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DLA-ARN SHORT-TERM PROJECT REPORT

Evaluate and Implement Special Measurement System Using Gerber Garment Technology's MTM Software

DDFG-T1-P5 Phase 0

Contract Number	SPO 10095-D-1044
Contractor	Haas Tailoring Company
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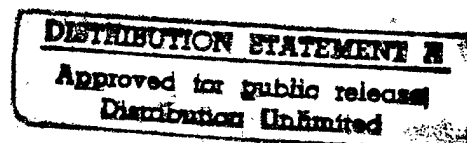


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1. Introduction

The DDFG-T1P5 Phase 0 Short Term Project conducted by Haas Tailoring Company evaluated the Gerber made-to-measure software system to determine if it is capable of producing special measure military uniforms. The evaluation consisted of training for the Haas electronic pattern design staff (CAD Operators), installation of the Gerber system, and three months of actual use of the system on special measure military orders. The objective of the evaluation was to determine if the Gerber system provided the necessary capabilities for a special measure Defense Apparel Manufacturer to produce custom uniform patterns in a timely manner. If we identified deficiencies, we were to provide suggestions on overcoming these deficiencies.

An additional section of this report details the distribution of Air Force special measurement orders received by Haas Tailoring over the duration of this project. We used a subset of these orders as part of the evaluation of the Gerber system.

The Gerber made-to-measure software program is a pre-processor-like program for the main Gerber pattern definition and generation system known as AccuMark. The primary features of the made-to-measure system are that it:

- Provides an order entry form for made-to-measure or production orders.
- Uses rules and measurements which are specified and defined by each individual user.
- Converts order information into AccuMark order and size code tables.
- Can use a batch processing module to process generated orders immediately or store submitted orders for processing at a later time.
- Can generate markers, cut, and/or plot data.

2. MTM Software Evaluation Criteria

During the use of the system, Haas will keep a record log for each order, document whether the order was processed with no problem, some difficulty or great difficulty. We will keep track of all specific problems and at the end of the four-month evaluation, write a detailed report on our findings. The details of the report will encompass the evaluation criteria of the DDFG-T1-P5 task plan that includes:

1. System set-up and administration
2. Ease of implementation
3. Robustness of alteration set
4. Measurement validation and correlation
5. Automatic alteration
6. System openness
7. Applicability to DPSC's mission
8. Speed and accuracy
9. Compatibility to cutting systems

In addition, all garments from the three-month database which were processed with some difficulty or great difficulty will be analyzed. The deficiencies will be identified through garment blue penciling and marker making.

3. MTM Software Evaluation Procedures

The garments used during the evaluation were the U.S. Air Force-Men's Coat, U.S. Air Force- Woman's Coat, and U.S. Air Force-Woman's slacks and skirt. The orders used in the evaluation (approximately 30 orders) were special measurement orders received by Haas Tailoring Company for the above-mentioned garments from September 1 through December 31, 1996.

The orders were "blue penciled" (identification of alterations required to create a custom pattern from the recruit's measurements and posture data) using the Haas Tailoring expert system. This list of required alterations was provided to a CAD operator who interactively selected the appropriate base pattern, selected and applied the specified alteration in the specified amount, and submitted the custom pattern to the marker making operation.

Each special measure order received during the evaluation period was assessed to determine if the diverse set of alterations called for by Blue Pencil could be performed by the Gerber system or if the order should be processed by our internal pattern creation system.

4. MTM Software Evaluation Results

CRITERA	RESULT
System set-up and administration	Pass
Ease of implementation	Pass
Robustness of alteration set	Pass
Measurement validation and correlation	Inconclusive
Automatic alteration	Pass
System openness	Inconclusive
Applicability to DPSC's mission	Inconclusive
Speed and accuracy	Pass
Compatibility to cutting systems	Pass

4.1 System Set-up Process

A Gerber made-to-measure system, leased by Haas Tailoring from Gerber Garment specifically for the Phase 0 project, was installed and setup by Haas computer-aided design (CAD) personnel. The system was installed in early September 1996. Although scheduled for training in September, Gerber postponed the training class until mid-November.

In general, setting up the made-to-measure system required that we create and establish:

- Source files for selecting AccuMark models, pieces, libraries, and parameter tables.
- Base measurement tables
- Garment types, including measurements, models, base files, alterations, order options, and sub-options.
- Rules (based on user-defined conditions) to be used to convert made-to-measure orders into AccuMark markers and side code tables.

- Preferences for the default batch processing parameter table and AccuMark storage areas, libraries, and parameter tables.

In order to evaluate the system we had to a) load the patterns being considered, b) define and create a universe of possible alterations, and, where possible, c) set up measurement validation procedures within the system. The garments used during the evaluation were the U.S. Air Force-Men's Coat, U.S. Air Force- Woman's Coat, and U.S. Air Force-Woman's Slacks and Skirt. The original patterns for these garments were supplied by DPSC and imported into the Gerber system by Haas.

4.2 Ease of Implementation

Haas Tailoring Company's Computer-Aided Design (CAD) staff have worked with a variety of apparel design and pattern generation systems over the past 15 years. The systems used by this CAD staff have included Gerber's AM and AccuMark series of products and internally developed design systems. The implementation of the Gerber made-to-measure system was straightforward and was accomplished without significant problem. Based upon our prior experience, we set the system up and began using it prior to the formal training class. We recommend that unless one has significant experience with CAD tools they should wait until they have attended the Gerber training course before they begin using the system. Additional prerequisites for working with the Gerber made-to-measure software was a working knowledge of Windows 95, and the Gerber AccuMark software for windows.

4.3 Robustness of Alteration Set

To complete the Phase 0 project within the four month time-frame, we created a subset of possible alterations that could be required by a given order. For example, there are approximately 60 points of alteration for a man's dress uniform jacket. These points of alteration result in over 680 alteration rules for a man's dress uniform jacket.

We created approximately 20 of the more complicated rules based upon a random sample of the special measure orders we received to see if the system could handle the complex conditions. These alteration rules discussed in Section 5 were extracted from our internal expert system and pattern creation engine and reformatted (re-parameterized) to be used by the Gerber system. Setting up a subset of alteration rules for each garment took approximately six weeks.

The alteration set supported by the Gerber system could adequately handle all of the alterations required to create a dress uniform jacket. Because it could handle the difficult alterations, we concluded it can handle simple ones.

4.4 Measurement Validation and Correlation

We setup a subset of measurement validation rules/conditions. This aspect of the system was lacking in capability. Before an order is processed and a custom pattern created, a special measure manufacturer wants to have a high confidence that the alterations selected and the amounts being specified are reasonable. To determine reasonableness, the systems should be able to perform a "cross-measurement" comparison and evaluation. For example, validating the chest measurement with weight or pant inseam with height. The Gerber system could perform "range checks" for single measurements, but could not assess the measurements in combination. For this reason, all orders being processed were first run through our internal Blue Pencil program which does a reasonableness check of the measurements in combination prior to accepting the measurement set as valid data.

The Gerber system had very little support for measurement validation and correlation. The system could adequately validate individual measurements against acceptable ranges of values, but there is no provision for cross measurement comparisons [i.e., the alteration rules do not provide for compound rule subjects]). This lack of cross validation left open the possibility of creating grossly mis-proportioned

patterns and the system indicating a successful completion. Essentially, the Gerber system will do exactly what it is told without questioning the combination of measurements. In the production world, measurements and body specifications are validated at each step where they may change or affect the current process step.

4.5 Automatic Alteration

The question being pursued was, "Can the Gerber system automatically alter base patterns based upon a given set of customer's measurements and posture descriptions?" We found that the Gerber system could perform automatic alterations under a specific set of conditions. For example, the software could automatically handle coat length, coat point to point, coat sleeve length, pant inseam, pant rise, pant waist, skirt waist and length with little difficulty. There needed to be a front end program that analyzed and validated the combined measurement/posture set. In addition, a great deal of effort had to be focused on setting up a valid set of alteration rules. To make it truly automatic and an integral part of the special measurement pattern generation system, the batch processing aspects of the system have to be integrated into the information and data flow. Since the system is open, as discussed in Section 4.6, this task could be accomplished with appropriate expertise in the area of software design and development. Programs and/or trigger events need to be written to queue orders for processing and to queue the results of processing an order for the next step – marker making. This task would not be difficult if adequate in-house expertise in the area of systems integration were available. Haas Tailoring Company has done this type of development with existing software systems, and believes it could be done with the Gerber MTM System.

4.6 System Openness

DPSC stores and maintains its patterns on a Microdynamics Micromark system. The underlying Gerber AccuMark software was able to directly import this pattern format

into its pattern/model database for use by the made-to-measure pre-processor. In addition, it supports the import of the industry de facto standard DXF format.

The made-to-measure system uses Microsoft Access as its underlying database management system. If one was so inclined, one could write alteration rule import and export software utilities to automatically populate and analyze the alteration rule set.

Their internal file formats are proprietary to Gerber, but, under non-disclosure, some of their formats are obtainable.

The software uses standard, off-the-shelf Intel/Microsoft-based computers, e.g., there are no special hardware requirements.

The MTM system can only be used with Gerber's Accumark grading and marking system. A company owning another vendor's marking and grading system could not utilize the MTM software.

4.7 Applicability to DPSC's Mission

It is our opinion that if fully implemented (all alteration rules created for each garment type for each service branch) with a front-end measurement validation system, the Gerber made-to-measure system can handle the special measurement pattern design and creation needs of DPSC. It can handle the limited diversity of patterns and alterations that exist for military uniforms. If fully implemented, the Gerber made-to-measure/AccuMark system should allow DPSC and Defense Apparel Manufacturers to create a better garment, in a shorter time frame at a less cost.

4.8 Speed and Accuracy

Hosted on a Windows95-based 133 mhz. Pentium processor with 32MB of memory and a significant amount of hard disk space, the system performed without

pause or delay. We compared the resulting patterns from the Gerber made-to-measure system with patterns generated via our own internal system and there was no significant difference.

4.9 Compatibility with Cutting Systems

As a pre-processor for the AccuMark system, Gerber's made-to-measure system does not directly drive cutting systems. The AccuMark system is the marker making, plotter driver, and cutter driver software. It supports driving every CNC cutter that Gerber manufactures as well as other vendor's cutters. Essentially, the AccuMark system can create industry standard cut data files that can be used by numerous cutting systems.

5. Special Measurement Order Evaluation

5.1 A/F Special Measurement Order Breakdown

The following table represents the breakdown of Air Force special measurement orders received by Haas Tailoring Company from September 1, 1996 through December 31, 1996. The sample size was 335 special measurement orders. A select subset of these orders were used during the evaluation of the Gerber made-to-measure system. Note: This order breakdown does not include the volume of orders received under the special measurement "Blank" program between Haas Tailoring Company and Lackland AFB. Including the Lackland program would have significantly skewed the table under the Enlisted column.

AIR FORCE SPECIAL MEASUREMENT ORDER BREAKDOWN

GARMENT	JROTC	ROTC	NEW RECRUITS
MALE COAT	5%	0%	95%
MALE TROUSER	24%	2%	74%
FEMALE COAT	41%	0%	59%
FEMALE SLACK	70%	0%	30%
FEMALE SKIRT	24%	16%	60%

5.2 Special Measurement Order Log

We maintained a detailed written log of the special measurement orders received during the evaluation period (September 1, 1996 through December 31, 1996). This log is quite voluminous; therefore, the entire log is not included with this report. Copies of this log are available upon request.

Orders were processed in the following manner.

1. Orders were received from DPSC on 358(male) or 1111(female) special measurement forms.
2. Orders were transposed to Haas Tailoring Company's internal male and female order forms.
3. Orders were checked for completeness and accuracy. If there was a problem, a phone call to DPSC's S/M or design department was made to correct the problem.
4. Orders were manually "blue-penciled" for pattern selection and alteration set definition.
5. Orders were entered into the Gerber MTM system. If a MTM rule was not present in the system, a new MTM rule was created to handle the order.
6. Patterns were generated using Haas's manual methods as well as through the Gerber MTM system. Variations were made to the cut line and not the sew line. D.P.S.C. provided patterns do not include sew lines. We have made a recommendation to D.P.S.C. to include sew lines in patterns provided by their CAD department.
7. Patterns were then compared using each approach. If significant differences were apparent, the MTM rules were modified and correct to reflect the correct pattern.

8. Finished garments were measured and validated against original patterns. Coat measurements that were validated include chest(bust), waist, seat(hip), length, waist length, sleeve length, and point to point. Pant measurements that were validated include seat(hip, waist, inseam(length), rise, knee, bottom, and thigh. Skirt measurements that were validated include seat(hip), waist, and length.

5.3 Alteration Rules

The following sections describe alteration rules based upon garment type. Included are coat, trouser, slack, and skirt rules. The 500+ alteration rules utilized in this project are common rules of thumb in the apparel industry and should be available from any made-to-measure manufacturer. Therefore, listing of the 500+ alteration rules is beyond the scope of this report.

5.3.1 Coat

RULE	DESCRIPTION
Length Variance	Determines if regular, short, long, or extra-long pattern is to be used.
Length	Based upon the customer's jacket length, what is the alteration amount needed to be applied to the base pattern to achieve desired result.
Point To Point	Based upon the customer's point to point, what is the alteration amount needed to be applied to the base pattern to achieve desired measure.
Sleeve Length	Based upon the customer's sleeve length, what is the alteration amount needed to be applied to the base pattern to achieve desired measure.
Waist Length	Based upon the customer's waist length, what is the alteration amount needed to be applied to the base pattern to achieve desired measure.
Waist	Based upon the customer's waist measurement, what is the alteration amount needed to be applied to the base pattern to achieve desired measure.
Seat	Based upon the customer's seat measurement, what is the alteration amount needed to be applied to the base pattern to achieve desired measure.
Bicep	Based upon the customer's bicep measurement, what is the alteration amount needed to be applied to the base pattern to achieve desired measure.
Shoulder/Posture	Based upon customer's shoulder and posture descriptions, alterations are made to pattern with respect to neck, chest, back, shoulders, and seat descriptions.

5.3.2 Trouser/Slack

RULE	DESCRIPTION
Length Variance	Determines if regular, short, long, or extra-long pattern is to be used.
Outseam	Based upon the customer's outseam measurement, what is the alteration amount needed to be applied to the base pattern to achieve desired measure.
Inseam	Based upon the customer's inseam measurement, what is the alteration amount needed to be applied to the base pattern to achieve desired measure.
Waist	Based upon the customer's waist measurement, what is the alteration amount needed to be applied to the base pattern to achieve desired measure.
Thigh	Based upon the customer's thigh measurement, what is the alteration amount needed to be applied to the base pattern to achieve desired measure.

5.3.3 Skirt

RULE	DESCRIPTION
Length Variance	Determines if regular, short, long, or extra-long pattern is to be used.
Length	Based upon the customer's length measurement, what is the alteration amount needed to be applied to the base pattern to achieve desired measure.
Waist	Based upon the customer's waist measurement, what is the alteration amount needed to be applied to the base pattern to achieve desired measure.

5.4 Unusual Or Difficult Alteration Rules

During our evaluation period, there were not many instances of unusual or difficult alteration rules. Examples were with the Junior R.O.T.C. female coat orders. Many of these female cadets were extremely large and fell outside the tariff range of sizes. Coat patterns had to be graded far beyond the normal tariff to accommodate these orders. The same held true for the skirt and slack orders for the same population.

5.5 Points Of Alteration**5.5.1 Coat**

PATTERN	ALTERATION POINTS
Forepart	Short from regular Long from regular X-Long from regular Length Point to Point Waist at front edge Waist at sidebody seam Seat at sidebody seam Square shoulders Slope shoulder Open/Close for posture Full/Flat chest/bust Shoulder width Armhole
Sidebody	Short from regular Long from regular X-Long from regular Length Waist at forepart seam Waist at side seam Seat at forepart seam Seat at side seam Armhole
Facing(Lapel)	Short from regular Long from regular X-Long from regular Length Waist at front edge Open/Close for posture

Back	Short from regular Long from regular X-Long from regular Length Waist at side seam Waist at center seam Seat at side seam Seat at center seam Point to Point Square shoulders Slope shoulder Open/Close for posture Shoulder width Collar Blade
Sleeves	Short from regular Long from regular X-Long from regular Length Bicep

5.5.2 Trouser/Slack

PATTERN	ALTERATION POINTS
Front	Short from regular Long from regular X-Long from regular Length Knee Bottom Rise Waist at fly seam Waist at side seam Thigh Hip

Back	Short from regular Long from regular X-Long from regular Length Knee Bottom Rise Waist at center back seam Waist at side seam Thigh Hip
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5.5.3 Skirt

PATTERN	ALTERATION POINTS
Front	Length Waist at center seam Waist at side seam Seat(Hip) at side seam Center front length
Back	Length Waist at center seam Waist at side seam Seat(Hip) at side seam Center back length

6. Conclusion

As with all of the software evaluated in the DDFG-T1P5 Project, the Gerber made-to-measure system had its strengths and weaknesses. Our conclusion is that the Gerber system could be used as a production system that meets DPSC's requirements for creating special measure patterns.

There were deficiencies or shortcomings that require correction or adaptation to improve its efficiency and productivity. We recommend the following:

- a) A front end application that checked and validated the combination of measurements being requested (within the Gerber system individual measurements may be range tested, but there is no provision for cross measurement comparisons [i.e., the alteration rules do not provide for compound rule subjects]) is required to assure the proper patterns are generated.
- b) A complete set of alteration rules needs to be defined. For example, there are approximately 680 rules to be defined for a dress uniform jacket. In its evaluation Haas created approximately 20 of the more complicated rules to see if the system could handle the complex conditions. For a D.A.M. with CAD capabilities, it would take a great deal of in-house expertise in the area of pattern design as well as pattern "Blue Penciling" to define all the rules needed to produce special measurement uniforms. An alternate approach would be to analyze a comprehensive database similar to that of Haas Tailoring Company's historical data.
- c) The batch processing aspects of the system was integrated into the information and data flow. Programs and/or trigger events had to be written to

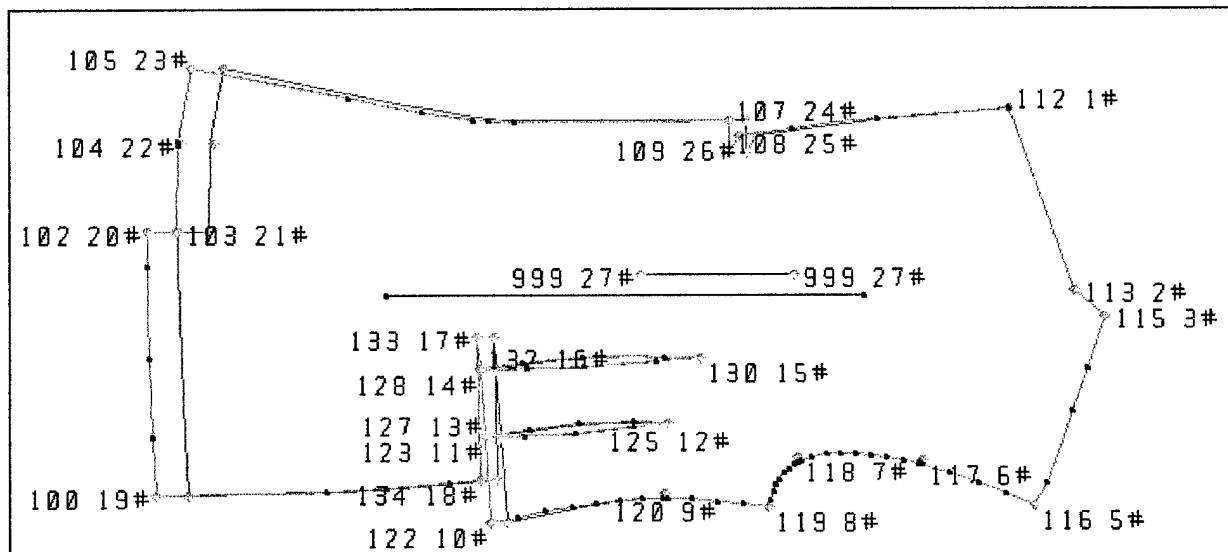
queue orders for processing and to queue the results of processing an order for the next step – marker making.

7. Appendix

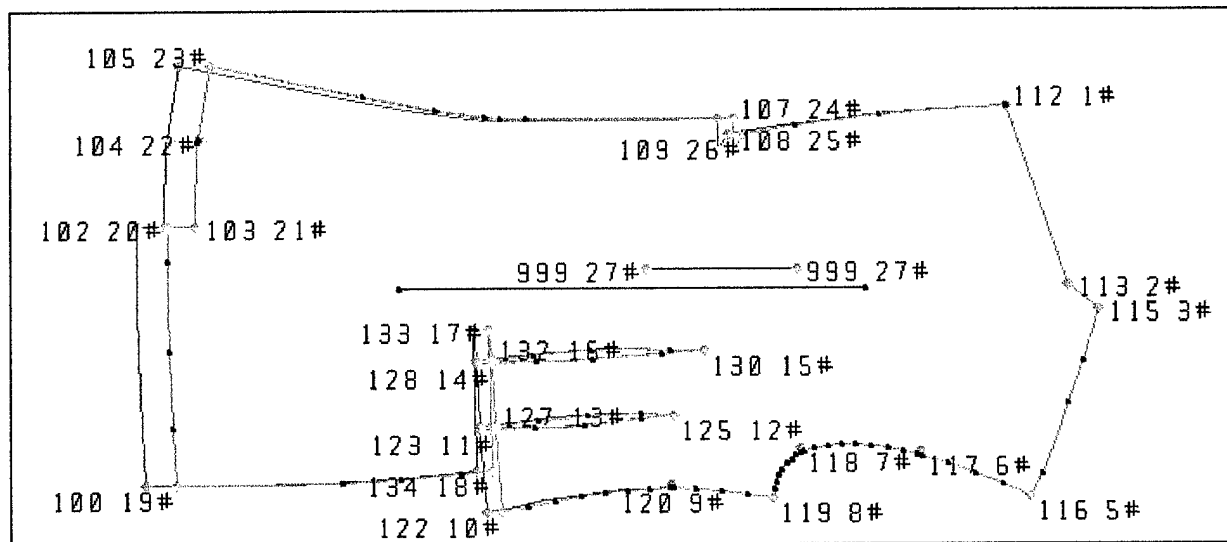
Graphics Legend: Grey Line - Base Pattern
Green Line - Altered Pattern
Black Number - Grade Point Number used for alteration movement
Purple Number - Grade Rule Number used for pattern grading table
Blue Line - Pattern Grain Line

7.1 Coat Alterations

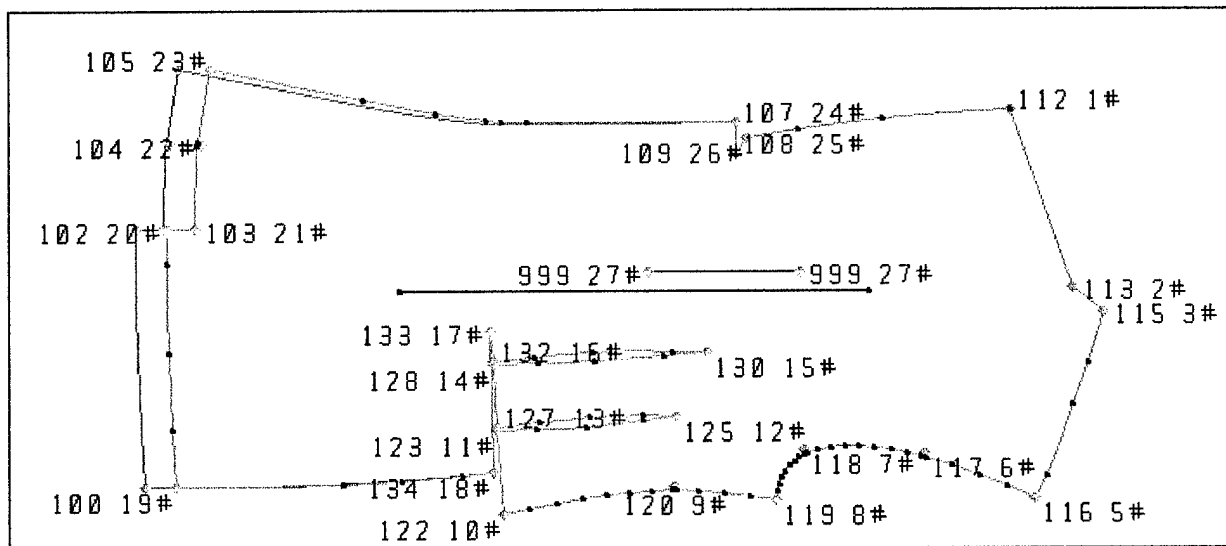
Forepart: Short From Regular



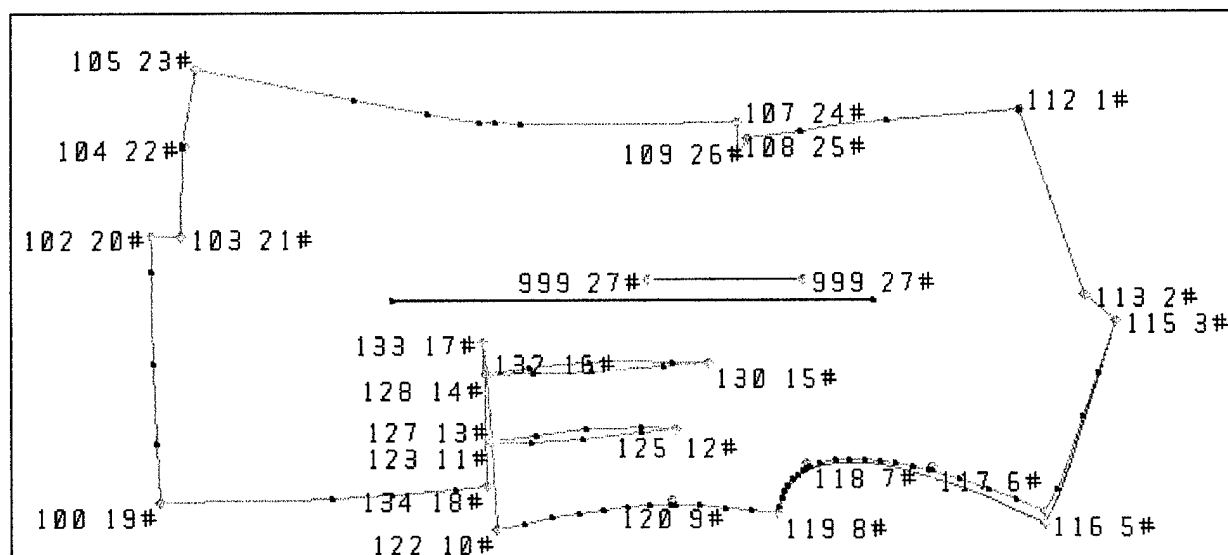
Forepart: Long From Regular



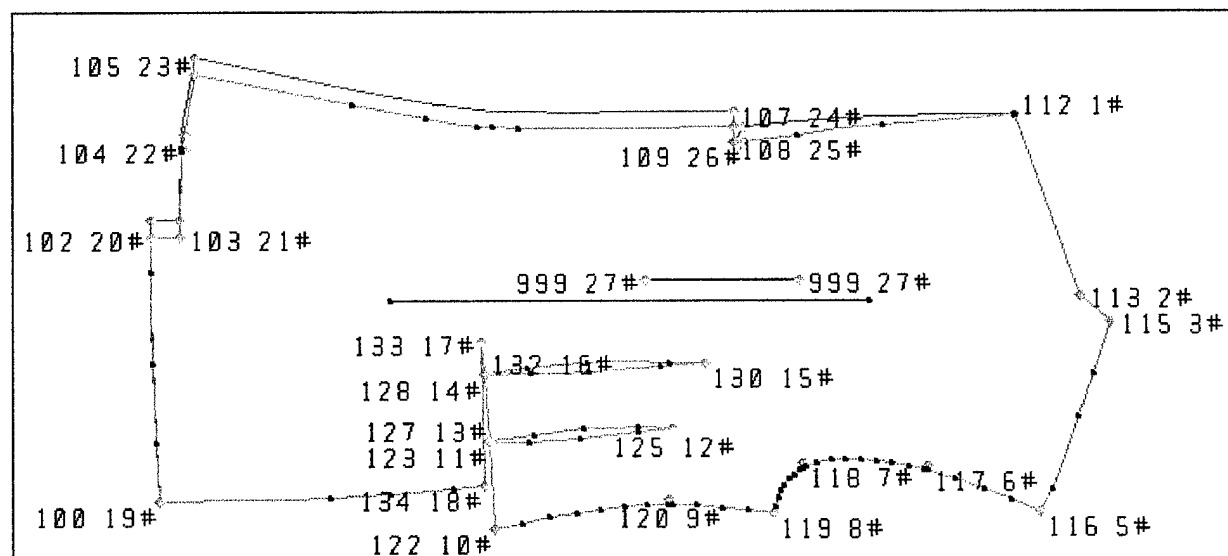
Forepart: Length



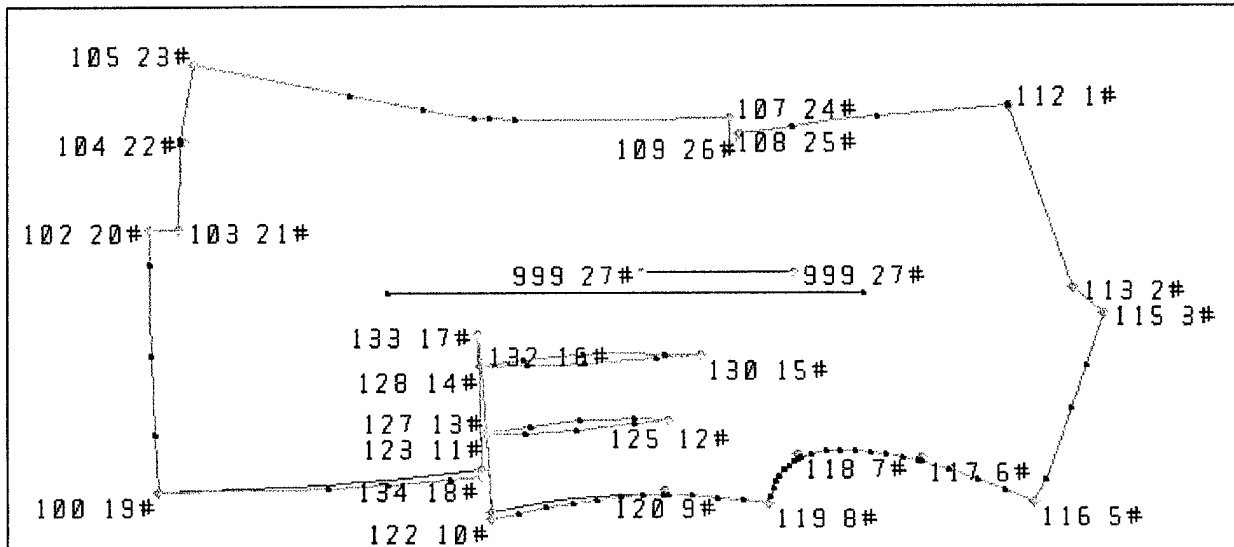
Forepart: Point To Point



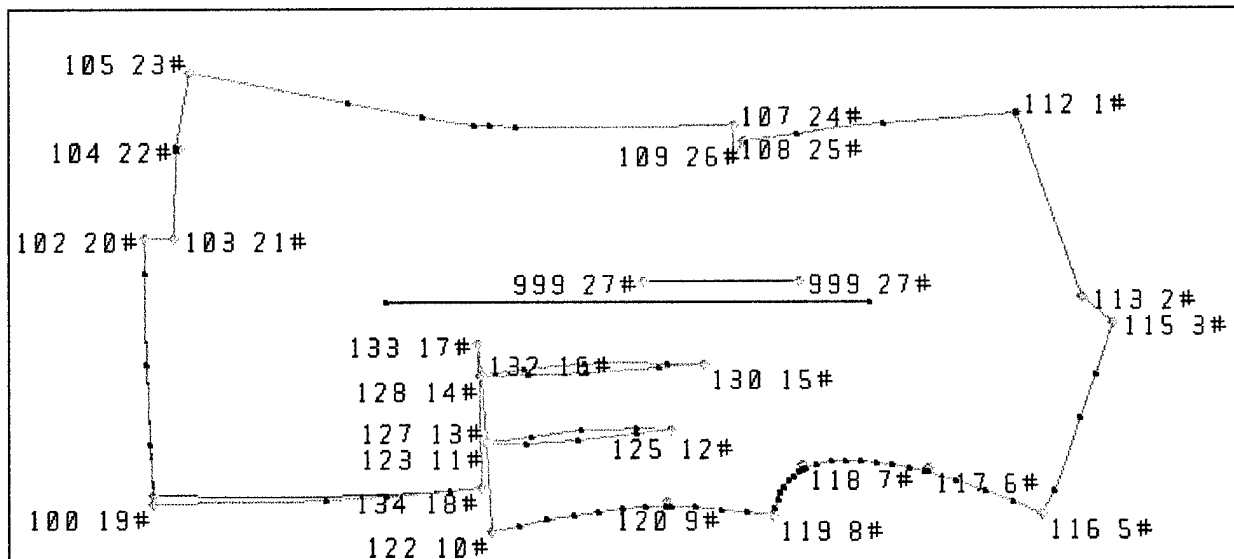
Forepart: Waist At Front Edge



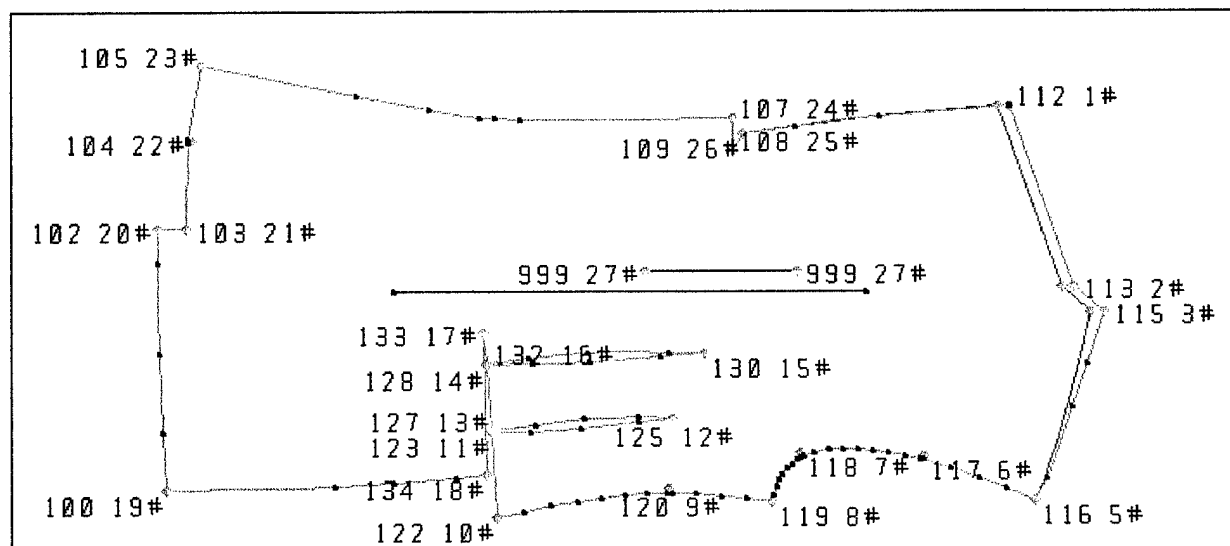
Forepart: Waist At Sidebody Seam



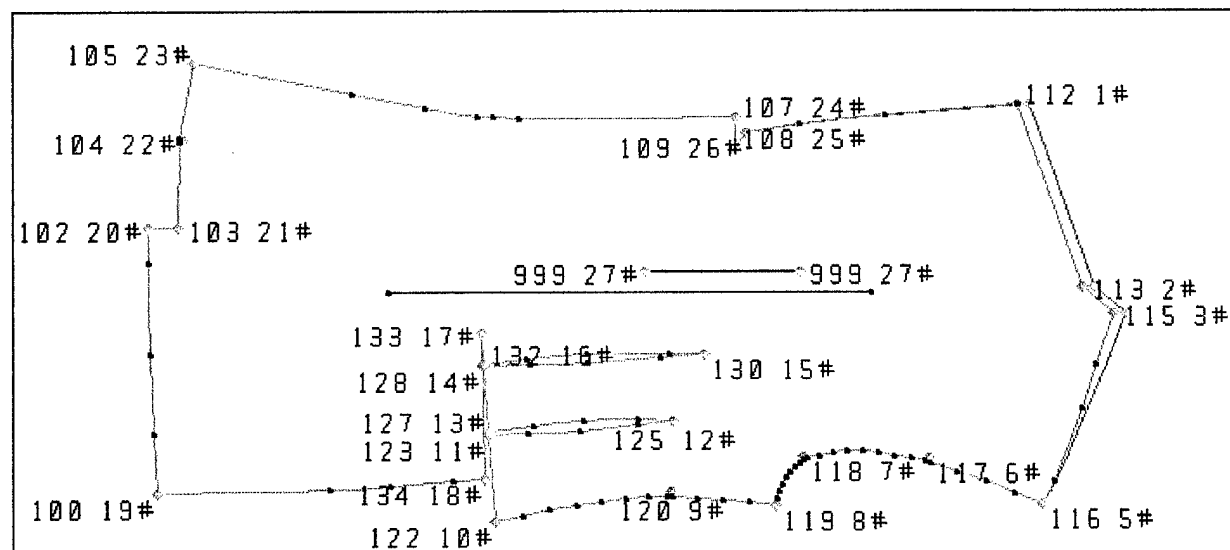
Forepart: Seat At Sidebody Seam



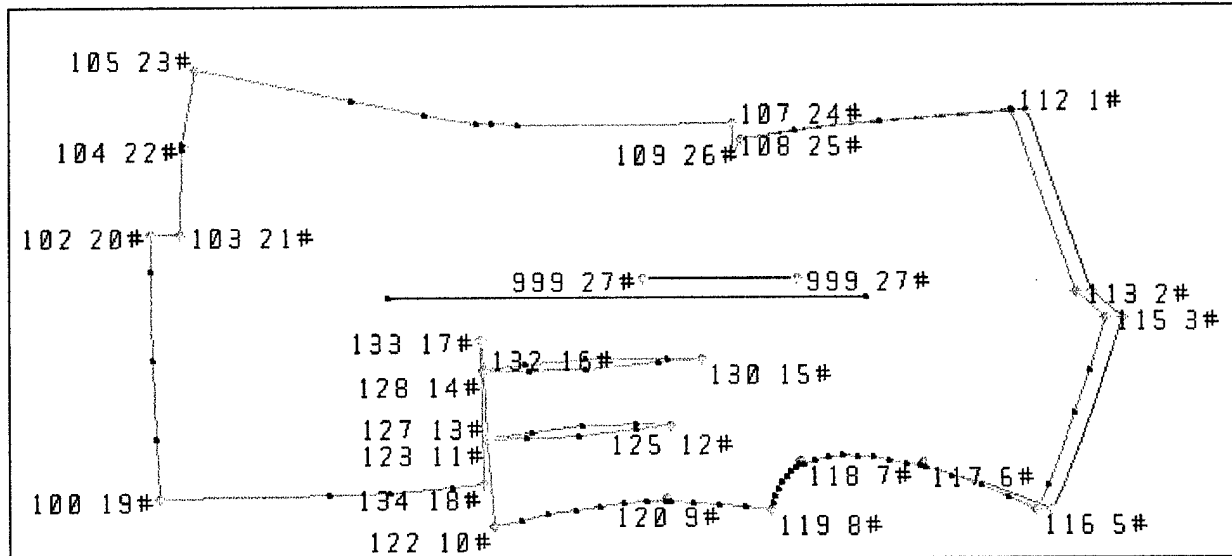
Forepart: Square Shoulders



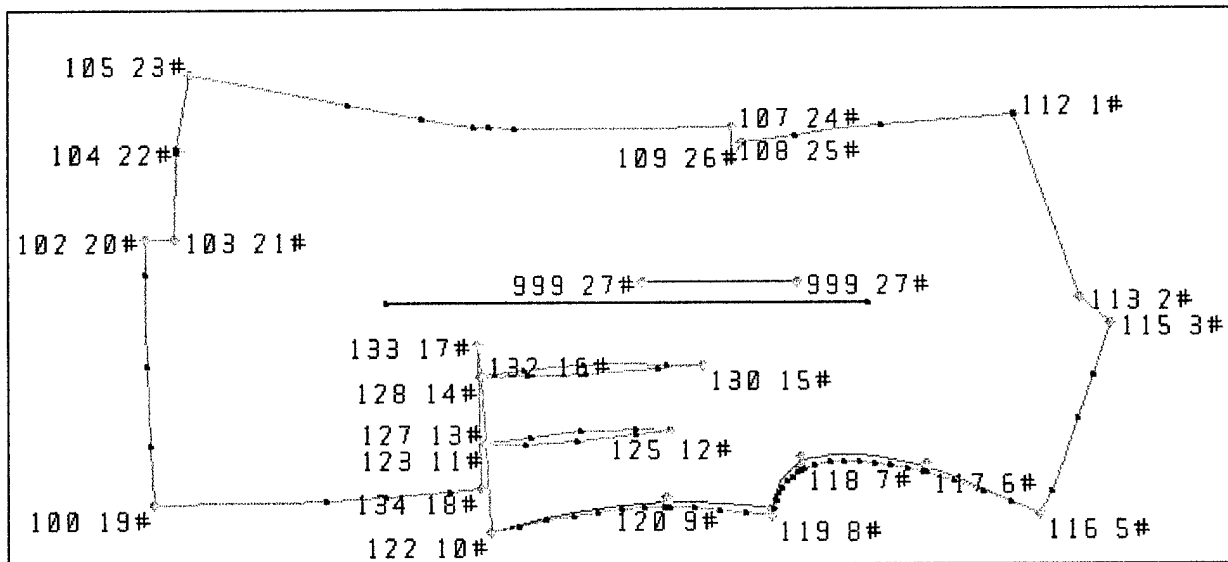
Forepart: Slope Shoulders



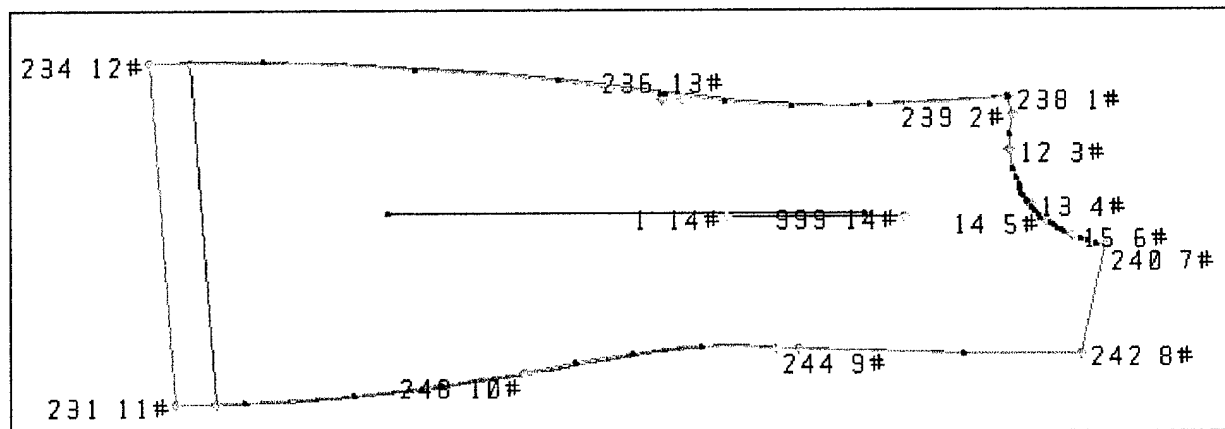
Forepart: Open/Close For Posture



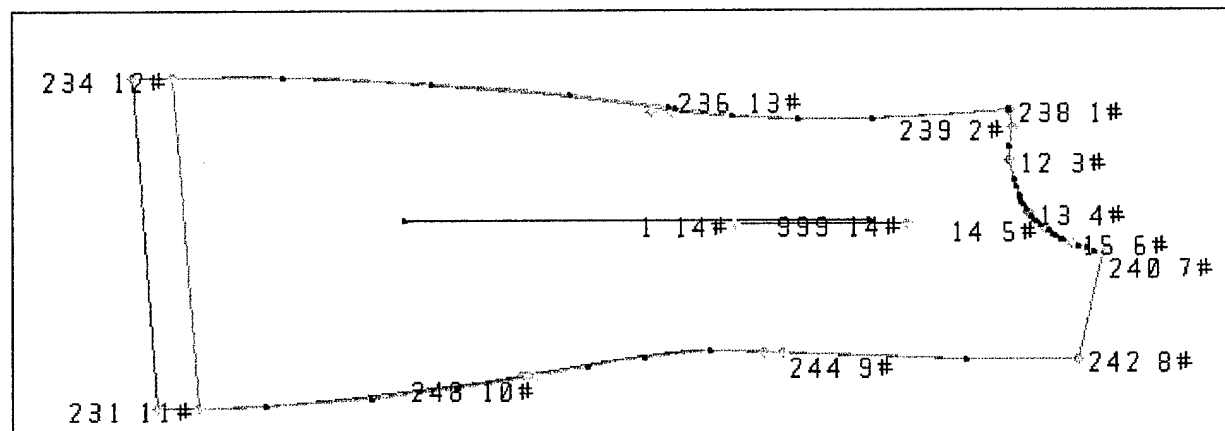
Forepart: Full/Flat Chest/Bust



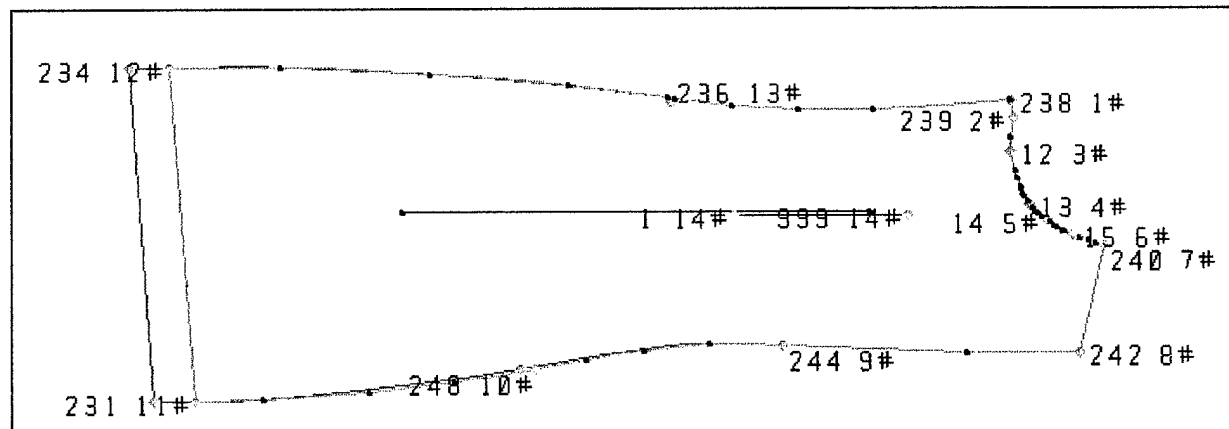
Sidebody: Short From Regular



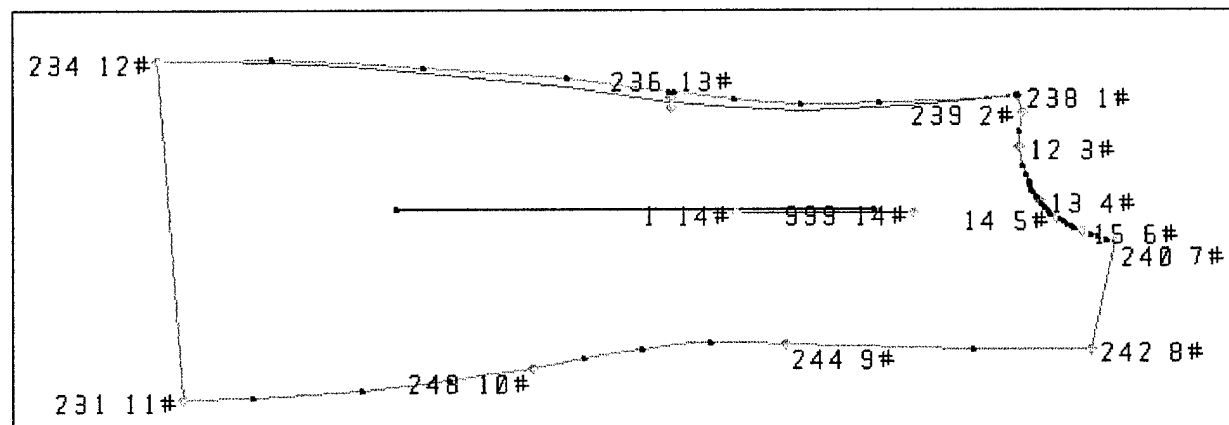
Sidebody: Long From Regular



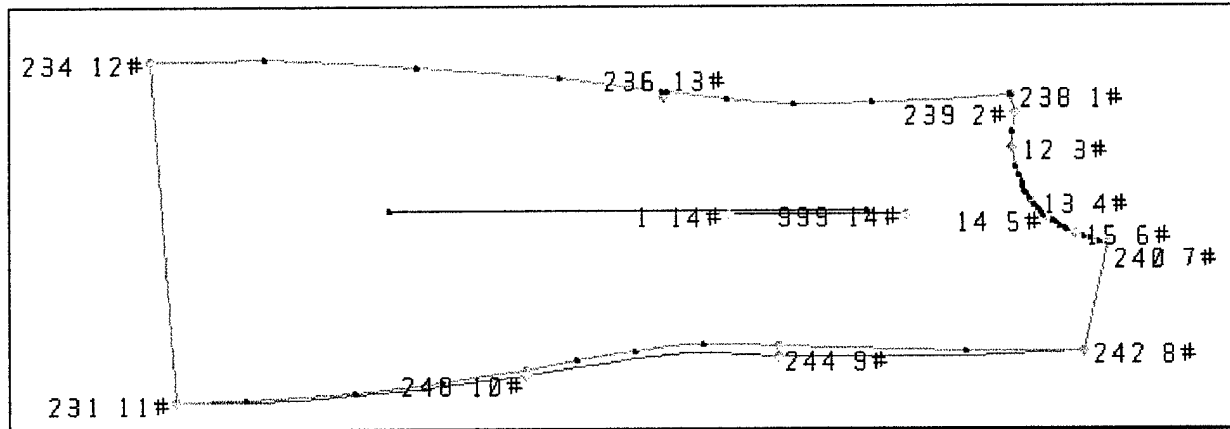
Sidebody: Length



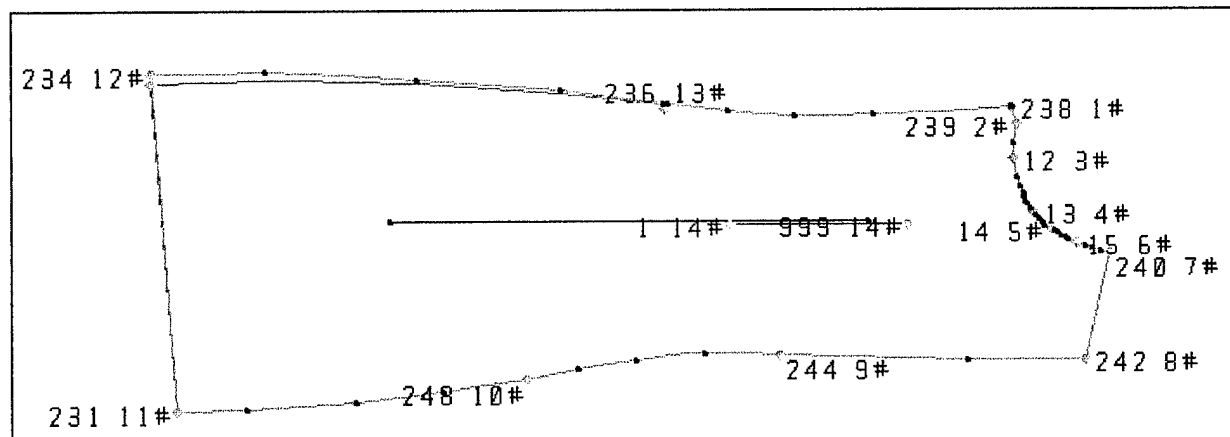
Sidebody: Waist At Forepart Seam



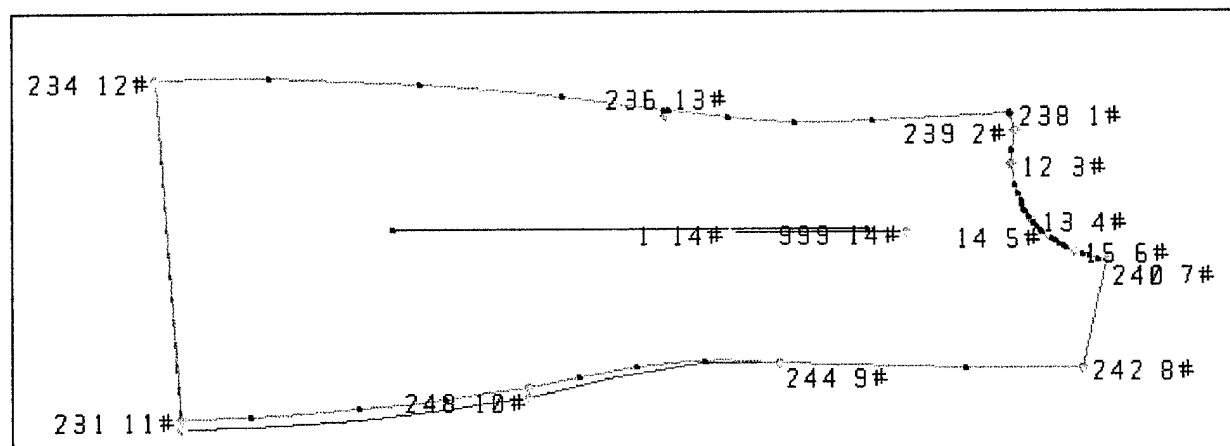
Sidebody: Waist At Side Seam



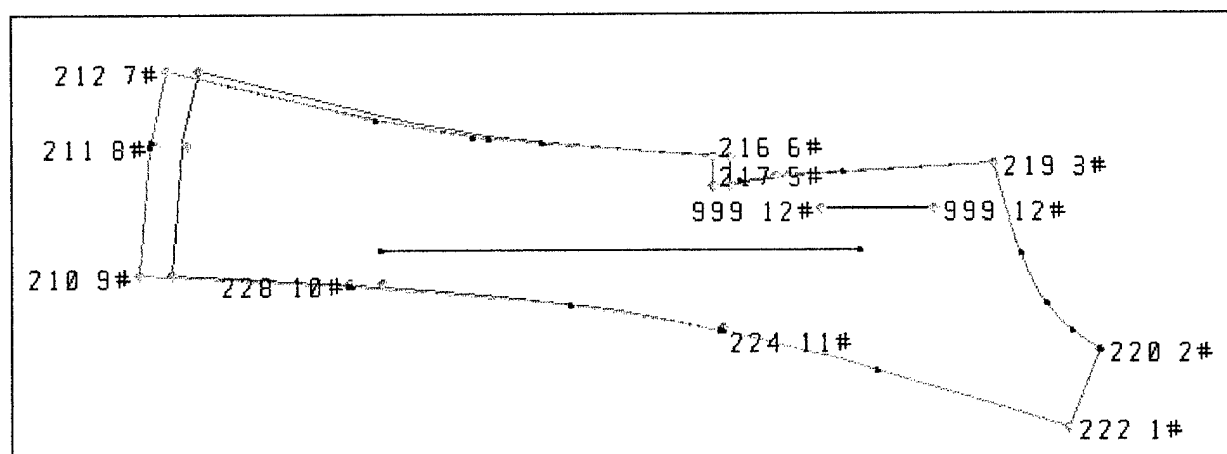
Sidebody: Seat At Forepart Seam



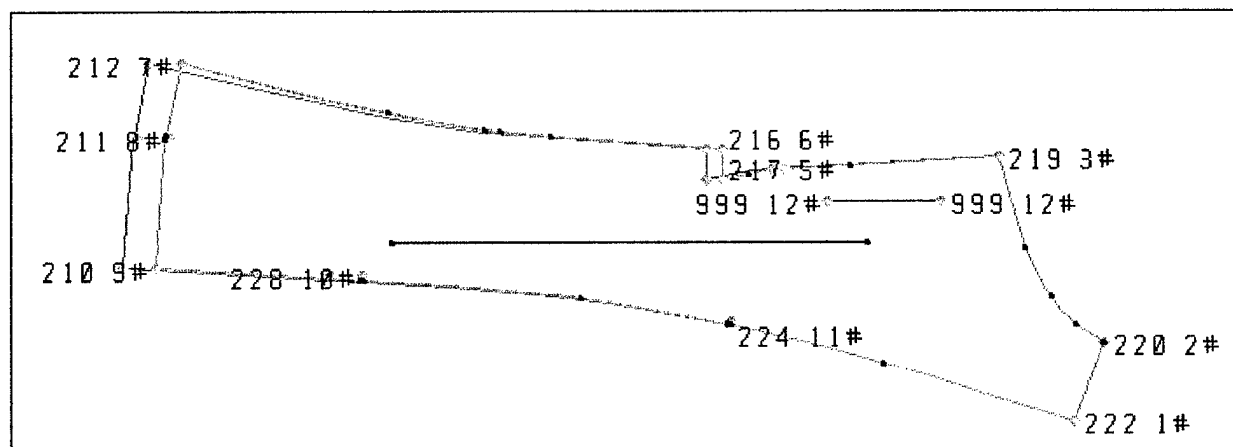
Sidebody: Seat At Side Seam



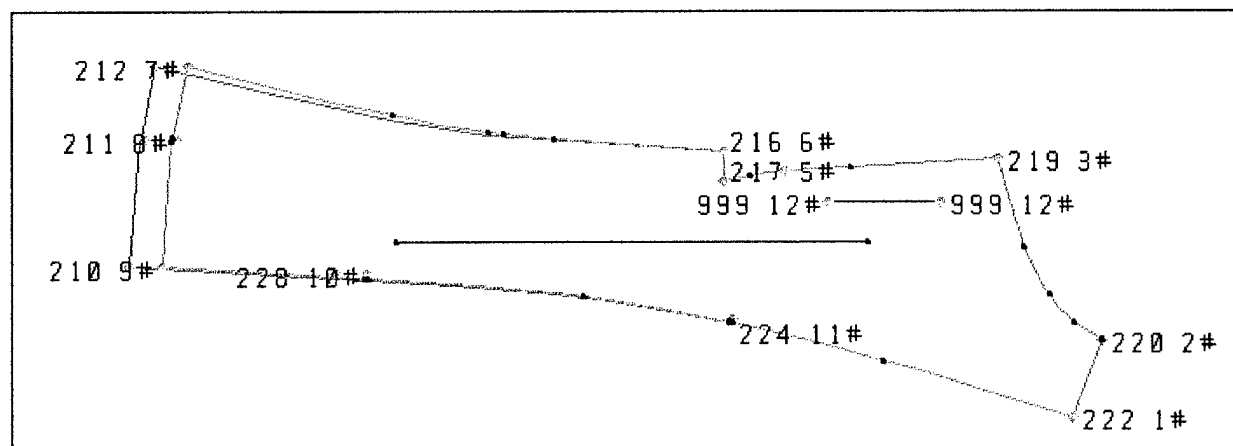
Facing: Short From Regular



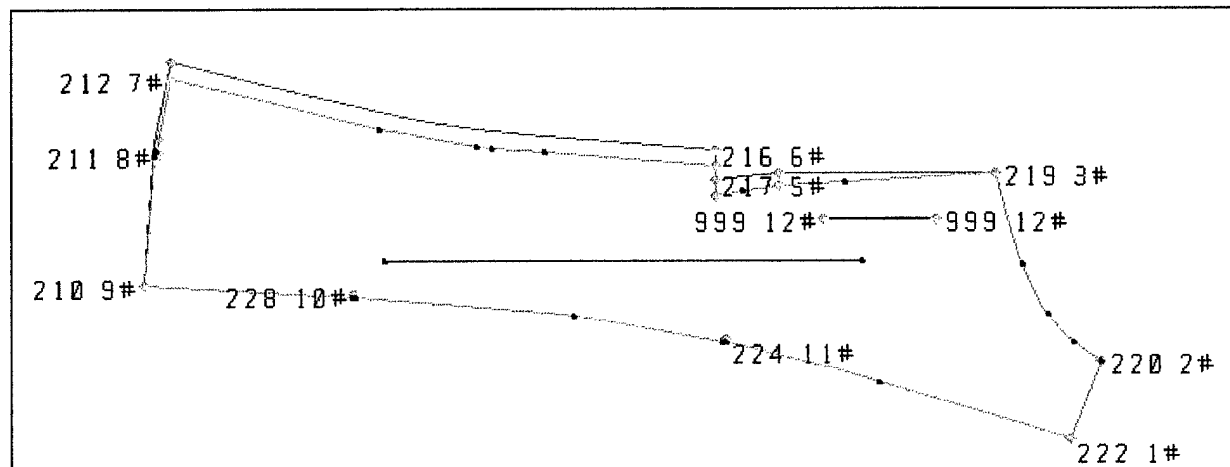
Facing: Long From Regular



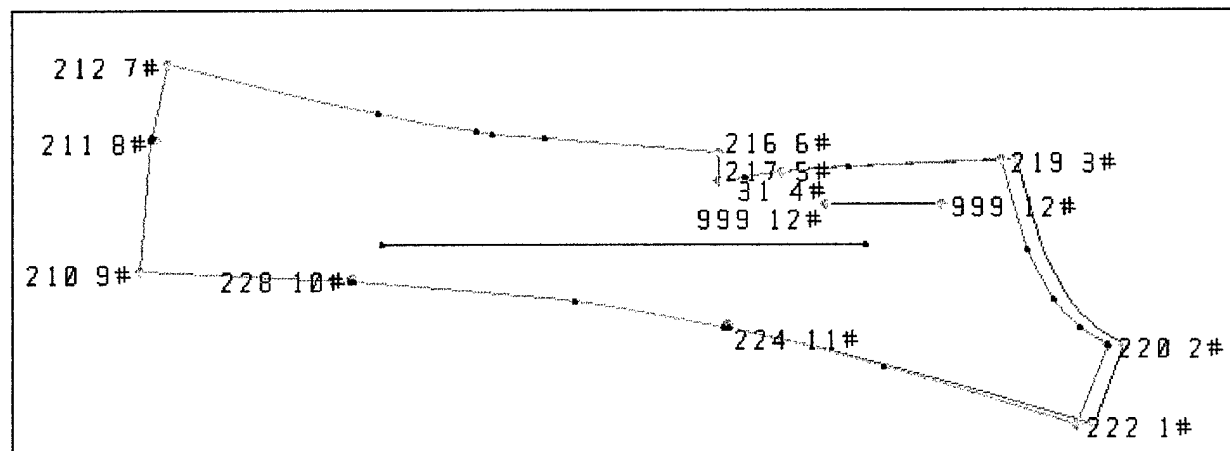
Facing: Length



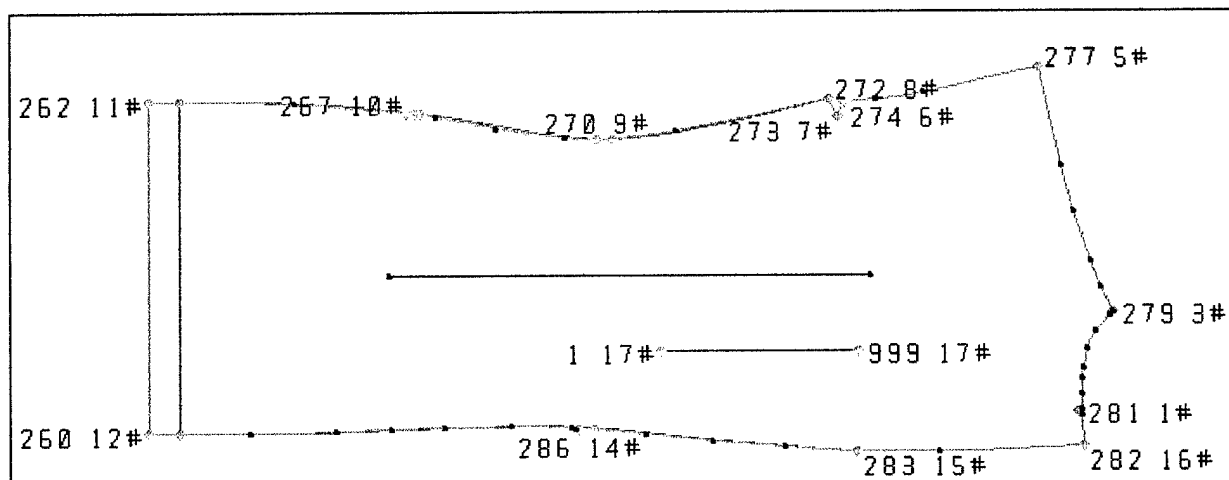
Facing: Waist At Front Edge



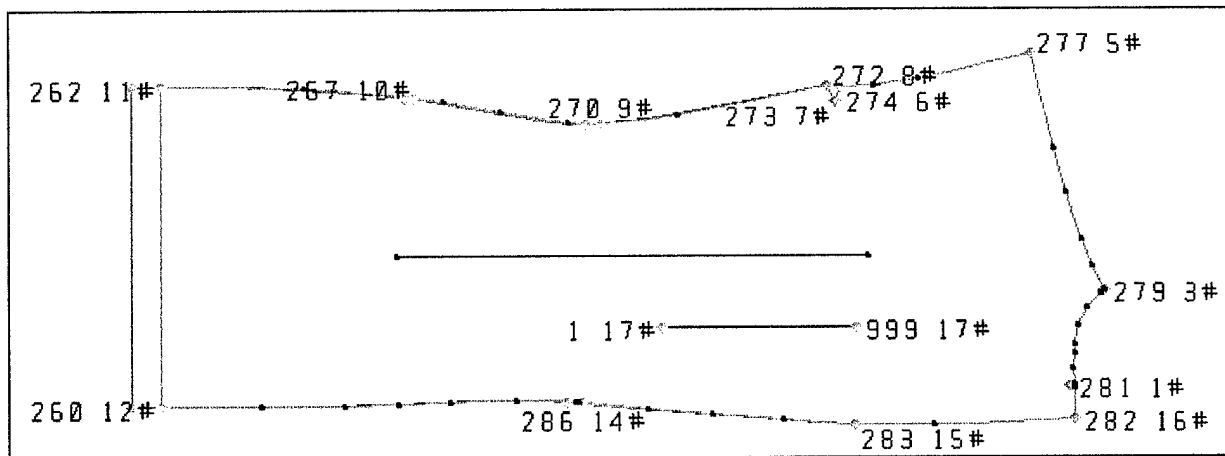
Facing: Open/Close For Posture



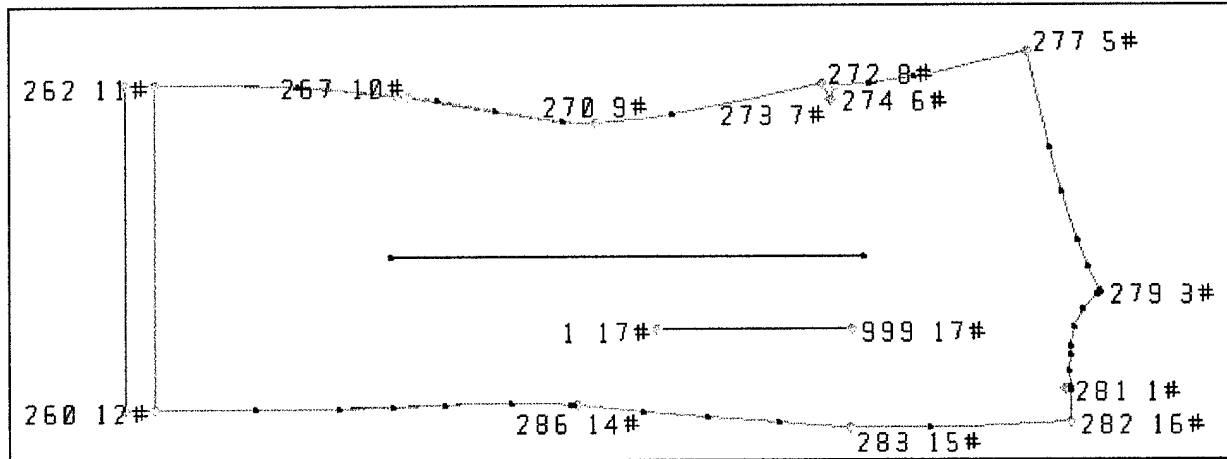
Back: Short From Regular



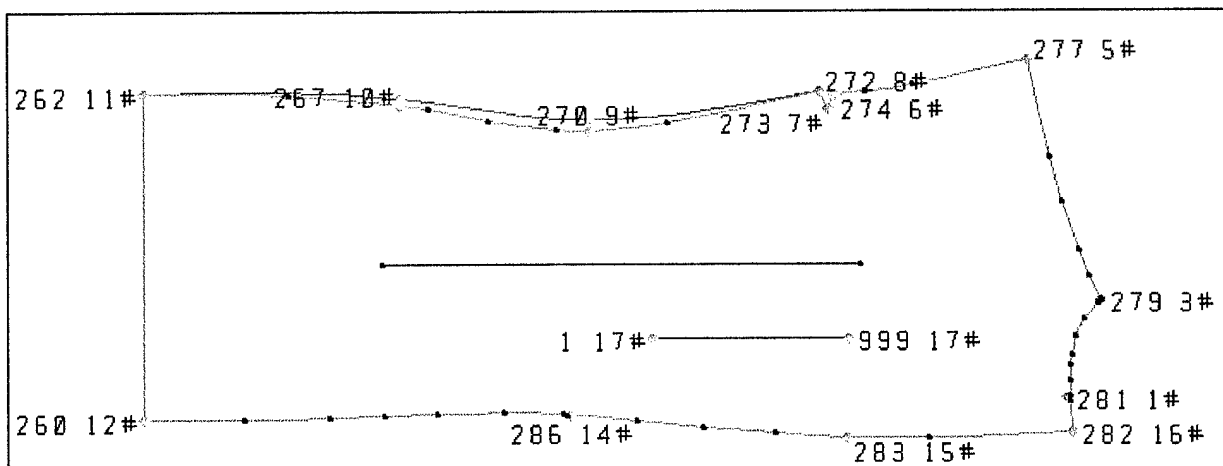
Back: Long From Regular



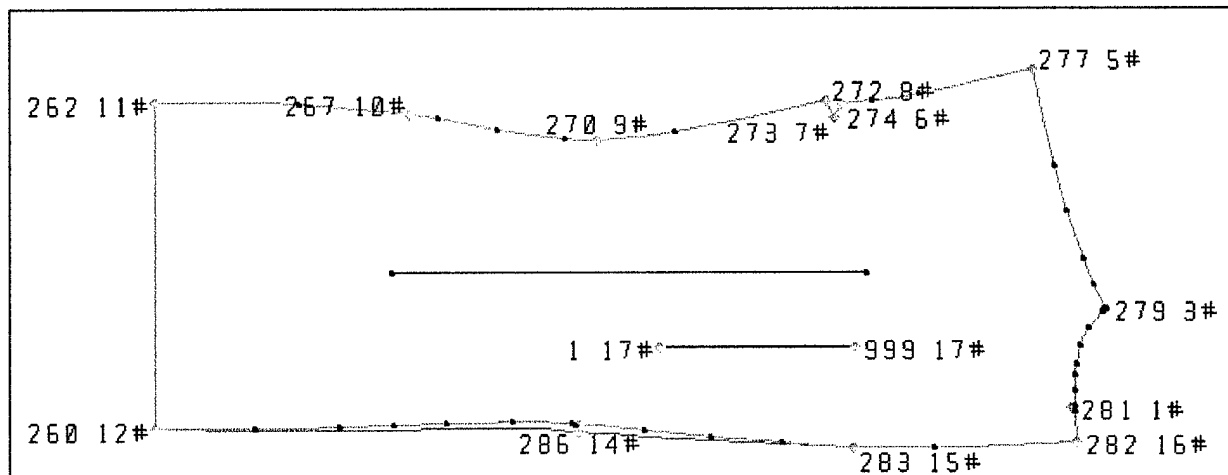
Back: Length



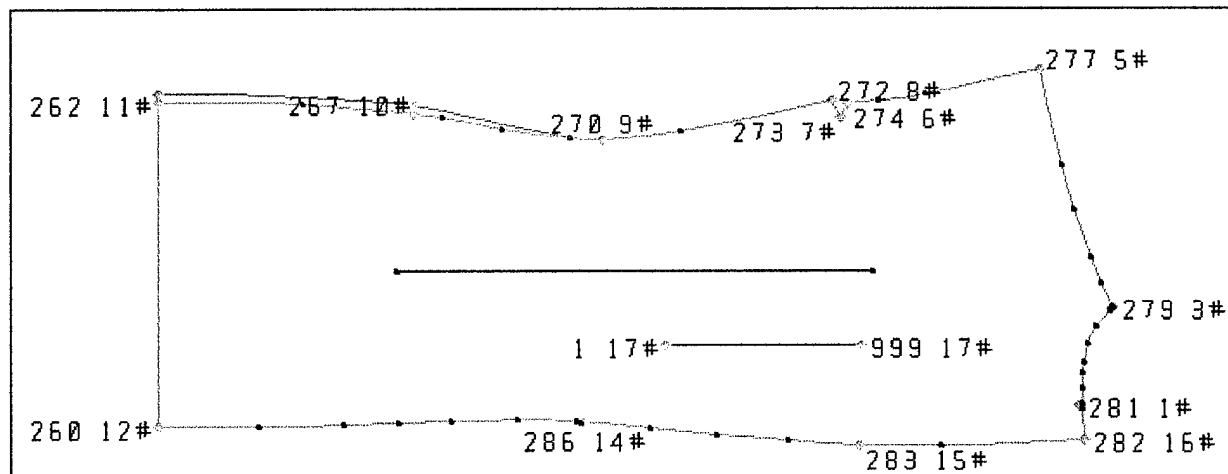
Back: Waist At Side Seam



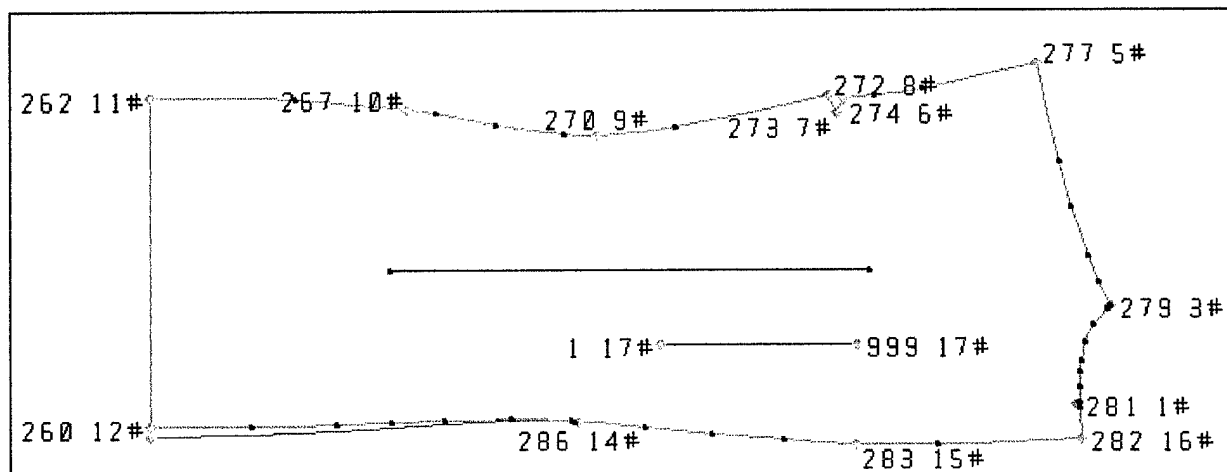
Back: Waist At Center Seam



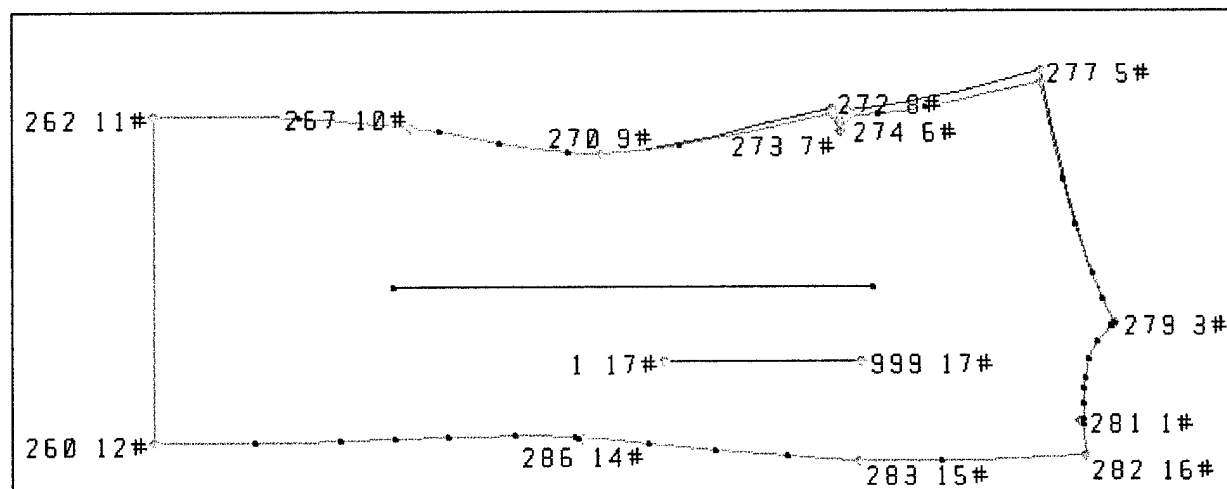
Back: Seat At Side Seam



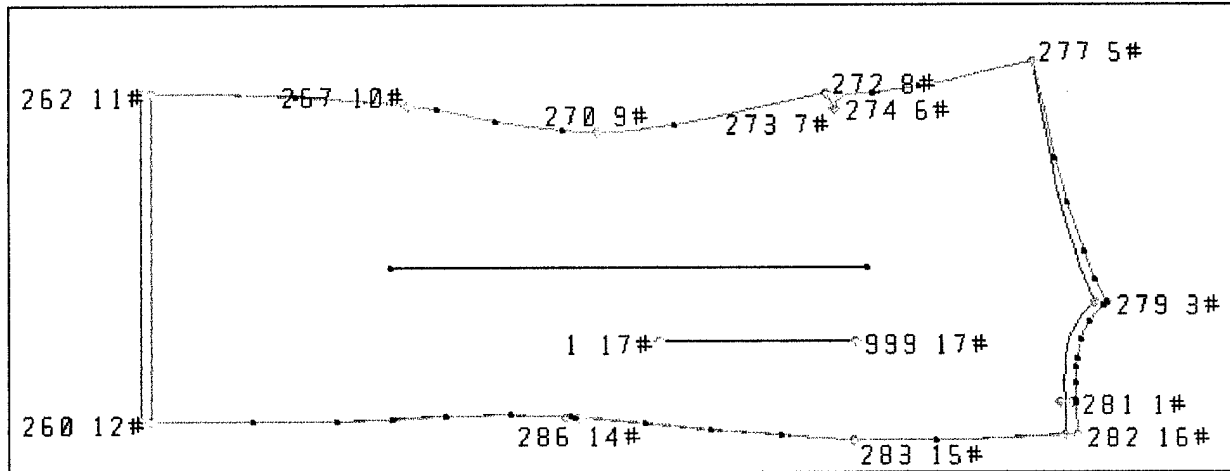
Back: Seat At Center Seam



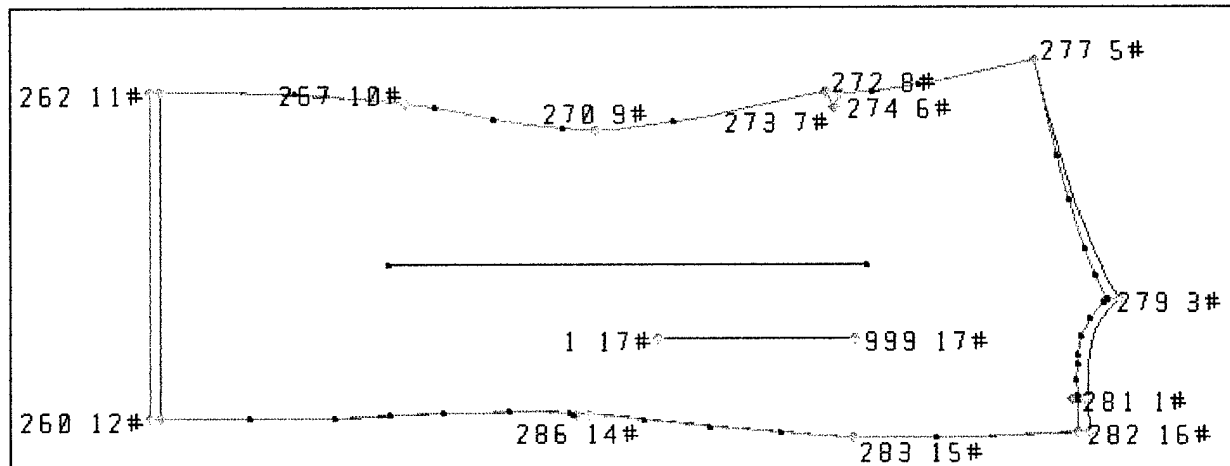
Back: Point To Point



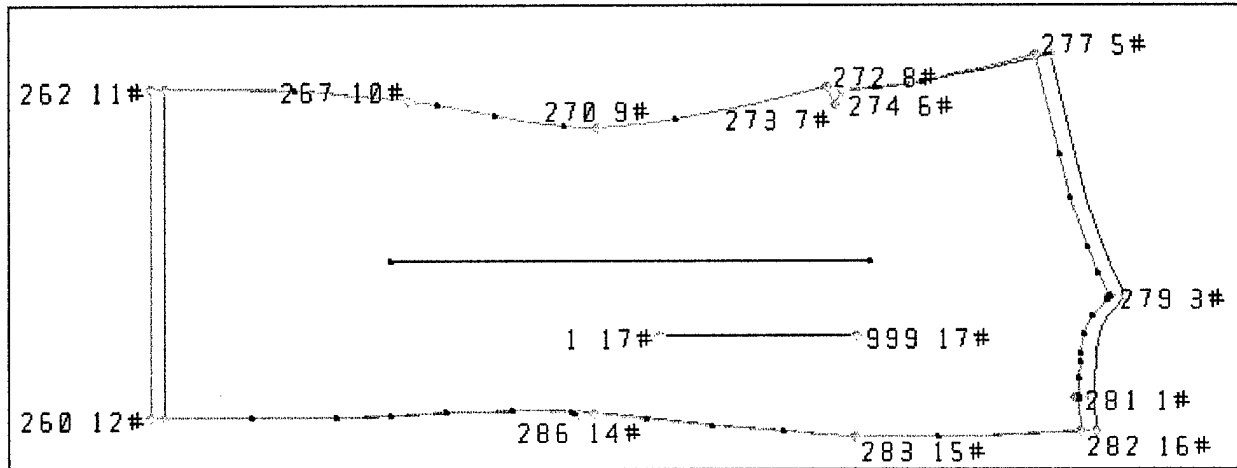
Back: Square Shoulders



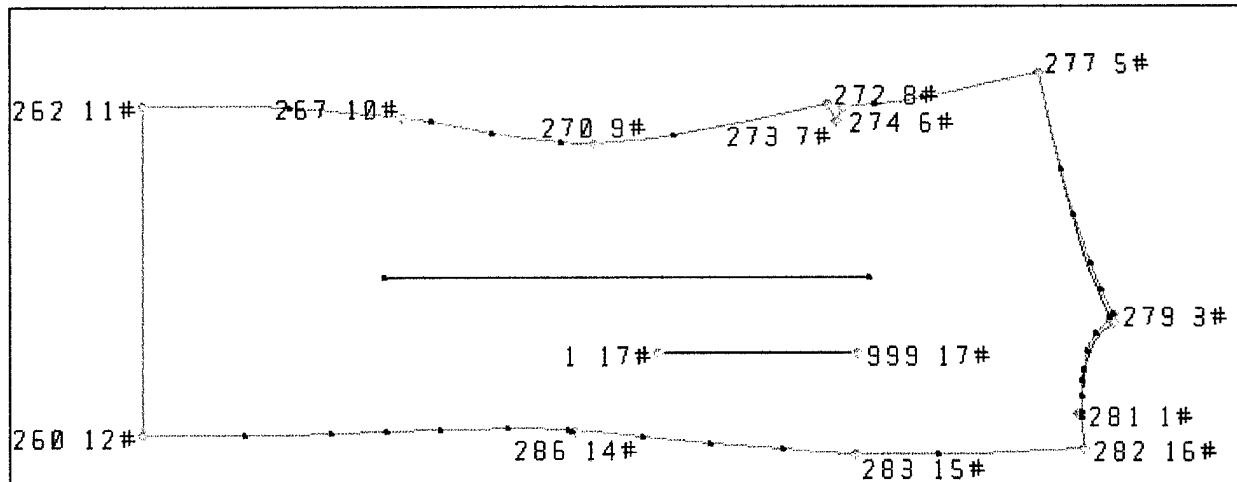
Back: Slope Shoulders



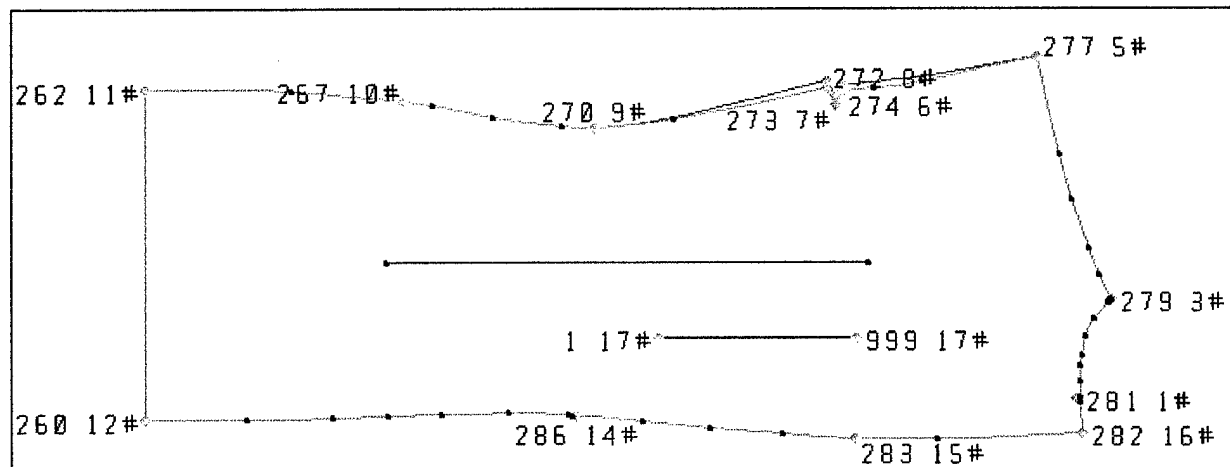
Back: Open/Close For Posture



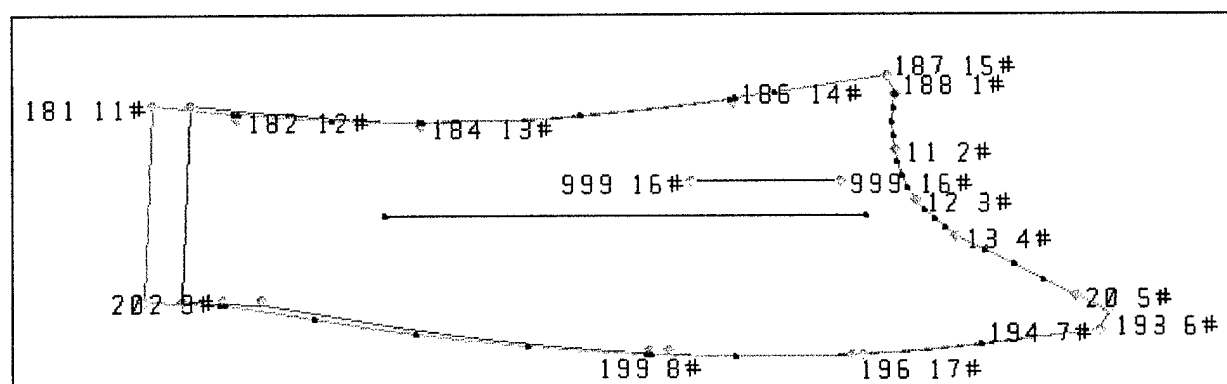
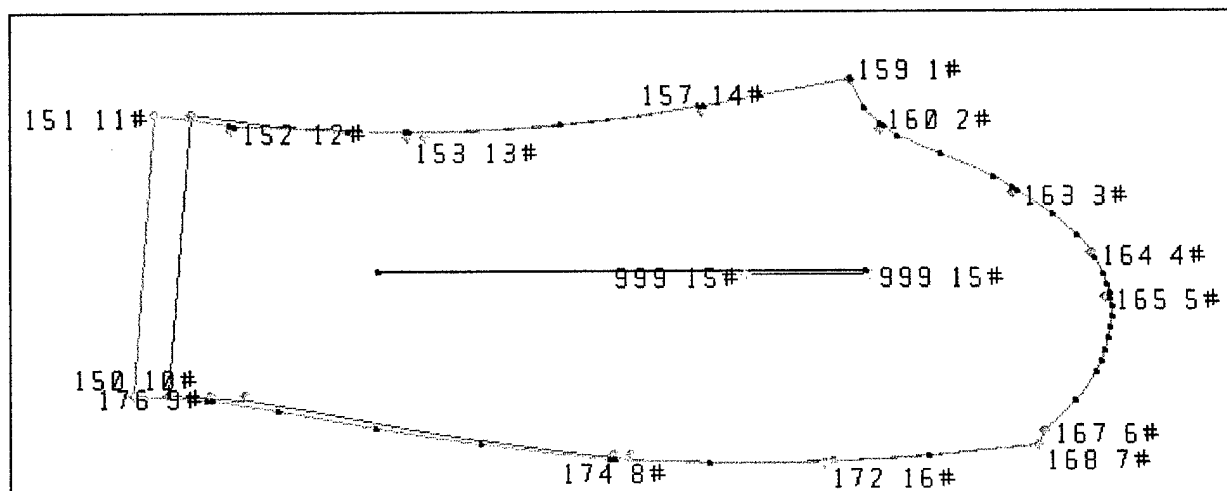
Back: Collar



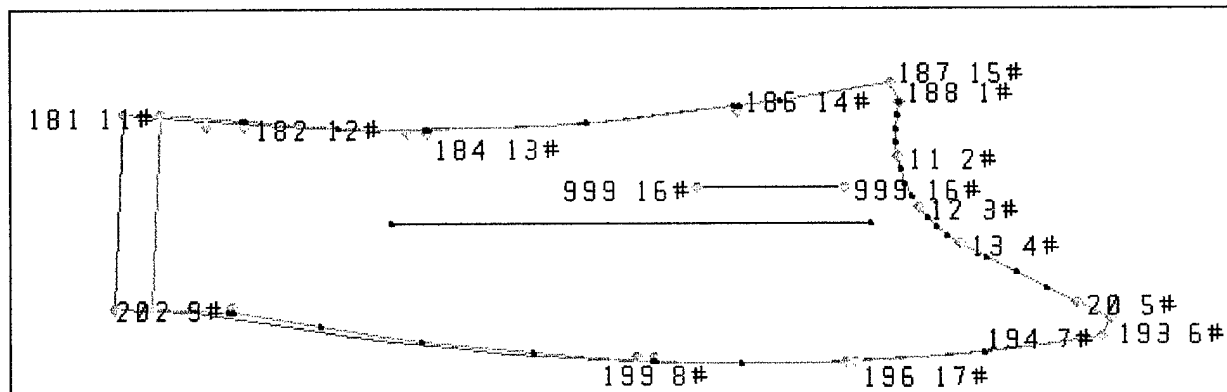
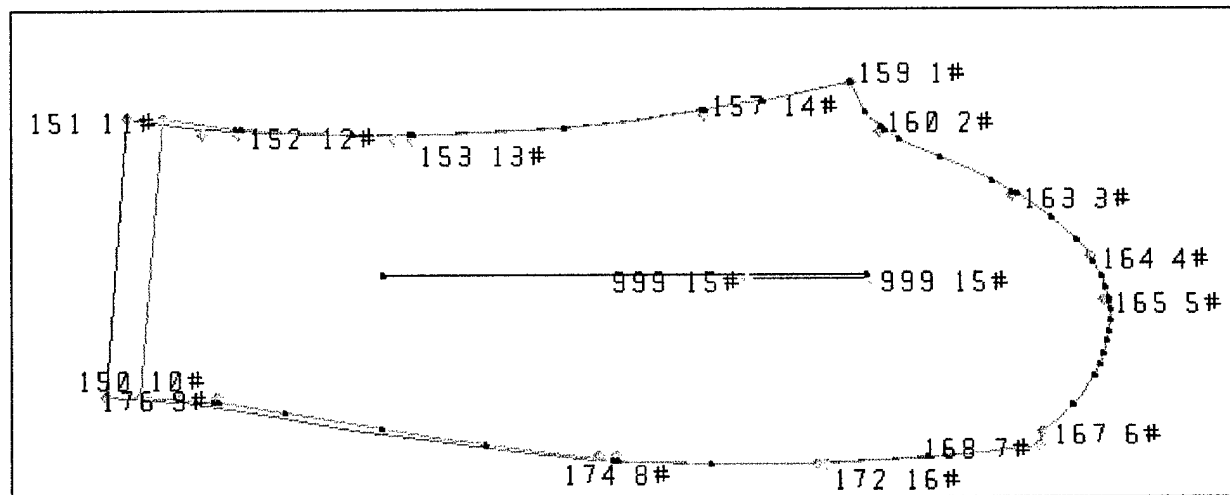
Back: Blade



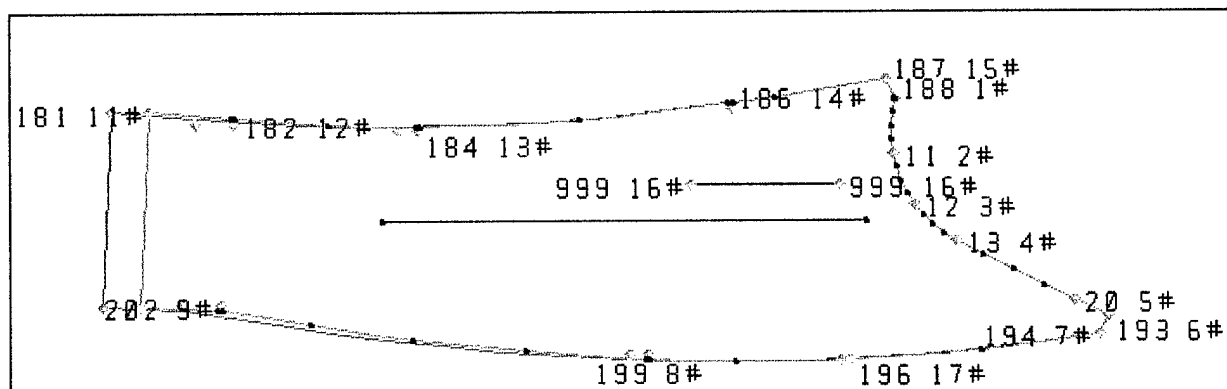
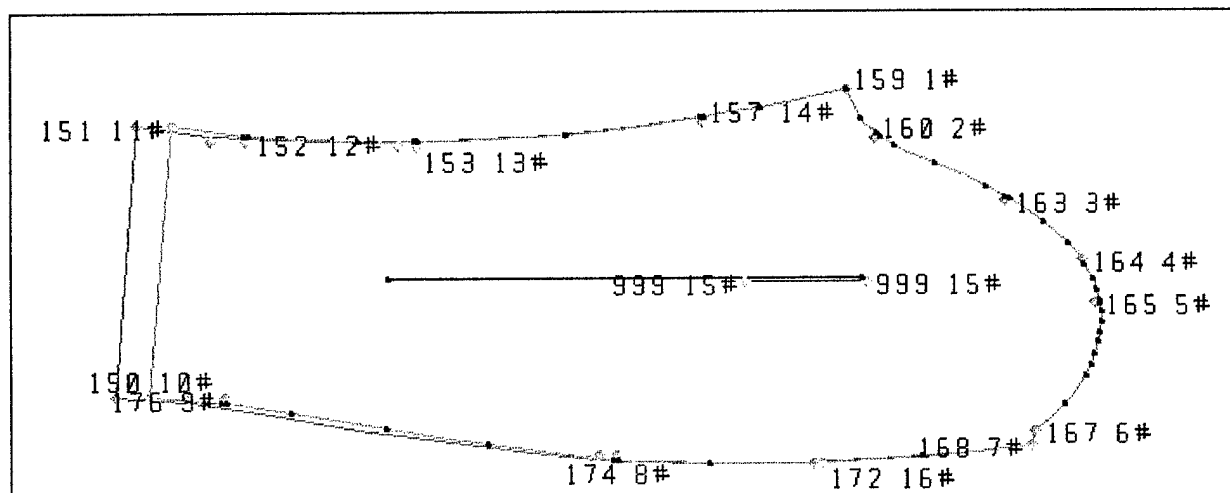
Sleeves: Short From Regular



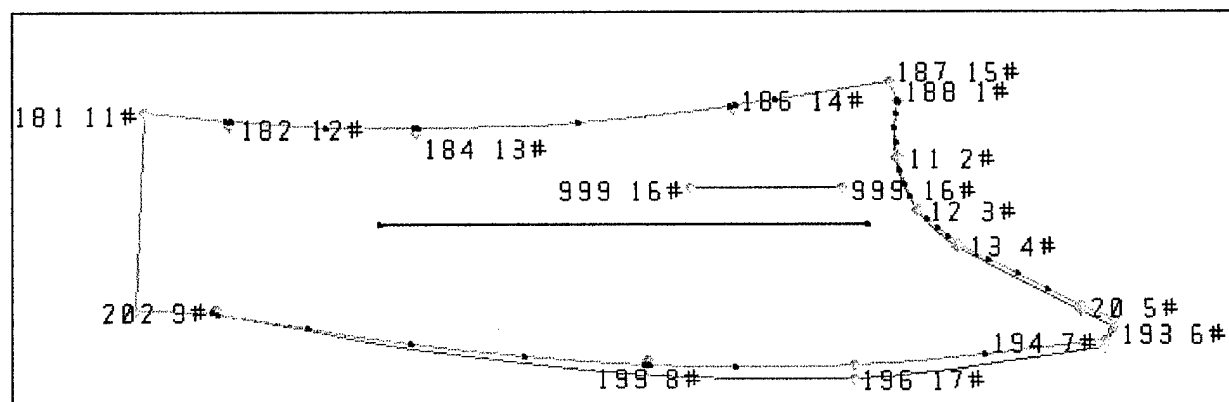
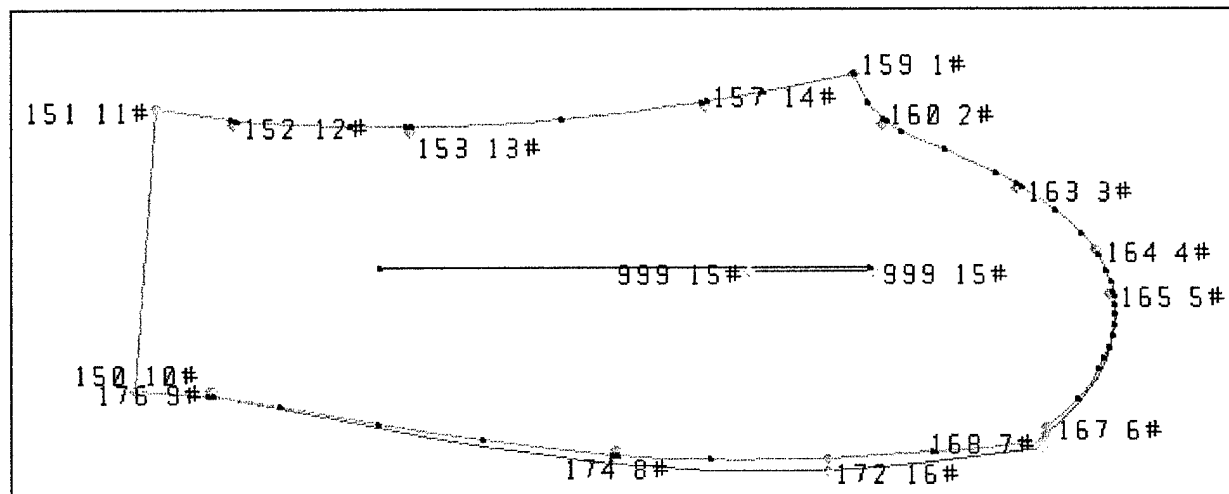
Sleeves: Long From Regular



Sleeves: Length

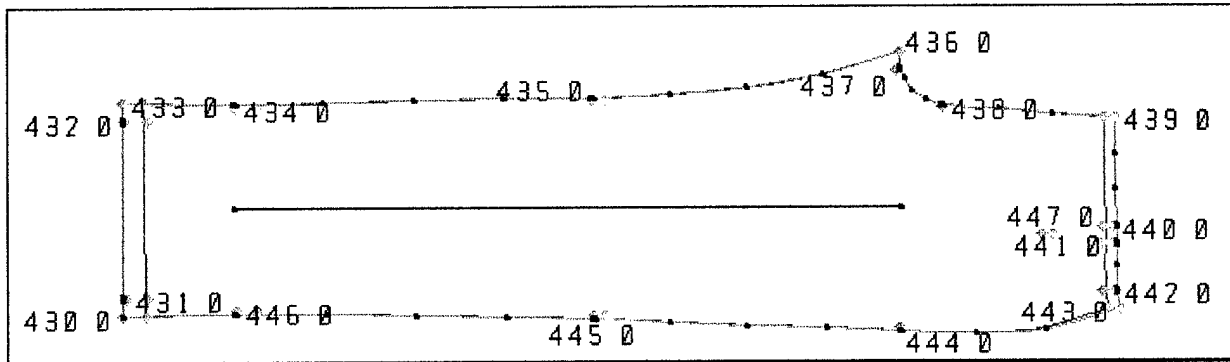


Sleeves: Bicep

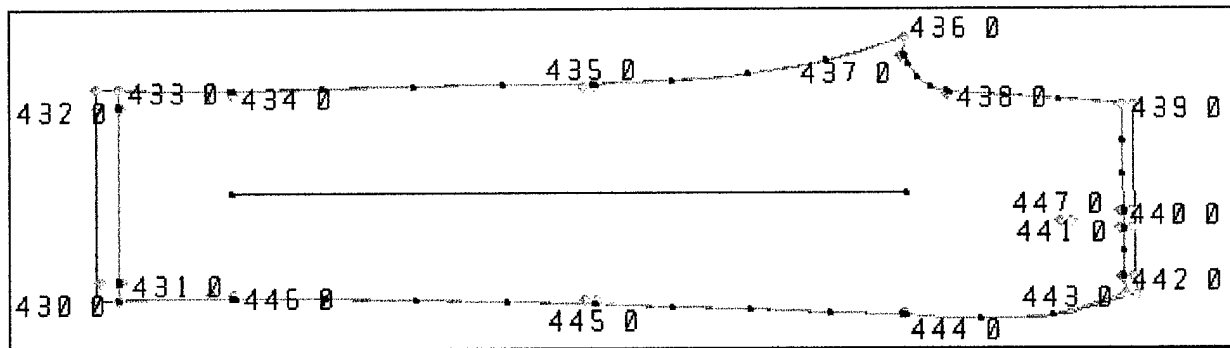


7.2 Trouser/Slack Alterations

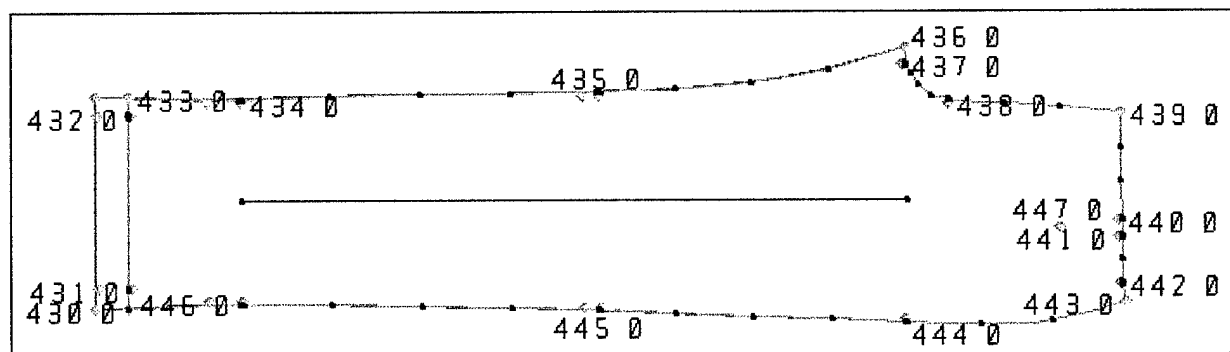
Front: Short From Regular



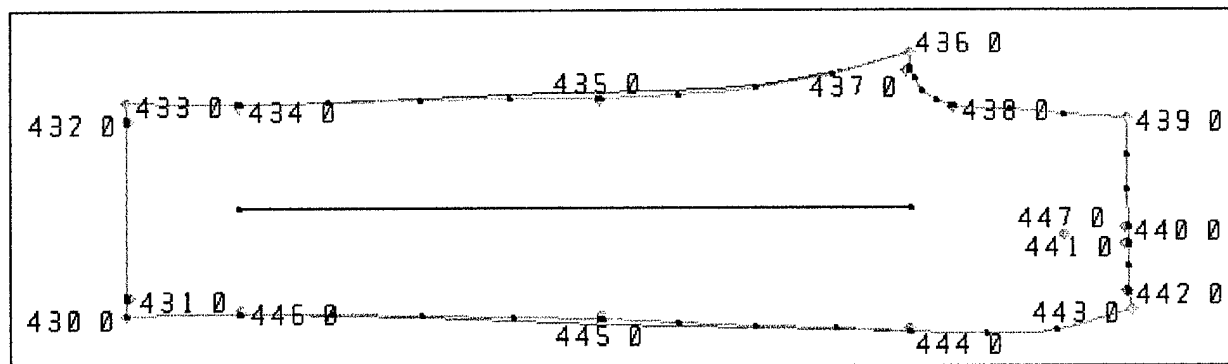
Front: Long From Regular



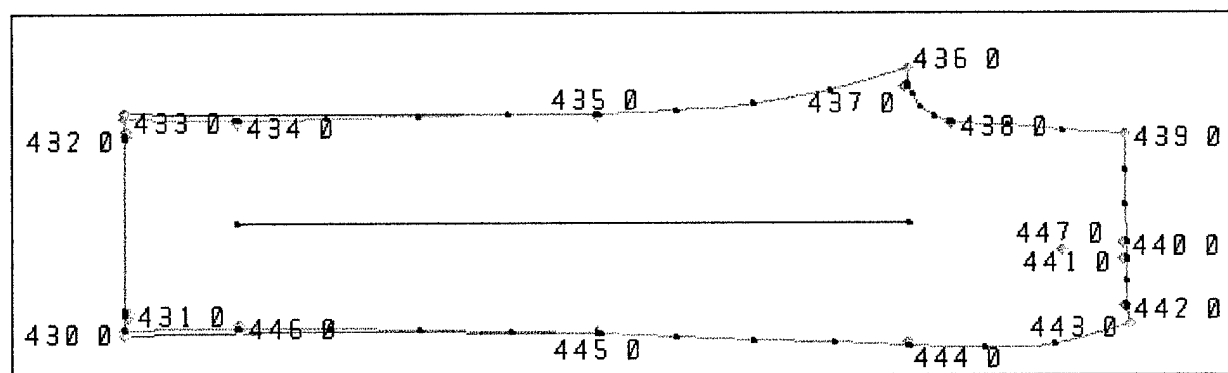
Front: Length



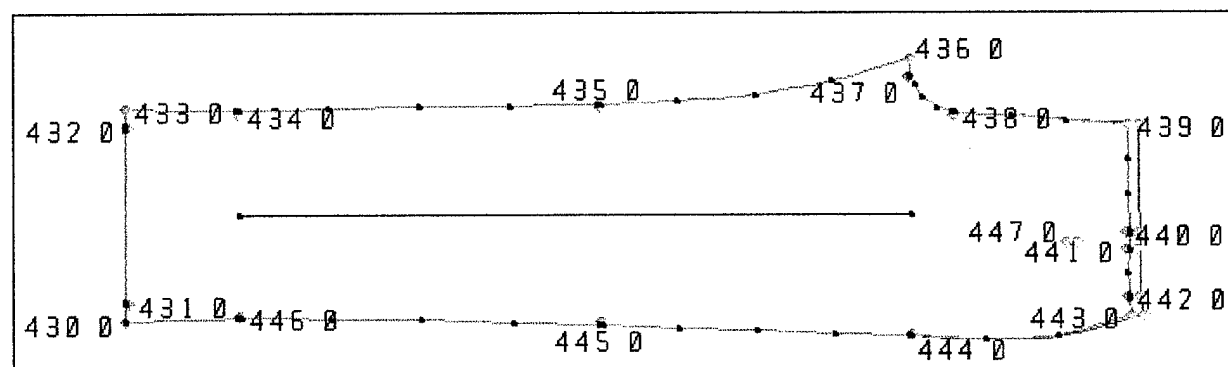
Front: Knee



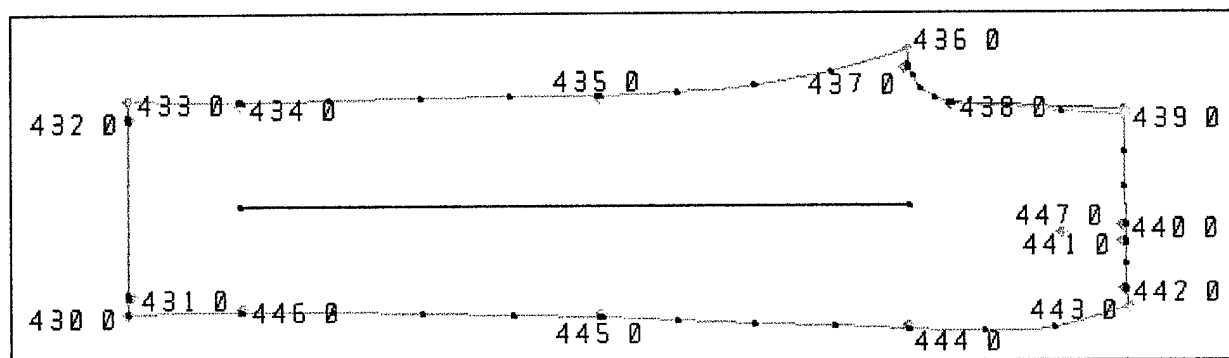
Front: Bottom



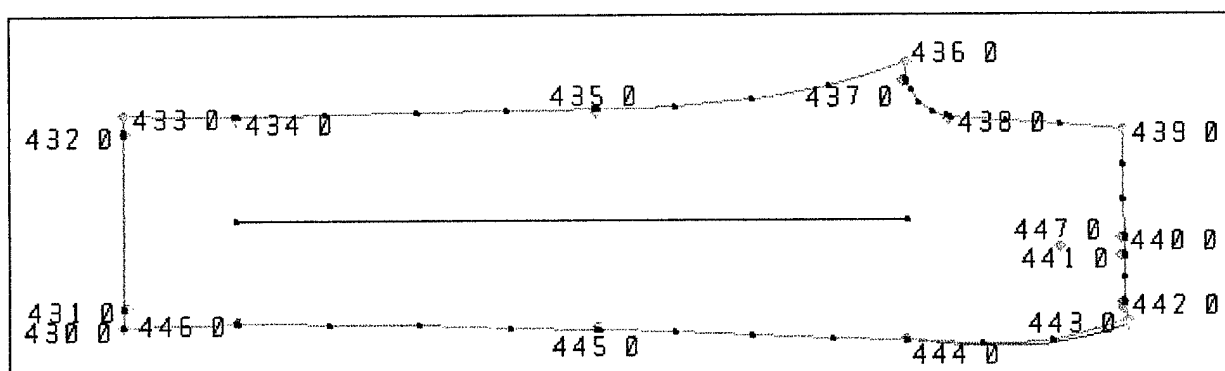
Front: Rise



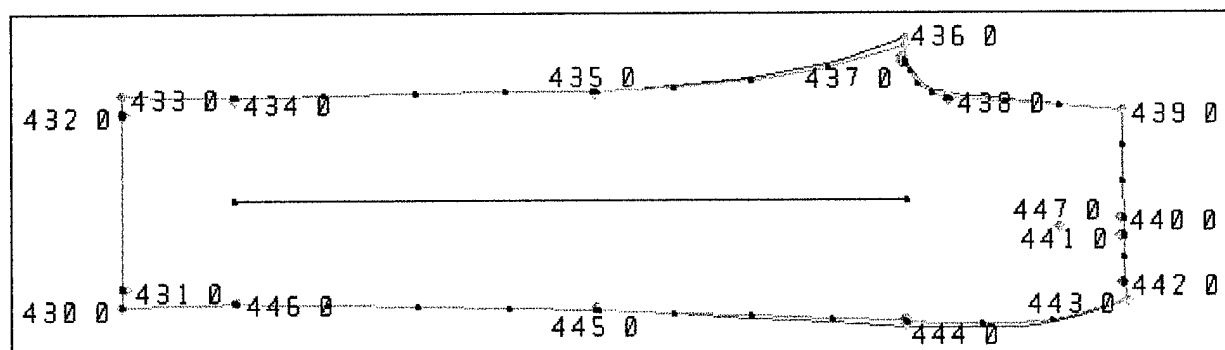
Front: Waist At Fly Seam



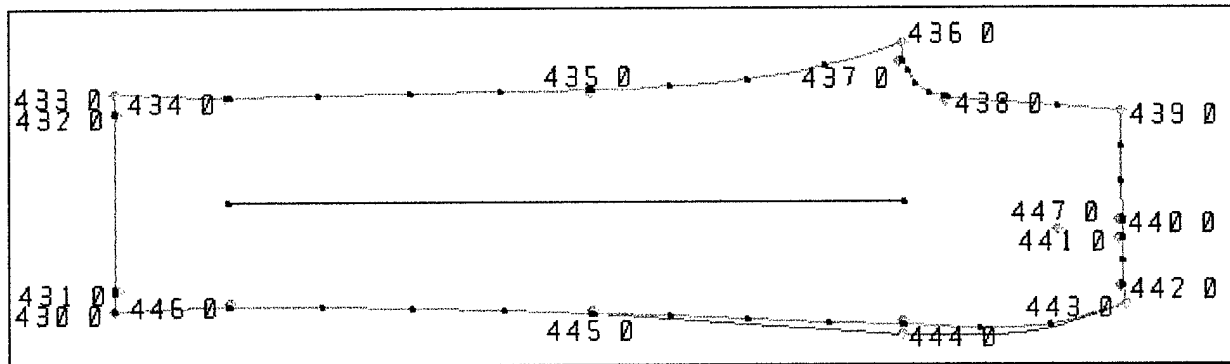
Front: Waist At Side Seam



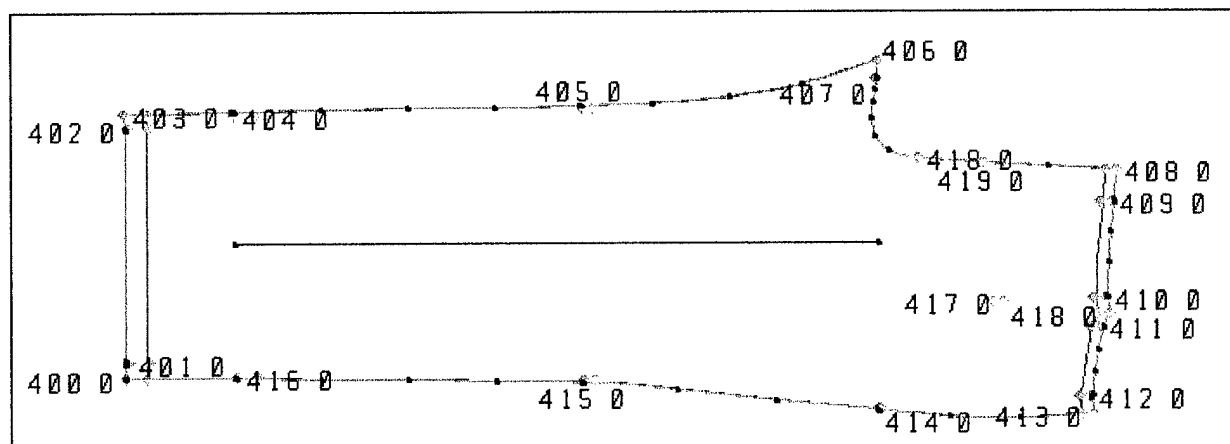
Front: Thigh



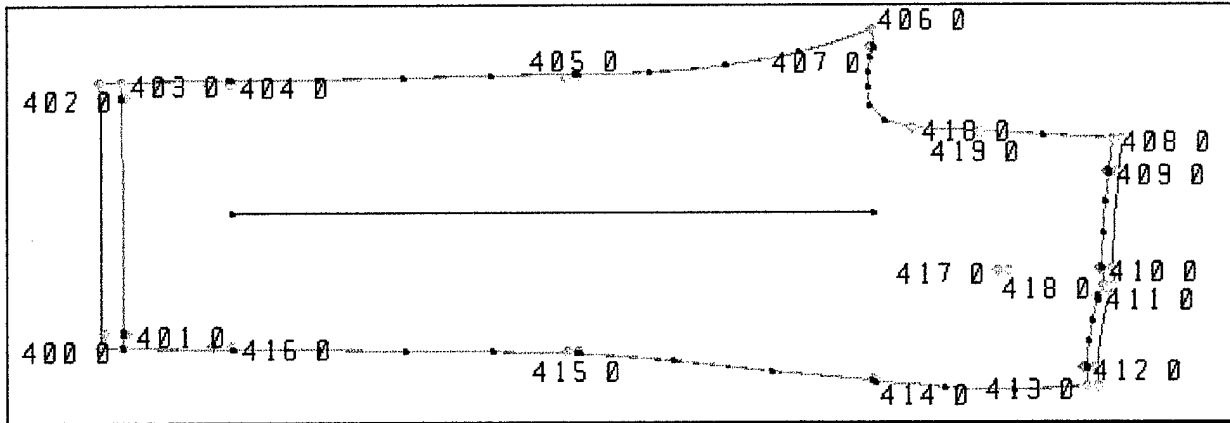
Front: Hip



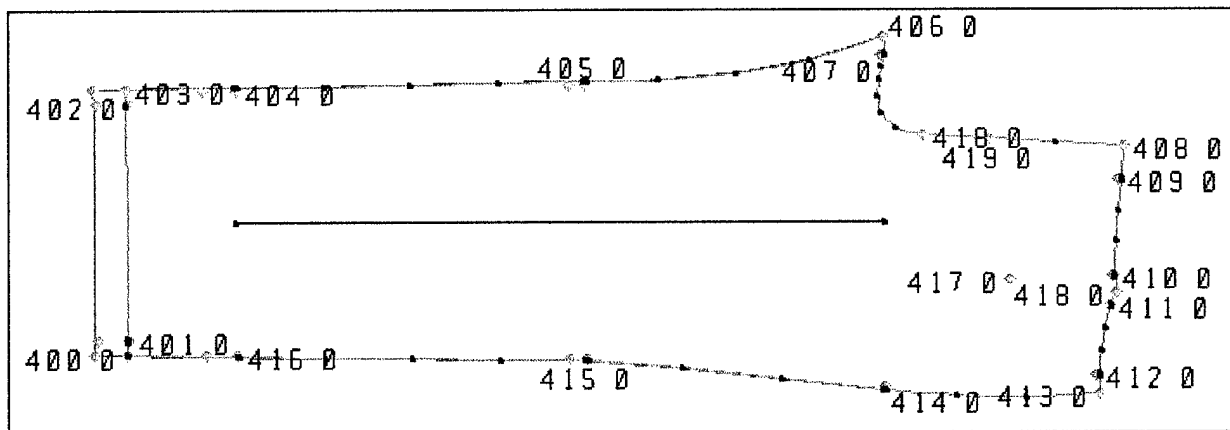
Back: Short From Regular



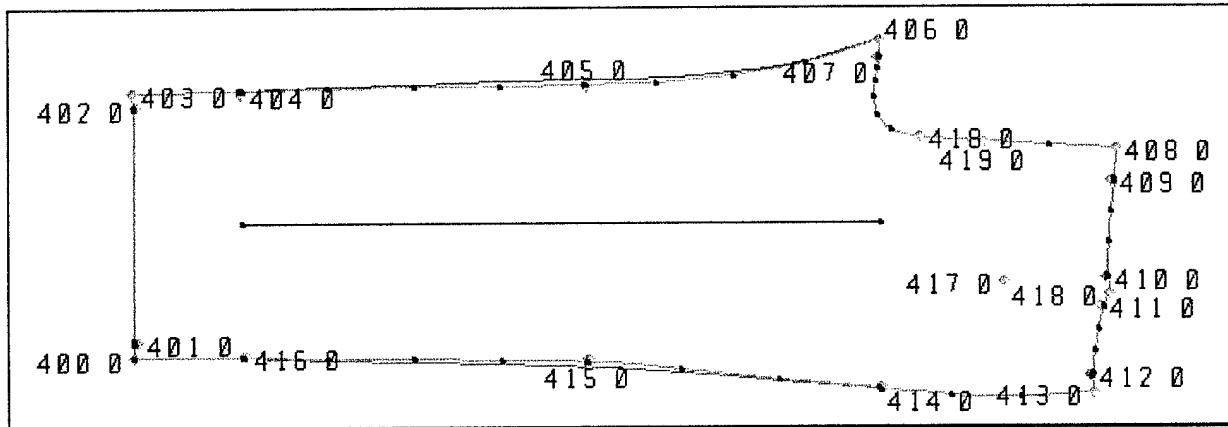
Back: Long From Regular



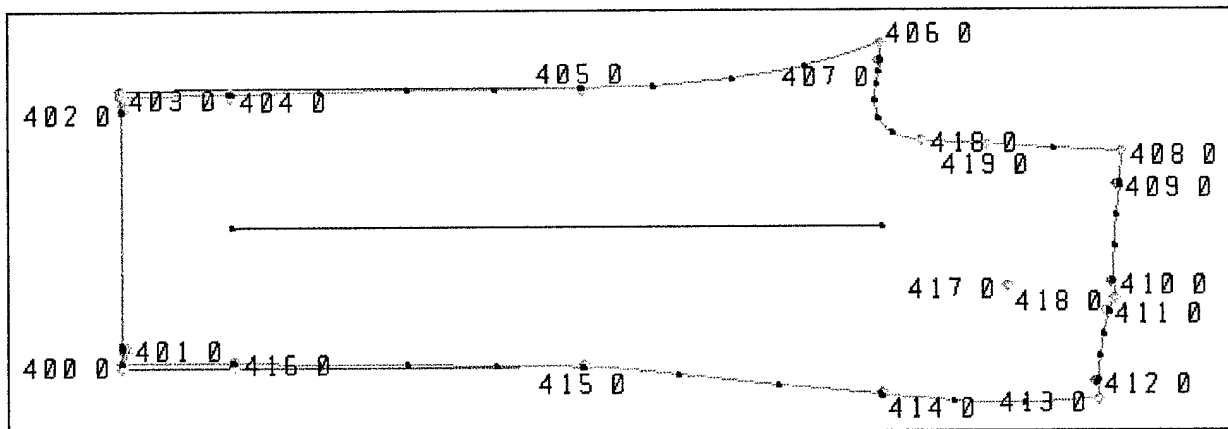
Back: Length



Back: Knee

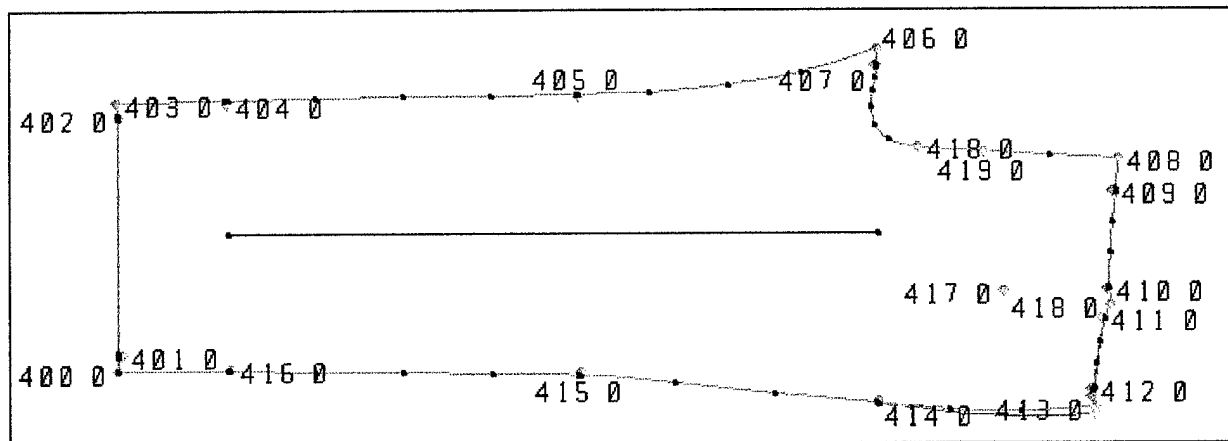


Back: Bottom

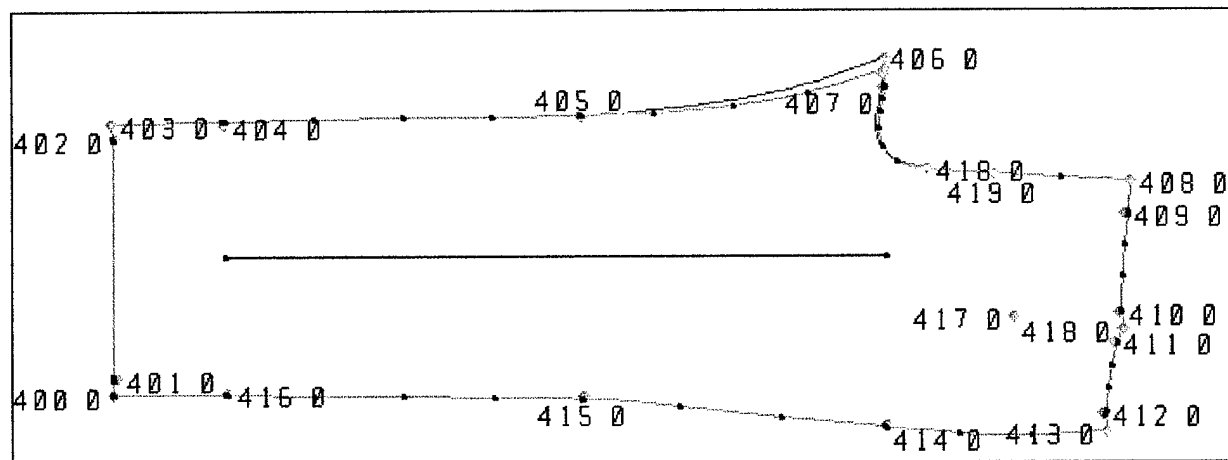


The graph shows the dependence of the number of nodes N on the number of iterations k . The x-axis represents the number of iterations k , and the y-axis represents the number of nodes N . The graph consists of two main horizontal segments. The upper segment starts at $(0, 402)$ and ends at $(409, 409)$. The lower segment starts at $(0, 400)$ and ends at $(412, 412)$. Both segments show a slight upward trend. A vertical line segment connects the two segments at $k=409$, with points labeled 418, 419, 410, 411, and 412. A horizontal line segment is also shown at $N=405$, spanning from $k=403$ to $k=407$.

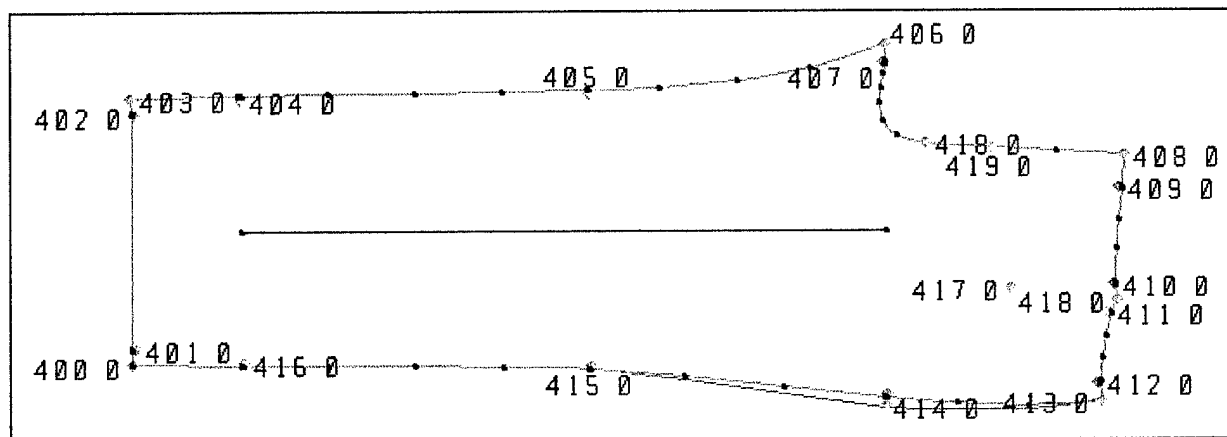
Back: Waist At Side Seam



Back: Thigh

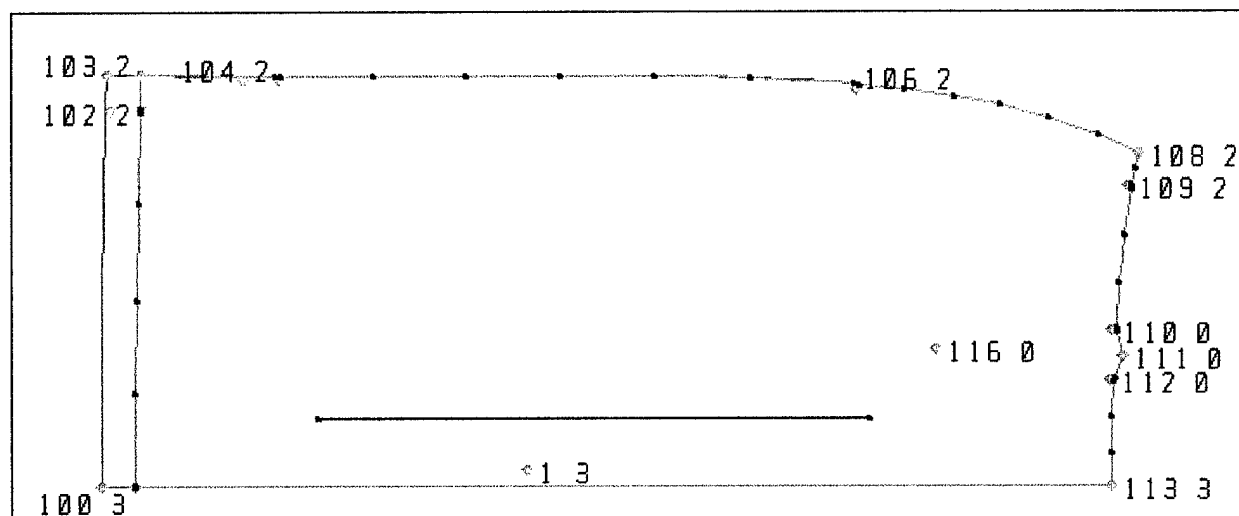


Back: Hip

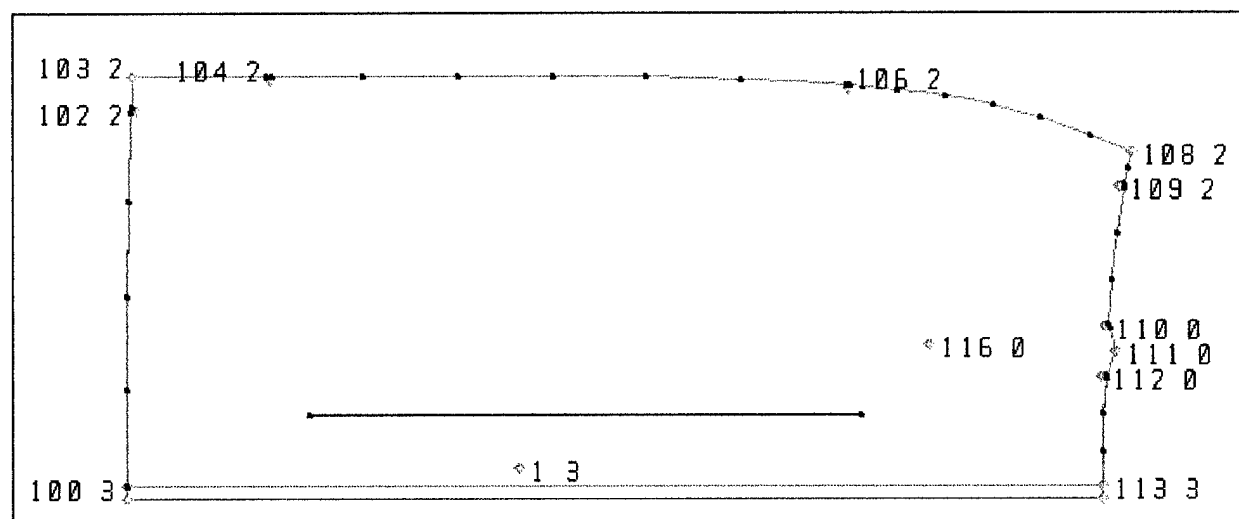


7.3 Skirt Alterations

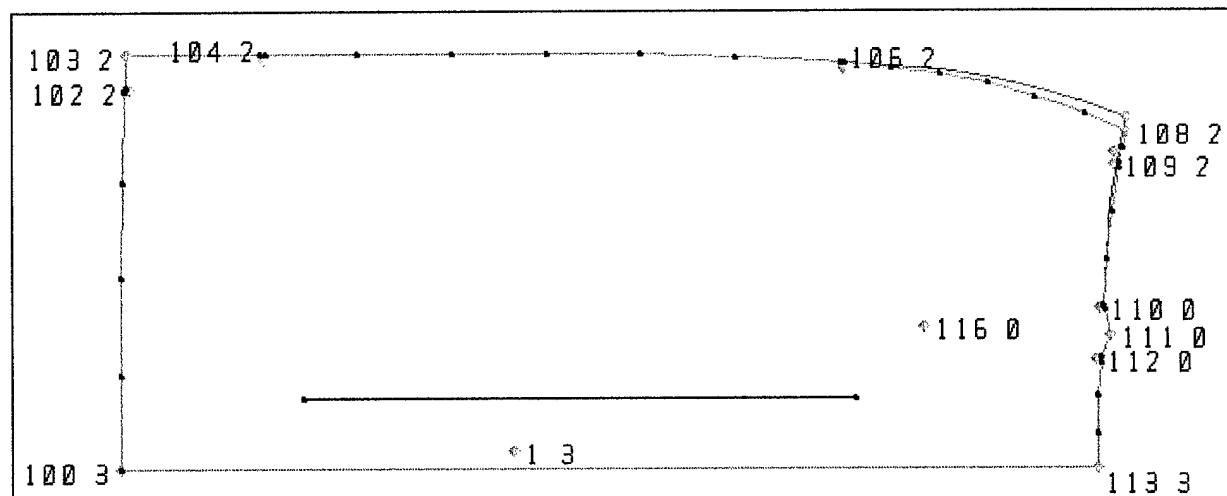
Front: Length



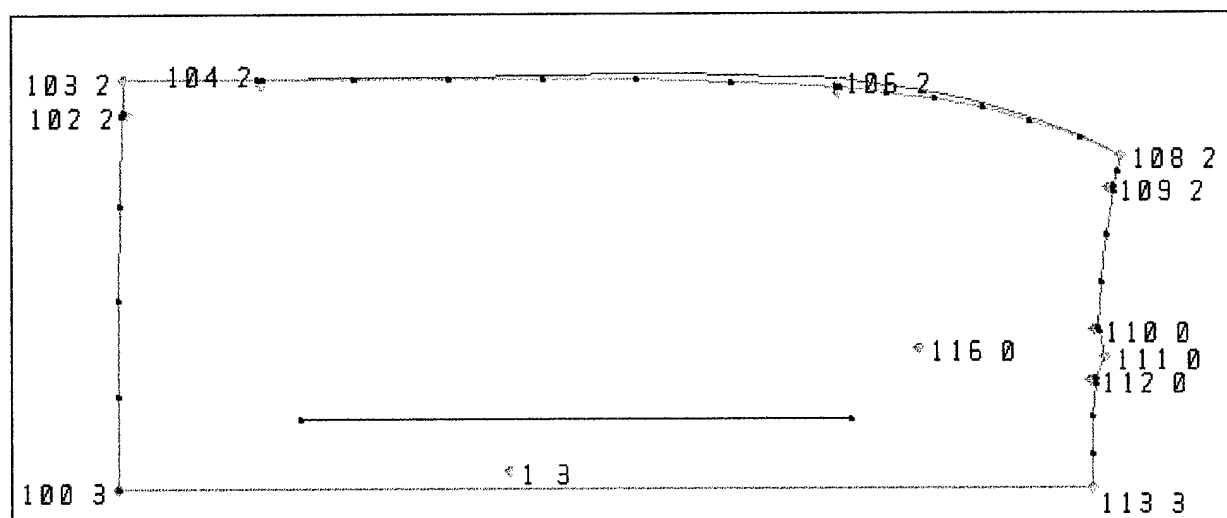
Front: Waist At Center Seam



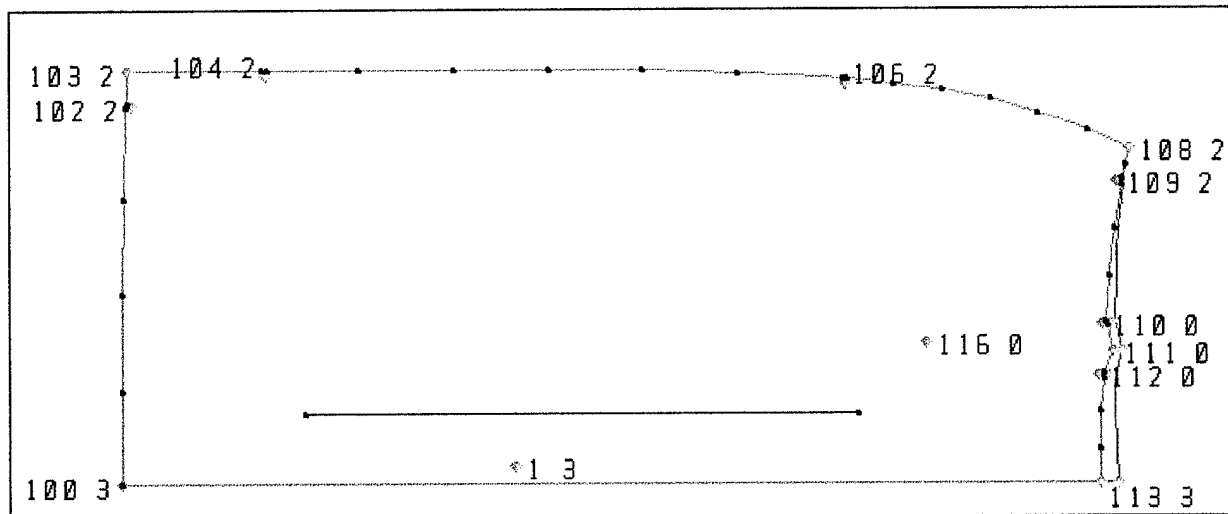
Front: Waist At Side Seam



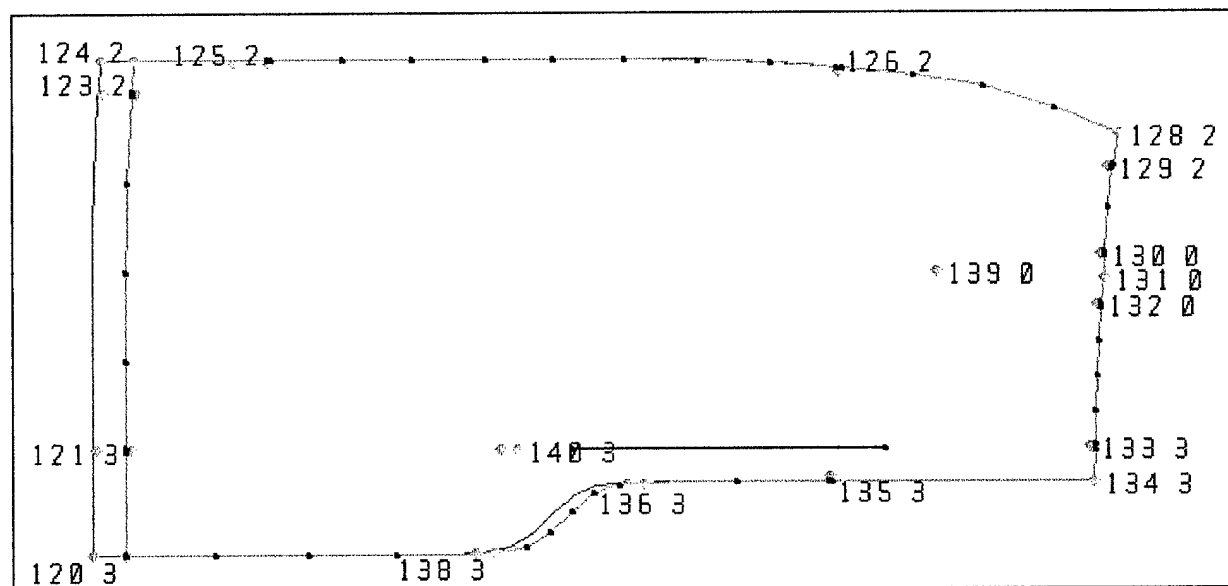
Front: Hip



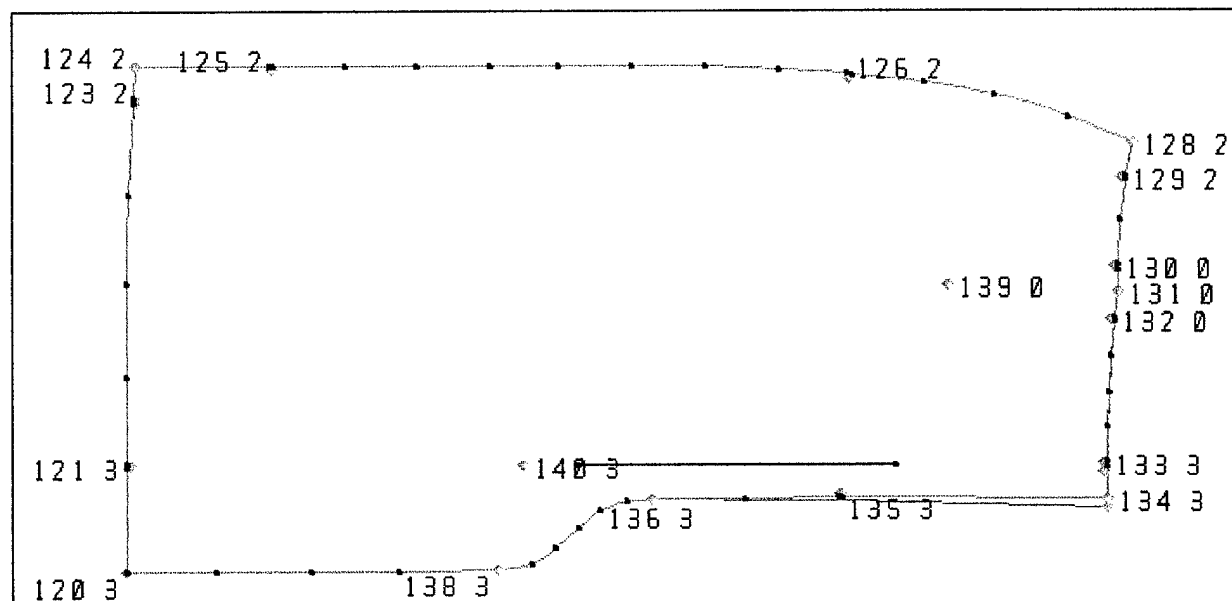
Front: Center Front Length



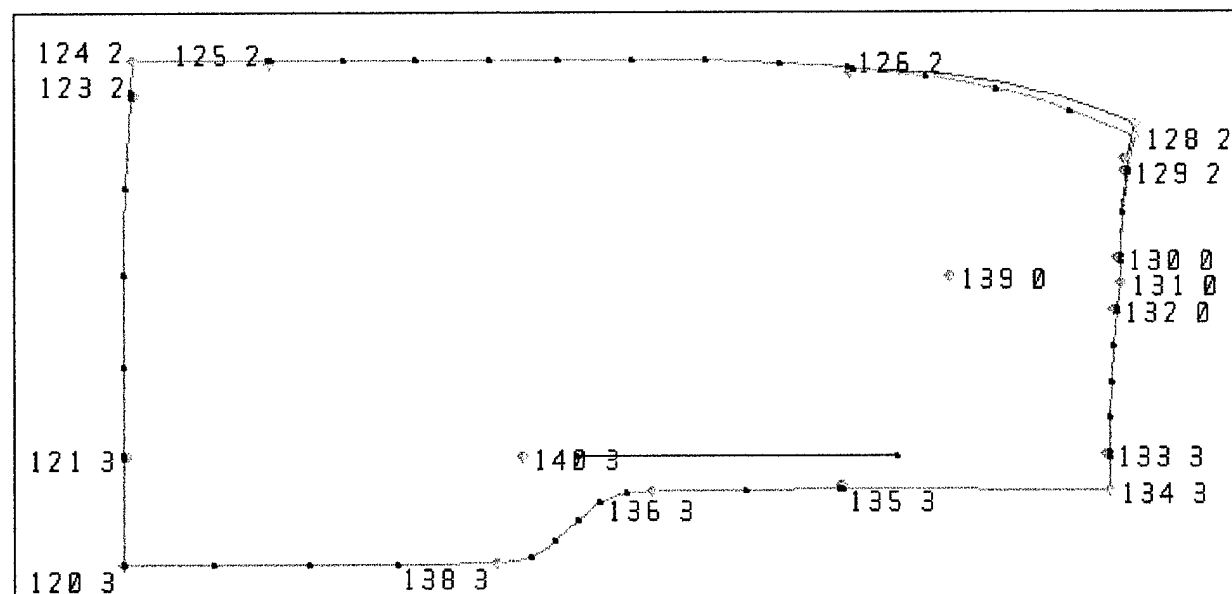
Back: Length



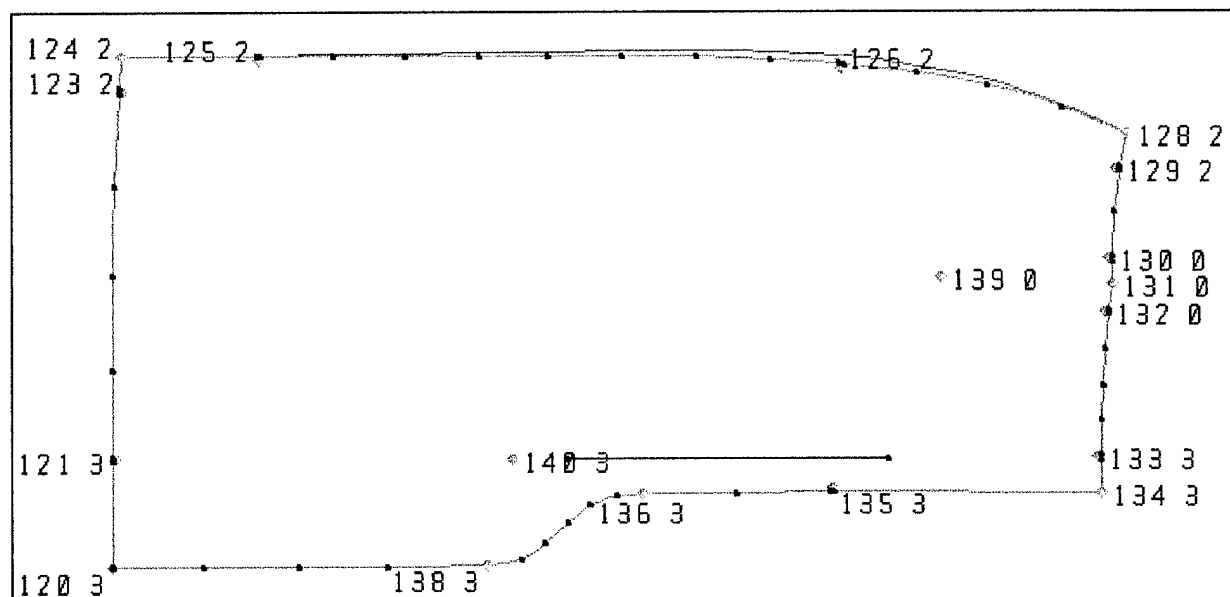
Back: Waist At Center Seam



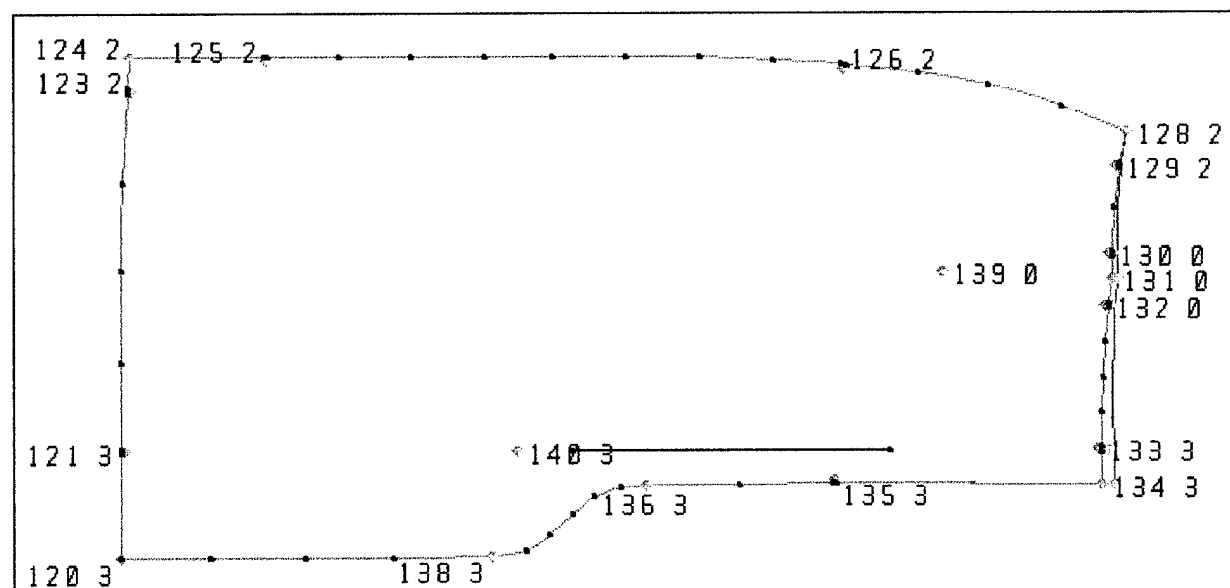
Back: Waist At Back Side Seam



Back: Hip



Back: Center Back Length



7.4 Sample Order

COAT	MEASUREMENT	PATTERN	PATTERN CHANGE
Bust	38	Size 12	
Waist	29	29.50	-.500
Seat	40	40.50	-.500
Length	28	27.00	1.000
Waist Length	16	15.625	.375
Sleeve Length	17.5	17	.500
Square Shoulders	YES		.375

SLACK	MEASUREMENT	PATTERN	PATTERN CHANGE
Hip	40	Size 10	
Waist	29	27	2.00
Inseam	29	30	-1.00
Rise	10.75	10.25	.500
Knee	21	20	1.00
Bottom	17	16.50	.500

SKIRT	MEASUREMENT	PATTERN	PATTERN CHANGE
Hip	40	Size 12 (10" Drop)	
Waist	29	28.50	.500
Length	31	30.00	1.00

