FINAL REPORT

AUTOMATED TROUSER FRONT POCKET ASSEMBLY

Prepared for

U.S. DEPARTMENT OF COMMERCE
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GEORGIA INSTITUTE OF TECHNOLOGY
A UNIT OF THE UNIVERSITY SYSTEM OF GEORGIA
SCHOOL OF TEXTILE ENGINEERING
ATLANTA, GEORGIA 30332

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Executive Summary

This report presents results of work completed as part of a Department of Commerce, Office for Trade Adjustment Assistance contract with the Georgia Institute of Technology. The overall purpose of the project work was to evaluate and develop strategies for improving the competitiveness of the American Apparel Industry in the world market place. The purpose of the effort reported herein was to design and develop a workstation for automated assembly of trouser front pockets as a specific demonstration of apparel assembly techniques that may be broadly applicable in automated apparel assembly systems. Secondary objectives were to evaluate the applicability of specific technologies developed as part of the project work to automated assembly of apparel and to provide a data base on fabric friction, an essential parameter in the design of systems for separating cut parts from a stack.

The prototype of the automated front pocket assembly machine was designed and constructed by Automatech Industries. This machine was designed to accept a bundle of cut pockets in a clamp, the clamp being used to orient the pockets with respect to the sewing machine. A single ply separation device developed as part of the project was used to select single pockets from the stack for sewing. An operator selected and registered facings on the pocket and the facings were attached by the automatic sewing operation. With the increased automation offered by the machine, one operator can operate 2 (or perhaps more machines). Furthermore, less operator skill was required than with manual facing attachment.

Trials of the machine were conducted in a jean's manufacturing plant. Results of the trials suggested that the clamping system was not required for the automatic sewing operation. A simple belt and pin assembly under servo control could be used to automatically sew combinations of lines and arcs of circles for attaching facings to the pocket. In-plant studies of the modified facing attachment machine suggested that 7 seconds would be required per facing attachment. Since one operator can run 2 machines, output per operator would be 8.6 pairs of pocket per minute. At 80% machine efficiency two operators with the automated machine could produce the same number of pockets now being produced by five operators. This would give a pay off of the capital investment in the new machines in approximately 1 year.

Studies of other apparel production steps suggest that the techniques developed in the project are applicable to many assembly operations. These studies suggest the possibility of designing a multipurpose work station for apparel plants for use in producing many of the subassemblies required in the production process. This possibility will be the subject of future work in automated apparel assembly systems.

I. INTRODUCTION

Automated apparel assembly systems are essential to the long-term growth and survival of the apparel industry in the United States. The importance of this area has been well recognized in a number of recent conferences and analyses of the apparel industry (1-3). The current research project was undertaken to develop some new approaches in automated apparel assembly and to provide fabric data to assist others working in this area.

The overall research program was under the direction of Dr. Wayne Tincher, Professor in the School of Textile Engineering of the Georgia Institute of Technology.

The objectives of the project were:

Task I. Objective: To Develop a Prototype Work Station for Automated Assembly of Trouser Front Pockets.

Department of Commerce data on total volume of men's and boy's pants produced by the United States Apparel Industry indicates that millions of front pockets are required annually. Production of these pockets necessitates a labor force of between 3 and 4 thousand operators. The similarity of operation in front pocket manufacturing and the large volume required suggested that this area of apparel production be considered for automated assembly systems.

A proposal was submitted to the Georgia Institute of Technology by AUTOMATECH INDUSTRIES on August 13, 1981 to develop a prototype pocket assembly machine. This proposal suggested two key innovations that should overcome difficulties that have confronted automated apparel assembly systems before. First, a clamping system was proposed which maintains cut pieces in a stack in register and permits orientation of the entire bundle during the assembly process. Second, a device was suggested that can separate single pieces of fabric from a stack for sewing or other assembly operations. The design of this device was such that it could separate single fabric pieces reliably for a wide range of fabric weights, weaves, surfaces, textures, and orientations within a bundle. There have been major problems with similar devices previously developed for separating parts in automated apparel assembly.

The innovations described in the proposal were designed to provide the technical breakthroughs required for development of an automated pocket assembly machine. In addition, these innovations were expected to have important applications in other automated apparel assembly operations.

Task I was conducted by Mr. Herman Rovin of Automatech Industries in Greenville, South Carolina.

Task II. Objective: To determine the variability and to assess the barriers to greater uniformity in trouser pocket design in apparel manufacturing. A major problem limiting the applicability of any automated apparel assembly process is the variability required by styling. However, in the case of trouser pockets many of the variations may be related to tradition rather than design requirements. A survey of several trouser manufacturers was conducted to determine the variations in pocket design and to assess the possibilities of greater uniformity. This study should permit an estimate of the range in apparel products which will be amenable to automated pocket assembly.

Task III. Objective: To assess the applicability of the Automatech clamping orientation system and the single piece separation device to other automated apparel assembly operations. The innovations suggested in the Automatech proposal may have application in other automated apparel assembly systems. A careful survey of selected apparel assembly operations was conducted with the purpose of ascertaining the advantages that the clamping orientation system and/or the single piece separation device may have in automation of the operations.

Tasks II and III were under the direction of Mr. Larry Haddock, Director of the School of Textile and Apparel Engineering Technology at Southern Technical Institute.

Task IV. Objective: To establish the range of fabric weights, surface characteristics, etc., that can be separated by the piece selection device. The "pick and peel" concept utilized in the single piece separation device depends on relationships of the fabric-fabric and fabric-device friction. The range of applicability of the device to fabrics widely different in weight and surface textures will depend on these frictional characteristics. A system for measurement of the appropriate frictional characteristics was developed and used to determine coefficients of friction for a variety of textile fabrics. These data should provide a useful base for design of the "pick and peel" piece separation system.

Task IV was conducted by Dr. W. W. Carr, Associate Professor in the School of Textile Engineering at Georgia Institute of Technology.

II. DEVELOPMENT OF A PROTOTYPE WORK STATION FOR AUTOMATED ASSEMBLY OF TROUSER FRONT POCKETS.

The development of automated assembly of trouser front pockets has been predicated on the assumption that for the near future apparel will continue to be produced from cut pattern pieces assembled by conventional joining processes (sewing, fusion, adhesive bonding, etc.) People will be used to load, unload, tend, repair and service machines. No skills such as are necessary in the art of manual sewing will be required. There are five basic cloth handling procedures that must be mastered for automated assembly with these assumptions:

a) Step one: The ability to reliably separate one piece of cloth from a cut stack of parts regardless of:

Type of cloth (knit, woven, non-woven)

Size of the piece

Shape of the piece

Pieces laid alternately left and right

b) Step two: The ability to register or align each individually separated piece of cloth into its proper position for joining to another piece or to a sub-assembly of pieces. Registration must be accomplished regardless of size, shape, type of cloth or color of cloth.

c) Step three: The ability to combine the one properly separated and registered piece of cloth to another similarly separated and registered piece so that both pieces lay in proper juxtaposition to each other as well as to a theoretical joining line.

d) Step four: The ability to join both combined pieces of cloth regardless of their size, shape or type by some method such as sewing, welding, or adhesion with glue. The joining may also require hem forming or progressive stitching and the joining path may be a straight line, or any form of curve, or combination of straight lines or curves.

e) Step five: The ability to remove the finished and joined assembly to a stack or to a second tandemed operation. There is a practical limitation to the number of operations that can be consecutively conducted due to the decrease by geometric progression of the overall efficiency.

In a pair of trousers as we know them today, there exist perhaps fifty to sixty-five independent operations that go into the total assembly of the pair of pants. Each of these operations can involve work on only a single ply of cloth, work on joining two single plies of cloth, or work on a single ply of cloth joined to a previous sub-assembly of two or more plies of cloth. In addition, certain practical considerations further complicate the apparel making process. Some of these are:

1. The limit to the number of pieces that can be cut at one time from a lay of cloth.
2. Material utilization.
3. Shade matching.
4. Pattern matching such as plaids or corduroys, for example.
5. Order sizes.
6. Inventories.

Mastering the above mentioned steps further implies that individual pieces be moved or transferred through each of the five steps. These motions may be straight lines or articulated shapes and can involve the use of belts, overhead conveyers, programmed robots, or dedicated transfer devices.

Further, since it is not possible to do sequential operations in tandem through as many as sixty-five operations, then it also becomes necessary to move stacks of sub-assembled sections to meet with other stacks of sub-assembled sections for additional joining operations.

A) Separation of Single Fabric Pieces - Design and Performance

The first part of the project was to develop a means for separating one piece of cloth from a stack as described in step one. For this purpose, the "slicker-picker" outlined in concept in the original proposal has been developed. There have, over the years, (perhaps the past twenty) been many attempts at cloth separation by such firms as Pfaff, A.E.L., Jacobs, United Shoe Machinery, Jet-Sew, Gepec and perhaps another half-dozen or so firms. Every method of application - sticky tape, precise penetration of pins, vacuum, mechanical rolling, twisting or stretching has been attempted. Only one unit, the "Clu-Picker" by Cluett Peabody (Jet-Sew) has managed to survive. Its reputation on specific types of cloth has been fairly good but it still does not appear to have solved the problems of cloth separation regardless of the nature of the type of cloth involved. The main reason for this appears to be the fact that like all other previous types of pickers, they attempt to pick only one piece from the stack of cut parts.

This concept of picking must rely on the force of attraction (due to friction etc.) between pieces being sufficiently low, that only one piece is removed from the stack. This force of adhesion between pieces in the stack is subject to a number of variables that are beyond the control of the machine designer.

Cloth pieces will stick to each other due to such conditions as:

1. Nap
2. Static electricity
3. Interweaving of strands at the cut edges
4. Actual welding of edges (especially in the case of polyesters that may have been cut with dull knives).
5. Mechanical interlocking such as in the wales of corduroy.

To date, the human hand has been the only device capable of successfully separating any piece, of any type, from any stack of cloth. The human, does not, however, attempt to pick up one piece in the first motion. Rather it endeavors to pick up several and then discard those that it does not want. The human then relies on the sensing ability built within its fingers, brain, and nervous system to detect the fact that it has discarded all but one piece. The imitation of the human process is the concept on which the 'slicker-picker' is based. The picker has a rotating wheel covered with a polyurethane rubber that rotates atop a stack of cut parts. This rotation will lift several plies from the stack. The top ply is held by a small piece of cloth with embedded vertical wires (card-clothing), and the wheel's direction is reversed to return the unwanted pieces to the stack of cut parts. Thus, the 'slicker-picker' does not attempt to separate cut parts for which the uncontrolled force of attraction between two pieces is the determining factor in the separation process. Rather the 'slicker-picker' removes several pieces from the stack, holds the top piece by a piece of card clothing (with a controlled adhesive force), then separates the additional cut parts from this restrained top piece. The separation process, therefore, is determined by the friction of the rotating wheel against the fabric and the restraining force of the card clothing. In the 'slicker-picker' both of these forces can be controlled independently of the nature of the cloth. This makes the 'slicker-picker' distinct from all other types of pickers that have so far been invented or produced. It also makes the probability of success for the 'slicker-picker' greater in its ability to separate a wide variety of weights and types of cloth.

The detail designs of both the card clothing and the poly-urethane wheel required significant levels of mechanical know-how to construct them to function properly. This was mostly attained through trial and error procedures.

Any effects on the separation process due to the height of the stack of cut parts were nullified by having the separator sense when it met the top layer so that no undue strains or pressures were put on the stack. This prevented the "mushiness" or compressibility of a tall stack (as compared to a very short stack) from affecting the action of the separating device. A cloth covered foam rubber bed was used beneath the stack so that the action of the sensing device would still face the same relative compressibility as it approaches the end of a stack as it would with a full stack.

The separator has a self contained clamp which reclamps the entire stack each time a ply has been separated. In this manner the separated ply can be removed by a host of different devices without disturbing the rest of the stack. The separator design is such that it covers only a 4 1/4" length of piece. The lower limit as to size of piece that can be separated is obviously 4 1/4" plus at least one inch more for a transfer device to grab the segmented pieces. The width of the separator is 2 inches. Large pieces of cloth can be separated by placing the picker in a catty-cornered attitude with respect to the stack. On a pant leg, for instance, two separators could be used one in each corner, either at the cuff end or at the waist end.

Thus the design of the separation system makes possible the following accomplishments:

1. It is capable of separating one ply of cloth (and one ply only) from a stack of cloth.

2. The height of the stack can vary up to 3" (a typical height for stacks of cut parts).

3. It is capable of separating any size or shape from a few inches to 4 feet (a range from fly pieces to pant legs were considered to be the end limits).

4. Any changes to the hardware required to handle various textures or thicknesses of cloth can be made quickly by plant operating personnel in accordance with previously established settings.

5. The softness or "mushiness" of the stack does not affect the ability to separate a single ply.

6. The separator is not required to transfer the individual separated piece, but can work in conjunction with various cloth handling machines and/or robots.

7. The separator is capable of accepting a signal (pulse only) to start its operation.

8. The separator in turn is capable of sending out a signal upon completion of its cycle. (switch closure only).

9. The separator when production engineered should be capable of selling at a retail level not to exceed $1,500 to ensure wide acceptance in a variety of assembly operation.

All of the design criteria have been met, with only two exceptions:

1. Cloths such as 'tricot' will not be separated by this device or virtually any other device. The delicacy of the material prohibits most handling because of the possibility of damage to the cloth. Further, it has a natural tendency to roll into a cylindrical shape after having been cut.

2. The time cycle varies from 4 seconds to 5.5 seconds depending on the type of cloth. The thickness and stiffness of the cloth affect the ability of the picker to pick up several plies. Therefore, more time is needed to pick. The same is true of the peeling cycle. More time is required to peel off the unwanted plies based on their thickness and stiffness. This will require more than 1 picker on a machine to maintain production rates.

The following cloths have been tried successfully but testing was not extensive.

1. Denim (6 oz to 14 oz)
2. Corduroy (light wales)
3. Sheeting (polyesters or cotton)
4. Shirting (polyesters or cotton)
5. Flannelette
6. Seer Sucker
7. Non-woven
8. Double knit (for pants or skirting)
9. Pocketing Material
10. Some light curtain fabrics

The separator requires only three adjustments to function properly on all types of cloth.

1. The sensing of the top layer of the stack. This will determine how far the picker wheel will penetrate the stack. For very light cloths (thin

and limp) the penetration should be minimal in order not to pick up too many and therefore have to peel off too many pieces. This will also prevent the more delicate fabrics from being damaged by continuous pick-up and peel-off. For heavy or stiff cloths (such as denim) the penetration should be maximum.

2. The penetration of the points of the card clothing must also be adjusted for light or heavy cloths. Obviously the penetration can be greater for thick cloths. On lighter cloth, the penetration must be minimal in order to keep from sticking through two pieces. The amount of penetration on the light cloth is not minutely critical since the beating of the peeling wheel during peeling will help to dislodge the second piece which may have been partially penetrated by the carding.

3. Timing adjustments for both the length of pick time and the length of peel time are required again based on the variations between light and heavy cloths.

All of these adjustments can be made in a matter of seconds and are denoted by dial settings so that they can be recorded and returned to at will. Alternatively the card clothing can be mounted on a metal slide which allows easy replacement of the metal teeth for different types of fabrics.

The prototype separator design includes the ability to function completely automatically, or in a step-by-step fashion. This system allowed for independent observation of each step in the process. This, of course, was done with the intention of using the prototype as a test bench to determine the ranges of cloth types it could handle, and may not be necessary in production models.

The 'slicker picker' has performed quite well in lab trials, and has created considerable interest among apparel manufacturers. It has great promise as an important component in a wide range of automated apparel assembly systems.

B) Automated Front Pocket Assembly

The second part of this project was to develop a machine which would automatically join the facing piece of a front pocket to the base pocket material itself. This portion of the development concerned itself with some of the conditions of the other four steps previously mentioned (i.e. register, combine, join and stack). Problems concerned with the registration of the pocket itself were to be handled by means of the 'bundle-boy' concept which effectively clamped the entire bundle of pocket pieces as soon as they were cut on the cutting table. This procedure assured the registration of the entire bundle and consequently each piece in the bundle. Since each bundle was clamped in exactly the same place, the clamp bore a relationship to the sewing machine needle and the proposed stitch path. By placing the clamp in the position on the machine, then every pocket in turn could be selected by the 'slicker picker', passed under the needle and thereby stiched in the same place on each and every pocket. The clamp in principle supplied the means for:

1. Registering each pocket in the proper position to the needle.

2. Moving each pocket (as laid down one at a time from the clamped bundle) past the needle in the proper path.

3. Provide a means for stacking each finished sewn pocket (since they are still clamped).

4. As removed from the machine, still in the clamp, the entire bundle orientation is still known so that it can be properly registered for

subsequent operations such as closing, or attaching to the front pant-leg panel. This procedure does much to overcome the difficulties of the remaining four steps in so far as the pocket is concerned.

The facing piece presents other problems since it could not be bundled and for this project it was decided that the facing would be manually applied to each pocket. Manual placing for the moment solved the problems of:

1. Separation of facings (a second 'slicker picker' could have been used, but gave no advantages since registration was manual).

2. Registration of each facing with respect to each pocket and with respect to the desired stitch path.

3. Handling of left and right facings intermixed in a bundle which is the normal way they come from the cutting room.

To the best of this writer's knowledge, complete automation of the pocket facing operation was attempted as far back as 1966 by Automation Engineering Laboratories of Stamford, Conn. Hardware was indeed built and installed in many major sewing plants in the United States. Foremost among these was the Levi-Strauss plant in Knoxville, Tenn. The equipment was far ahead of its time and suffered from many problems:

1. Engineers designing equipment without sufficient knowledge of the problems of apparel assembly.

2. Ideas were applied that were ahead of the state of the art in controls (such as microprocessors).

3. The basic five-steps (previously mentioned) that had to be mastered were far from being mastered.

4. Equipment built was too costly and too subject to break down to result in an effective Return on Investment (R.O.I.).

5. The equipment was geared to total automation, not deskilling or semi-automation.

Since that time, the Levi-Strauss Co. has, through its facility in Richardson, Texas (which took over personnel and rights from A.E.L. after it closed) made machinery for semi-automatically applying facings to pockets. The facings, and the pockets are separated, registered, and placed in the proper position at the needle by an operator. The sewing is accomplished automatically by edge-sensing the facing piece and the finished part is stacked automatically. Levi has also made a machine for closing the 'faced' pocket, but it too is semi-automated. (An operator takes a faced pocket from the previous stack, folds it in half and places it at the needle. Again the sewing is accomplished automatically by edge sensing the pocket outline). The degree to which combining of the two operations can be carried out is not known. The only other equipment being worked on at this time with regard to front pockets is a pocket closing machine by AMF sewing division.

No other attempts at total automation of front pockets which would include facing, closing and attaching to the leg have gone beyond what was attempted in this project.

The design and construction specifications for the front pocket facing machine were as follows:

1. The machine must be capable of joining a facing to pocket lining considering these stitch paths:

a) A straight line

b) Two straight lines at an angle to each other

c) A continuous curved path consisting of two straight lines both tangent to a segment of a circle.

2. It must be capable of sewing radii from 2 to 5 inches.

3. It must be capable of using a lockstitch, a chain stitch or a double needle chain stitch with a top cover stitch.

4. It must be capable of accepting a bundle of pocket linings that were clamped (as they were cut) in order to maintain the orientation of each pocket lining in the bundle.

5. It must be capable of moving the pocket bundle past the sewing needle in any of the previously described paths.

6. It must be capable of accepting any size of pocket.

7. It must be capable of accepting a wide range of pocket shapes.

8. It must be capable of sewing either left pockets or right pockets, but not alternately.

9. It must be capable of a six second maximum time cycle (not including the time for the operator to manually place the facing).

10. It must accept a manually placed facing which can be placed in two seconds.

11. One operator should be capable of tending two machines. (Supposedly one of them doing right facings, and one doing left facings).

12. It must be capable of sewing facings that have previously had watch pockets attached to them or flat facings only.

13. The bundle clamp should be capable of easy loading and removal (preferably in seconds).

14. The bundle clamp should be capable of being mass produced for under $10 each.

15. The clamp should be capable of holding a minimum of eighty pockets.

16. The clamp must be capable of holding any size or shape of pocket without interfering with the sewing head and without the loss of registration of any piece in the bundle.

17. The clamp should be capable of holding all pieces in secure registration even though the entire clamped bundle may be manhandled or conveyed from operation to operation.

18. The machine should be able to be reproduced for a retail price in the range of $25,000.

19. The machine should occupy minimal floor space

20. The machine should use minimal power.

An overall view of the completed machine is shown in Figure II-1.

The mechanical design of the machine was made in two main sections. The first section supported the sewing machine, auxiliary drive, and pivot pin. (along with the associated valves for their operation). The second section supported the carriage and clamp and the linear and rotary drive system. Physical bolting together and alignment of the two sections, as well as hook-up to power, requires a few hours of time during installation. The operator was trained to handle the machine within one hour.

The control and synchronization of the moving carriage relative to the sewing machine was all done by electrical D.C. Servo drives. A D.C. tachometer mounted to the sewing machine basically monitored the sewing speed. The linear and rotary servo drives for the carriage also had D.C. tachometers mounted to their drive motors. These tachometers were electrically slaved to the sewing machine tachometer and consequently followed every minute variation in sewing speed. The small auxiliary belt drive which came down upon the facing and pocket combination was also driven by a D.C. Servo and consequently followed the sewing machine output as did the carriage. The

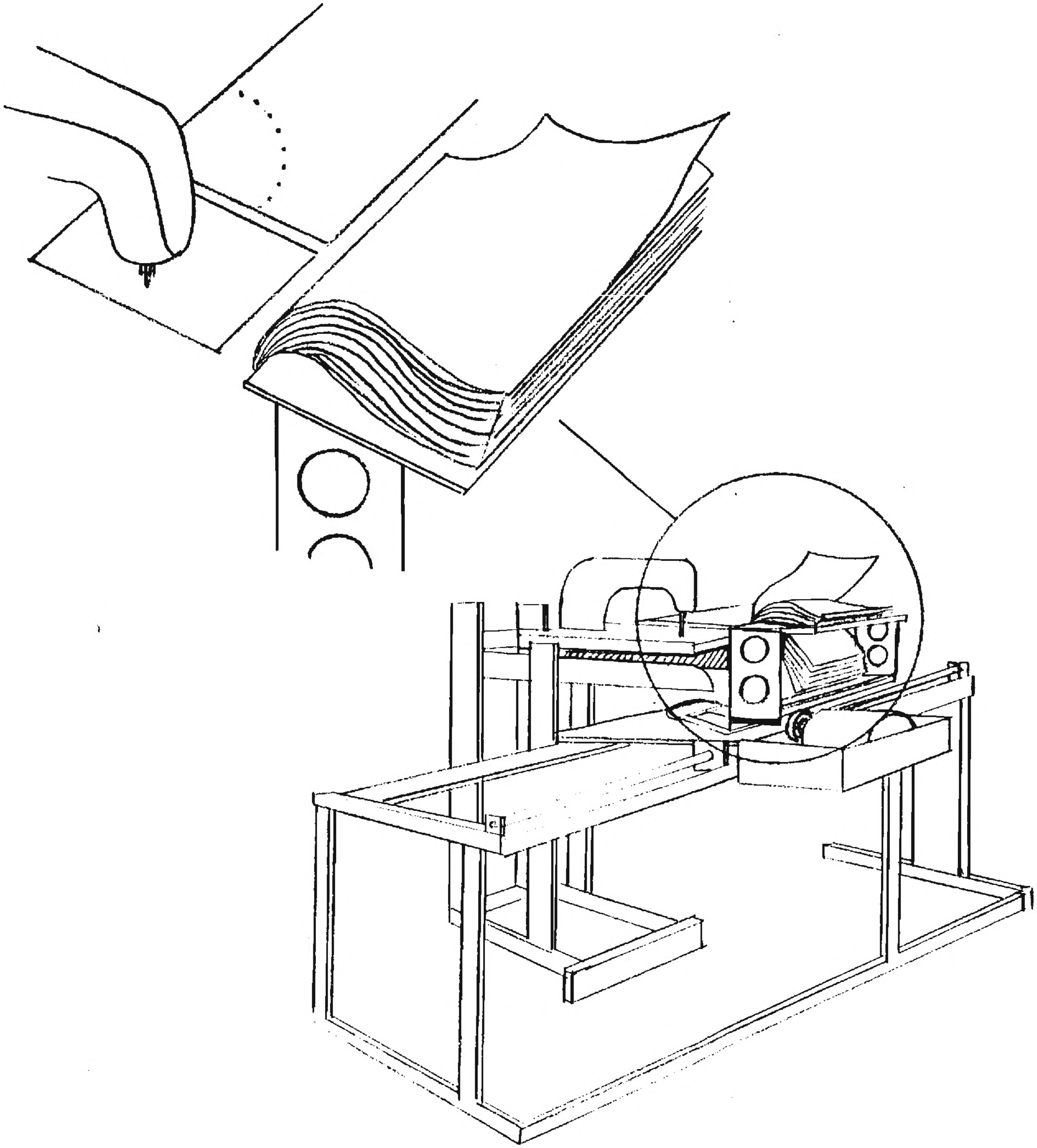


Figure II-1. An Overall View of the Prototype Pocket Facing Machine auxiliary belt drive also had the ability to lift and drop since it was only used during straight sewing paths. A pivot pin which also lifted and dropped in reciprocal fashion to the belt was used for curved paths. The length of path desired, either straight or curved (along the circumference) were controlled from the respective linear or rotary tachometers. The velocity output of the tachometers was integrated with respect to time, thereby giving a measure of distance. Should an operator wish to change the length of a particular path, it required only the turning of a numbered dial. The numbers which represented the particular paths desired were recorded along with the respective sizes. In this manner, each setting could rapidly be retrieved and altered for size changes.

If a straight path only was desired then the rotary servo was simply shut-off. If the rotary servo was signaled on and off during sewing, then the machine would sew a pre-set straight line to start with, automatically switch to rotary drive (and stop the linear motion) for the desired length of curve and then stop the rotary and switch back to linear motion.

The machine could also be made to sew two straight lines at an angle to each other in the following manner:

1. Start by sewing a pre-set straight line. The carriage and auxiliary belt drive would follow.

2. Stop sewing at the pre-determined point. This would cause the carriage and belt to also stop.

3. Lift the belt and drop the pivot pin.

4. Without sewing cause the rotary drive to turn through a pre-set electrical voltage value which is commensurate with the angle desired.

5. At the end of rotation, stop the rotary drive, drop the belt and lift the pivot pin.

6. Instruct the sewing machine to start again. This will cause the carriage and belt to follow in a straight line for the second desired stitch path.

This method of sewing two straight lines at an angle was not included in the electrical control of the prototype.

There is no pocket shape or style known that cannot be sewn by the system described. It may require slight changing of the curvature so that the curve consists of straight lines and radii and not things such as hyperbolas or parabolas.

A description of the sewing control system design is given in Appendix A.

All of the machine design criteria were met with two exceptions:

1. In the case of small size pockets for boys trousers, it may be necessary to cut the right and left pockets as one piece rather than two separate ones. This will provide a larger piece more susceptible to being clamped than either of the two separate ones. After the sewing has been completed, it will then be necessary to cut the entire bundle into two separate bundles.

2. The time cycle will probably increase for small radii. This is due to the fact that the entire bundle and its associated carriage must swing at an increased rate of speed. The inertia and mass of both the carriage and bundle requires that the angular velocity be decreased.

The prototype machine was designed to sew jeans facings. This requires sewing the most difficult of all three paths i.e: two straight lines tangent to an arc of a circle. The prototype could have been easily modified for work pants pockets also. The other reasons were obviously because there is a very large market and because a jean's manufacturing company was contributing in-kind to this development contract. Sizes of pockets ranging from 28 through 40 were considered in the design. All the facing shapes were reviewed with the jeans manufacturer in order to minimize the amount of changing due to size. In this regard, attention was also paid to assuring proper material utilization and that none of the facing shape changes would be disapproved by merchandizing.

Identifying marks were made on the clamps to indicate where to place a particular size bundle in the clamp. Simple cardboard templates were also employed to assist in registering a clamp on a bundle with respect to the edges of the pocket that had to align with the facing and also with the proper starting point of the needle on the pocket.

The accuracy requirements for the stitch path were set at ± 1/8" variation along the stitched facing contour. The prototype was set to sew right facings either flat or with watch pockets attached. The machine was designed so that it could be altered to sew left facings as well. (This alteration, however, was not to be accomplished during production running. In production use, it was anticipated that one machine would be set to sew rights of any size and a second machine would be set to sew lefts of any size). The prototype was designed to function in any of three modes:

1. Fully automatic i.e. sew a facing and return and wait for the operator to place another facing on the pocket. Included in the design was the automatic cutting of the thread chain on each pocket and the ability to automatically move the sewn unit out of the way of the next piece.

2. Single cycle i.e. sew one facing at a time and stop. The operator would then have to return the carriage manually (by pressing a switch). This was done to assist in observing the machine action during testing.

3. Step-by-Step i.e. all the steps in one cycle were accomplished manually by the operator or technician through a series of push-buttons. This

was again done to assist in observation during testing, for ease of set-up and for ease of teaching the machine operation.

C) Prototype Testing

From the outset of this contract, in-plant testing was to be done at a cooperating jeans manufacturer's facility. A mechanic from the manufacturer was sent to the Automatech facility for training. After one week of training, the machine was delivered to the plant on May 24, 1983 and installed by Automatech and plant personnel.

The machine was installed in the shop area and not on the production floor. It was agreed that since much record keeping and information was to be compiled, the machine would cause too much disruption on the production floor. The chief industrial engineer was placed in charge of the project by the jeans manufacturer. The mechanic trained by Automatech was available on call should he be needed and a regular sewing operator was assigned to run the machine. Cooperation, and interest by all of the plant personnel was excellent. Video tapes were made during the set-up and training periods to assist in subsequent re-study of what happened and what may have gone wrong. Some faulty components within the machine were discovered during this time.

It was mutually agreed to start with one size (32) so that response and repeatability of the machine could be recorded. After sufficient testing was done with one size, other sizes were to be tried to note the alterations due to size changes. These alterations were:

1. Change the position of the clamp as related to each size
2. Adjustment of the clamp position in the machine carriage with each size.

3. Adjustments to the machine in either:

   a) Switch settings

   b) Servo control system settings

   c) Rate settings (for different curves)

   d) Position changes to the sewing head, and pivot pin for different radii.

The outline of the contour to be sewn was agreed to by Automatech and the jeans manufacturer so as to conform to acceptable standards for their merchandizing and to proper mathematical description for machine purposes. As much as possible standardizations were made in the area of the radius described on each facing. It was found that making a 4" or 4 1/2" radius on all sizes from 28 through 40 would not affect their desired design, their merchandizing or their material utilization. The manufacturer produces jeans solely for a major brand name design. Their standards are certainly as rigid as can be anticipated anywhere. This standardization would obviously negate the need to make as many changes in the machine settings with size changes.

The prototype facing machine was tested at the plant for 3 1/2 weeks. Standard production pieces were cut for the machine testing. The pieces used were not put back into production trousers since it was necessary to examine and evaluate the results. This would mean a severe hold-up of present production as well as problems of shade matching.

The initial results were compiled and sent to Automatech for review. Several Automatech personnel visited the plant during these first few weeks of testing. With the exception of two intermittantly faulty relays, no other mechanical or electrical difficulties were encountered. The biggest problem that was encountered was the failure of the machine to <u>repeat</u> its path (within specified limits) on a consistent basis. Automatech personnel felt that this problem could not be solved on the test site so it had the machine returned to its facility on June 14, 1983.

The machine was returned to Automatech and was analyzed to determine the cause or causes of this non-repeatibility. The non-repeatibility caused problems in switching back and forth between sizes since dial settings, when switched back to the values found acceptable for a particular size, did not cause the machine to repeat the same contour when reset. Other than this, the product produced was found to be sewn properly and asthetically very acceptably

Automatech found two causes for this problem:

1. The pivot pin cylinder was of too small a size which at the air pressure set caused the pin to bounce and consequently did not hold the proper center for rotation.

2. Switch information to cause the rotation to start was derived from the motion of the linear drive on the bundle carriage. Because of the mass and inertial characteristics of the bundle carriage relative to the feed-dog output and response of the sewing machine, the bundle carriage should not have been used for this source of information.

The results of the above two conditions are causing the machine to be erratic in its response to pre-set values.

The prototype machine was used temporarily again to analyze and correct this condition. After correction and re-wiring of the machine, it was returned to jeans manufacturer for further testing.

The modified prototype machine performed in a satisfactory manner in the second series of tests. Based on these tests, good estimates of time cycles and a preliminary estimate of return on investment have been made and are given in Appendix B.

The modified machine was exhibited at the Bobbin Show in Atlanta, Georgia in 1983. The prototype machine generated considerable interest and several machines were purchased by companies interested in further evaluation of this approach to automated apparel assembly.

III. BARRIERS TO GREATER UNIFORMITY IN TROUSER POCKET DESIGN

The second project task was directed toward determining the barriers to more uniform trouser pocket design. Styling requirements clearly require differences in pocket design that must be accomodated by automated assembly equipment. However, in some cases variations in trouser pockets may be due to tradition or other reasons not actually required for styling or assembly reasons. This phase of the project was undertaken to assess the differences that exist in trouser front pockets and to determine if greater uniformity is possible.

The front pockets from several different companies manufacturing several different types of ladies', men's and children's trousers were evaluated and assigned categories of style, types of construction, machinery required, and types of garment seams. The measurements of each of the pattern parts of these pocket designs were determined and evaluated. This information will assist in determining the variability in product design from company to company across various product lines in men's, ladies', and children's trousers. Both the pocket facings and pocket bagging was measured to determine the extent of variability according to product and size ranges. This range in variability will assist in determining the barriers to achieving greater uniformity in trouser pocket design in the future.

The great majority of trousers manufactured fall into one of four general categories or construction types. These are commonly known and recognized within the industry as jeans, casual, on-seam, and work pants. These basic types of construction vary according to number of facings per pocket, type of seam used to attach the facing to the pocket, type of sewing stitch used, and the length, shape, and number of seams used to attach the facing to the pocket. Table III-1 presents these variations in accordance with normally accepted industry conventions.

Jeans front pocket construction consists of one pocket facing per pocket bag. The facing is normally attached to the pocket bagging with the facing lying flat on the pocket bagging and attached with a Federal stitch type 600 cover stitch type or seam. The shape of the seam is normally categorized as a straight seam which curves through an arc and continues through a straight seam. The two straight portions of the seam may or may not be at 90° angles to each other. The arc of the curve between the two straight portions of the seam are normally a two-inch to a five-inch radius. The attachment of the pocket facing to the pocket bagging is normally accomplished by one common seam or one common stitch path.

The casual trouser front pocket always has two pocket facings per pocket bag. The facing is normally attached to the pocket lining by folding the edge of the facing and stitching it down. This type of seam configuration is designated by Federal stitch type LSd-1. The type of stitch used to attach the facing to the pocket bagging is normally a Federal stitch type 301 or 401 stitch. The shape of the seam is normally a straight seam with a stop at a point, a pivot and move of the pocket bag, followed by another straight seam. This seam can be viewed as two separate stitch paths with a common point.

The on-seam type of trouser pocket is normally used with dress style trousers. As its name implies, this type of front pocket design requires that the ends of the pocket be either on the sideseam, or close to it, both top and bottom. The intention is to permit the hand of the user to enter the pocket from a horizontal direction. This type of pocket design may have either one or two pocket facings per pocket bag. The pocket facing is normally turned

Table III-1

BASIC POCKET STYLES

TROUSER STYLE	NO. OF POCKET FACINGS/POCKET	TYPE OF SEAM	TYPE OF STITCH	NO. AND DESCRIPTION OF STITCH PATH(S)
Jeans	1	LSa-1 (Flat)	602 Cover	(One) Straight, Curve, Straight (One Common Path)
Casual	2	LSd-1 (Single Fold)	301 or 401 Lock or Chainstitch	(Two) Straight, Pivot, Straight (Common Point)
On-Seam	2/1	LSd-1 (Single Fold)	301 or 401 Lock or Chainstitch	(Two/One) Straight, Curve Off (2 Separate Stitch Paths)
Work	1	LSd-1 (Single Fold)	301 or 401 Lock or Chainstitch	(One) Straight, Curve Off (One Common Path)

under in the Federal stitch type LSd-1 configuration. Federal stitch types 301 or 401 are commonly used to attach the front pocket facing to the pocket lining. The type of stitch path on this garment is normally a straight seam along the length of the pocket facing with a slight curve as the seam sews off the edge of the fabric. This requires that the pocket be repositioned and moved during the formation of this stitch path.

The work pocket type of design is very similar to the on-seam style of trouser front pocket. However, it requires only one pocket facing per pocket bag. It is also attached with a 301 or 401 type of stitch in a Federal stitch type LSd-1 configuration. This seam also runs straight down the edge of the pocket facing and curves at the end to sew off of the two plies of material. It also differs from an on-seam type of pocket in that it can permit the vertical entry of the user's hand into the pocket.

In addition to the many different measurements shown in attached charts which reveal the size and shape variations of pocket facings and pockets from one company to another, there are other possible variations. Pockets also vary in the types of fabric used for both the pocket facing and the pocket bagging. Also, some pockets are lined or fused with interlining to increase the wearability and durability of the pocket design. Different weights of fabric are also used in both the pocket facing and pocket bagging materials. The pocket facing colors usually match the color and fabric of the shell or outer fabric of the trousers. The color of the pocket bagging is sometimes varied in order to prevent shading or silhouetting of the pocket bag underneath the trouser shell fabric. Almost all of the trouser front pocket constructions require that the completed pocket facing and pocket bagging be caught in both the sideseam (outseam) and the waistband attaching seam. Some garment styles also require that the pocket assembly be caught in the front fly seam as well.

The pocket facings change in size and shape due to the designer or merchandisers interpretation of the requirements of the particular design. The facings should always conceal the pocket bagging or shape of the pocket inside. In some cases, its shape is made with a curvature or shape parallel or very similar to the outside shape of the front of the garment. The size and shape of the pocketing or interlining material also varies according to the individual preference of the designer or merchandiser. No common convention seems to exist from one company or brand name to another as to the requirements of pocket size and shape. Retail companies, both nationally branded labels and private labels, have varying requirements as to the depth of the pocket and width of the pocket requirements. Apparel manufacturers normally accept the requirements of the retail companies in designing and developing facing and pocketing patterns.

Several typical examples of the style of pockets and variations in sizes of pockets and forms are given in Appendix C .

The primary barriers to achieving greater uniformity in trouser front pocket design are styling, merchandising, and material utilization consideration. Stylists, or designers, prefer to have the ability to change the length and width dimensions of front pockets according to their individual interpretations of the design requirements. Some apparel and retail companies have standard depth and width requirements for pockets according to the style of pocket or style of the garment and the shape of the sideseam and waistband seam curvatures.

Merchandisers of apparel products can be anticipated to create front pocket designs which enhance the desirability of their product in the eyes of the consumers. They are primarily concerned with depth and width of pocket dimensions, the durability of the pocketing material used, and comfort or perception of feel of the fabric used in the pocketing construction.

Material utilization refers to the efficiency of using the fabric as completely as possible to reduce the waste of usable fabric. This is normally measured as a percentage of the fabric used in a garment compared with the volume of fabric purchased per garment. By changing the size and shape of both pocket facings and pocket bagging designs, apparel manufacturers have learned to optimize the yield of fabric by reducing the fabric waste in each design. Apparel manufacturers and designers will be reluctant to change the size and shapes of garment pockets and facing if it adversely affects their historical fabric usage percentages. As a general rule of thumb, the smaller the garment part, the greater the efficiency of fabric usage. Also, the rounding of the edges of parts may also enable smaller amounts of fabric to be used to create the same size design.

The method most likely to become successful in achieving greater uniformity in trouser front pocket design involves a voluntary approach on the part of the apparel manufacturer to conform to standard sizings and shapes. If there are valid reasons for an apparel manufacturer to gain in efficiencies or cost considerations, then they can be expected to voluntarily comply or seek greater uniformity in trouser front pocket designs. Five ways in which greater uniformity of pocket design will have potential economic benefits are:

1. Limiting machine downtime
2. Increasing fabric utilization
3. Reduction of cycle-time and throughput time
4. Improving quality
5. Reducing direct labor and training time

Machine downtime is a critical factor in the operation of automated systems. Each time the machine must be programmed for a different size or shape configuration, the operator must make manual adjustments to the settings and programmings of the machine. When a variety of styles and sizes are running through the same operation, the operator may have to spend a major amount of time changing the settings and adjustments. Obviously there is a great economic advantage to reducing these change-over times to as few instances as possible during a working day. This can be easily accomplished by conscientiously setting size ranges and grouping styles so as to reduce these number of changes to a minimum.

The opportunity to conserve fabric and improve fabric utilization is a universally recognized goal for all apparel manufacturing companies. the cost of fabric and interlining normally constitutes between 30% and 50% of the total wholesale cost of any apparel item. Therefore, any savings of fabrics are readily acceptable as a means of achieving a reduction of manufacturing costs. By standardizing trouser front pocket designs and optimizing the shape and use of these garment parts in a production marker, fabric savings can be produced in shell fabric and pocketing or interlining.

The process of mechanizing or automating the assembly of trouser front pockets will reduce the cycle times required on one or more operations. It will also be possible to combine two or more operations into one operation. This saving of time results in corresponding reductions in throughput time or the amounts of time it requires to process a garment through all the stages of its assembly process. The reduction in throughput time is caused by reducing the amount of time that the garment is actually being sewn and reducing the amount of time the garment must await its turn in line in the holding area or in process storage between each of the sewing operations. Throughput time can also be reduced by the use of automated systems on two-shift or multi-shift situations. This is popularly done with automated systems, and it serves to further reduce the amount of working days in process.

It is possible to achieve measurable quality improvement by the use of mechanized or automated systems. One of the major benefits of these systems is to improve the uniformity of the assembly work. By controlling the variations on trouser front pockets designs, an apparel company can realize a more uniform and consistent level of quality in their sewn products.

The use of automated systems also produces savings in direct labor and in training time. Direct labor cost is decreased by shortening machine cycle times and in-process cycle times. Training time is reduced by requiring the development of fewer skills on the part of the sewing assembly operators. This deskilling process can result in substantially reduced training time requirements and in skills development requirements.

The use of automated equipment can be shown to have many desirable advantages for an apparel manufacturer in today's marketplace.

The communication of these advantages and the potential savings which are available will serve to increase the likelihood of a voluntary approach to provide greater uniformity in trouser front pocket design.

IV. APPLICABILITY OF THE AUTOMATECH CLAMPING-ORIENTATION SYSTEM AND THE SINGLE PIECE SEPARATION DEVICE TO OTHER AUTOMATED APPAREL ASSEMBLY OPERATIONS

This part of the project focussed on the potential usage of the clamping-orientation and the single ply separation devices to specific operations in the assembly of apparel products. A wide range of representative apparel products was examined. Each of the assembly operations required to manufacture each garment type was listed. Each operation was then evaluated to assess the feasibility of using the clamping-orientation system as well as the single ply separation device or combination of both. A notation was made if neither of the two are applicable to that particular operation.

Several criteria were used to determine the garment types evaluated in the scope of this analysis. Those selected were garments normally manufactured by both large manufacturers and small contractors. The garment types also represent a range in production lots from low volume orders to extremely high volume production. These selected garments represented ladies' wear, men's wear and children's wear products. Some of the garments were style-type production while others were representative of non-styled or a basic type of garment production.

The next phase of the analysis included an estimated total direct labor content for each garment. The work content was measured in standard time values as expressed by standard allowed minutes (SAM) and standard allowed hours (SAH) calculations which are used by the great majority of apparel manufacturing companies. The approximate labor content of each operation was expressed for the purpose of allowing a quantitative analysis of each. The operations which can be viewed as having potential usage for the clamping-orientation device and/or the single ply separation device were identified and totalled and compared for each garment. This permitted the calculation and determination of the percentage of impact or coverage potential that these new devices can experience on these garments.

The standard time value calculations, SAM and SAH values, are calculated by dividing the daily quota or expected volume from each operator into either 480 to calculate SAM values or 8 to calculate SAH values. These standard time values therefore represent the amount of productive time an average production operator will require to finish an operation. Each value can be directly compared to other operations to effectively judge the relative amounts of time required to complete each operation. The higher the standard allowed time value, the greater the amount of time required to complete each operation. These standard time values also include allowances for bundle handling time, machine delays, personal fatigue, and incentive adjustments. Since these standard time values are consistent from one operation to another, they can be added to total the expected amount of time to complete an entire garment through each of its operations, or sequence of operations. The totals for each garment type can then be compared with each other to determine which garment types require the greatest concentration of operator production times. If needed, these direct labor totals to each garment type can be multiplied by the approximate number of garments manufactured during each cycle, season, or year to determine the total amount of productive time required in each garment type. This type of analysis would reveal the garment types with the largest amount of production labor saving potentials.

Each of the selected garment types was then reviewed to select the best overall potentials for usage. A variety of factors were used to determine the optimum operations. These factors included considerations for the size of the manufacturer, the normal volume to be anticipated, garment construction type, styling considerations, and general acceptability to a wide range of apparel manufacturing operations.

In evaluating the operations in each garment, several criteria were used to select and determine which of the two new automated devices would be suited for their usage and application. These determinations and recommendations were denoted on each garment analysis sheet. In general, the closer the operation is to the initial assembly operations which follow the cutting process, the greater the likelihood of using both or either of these new automated devices. This is due primarily to the neat and precise ordering of each garment part and stack of parts immediately after the cutting process. This enhances the machine's ability to correctly select, separate, transfer, and orient each ply before it is mated and/or delivered to the machine for stitching or bonding. This factor will account for the preference of initial or early assembly operations on each garment part. As the garment progresses through the assembly sequence of operations, the orientation of each part is affected and the resulting shape of the garments after each operation become more variable and therefore less suitable for automated selection and sewing.

Results of the analysis of 26 separate apparel assembly operations is given in Appendix D. The total SAM units of potential application of the clamping and or single ply separation system are summarized and the total SAM units of potential applications are given in Table IV-1.

The total assembly time units for potential application of the clamp and separation device ('slicker-picker') are given in the second column. The percent that these assembly time units represent of the required assembly time are given in column three of Table IV-1.

The data in the third column of table IV-1 have been rearranged in Table IV-2 to indicate which apparel operations could benefit most in the percent of total assembly time to which the technological development of this project might be utilized. The items highest on this list are those consisting of few parts with relatively simple sewing opeations.

The data in column two of Table IV-1 have been rearranged in Table IV-3 to show the total time required for operations in various apparel items for which the clamp and ply separation device might be applied. In this case the maximum time savings should probably be realized with some complex apparel assembly operations such as men's suit coats or raincoats.

These results suggest that the developments deriving from the project work can have significant impact on assembly of men's, women's and children's apparel. The possible economic impact of the use of the clamp and separation device in these applications has not been determined.

Table IV-2

SUMMARY OF % APPLICATIONS

PRODUCT	% APPLICATION
Ladies Rayon Balbriggan Panties	51%
Ladies Nylon Tricot Panties	43%
Ladies Woven Swim Suit	40%
Children's Underwear (Boys' Ribbed Knit Shorts)	36%
Ladies Woven Pajamas	33%
Men's Unlined Jacket	24%
Knitted Sport Shirts (Long Sleeves)	24%
Knitted Polo Shirts	24%
Men's Raincoats	22%
Children's Play Clothes	21%
Boys' Dress Trouser	21%
Men's Knit Underwear (Tee Shirts)	20%
Ladies Sweaters (Cardigan-Long Sleeve)	19%
Ladies Wool Skirt	18%
Boys Sport Coat	18%
Work Pants	18%
Dress Shirts	17%
Children's Underwear (Children's Gown)	17%
Children's Coats	14%
Coveralls	14%
Men's Pajamas	13%
Work Jackets	11%
Ladies Blouse	8%
Men's Sweaters	8%
Men's Suit Coat	7%

Table IV-3

SUMMARY OF TOTAL SAM/UNIT

OF POTENTIAL APPLICATIONS

PRODUCT	POTENTIAL APPLICATIONS
Men's Suit Coat	12.062
Men's Raincoats	7.571
Ladies Woven Swim Suit	6.624
Children's Coats	4.333
Ladies Woven Pajamas	4.162
Work Pants	3.955
Coveralls	3.771
Men's Unlined Jacket	3.689
Knitted Sport Shirts (Long Sleeves)	3.070
Boys Dress Trouser	3.066
Boys Sport Coat	3.024
Ladies Wool Skirt	2.625
Dress Shirts	2.553
Ladies Sweaters (Cardigan-Long Sleeve)	2.428
Work Jackets	2.100
Men's Pajamas	1.962
Ladies Rayon Balbriggan Panties	1.464
Ladies Knit Dress	1.322
Ladies Blouse	1.274
Knitted Polo Shirts	1.186
Ladies Nylon Tricot Panties	.964
Children's Play Clothes	.941
Men's Sweaters	.700
Children's Underwear (Boys' Ribbed Knit Shorts)	.635
Children's Underwear (Children's Gown)	.533
Men's Knit Underwear (Tee Shirts)	.525

Table IV-1

SUMMARY OF SEQUENCE OF OPERATIONS

SEQUENCE OF OPERATIONS	TOTAL SAM/UNIT OF POTENTIAL APPLICATIONS	% APPLICATION
Men's Unlined Jacket	3.689	24%
Work Jackets	2.100	11%
Boys Sport Coat	3.024	18%
Boys Dress Trouser	3.066	21%
Ladies Woven Swim Suit	6.624	40%
Ladies Woven Pajamas	4.162	33%
Ladies Rayon Balbriggan Panties	1.464	51%
Ladies Nylon Tricot Panties	.964	43%
Ladies Sweaters (Cardigan-Long Sleeve)	2.428	19%
Ladies Wool Skirt	2.625	18%
Ladies Blouse	1.274	8%
Ladies Knit Dress	1.322	17%
Men's Knit Underwear (Tee Shirts)	.525	20%
Men's Pajamas	1.962	13%
Work Pants	3.955	18%
Coveralls	3.771	14%
Knitted Sport Shirts (Long sleeves)	3.070	24%
Knitted Polo Shirts	1.186	24%
Dress Shirts	2.553	17%
Men's Sweaters	.700	8%
Children's Underwear (Children's Gown)	.533	17%
Children's Underwear (Boys' Ribbed Knit Shorts)	.635	36%
Children's Coats	4.333	14%
Children's Play Clothes	.941	21%
Men's Raincoats	7.571	22%
Men's Suit Coat	12.062	7%

V. FRICTIONAL CHARACTERISTICS OF APPAREL FABRICS

A. Introduction

Separation of fabrics is a necessary step in automating apparel assembly processes. Fabric separation devices depend on relationships of fabric to fabric and fabric to device friction. The range of applicability of the device to fabrics widely different in weight and surface textures will depend on these frictional characteristics. Thus the design of widely applicable fabric separation devices requires information on the frictional characteristics of various textiles; however, limited data are available in the literature. In an effort to fill this void, an investigation has been conducted to determine the coefficients of friction between a variety of fabrics and other materials.

There are two classical laws of friction which have been ascribed to the French scientist Amontons (4), who stated them in 1669, but Leonardo da Vinci mentioned them earlier. These laws state that: (1) the coefficient of friction is independent of contact area of bodies which are sliding on each other and (2) the force of friction is proportional to the load acting perpendicular to these surfaces. The proportionality constant, μ, is called "coefficient of friction."

Amontons' laws are only approximately valid. They hold fairly well for metals, ice, and other hard materials, but are less valid for fibers and other relatively soft materials. The coefficient of friction is not constant for fibers, but decreases when the load increases.

Howell (5) developed the relation $F = aR^n$ where F is the frictional force, R is the normal force, a is a coefficient (equal to μ only when n = 1), and n is called the friction index. This empirical frictional relation is now generally accepted for textile materials.

The friction index varies from material to material depending on the geometry of the irregularities (asperities) covering the surfaces and the nature of the deformation that the surface undergoes. The friction index can be as low as 0.67 for two perfectly elastic solids in contact and as high as 1.0 for two surfaces having actual area of contact determined by purely plastic deformation of asperities.

A limited number of fabric friction studies have been conducted. The Draper Corporation [6] has reported a study to generate fabric friction data to aid in the design of an apparatus to automate the sleeve-making process. Draper's proposed sleeve-making concepts employ the use of frictional planer contact with the surface of cloth to support and move fabric pieces. Gathering is accomplished by sliding one ply of fabric over another. Two types of frictional surfaces are needed to perform these tasks: a "sticky" surface, to hold and move the cloth, and a "slippery" surface, to allow the fabric to slide easily. In the Draper study, the coefficient of friction (μ) was defined as the ratio of the tangential force (F) required to cause one material to break loose and slide over the other, and the normal contact force (N) between the two materials, that is $\mu = F / N$. The range of parameters used in the Draper study are given in Table V-I.

Major observations and conclusions drawn from the Draper Study were:

1. The coefficient of friction between a particular fabric and polyurethane foam is always higher than that between that fabric and itself.

2. The coefficient of friction between a fabric and itself is always greater than that between that fabric and any "slippery" surface (i.e., polished steel, polished aluminum, and teflon).

3. The coefficient of friction between a fabric and the foam tends to decrease as normal loading increases.

4. The coefficient of friction between a fabric and itself also tends to decrease as normal loading increases.

5. The coefficient of friction between a fabric and each of the "slippery" surfaces tends to remain relatively constant as normal loading increases.

6. Of all three "slippery" surfaces, polished steel tends to have the lowest coefficient of friction.

Thorndike and Varley (7) measured coefficients of static friction between fabrics. Parameters investigated included: fabric structure, yarn types, moisture regain; and pH. Cloths made in plain-weave and twill-weave were tested. Normal-draft yarn and high-draft yarn were used. To test regain, a constant temperature ($25.5 \pm 0.5^{o}C$) was maintained while the relative humidity varied between 45% and 8%. The pH tested ranged from 3.1 to 6.8. The tests were limited to measurements between pairs of samples from the same fabric.

Thorndike and Varley found the coefficient of static friction to be approximately 10% greater in weft direction than when sliding along the warp direction. Apparently, an increase in float was accompanied by a reduction in the coefficient of static friction. The mean value of the coefficient of static friction was lower for the worsted panama cloth prepared from yarn spun on high draft system than from those spun on normal draft systems. Limited experimental evidence (tests on one cloth) indicated influence of moisture regain was not great. There was a small reduction in the coefficient of static friction as regain increased. It was suggested that an alkaline cloth with its "soapy" handle has a higher value of coefficient of static friction than a similar cloth with a lower pH.

Wilson (8) measured fabric on fabric dynamic friction using an apparatus designed so that frictional forces were recorded as a function of the orientation of the fabric relative to a specified direction.

The range of parameters used in Wilson's fabric on fabric dynamic friction tests are listed in Table V-2. For all fabrics investigated, the frictional force F_p per unit area was found to be related to the pressure P by the relation $\log F_p = C + N \log P$ where N and C are constants for a given fabric. Both F_p and P are expressed in gm per square cm. This relation is consistent with the adhesion theory of friction if it is assumed that the number N_p of asperity contacts varies with the pressure according to the relation $N_p = aP^b$ where a and b are constant for a given fabric. In no case was there any evidence for the existence of an electrical (coulombic) component of friction.

Plots of log F_p against log P show a linear relationship with N being the slope and C, being the intercept. The values of N (ranged from 0.57 to 1.06) and C (ranged from 0.57 to 1.06) depend mainly on the structure of the yarns from which the fabric was woven and to a lesser

Table V-1. Parameters of Draper Friction Experiments

Parameters	Ranges	
Normal Pressure (psi)	0.025 - 0.490	
Fabrics and Weights	100% Wool	7.75-13 oz
	55% Polyester/ 45% Wool	7.75-12.5 oz
	100% Polyester	7.75-10.75 oz.
	100% Acetate	3.0 oz
	Fusable Wigan	
Materials Pairs	Fabric to Fabric	
	Fabric to Polyurethane Foam	
	Fabric to Polished Aluminum	
	Fabric to Polished Steel	
	Fabric to Teflon Film	
Number of Tests Per Condition	3	

Table V-2. Parameters of Wilson's Dynamic Friction Tests

Parameters	Ranges
Normal Pressure (psi)	0.02 psi - 4.27 psi
Fabrics Construction:	
Picks/in	36-132
Ends/in	38-272
Types of Yarns	Spun Yarns
	Continuous Filament Yarns

degree on the weave of the fabric, the chemical nature of the component yarns and the finish applied.

OBJECTIVE AND SCOPE

The objective of this phase of the project was to develop a system for measuring the frictional characteristics of textile fabrics and to use the system to determine coefficients of friction for a variety of textile fabrics.

Frictional tests were performed on the fabrics to determine static and kinetic frictional characteristics. The fabrics selected for testing were those most commonly used for apparel. The effects of the following parameters on friction were studied: weave structure, fabric weight, warp/weft orientation, and normal stress (pressure). A set of preliminary tests were run to evaluate the testing system. The main set of tests performed are summarized in Table V-3.

EXPERIMENTAL

The apparatus for conducting static friction measurements is illustrated in Figure V-1. The major components of the apparatus include an aluminum platform, a plexiglass sled, a teflon wheel, and an Instron Tensile Tester.

The aluminum platform was used as a surface for mounting a 6 inch by 12 inch specimen of the test sample in a horizontal position. The test sample was attached to the platform and sled using a water soluble glue.

The plexiglass sleds provided a surface for mounting the mating fabric specimen to be tested. Two sleds (one having a 1 inch by 1 inch

Table V-3. Range of Main Test Parameters

Fabric Description			Direction of Fabric			
Fiber Content	Weave Structure	Fabric Weight oz/yd^2	Warp to Warp	Warp to Weft	Weft to Weft	Normal Pressures (Psi)
100% Polyester	Plain	0.70	X	X	X	.05, .1, .3, .5, 1.0, 1.5, 3.0, 5.0
	Plain	6.30	X	X	X	.05, .1, .3, .5, 1.0, 1.5, 3.0, 5.0
	Twill	6.60	X	X	X	.05, .1, .3, .5, 1.0, 1.5, 3.0, 5.0
	Plain	7.75	X	X	X	.05, .1, .3, .5, 1.0, 1.5, 3.0, 5.0
65% Polyester/	Plain	3.00	X	X	X	.05, .1, .3, .5, 1.0, 1.5, 3.0, 5.0
35% Cotton	Plain	6.10	X	X	X	.05, .1, .3, .5, 1.0, 1.5, 3.0, 5.0
50% Polyester/	Plain	2.80	X	X	X	.05, .1, .3, .5, 1.0, 1.5, 3.0, 5.0
50% Cotton	Plain	3.60	X	X	X	.05, .1, .3, .5, 1.0, 1.5, 3.0, 5.0
100% Cotton	Plain	3.00	X	X	X	.05, .1, .3, .5, 1.0, 1.5, 3.0, 5.0
	Twill	10.75	X	X	X	.05, .1, .3, .5, 1.0, 1.5, 3.0, 5.0
80% Polyester/ 20% Wool	Plain	7.75	X	X	X	.05, .1, .3, .5, 1.0, 1.5, 3.0, 5.0

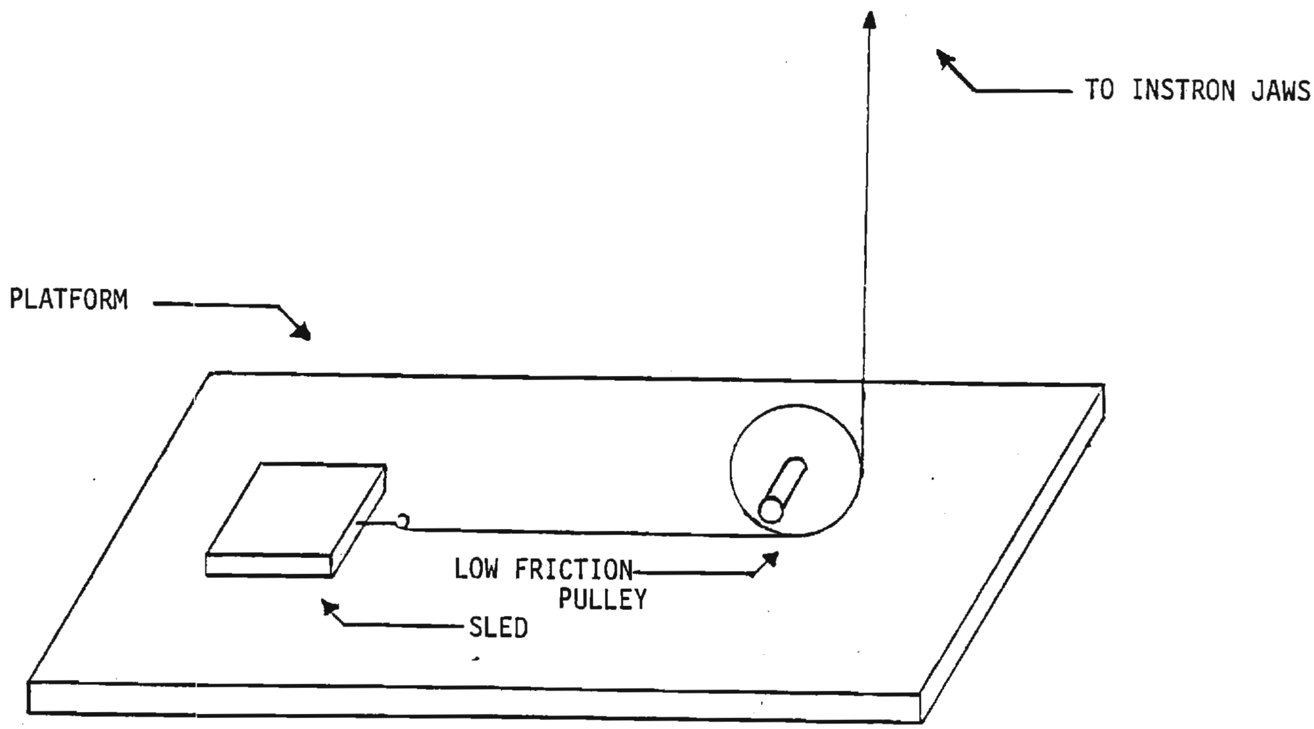


Figure V-1. Schematic of Apparatus for
Static Friction Tests

surface and the other having a 2 inch by 2 inch surface) were used for most of the tests. A small screw was threaded into a side of each of the sleds. The screws were used to attach thread which was also connected to the jaw of the Instron.

The teflon wheel was used to deflect the yarn connected to the sled from a horizontal direction to a vertical direction toward the Instron jaw. The wheel was mounted on a horizontal shaft using a low-friction bearing. Tests showed that the rotating teflon wheel introduced a negligible small affect on the friction measurements.

The Instron Tensile Tester was incorporated to pull the sled along the platform at constant speed and record the resulting frictional forces. A 5000 gram load cell was used with maximum scales on the chart being 500 grams, 1000 grams, and 2000 grams. The chart speed was set at 2 inches per minute. The crosshead speed was set at 10 inches per minute.

The procedure used in conducting the tests was:

1. Prepare the Instron for testing - The proper load cell was installed and allowed twenty minutes warm up time. The gears were changed for proper crosshead and chart speeds.

2. Prepare the fabrics - Conditioned fabrics were cut in designated orientation for testing. A 6-inch by 12-inch piece was cut for the platform. Either a 1 by 2.5 inch or 2 by 4.5 inch piece was cut for the sled, depending on the sled used for testing.

3. Attach fabrics to platform and sled - Fabric was attached to platform and sled in the direction specified for testing using a water soluble glue. The glue was allowed to dry before the tests were conducted on the fabrics.

4. Attach connecting thread to sled and to Instron - A Kevlar 29 thread was tied to the screw in sled and the other end was clamped in the Instron jaw to connect the sled with the Instron.

5. Position the sled on platform - The platform was aligned so it will move perpendicularly to the Instron crossbar. The teflon wheel was placed directly below Instron jaw, and the sled as positioned on platform ensuring fabric to fabric alignment.

6. Set normal load on sled by adjusting weights on sled - Weight was placed on top of sled to produce the desired pressure between the sled and platform. This weight was calculated incorporating the weight of the sled.

7. Start the Instron to begin test - The Instron was started which raised the crossbar pulling the sled along the platform at constant speed. The pen recorder plotted the frictional force versus time. The force record just prior to sled movement was the static frictional force while the force recorded once sliding began was the kinetic frictional force.

8. Stop Instron to end test - The Instron was stopped which ended test. The crossbar was returned to initial position for the next test.

9. Repeat items 2 and 3 as necessary. A test could be conducted using each side of the sled before the fabric must be changed. Twelve test could be run for each fabric attached to the platform using the 1 inch by 1 inch sled.

10. Repeat items 4 through 9.

Preliminary tests were conducted to determine the effect of switching the fabric orientation of the sled with fabric orientation of the platform. Tests results showed that the effect was negligible.

Therefore, weft to warp tests were conducted using the platform fabric with weft orientation and sled fabric with warp orientation.

EXPERIMENTAL RESULTS

Preliminary tests revealed that the system developed for measuring frictional characteristics of textile fabrics could be used to obtain reproducible frictional data on textile materials. The tests provided information for planning and interpreting data obtained during the main tests.

A typical plot of frictional force versus time when movement of the sled is initiated is shown in Figure V-2. The maximum value is the initial force to move the sled which is interpreted as the force required to overcome static friction. The force then decreased and oscillated between two extremes, apparently due to static-slip phenomenon. The force required to move the sled in this region was interpreted as the force necessary to overcome kinetic friction.

The preliminary tests revealed that repeated tests on the same fabric sample resulted in lower coefficients of friction. The coefficient of static friction significantly decreased with each test while the coefficient of kinetic friction decreased gradually with repeated tests. Previous investigations have observed similar phenomenon. Thorndike and Varley (7) noted that when the same cloth-covered brass plate was allowed to slide repeatedly with the same end leading, the coefficient of static function was found to decrease gradually. On reversing the block, end for end, the first value of the static coefficient was higher and subsequent values again decreased. Presumably this was due to the alignment of surface fibers. Wilson (8) found that

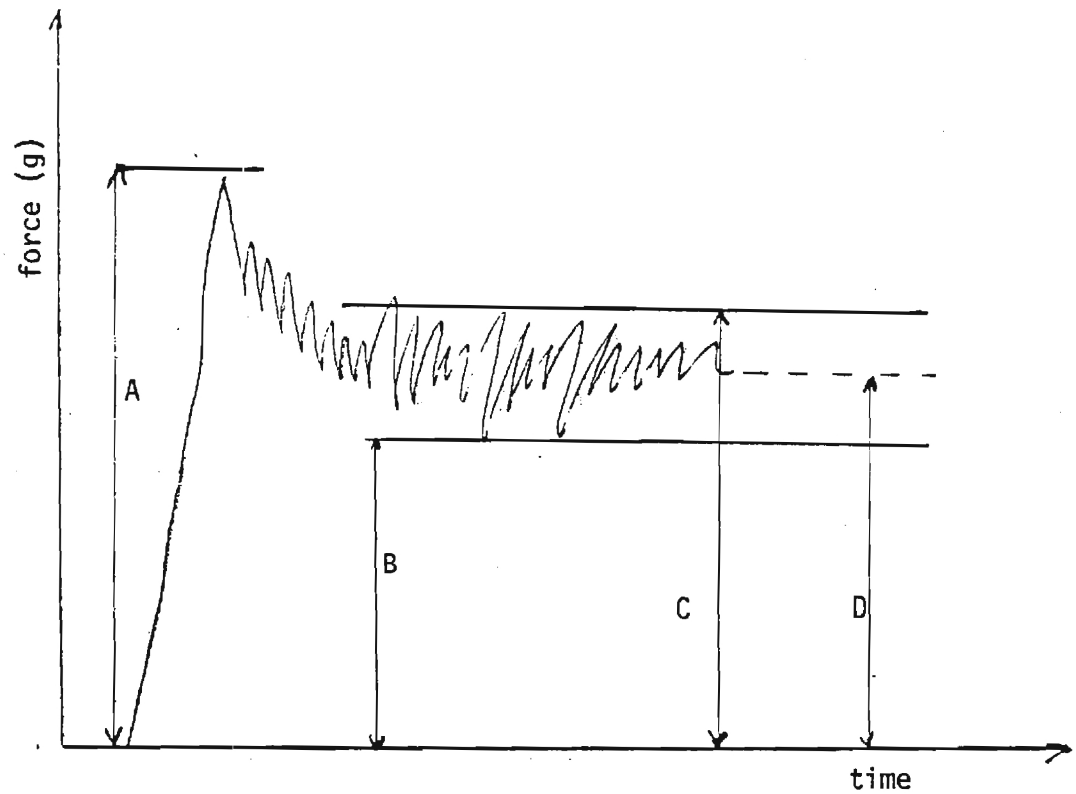


Figure V-2.

A = Value of Static-Friction

B ↔ C = Range of Kinetic Friction
Demonstrates Stick-slip Characteristics

D = Average Value of Kinetic Friction

the frictional force, particularly with the fabrics woven from spun yarns, was slightly higher on the first revolution of the instrument than on succeeding revolutions; consequently the instrument was always run for two revolutions at a given load before measurements were recorded.

The static friction that fabric separation devices must overcome to function properly is probably the initial value and not the value recorded after repeated test runs. Therefore, it was concluded that only one test would be run on a surface area, and the initial value of static friction would be recorded.

The results of the static coefficient of friction tests are summarized in Table V-4. The coefficient of static friction usually increased as the normal force per unit area increased. The results differ from the classical view (4) that the relation between the frictional force and the load is constant, but agrees with the results of Wilson (8).

Wilson's (8) Equation:

$$F/A = a\ (N/A)^m \tag{1}$$

has been used to model the relationship of the force, F, as a function of the normal pressure, N. By taking logarithms of both sides of the equation, the following is obtained:

$$\log F/A = n \log N/A + \log a$$

Table V-4. Static Values

Fabric Description			N/A	F/A (psi)			μ		
Fiber Content	Weave Structure	Fabric Weight oz/yd^2	(psi)	Warp to Warp	Warp to Weft	Weft to Weft	Warp to Warp	Warp to Weft	Weft to Weft
100% Polyester	Plain	0.70	.05	.019	.023	.041	.398	.458	.819
			.1	.033	.043	.087	.332	.429	.871
			.3	.096	.120	.247	.322	.401	.823
			.5	.161	.198	.389	.321	.396	.779
			1.0	.324	.374	.717	.323	.374	.717
			1.5	.478	.552	1.069	.319	.368	.713
			3.0	.965	1.155	1.998	.321	.384	.666
			5.0	1.669	2.022	3.380	.333	.401	.675
100% Polyester	Plain	6.30	.05	.054	.052	.054	1.084	1.039	1.075
			.1	.100	.095	.096	1.0	.956	.964
			.3	.238	.223	.222	.793	.744	.740
			.5	.401	.338	.319	.802	.676	.638
			1.0	.755	.581	.556	.755	.581	.557
			1.5	1.018	.886	.728	.679	.591	.485
			3.0	2.019	1.314	.386	.673	.437	.462
			5.0	2.994	2.382	2.215	.599	.466	.443
100% Polyester	Twill	6.60	.05	.048	.047	.041	.969	.943	.823
			.1	.076	.074	.060	.895	.822	.698
			.3	.235	.198	.208	.778	.659	.693
			.5	.398	.311	.287	.803	.635	.587
			1.0	.656	.615	.546	.663	.622	.552
			1.5	.984	.838	.804	.656	.559	.536
			3.0	1.831	1.526	1.534	.610	.529	.511
			5.0	2.807	2.637	2.240	.561	.527	.448

Table V-4. Static Values (Cont.)

Fabric Description			N/A	F/A (psi)			μ		
Fiber Content	Weave Structure	Fabric Weight oz/yd^2	(psi)	Warp to Warp	Warp to Weft	Weft to Weft	Warp to Warp	Warp to Weft	Weft to Weft
100% Polyester	Plain	7.75	.05	.052	.055	.051	1.048	1.092	1.073
			.1	.081	.083	.095	.807	.836	.951
			.3	.182	.187	.205	.606	.621	.682
			.5	.256	.267	.294	.512	.534	.588
			1.0	.457	.483	.544	.456	.482	.543
			1.5	.626	.651	.794	.417	.434	.529
			3.0	1.194	1.299	1.455	.398	.433	.485
			5.0	2.159	2.109	2.628	.431	.421	.525
65% Polyester/ 35% Cotton	Plain	3.0	.05	.054	.056	.052	1.092	1.119	1.031
			.1	.097	.101	.103	.973	1.009	1.030
			.3	.217	.215	.232	.778	.713	.774
			.5	.315	.302	.351	.629	.605	.702
			1.0	.538	.466	.583	.538	.486	.583
			1.5	.711	.713	.788	.474	.476	.526
			3.0	1.285	1.226	1.561	.429	.409	.520
			5.0	2.090	2.095	2.489	.418	.418	.498
65% Polyester/ 35% Cotton	Plain	6.10	.05	.048	.050	.047	.951	1.004	.942
			.1	.078	.081	.082	.763	.814	.827
			.3	.171	.185	.199	.569	.615	.718
			.5	.255	.272	.310	.509	.544	.622
			1.0	.454	.471	.614	.454	.471	.613
			1.5	.687	.659	.911	.458	.439	.607
			3.0	1.241	1.238	1.453	.413	.413	.484
			5.0	2.111	2.039	2.926	.422	.408	.585

Table V-4. Static Values (Cont.)

Fabric Description			N/A	F/A (psi)			μ		
Fiber Content	Weave Structure	Fabric Weight oz/yd^2	(psi)	Warp to Warp	Warp to Weft	Weft to Weft	Warp to Warp	Warp to Weft	Weft to Weft
50% Polyester/ 50% Cotton	Plain	2.80	.05	.099	.05	.051	.987	1.013	1.022
			.1	.087	.077	.084	.876	.774	.641
			.3	.171	.162	.184	.570	.540	.612
			.5	.250	.256	.263	.502	.512	.521
			1.0	.461	.489	.462	.461	.489	.404
			1.5	.561	.689	.624	.374	.459	.416
			3.0	1.160	1.13	1.220	.385	.376	.406
			5.0	1.890	1.936	2.028	.379	.388	.406
100% Cotton	Plain	3.0	.05	.060	.056	.062	1.190	1.128	1.242
			.1	.091	.093	.105	.912	.929	1.053
			.3	.218	.265	.218	.727	1.02	.725
			.5	.308	.307	.327	.617	.682	.655
			1.0	.530	.520	.568	.530	.520	.568
			1.5	.740	.724	.786	.493	.482	.524
			3.0	1.36	1.33	1.328	.454	.442	.442
			5.0	2.26	2.23	2.406	.452	.446	.481
100% Cotton	Twill	10.75	.05	.029	.029	.034	.573	.501	.678
			.1	.047	.049	.052	.473	.500	.518
			.3	.119	.137	.132	.399	.455	.439
			.5	.195	.208	.160	.391	.416	.420
			1.0	.398	.424	.456	.398	.424	.456
			1.5	.563	.608	.646	.375	.405	.430
			3.0	1.097	1.233	1.283	.366	.411	.427
			5.0	2.008	2.107	2.453	.401	.421	.490

Table V-4. Static Values

Fabric Description			N/A	F/A (psi)			μ		
Fiber Content	Weave Structure	Fabric Weight oz/yd^2	(psi)	Warp to Warp	Warp to Weft	Weft to Weft	Warp to Warp	Warp to Weft	Weft to Weft
50% Polyester/ 50% Cotton	Plain	3.60	.05	-	-	-	-	-	-
			.1	.077	.083	.086	.868	.927	.967
			.3	.197	.201	.207	.658	.669	.690
			.5	.271	.275	.310	.553	.561	.634
			1.0	.526	.506	.588	.532	.511	.594
			1.5	.744	.728	.859	.496	.485	.573
			3.0	1.453	1.477	1.769	.484	.493	.509
			5.0	2.439	2.597	2.989	.487	.519	.597
80% Wool/ 20% Polyester	Plain	7.75	.05	.074	.072	.073	1.471	1.436	1.454
			.1	.119	.123	.122	1.190	1.234	1.226
			.3	.239	.247	.252	.796	.622	.837
			.5	.375	.367	.371	.751	.736	.744
			1.0	.587	.617	.636	.587	.617	.636
			1.5	.607	.640	.796	.538	.560	.531
			3.0	1.459	1.357	1.444	.486	.451	.482
			5.0	2.152	2.157	2.251	.430	.431	.450

This equation is plotted for the static values of several of the fabrics in figures V-3, V-4, and V-5.

If we let Y = log F/ A, X = log N/A, and b = log a, equation (2) can be written as the equation of a straight line.

$$Y = m x + b$$

When m is the slope of the line and b is the intercept of the Y axis.

A linear regression was performed on all the test data to determine if the data could be fit by a straight line. A close correlation to a straight line was obtained. Correlation coefficients which are a measure of how well the straight line fits the data were calculated. A value of 1.0 indicates a perfect fit. Value of correlation coefficients ranged from 0.943 to 0.999 for static friction and 0.879 to 0.999 for kinetic friction.

The calculated values of m and b for both static and kinetic friction are given in Table V-5. Values of static and kinetic coefficients of friction are also given in these tables.

The closeness of fit for the static data suggest that the Wilson model is a very good predictor of the behavior of textile materials with the model giving excellent agreement for the static friction. The model should be very useful in guiding friction studies for design of automated apparel assembly equipment.

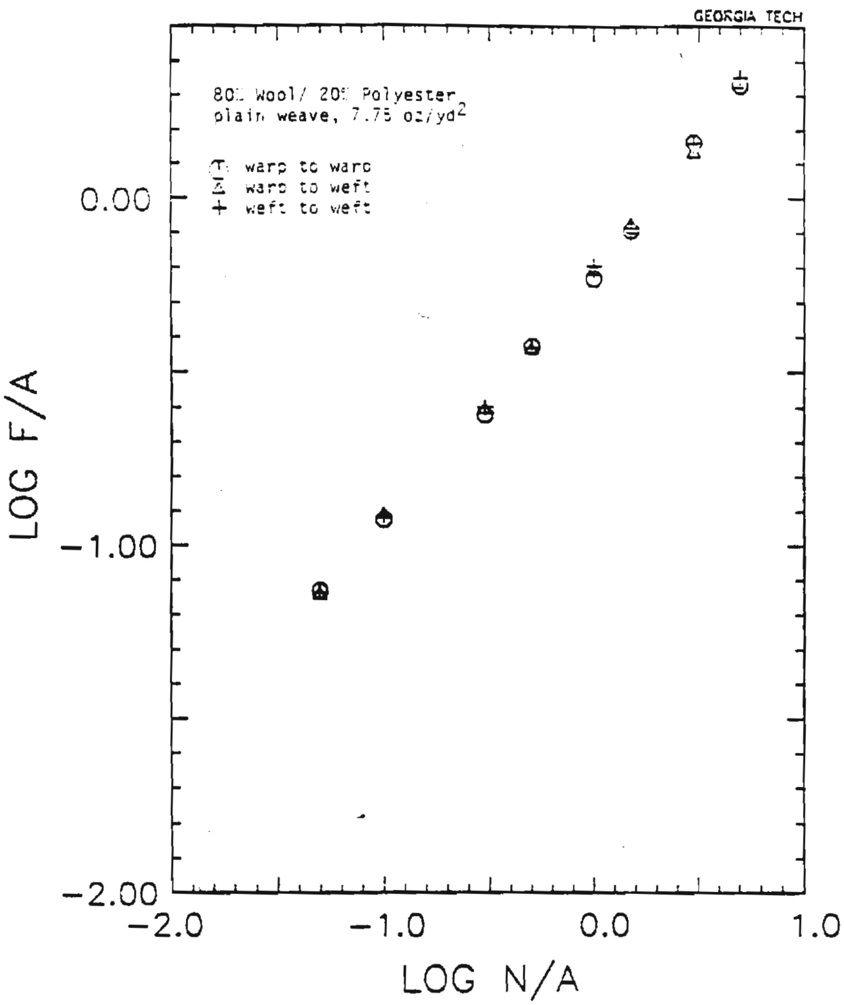


Figure V-3. Static Values (Frictional Force vs. Pressure)

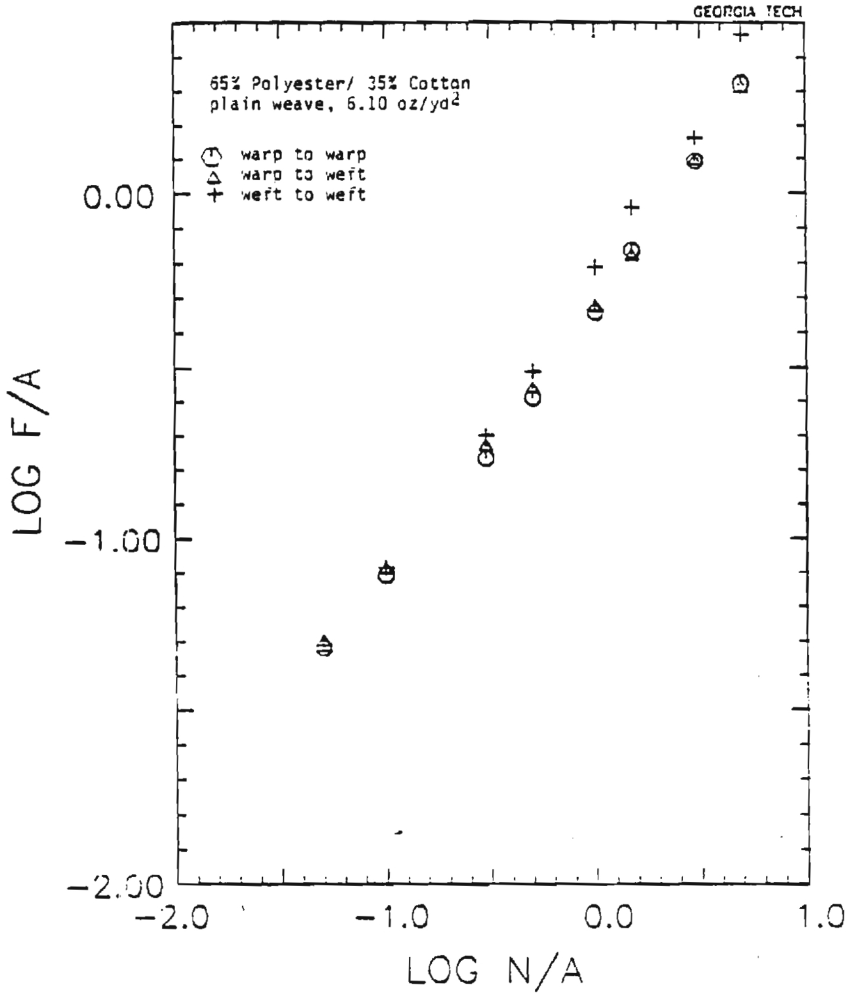


Figure V-4. Static Values (Frictional Force vs. Pressure)

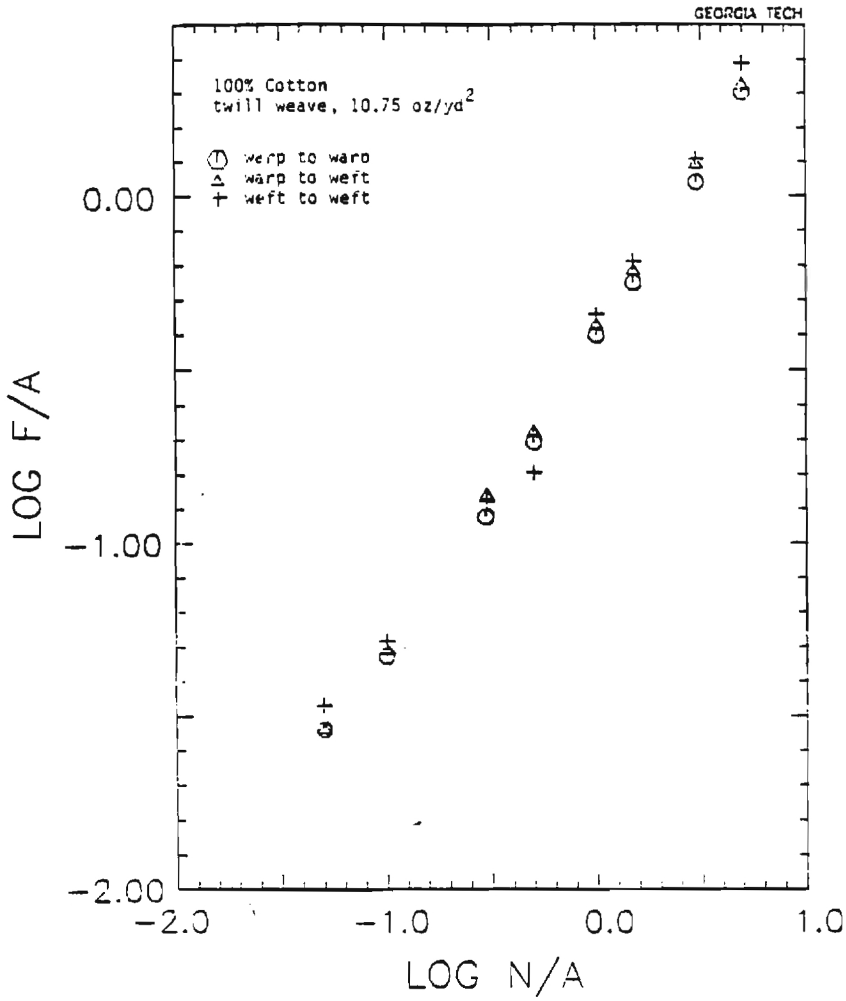


Figure V-5. Static Values (Frictional Force vs. Pressure)

Table V-5

Fiber Content	Fabric Weight oz/yd^2	Weave Structure	Direction of Fabrics: Warp to Warp	Direction of Fabrics: Weft to Warp	Direction of Fabrics: Weft to Weft	m Static Friction	m Kinetic Friction Low	m Kinetic Friction High	m Kinetic Friction Avg.	a Static Friction	a Kinetic Friction Low	a Kinetic Friction High	a Kinetic Friction Avg.
100% Polyester	0.70	Plain	X			.978	.950	.934	.939	.327	.263	.279	.270
				X		.965	.925	.908	.973	.394	.318	.333	.354
					X	.942	.869	.867	.868	.733	.573	.599	.586
	6.30	Plain	X			.882	.825	.821	.822	.745	.533	.571	.549
				X		.812	.755	.756	.757	.598	.439	.477	.458
					X	.792	.763	.746	.753	.573	.446	.469	.458
	6.60	Twill	X			.897	.844	.838	.839	.679	.551	.593	.569
				X		.880	.864	.834	.850	.597	.492	.520	.507
					X	.895	.873	.843	.856	.552	.450	.485	.468
	7.75	Plain	X			.937	.814	.756	.753	.652	.500	.486	.395
				X		.791	.767	.744	.751	.515	.401	.438	.421
					X	.833	.789	.779	.781	.590	.431	.482	.456
65%/35% Polyester/Cotton	3.0	Plain	X			.777	.733	.729	.733	.553	.417	.438	.427
				X		.762	.713	.709	.711	.541	.404	.423	.414
					X	.817	.779	.751	.757	.621	.449	.459	.449
	6.10	Plain	X			.817	.753	.744	.749	.498	.355	.389	.372
				X		.799	.754	.731	.742	.505	.373	.396	.384
	2.80				X	.882	.800	.796	.798	.617	.436	.472	.454

V-5 (Continued)

Fiber Content	Fabric Weight oz/yd^2	Weave Structure	Direction of Fabrics: Warp to Warp	Direction of Fabrics: Weft to Warp	Direction of Fabrics: Weft to Weft	m Static Friction	m Kinetic Friction Low	m Kinetic Friction High	m Kinetic Friction Avg.	a Static Friction	a Kinetic Friction Low	a Kinetic Friction High	a Kinetic Friction Avg.
50%/50% Polyester/Cotton	2.80	Plains	X			.776	.749	.745	.748	.471	.306	.327	.315
				X		.799	.758	.751	.755	.485	.306	.321	.313
					X	.692	.729	.726	.729	.398	.313	.332	.322
	3.60	Plain	X			.879	.821	.828	.825	.548	.366	.386	.378
				X		.872	.814	.837	.822	.55	.361	.381	.369
					X	.910	.843	.859	.851	.631	.384	.410	.398
100% Cotton	3.0	Plain	X			.784	.697	.693	.698	.567	.335	.351	.343
				X		.771	.676	.672	.675	.583	.343	.362	.352
					X	.775	.675	.606	.683	.594	.338	.365	.351
	10.75	Twill	X			.923	.883	.867	.870	.402	.275	.301	.289
				X		.934	.911	.887	.898	.433	.289	.321	.305
					X	.937	.865	.852	.855	.477	.301	.337	.319
80%/20% Wool/Polyester	7.75	Plain	X			.731	.721	.701	.711	.625	.423	.448	.436
				X		.728	.720	.692	.705	.627	.415	.441	.428
					X	.735	.729	.703	.715	.638	.426	.451	.438

APPENDIX A

THEORY OF MACHINE OPERATION

Appendix A

THEORY OF MACHINE OPERATION

A. Description of the path to be followed and sewn (REF Fig. 1).

B. The sewing machine speed is set (by hand tach) at 2400 RPM or 2400 stitches per minute. The number of stitches desired is 8 stitch per inch. The total length of sew path is determined by the size of facing, but is, of course, a constant for each given size.

C. Assuming as per Figure 1

AB = 2 inches

BC (along the curve) = 1/4 (2 π OB) = 1/4 (2 X 3.14 X 4) = 6.28"

CD = 3 inches

Total Path = 2 + 6.28 + 3 = 11.28"

Total path = 11.28 x 8 = 90.24 stitches

An electrical tachometer generator mounted to the sewing head and geared to its handwheel is rated to produce 2.5 volts/1000 RPM or 2.5 volts/1000 st/min since each revolution of the handwheel is equal to one stitch. Each stitch, therefore, is represented by

$$\frac{2.5 \text{ volts}}{1000 \text{ sts}} = .0025 \text{ volts/stitch/min}$$

Three voltages are required to fix the length of the two straight and one curved sewing path. These three distinct voltages are set by means of potentiometers on what are termed integrator cards. The integrator accepts the rate output of its tachometer generator and mathematically integrates the rate to obtain a distance measurement. The integrated rate is constantly compared to the present value. When the two values are equal, a relay (or transistor as the case may be) is then energized which causes the machine to follow a different set of instructions. The machine contains three D.C. servo drive systems which follow the instructions from the tach generator and respective integrators. Two servos drive in a linear motion and one drives in a rotary motion. As previously shown, the desired path

TYPICAL JEANS FACING STITCH PATH

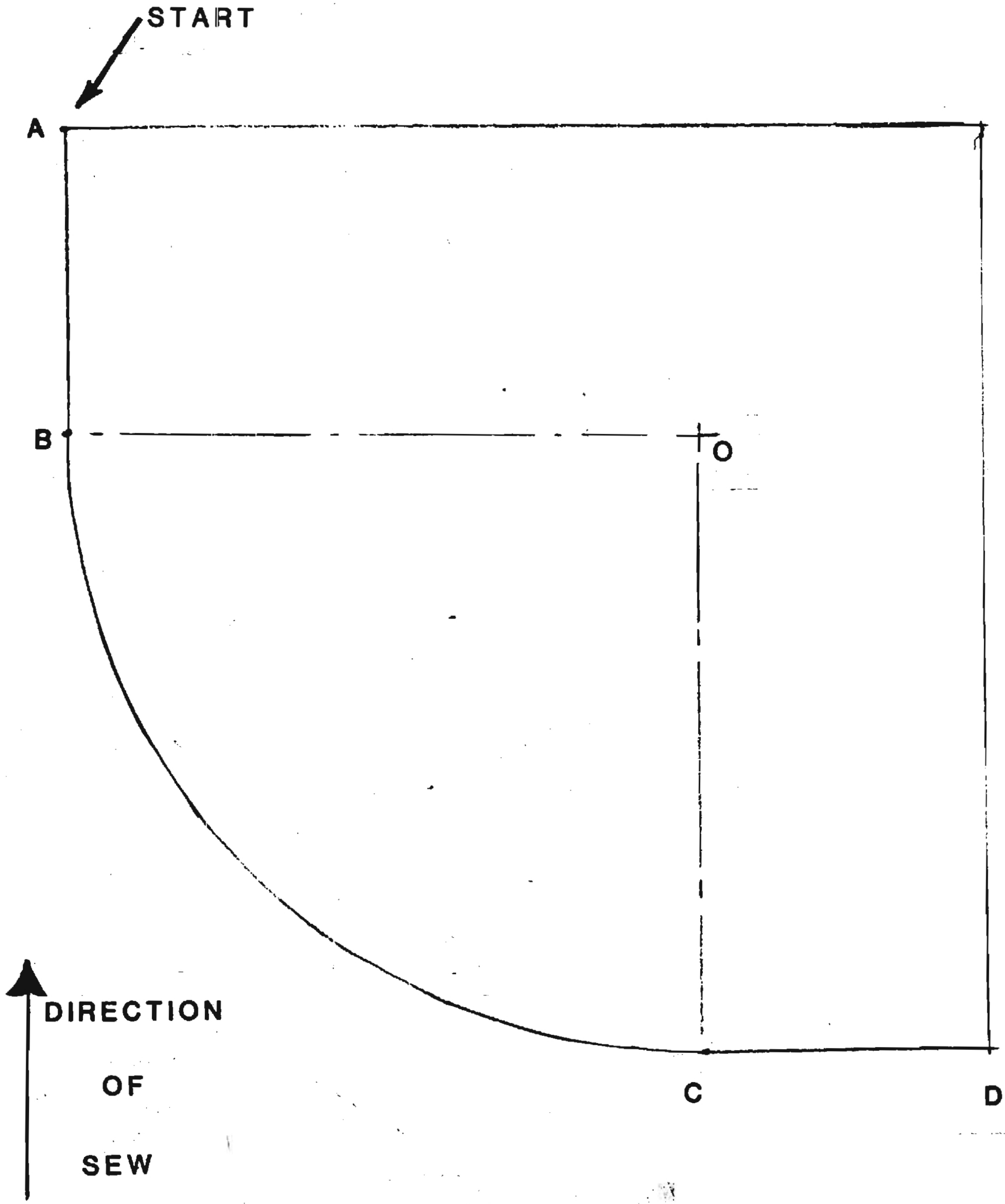


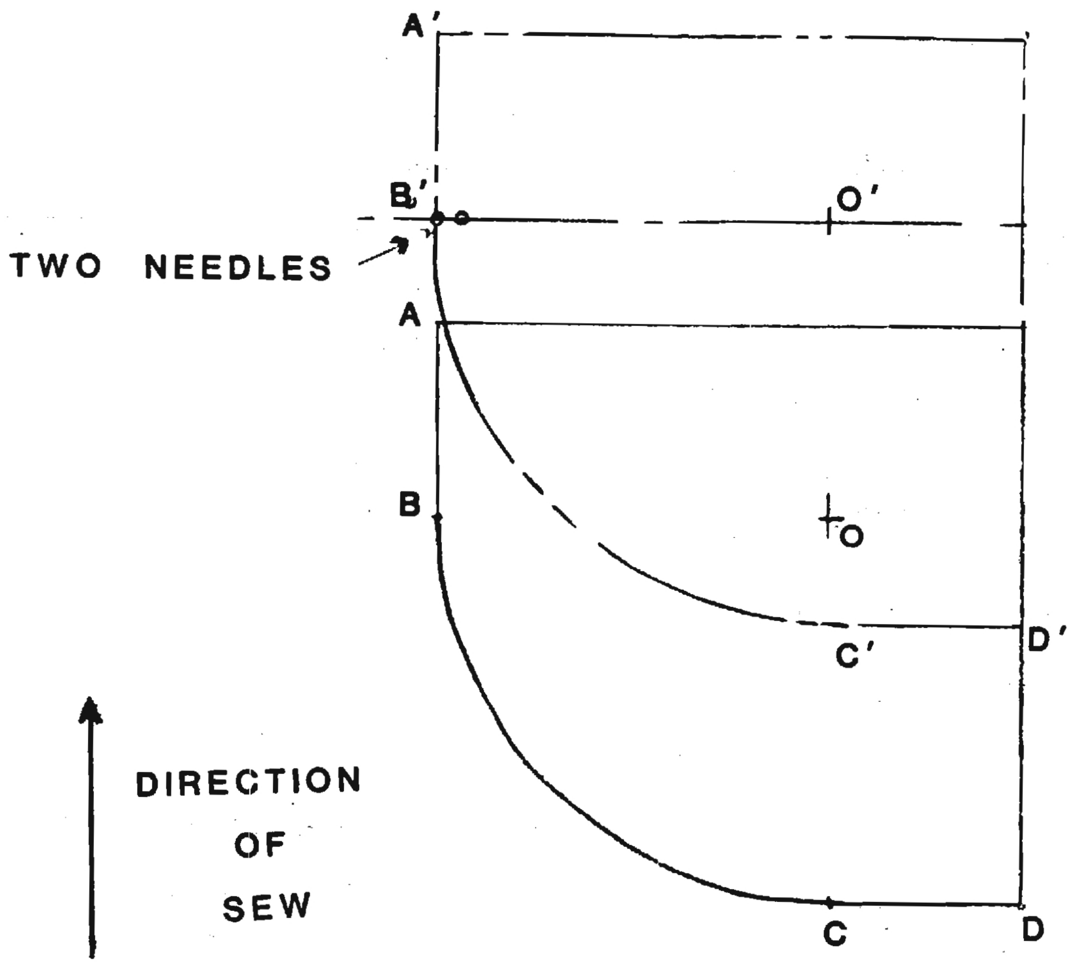
FIGURE 1

The rotary drive system is mounted atop a plate which is driven linearly on rails. Mounted to the rotary arm is a carriage and table which support the clamped bundle of pocket linings. In its starting position, the pockets within the clamp and the position of the clamp itself on the carriage have been pre-determined for the size and shape of the unit to be sewn. the values of AB, BC and CD having also been predetermined, are then set on the respective numbered dials for each integrator card. Once the operator places the facing in the proper position on top of the lining and in the proper linear orientation to the sew-line (or linear rails) she hits a 'start' button. Actuation of the start button will cause the clutch on the sewing machine drive motor to engage. When the sewing machine starts to turn, its tach generator will begin to emit a signal. This signal will start the linear D.C. servo drive to follow. The pocket bundle and the one lining to be sewn will then proceed to be driven past the needle in a straight line. When the point O' (refer to Fig. 2) coincides with point O (the fixed center of rotation) the comparison of the integrator controlling the first linear sew will have been accomplished. Also, at this time, the center of the rotary arm will be directly below the desired center of rotation for sewing the radius. Satisfaction of the first linear integrator will start the rotary D.C. servo to drive and stop the linear servo. (all servos are dynamically braked on stopping). Again, the following of the rotary servo will be monitored and compared to the preset value on the second integrator card. When this condition has been satisfied, the rotary servo will be stopped and the linear servo will be turned on again. The bundle in the meantime, will have been driven through the first linear motion (AB) and then through the rotary motion (BC) and now through the next linear motion (DC). The linear servo will now follow the instructions from the third integrator card. When the third comparison has been met, all motion will cease. The cutters will then be instructed to clip the threads and the carriage will be instructed to return to its starting position to proceed with the next piece.

At the time that the rotary servo is engaged to sew path BC, a pivot-pin which is operated by an air cylinder will descend upon the facing being sewn and establish the center point 'O' for rotation. During the linear sewing portions of the cycle, a small belt drive, also servo driven and following the same tach signals, descends upon the facing. This belt

ARRANGEMENT OF FIXED ROTATION CENTER O'

AND FACING CENTER O



NOTE: O AND O' WILL COINCIDE AT THE END OF FIRST SEW PATH A'B'

FIGURE 2

being synchronized with the feed dogs of the sewing machine (by virtue of the tach generator on the sewing head) assures that the facing and lining will drive in a straight line parallel with the linear table rails. The belt and pivot pin are lifted and dropped in opposing relationship to each other during the complete cycle.

As previously mentioned, each servo drive has its own tach generator. The sewing machine tach generator provides the signal input to be followed by all of the other tachometers. The feedback system consequently 'closes' the loop insuring that what has been requested has indeed been accomplished.

It now becomes evident that if a straight line path only was desired, the rotary system would be shut-off, the first linear sew would be pre-set to the proper integrated length, the cutters would be instructed to cut at the end of that sew distance, and the carriage would be told to return to its starting position.

In the event two straight paths at a given angle to each other was desired, then the first linear sew would set for its proper distance and the sewing machine would then be told to stop sewing. A signal to the rotary D.C. servo (from a source other than the sewing machine tachometer) would then tell the rotary drive to turn the pocket bundle about the center-line of the needle. At the end of the rotation, the second linear sew would be engaged causing the carriage to again be moved in a straight line for its predetermined distance.

The only other elements in the system are the respective power amplifiers that drive the D.C. motors. These units must accept the low level signal from the servo drive cards and amplify them to the power levels required by the motors. The servo cards in turn control the speeds and directions desired by each of the servo units, as well as the dynamic braking.

APPENDIX B

TYPICAL EXAMPLE OF R.O.I. ON JEANS POCKET FACING EQUIPMENT

Appendix B

TYPICAL EXAMPLE OF R.O.I. ON JEANS POCKET FACING EQUIPMENT

Assume a jeans manufacturer whose production is approximately 2750 dozen jeans per week or 550 dozen jeans per day. This means he must produce 550 dozen pair of pockets per day.

Currently he employs 5 operators to attach facings to pockets. Each operator produces 100 dozen pair of pockets per day. The manufacturer decides to purchase 2 pocket facing machines and to operate them for 2 eight hour shifts. The machines can be expected to produce 275 dozen pair of pockets each shift. The 2 shifts will then meet his production needs of 550 dozen pair of pockets each day.

Since one operator can run 2 machines, the manufacturer needs only one operator for each shift. This is a cost saving of 3 operators. The cost of 2 machines is approximately $40,000 to $50,000. If the cost per year for one operator, including fringes and training, is $15,000, the machine will then pay off in approximately one year.

THE "AFM" AUTOMATIC FACING MACHINE

JEANS POCKET--ONE FACING

Time for machine to attach facing:	5 seconds
Time for operator to place facing:	2 seconds
	7 seconds

Since one operator can run 2 machines, production output is one pair of pockets every 7 second or 8.6 pair per minute.

Output per hours:	43 dozen pair
Output per 8 hour working day:	344 dozen pair
Allow an 80% machine efficiency:	
Total Output:	275 dozen pair per day

APPENDIX C

VARIATIONS IN SIZES AND STITCH PATHS ON TROUSER FRONT POCKETS

Company A

STYLE	FACING #1		FACING #2		POCKET	
	Length	Width	Length	Width	Length	Width
Mens #1	7"	2"	7"	2"	12"	12"
" #2	7½"	2"	7½"	2"	14"	14"
" #3	9"	3½"	9"	1½"	13"	16"
" #4	9"	3½"	9"	2"	12"	15"
" #5	7"	5½"	7"	4"	10"	16"

Company B

Mens #1	7½"	2"	7½"	2"	13½"	14"
" #2	7½"	3"	7½"	2"	12"	14"
" #3	8"	3"	8"	1½"	13"	14"
" #4	8"	4"	8"	1½"	13"	14"
Mens Western	7½"	3"	7½"	3"	12"	25"

Company C

Mens #1	8½"	3"	8½"	1½"	13"	13"
Mens Ranch	7"	5"	6½"	3"	13"	13"
Mens Casual-Large	8"	4"	8"	1½"	13"	13"
" " Small	8"	4"	8"	1½"	12"	12"
Fun Fashion	8½"	3"			13"	12"
Mens Shorts	8½"	3"			10½"	13"
Mens Work-Small	5"	3"			8½"	10"
" " -Med.	7½"	3"			10½"	12"
" " -Large	8¼"	3"			13"	14"
" " -XL	9"	5"			15"	12"
Ladies Work - Small	5"	3½"			9"	10"
" " - Med.	8"	3½"			11"	12"
" " - Large	8"	3½"			11"	13"

Company D

STYLE	FACING Length	FACING Width	FACING Radius	POCKET Length	POCKET Width
Mens Large	6½"	6½"	5"	15"	10½"
Mens Med.	6"	6"	5"	14"	10½"
Mens Small	53/4"	5"	4"	15"	10½"
Boys Reg.	4½"	5"	3"	9½"	8"
Boys Slim	4"	4½"	3"	9½"	7½"

Company E

Mens Regular	5"	6½"	4¼"	10½"	15"
Mens Cotinental Reg.	5"	6½"	4¼"	10½"	15"
" " Slim	5"	5½"	4¼"	10½"	13"

Company F

Regular Small	7"	6"	3"	20"	10"
" Large	6½"	7"	3"	20½"	12"
Calvin Klein	6½"	6½"	3"	20"	20"

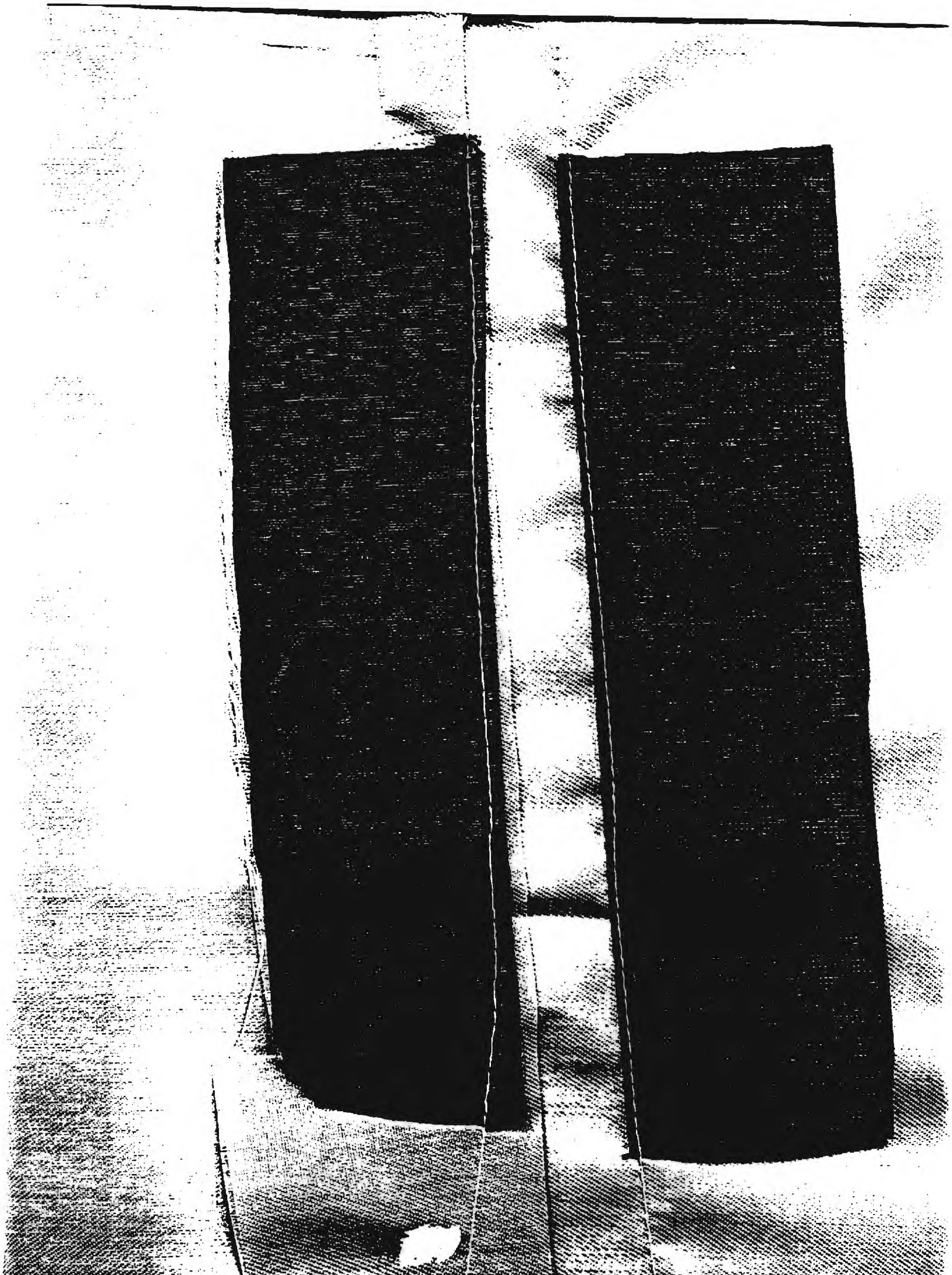
Company G

STYLE	Size	Length	FACING Width	Radius	POCKET Length	Width
Mens Jeans	28-42	6"	5½"	4½"	11"	13½"
Mens Scoop	28-31	7"	5½"	5½"	11"	13"
" "	32 & Up	7"	5½"	5½"	11"	14"
Students Scoop	25-30	5½"	5½"	5½"	9½"	12"
" Quarter Top	25-30	9"	33/4"	N/A	11"	11"
Boys Quarter Top	8-14	8"	3½"	N/A	10"	11"
Boys Scoop	12-14	5½"	43/4"	4"	9"	12"
" "	8-11	5"	43/4"	4"	8½"	11"

Company H

Mens Quarter Top	42-54	10"	5"	N/A	14"	14"
" " "	28-31	9"	4½"	N/A	12"	12"
" Half Top	32-44	8½"	6½"	N/A	12"	15½"
" " "	24-27	8"	5"	N/A	11"	12½"
Boys Quarter Top	14-20	9"	4½"	N/A	11"	12"
Womens " "	5-18	9½"	4"	N/A	11"	12½"
" " "	0- 3	9½"	4"	N/A	11"	12"
Girls " "	10-14	7½"	4½"	N/A	9½"	12"
" " "	7- 8	7"	4½"	N/A	9"	11"

Company A



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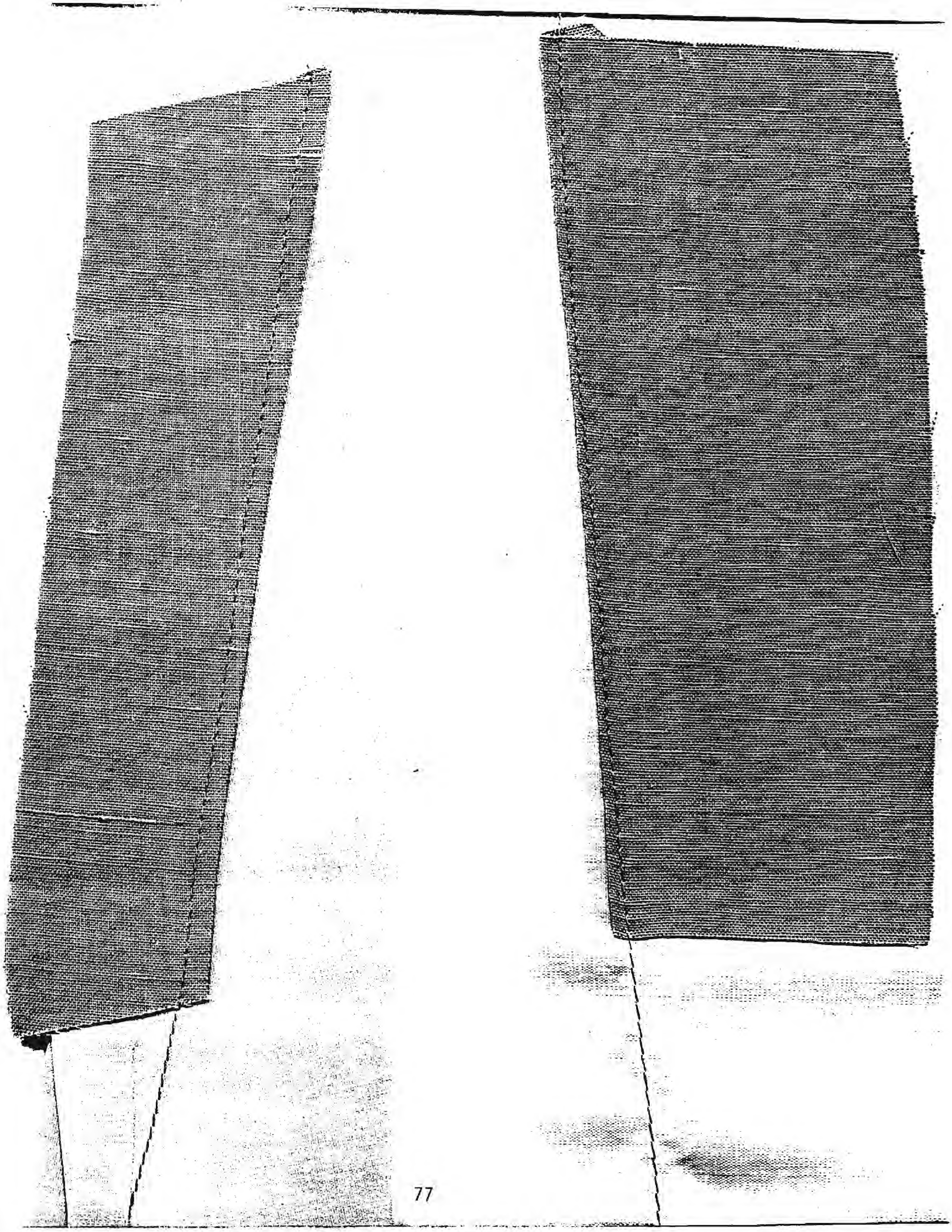
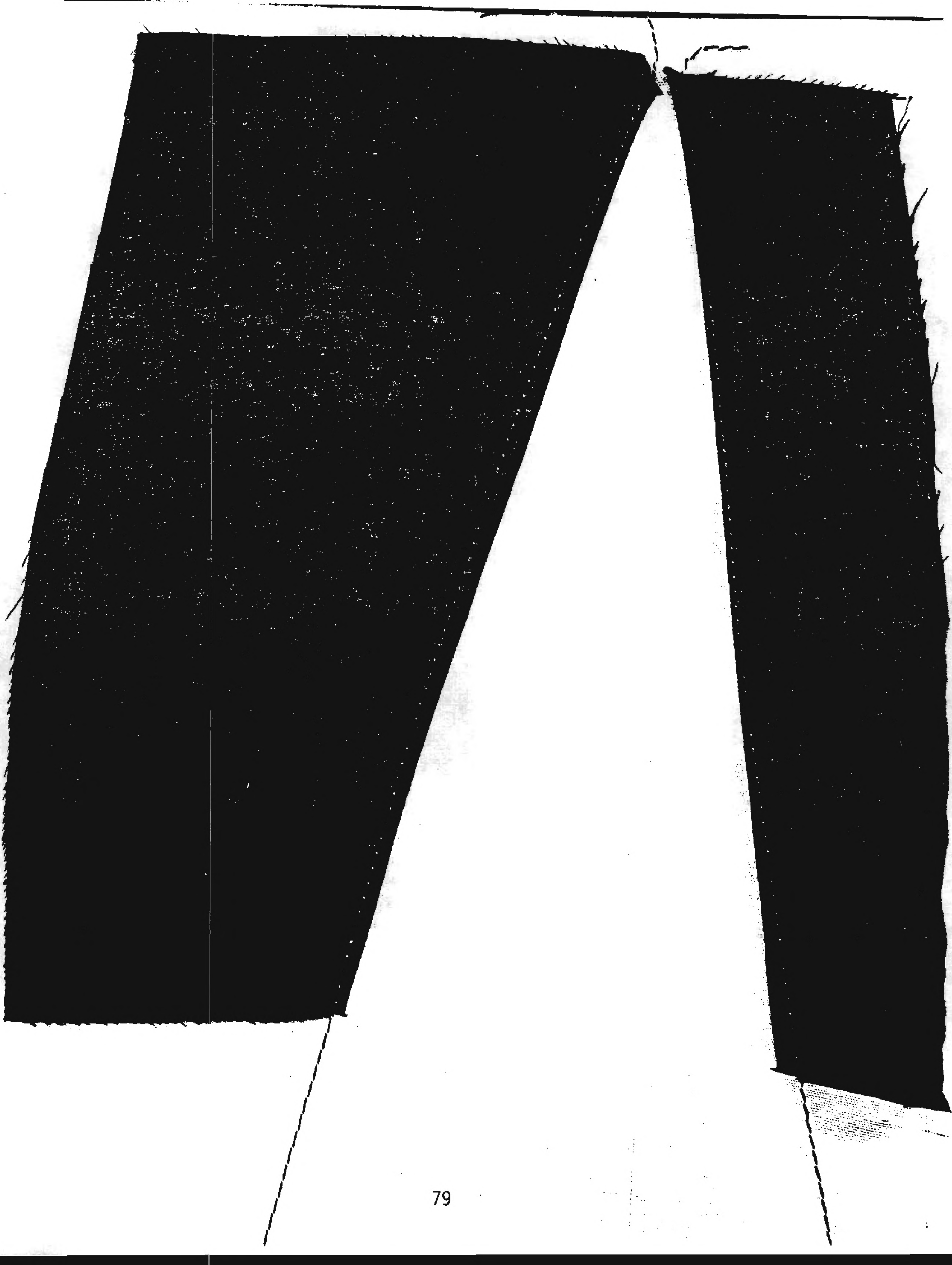
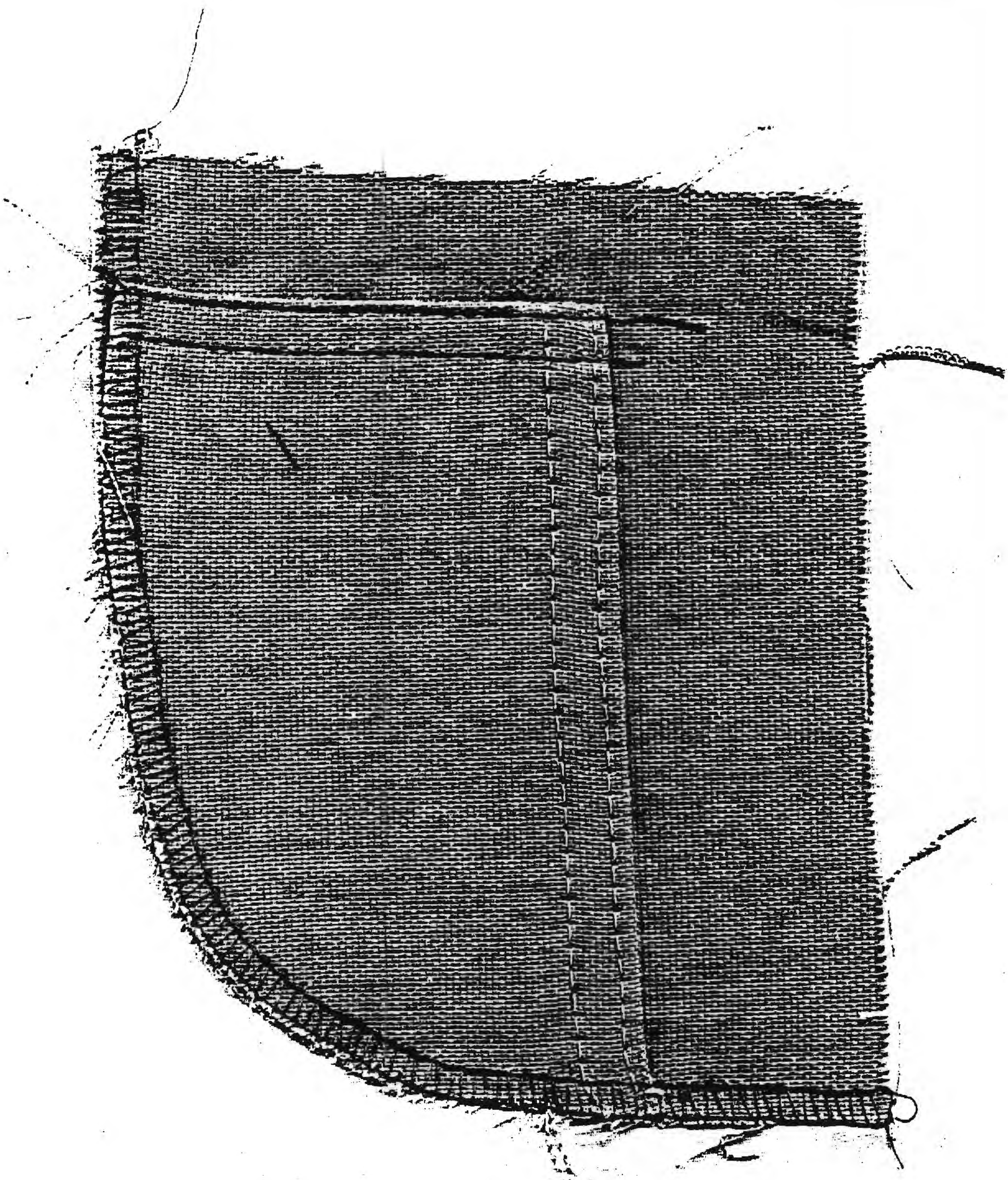


Company C

Company C



Company D



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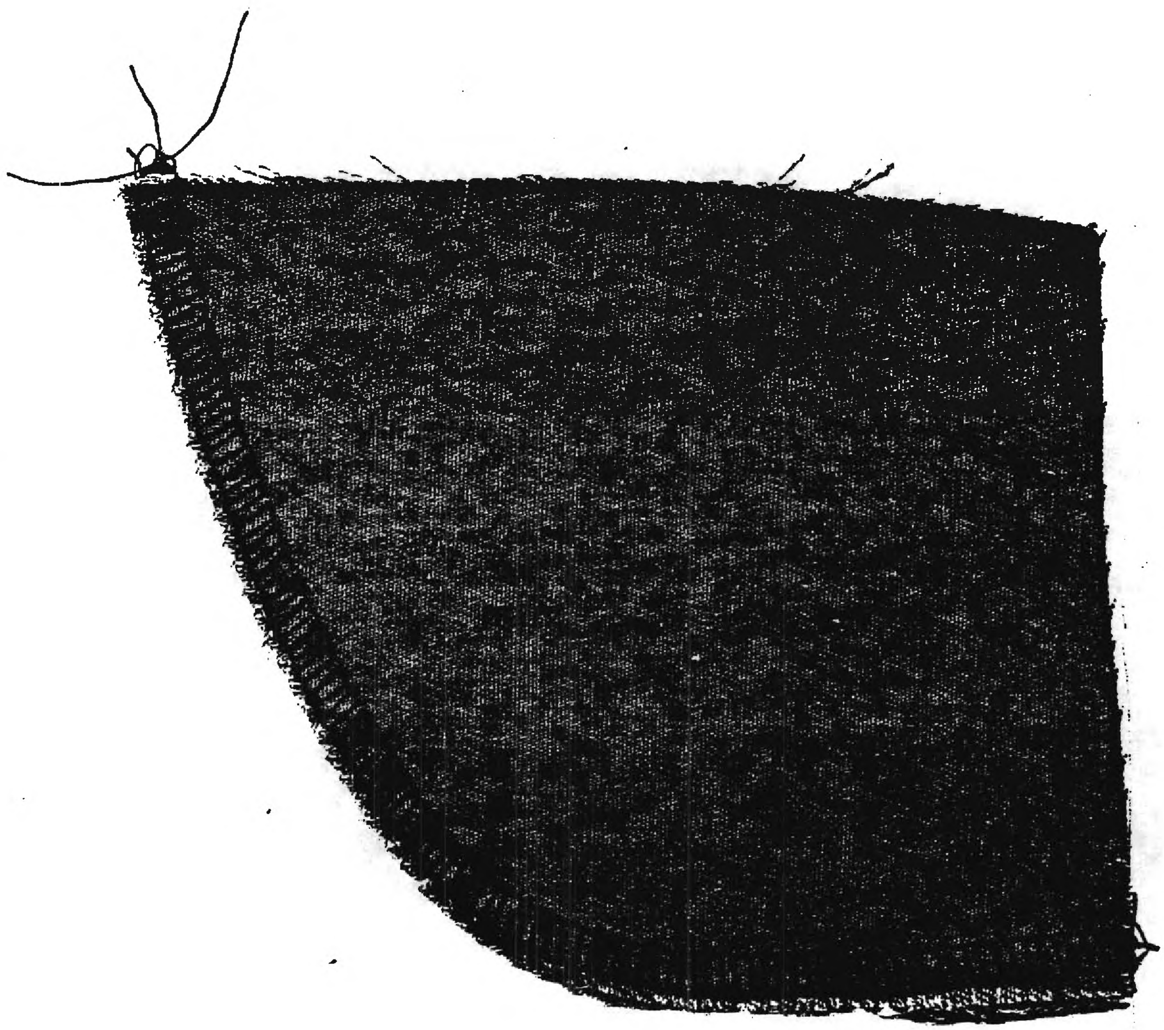
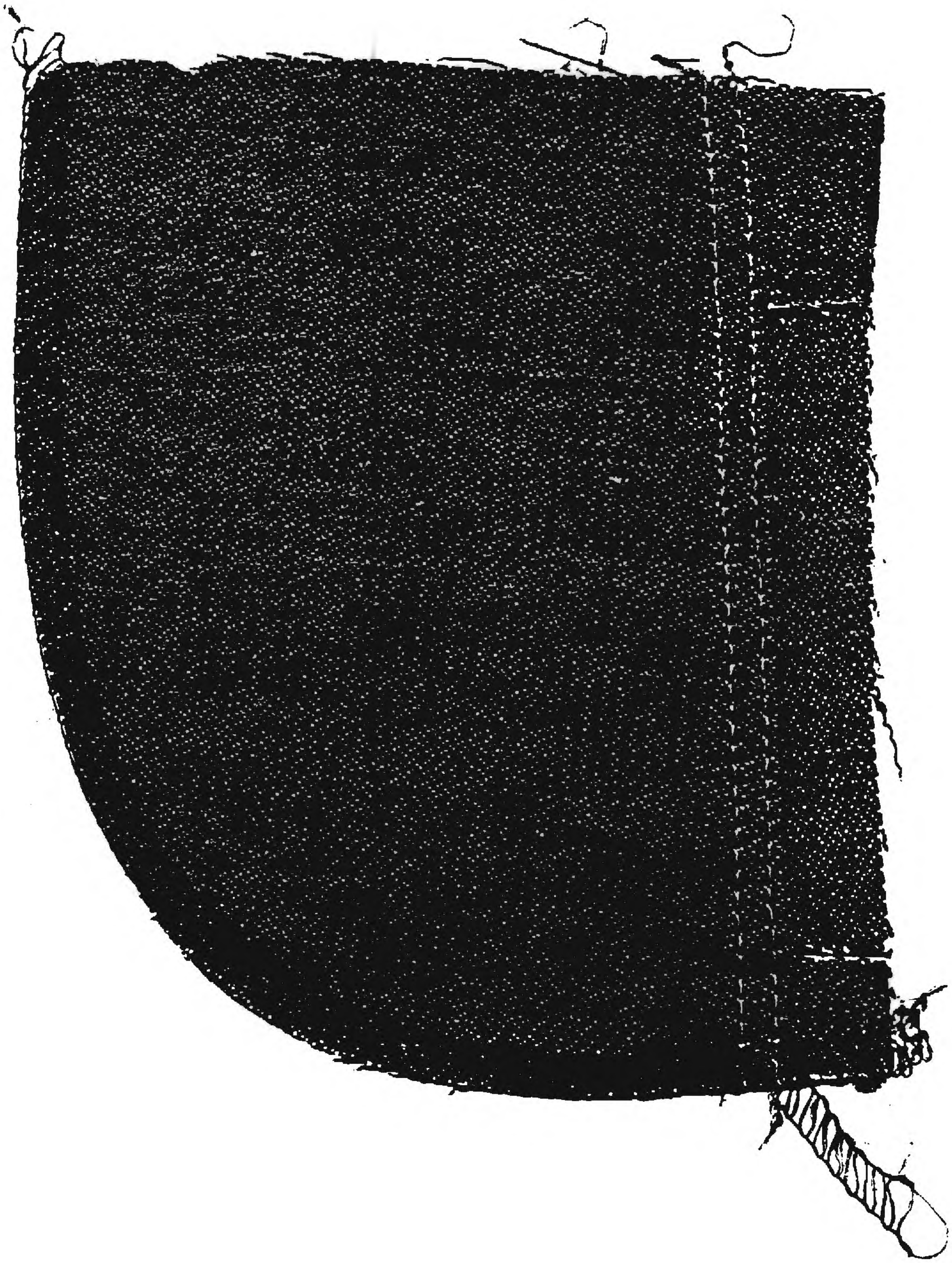


Company E



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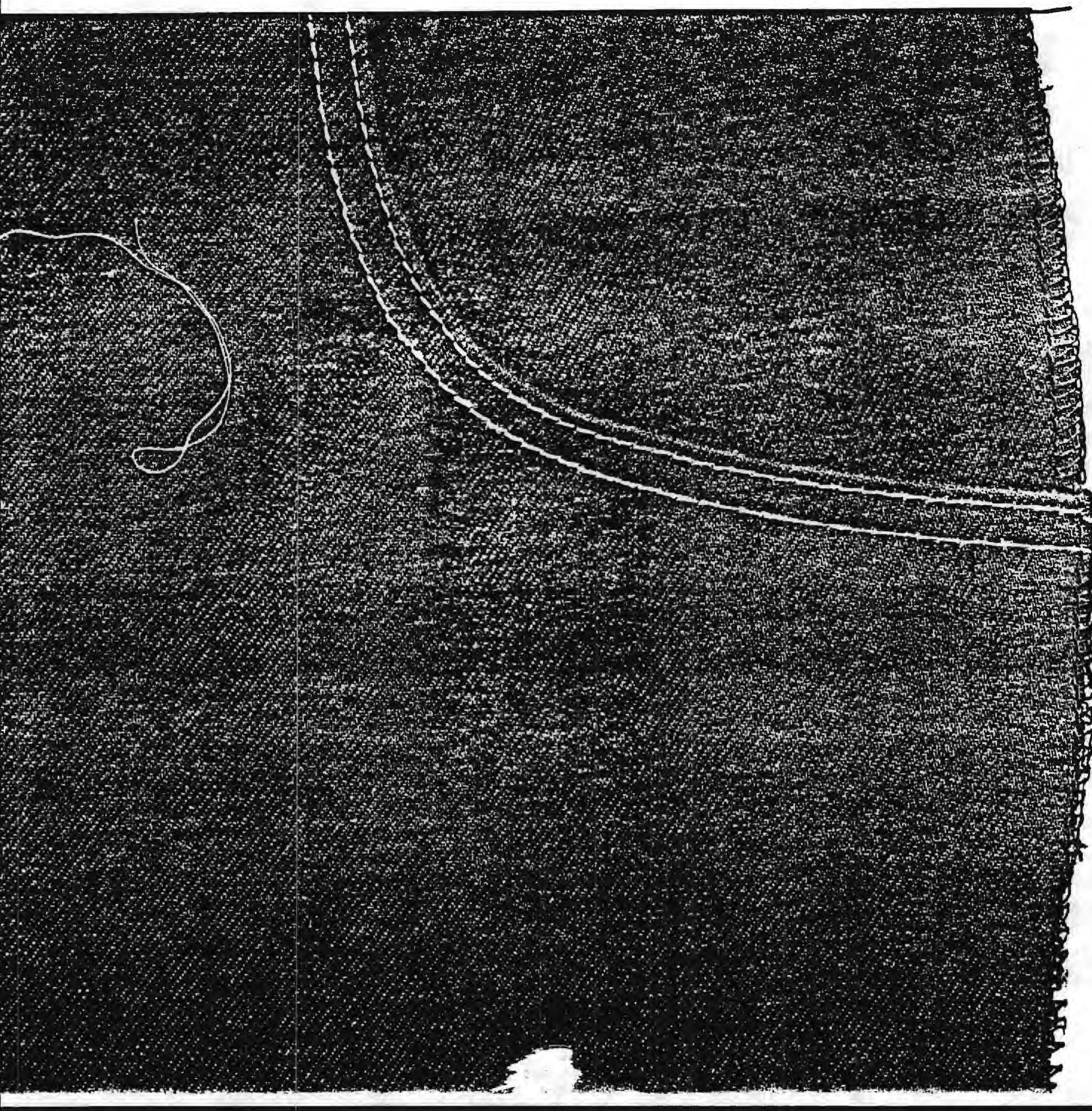

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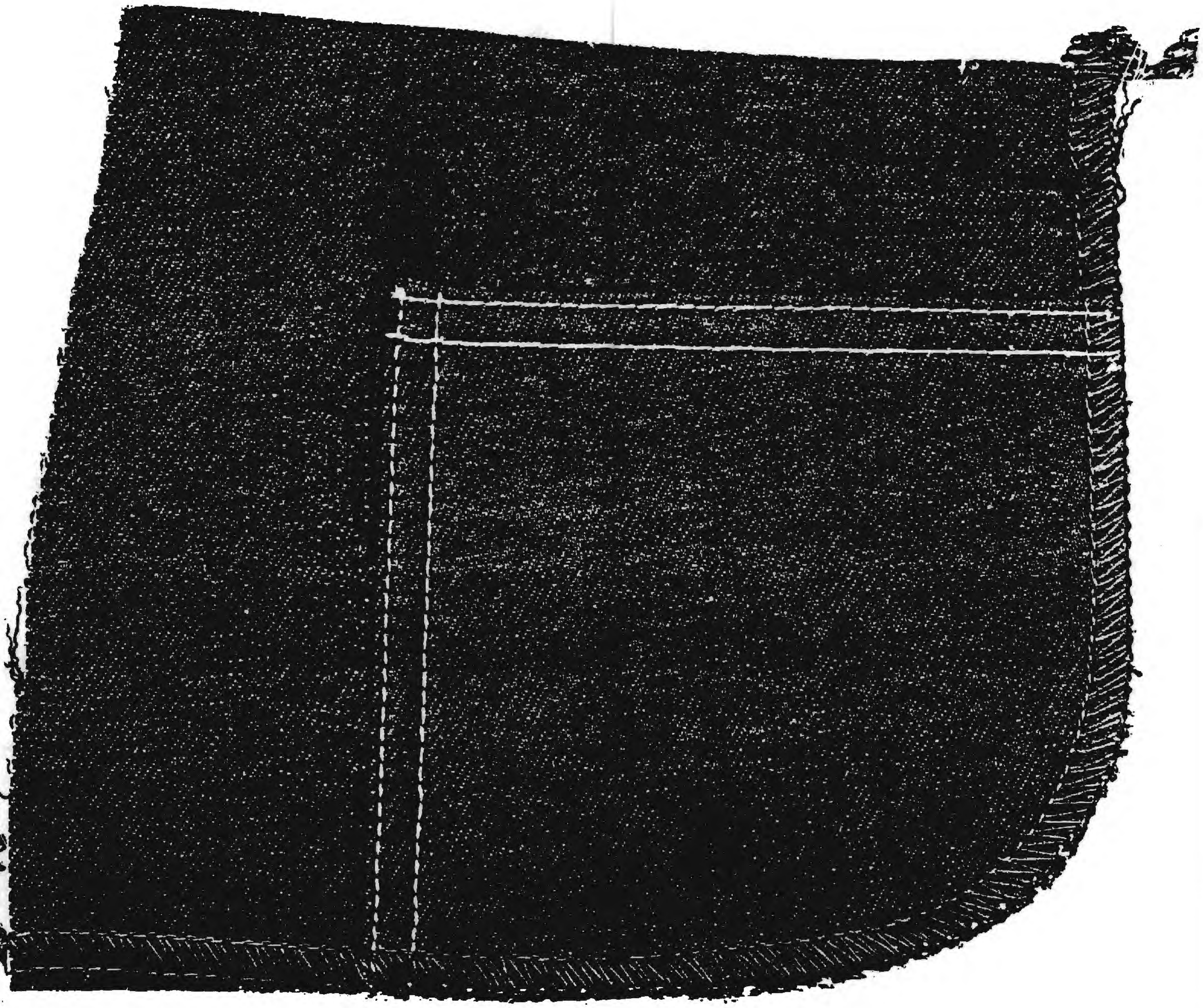

APPENDIX D

ASSESSMENTS OF THE APPLICABILITY OF THE CLAMPING SYSTEM AND PLY SEPARATION DEVICE IN APPAREL ASSEMBLY

<u>SEQUENCE OF OPERATIONS FOR MEN'S UNLINED JACKET</u>

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL* APPLICATION
	<u>Preliminary Operations</u>				
1.	Fuse lining to collar and cuffs	---	30	.166	C
1a.	Runstitch collar & Lining	301 SSa-1	15	.333	C
2.	Trim collar points	---	25	.200	C
3.	Turn & press collar	---	25	.200	N
4.	Close ends of cuffs	301 SSa-1	16	.313	C
5.	Turn cuffs	---	25	.200	N
6.	Serge front facings & pocket welt	504 EFd-1	8	.625	C
7.	Attach sleeve facing	301 BSc-1	13	.385	C
8.	Tack sleeve facing	---	12	.417	N
	<u>Fronts</u>				
9.	Stitch lining strip to right & left front	301-SSa-1	7½	.667	C
10.	Sew pocket welt to right & left front	301 LSq-1	5	1.000	A
11.	Attach front facings & zipper to right & left fronts	301 SSa-1	3	1.667	N
12.	Topstitch fronts, right & left	301 SSq-2	4	1.250	N
13.	Cord pockets opening & stitch facing to form pocket	301 LSd-1	5	1.000	N
	<u>Assembly Operations</u>				
14.	Join shoulders, set sleeves, close sleeves & side	515 SSa-1	3½	1.429	N
15.	Tack elastic to bottom over each side seam	301 SSa-1	6	.833	N
16.	Attach collar, insert label	301 SSa-1	8	.625	N
17.	Stitch collar down	301 LSd-1	9	.555	N
18.	Attach cuffs	504 SSa-1	8	.625	N
19.	Stitch cuffs down	301 LSd-1	9	.555	N
20.	Hem bottom	301 EFb-1	7	.714	N
21.	Stitch elastic	301-OSa-1	10	.500	N

SEQUENCE OF OPERATIONS FOR MEN'S UNLINED JACKET (Cont.)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
	Preliminary Operations				
22.	Button Hole Cuff	---	15	.333	N
23.	Button Sew	---	6	.833	N
			Total SAM/UNIT	15.425	

Total SAM/UNIT of Potential Applications = 3.689

% Application = 24%

[I]A = ply separation device and clamp applicable
C = clamp applicable
N = neither applicable

SEQUENCE OF OPERATIONS FOR WORK JACKETS

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
	Pockets				
1.	Hem waist & right breast pockets	301 EFb-2 401 EFb-2 (Inv)	10	.500	C
2.	Hem left breast pocket opening, join breast pocket pieces	301 EFa-2 LSb-2	6	.833	N
3.	Bartack opening in left breast pocket	---	35	.143	N
4.	Decorative stitch waist patch pockets	401 OSa-2	25	.200	C
5.	Hem inside breast pocket top	301 EFa-1	15	.333	C
6.	Crease waist pockets (2)	---	12½	.400	N
7.	Crease right breast pocket	---	25	.200	N
8.	Make buttonhole in left breast pocket	---	20	.250	N
9.	Crease left breast pocket	---	25	.200	N
	Collars				
10.	Runstitch collars	301 SSa-1	15	.333	C
11.	Trim collar points & turn	---	25	.200	N
12.	Topstitch collars	301 SSe-3	16	.313	N
	Sleeves				
13.	Gore sleeves	401 LSc-3	12½	.400	C
14.	Sew cuff facing on, turn, sew down, and topstitch edge of cuff	301 SSa-2	2½	2.000	N
15.	Close sleeves	401 LSc-3	12½	.400	N
	Fronts				
16.	Set right & left waist pockets & right breast pocket	301 LSd-2	4	1.250	N
17.	Set left breast pocket & stitch in pencil pocket	301 LSd-2	10	.500	N
18.	Set inside breast pocket	301 LSd-1	12½	.400	N

SEQUENCE OF OPERATIONS FOR WORK JACKETS (Cont.)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
19.	Sew facing to right & left front openings	301 SSa-1	7½	.667	N
	Backs				
20.	Join backs	401 LSc-3	15	.333	C
21.	Sew label over back seam	301 SSa-1	15	.333	N
	Assembly				
22.	Join shoulders	401 LSc-3	18	.278	N
23.	Close sides	401 LSc-3	10	.500	N
24.	Sew down right & left front facing & edge-stitch front facings	301 LSd-1	2½	2.000	N
25.	Hem bottoms	301 EFb-1 (Inv)	7½	.667	N
26.	Sew collar on and down	301 SSa-2	4	1.250	N
27.	Set sleeves	401 SSa-1	5½	.910	N
27a.	Raise sleeve seam	301 LSq-2b			N
28.	Make buttonholes in center plait (5) cuffs (4)	---	6	.833	N
29.	Attach buttons to button stay (5)	101	12½	.400	N
30.	Attach buttons to cuffs (2) & right breast pocket (1)	101	15	.333	N
31.	Bartack waist & right breast pocket, pencil opening on left breast pocket, cuffs 10 tacks	---	8	.625	N
32.	Trim and inspect	---	4	1.250	
		Total SAM/UNIT		19.234	

Total SAM/UNIT of Potential Applications = 2.100

% Application = 11%

SEQUENCE OF OPERATIONS FOR BOYS SPORT COAT

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
	Coat Lining				
1.	Sew facing to right & left front lining panels	301 SSa-1	7	.714	C
2.	Hem neck facing	301 EFa-1	15	.333	N
3.	Sew neck facing & label to back lining	301 LSd-1	12½	.400	N
4.	Gore sleeve linings	301 SSa-1	15	.333	C
5.	Join shoulder	301 SSa-1	16	.313	N
6.	Set sleeves	301 SSa-1	8	.625	N
	Coat Shell				
7.	Hem right & left waist & left breast pocket	301 EFa-1	15	.333	C
8.	Crease waist & breast pocket	---	15	.333	C
9.	Piece under collar	301 SSa-1	25	.200	N
10.	Quilt under collar	301 SSa-1	18	.278	C
11.	Runstitch collar	301 SSa-1	15	.333	C
12.	Trim collar points and turn	---	25	.200	B
13.	Gore sleeves	301 SSa-1	10	.500	C
14.	Set right & left waist & left breast pocket	301 LSd-1	4	1.250	N
15.	Join shoulders	301 SSa-1	16	.313	N
16.	Set sleeves	301 SSa-1	7½	.667	N
17.	Set in shoulder pads	301 SSa-1	10	.500	N
	Assembly Operations				
18.	Sew lining to right & left front of shell, also seam collar in neck opening	301 SSa-1	3	1.667	N
19.	Sew sleeve lining to sleeve shell	301 SSa-1	6	.833	N
20.	Sew back lining to shell backs and right & left front linings to shell	301 SSa-1	4	1.250	N
21.	Close right sleeve & side-seam of jacket shell and lining	301 SSa-1	9	.555	N

SEQUENCE OF OPERATIONS FOR BOYS SPORT COAT (Cont.)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
22.	Close left sleeve & sideseam of jacket shell & lining, leaving elbow of lining open to pull jacket shell through	301 SSa-1	9	.555	N
23.	Turn jacket right side out	---	12½	.400	N
24.	Close elbow of left sleeve lining	301 SSc-1	10	.500	N
25.	Edgestitch collar & right & left front facing	301 SSc-2	3	1.667	N
26.	Make buttonhole in Centerplait	---	10	.500	N
27.	Sew button to button stay	101	12	.417	N
28.	Trim and Inspect	---	4	1.250	N
		Total SAM/UNIT		17.219	

Total SAM/UNIT of Potential Applications = 3.024

% Application = 18%

SEQUENCE OF OPERATIONS FOR BOYS DRESS TROUSER

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
	Preliminary Operations				
1.	Make belts (one operation)	301 LSz-2	12½	.400	C
2.	Finish belt ends	301 SSb-1	6	.833	N
3.	Make belt loops (6)	406 EFh-1	70	.071	N
4.	Staple belt loop to belt inserting buckle	---	15	.333	N
5.	Set eyelets in belt (5)	---	25	.200	N
6.	Face side pockets	301 LSd-1	10	.500	C
	Fronts				
8.	Sew one pleat in each front	301 OSe-1	10	.500	C
9.	Hang & cord side pockets	301 SSe-2	5	1.000	A
10.	Hem edge or right & left fly, attach zipper to right & left fly, close	301 EFa-1	4	1.250	N
	crotch & topstitch left fly & cord crotch	301 EFa-1	4	1.250	N
11.	Serge in & out seams	504 EFd-1	15	.333	C
12.	Bartack fly & front pocket	---	25	.200	N
13.	Sew waistband lining to front panels and insert belt loops	301 SSa-1	10	.500	N
	Backs				
14.	Serge in & out seams and seat seams	504 EFd-1	15	.333	C
15.	Close seat seam	301 SSa-1 515 SSa-2	12 15	.417 .333	N N
16.	Sew covered elastic to backs inserting belt loops	401 LSm-2 (Inv)	25	.200	N
	Assembly Operations				
17.	Close side seams	301 SSa-1	8	.625	N
18.	Inseam	301 SSa-1	9	.555	N
19.	Sew down waistband in right & left fronts	301 LSd-1	8	.625	N
20.	Serge leg openings	503 EFd-1	11¼	.444	N
21.	Hem leg openings	301 EFa-1	12½	.400	N

SEQUENCE OF OPERATIONS FOR BOYS DRESS TROUSER (Cont.)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATIO[N]
22.	Tack down belt loops	---	10	.500	N
23.	Make buttonholes in waistband	---	22	.227	N
24.	Sew button to waistband	101	25	.200	N
25.	Form & tack cuffs	101	25	.200	N
26.	Trim and Inspect	---	5	1.000	N
27.	Press tops	---	9	.555	N
28.	Press legs	---	9	.555	N
		Total SAM/UNIT		14.539	

Total SAM/UNIT of Potential Applications = 3.066

% Application = 21%

SEQUENCE OF OPERATIONS FOR LADIES WOVEN SWIM SUIT

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATIO[N]
	Preliminary Operations				
	Shoulder Straps				
1.	Make shoulder straps	301 EFj-1	15	.333	N
2.	Make (3) buttonholes in each strap	---	10	.500	N
	Bra Linings				
3.	Seam centers of right & left cotton & pellon bra cups, also join cups	301 SSa-1	8	.625	C
4.	Serge bottom of bra cups, inserting ¼" cotton tape	504 SSa-1	25	.200	N
5.	Sew on label & size tag	301 SSa-1	15	.333	B
6.	Tape over bra cup seam, insert stays	401 SSf-3	26	.192	N
	Backs				
7.	Seam backs	504 SSa-1	30	.166	C
8.	Sew elastic to back ½" apart, puckering back	401 OSb-2 (Mod)	1	5.000	A
9.	Overedge ½" elastic to top of backs	504 SSa-1	25	.200	N
	Fronts				
10.	Serge decorative bra flanges (4) & skirt front	504 EFd-1	10	.500	C
11.	Blindhem edge of decorative bra flanges (4) & skirt front (5/8" hem)	103 EFa-1	10	.500	N
12.	Join center front tops together with lining & center front trunk together with lining	301 SSa-1	8	.625	N
13.	Join side bra flanges to center bra flanges	301 SSa-1	5	1.000	N
14.	Shirr bra flanges to side panels with lining & shirr center bra flanges to size	301 SSa-1	12	.417	N

SEQUENCE OF OPERATIONS FOR LADIES WOVEN SWIM SUIT (Cont.)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
15.	Shirr skirt to trunk (left side only)	301 SSa-1	16	.313	N
16.	Sew left bra panels to center front & top to trunk	515 SSa-2	8	.625	N
17.	Sew on right side	515 SSa-2	12	.417	N
18.	Close bra darts inserting bottom center flanges	301 SSa-1	7	.714	N
19.	Close top of suit	301 SSa-1	4	1.250	N
20.	Assemble bra lining	---	8	.625	N
21.	Sew bra lining & shoulder straps on & down	301 LSq-2	3	1.667	N
22.	Tack intercenter bra flanges	101	50	.100	N
23.	Tack apex stays in bra lining (2)	---	30	.166	N
		Total SAM/UNIT		16.468	

Total SAM/UNIT of Potential Applications = 6.624

% Application = 40%

SEQUENCE OF OPERATIONS FOR LADIES WOVEN PAJAMAS

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATIO:
		COAT			
	Preliminary Operations				
1.	Attach piping to pocket facing	301 SSk-1 (Mod)	30	.166	C
2.	Attach facing to pocket	301 SSa-1	40	.125	C
3.	Fold & stitch down pocket facing	301 EFb-1 (Mod)	25	.200	N
4.	Runstitch collars & insert piping	301 SSk-1	15	.333	C
5.	Hem left & right front facing	301 EFa-1	15	.333	C
	Assembly Operations				
6.	Attach left & right front facing & insert pipings	301 SSk-1	7½	.667	A
7.	Attach pocket to right front	301 LSd-1	10	.500	N
8.	Attach yoke patch	301 LSd-1	12	.417	C
9.	Join shoulder	401 LSc-2	15	.333	N
10.	Gore sleeves	401 LSc-2	9	.555	C
11.	Set sleeves	401 LSc-2	8½	.588	N
12.	Sew collar on	301 SSa-1	8	.625	N
13.	Sew collar down & insert hanger label	301 LSd-1	8	.625	N
14.	Close sleeves & sides	401 LSc-2	7½	.667	N
15.	Hem sleeves	301 EFb-1	10	.500	N
16.	Hem bottom	301 EFb-1	6	.833	N
17.	Buttonhole front	---	12	.417	N
18.	Sew on button	101	15	.333	N
19.	Trim and Inspect	---	5	1.000	N
		PANTS			
1.	Seat seam	401 LSc-2	12½	.400	C
2.	Attach waist elastic to back	401 LSk-2 (Mod)	15	.333	A
3.	Front seam & inseam	401 LSc-2	6	.833	A
4.	Tack cut-on front waistband to elastic & stitch down	301 SSa-1	7½	.667	N

SEQUENCE OF OPERATIONS FOR LADIES WOVEN PAJAMAS (Cont.)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATIOI
5.	Hem legs	301 EFb-1	12	.417	N
6.	Trim and Inspect	---	7	.714	N
		Total SAM/UNIT		12.581	

Total SAM/UNIT of Potential Applications = 4.162

% Application = 33%

LADIES PANTIES, VEST AND SNUGGIES

SEQUENCE OF OPERATIONS FOR LADIES RAYON BALBRIGGAN PANTIES

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
1.	Join crotch pieces	504 SSa-1	10	.500	C
2.	Attach crotch piece to front & back	504 SSa-1	7	.714	C
3.	Attach leg elastic	401 EFg-2	20	.250	A
4.	Close right side seam	504 SSa-1	30	.166	N
5.	Attach waist elastic	406 LSb-1 (Inv)	30	.166	N
6.	Close left side	504 SSa-1	26	.192	N
7.	Tack elastic	---	32	.156	N
8.	Trim & Inspect	---	7	.714	N
		Total SAM/UNIT		2.858	

Total SAM/UNIT of Potential Applications = 1.464

% Application = 51%

SEQUENCE OF OPERATIONS FOR LADIES NYLON TRICOT PANTIES

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
1.	Attach crotch piece to front	607 FSa-1	20	.250	C
2.	Cuff legs	607 FSa-1	7	.714	C
3.	Close crotch	607 FSa-1	28	.179	N
4.	Attach waist elastic	401 EFg-2	30	.166	N
5.	Close waist elastic	504 SSa-1	45	.111	N
6.	Bartack waist elastic (1)	---	45	.111	N
7.	Trim & Inspect	---	7	.714	N
		Total SAM/UNIT		2.245	

Total SAM/UNIT of Potential Applications = .964

% Application = 43%

SEQUENCE OF OPERATIONS FOR LADIES SWEATERS

(Cardigan - Long Sleeve)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATIO
1.	Close first shoulder	504 SSa-1	7	.714	C
2.	Attach collarette	504 SSa-1	7	.714	C
3.	Close second shoulder	504 SSa-1	7	.714	N
4.	Set top of sleeve	---	5	1.000	C
5.	Set underarm portion of sleeves	101 SSa-1	5	1.000	N
6.	Close sleeves & sides	101 SSa-1	5	1.000	N
7.	Close collarette	504 SSa-1	4	1.250	N
8.	Attach button & Buttonhole facings	301 SSa-1	2	2.500	N
9.	Attach label	101	15	.333	N
10.	Buttonhole front	---	5	1.000	N
11.	Button sew front	101	5	1.000	N
12.	Trim and Inspect	---	4	1.250	
		Total SAM/UNIT		12.475	

Total SAM/UNIT of Potential Applications = 2.428

% Application = 19%

SEQUENCE OF OPERATIONS FOR LADIES WOOL SKIRT

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIA[L] APPLICATI[ON]
	Preliminary Operations				
1.	Piece bow strap	301 SSa-1	15	.333	C
2.	Make bow	301 SSa-1	12½	.400	N
3.	Turn bow	---			
4.	Stitch darts in front panel & lining	301 OSf-1	3	1.667	C
	Assembly Operations				
5.	Join back panels	301 SSa-1	8	.625	C
6.	Attach kickpleat, finish & attach bow	301 SSa-1	2½	2.000	N
7.	Sew lining to back	301 SSa-1	12½	.400	N
8.	Join side seams	301 SSa-1	4½	1.111	N
9.	Attach zipper	301 LSb-1	4½	1.111	N
10.	Finish waistband ends sew on & stitch down waistband & insert hanger loops & label	301 BSg-2	2½	2.000	N
11.	Attach tape, bottom	101 LSa-1	6½	.770	N
12.	Hem bottom	306 EFa-1	12½	.400	N
13.	Buttonhole band	---	6	.833	N
14.	Sew on button	101	6	.833	N
15.	Trim and Inspect	---	4	1.250	N
16.	Press	---	12½	.400	N
		Total SAM/UNIT		14.133	

Total SAM/UNIT of Potential Applications = 2.625

% Application = 18%

SEQUENCE OF OPERATIONS FOR LADIES BLOUSE

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATIO:
1.	Sew lace to bow, ruffling lace (3)	301 LSa-1	10	.500	N
2.	Make spaghetti trim for decorative bows	301 SSa-1	12	.417	N
3.	Tack on bows	101	25	.200	N
	Fronts				
4.	Make tucks	301 OSf-1	7½	.667	C
5.	Sew lace to right & left side of tucking	301 SSa-1	7½	.667	N
6.	Sew darts in front	301 OSf-1	16	.313	N
7.	Tack bows to front	301 SSa-1	30	.166	N
8.	Sew on buttons	101	15	.333	N
9.	Hem back button & buttonhole facing	301 EFa-1	5	1.000	N
10.	Sew darts in back	301 OSf-1	16	.313	C
	Assembly Operations				
11.	Join shoulders	515 SSa-2	18	.278	N
12.	Join sleeves	515 SSa-2	8	.625	N
13.	Close sleeves & sides	515 SSa-2	9	.555	N
14.	Hem sleeves	503 EFc-1	17	.294	C
15.	Sew french piping to neck opening	301 BSg-1 (Mod)	7½	.667	N
16.	Finish top of back facings	301 SSa-1	18	.278	N
17.	Make buttonholes in	---	7½	.667	N
18.	Sew buttons to back (6)	101	10	.500	N
19.	Hem bottoms	301 EFb-2	7½	.667	N
20.	Trim and Inspect	---	5	1.000	
		Total SAM/UNIT		10.107	

Total SAM/UNIT of Potential Applications = 1.274

% Application = 8%

SEQUENCE OF OPERATIONS FOR LADIES KNIT DRESS

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
1.	Close sleeves	504 SSa-1	17	.294	C
2.	Finish bottom of collar	301 SSa-1	20	.250	C
3.	Join shoulders	504 SSa-1	18	.278	A
4.	Attach collar to neck opening	504 SSa-1	6	.833	N
5.	Coverstitch neck seam	406 SSh-2	18	.278	N
6.	Finish ends of collar	301 SSa-1	8	.625	N
7.	Sew dart in front side openings	301 OSf-1	10	.500	C
8.	Close sides	504 SSa-1	5	1.000	N
9.	Set sleeves	504 SSa-1	5½	.910	N
10.	Tack label to neck opening	101	25	.200	N
11.	Sew buttons to collar	101	25	.200	N
12.	Tack collar	101	25	.200	N
13.	Trim and Inspect		4	1.250	N
14.	Hem Bottom	103 EF1-1	5	1.000	
		Total SAM/UNIT		7.818	

Total SAM/UNIT of Potential Applications = 1.322

% Application = 17%

SEQUENCE OF OPERATION AND EQUIPMENT REQUIRED
FOR THE MANUFACTURE OF MEN'S KNIT UNDERWEAR

TEE SHIRTS

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
1.	Hem sleeves	503 EFc-1	40	.125	C
2.	Close sleeves	504 SSa-1	12½	.400	C
3.	Hem bottom	503 EFc-1	25	.200	N
4.	Join right shoulder	504 SSa-1	30	.166	N
5.	Attach collar, insert Hanger label	504 SSa-1	24	.208	N
6.	Close left shoulder	504 SSa-1	28	.179	N
7.	Tape neck & shoulder seams	401 SSf-3	12½	.400	N
8.	Sew in sleeves	504 SSa-1	5½	.910	N
		Total SAM/UNIT		2.588	

Total SAM/UNIT of Potential Applications = .525

% Application = 20%

SEQUENCE OF OPERATIONS FOR MEN'S PAJAMAS

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATIO[N]
		COATS			
1.	Runstitch collars	301 SSa-1	18	.278	C
2.	Turn collars	---	15	.333	N
3.	Hem top of pockets	301 EFb-1	30	.166	C
4.	Gore sleeves	401 LSc-2	15	.333	C
5.	Attach cuff to sleeve	401 BSc-1	12½	.400	C
6.	Hem fronts	301 EFb-1	13	.385	C
7.	Sew on neck patch	301 LSd-1	5	1.000	N
8.	Attach pocket to left front	301 LSd-1	8	.625	N
	Assembly				
9.	Join shoulders	401 LSc-2	18	.278	N
10.	Set sleeves	401 LSc-2	9	.555	N
11.	Close sleeves & side	401 LSc-2	9	.555	N
12.	Attach collar	301 SSa-1	9	.555	N
13.	Stitch collar down	301 LSd-1	10	.500	N
14.	Hem bottom	301 EFb-1	6	.833	N
15.	Buttonhole front	---	12½	.400	N
16.	Sew buttons to front	101	15	.333	N
17.	Trim & Inspect	---	6	.833	N
	PANTS (ELASTIC BAND)				
1.	Make hanger loop	301 EFp-1	50	.100	N
2.	Join seat seam	401 LSc-2	12½	.400	C
3.	Attach elastic	401 SSt-2	20	.250	N
4.	Sew on right fly piece	301 SSa-1	7½	.667	N
5.	Stitch down right fly piece	301 LSd-1	7½	.667	N
6.	Buttonhole left fly piece	---	20	.250	N
7.	Sew on left fly piece	301 SSa-1	7½	.667	N
8.	Topstitch left fly	301 LSaq-1	7½	.667	N
9.	Join crotch	301 LSas-2	10	.500	N
10.	Inseam	401 LSc-2	10	.500	N
11.	Buttonhole top of fly	---	20	.250	N

SEQUENCE OF OPERATIONS FOR MEN'S PAJAMAS (Cont.)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
12.	Sew in buttons	101	20	.250	N
13.	Hem bottoms	301 EFb-1	12½	.400	N
14.	Trim & Inspect	---	6	.833	N
		Total SAM/UNIT		14.763	

Total SAM/UNIT of Potential Applications = 1.962

% Application = 13%

SEQUENCE OF OPERATION ON WORK PANTS

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
1.	Make belt loops small (1)	406 EFh-1	70	.071	N
2.	Make belt loops large (6)	406 EFh-1	50	.100	N
3.	Make watch pocket	505 SSa-1	35	.143	C
4.	Attach front pocket facings	301 LSd-1	9	.555	C
5.	Bag front pockets	301 SSa-1	20	.250	C
6.	Attach hip pocket facing	301 LSd-1	18	.278	C
7.	Attach hip pocket welt	301 BSc-1	15	.333	C
8.	Bag hip pocket & turn	301 SSa-1	18	.278	C
9.	Topstitch hip pocket	301 SSe-2	9	.555	N
10.	Serge left fly piece	503 EFd-1	40	.125	C
11.	Attach zipper tape to left fly	401 SSa-2	18	.278	N
12.	Attach lining to right fly	301 LSb-1	16	.313	C
13.	Attach zipper tape to right fly	504 SSa-1	25	.200	N
14.	Tack loops to waistband right & left	101	10	.500	N
15.	Attach prepared waist-band lining to right & left band	404 LSb-1	12	.417	N
16.	Tack size ticket to waistband	101	18	.278	N
17.	Tack label to waist-band lining	101	15	.333	N
	Fronts				
18.	Serge left & right front panels	503 EFd-1	9	.555	C
19.	Sew on left fly	301 SSa-1	15	.333	N
20.	Sew on right fly	301 SSa-1	15	.333	N
21.	Set watch pocket right & left front pockets, turn, topstitch & tack top & bottom of pockets	301 SSa-1	5	1.000	N
	Backs				
22.	Serge right & left back panels	503 EFd-1	8	.625	C

SEQUENCE OF OPERATION ON WORK PANTS (Cont.)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
	Backs				
23.	Close darts right & left	301 OSf-1	10	.500	A
24.	Set right & left hip pocket	301 LSd-1	5	1.000	N
25.	Close top of hip pocket right & left	301 LSd-1	5	1.000	N
	Assembly				
26.	Side seam	401 SSa-1	7½	.667	N
27.	Inseam right & left panel	401 SSa-1	10	.500	N
28.	Topstitch right & left front pockets	301 SSe-2	7½	.667	N
29.a.	Sew on waistband	401 SSa-1	5	1.000	N
29.b.	Finish waistband ends at fly	301 SSc-1	5	1.000	N
30.	Topstitch left fly and join crotch	301 EFa-1 SSa-1	9	.555	N
31.	Seat seam	401 SSa-2	10	.500	N
32.	Press side seam & seam	---	10	.500	N
33.	Buttonhole band & hip pocket	---	12	.417	N
34.	Sew button to band & hip pocket	101	15	.333	N
35.	Stitch down waistband and right fly	301 LSq-2 (Mod)	6	.833	N
36.	Tape crotch	301 SSb-1	12	.417	N
37.	Hem bottom	301 EFb-1	9	.555	N
38.	Tack cuffs	101	13	.385	N
39.	Bartack pockets, crotch & back loop	---	5	1.000	N
40.	Trim & Inspect	---	8	.625	N
41.	Press top	---	10	.500	N
42.	Press legs	---	10	.500	N
43.	Final Inspect & Fold	---	10	.500	N
		Total SAM/UNIT		21.807	

Total SAM/UNIT of Potential Applications = 3.955
% Application = 18%

SEQUENCE OF OPERATIONS FOR COVERALLS

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
	Collars				
1.	Runstitch collars	301 SSa-1	15	.333	C
2.	Trim collar points	---	25	.200	A
3.	Turn & press collar	---	15	.333	A
	Pockets & Flaps				
4.	Runstitch right breastpocket & flap	301 SSa-1	18	.278	C
5.	Turn and topstitch right breast pocket flap	301 SSe-3	20	.250	A
6.	Hem top or right & left breast pockets	301 EFa-2	25	.200	C
7.	Hem top of hip pockets	301 EFb-2	25	.200	C
8.	Attach reinforcing to hip pocket	301 SSa-2	20	.250	N
9.	Attach label to top of left breast pocket	301 SSa-1	15	.333	N
10.	Fold top of rule pocket & stitch down	301 EFa-2	25	.200	N
11.	Crease breast, hip and rule pockets	401 Lsd-1	12½	.400	N
12.	Attach front pocket facing	401 LSd-1	10	.500	C
13.	Make front pocket	301 SSe-2	12½	.400	N
14.	Hem side of front pockets for hand hole opening	301 SSp-1	5	1.000	N
15.	Serge front pocket hand hole facing	504 EFd-1	35	.143	N
	Sleeves				
16.	Piece cuff facing	301 SSa-1	18	.278	C
17.	Attach snap to cuff facing	---	37½	.133	C
18.	Fell sleeve pieces (Gore)	401 LSc-3	15	.333	C
19.	Attach cuff facing, turn and topstitch, & stitch facing down	301 SSe-2	4	1.250	N

SEQUENCE OF OPERATIONS FOR COVERALLS (Cont.)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
	Waist Section (Fronts)				
20.	Set left breast pocket stitch in pencil pocket	301 LSd-2	10	.500	N
21.	Set right breast pocket & pocket flap	301 LSd-2	8	.625	N
22.	Make right cut-on zipper facing	301 EFb-1	7½	.667	N
23.	Attach lapel facing turn & topstitch lapel edges. Also stitch facing down Stitch across bottom of right facing only	301 SSe-2	5	1.000	N
	Waist Section (Backs)				
24.	Fell back pieces	401 LSc-3	12½	.400	C
25.	Attach label	301 SSa-1	15	.333	C
26.	Make right & left back pleats tacking down bottom section & stitching across pleats at top and bottom	301 OSf-2	5	1.000	N
	Waist Section (Assembly)				
27.	Fell shoulders	401 LSc-3	15	.333	N
28.	Sew collar on & down topstitch collar	301 SSq-4	4	1.250	N
29.	Set sleeves	401 LSc-3	7½	.667	N
	Pants Section				
30.	Set front swing pockets	301 SSp-2	12½	.400	N
31.	Stay top of front pockets & tack hand hole facing to bottom of front pockets	301 SSa-1	15	.333	N
32.	Set rule & hip pockets	301 LSd-2	7½	.667	N
33.	Fell seat seam	401 LSc-3	15	.333	N
	Assembly				
34.	Join (R&L) front waist and pants sections together	301 SSa-1	5	1.000	N
35.	Fell back center waist & pants sections together	401 LSc-3	5	1.000	N

SEQUENCE OF OPERATIONS FOR COVERALLS (Cont.)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
36.	Join crotch	301 LSas-2 (Mod)	12½	.400	N
37.	Fell sleeves & side-seams of waist & pants	401 LSc-2	2	2.500	N
38.	Fell pants inseam	401 LSc-3	10	.500	N
39.	Attach waistband	401 SSag-5	12½	.400	N
40.	Attach (R&L) two way zipper tape to center fronts, stitching down & finishing both fronts	301 EFb-2 (Mod)	2½	2.000	N
41.	Finish crotch	301 LSas-2	10	.500	N
42.	Buttonhole left	---	7	.714	N
43.	Attach button metal to right lapel (2)	---	9	.555	N
44.	Attach snaps (metal) to right breast pocket, breast pocket flap and cuff	---	6	.833	N
45.	Bartack breast, hip, rule, front pockets, crotch, back, pleats & cuff openings	---	6	.833	N
46.	Hem legs	301 EFb-1-Inv	12½	.400	N
		Total SAM/UNIT		27.157	

Total SAM/UNIT of Potential Applications = 3.771

% Application = 14%

SEQUENCE OF OPERATIONS ON KNITTED SPORT SHIRTS

(Long Sleeves)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATIO[N]
1.	Fuse collar	---	10	.500	C
2.	Runstitch collars	301 SSa-1	12½	.400	C
3.	Trim collar points	---	9	.555	N
4.	Turn collar	---	9	.555	N
5.	Topstitch collar	301 SSe-2	15	.333	N
6.	Close end of cuff	301 SSa-1	12½	.400	A
7.	Turn cuff				
8.	Sew sleeve facing on and down	301 SSa-1	5	1.000	C
9.	Tack sleeve facings	301 SSa-1	15	.333	N
10.	Sew on right & left front facings	301 SSa-1	6½	.770	C
11.	Cord left facing & box	301 SSe-2	8	.625	N
12.	Serge facings	504 EFd-1	16	.313	N
	Assembly				
13.	Join shoulders	504 SSa-1	18	.278	N
14.	Set sleeves	504 SSa-1	8	.625	N
15.	Close sleeves & side	504 SSa-1	7½	.667	N
16.	Hem bottom	503 EFc-1	20	.250	N
17.	Sew collar on	301 SSa-1	6½	.770	N
18.	Stitch collar down	301 LSd-1	6½	.770	N
19.	Attach cuffs	301 SSa-1	6½	.770	N
20.	Stitch cuffs down	301 LSd-1	6½	.770	N
21.	Buttonhole fronts and cuffs	---	12½	.400	N
22.	Sew button to front and cuffs	101	18	.278	N
23.	Trim and Inspect	---	4	1.250	N
		Total SAM/UNIT		12.612	

Total SAM/UNIT of Potential Applications = 3.070

% Application = 24%

SEQUENCE OF OPERATIONS ON KNITTED POLO SHIRTS

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
1.	Hem sleeves	503 EFc-1	40	.125	C
2.	Close sleeves	504 SSa-1	18	.278	A
3.	Bartack sleeves	---	25	.200	A
4.	Hem bottom	503 EFc-1	20	.250	C
5.	Close collarette	504 SSa-1	35	.143	N
6.	Hem pocket top taping	301 EFa-1 (Mod)	15	.333	C
7.	Set pocket	301 LSd-1	15	.333	N
8.	Close right & left shoulder	504 SSa-1	25	.200	N
9.	Attach collarette and label	504 SSa-1	8½	.588	N
10.	Tape neck & shoulders	401 SSf-3 (Mod)	12½	.400	N
11.	Set sleeves	504 SSa-1	5½	.910	N
12.	Trim & inspect	---	4	1.250	N
		Total SAM/UNIT		5.010	

Total SAM/UNIT of Potential Applications = 1.186

% Application = 24%

SEQUENCE OF OPERATIONS FOR DRESS SHIRTS

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
	Collars				
1.	Fuse collar & band	---	50	.100	C
2.	Attach plastic stays	301 SSa-1	30	.166	C
3.	Runstitch collar	301 SSa-1	15	.333	C
4.	Trim collar points & turn & press collar	---	18	.278	N
5.	Topstitch collar	301 SSe-2	16	.313	N
6.	Trim collar edge	---	20	.250	N
7.	Crease collar band	---	37½	.133	C
8.	Attach collar band to collar	301 SSa-1	15	.333	A
9.	Turn & press collar band	---	18	.278	N
10.	Sew down collar band	301 SSq-2	18	.278	N
11.	Buttonhole collar band	---	37½	.133	N
12.	Button sew collar band	101	37½	.133	N
13.	Trim & notch collar band	---	37½	.133	N
	Cuffs				
14.	Precrease cuffs	---	20	.250	C
15.	Topstitch cuffs	301 SSc-1	7½	.667	N
16.	Buttonhole cuffs	---	25	.200	N
17.	Button sew cuffs	101	24	.208	N
	Pockets				
18.	Serge pocket tops	504 EFd-1	40	.125	C
19.	Precrease pockets	---	25	.200	C
	Fronts				
20.	Attach button stay	401 LSk-2	25	.200	C
21.	Buttonhole fronts	---	10	.500	N
22.	Button sew front	101	10	.500	N
23.	Set pocket to left front	301 LSd-1	6	.833	N
	Backs				
24.	Attach label to yoke	301 LSd-1	16	.313	C
25.	Set back yoke	401 LSf-1	16	.313	N

SEQUENCE OF OPERATIONS FOR DRESS SHIRTS (Cont.)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
	Sleeves				
26.	Attach sleeve facing	301 BSc-1	12½	.400	C
27.	Tack sleeve facing	301	10	.500	N
	Assembly				
28.	Join shoulder seam	301 SSa-1	15	.333	N
29.	Attach and sew down collar	301 SSa-1	4	1.250	N
30.	Set sleeves	401 LSc-1	8	.625	N
30.a.	Set sleeves	401 LSaw-3	8	.625	N
31.	Close side seam and sleeves	401 LSc-2	8	.625	N
32.	Set cuff (Precreased)	301 LSe-1	7½	.667	N
33.	Hem bottom	301 EFb-1	7½	.667	N
34.	Trim & Inspect	---	5	1.000	N
35.	Press & Fold	---	5	1.000	N
		Total SAM/UNIT		14.862	

Total SAM/UNIT of Potential Applications = 2.553

% Application = 17%

SEQUENCE OF OPERATIONS FOR MEN'S SWEATERS

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
1.	Close sleeves	504 SSa-1	10	.500	C
2.	Attach pocket welt to pocket lining	504 SSa-1	25	.200	C
3.	Set pockets	301 SSa-1	2½	2.000	N
4.	Close pockets	504 SSa-1	15	.333	N
5.	Close shoulders & insert tape	504 SSab-1	16	.313	N
7.	Attach front facing	504 SSa-1	7½	.667	N
8.	Tape neck	401 SSf-3	18	.278	N
9.	Finish front & bottom	301 EFa-1 (Mod)	7½	.667	N
10.	Close sides	504 SSa-1	10	.500	N
11.	Set sleeves	504 SSa-1	5½	.910	N
12.	Buttonhole front	---	10	.500	N
13.	Button sew front	101	12½	.400	N
14.	Trim & Inspect	---	4	1.250	N
		Total SAM/UNIT		8.518	

Total SAM/UNIT of Potential Applications = .700

% Application = 8%

SEQUENCE OF OPERATIONS ON CHILDREN'S UNDERWEAR

CHILDREN'S GOWN

1.	Hem right & left front pieces, taping	401 EFa-2 (Mod)	15	.333	B
2.	Hem sleeves, taping	401 EFa-2 (Mod)	25	.200	B
3.	Set sleeves and Close sides	607 FSa-1	5	1.000	N
4.	Bind neck	602 BSa-1	25	.200	N
5.	Hem bottom	503 EFc-1	20	.250	N
6.	Tack fronts & sleeves	---	20	.250	N
7.	Attach grippers	---	35	.143	N
8.	Trim & Inspect	---	6	.833	N
		Total SAM/UNIT		3.209	

Total SAM/UNIT of Potential Applications = .533

% Application = 17%

SEQUENCE OF OPERATIONS ON CHILDREN'S UNDERWEAR (Cont.)

BOYS' RIBBED KNIT SHORTS

IO. OF)PERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
1.	Bind fly pieces	602 BSa-1	55	.091	C
2.	Tape fronts & attach fly pieces	607 LSz-1 (Mod)	20	.250	B
3.	Bind legs inserting elastic	602 BSa-1	17	.294	C
4.	Preclose elastic	607 FSa-1	33	.152	N
5.	Attach elastic to waist	407 LSa-1	17	.294	N
6.	Close inseam	607 FSa-1	28	.179	N
7.	Tack legs	---	31	.161	N
8.	Attach label	301 LSd-1	15	.333	N
		Total SAM/UNIT		1.754	

Total SAM/UNIT of Potential Applications = .635

% Application = 36%

SEQUENCE OF OPERATIONS ON CHILDREN'S COATS

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
	Make Lining				
1.	Attach label to back lining panel	301 SSa-1	15	.333	B
2.	Make darts in back panel and join shoulders	301 SSa-1	8	.625	B
3.	Set sleeves	301 SSa-1	9	.555	N
4.	Close sleeves and sides to waist	301 SSa-1	10	.500	N
5.	Make darts in skirt of paper lining	301 OSf-1	12	.417	N
6.	Make darts in skirt of rayon lining	301 OSf-1	12	.417	B
7.	Attach paper and rayon skirt lining at waist and sides	301 SSa-1	8	.625	N
8.	Hem bottom of skirt lining	103 EFb-1	15	.333	N
9.	Join top and skirt lining at waist	301 SSa-1	12	.417	N
	Make Shell				
10.	Join and quilt under-collar	301 SSa-1	8	.625	C
11.	Runstitch collar	301 SSa-1	15	.333	C
12.	Topstitch collar and close bottom of collar	301 SSe-2	12	.417	N
13.	Make front bow	301 SSa-1	5	1.000	N
14.	Attach and cord yoke to front panels	301 LSq-2	2½	2.000	C
15.	Attach and cord top & bottom of front panels at waist forming pleats in skirt	301 LSq-2	5	1.000	N
16.	Attach burlap tape & front facings	301 SSa-1	10	.500	N
17.	Sew burlap to right & left front armhole openings	301 SSa-1	5	1.000	N
18.	Piece back, forming pleats in skirt	301 SSa-1	2	2.500	N
19.	Tape right and left back armhole openings	301 SSa-1	8	.625	N
20.	Press seams open	---	8	.625	N

SEQUENCE OF OPERATIONS ON CHILDREN'S COATS (Cont.)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
21.	Join shoulder seams and insert burlap lining	301 SSa-1	15	.333	N
22.	Close sleeves	301 SSa-1	12	.417	N
23.	Close sides	301 SSa-1	10	.500	N
24.	Set sleeves	301 SSa-1	7½	.667	N
25.	Attach collar	301 SSa-1	7½	.667	N
26.	Attach front and neck facing to collar and finish top of front	301 SSa-1	3	1.667	N
27.	Attach ribbon to bottom of coat	101 SSa-1	10	.500	N
28.	Hem coat felling ribbon down	103 EFa-1	12	.417	N
29.	Stay pleats in bottom of back skirt panel	301 OSf-1	5	1.000	N
30.	Attach shoulder pad	301 SSa-1	8	.625	N
31.	Finish lower front facing and attach lining to front and neck facings	301 SSa-1	2½	2.000	N
32.	Attach sleeve lining to sleeve shell	301 SSa-1	5	1.000	N
33.	Tack lining to shoulder pads, back pleats in skirt and lower front facings	101	2	2.500	N
34.	Buttonhole front	---	6	.833	N
35.	Button sew front	101	12	.417	N
36.	Attach bow	---	2	2.500	N
37.	Trim and Inspect	---	4	1.250	N
		Total SAM/UNIT		31.140	

Total SAM/UNIT of Potential Applications = 4.333

% Application = 14%

SEQUENCE OF OPERATIONS FOR CHILDREN'S PLAY CLOTHES

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATIO[N]
	Preliminary Operations				
1.	Make pocket button loop	301 BSc-1	40	.125	N
2.	Tack button loop to side pocket opening	301 SSa-1	25	.200	N
3.	Bind front pocket	301 BSc-1	18	.278	B
4.					
	Assembly Operations				
4.	Attach right & left front pocket	301 SSa-1	15	.333	N
5.	Join front seam	401 LSc-2	13	.385	C
6.	Attach front waistband	301 BSc-1	20	.250	N
7.	Join back seam	401 LSc-2	18	.278	C
8.	Attach covered waist-band	401 EFg-2	15	.333	N
9.	Close side seams	515 SSa-21	9	.555	N
10.	Attach cuffs	401 BSc-1	15	.333	N
11.	Close seam	515 SSa-2	15	.333	N
12.	Button sew pockets	101	35	.143	N
13.	Trim & Inspect	---	5	1.000	N
		Total SAM/UNIT		4.546	

Total SAM/UNIT of Potential Applications = .941

% Application = 21%

SEQUENCE OF OPERATIONS FOR MEN'S RAINCOATS

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATIO[N]
	Collar Band				
1.	Quilt band or fuse	301 SSv-2	220	.272	C
	Collar				
2.	Quilt collar	301 SSv-2	220	.272	C
2.a.	Fuse collar lining	---	500	.120	C
3.	Runstitch collar	301 SSa-1	150	.400	C
4.	Trim collar	---	500	.120	C
5.	Turn collar	---	500	.120	C
6.	Shape collar points	---	500	.120	C
7.	Topstitch collar	301 SSe-2	180	.333	C
8.	Press collar	---	300	.200	N
9.	Set collar band - 1st step	301 SSa-1	130	.461	B
10.	Set collar band - 2nd step	301 SSa-1	130	.461	B
11.	Turn collar band	---	500	.120	N
12.	Topstitch band & close bottom	301 LSak-1	130	.461	N
13.	Make loop	406 EFh-1	840	.071	N
14.	Tack loop on band	---	300	.200	N
	Pocket Welt				
15.	Runstitch pocket welts or fuse lining to pocket welt	301 SSa-1	180	.333	C
16.	Turn pocket welt	---	500	.120	N
17.	Topstitch pocket welt	301 SSe-2	220	.272	N
18.					
	Sleeve Tab				
18.	Runstitch sleeve tab	301 SSa-1	300	.200	C
19.	Turn sleeve tab	---	400	.150	N
20.	Topstitch sleeve tab	301 SSe-2b	300	.200	N
21.	Buttonhole sleeve tab	---	420	.143	N
22.	Prepare pockets	---	200	.300	N
	Canvas				
23.	Sew tape to canvas facing reinforcement or fuse	401 SSa-1	70	.857	N

SEQUENCE OF OPERATIONS FOR MEN'S RAINCOATS (Cont.)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
	Sleeves				
24.	Piece sleeve	401 SSa-1	180	.333	C
25.	Press open seam	301 SSa-1	400	.150	N
26.	Set cuff wigan or fuse	401 SSa-1	180	.333	C
27.	Close sleeve	301 SSa-1	130	.461	N
28.	Topstitch sleeve	401 LSak-1	180	.333	N
	Backs				
29.	Piece back	301 SSa-1	70	.857	C
30.	Topstitch back	301 LSak-1	100	.600	A
	Neck Yoke				
31.	Piece neck yoke	301 SSa-1	240	.250	C
	Facings				
32.	Make fly & topstitch	301 SSe-2	240	.250	A
33.	Buttonhole fly	---	120	.500	A
34.	Bartack ends of fly	---	300	.200	A
35.	Tack fly	---	300	.200	A
36.	Join neck yoke to facing	301 SSa-1	240	.250	N
37.	Hem along edges of facing & neck yoke	301 EFa-1	60	1.000	N
38.	Press facing	---	400	.150	N
	Sleeve Lining				
39.	Inseam Sleeve	515 SSa-2	180	.333	C
40.	Close sleeve	516 SSa-2	170	.353	N
	Body Lining				
41.	Join sides	516 SSa-2	100	.600	N
42.	Make gussets	301 EFh-1	420	.143	N
43.	Hem lining bottom, inserting gussets	301 EFb-1	60	1.000	N
44.	Set sleeves	516 SSa-2	90	.667	N
45.	Serge lining edges	504 EFd-1	20	3.000	N
	Fronts				
46.	Set pockets & welts	301 SSa-1	220	.272	C

SEQUENCE OF OPERATIONS FOR MEN'S RAINCOATS (Cont.)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATIO[N]
	Fronts				
47.	Bag pockets	301 SSa-1	260	.231	C
48.	Close pockets	301 SSa-1	140	.429	N
49.	Topstitch pocket welts	301 LSak-1	100	.600	N
50.	Set canvas facing reinforcement to front or fuse	301 SSa-1	120	.500	N
	Assembly				
51.	Join side seams	301 SSa-1	140	.429	N
52.	Attach tape to side seams	301 SSa-1	180	.333	N
53.	Topstitch side seams	301 LSak-1	140	.429	N
54.	Set sleeves	301 SSa-1	140	.429	N
55.	Topstitch armhole	301 LSak-1	70	.857	N
56.	Set collar & runstitch facings to fronts at top	301 SSa-1	300	.200	N
57.	Runstitch facings to fronts	301 SSa-1	60	1.000	N
58.	Attach lining at front	401 LSa-1	50	1.200	N
59.	Attach lining at cuff	401 SSa-1	100	.600	N
60.	Turn out coat	---	200	.300	N
61.	Button sew at vent	101	360	.167	N
62.	Sew vents, attach lining at vent & top-stitch buttonhole side	301 EFa-1	100	.600	N
63.	Hem bottom, sewing in gussets	301 EFb-1	60	1.000	N
64.	Topstitch on fronts	301 SSe-2	60	1.000	N
65.	Edge press fronts	---	80	.750	N
66.	Buttonhole vent	---	180	.333	N
67.	Small buttonhole at front top	---	420	.143	N
68.	Mark for button sew	---	200	.300	N
69.	Button sew small	101	360	.167	N
70.	Button sew large & wrap (with stay button)	101	120	.500	N
71.	Trim & Inspect	---	50	1.200	N
72.	Press	---	50	1.200	N

Total SAM/UNIT 33.438
Total SAM/UNIT of Potential Applications = 7.571
% Application = 22%

SEQUENCE OF OPERATIONS FOR MEN'S SUIT COAT

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATIO[N]
	Preliminary Operation				
	Collars				
1.	Seam under collar	301 SSa-1	140	.429	C
2.	Press collar seam open	---	180	.333	N
3.	Pad under collar	103 OSa-1	140	.429	N
4.	Click collar	---	70	.857	N
5.	Make collar shape	---	70	.857	N
6.	Trim canvas collar	---	70	.857	N
7.	Baste top collar to under collar	101 SSa-1	100	.600	C
8.	Zig-zag collar	304 SSa-1	100	.600	N
9.	Edge baste collar	101 SSa-1	100	.600	N
10.	Press collar	---	280	.214	N
11.	Trim lower edge & sew on hanger	301 SSa-1	70	.857	N
	Sleeves				
12.	Serge sleeves	504 EFd-1	130	.461	C
13.	Sew inseam	301 SSa-1	100	.600	C
14.	Press inseam	---	200	.300	N
15.	Sew wigan or fuse	301 SSa-1	140	.429	N
16.	Mark vent	---	300	.200	N
17.	Make vent	301 SSa-1	10	6.000	N
18.	Baste Cuff turn up	301 SSa-1	100	.600	N
19.	Tack size ticket	101	120	.500	N
20.	Sew elbow seam & tack cuffs	301 SSa-1	40	1.500	N
21.	Make sleeve lining	301 SSa-1	50	1.200	N
22.	Fell sleeve lining at cuff	314 LSb-1 (Mod)	50	1.200	N
23.	Tack sleeve lining to sleeve seam	301 SSa-1	90	.667	N
	Backs				
24.	Serge back & vent	504 EFd-1	120	.500	C
25.	Sew tape to vent or fuse	301 SSa-1	140	.429	C
26.	Bookfold seam & left vent	103 EF1-1	160	.375	N
27.	Seam back	301 SSa-1	70	.857	N

SEQUENCE OF OPERATIONS FOR MEN'S SUIT COAT (Cont.)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
28.	Baste left vent close, attach	301 SSa-1	280	.214	N
29.	Cord lining vent	301 SSe-2	100	.600	N
30.	Press back seam	---	140.	.429	N
31.	Fell left vent	313 LSd-1 (Mod)	120	.500	N
32.	Baste vent lining	301 SSa-1	280	.214	N
33.	Fell vent lining	313 LSd-1 (Mod)	120	.500	N
34.	Serge yoke	504 SSa-1	400	.150	N
35.	Hem yoke, insert lining tab R&L	301 EFb-1	100	.600	N
36.	Baste yoke to back	301 SSa-1	140	.429	N
37.	Back tack yoke	---	280	.214	N
38.	Sew darts	301 SSa-1	20	3.000	C
39.	Serge facing	504 EFd-1	140	.429	C
40.	Seam lining to facing	301 SSa-1	70	.857	C
41.	Sew facing to pocket & Union label	301 LSd-1	70	.857	N
42.	Sew on lining pocket	301 SSa-1	40	1.500	N
43.	Cut & open pocket	---	100	.600	N
44.	Make lining pocket	301 SSe-2	20	3.000	N
45.	Tack lining pocket to facing	103 OSa-1	140	.429	N
46.	Press breast lining pocket	---	140	.429	N
	Pocket & Flaps				
47.	Fuse pocket flap	---	200	.300	C
48.	Make pocket flaps	301 SSa-1	70	.857	C
49.	Press flaps & turn	---	100	.600	N
50.	Baste flaps	101 SSa-1	280	.214	N
51.	Hem top & attach coin pocket	301 EFb-1	70	.857	N
52.	Sew on pocket facings	301 SSa-1	90	.667	N
53.	Sew darts in fronts	301 OSf-1	20	3.000	C
54.	Serge fronts	504 EFd-1	100	.600	C
55.	Tape armhole front or fuse	301 SSaa-1	40	1.500	N
56.	Bookfold front	103 EFa-1	130	.462	N

SEQUENCE OF OPERATIONS FOR MEN'S SUIT COAT (Cont.)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
	Pocket & Flaps				
57.	Press darts	---	100	.600	N
58.	First pocket Operation set side and breast pockets	301 SSa-1	10	6.000	N
59.	Second pocket Operation	301 SSa-1	10	6.000	N
60.	Tack welt, side & breast	301 SSa-1	20	3.000	N
61.	Bast pocket	101 SSa-1	140	.429	N
62.	Pocket sew around	301 SSa-1	70	.857	N
63.	Open welt seam	---	140	.429	N
64.	Pocket press	---	50	1.200	N
65.	Baste canvas or fuse front	--- 301 SSa-1	30 20	2.000 3.000	N N
66.	Baste bridle	101 SSa-1	130	.462	N
67.	Pad lapels	103 OSa-1	20	3.000	N
68.	Trim canvas	301 SSa-1	40	1.500	N
69.	Press front	---	60	1.000	N
70.	First baste facing	301 SSa-1	70	.857	N
71.	Sew edge tape	301 SSa-1	20	3.000	N
72.	Fell edge tape	103 LSa-1	50	1.200	N
73.	Flat press	---	70	.857	N
74.	Turn coat	---	110	.545	N
75.	Edge baste front	101 SSe-2	20	3.000	N
76.	Second baste facing	301 SSa-1	70	.857	N
	Assembly Operations				
77.	Front & back pair	---	100	.600	N
78.	Facing tack	103 SSa-1	100	.600	N
79.	Side seam	301 SSa-1	50	1.200	N
80.	Tape back armhole	301 SSaa-1	100	.600	N
81.	Side seam press	---	100	.600	N
82.	Bottom bind	301 BSb-1	60	1.000	N
83.	Bottom baste	101 BSa-1	100	.600	N
84.	Bottom fell	314 EFm-1	70	.857	N
85.	Baste lining	301 SSa-1	20	3.000	N
86.	Lining fell	313 LSd-1 (Mod)	50	1.200	N

SEQUENCE OF OPERATIONS FOR MEN'S SUIT COAT (Cont.)

NO. OF OPERATION	DESCRIPTION OF OPERATION	STITCH & SEAM TYPE	EST. DOZ PER HOUR	SAM/UNIT	POTENTIAL APPLICATION
	Assembly Operations				
87.	Gorge trim	---	50	1.200	N
88.	Shoulder pad baste	301 SSa-1	100	.600	N
89.	Join shoulder seams	301 SSa-1	50	1.200	N
90.	Shoulder seam press	---	100	.600	N
91.	Tack front gorge	301 SSa-1	60	1.000	N
92.	Join shoulder lining	301 SSa-1	40	1.500	N
93.	Baste shoulder & neck	301 SSa-1	60	1.000	N
94.	Collar pair	---	140	.429	N
95.	Sew collar at gorge	301 SSa-1	100	.600	N
96.	Gorge baste & tack	301 SSa-1	60	1.000	N
97.	Collar corner tack	---	40	1.500	N
98.	Fell lining corners	---	20	3.000	N
99.	Tack vents	---	20	3.000	N
100.	Baste top & undercollar	301 SSa-1	70	.857	N
101.	Fell top collar	---	40	1.500	N
102.	Press edges	---	70	.857	N
103.	Fell under collar	---	40	1.500	N
104.	Match sleeves	---	60	1.000	N
105.	Sleeve sew		20	3.000	N
106.	Press armholes	---	50	1.200	N
107.	Front armholes baste	301 SSa-1	70	.857	N
108.	Armhole tack	301 SSa-1	60	1.000	N
109.	Trim armhole, sew in sleeve head	301 SSa-1	40	1.500	N
110.	Fell sleeve lining at shoulder	---	5	12.000	N
111.	Close out sleeve lining	---	10	6.000	N
112.	Clear & Inspect	---	10	6.000	N
113.	Buttonhole	---	5	12.000	N
114.	Finishing pressing	---	5	12.000	N
115.	Sew button sleeve & front	---	10	6.000	N
		Total SAM/UNIT		180.409	

Total SAM/UNIT of Potential Applications = 12.062

% Application = 7%