operator turns a master handle the amount indicated by grading rules. At this time the coupled rollers have moved their particular layer of paper into the proper position. The operator then draws the appropriate line on the top sheet of paper, thus transferring a mark to all layers. The operator continues in this fashion, first adjusting the master roller and then transferring a line. Curves are graded after main segments of the pattern are completed.

The cost of leasing this equipment, which has been on the market several years, is $1200 per year. Firms which manufacture a wide variety of styles are the prime users of such equipment.

Marker Making

Various systems are presently used in the making of markers. The system used exclusively in the past utilized full size patterns, laying them manually until a satisfactory arrangement had been made. A more recent system uses reduced-size patterns and places them manually until a satisfactory marker is achieved and then the reduced scale marker is translated to full size. The newest form of marker production is the use of a computer to create a marker which maximizes the utilization of cloth.

The use of miniaturized patterns today is fairly commonplace; the method by which the marker is produced, however, varies widely. When miniaturized patterns first came into use, a photograph of the completed "scale" marker was made, and this was then utilized by the cutting room to produce a full-size marker using the large pattern, and simply using the scale photocopy as a guide. Gaetan (27) reported the use of light-sensitive paper rather than photographs for factories which still made the full-size marker manually. The expense was thus reduced. In 1965 equipment was shown at Cologne, Germany, which, through the use of electronics, was able to scan the miniaturized layout and produce a full-scale perforated marker (utilizing pin pricks) or a drawn marker (marker pen).(23). Later improvements in this same equipment enabled full-size markers to be made, with the areas in which no pattern appeared marked with parallel lines. The closeness of these lines influences the accuracy of the pattern (16). Still further refinements were achieved when the lines were converted to dots. The concentration of dots was set at 256 per square inch (24).

The ability to grade patterns by computer also has led to research in marker-making by computer. Art (2) presented the theoretical methodology of linear coordinates and computer placement of pattern pieces. Up to the present, the inability of the computer to "visualize" the shape of a pattern by use of the coordinates has hindered the development of a process of computerized marker-making. Computer-assisted marker-making is discussed in the Journal of the Apparel Research Foundation (29). This method consists of employing a team of marker makers using scanning equipment, a computer and their own knowledge about shapes in order to develop a marker which would maximize cloth utilization.

A complete analysis of computerized marker making in 1973 is presented by Gaetan (26). He states:

> To date [March, 1973] Bobbin is aware of eight companies actively engaged in the design of systems to sell to the apparel industry which can fall under the general label of computerized marker making. And . . . there are five companies now utilizing computerized marker making, one that may have an automatic system installed by press time and another with an automatic system on order (p. 20).

Gaetan divides marker making into three systems. The first, or basic system operates as an interactive system. The experienced marker-maker manually lays out all pieces with the assistance of a cathode ray tube (CRT). The next level of technology is that in which the computer is directed to make the marker and the capacity for editing via CRT is provided so that refinement may be accomplished by human assistance. The most advanced level of technology is that in which the computer is directed to produce the marker, and the results need no refinement. This level of technology has not yet become reality.

Spreading Fabric for Cutting

In August of 1965, Cutting Room Appliances Corporation demonstrated its Champion Spreader with electric drive at the exhibition of equipment at Cologne, Germany. This piece of equipment is a turnable spreader with both electric eye edge control and automatic cut-off knife. In the evaluation of the Apparel Research Foundation this will "open many possibilities for improvements in spreading methods" (33, p. 5). Improvements in the Champion Spreader were made by this firm, and in 1965 an improved model was shown at the Bobbin Show. Features of this model include:

> Face-to-face spreading, either right to left or left to right, with automatic cut-off at the left or right, respectively, and face-to-face spreading with knife cut-off at both ends of the spread. A new method of achieving an even cut-off at the end of the spread was achieved by an attachment which provides a height adjustment for the automatic knife. The speed of this spreader was stated to be 45 yards per minute (32, p. 2).

Another spreader, introduced at the same show by CRA, was designed for high speed spreading face-to-face. The speed was listed as 120 yards per minute, maximum. An additional timesaver is the "piggyback feature" which carries a spare roll of fabric ready to load without a return to the end of the table. Maximum roll size and weight are 28" diameter and 300 pounds per roll (32).

Also introduced at this show was The Brutus Spreading Machine manufactured by Cutters' Exchange. This was a basic Martin spreader with the addition of a cut-off knife. Cut-off was possible at only one end with a clamp utilized at the other.

In 1971, a spreading machine capable of aligning stripes automatically was announced. This development was made possible by the use of a photoelectric stripe-sensing head which is positioned at the front of the machine. Accuracy of plus or minus 1/32" can be achieved at speeds of 75 yards per minute. Also, the edge control assists in accurate laying by correcting for shifted fabric on the roll (63).

Automated Cutting Systems

Automatic cutting systems were discussed in the June, 1969 Bobbin. The advantages of the first system presented include the versatility of manual cutting and the accuracy of die cutting. The Cincinnati Milling Machine Company has made installations in two plants, one a diversified line of wearing apparel and the other automobile upholstery. The manufacturer delineates benefits for the user as,

> . . . consistent accuracy of cut pieces, faster cutting than by manual methods, better materials utilization, elimination of manual marking of fabric prior to cutting, elimination of manual operations required for notching or producing blind darts, more effective utilization of the skills of experienced cutters, greater freedom of design and styling, reduced lead time and improved management control of production (36, p. 42).

The process whereby automatic cutting is achieved is as follows: digitizing the pattern, entering the punched data (obtained by the digitizing) into the computer, making of a miniature marker, entering the marker data into the computer, and the generation of a control tape.

The second system, the Gerbercutter, also employs digitized data. The Gerber System, selling in 1971 at approximately $100,000, consists of the computer control and a cutter drive system, modular spreading and cutting tables, and a transporter table for moving the cutting head and carriage.

In 1971, an operation which employs the Gerber Cutter was reported to be turning out between 10,000 and 12,000 garments per week and was running two shifts. This rate of cutting could be increased if it were not for the fact that the spreading of cloth held up operations. Changes and improvement in the machine are summarized as follows:

> 1. The plastic foam table top has been replaced by a surface resembling coarse scrub brushes. . . . The life [of the brush-like surface] is estimated at more than 10 years cutting on a three-shift operation.
>
> 2. The Gerber Cutter head mounting has been modified with replacement of the vertical cross-travel bearings by horizontal bearings, as well as other minor modifications.
>
> 3. The cutting speed of the machine is 360 inches per minute, the machine speed in X or Y direction, or skewing is 720 inches per minute.
>
> 4. Drilling and notching are performed at the rate of 72 per minute. Blade raising and plunging time is about 1/2 second for each operation not including the time to move the machine.
>
> 5. The cutter is being used on stepped lays with perfect cutting . . . without any difficulties at the changes in height. Blade life has been averaging 5,000 cut parts on polyester double knits for ladies'dresses (54, p. 34).

The introduction of knits has caused a great impact in the cutting room. Because knits are supplied in much wider widths than were previously supplied in woven yardgoods, the recommended width of table is 78 inches, which can be used with 72-inch spreaders. The speed at which knits can be spread is much lower than that for wovens. If speed is forced, the lays will shrink, giving trouble with marker fitting and also with quality. If material is hand fed and spread in order to reduce tension, production will necessarily be curtailed greatly. Also, after knits have been spread on top of one another, they cannot be shifted, or distortion will occur. The cutting itself is more difficult because the lays are "softer", and cutters must have time to become familiar with cutting higher lays which result from the necessary numbers of garments to be cut. "New modern equipment required for knits today can pay for itself quicker than any in recent memory" (51, p. 20).

Perhaps the most widely publicized innovation in cutting today is the use of the laser. The term laser is an acronym for the phrase, "Light Amplification by Stimulated Emission of Radiation". Also, it is defined as "a device that utilizes the natural oscillations of atoms for amplifying or generating electro-magnetic waves in the visual region of the spectrum.(70, p. 1274a). Genesco demonstrated a computer controlled laser fabric cutting machine on March 9, 1971, which cuts a single lay of fabric and thus is widely divergent from "What has always been done." This equipment is also very costly. An estimate of cost with accuracy estimated within plus or minus 35% was $186,000 for a complete system capable of cutting 300,000 men's suits which gives an estimated cutting cost of $0.62 per suit (40, p. 14).

The Apparel Research Foundation presented a comparison of knife cutting and laser cutting (40). The advantages of laser cutting include:

Precision cutting with practically zero kerf[1/] (1/32").
Ability to cut almost any material.
Ability to cut in any direction without rotating the blade.
Instant starting and stopping. The laser on-off time is only two thousandths of a second.
Cuts extremely small radii at fairly high speeds.
No delays at corners for raising and "plunging" the blades.
Cuts slits and circles without plunging.
No sharpening required or replacement of broken blades.
Less programming -- simple programming.
Speed -- top cutting speed is 1800 inches per minute versus 300"/400" net on blades.
Laser can cut a single ply. No automatic knife method is known.
Fabric is not disturbed by cutting action.
No hold down system is necessary.
No underlay or cover seal is necessary.
Nicks and notching are possible without knife repositioning delays.
Nicks can be made as cutting progresses -- need not be made in advance.
When cutting common lines shared by two patterns, a knife tends to track the previous cut whereas the laser's butting path is independent of the fabric.

[1/] Kerf - "The width of cut that a saw or cutting torch makes in wood or other material" (70, p. 1238a).

Laser can cut closer to the selvages.
Knits and stretchy fabrics, if not fully relaxed before spreading, will shift and change shape after cutting. If this shifting occurs while a pattern is being cut, incomplete severance could result, if the starting point and the end of the cut do not match.
Better visibility for nicks and notches.
Laser can edge-code parts for identity while cutting.
Some small parts can be shifted slightly by the draft of the air jet or the cutting zone exhaust, and occasionally cause an incomplete cut (p. 9).

Gaetan states, "Genesco has gambled a million dollars. I believe they have won. Furthermore, I believe that they have taken a great step into the future and in so doing, they have vaulted the entire industry forward with them" (28, p. 661).

Shade Matching

In the past it has been very difficult to match shades of color accurately. This problem resulted in untold losses to manufacturers in cases in which off-shade goods have been cut and perhaps even sewn prior to the discovery that the color matching was unacceptable. One means of control of this problem has been the use of the Soabar equipment. This technique keeps pieces of garments in order so that each garment will be of a single piece of fabric. This method does not give any control of differing dye lots when garments must be used together, however, as occurs in the construction of garment sets (such as slacks and jacket, skirt and vest, or a combination of all of these). In this case the fabric for one piece may be, and often is, cut from a dye lot and bolt of goods different from the others.

In this instance it is vital that some accurate means of assessing piece goods be available for use when goods are received from the shipper. Often the means of such assessment are difficult, with non-standard light, including intensity, color and value. Electronic means for matching fabric shades have existed for some time, but the cost has been extremely high. Davis (15) reports on the availability of the AC Electronic Shade Matcher. This tool, and it must be realized that it is only a tool, not a decision maker, can offer standardized shade matching at a moderate cost. Today it is possible for the average factory to evaluate piece goods as they are received and eliminate costly errors.

Fusing

The advent of fusibles was greeted with both acclaim and horror. Great claims were made that because of the introduction of the permanent press fabrics, fusibles would soon be the only type of interfacing used. This claim was soon pushed aside as the fusibles did not live up to the advance billing they had received in the 1960's. Many of the misconceptions which had arisen resulted from the use of the firm-bodied fusible materials such as those used in the apparel industry in Europe. The market in the United States demanded the soft "hand" which has been available here since the late 1960's.

Solomon (61) summarizes the claims for fusing as follows:

1) Reduces labor cost without cheapening the garment. Labor costs are reduced by eliminating taping, basting, padding, felling and many other operations. The fusing operation can be successfully performed by low salaried, unskilled labor on a highly productive basis.

2) Eliminates puckered seams. The puckered seam which has plagued manufacturers for years is completely eliminated if the seam is fused.

3) Increases seam strength. The bonding of the plies of material at the seam point adds strength to the seam by distributing the tensions to the two plies of materials plus the thread as opposed to stress on thread only as is the case in an unfused garment.

4) Imparts a smoother look to coat fronts, collars, pockets, flaps, welts, tabs, etc. The above mentioned areas that have been fused, look neater and retain their smooth look longer.

5) Increases strength of the garment at all points of the fuse. This added strength is obtained by bonding two and three plies of material to make one super-strong ply of material.

6) Dimension stability: Eliminates much of the stretching and distorting, resulting in a much more stable garment.

Shape retention of the garment is built-in when it has been fused. An initially cheap piece of fabric becomes full-bodied and wear resistant when fused (p. 78).

In 1972 the manufacturers still seem to be afraid of the new and untried way of doing things (55). However, continued improvement and the entry of various firms into the area of fusibles led to the conclusion that fusibles are here to stay, and maybe they will really do the job for which they were once so highly touted. Roane (56) indicates that two of the factors which have influenced this change are 1) the shortage of qualified machine operators and 2) the possible reduction of costs in an ever-tightening, cost-profits squeeze.

Fusing equipment is becoming more sophisticated: both equipment and materials have been more completely researched, and control is becoming significantly more accurate than before. Fusing is being done by heat and pressure as well as by infra-red system (34). Today, the manufacturer who finds fusing important in the production of his particular line will find on the market a variety of equipment and materials which will enable him to do the job quickly and economically.

Control Mechanisms

Automatic control of machinery in the apparel industry has been a goal for some years. Equipment which is used in the apparel industry is different from general manufacturing in that it may need to be stopped and started up to 20 times per minute. Also, the range of stitches set will be from 2,000 to 8,000 stitches per minute. Other factors which may need to be controlled (i.e., monitored) may be the position of a piece of fabric, the detection of the trailing edge of fabric, the failure of thread, binding, or other accessory to the sewing of the seam.

Prior to 1969, most research in the field of automatic control took the direction of ". . . electrical sensing and logic to control pneumatic equipment via solenoid valves" (40, p. 100). A thorough review of the basic facts on the use of fluidics was written by the Apparel Research Foundation in 1969 (21). Nutt (47) also discussed the technology of applying fluidics to the apparel industry.

By 1972, various applications utilizing these principles were on the market. They include, but are not limited to, an automatic belt loop feeder from Rochester Button Company, an automatic shirt front hemmer by USM Corporation, and an automatic system for inserting and cutting elastic waist band material and made by So-Fast Corporation.

Numerically Controlled Stitching Equipment

Another research application led to control of the location of stitches in a seam. This is done by various methods which range from the numerically controlled equipment to that controlled by cams. The Journal of the Apparel Research Foundation defines numeric control as . . .

> . . . the automatic guidance and operation of a machine through its cycle by a computer-like cabinet of electronic parts. It literally 'plays' a magnetic or punched tape to obtain its instructions of what to move next, where to move it, how fast to move, when to speed up or slow down, and when to stop (46, p. 2).

In June of 1971 an NC (as numerical control is designated in the trade) application was demonstrated at the Arrow Company (25). This equipment was produced by the Gerber Company and at the time of disclosure to the press had been installed and was functioning at two plants (Troy, N. Y. and Lewistown, Pa).

> According to the company [Arrow], the new unit enables an operator with only a week or so of training to produce collars of equal quality and better consistency than those for which it now takes four to six months of training to achieve and at a rate at which it now takes a year or more to reach (58, p. 27).

Gaetan (25) states that aerospace technology has been transplanted into stitching procedures in the garment industry. In so doing, the following has been accomplished:

> 1. Training time has been reduced to a matter of hours compared with several months. . .
>
> 2. . . . a reduction of 8 percent on the standard allowed minutes for shirts [has been achieved].
>
> 3. The cam manufacturing and change costs eliminated entirely.
>
> 4. Operator flexibility on different operations, without loss of training time or earning.
>
> 5. . . . consistent top quality parts which are very important for turning, final shape, banding the collar and even the collar setting operation (p. 68).

In the review of the 1971 Bobbin Show, Gaetan (27) discussed other numerically controlled sewing units. Necchi's unit is claimed to have an entirely different concept from Gerber's. Juki has a machine on the market, but chose not to exhibit in Atlanta in 1971 or 1972.

Profile Stitchers

Various other systems of machine control of placement of stitches are in use. The profile stitchers which were described in 1965 consist of a means of clamping fabric in place, and of moving the clamp through the seam area. This movement is effected by the use of a control template. The Durkopp 738 profile stitcher was analyzed by the Journal of the Apparel Research Foundation (19) and the following characteristics were noted which set it apart from other cam-controlled or template-controlled profile stitchers:

1. A larger capacity (about 7" x 26").
2. Instantaneous changeover. The template/clamp assembly provides total control.
3. The machine is faster than most cam-controlled tackers (e. g. 2, 300 to 4, 000 rpm).
4. The template loading permits the operator to do almost all of the loading while the machine is running.
5. Training time is reduced to a few hours because no sewing skills or foot pedal coordination are required.
6. The machine can accomodate pre-cut shapes or it can be used with an edge trimmer knife to produce a uniform margin.
7. Dual template (for right and left parts) can be obtained.
8. It is an interior clamped system (which means that it cannot sew completely around any article).

9. The machine cannot sew acute angle points.

10. Templates cost from $175 to $300 each, and must be ordered from Germany at the present time. Delivery time is expected to be from two to five weeks.

11. Mechanic training is essential. Manuals are in German and English translations must be specified if so desired when ordered (p. 18-19).

Various profile stitchers have different clamping techniques and thus offer different advantages to the buyer. Adier, Pfaff, Necchi and Durkopp all produce this type of machine. In 1970, the Journal of the Apparel Research Foundation (48) discussed a new type of profile stitcher which had been developed internally by the Warner Lingerie Division of Warnaco. Its salient features are the following:

1. It is a 360 degree profile stitcher. Thus it can sew around the entire perimeter of any design within a three-foot circle or a rectangle about three feet by four feet.

2. X/Y movement is controlled by moving the fabric clamp and the fabric while "Theta" is obtained by moving the sewing head in a circle, the center of which is the needle.

3. It eliminates the need for a variety of templates, since guidance is optical rather than mechanical.

4. Rotation ofthe machine maintains "tangency" at all times.

5. The machine was designed specifically for the zig-zag stitch, triple stitch and other oscillating needle bar stitches.

6. Because of its "tangency" capability it is also suitable for overedging and other chainstitch machines.

7. It is the first publicized profile stitching application potentially capable of handling two needle and other multi-needle work with alternating pivot selection on the inner or outer needle.

8. The feeder, utilizing a supply table mounted on a cross slide, is able to feed and match a number of different parts with only one feeder unit by successively bringing the different parts under the pick-up point of the feeder (p. 19).

A thorough discussion of the capabilities of the profile stitchers currently on the market is available in the Journal of the Apparel Research Foundation (52).

Contour seamers are similar types of equipment which move along a seam of a garment and are guided by the edge of the fabric. Most often the control is achieved by optical means. Comparisons of the contour seamers on the market in 1970 and 1971 are available in the Journal of the Apparel Research Foundation (12, 10). Of special interest is the C.E.T.I.H. (Centre d'Etudes Techniques des Industries de L'Habillement) contour seamer. This piece of equipment has the ability to match parts of unequal length and dissimilar curvature together in a straight line before seaming. This capability is judged by the Apparel Research Foundation to be an extremely important breakthrough.

Cam controlled machines are also available to the industry. They are utilized primarily to apply decorative reinforcements or applique. Most of the use of this type of machine is involved in repetitive designs which are relatively small. The Journal of the

Apparel Research Foundation discussed cam-controlled tackers, low cost alternatives to the profile stitchers in 1970 (11).

Specialized Automatic Equipment

Automatic machines which have a specialized purpose are also available. Several Automatic Pocket Attaching Machines were demonstrated at the 1972 Bobbin Show held in Atlanta, Georgia. An example was the Compo-Adler Pocket Creasing and Setting Machine, Model 802, which combines two operations into one fast, semi-automatic method of setting the pocket requiring only the loading of the machine by an operator. The machine folds and stitches the pocket. Information on this equipment is available from Compo Industries, Incorporated (9). Another was the 3518 Pfaff Automatic Pocket Folding and Sewing Unit. This unit, which was designed for sewing pockets on pants, jeans, shirts, pajamas, smocks, etc., was described as follows:

> Cam-controlled lockstitch pocket setter with thread trimmer, folding unit, loading and sewing stations, automatic stacker and air blast unit - tucks in corners of folded pocket to insure neat top edge.
>
> For folding and sewing pockets on pants, jeans, shirts, pajamas, smocks, etc. On one version the controls are designed so that the pocket seam is sewn twice, creating a double row of stitching.
>
> All the operator has to do is position the workpiece under the folding unit, place the pocket blank into the pocket plate, and start the machine. Everything else

is done automatically. The pocket is folded, the workpiece and folded pocket are transferred to the sewing station, the pocket is sewn on. Its seam is secured on both ends and the finished workpiece stacked (64, p. 4).

The performance of this machine on a single unit is approximately 6 pockets per minute. When this unit is set up in tandem, the optimum production is 10 pockets per minute with one operator. This unit is controlled by pneumatic logic [a logic system in which sensors are air activated].

Several dart sewers and other short seam units are available. Durkopp, Necchi, Pfaff, Singer, and Adler all market equipment which is very specialized. These types of equipment were all discussed by the Apparel Research Foundation (4). Characteristics and capabilities of each machine are listed and compared. A special purpose machine, Brother LS 3 B800-500 is designed to set cuffs automatically. At the time this article was written the machine under discussion was a prototype. Specifications are listed in the Journal of the Apparel Research Foundation (3). Another specialized device is available for hemming short-sleeved shirts by a semi-automatic method (57).

Another example of automated equipment which has been designed to de-skill an operation is the new Union-Special semi-automated Trouser Fly Sewing Station, Style 2800 E-I. Increases in production where this equipment has been introduced have been

1600 flys per day, per operator. In other instances, up to 2000 pairs of slacks have been produced in the same time span with the same amount of labor (45).

This discussion of specialized equipment is not complete, as the industry is ever changing, improving, innovating. Evidence of this fact is the number of new pieces of equipment which are shown each year at the various trade shows, both nationally and internationally.

Work Aids

Additional progress in equipment is being made in areas other than the sewing machine itself. A variety of types of automated turners are available. These range from pants turners and other large garment turners which are often air operated (33), to belt and strap turners. These turners of small parts vary in the method of manipulation.

In many instances a mechanized improvement has been designed by the engineers in the plant (53). A button feeder capable of supplying buttons in four colors is discussed in the Journal of the Apparel Research Foundation (22). Close coupled pullers have been in use for several years. These additions to the sewing machine have enabled manufacturers of knits, and often other types of fabric, too, to achieve much more consistent seams. This device simply pulls the seam through the machine with equal tension so that unequal feeding does not occur. In 1971, another type of work aid was introduced: the Bobbin Monitor. This addition to a sewing machine provides for continuous monitoring of the bobbin thread and stops the machine before the bobbin thread runs out. Thus it prevents visible defects in garments. This equipment will provide for a double row of bobbin thread for a distance of about one inch (67).

A number of stackers are presently used in tandem with various sewing units. These sometimes pick up and position by vacuum, in other situations via clips or other mechanisms. One of the major problems that has been encountered with equipment which moves fabric is the limp nature of fabric itself. Unlike paper, which is comparatively rigid, or metal, cloth moves on the bias, and under stress it changes shape. The evidence of the variety of equipment available today demonstrates that the problem of handling fabric can be solved in a number of ways.

In addition to stackers, conveyors are being seen in an increasing number of areas. Conveyors now move tote boxes with cut pieces of garments, move the work in progress itself, and are often found moving the finished product in the storage area.

Finishing and Packaging

Depending upon the type of garment, the type of fabric used and other criteria, the finishing, folding, bagging, or other handling of the garment can be very complex. Many items are folded, such as shorts, tee-shirts, and others. Automatic folding machines exist and can be designed from a group of specifications to fold almost any garment that a manufacturer should want to fold prior to distribution for sale. Machines such as these are discussed in the Journal of the Apparel Research Foundation (5). Many garments are treated with a durable press finish. This can be done by either a resin-treated system or the newer vapor-phase system. In the former case, fabric is treated with a resin prior to production of a garment and then permanently pressed prior to shipment. A newer procedure (69) consists of producing garments of fabric which has not been resin treated and then, via the use of "Vapor-Phase durable press", finishing the garment so that it is virtually wrinkle free for the consumer. This process, called the Ameriset process, involves the treatment of apparel with formaldehyde gases in a sealed reaction chamber. A number of advantages are listed, including abrasion and crease resistance and retention of hand as well as tensile strength. Basically this treatment provides for a return to the marketplace for durable press cotton as it seems to provide answers to many of the questions and problems which have been extant with the use of 100 percent cotton. This may enable cotton to make a "comeback".

The problem of finishing garments, whether in the factory or in distribution centers of stores, is widespread, and several solutions have been proposed. In 1970 an automated steam cabinet was introduced. This equipment channels garments from a conventional overhead monorail system and processes garments through a three-stage finishing process. Garments are heated, then steamed under precise humidity conditions, and finally dried (65). Miranker (43) proposes the use of infrared devices; these are predicted to be the garment finishing equipment of the future. The LS-111 Infrared Cyclo-Steamer has been shown to make more economical use of electrical power and steam than current equipment. In addition, garments can be processed on plastic hangers and do not need to be transferred from the metal hangers as with a hot-air system. Only time will tell whether this newer application of finishing will live up to the claims that are made now.

In 1971, an automated garment bagging system was shown at the Bobbin Show in Atlanta. This piece of equipment accepts garments of any length and on any type of hanger. Standard monorail systems deliver garments to the bagger. Bagging material is supplied on a roll; and the bottom of the garment is sensed, the length of bag is determined by the length of garment and the garment is bagged. The claims made for this equipment are that it will pay for itself in most operations within a year's time by the saving in bagging material and labor. Because of the flexibility of the equipment, garments can come to the bagger in random assortment and still can be bagged in the correct length of bag, all without any direct operator labor (6).

Innovations in the industry will not wait, indeed the industry itself cannot wait, for pressures from importers and competitors continually force the assessment and changes of equipment.

The Use of Electronic Data Processing

Electronic data processing and the use of the computer vary greatly from plant to plant and firm to firm. This usage can be carefully planned and implemented as part of the overall production process, or implemented by sections as it becomes imperative. Computer usage varies from payroll and inventory of materials on hand to inventory of stock ready to be shipped. In addition to the computer processing in market research and production planning, the computer is now in use on the production line. The computer is coupled for use with laser cutters, numerically controlled cutting, the making of markers and the grading of patterns. All of these latter operations are outside the "regular" use of EDP.

III. PROCEDURES

Design of the Instrument

An instrument was designed to yield data which would then be analyzed statistically, so that conclusions could be drawn about the types of mechanized and automated equipment used in the apparel industry in the State of Washington. This questionnaire (Appendix I) had four sections. Section One included information about the plant, including the age of the firm and plant, whether it was part of a multi-plant firm or not, the direct labor employment level, the primary products and the market for which these products were designed. Section Two consisted of a three-part checklist of equipment:

1. Whether the equipment was in use in this plant five years ago,
2. Whether the equipment was currently in use in 1972, and
3. Whether the equipment was anticipated to be in use in 1975.

Section Three consisted of questions about the reasons for moving toward more mechanized or automated equipment. Questions in Section Four related to predictions for the future. Both Section Three and Four provided opportunity for respondents to give answers to open-ended questions.

A decision was made to survey all of the apparel manufacturers of the State of Washington which were in operation on December 31, 1971. Several factors influenced this decision. The major factors were the number of manufacturing firms (estimated to be about 50), their location and the variety of products. Over half of the firms were located in the City of Seattle, and many others were situated in nearby communities; relatively few were located in outlying parts of the state. The primary products varied from skiwear and general outerwear to neckwear, pants, dresses, gloves and swimwear. Several firms were the only producers of a certain classification of apparel. The problems of drawing a representative sample became more difficult than choosing to survey the entire population.

The list of firms to be contacted was obtained from the Directory of Manufacturers, Department of Commerce, State of Washington, Olympia, Washington. Because a new Directory was in the process of being compiled when the list was obtained, a copy of a section of the 1969 Directory was forwarded from the Department of Commerce for use. This listing was then checked against lists of firms which were held by persons connected with the apparel industry. A thread salesman and a man who repaired machines were able to provide changes in names and addresses of firms. A number of firms had gone out of business, new ones had come into being, and others had changed names or addresses.

Arbitrary criteria were decided upon in adding names to the list and removing others.

1. If a firm was no longer in the current telephone book it was considered to be out of business.

2. If a firm was listed in the current telephone book, but the number had been disconnected and there was no new listing, it was considered to be out of business.

3. Firms which were in the telephone book or listed by a salesman in the apparel industry were added to the list.

4. If firms did not reply to letters nor were they available by telephone after repeated attempts (a minimum of five), they were considered to be out of business. Only one firm fell into this category.

5. New names were inserted for old ones where indicated.

6. Firms which had come into being after January, 1972 were not included.

7. Firms which were not wholesale manufacturers were omitted from the list. This applied to custom manufacturers of fur garments, leather garments and millinery.

8. Multi-plant firms were considered as individual plants with each location listed separately. Because of many factors,

equipment at different locations of multi-plant firms tended to be different. Therefore, in order to be able to analyze data statistically, the plants were treated as separate entities.

The completed list of plants totaled 46.

The general procedure for securing the completion of a questionnaire was as follows:

1. Obtain an appointment for an interview, at which time the research project was explained.

2. Give the questionnaire to a representative of the company. The position of the respondent varied according to the size of the plant. Usually the production manager or equivalent completed the questionnaire.

3. If time was available the researcher waited while the respondent completed the questionnaire. This was the preferred method. In many instances the respondents requested permission to return the questionnaire via mail. If the questionnaire was not received within two weeks a follow-up phone call or letter was used to request completion of the questionnaire.

Appointments for plants not located within King, Pierce or Snohomish counties were made by letter. A copy of the letter is included (Appendix II). These plants were contacted during the week of March 27, 1972. Appointments for plants located within King, Pierce or Snohomish counties were made via telephone; the visits to these plants took place between April 10, 1972 and June 16, 1972. The only exception to the above procedure was one plant located in Skagit county. Because of costs of time and money, a letter explaining the questionnaire and its purpose was sent to this firm, along with a questionnaire. The completed questionnaire was returned.

During the distribution of questionnaires, only one firm refused to see the researcher. One firm returned the questionnaire with an accompanying letter explaining that some of the questions involved information that was considered confidential by that firm; therefore, they declined to fill it out. A total of 37 plants returned completed questionnaires. This represents 80.4 percent of the plants in the state.

Methods of Analysis of Data

The information on each questionnaire was coded into keypunch data sheets. The data were then keypunched onto cards for use with the computer. The cards were manually verified to be accurate.

Various procedures were utilized in order to be able to present clearly the information on the questionnaires. The first section of the questionnaire concerned information about the plant, the age of the firm and plant, the product made, and the market classification, as well as the size of the plant and whether a single plant or part of a multi-plant firm.

The second section of the questionnaire provided equipment profiles at three time designations (5 years ago, present, and 3 years in the future). The use of the computer facilitated analysis of the data from these two sections and the inter-relations that might be present.

The computer print-out consisted of the numbers of plants and the percentages of plants holding each specific type of equipment to be calculated for:

1. All plants considered.
2. Plants producing skiwear.
3. Plants producing general outerwear.
4. Plants producing sportswear.
5. Plants producing swimwear.
6. Plants producing pants.
7. Plants producing dresses and skirts.
8. Plants producing gloves.
9. Plants producing down products.
10. Plants producing sportcoats.
11. Plants producing apparel not listed in the above column.

Also included were the numbers of plants which listed these designations as any of the three choices for product made.

The equipment holdings of plants were analyzed in a similar manner with respect to age of firm, age of plant, number of persons employed in direct labor jobs, the market designation and whether the plant was a single-plant firm or belonged to a multi-plant organization.

A number of hand calculations were made by means of a small electronic hand calculator. These included the percentages of plants in each of the product classifications, the mean age of the firms and plants, the mean of the high and low number of persons employed in direct labor jobs, the percentages of the plants which belonged to multi-plant organizations and the percentage of plants which were single-plant firms. The percentages of firms falling into each of the market classifications was also computed. In addition, the standard deviation was computed for the age of the firm and plant, as well as the employment level in the plants.

Opinions concerning the reasons for increased mechanization and automation in the apparel industry were sought. The questions seeking these opinions were posed in the following format. A statement was made, and below it a scale was provided on which the respondent could rank his answer from 0 to 10, with 0 being the low value and 10 being the highest possible value. The answers given were measured in centimeters and given a scale value equal to their length. The mean value of the numerical responses was computed.

A similar procedure was followed for predictions for the future.

Preparation of Graphs

All graphs were drawn in twice the finished scale and photo-reduced. Clear overlays are presented in order that the three time designations can be viewed simultaneously.

IV. RESULTS AND CONCLUSIONS

The results can be divided into several sections: first, the discussion of the general answers on Part One of the questionnaire; second, the data yielded by Part Two, the list of equipment and when it was held; and last, a discussion of the answers given in Parts Three and Four.

Descriptive Information About Apparel Manufacturers

The responses to the question which asked for the prime product or products of the plant indicated that skiwear was the prime product of 21.2 percent of the apparel manufacturing firms in the state. General outerwear for children and adults was the prime product of 18.4 percent of the manufacturers in the state. The remaining 60.5 percent of the firms produced sportswear, swimwear, neckwear, pants, dresses and skirts, coats, gloves, down products, sport coats, or items which could not be classified under any of the previous categories. These data were analyzed in two categories, first as the prime product of the firm, and secondly as one of the first three products of the firm. When these latter data (of the three products of the firm) were analyzed, the results were similar. The products of the apparel manufacturing firms in the State of Washington were primarily skiwear, general outerwear, and down products. Even so, a number of other types of merchandise were produced, and there was no single classification into which apparel manufacturing could be categorized.

The second question asked was, "How long has the firm been in existence?" The answers received varied from one year to ninety years. No data were considered for firms that had been in existence less than one year. The mean age of the firms was 38.6 years, and the standard deviation was 23.3 years.

Question Three dealt with the age of the particular plant. The answers ranged from 2 months to 70 years. In many instances the age of the plant and the age of the firm were identical; however, in more than half of the firms the age of the plant was less than the age of the firm, indicating that the plant had either moved or outgrown its facilities. The mean age of the plant was 21.2 years; the standard deviation was 18.8 years. The data for questions two and three were scatter-plotted and it was apparent that the data did not fall in a standard bell curve. The curves were skewed, with long trailing ends for the higher numbers of years.

Question Four asked whether the plant was part of a group of plants; in other words, was there more than one plant or was it a single-plant firm. Multi-plant firms accounted for 43.2 percent of the plants; 56.8 percent were single-plant firms.

Question Five dealt with the average number of persons employed in direct labor each quarter of the year surveyed. The mean number of persons employed by all firms in the State of Washington was 94.3 at the highest point of the employment cycle. At the lowest point of the cycle there was an average of 81.2 employees. The standard deviation in the first instance was 88.9, and in the low case was 84.6. These data indicate a very skewed curve with a few firms having a number of employees which is much higher than the average. The highest employment level was over 200 by two firms and approximately 250 by a third firm. Most of the other replies to this question fell between 25 and 125.

Question Six asked for the designation of the quality of the product produced. Four categories were provided: first, quality products, price no object; secondly, quality products, within a moderate price range; third, mass market; and fourth, low price market. Only the producers of gloves replied that their products were destined for either the mass market or the low priced market. The percentages by categories are as follows:

Quality products, price no object	21.6
Quality products, moderate price	67.7
Mass market	8.1
Low price market	2.7

The data from this section were used to define categories so that the data from the following section could be analyzed.

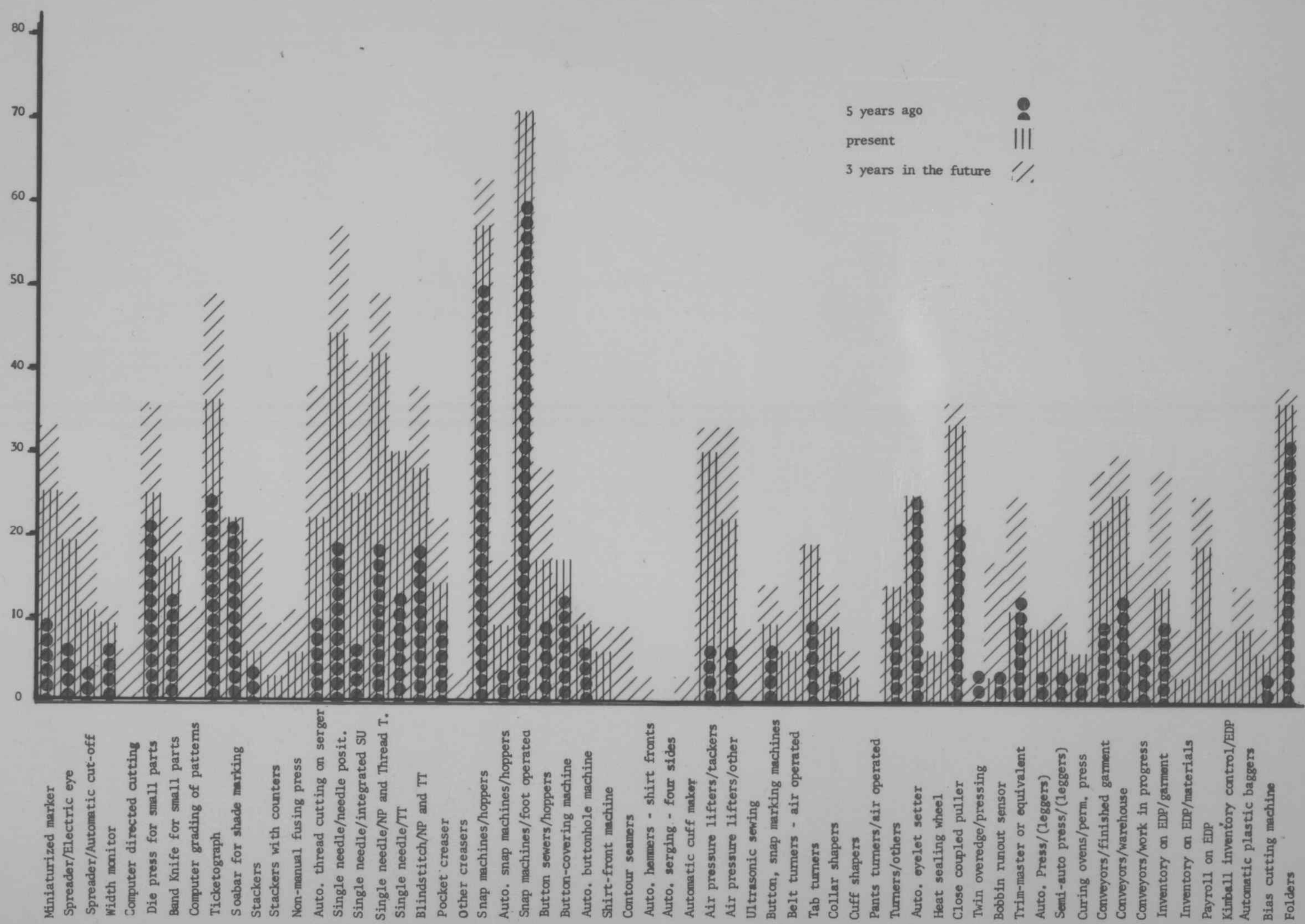
Equipment Profiles

The firms provided a profile of equipment held at three different time periods; five years ago, the present (1972), and a predicted holding three years in the future. The equipment profiles were analyzed according to what product the firm made, the age of the firm, the age of the plant, the size of the plant, whether it was multi-plant or a single plant firm, and last, what quality of product was made. The next section will deal with the analysis of these equipment profiles.

For All Firms Investigated

The first set of graphs, Figure 1, is for the total number of firms replying to the survey. The graph for the time period five years ago is shown as the base graph. The graphs for the present and the predicted holding of equipment three years later are shown as clear overlays so that a visual display of the changes in the pattern of equipment holding is evident. As can be seen, five years ago no firm in the State of Washington used computer directed cutting, computer grading of patterns, stackers with counters, non-manual fusing presses, creasers for parts of garments other than pockets, automatic shirt-front machines, contour seamers, automatic hemmers, automatic serging of panel with four sides serged,

Figure 1. Equipment profile of all manufacturers of apparel State of Washington.


5 years ago
present
3 years in the future
80
70
60
50
40
30
20
10
0
Miniaturized marker
Spreader/Electric eye
Spreader/Automatic cut-off
Width monitor
Computer directed cutting
Die press for small parts
Band Knife for small parts
Computer grading of patterns
Ticketograph
Soabar for shade marking
Stackers
Stackers with counters
Non-manual fusing press
Auto. thread cutting on serger
Single needle/needle posit.
Single needle/integrated SU
Single needle/NP and Thread T.
Single needle/TT
Blindstitch/NP and TT
Pocket creaser
Other creasers
Snap machines/hoppers
Auto. snap machines/hoppers
Snap machines/foot operated
Button sewers/hoppers
Button-covering machine
Auto. buttonhole machine
Shirt-front machine
Contour seamers
Auto. hemmers - shirt fronts
Auto. serging - four sides
Automatic cuff maker
Air pressure lifters/tackers
Air pressure lifters/other
Ultrasonic sewing
Button, snap marking machines
Belt turners - air operated
Tab turners
Collar shapers
Cuff shapers
Pants turners/air operated
Turners/others
Auto. eyelet setter
Heat sealing wheel
Close coupled puller
Twin overedge/pressing
Bobbin runout sensor
Trim-master or equivalent
Auto. Press/(leggers)
Semi-auto press/(leggers)
Curing ovens/perm. press
Conveyors/finished garment
Conveyors/warehouse
Conveyors/work in progress
Inventory on EDP/garment
Inventory on EDP/materials
Payroll on EDP
Kimball inventory control/EDP
Automatic plastic baggers
Bias cutting machine
Folders

automatic cuff makers, ultrasonic sewing, belt turners which were air operated, cuff shapers, pant turners which were air operated, or heat sealing wheels. In addition, inventory of materials was not held on electronic data-processing (EDP) materials, payroll was not on EDP, Kimball inventory control tags were not produced for electronic data processing, and automatic plastic baggers did not exist.

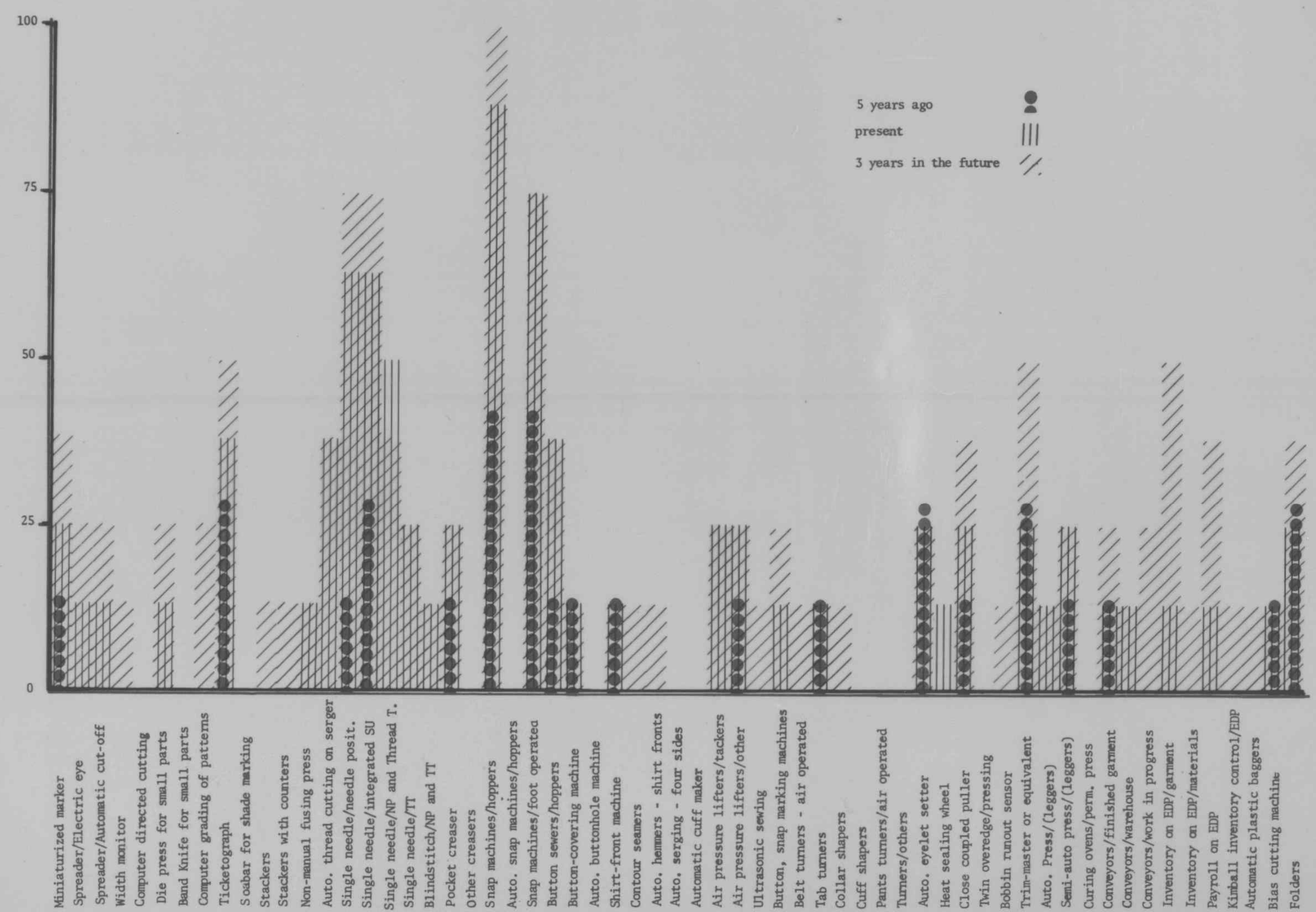
At the present time, some of these pieces of equipment still are not being used by manufacturers in the State of Washington. Computer directed cutting, computer grading of patterns, creasers, contour seamers, automatic hemmers for shirt fronts, automatic serging, automatic cuff makers, ultrasonic sewing, air operated pants turners, and the twin overedge are not in use. More firms responded that they used the equipment at present or predicted that they would use it three years in the future than in the past. Therefore, in a few isolated cases the percentages dropped while the real numbers of firms remained the same. In one case a firm which was using a piece of equipment similar to the ManSew (twin overedge with pressing attachment) no longer was using this equipment. In most cases it is quite evident that the number of firms using almost all types of automated or mechanized equipment is increasing.

When these same firms were asked if they expected to be using automated or mechanized equipment three years in the future, there were very few types of equipment which they did not expect to be using. The pieces of equipment which were not anticipated to be used were the automatic serger which completes four sides of a panel without operator assistance, and air operated pants turners. The firms which produced pants believed that manual turners were more efficient, did less damage in terms of raveling and seam damage, and were faster than the air operated turners.

By Type of Product

Figure 2 presents data on equipment used by skiwear manufacturers. As may be seen from the graph, the equipment used by the skiwear manufacturers 5 years ago can be listed more easily than that which was not used. Very few automated or mechanized pieces of equipment were used. Perhaps this was due to the style problem which always affects the skiwear industry with the short runs and the large number of sizes produced. When the profile of equipment used by skiwear manufacturers at the present time is evaluated, it is apparent that many items still are not in use. This situation was attributed to the fact that automated equipment is not readily adaptable to the type of item produced. Generally the problem of short runs, style changes, and also the relatively small size of the firms contribute to this distinctive profile. When these firms predicted what types of equipment they would be using three

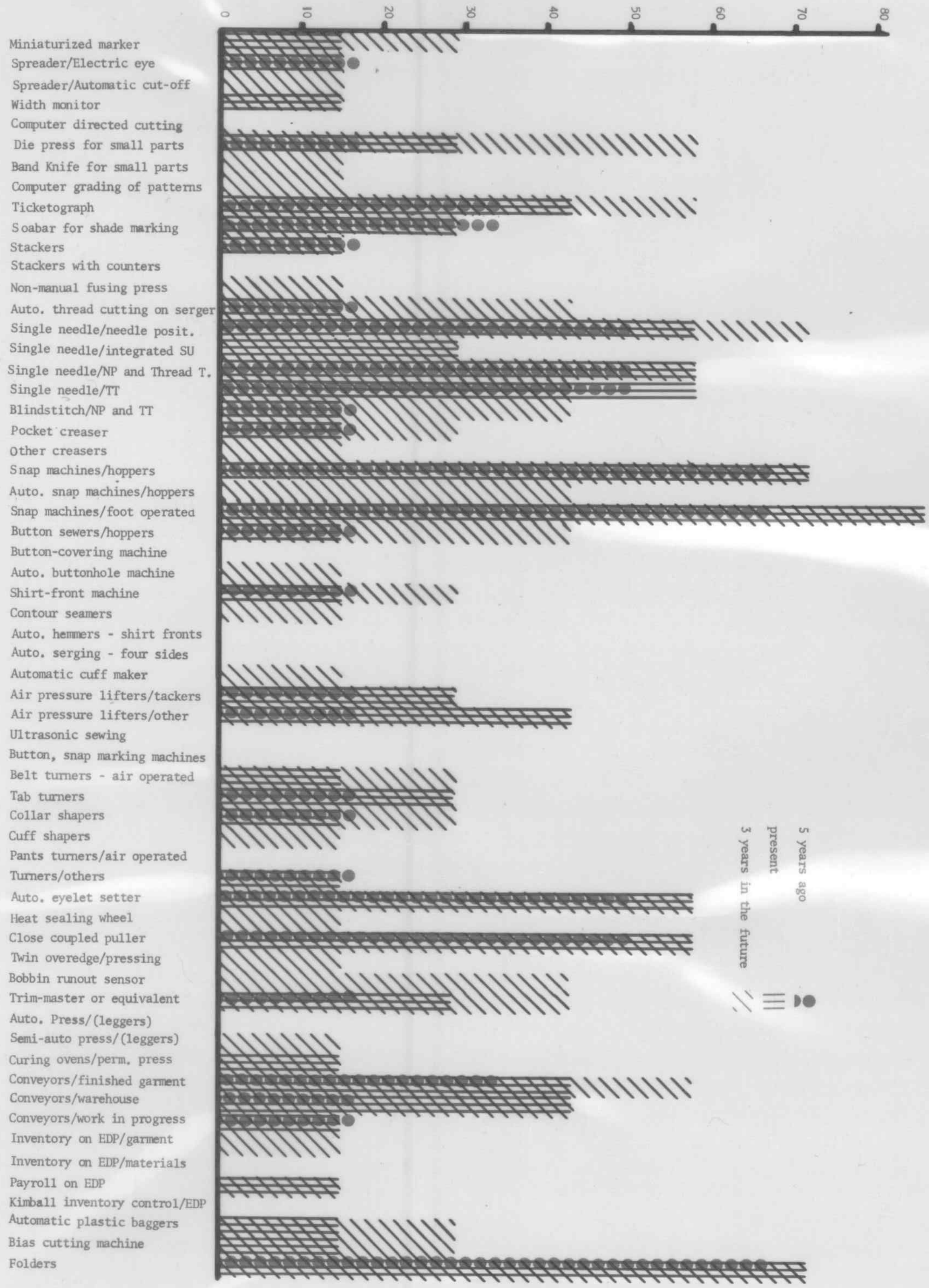
Figure 2. Equipment profiles of skiwear manufacturers.


100
75
50
25
0
5 years ago
present
3 years in the future
Miniaturized marker
Spreader/Electric eye
Spreader/Automatic cut-off
Width monitor
Computer directed cutting
Die press for small parts
Band Knife for small parts
Computer grading of patterns
Ticketograph
Soabar for shade marking
Stackers
Stackers with counters
Non-manual fusing press
Auto. thread cutting on serger
Single needle/needle posit.
Single needle/integrated SU
Single needle/NP and Thread T.
Single needle/TT
Blindstitch/NP and TT
Pocket creaser
Other creasers
Snap machines/hoppers
Auto. snap machines/hoppers
Snap machines/foot operated
Button sewers/hoppers
Button-covering machine
Auto. buttonhole machine
Shirt-front machine
Contour seamers
Auto. hemmers - shirt fronts
Auto. serging - four sides
Automatic cuff maker
Air pressure lifters/tackers
Air pressure lifters/other
Ultrasonic sewing
Button, snap marking machines
Belt turners - air operated
Tab turners
Collar shapers
Cuff shapers
Pants turners/air operated
Turners/others
Auto. eyelet setter
Heat sealing wheel
Close coupled puller
Twin overedge/pressing
Bobbin runout sensor
Trim-master or equivalent
Auto. Press/(leggers)
Semi-auto press/(leggers)
Curing ovens/perm. press
Conveyors/finished garment
Conveyors/warehouse
Conveyors/work in progress
Inventory on EDP/garment
Inventory on EDP/materials
Payroll on EDP
Kimball inventory control/EDP
Automatic plastic baggers
Bias cutting machine
Folders

years in the future they did not include computer-directed cutting. However, they did include computer grading of patterns. Shade marking was not, and has not been a problem in that industry, and therefore the Soabar for shade marking was not in use and was not predicted for the future. Creasers for a variety of pieces other than pockets are not often used, and even in this industry, where many snaps are used, the use of the automated snap machine with hoppers was not predicted. Since very few buttonholes are made on skiwear, automatic buttonhole machines also were not thought to be needed. Again, serging and cuff making are not the types of operations that are commonly done in the skiwear industry, and so pieces of equipment for these purposes were not predicted to be in use. Cuff shapers, pants turners, and turners in general also fell into this category. The ManSew twin overedge with the pressing attachment is most often used in ladies wear for which a finished seam is needed. Curing ovens for permanent press garments simply do not exist in the skiwear industry at present. Because of methods of construction and the end product, those pieces of equipment which were not needed for the specific types of operations being done in the skiwear industry were not predicted to be found in any skiwear manufacturing plant in the State of Washington three years in the future.

Figure 3 presents the equipment profiles of manufacturers of

Figure 3. Equipment profiles of general outerwear manufacturers.


0
10
20
30
40
50
60
70
80
5 years ago
present
3 years in the future
Miniaturized marker
Spreader/Electric eye
Spreader/Automatic cut-off
Width monitor
Computer directed cutting
Die press for small parts
Band Knife for small parts
Computer grading of patterns
Ticketograph
Soabar for shade marking
Stackers
Stackers with counters
Non-manual fusing press
Auto. thread cutting on serger
Single needle/needle posit.
Single needle/integrated SU
Single needle/NP and Thread T.
Single needle/TT
Blindstitch/NP and TT
Pocket creaser
Other creasers
Snap machines/hoppers
Auto. snap machines/hoppers
Snap machines/foot operated
Button sewers/hoppers
Button-covering machine
Auto. buttonhole machine
Shirt-front machine
Contour seamers
Auto. hemmers - shirt fronts
Auto. serging - four sides
Automatic cuff maker
Air pressure lifters/tackers
Air pressure lifters/other
Ultrasonic sewing
Button, snap marking machines
Belt turners - air operated
Tab turners
Collar shapers
Cuff shapers
Pants turners/air operated
Turners/others
Auto. eyelet setter
Heat sealing wheel
Close coupled puller
Twin overedge/pressing
Bobbin runout sensor
Trim-master or equivalent
Auto. Press/(leggers)
Semi-auto press/(leggers)
Curing ovens/perm. press
Conveyors/finished garment
Conveyors/warehouse
Conveyors/work in progress
Inventory on EDP/garment
Inventory on EDP/materials
Payroll on EDP
Kimball inventory control/EDP
Automatic plastic baggers
Bias cutting machine
Folders

general outerwear. As can be seen from the graph, the types of equipment held by firms producing general outerwear were not quite so restricted as those producing only skiwear. However, many of the automated types of equipment which are primarily for women's wear, making of buttonholes, contour seamers, and others similarily were not found. The percentages of firms holding equipment in this category were somewhat higher than those found in skiwear, even when the period of five years ago is considered. It is apparent, when one looks at the overlay covering the present-day equipment profile of firms in the general outerwear category, that there has not been a great deal of change in the last five years. A few changes, usually increases, have occurred, and because of the larger number of firms surveyed at the present time, some percentages have dropped. Again, however, the number of firms remains the same. The equipment predicted to be in use by the general outerwear manufacturers also remains much the same. There are a few increases and a few additions, but very few striking gains. In only four instances are gains noted. First, the percentages of die-press cutting for small parts jump from 28 to 58. Automatic thread cutting on sergers is predicted to increase, automatic snap machines with hoppers are likely to be present in over 40 percent of the firms in the state, and the new bobbin run-out sensor will likely be found in over 40 percent of the firms in the state.

As can be seen by comparing Figure 4, the set of graphs for firms other than skiwear and general outerwear, with graphs that showed the total equipment holdings and predicted holdings (Figure 1), there is a great deal of similarity. The percentages are small in most cases, and conclusions remain very similar to those drawn when the discussion of the total number of firms in the State of Washington was presented.

By Size of Plant

Figure 5 presents a graph and two overlays that are perhaps the most predictable of all of those generated by the data collected. The automated equipment held by the plants which employ between 1 and 75 employees is limited, and the percentages are very low. The one exception to this observation is snap machines, which are foot operated. They are not as automated as many other devices, and perhaps, therefore, should not have been included in the survey, but as they were, the data are presented.

The firms that employ between 76 and 150 persons are grouped in Figure 6. The number of these firms holding automated or mechanized equipment is much larger than for firms with fewer employees, and the variety of equipment held is much greater. Firms predicted that in three years, between 50 percent and 88 percent of the firms will hold almost half of the types of automated

Figure 4. Equipment profiles for manufacturers of products other than ski wear and general outerwear.

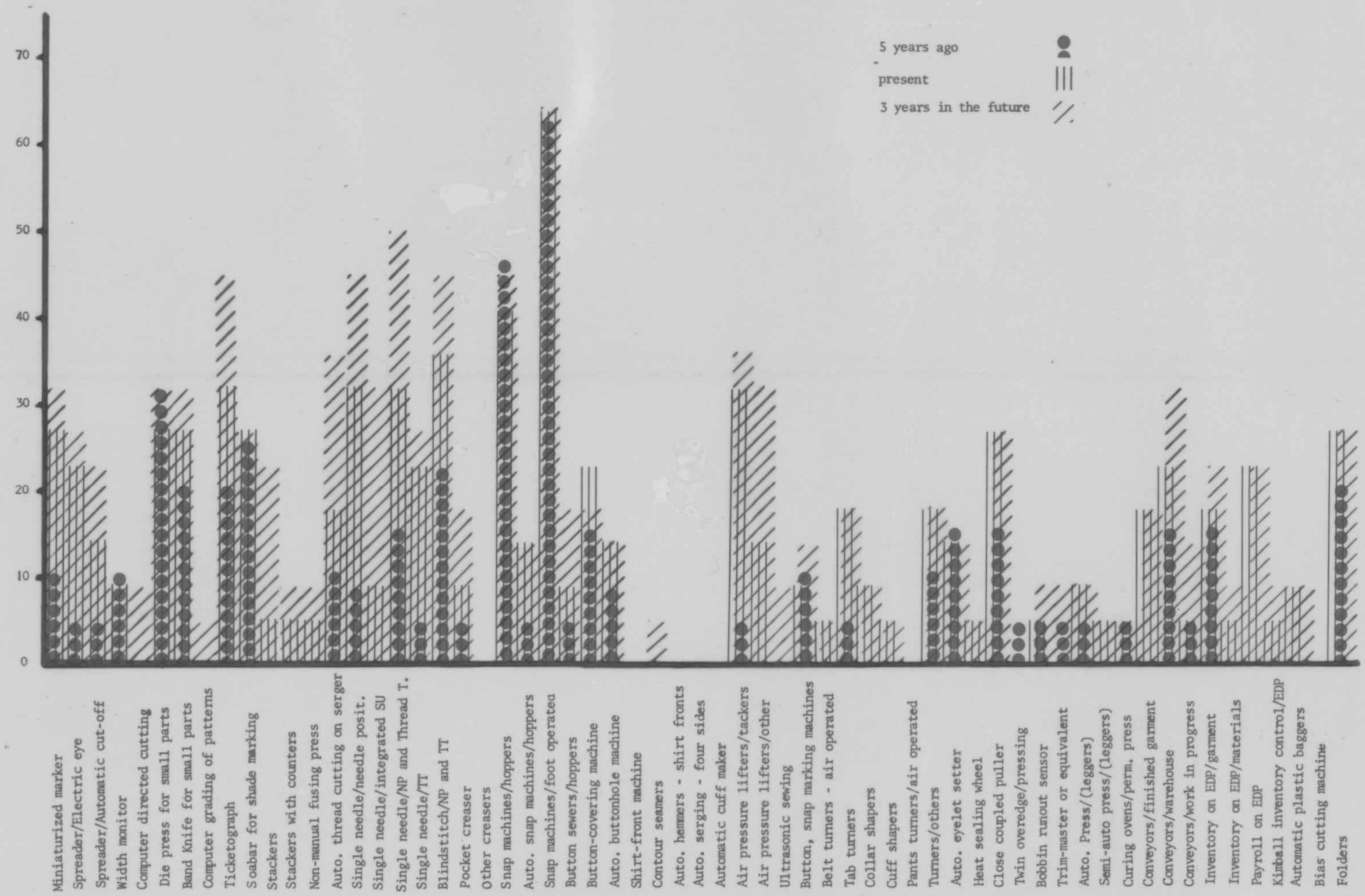
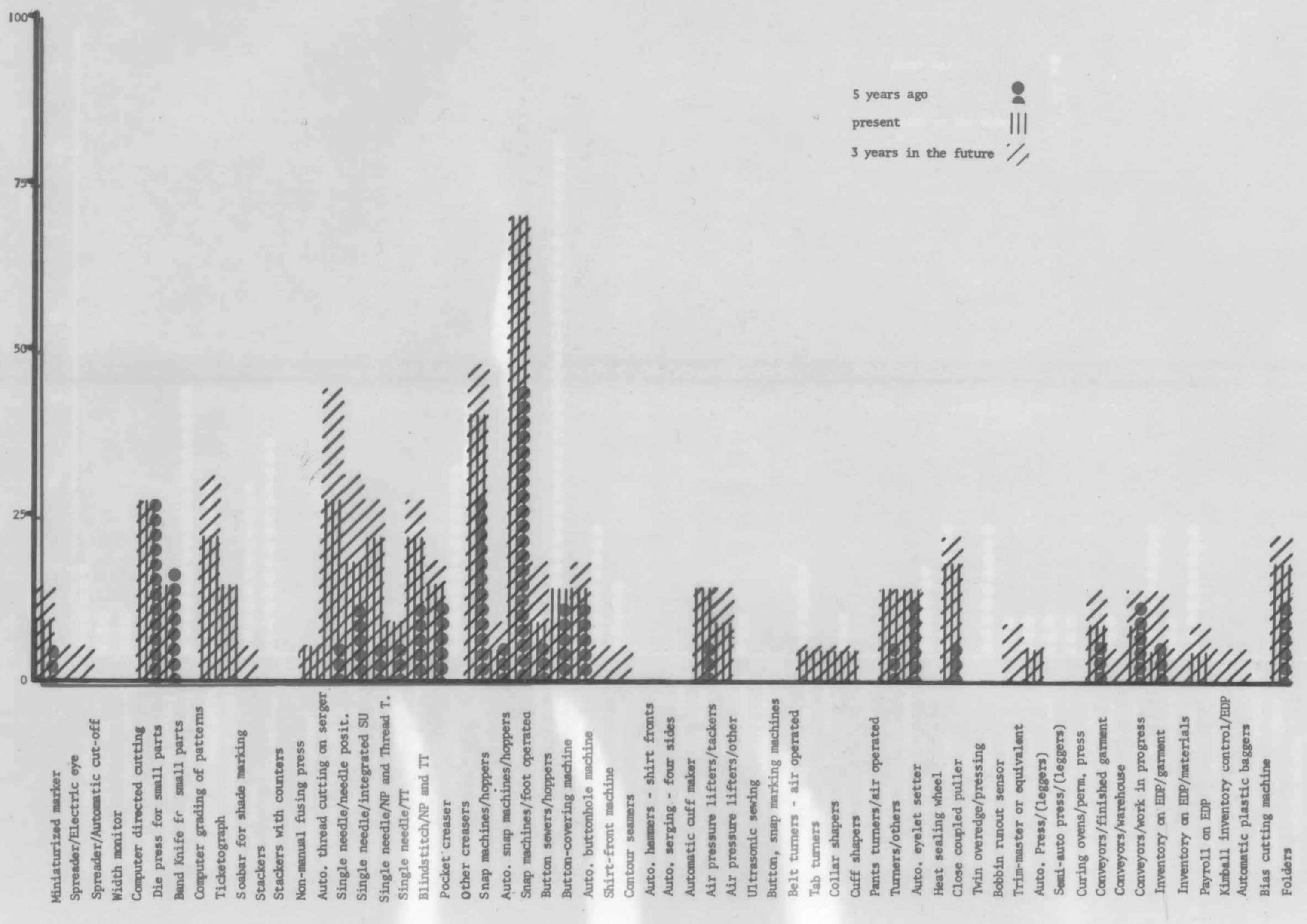

5 years ago
present
3 years in the future
70
60
50
40
30
20
10
0
Miniaturized marker
Spreader/Electric eye
Spreader/Automatic cut-off
Width monitor
Computer directed cutting
Die press for small parts
Band Knife for small parts
Computer grading of patterns
Ticketograph
Soabar for shade marking
Stackers
Stackers with counters
Non-manual fusing press
Auto. thread cutting on serger
Single needle/needle posit.
Single needle/integrated SU
Single needle/NP and Thread T.
Single needle/TT
Blindstitch/NP and TT
Pocket creaser
Other creasers
Snap machines/hoppers
Auto. snap machines/hoppers
Snap machines/foot operated
Button sewers/hoppers
Button-covering machine
Auto. buttonhole machine
Shirt-front machine
Contour seamers
Auto. hemmers - shirt fronts
Auto. serging - four sides
Automatic cuff maker
Air pressure lifters/tackers
Air pressure lifters/other
Ultrasonic sewing
Button, snap marking machines
Belt turners - air operated
Tab turners
Collar shapers
Cuff shapers
Pants turners/air operated
Turners/others
Auto. eyelet setter
Heat sealing wheel
Close coupled puller
Twin overedge/pressing
Bobbin runout sensor
Trim-master or equivalent
Auto. Press/(leggers)
Semi-auto press/(leggers)
Curing ovens/perm. press
Conveyors/finished garment
Conveyors/warehouse
Conveyors/work in progress
Inventory on EDP/garment
Inventory on EDP/materials
Payroll on EDP
Kimball inventory control/EDP
Automatic plastic baggers
Bias cutting machine
Folders

Figure 5. Equipment profiles of plants which employ less than 75 persons in direct labor jobs.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Width monitor
Computer directed cutting
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Band Knife fr small parts
Computer grading of patterns
Ticketograph
Soabar for shade marking
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Stackers with counters
Non-manual fusing press
Auto. thread cutting on serger
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Blindstitch/NP and TT
Pocket creaser
Other creasers
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Snap machines/foot operated
Button sewers/hoppers
Button-covering machine
Auto. buttonhole machine
Shirt-front machine
Contour seamers
Auto. hemmers - shirt fronts
Auto. serging - four sides
Automatic cuff maker
Air pressure lifters/tackers
Air pressure lifters/other
Ultrasonic sewing
Button, snap marking machines
Belt turners - air operated
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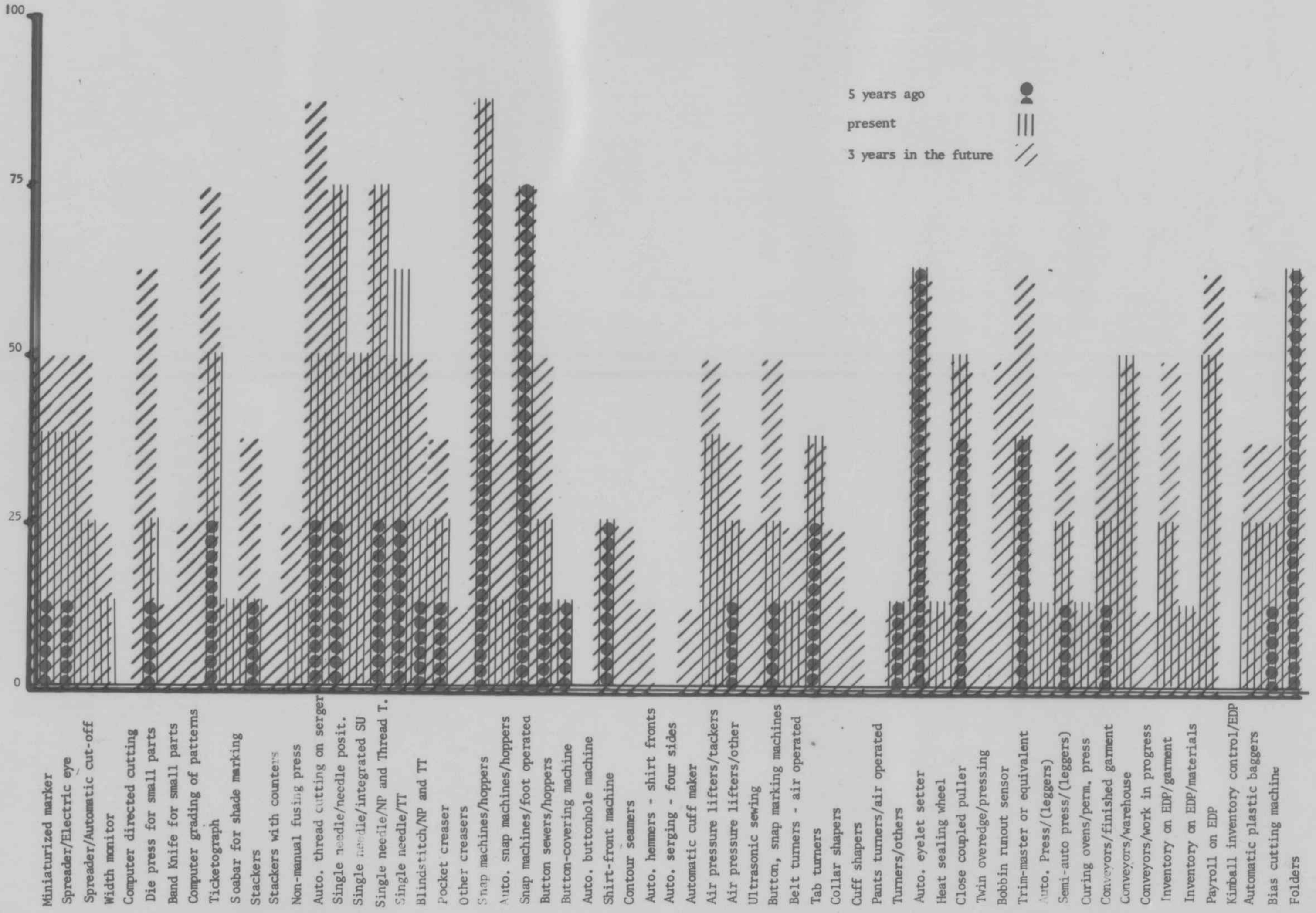
Collar shapers
Cuff shapers
Pants turners/air operated
Turners/others
Auto. eyelet setter
Heat sealing wheel
Close coupled puller
Twin overedge/pressing
Bobbin runout sensor
Trim-master or equivalent
Auto. Press/(leggers)
Semi-auto press/(leggers)
Curing ovens/perm. press
Conveyors/finished garment
Conveyors/warehouse
Conveyors/work in progress
Inventory on EDP/garment
Inventory on EDP/materials
Payroll on EDP
Kimball inventory control/EDP
Automatic plastic baggers
Bias cutting machine
Folders

Figure 6. Equipment profiles of plants which employ between 76 and 150 persons in direct labor jobs.



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Computer grading of patterns
Ticketograph
Soabar for shade marking
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Stackers with counters
Non-manual fusing press
Auto. thread cutting on serger
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Single needle/NP and Thread T.
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Blindstitch/NP and TT
Pocket creaser
Other creasers
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Snap machines/foot operated
Button sewers/hoppers
Button-covering machine
Auto. buttonhole machine
Shirt-front machine
Contour seamers
Auto. hemmers - shirt fronts
Auto. serging - four sides
Automatic cuff maker
Air pressure lifters/tackers
Air pressure lifters/other
Ultrasonic sewing
Button, snap marking machines
Belt turners - air operated
Tab turners
Collar shapers
Cuff shapers
Pants turners/air operated
Turners/others
Auto. eyelet setter
Heat sealing wheel
Close coupled puller
Twin overedge/pressing
Bobbin runout sensor
Trim-master or equivalent
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Semi-auto press/(leggers)
Curing ovens/perm. press
Conveyors/finished garment
Conveyors/warehouse
Conveyors/work in progress
Inventory on EDP/garment
Inventory on EDP/materials
Payroll on EDP
Kimball inventory control/EDP
Automatic plastic baggers
Bias cutting machine
Folders

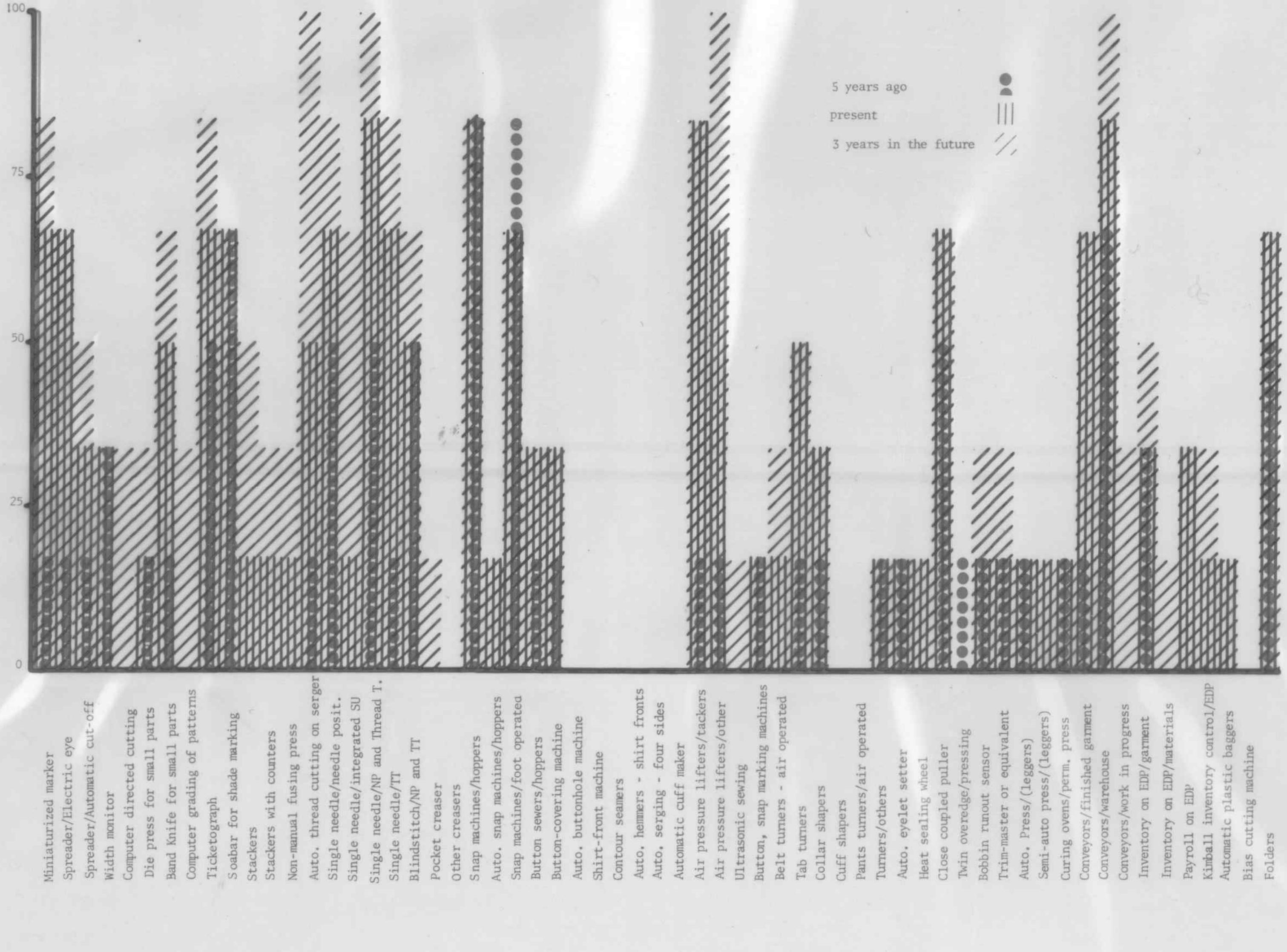
equipment which were asked about on the questionnaire.

It is interesting to note that, when one considers the data for the firms which employed 151 or more employees, (Figure 7), the variety of equipment was not as diverse as that which was held by the firms in the middle bracket on the basis of number of employees. The only reason which can be suggested is that, as firms become larger, they also become more specialized and therefore are less likely to need as wide a variety of types of equipment as might those in the middle employment-level category. Firms which employed over 150 employees produced skiwear, down products, pants and jeans, and swimwear. It is evident, however, that as size increased, the ability to buy equipment increased. Automated and mechanized equipment very often is quite expensive, and the financial base which enables firms to utilize this type of equipment often comes only with size.

Single-Plant and Multi-Plant Firms

The holdings, both real and predicted, of automated and mechanized equipment of the single-plant firms (Figure 8) were small and not of a wide variety. In comparison, the equipment held by plants which were part of multi-plant firms was quite extensive, (Figure 9), both in the percentages of firms which held a particular type of equipment and in the types of equipment held by firms in

Figure 7. Equipment profiles of plants which employ more than 150 persons in direct labor jobs.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Snap machines/foot operated
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Shirt-front machine
Contour seamers
Auto. hemmers - shirt fronts
Auto. serging - four sides
Automatic cuff maker
Air pressure lifters/tackers
Air pressure lifters/other
Ultrasonic sewing
Button, snap marking machines
Belt turners - air operated
Tab turners
Collar shapers
Cuff shapers
Pants turners/air operated
Turners/others
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Close coupled puller
Twin overedge/pressing
Bobbin runout sensor
Trim-master or equivalent
Auto. Press/(leggers)
Semi-auto press/(leggers)
Curing ovens/perm. press
Conveyors/finished garment
Conveyors/warehouse
Conveyors/work in progress
Inventory on EDP/garment
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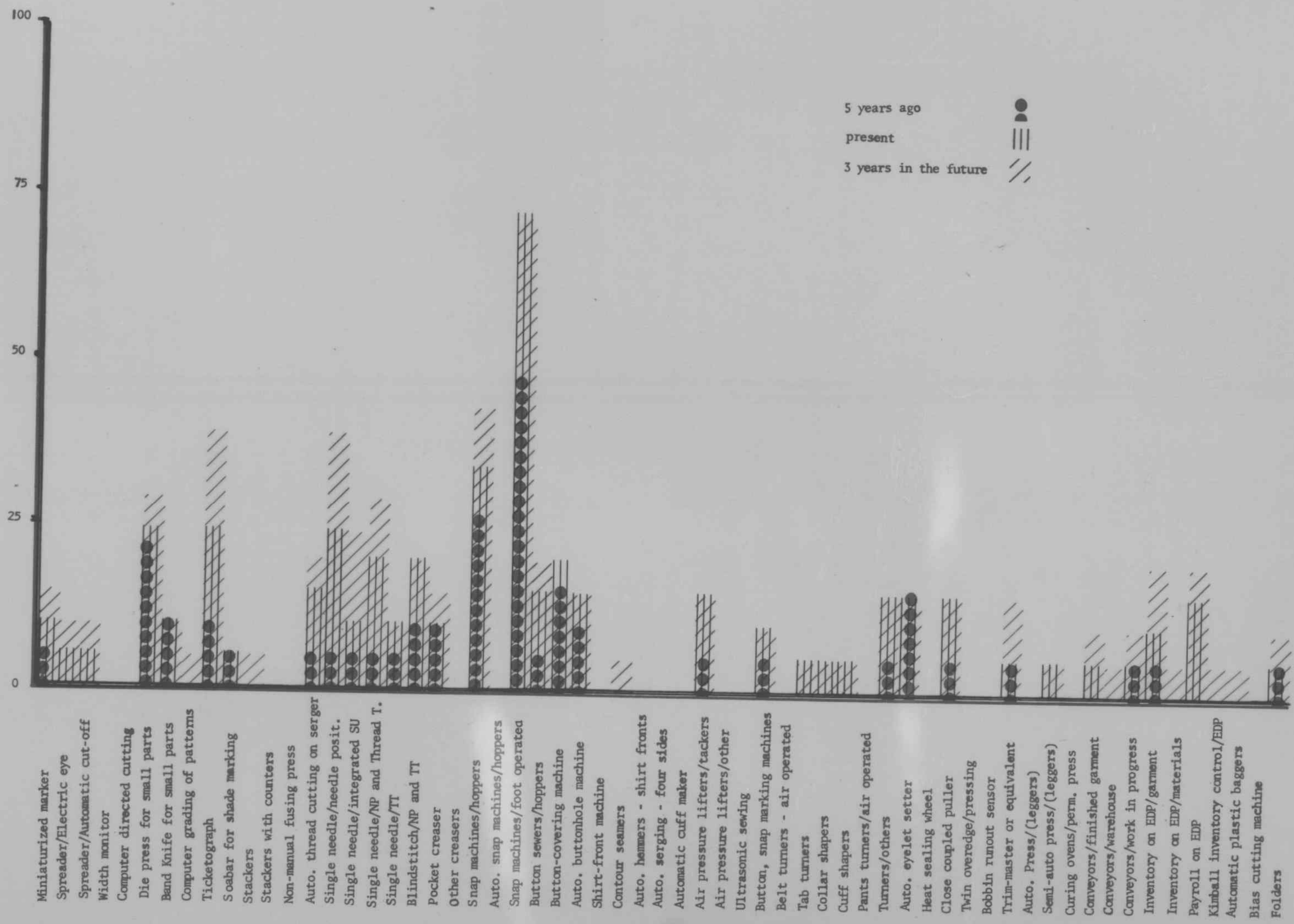
Payroll on EDP
Kimball inventory control/EDP
Automatic plastic baggers
Bias cutting machine
Folders

Figure 8. Equipment profiles of single-plant firms.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Band Knife for small parts
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Air pressure lifters/other
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Bobbin runout sensor
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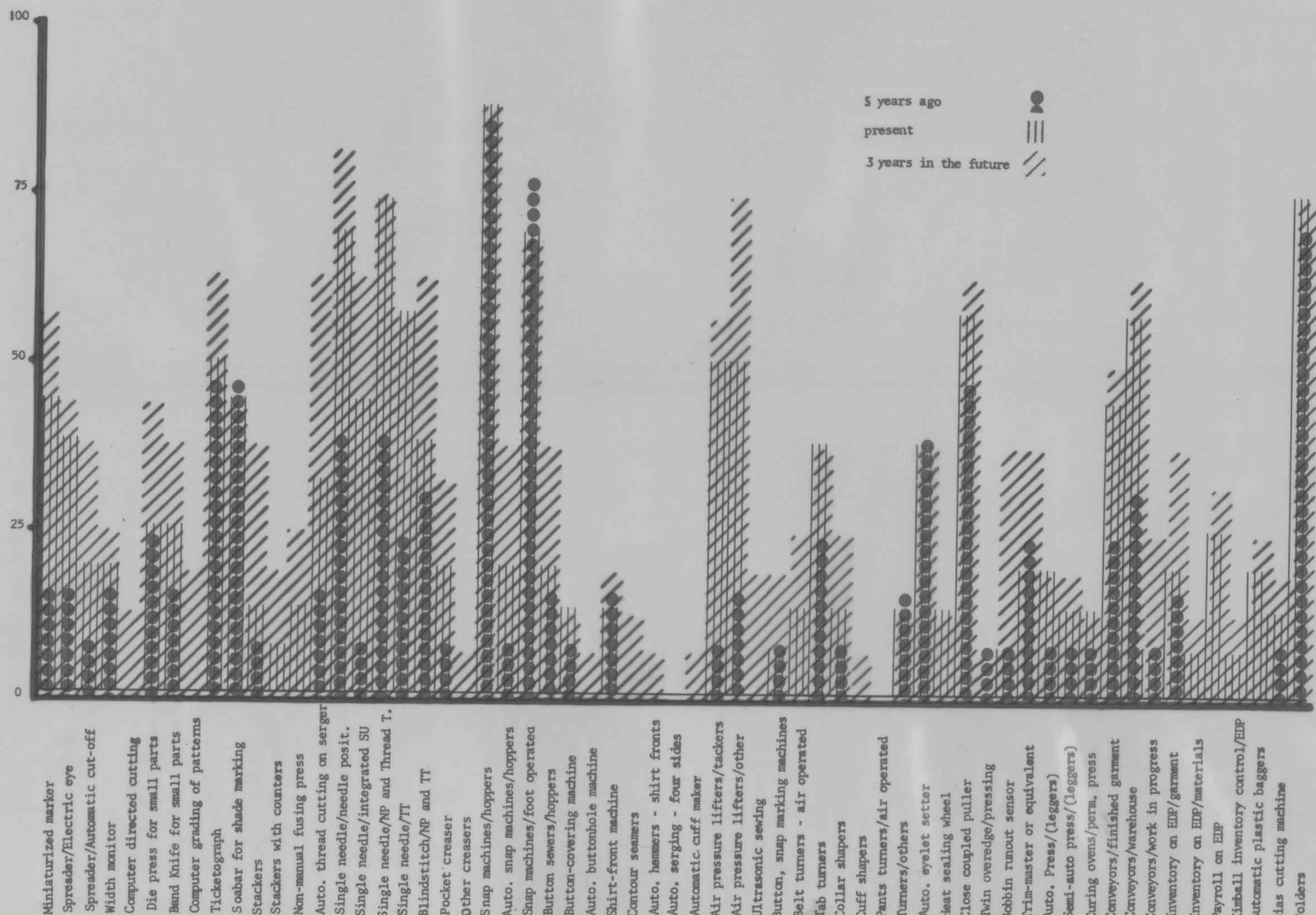
Semi-auto press/(leggers)
Curing ovens/perm. press
Conveyors/finished garment
Conveyors/warehouse
Conveyors/work in progress
Inventory on EDP/garment
Inventory on EDP/materials
Payroll on EDP
Kimball inventory control/EDP
Automatic plastic baggers
Bias cutting machine
Folders

Figure 9. Equipment profiles of multi-plant firms.



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Spreader/Electric eye
Spreader/Automatic cut-off
Width monitor
Computer directed cutting
Die press for small parts
Band Knife for small parts
Computer grading of patterns
Ticketograph
Soabar for shade marking
Stackers
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Single needle/NP and Thread T.
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Air pressure lifters/other
Ultrasonic sewing
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Belt turners - air operated
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Collar shapers
Cuff shapers
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Auto. eyelet setter
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Bobbin runout sensor
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Curing ovens/perm. press
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Inventory on EDP/garment
Inventory on EDP/materials
Payroll on EDP
Kimball inventory control/EDP
Automatic plastic baggers
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Folders

this category. Again, this discussion relates to the last paragraph. Here, financial base is very definitely a part of the explanation, in fact, most likely the primary part of the reason that multi-plant firms are able to buy and use more up-to-date automated or mechanized equipment. It also means that as plant expansion occurs, very specific plans are drawn concerning what types of equipment are needed, and as new equipment is purchased these plans are then implemented.

By Age of Firm, Age of Plant and Market Classification

Information on the age of the firm and the age of the plant was collected and analyzed. There was no obvious pattern of change, growth, or decline in the percentage of firms or plants which held each specific piece of equipment. In some instances there were not enough cases in a category to make graphing feasible. Therefore, these data are presented in tabular form in Appendix III showing the age of the firms and the percentages of the firms holding each type of equipment during each time span. The second portion of the table shows the same type of information according to the age of the plant.

Information on the market classification of the products of the plants was also collected and analyzed. These data are presented in the third section of Appendix III. No pattern of change was observed

Reasons for Increased Mechanization and Automation

When the managers of the apparel manufacturing plants evaluated the reasons for acquiring automated and mechanized equipment on a scale of 10 (10 being the highest possible value), the mean values for each reason were as follows:

Increased production without increasing costs	$\mu = 7.5$
Decrease cost per item	$\mu = 7.2$
Increase quality without increasing cost	$\mu = 5.6$
Hire less qualified personnel to do the same job	$\mu = 4.4$
Meet import problems more adequately	$\mu = 3.9$

A number of firms chose not to answer questions in this section, and therefore the number of responses from which the above means were computed is smaller than in the preceding sections of the study. In addition some firms answered one portion of questions in this section but not another. The number of responses fell between 22 and 29. In some instances the respondents qualified their answers by stating that they gave "only an opinion".

In the opinion of the respondents, the most important reasons for moving toward more mechanization and automation are to be able to reduce cost, or to increase production without increasing cost. The two statements which were thought to be the most important are nearly the same, merely stating the "value" from a different point. If one can decrease the cost per item, he can increase production without increasing total cost.

The ability to increase the quality without increasing cost per item was nearly as important. Examples of this type of equipment are the Reece welt pocket-maker and the Union Special Fly assembly machine. In addition, both of these pieces of equipment allow an inexperienced operator to produce a high quality product with very little training. As noted previously, the hiring of less skilled personnel was ranked in fourth position by the manufacturers.

The respondents ranked as last the problem of attempting to meet import problems more adequately. Conjecture can be offered that this is because of the fact that the manufacturers in this state cannot compete with imported products in the low-cost market or in the mass market, except in isolated cases such as the production of gloves. The impact of the devaluation of the dollar is not known at this time; in the future automated equipment may be one means of combating import problems. It is apparent that reducing cost and improving production capacity are most important for firms which are seeking an increased share of the market today.

Predictions for the Future

The last section of the questionnaire covered predictions for the future. The format for this section was the same as for Section Three. Three statements which had been made by various authors were presented to the industry respondents to evaluate as valid or not valid. The statements and the mean values of the responses are listed below:

> Mechanization and automation will not decrease the apparel manufacturing plant's need for direct labor personnel $\mu = 6.9$
>
> Mechanization or automation will enable the apparel industry to decrease direct labor significantly within the next five years $\mu = 2.3$
>
> Apparel manufacturing plants which are run without direct labor personnel are a possibility in the future $\mu = 2.1$

Thus it is evident that most firms in the State of Washington expect to employ a similar number of direct labor personnel in the future and do not expect automation and/or mechanization to decrease this direct labor need to a great degree. Apparel plants which are run without direct labor personnel are not considered to be a high possibility in the future in the State of Washington. Some plants are moving toward this goal, nationally, such as plants which produce shirts, but even so the achievement of this goal is far from sight.

Conclusions

When the apparel industry is considered as a whole it can be seen that mechanized and/or automated equipment is being added in most factories. Dale (14) believes that automation really does not apply to the apparel industry but that mechanization or reduction of labor content are more nearly accurate descriptions of what is taking place. This certainly is true in the State of Washington. Some segments of the industry are changing faster than others. The firms which manufacture gloves, for example, do so in almost the same manner as fifty or more years ago. Very few pieces of equipment which reduce the labor content of jobs are evident in these glove factories.

Another broader segment of the industry in the State of Washington which is not changing is comprised of those firms which are very small. They fall into two categories: they are either suffering the pangs of birth, or they are in the slow process of dying. The size of a firm can be taken as either a causal factor or as a result. Havinoviski states:

> As we enter the seventies, companies that fall behind technologically will find themselves in difficult times. In the initial state they may face rather intermittent work requirements along with shorter hours and will be able to afford a relatively lower pay and benefits. The final closing down and selling out of such companies, however, will be due more perhaps to their labor force leaving and joining more progressive firms than to their inability to either style or sell goods. Later, those companies that for some reason have survived, will be altogether unable to compete on the market place (31, p. 34).

Some firms must be considered to be in this state at the present. They cannot afford to update their equipment and therefore fall farther behind in the market.

In contrast to these small firms, however, are the majority of the firms in the state. Many of these firms belong to large, broad-based economic complexes which produce goods and services of many types. These firms are often outgrowing their factory and setting up additional factories or building new and up-to-date plants which can give the production capacity which is needed. Another type of firm is also growing. These are firms which cater to a specific market for which there is a high demand. Examples might be quality down products and quality skiwear. These firms cannot meet the market demand and at the same time maintain the quality standards which have enabled them to stand out from the industry unless they expand their facilities.

The apparel industry has recruited assistance from sources as divergent as the aerospace industry and the hand tailor. The changes available to the manufacturer of apparel today can only be termed staggering. In the opinion of Teresko (66) the technical feats which stand out are: 1) computer controlled cutting of cloth, 2) numerically controlled stitching, 3) the laser cutting of cloth, and 4) sewing with glue or ultrasonic energy instead of thread. The firms in the State of Washington have yet to apply these items. This fact, therefore, places this state among the followers in the industry instead of among the leaders. This is not to demean the manufacturers in any way; most are either 1) too small to take advantage of these excessively expensive types of equipment, or 2) operate in portions of the industry which have not yet been touched by the magic of automation.

The changes in the industry which have happened in the last five years fall mainly in the area of reduction of labor content. When automated equipment is designed that can cope with the wide number of styles, sizes and fabrics, the apparel manufacturers in the State of Washington will be very interested in them. Many of these manufacturers believe that automation and mechanization will be the saving grace of a difficult industry.

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APPENDICES

Questionnaire to be used by: Nadine Lathrop
218 Kensington
Kent, Washington 98031

Thesis to be presented in partial requirements of Master of Science, O.S.U.

Mechanization and automation in the apparel industry in the State of Washington

Section I:

Please check the appropriate space or spaces.

1. The three primary products of this plant are (number in order the top three).

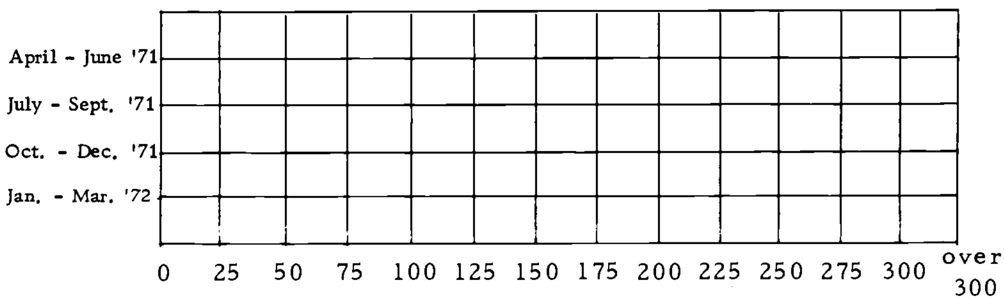
   _______ a) Ski wear
   _______ b) General outerwear for children and adults (excluding rain and dress coats)
   _______ c) Sportwear
   _______ d) Swimwear
   _______ e) Neckwear
   _______ f) Pants (including jeans)
   _______ g) Dresses, skirts, and other women's wear
   _______ h) Coats (both rain wear and dress coats)
   _______ i) Other, specify: ________________________________

2. How long has the firm been in existence? _______ years.

3. How long has this particular plant been in operation? _______ years.

4. Is this plant part of a multiplant firm? _______ Or, is it a single plant firm? _______.

5. Please chart the average number of direct labor personnel employed each quarter of the past year.



6. Please check the phrase which most nearly describes the market for which your products are designed.

   _______ quality products, price no object
   _______ quality products, within a moderate price range
   _______ mass market
   _______ low price market

Section II:

Please check the appropriate column in terms of equipment.

	Did you own or lease this equipment five years ago?	Do you own or lease this equipment today?	Do you expect to own or lease three years from now?
1. Miniaturized marker Marker maker & copiers (Eg. RR50)			
2. Spreader with electric eye and/or edge control.			
3. Spreaders with automatic cut-off.			
4. Width monitor for fabric width inspection.			
5. Computer-directed cutting (Eg. Gerger).			
6. Die press for small parts.			
7. Band knife for small parts.			
8. Computer grading of patterns.			
9. Ticketograph or equivalent.			
10. Soabar for shade marking.			
11. Stackers.			
12. Stackers with counters.			
13. Non-manual fusing press.			
14. Automatic thread cutting on serger (air or electric sensor).			
15. Single needle with needle positioner.			
16. Single needle with integrated sewing unit.			

	Did you own or lease this equipment five years ago?	Do you own or lease this equipment today?	Do you expect to own or lease three years from now?
17. Single needle with needle positioner and thread trimmer.			
18. Single needle with thread trimmer.			
19. Blindstitch with needle positioner and/or thread trimmer.			
20. Pocket creaser.			
21. Creasers (other) specify part.			
22. Snap machines (automatic with hoppers). Operator positions garments for each snap.			
23. Snap machines (automatic with hoppers) which move garment into position before applying snap automatically. One garment is positioned in machine.			
24. Snap machine, foot operated single feed.			
25. Button sewers (automatic with hoppers).			
26. Button-covering machine.			
27. Buttonhole machines (Eg. shirt), all sewn at one time.			
28. Buttonhole machines: shirt manually positioned & then moves automatically until all buttonholes are completed (automatic spacing) & ejected or removed manually.			
29. Contour seamers-no programming-automatically follows contour of garment.			
30. Automatic hemmers - shirt fronts.			

	Did you own or lease this equipment five years ago?	Do you own or lease this equipment today?	Do you expect to own or lease three years from now?
31. Automatic serging - 4 sides of a panel.			
32. Automatic cuff maker - seams, miters, cuts, turns, and stacks cuffs of knitted garments.			
33. Air pressure foot lifters on tackers.			
34. Air pressure foot lifters on other pieces of equipment.			
35. Ultrasonic sewing.			
36. Button, buttonhole or snap marking machines.			
37. Belt turners - air operated.			
38. Tab turners (or shapers)..			
39. Collar shapers.			
40. Cuff shapers.			
41. Pants turners (air operated).			
42. Turners (others). Please specify what ____________.			
43. Eyelet setter (cuts hole, positions eyelet and crimps it).			
44. Heat sealing wheel.			
45. Close coupled puller.			
46. Twin overedge with pressing attachment (E. g. Man-Sew).			
47. Bobbin runout sensor.			
48. Trimmers (final cleanup of garment)(Eg. Trim-master).			

	Did you own or lease this equipment five years ago?	Do you own or lease this equipment today?	Do you expect to own or lease three years from now?
49. Automatic press (Eg. leggers).			
50. Semi-automatic press (Eg. leggers).			
51. Curing ovens for permanent press.			
52. Conveyers - moving finished garment.			
53. Conveyers - in warehouse.			
54. Conveyers - move parts from one operator to next.			
55. Inventory of garments on EDP equipment.			
56. Inventory on EDP equipment			
57. Payroll on EDP equipment.			
58. Inventory control on EDP (E.g. Kimball Hangtag machine).			
59. Automatic plastic baggers for finished work.			
60. Bias cutting machine.			
61. Folders.			

Section III:

Reasons for moving toward more mechanization and automation.

Please rank each of the following on the provided scale. This scale is exactly ten centimeters long and you may rank your answer at any point along the scale (not necessarily at an even number such as 5 or 4). Please use 0 as a low value and 10 as a highest possible value.

Below is an example of this scale as I would wish you to use it.

Clothing costs have changed in the past five years due to:

a) Change in equipment 0 1 2 3 4 5 6 7 8 9 10

The answer above shows one evaluation that equipment has been responsible for the change in clothing costs to the degree of approximately 9.5 on a scale of 0 to 10.

Mechanized and automated equipment have been added in order to:

1. Hire less qualified personnel to do the same job.

0 1 2 3 4 5 6 7 8 9 10

2. Increase quality without increasing cost.

0 1 2 3 4 5 6 7 8 9 10

3. Increase production without increasing cost.

0 1 2 3 4 5 6 7 8 9 10

4. Meet import problems more adequately.

0 1 2 3 4 5 6 7 8 9 10

5. Decrease cost per item.

0 1 2 3 4 5 6 7 8 9 10

Please list any other reasons which have influenced the move to mechanization or automation in this apparel manufacturing plant.

Section IV:

Predictions for the future.

Please rank from 0 to 10 (using 0 as low value and 10 as a highest possible value), on the provided scale, the importance of the following items:

1. Mechanization and/or automation will enable the apparel manufacturing firm to decrease direct labor personnel significantly within the next five years.

   0 1 2 3 4 5 6 7 8 9 10

2. Apparel manufacturing plants which are run without direct labor personnel are a possibility in the future.

   0 1 2 3 4 5 6 7 8 9 10

3. Mechanization and automation will not decrease the apparel manufacturing plant's need for direct labor personnel.

   0 1 2 3 4 5 6 7 8 9 10

Please discuss the implications mechanization and automation have upon the operative personnel and other direct labor personnel in an apparel manufacturing plant.

PLEASE FOLD AND RETURN

APPENDIX II

218 Kensington
Kent, WA 98031
March 1972

Production Manager
XYZ Inc.
Anywhere, WA

Dear Sir:

As a graduate student in Clothing, Textiles, and Related Arts at Oregon State University, I am conducting a study in the area of mechanization and automation in the apparel industry in the state of Washington. I would very much like to be able to include your firm in the study.

The questionnaire that I have developed should take no longer than 20 minutes to complete. I have planned the following itinerary:

Centralia, Longview and Vancouver	March 27, 1972
Yakima, Moxee City and Pasco	March 28, 1972
Spokane	March 29, 1972
Wenatchee	March 30, 1973

I will be able to call you quite early in the morning and confirm a specific time which would be convenient for me to bring the questionnaire to you.

I sincerely hope that your firm will be able to participate in the study; I hope to have as many of the firms in the state participate as possible in order to improve the quality of data and resulting possible conclusions.

Respectfully,

(Mrs.) Nadine R. Lathrop
Graduate Student
Department of Clothing
Textiles and Related Arts.

Dr. F. E. Petzel
Department Chairman and
Major Advisor

	Age of Firm: 1 to 15 yrs -5	0	+3	16 to 25 yrs -5	0	+3	26 years or more -5	0	+3
1. Minaturized marker	17	13	38	0	0	0	9	30	34
2. Spreader Electric eye	34	25	38	0	0	0	0	19	23
3. Spreader/Automatic cut-off	17	0	13	0	0	0	0	15	26
4. Width monitor	17	13	13	0	0	0	5	8	12
5. Computer directed cutting	0	0	13	0	0	0	0	0	4
6. Die press for small parts	0	25	38	0	0	0	30	26	38
7. Band knife for small parts	0	0	25	0	0	0	17	23	23
8. Computer grading of patterns	0	0	0	0	0	50	0	0	12
9. Ticketograph	50	63	100	0	50	50	21	26	34
10. Soabar for shade marking	17	13	13	0	0	0	25	26	26
11. Stackers	17	13	25	0	0	0	0	4	19
12. Stackers with counters	0	0	0	0	0	0	0	4	12
13. Non manual fusing press	0	0	25	0	0	0	0	8	8
14. Auto. thread cutting on serger	17	13	38	0	50	50	9	23	38
15. Single needle/needles posit.	34	50	75	0	50	50	17	41	52
16. Single needle/integrated SU	0	0	38	0	50	100	9	30	38
17. Single needle/NP and Thread T.	34	38	63	0	50	50	17	43	45
18. Single needle/TT	17	13	13	0	50	50	13	34	34
19. Blindstitch/NP and TT	17	13	38	0	0	0	21	34	41
20. Pocket creaser	17	13	38	0	0	0	9	15	19
21. Other creasers	0	0	13	0	0	0	0	0	0
22. Snap machines/hoppers	67	63	75	50	50	50	46	56	60
23. Automatic snap machine/hoppers	0	0	13	0	0	0	5	12	19
24. Snap machines/foot operated	50	63	63	50	50	50	63	75	75
25. Button sewers/hoppers	0	13	38	0	50	50	13	15	23
26. Button covering machine	0	13	13	100	100	50	9	12	12
27. Auto. buttonhole machine	0	13	13	0	0	0	9	8	12
28. Shirt front machine	0	0	0	0	0	0	9	8	12
29. Contour seamers	0	0	25	0	0	0	0	0	4
30. Auto. hemmers - shirt fronts	0	0	0	0	0	0	0	0	4
31. Auto. serging - four sides	0	0	0	0	0	0	0	0	0
32. Automatic cuff maker	0	0	13	0	0	0	0	0	0
33. Air pressure lifters/Tackers	0	25	25	0	0	0	9	34	38
34. Air pressure lifters/others	0	0	13	0	0	0	9	30	41
35. Ultrasonic sewing	0	0	0	0	0	0	0	0	12
36. Button, snap marking machine	34	25	25	0	50	50	0	0	8
37. Belt turners - air operated	0	25	25	0	0	0	0	0	8
38. Tab turners	0	38	38	0	0	0	13	15	15
39. Collar shapers	0	13	25	0	0	0	5	8	12
40. Cuff shapers	0	13	25	0	0	0	0	0	0
41. Pants turners/air operated	0	0	0	0	0	0	0	0	0
42. Turners/others	17	25	25	0	0	0	9	12	12
43. Auto. eyelet setter	50	38	38	0	0	0	21	23	23
44. Heat sealing wheel	0	0	13	0	0	0	0	8	4
45. Close coupled puller	17	25	25	0	50	50	25	34	38
46. Twin overedge/pressing	0	0	13	0	0	0	5	0	0
47. Bobbin runout sensor	0	0	13	0	0	0	5	4	19
48. Trim master or equivalent	17	13	38	50	50	50	9	8	19
49. Auto. press/(leggers)	0	0	0	0	0	0	5	12	12
50. Semi-auto. press/(leggers)	0	13	25	0	50	50	5	4	4
51. Curing ovens/perm press	0	13	13	0	0	0	5	4	4
52. Conveyors/finished garment	0	25	25	0	0	0	13	23	30
53. Conveyors/warehouse	0	25	25	0	0	0	17	26	34
54. Conveyors/work in progress	0	0	0	0	0	0	9	8	23
55. Inventory on EDP/garment	0	0	13	0	50	50	13	15	30
56. Inventory on EDP/materials	0	0	13	0	0	0	0	4	8
57. Payroll on EDP	0	13	25	0	50	50	0	19	23
58. Kimball inventory control/EDP	0	0	13	0	0	0	0	4	8
59. Automatic plastic baggers	0	0	13	0	0	0	0	12	15
60. Bias cutting machine	0	0	13	0	0	0	5	8	8
61. Folders	34	25	25	0	0	0	34	41	45

	Age of Plant: 1 to 10 yrs. -5	0	+3	10 to 20 yrs. -5	0	+3	21 yrs. or more -5	0	+3
1. Minaturized marker	0	20	27	17	34	50	13	25	32
2. Spreader Electric eye	34	34	34	34	34	34	0	32	32
3. Spreader/Automatic cut-off	0	0	14	17	0	17	0	25	32
4. Width monitor	0	7	7	17	17	17	7	7	13
5. Computer directed cutting	0	0	0	0	0	17	0	0	7
6. Die press for small parts	0	7	20	17	34	50	38	38	44
7. Band knife for small parts	0	0	0	0	17	50	25	32	32
8. Computer grading of patterns	0	0	14	0	0	0	0	0	13
9. Ticketograph	20	40	60	34	50	67	25	25	32
10. Soabar for shade marking	10	14	14	34	34	34	25	25	25
11. Stackers	0	0	7	17	34	50	0	0	19
12. Stackers with counters	0	0	0	0	17	17	0	0	13
13. Non manual fusing press	0	0	0	0	0	34	0	13	13
14. Auto. thread cutting on serger	0	14	34	17	34	67	13	25	32
15. Single needle/needles posit.	30	67	80	34	50	67	7	19	32
16. Single needle/integrated SU	20	47	60	0	0	50	0	13	19
17. Single needle/NP and Thread T.	20	50	54	34	50	67	13	32	38
18. Single needle/TT	20	34	34	17	34	34	7	25	25
19. Blindstitch/NP and TT	20	34	47	17	0	34	19	32	32
20. Pocket creaser	10	14	20	0	0	17	13	19	25
21. Other creasers	0	0	0	0	0	17	0	0	0
22. Snap machines/hoppers	40	54	67	84	84	84	44	50	50
23. Automatic snap machine/hoppers	0	7	20	0	17	34	7	7	7
24. Snap machines/foot operated	60	87	87	67	50	50	57	63	63
25. Button sewers/hoppers	10	20	40	0	0	17	13	19	19
26. Button covering machine	10	14	14	17	34	17	13	13	13
27. Auto. buttonhole machine	10	14	20	0	0	0	7	7	7
28. Shirt front machine	10	7	14	0	0	0	7	7	7
29. Contour seamers	0	0	7	0	0	17	0	0	7
30. Auto. hemmers - shirt fronts	0	0	0	0	0	0	0	0	7
31. Auto. serging - four sides	0	0	0	0	0	0	0	0	0
32. Automatic cuff maker	0	0	0	0	0	17	0	0	0
33. Air pressure lifters/Tackers	10	27	34	0	34	34	7	32	32
34. Air pressure lifters/others	10	27	40	0	17	34	7	19	25
35. Ultrasonic sewing	0	0	7	0	0	0	0	0	13
36. Button, snap marking machine	0	7	14	34	34	34	0	0	7
37. Belt turners - air operated	0	0	7	0	34	34	0	0	7
38. Tab turners	20	20	20	0	34	34	7	13	13
39. Collar shapers	10	14	14	0	0	17	0	7	13
40. Cuff shapers	0	7	7	0	0	17	0	0	0
41. Pants turners/air operated	0	0	0	0	0	0	0	0	0
42. Turners/others	10	14	14	17	17	17	7	13	13
43. Auto. eyelet setter	30	27	27	34	34	34	19	19	19
44. Heat sealing wheel	0	0	0	0	0	17	0	13	7
45. Close coupled puller	20	34	40	17	50	50	25	25	25
46. Twin overedge/pressing	0	0	0	0	0	17	7	0	0
47. Bobbin runout sensor	0	0	20	0	0	17	7	7	13
48. Trim master or equivalent	10	14	40	34	17	34	7	7	7
49. Auto. press/(leggers)	0	7	7	0	0	0	7	13	13
50. Semi-auto. press/(leggers)	0	7	7	0	17	34	7	7	7
51. Curing ovens/perm press	0	0	0	0	17	17	7	7	7
52. Conveyors/finished garment	10	14	27	17	67	67	7	13	13
53. Conveyors/warehouse	10	20	27	17	50	50	13	19	25
54. Conveyors/work in progress	10	7	14	17	17	17	0	0	19
55. Inventory on EDP/garment	0	14	34	0	0	0	19	19	32
56. Inventory on EDP/materials	0	7	14	0	0	0	0	0	7
57. Payroll on EDP	20	27	34	0	17	17	0	13	19
58. Kimball inventory control/EDP	0	0	7	0	0	0	0	7	13
59. Automatic plastic baggers	0	14	20	0	17	34	0	0	0
60. Bias cutting machine	0	7	7	0	0	17	7	7	7
61. Folders	40	40	47	67	67	67	13	19	19

	Market Classification: Price no object -5	0	+3	Moderate Price -5	0	+3
1. Minaturized marker	15	25	38	10	28	36
2. Spreader Electric eye	0	13	25	10	20	24
3. Spreader/Automatic cut-off	0	0	25	5	12	20
4. Width monitor	15	13	13	5	8	12
5. Computer directed cutting	0	0	13	0	0	4
6. Die press for small parts	0	0	0	23	28	44
7. Band knife for small parts	29	25	25	5	12	20
8. Computer grading of patterns	0	0	25	0	0	8
9. Ticketograph	15	38	63	23	32	44
10. Soabar for shade marking	0	13	13	28	24	24
11. Stackers	0	0	13	5	8	24
12. Stackers with counters	0	0	0	0	4	12
13. Non manual fusing press	0	0	0	0	8	16
14. Auto. thread cutting on serger	0	13	38	10	24	40
15. Single needle/needles posit.	15	38	63	23	48	60
16. Single needle/integrated SU	0	25	50	10	28	44
17. Single needle/NP and Thread T.	15	43	63	23	44	48
18. Single needle/TT	15	50	50	14	28	28
19. Blindstitch/NP and TT	15	38	50	23	24	36
20. Pocket creaser	0	0	13	10	12	20
21. Other creasers	0	0	0	0	0	4
22. Snap machines/hoppers	58	50	50	46	60	68
23. Automatic snap machine/hoppers	0	13	13	0	4	16
24. Snap machines/foot operated	72	88	88	60	72	72
25. Button sewers/hoppers	0	13	38	14	20	28
26. Button covering machine	15	25	25	14	16	12
27. Auto. buttonhole machine	29	25	25	0	4	8
28. Shirt front machine	0	0	0	10	8	12
29. Contour seamers	0	0	0	0	0	12
30. Auto. hemmers - shirt fronts	0	0	0	0	0	4
31. Auto. serging - four sides	0	0	0	0	0	0
32. Automatic cuff maker	0	0	0	0	0	4
33. Air pressure lifters/Tackers	0	13	25	10	36	36
34. Air pressure lifters/others	0	13	25	10	28	36
35. Ultrasonic sewing	0	0	13	0	0	8
36. Button, snap marking machine	0	13	25	10	8	12
37. Belt turners - air operated	0	0	0	0	8	16
38. Tab turners	15	13	13	10	24	24
39. Collar shapers	0	0	0	5	12	20
40. Cuff shapers	0	0	0	0	4	8
41. Pants turners/air operated	0	0	0	0	0	0
42. Turners/others	15	13	13	10	16	16
43. Auto. eyelet setter	15	13	13	28	28	28
44. Heat sealing wheel	0	0	0	0	8	8
45. Close coupled puller	0	13	13	32	40	44
46. Twin overedge/pressing	0	0	0	5	0	4
47. Bobbin runout sensor	15	13	25	0	0	16
48. Trim master or equivalent	15	13	25	14	12	28
49. Auto. press/(leggers)	0	0	0	5	8	8
50. Semi-auto. press/(leggers)	0	13	13	5	8	12
51. Curing ovens/perm press	0	0	0	5	8	8
52. Conveyors/finished garment	0	13	13	14	28	36
53. Conveyors/warehouse	0	13	25	19	32	36
54. Conveyors/work in progress	0	0	13	10	8	20
55. Inventory on EDP/garment	15	38	50	10	8	24
56. Inventory on EDP/materials	0	13	25	0	0	4
57. Payroll on EDP	0	50	50	0	12	20
58. Kimball inventory control/EDP	0	0	13	0	4	8
59. Automatic plastic baggers	0	13	13	0	8	16
60. Bias cutting machine	0	0	0	5	8	12
61. Folders	15	13	13	41	44	48