CLAIMS

1. A shoe comprising an upper portion formed substantially of resilient foam material sandwiched between inner and outer layers, the upper portion being embossed by melted, depressed regions of the foam.

2. A shoe as claimed in Claim 1 wherein the upper portion has an embossed lasting margin.

3. A shoe as claimed in Claim 1 wherein edges of the upper portion are embossed to seal said edges.

4. The shoe component of Claim 1 wherein the resilient foam material is a porous breathable foam which in the presence of heat and pressure transforms internally to a point that the inner cell wall matrix of the foam becomes viscous, providing sufficient tack to accomplish a bonding within the matrix.

5. The shoe component of Claim 1 wherein embossing of the shoe component provides a predetermined functional design pattern on the shoe component.

6. The shoe component of Claim 1 wherein embossing of the shoe component contributes to specific strain performance factors in the shoe component.

7. The shoe component of Claim 1 wherein the embossing of the shoe component contributes to the maintaining of the proper shape of the shoe component.

8. The shoe component of Claim 1 wherein the shoe component is a one-piece upper.

9. The shoe component of Claim 1 wherein the shoe component is an eyestay overlay.

10. The shoe component of Claim 1 wherein the shoe component is a quarter overlay.

11. A component of a shoe comprising a multi-layered material embossed along the edges of the material, the embossing sealing the layers of the material together at the edge and reducing the thickness of the material in the embossed regions.

12. The shoe component of Claim 11 wherein the multi-layered material includes a layer of porous breathable foam which in the presence of heat and pressure transforms internally to a point that the inner cell wall matrix of the foam becomes viscous, providing sufficient tack to accomplish a monogamous bonding within the matrix.

13. The shoe component of Claim 1 wherein the shoe component is further embossed away from the edges of the material.

14. A shoe comprising an upper portion having back sides, sides and a toe area formed from a single sheet of material, the material being selectively embossed relative to the shoe structure such that depressions embossed in the material help maintain a proper shape of the shoe.

15. A shoe as claimed in Claim 14 wherein the shoe comprises a depression curved about the toe area to separate upper and side portions of the toe area.

16. A shoe as claimed in Claim 14 wherein said upper portion comprises a strap formed between sides of the shoe, the strap having transverse depressions thereacross.

17. A shoe as claimed in Claim 14 wherein said upper portion has a depressed lasting margin.

18. A shoe as claimed in Claim 14 wherein upper edges of back sides and sides of said upper portion are sealed by depressions.

19. A shoe as claimed in Claim 14 wherein the sheet of material comprises a resilient foam layer sandwiched between inner and outer layers.

20. A shoe as claimed in Claim 14 wherein the said upper portion has a depressed lasting margin.

21. A shoe as claimed in Claim 14 wherein upper edges of back sides and sides of said upper portion are sealed by depressions.

22. A shoe comprising an upper portion having back sides, sides and a toe area formed in a single sheet of material, the sheet of material comprising resilient foam material sandwiched between inner and outer layers, the material being embossed by melted, depressed regions of the foam to help maintain the shape of the shoe, the depressed regions including a lasting margin and upper edges of the back sides and sides.

23. A shoe as claimed in Claim 22 comprising a depression curved about the toe area to separate upper and side portions of the toe area.

24. A shoe comprising a plurality of heat-embossed, multi-layered shoe portions fastened together with a thermoplastic connector, the connector passing through the material of the connected portions and being such that once heated it restricts separation of said materials.

25. A shoe as claimed in Claim 24 wherein the thermoplastic connector comprises a first member having pins which extend through the material being fastened together, and a second member having holes which engage the pins of the first member while they are extended through said material.

26. The shoe of Claim 24 wherein the shoe portions comprise the left and right heel portions of a one-piece upper.

27. The shoe of Claim 24 wherein the multi-layer composition of said shoe portions includes a central layer of porous foam sandwiched between an inner layer and an outer layer.

28. A method of making a shoe component, comprising:

fabricating the shoe component in a desired shape from a multi-layered material; and

embossing the shoe component in select regions, the embossing sealing the layers of the material together at the edge and reducing the thickness of the material in the embossed regions.

29. The method of Claim 28 wherein said embossing of the shoe component comprises embossing with heat.

30. The method of Claim 28 wherein embossing said shoe component comprises embossing with high frequency energy.

31. The method of Claim 28 wherein said shoe component comprises a one-piece upper.

32. The method of Claim 28 wherein said shoe component comprises a multi-layered material having an outer layer, a resilient central layer, and an inner layer.

33. The method of Claim 32 wherein said resilient central layer is a porous foam which when heated, melts to a bonding adhesive.

34. The method of Claim 32 wherein said outer layer and said inner layer are tricot.

35. The method of Claim 32 wherein said outer layer and said inner layer are woven cotton.

36. The method of Claim 32 wherein the outer layer comprises leather.

37. The method of Claim 32 wherein said central resilient layer comprises polyurethane.

38. A method of fastening together portions of a shoe, the method comprising:

aligning the shoe portions with one another in a desired fashion;

inserting a thermoplastic connector through the shoe portions such that the shoe portions are adjacent one another with the thermoplastic connector passing through each of them;

subjecting the thermoplastic connector to sufficient energy to melt the thermoplastic connector such that when rehardened, the connector restricts the shoe portions from separating from one another.

39. The method of Claim 38 wherein the thermoplastic connector comprises a first member having pins which extend through the shoe portions, and a second member having holes which engage the pins of the first member while the connector is subjected to the melting energy.

40. The method of Claim 38 wherein the shoe portions comprise the left and right heel portions of a one-piece upper.

41. The method of Claim 38 wherein the shoe portions include a tongue.

42. The method of Claim 38 wherein the shoe portions include a portion formed of a multi-layer material, the material having a layer of porous foam, and heat-embossed depressed regions in the material.

43. The method of Claim 38 wherein the shoe portions include an overlay.

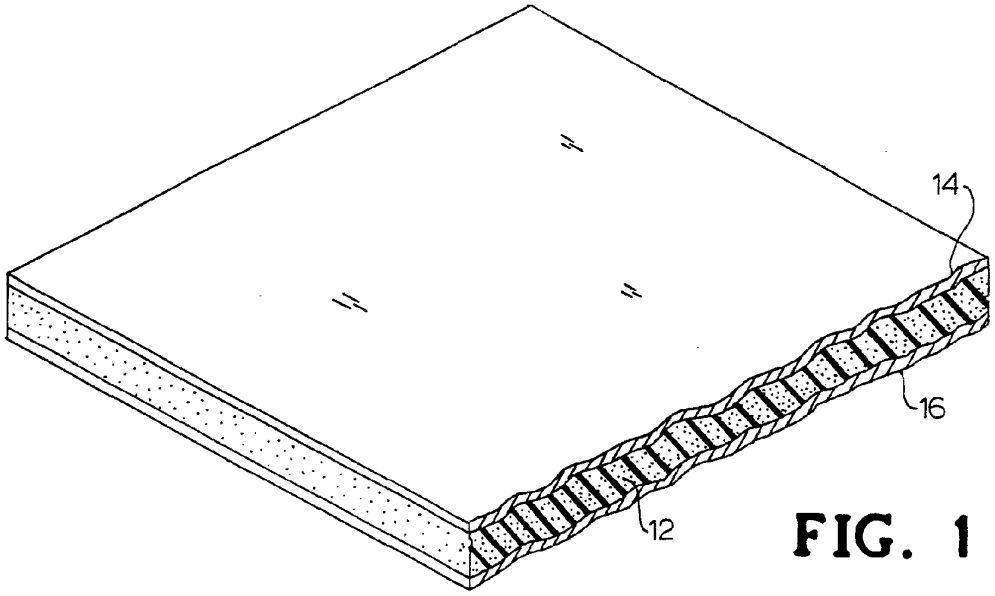


FIG. 1

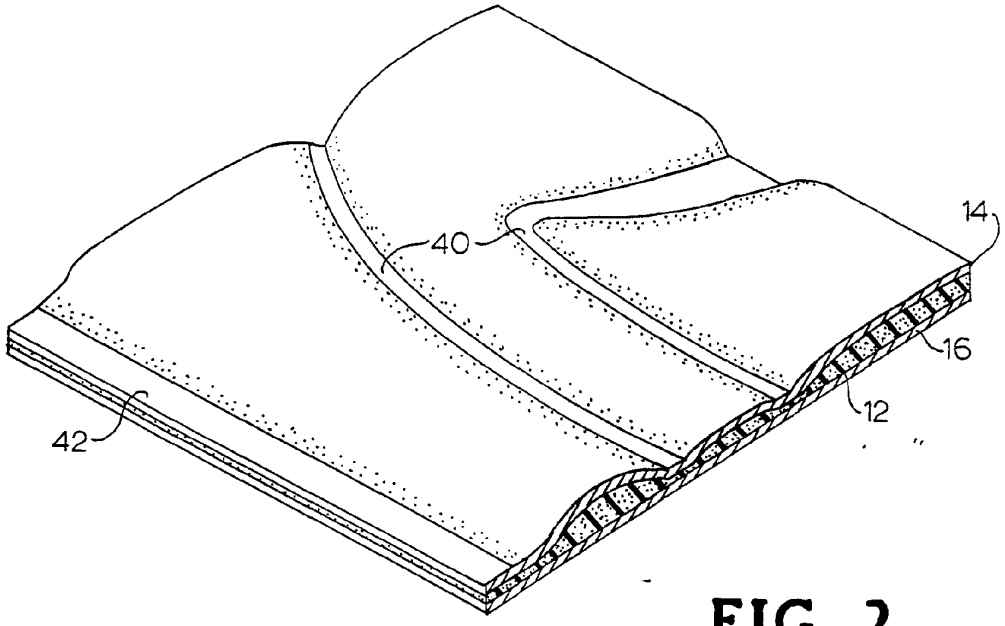


FIG. 2

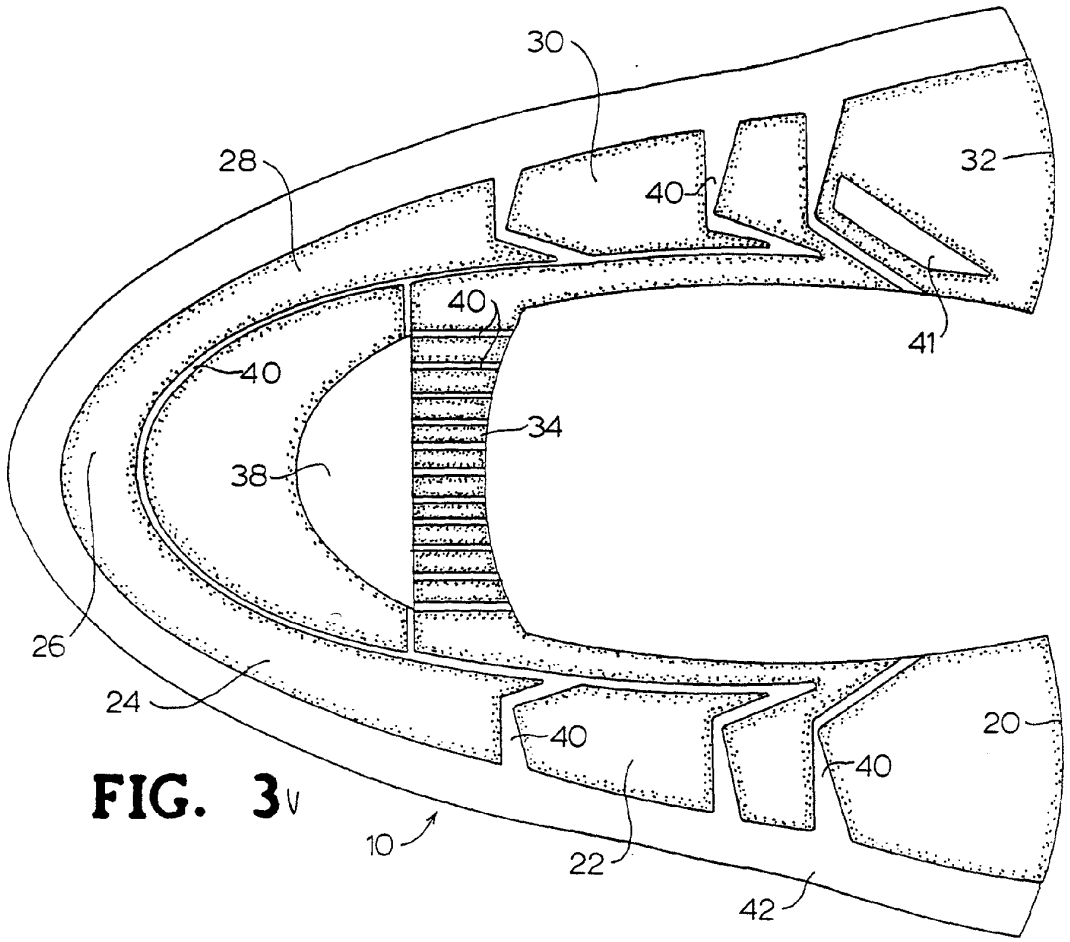


FIG. 3

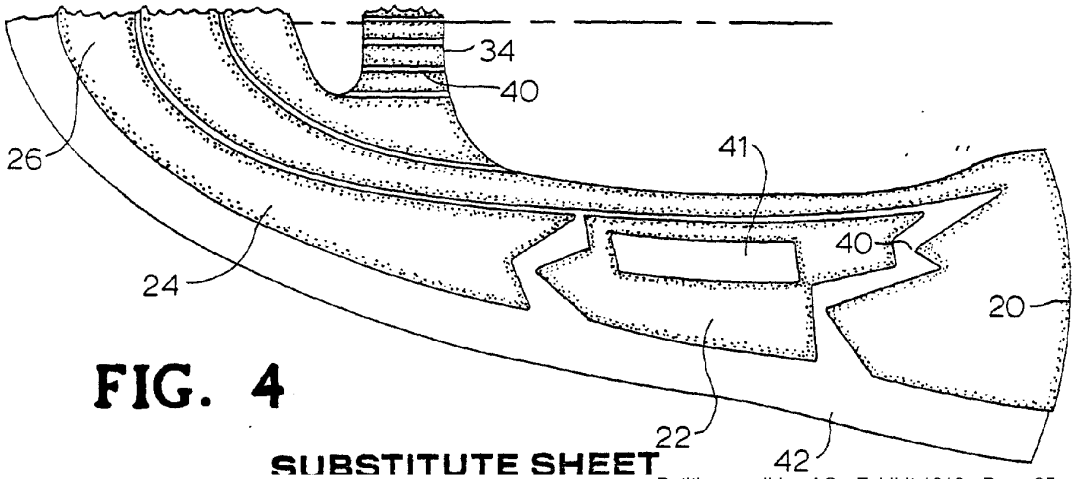


FIG. 4

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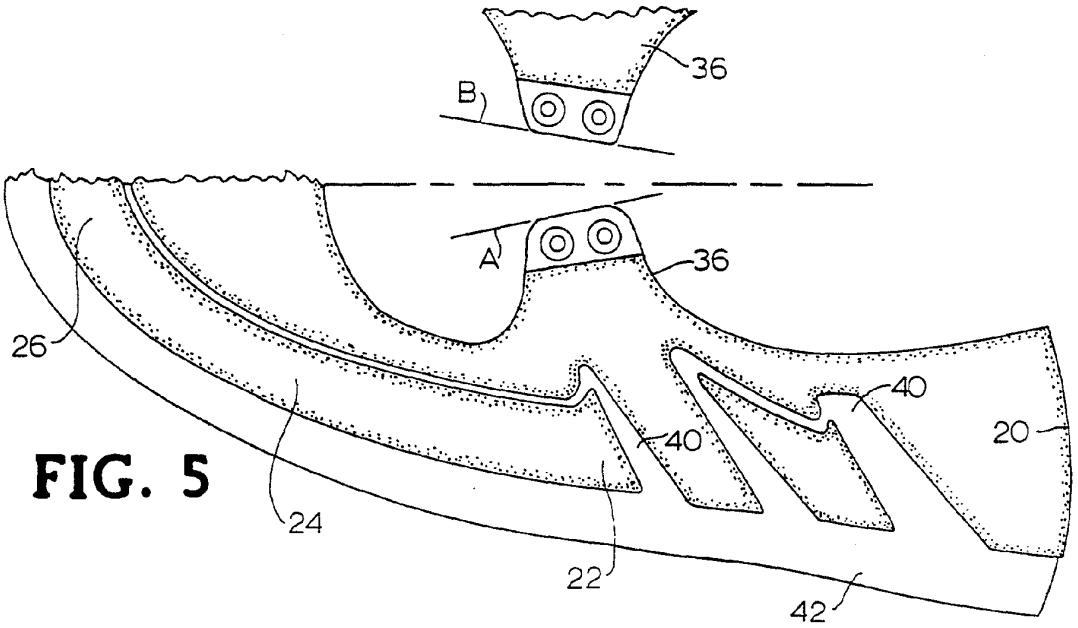


FIG. 5

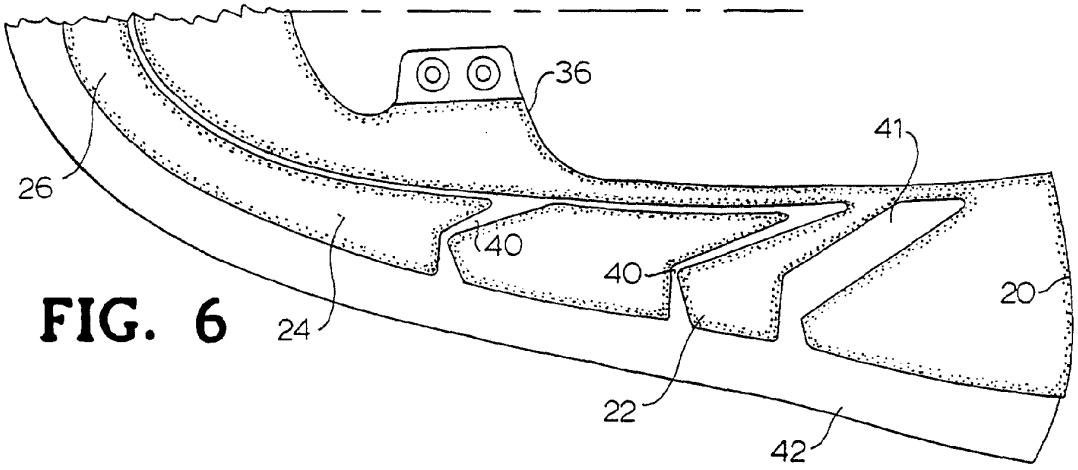


FIG. 6

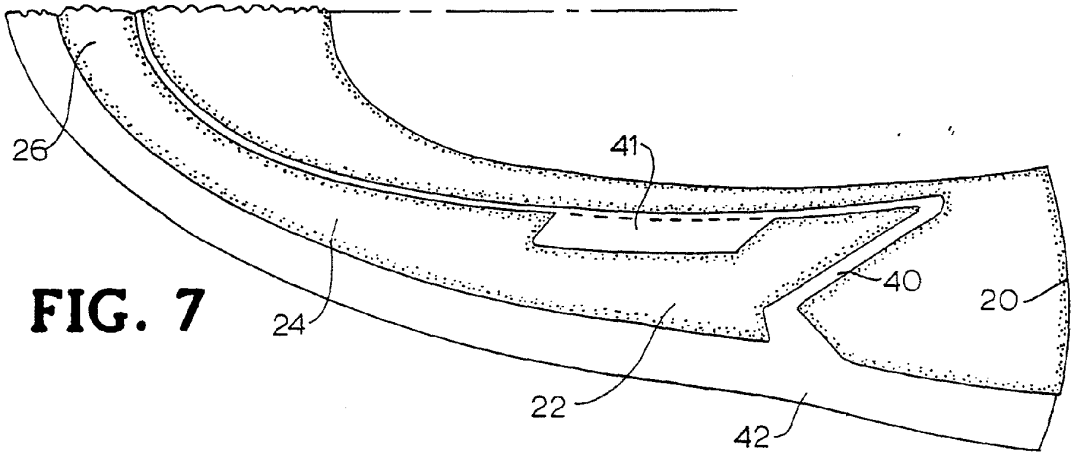


FIG. 7

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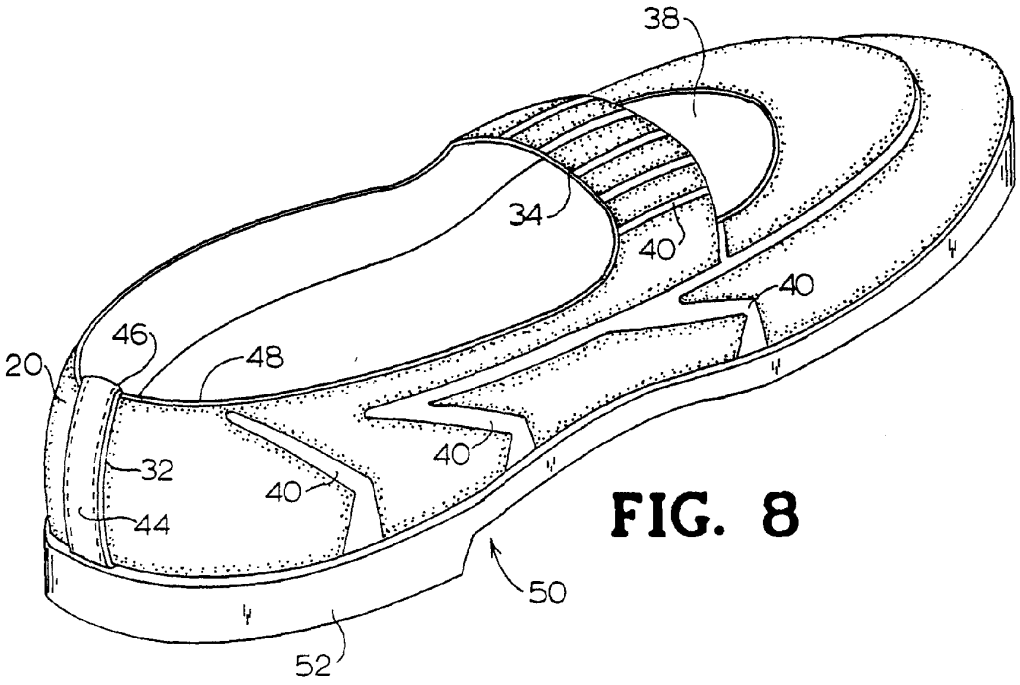


FIG. 8

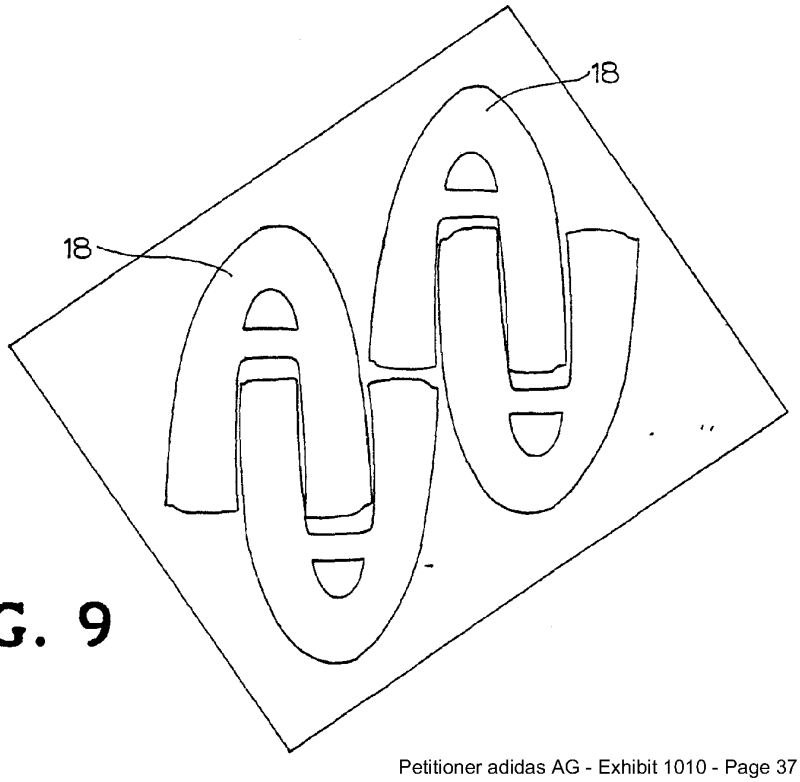


FIG. 9

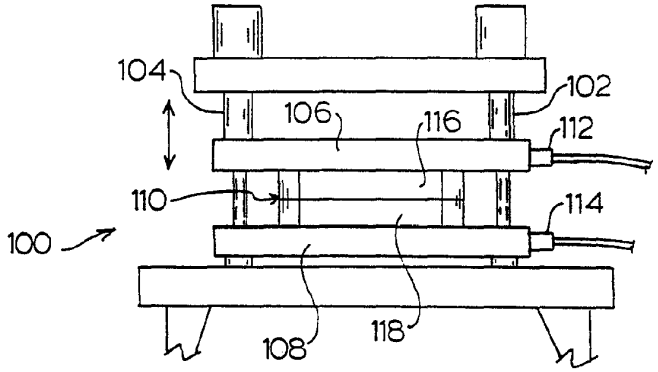


FIG. 10

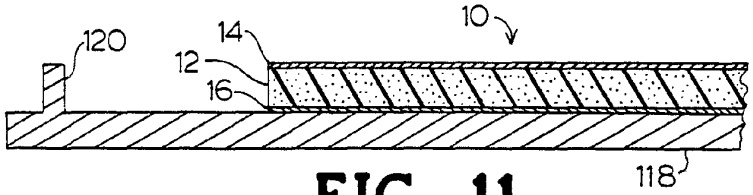


FIG. 11

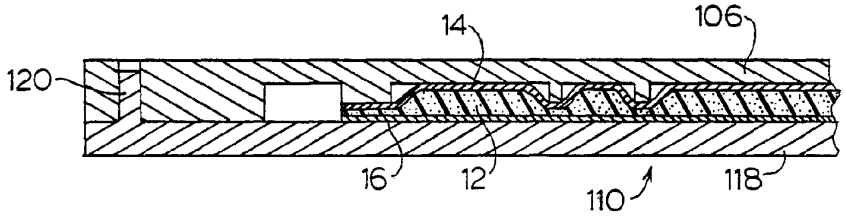


FIG. 12

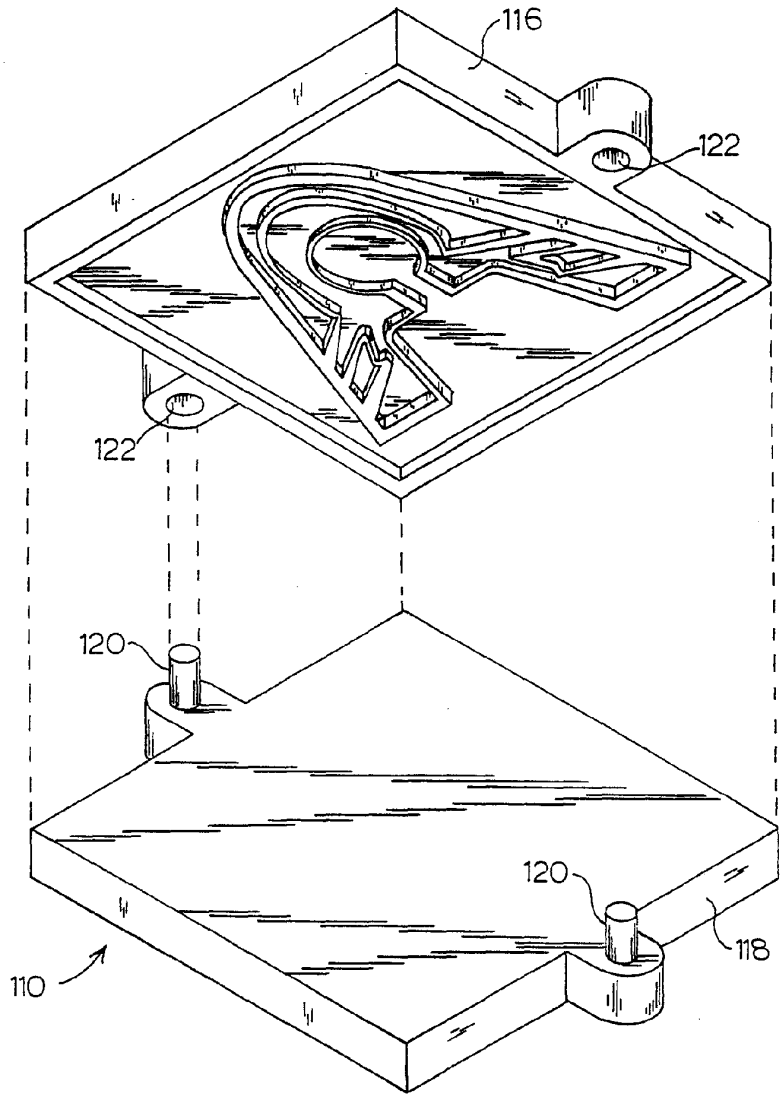


FIG. 13

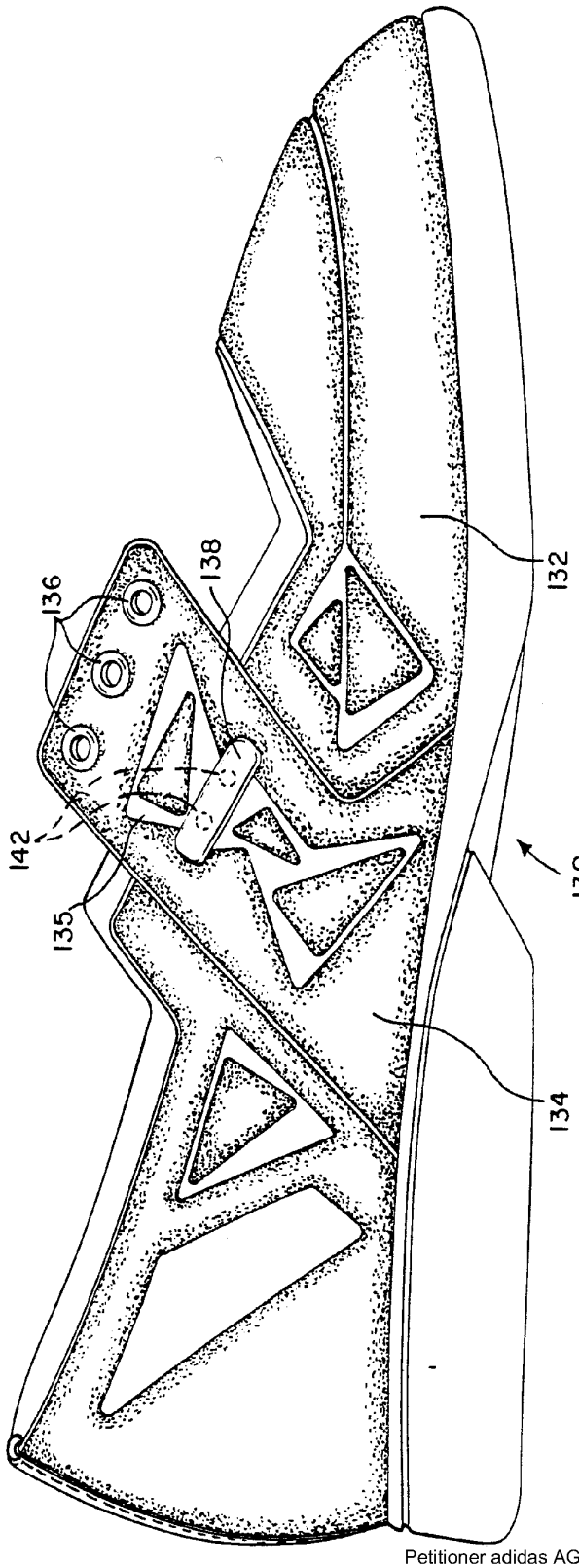


FIG. 14

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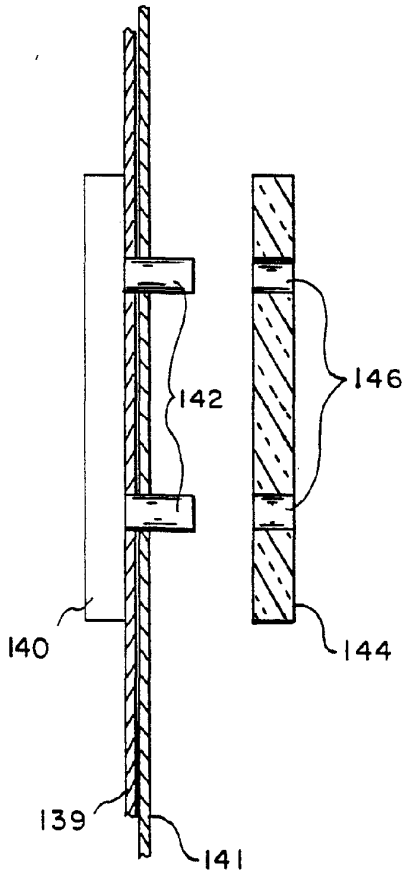


FIG. 15

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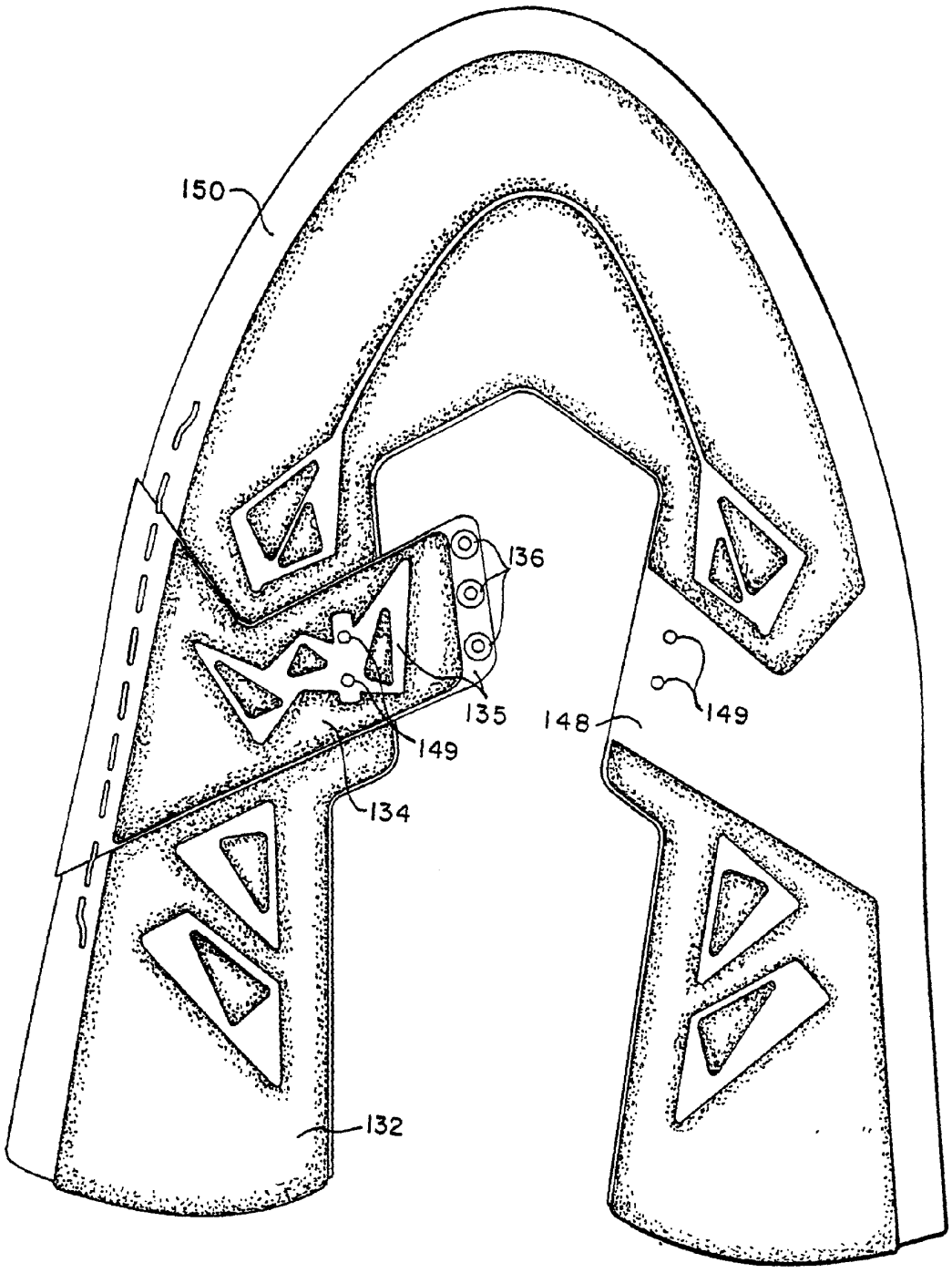


FIG. 16

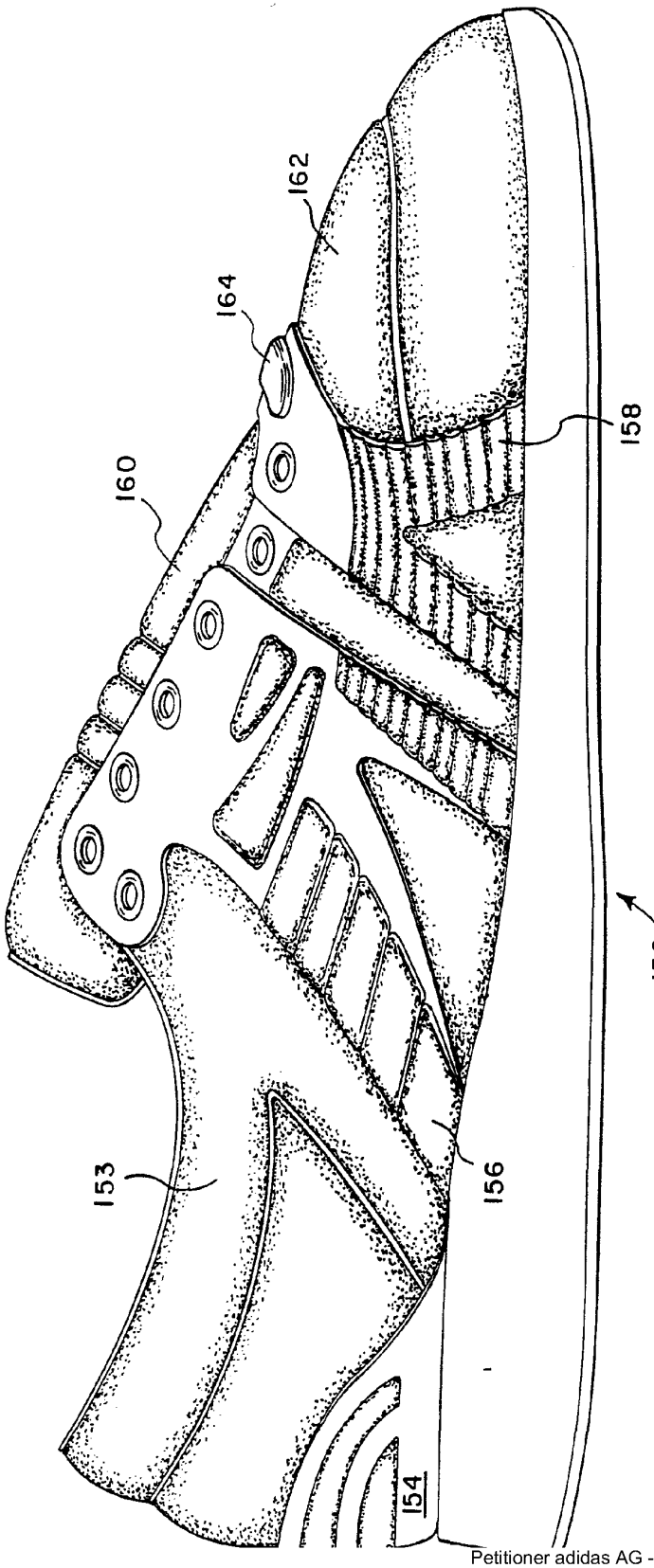


FIG. 17

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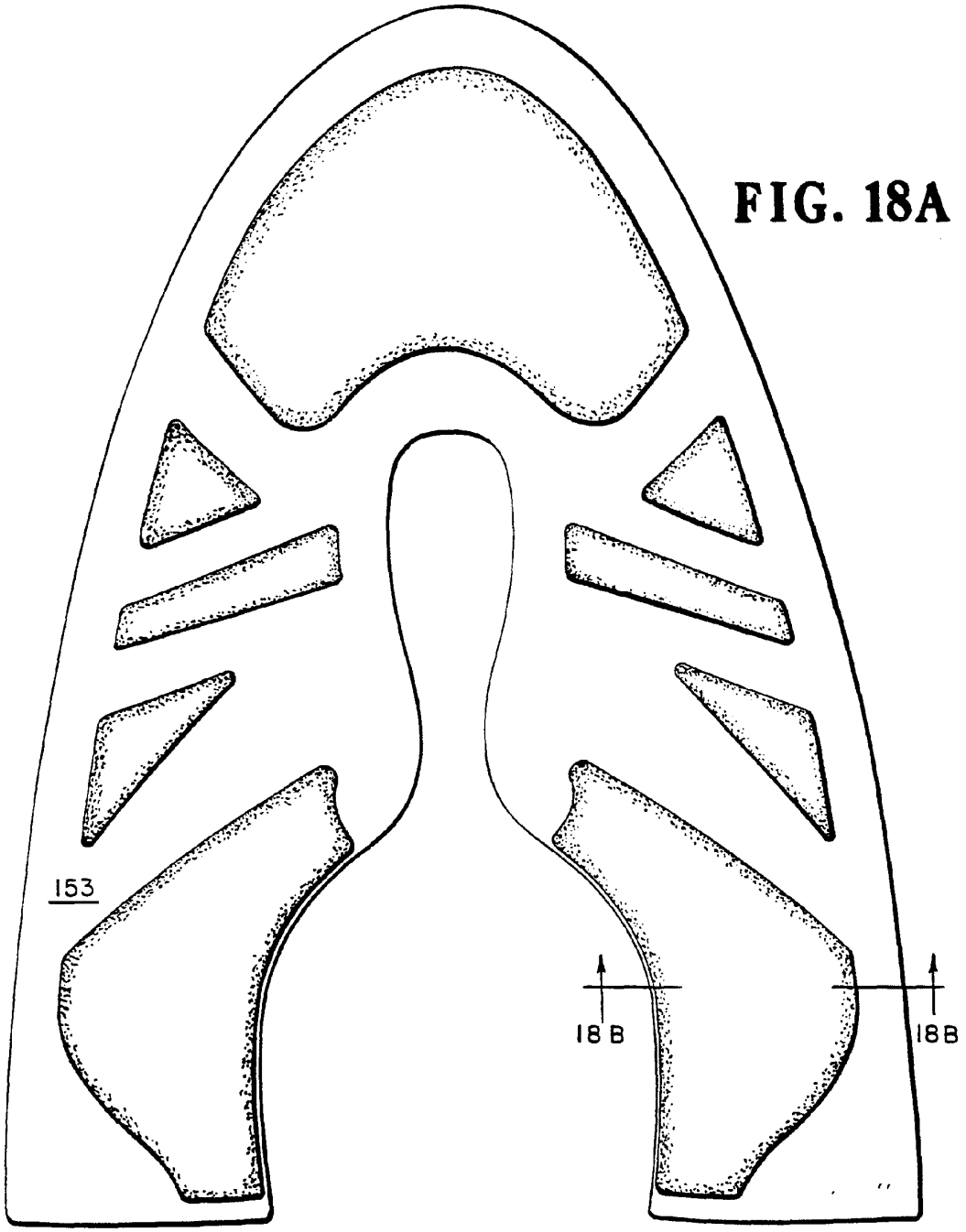


FIG. 18A



FIG. 18B

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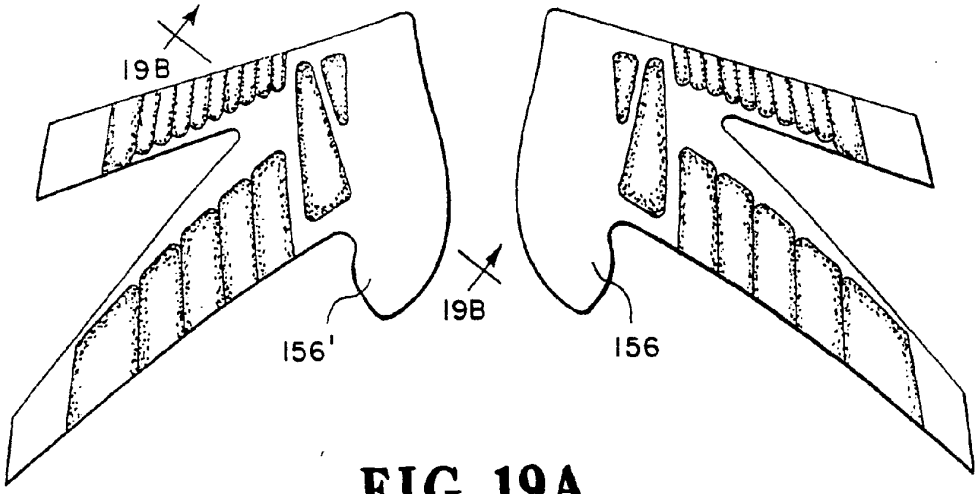


FIG. 19A

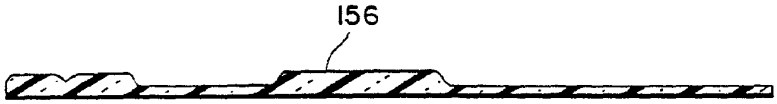


FIG.19B

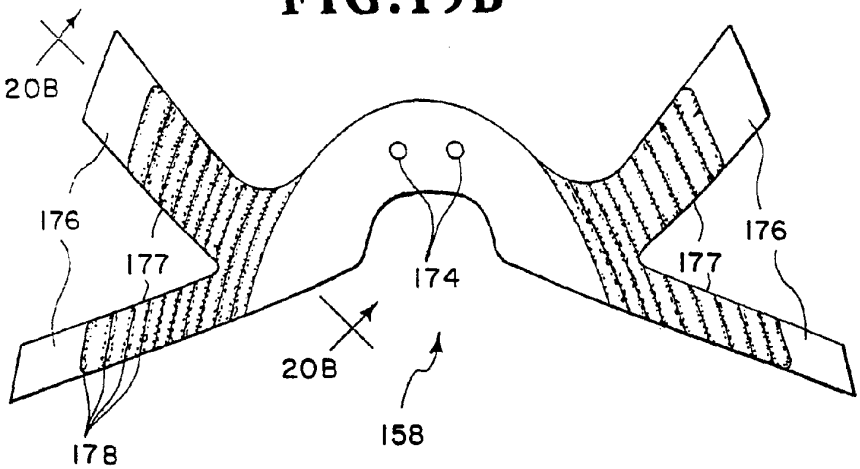


FIG.20A



FIG. 20B

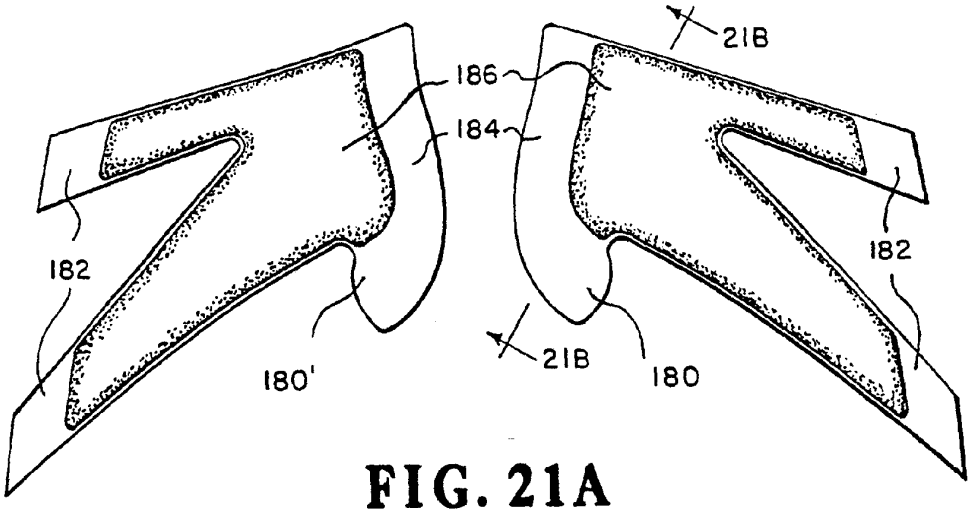


FIG. 21A



FIG. 21B

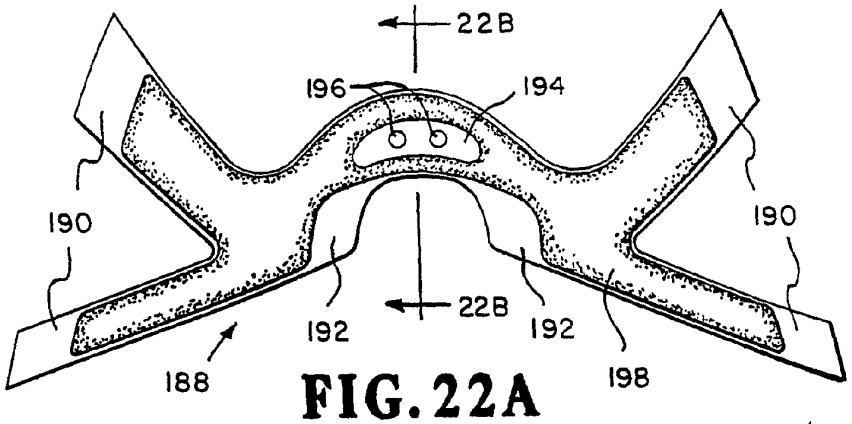


FIG. 22A

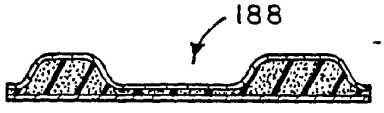


FIG. 22B

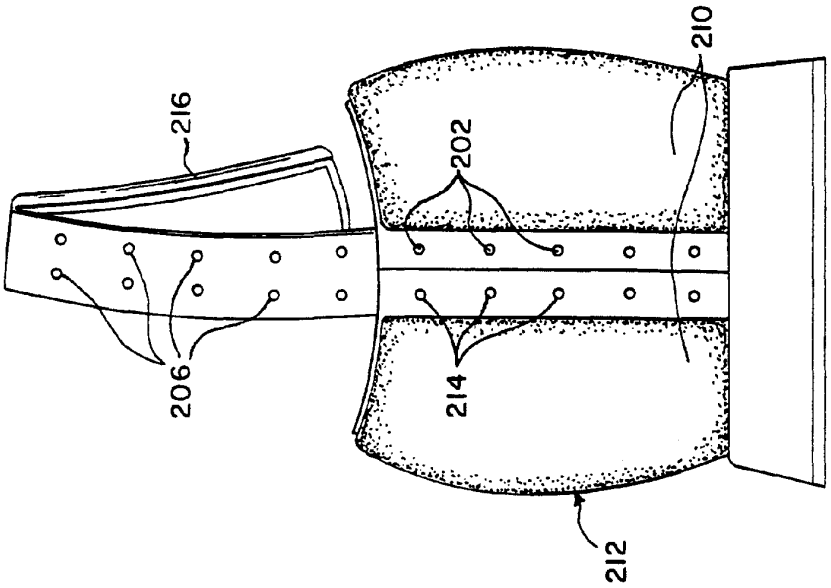


FIG. 23C

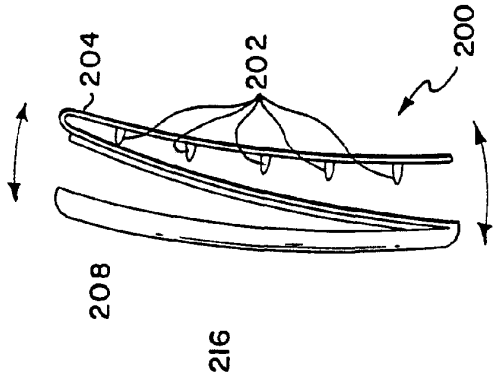


FIG. 23B

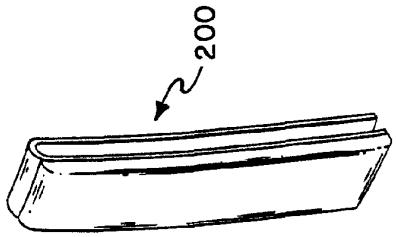


FIG. 23A

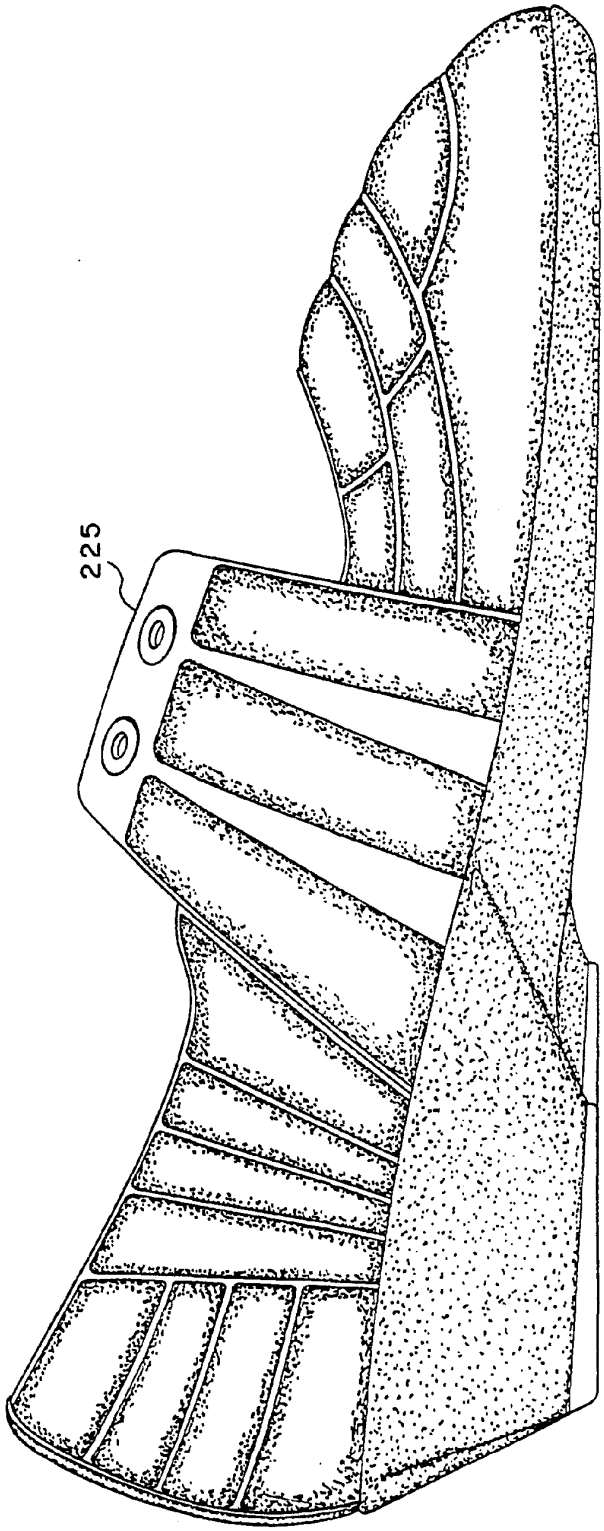


FIG. 24

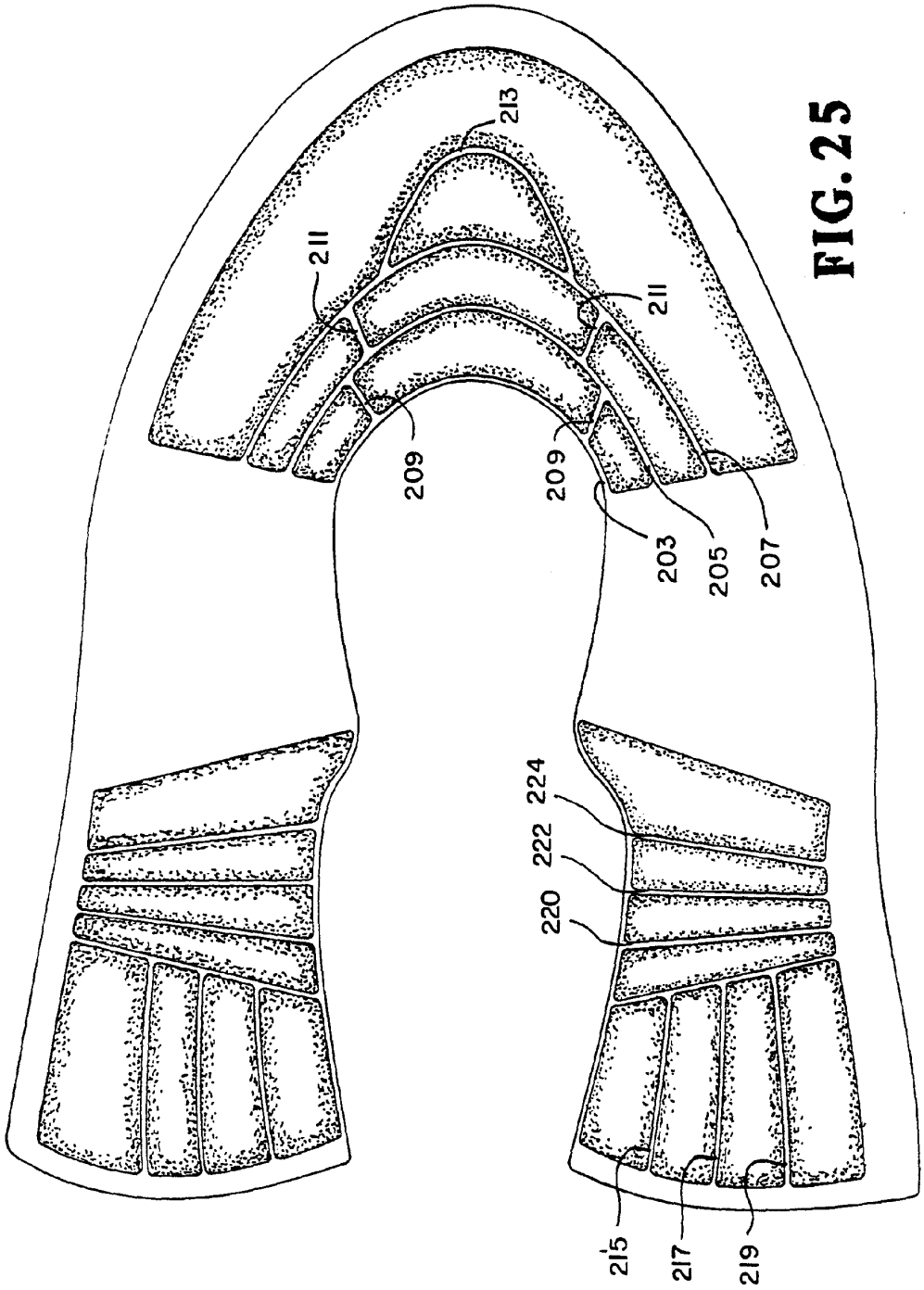


FIG. 25

SUBSTITUTE SHEET

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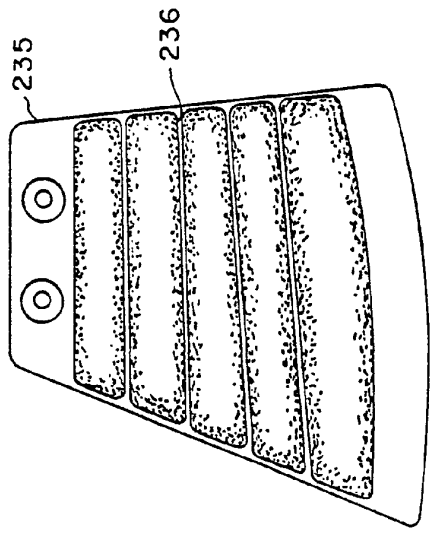


FIG. 28

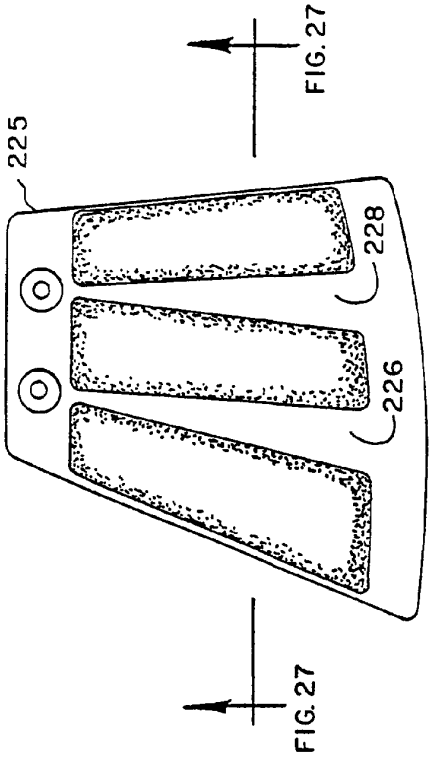


FIG. 26

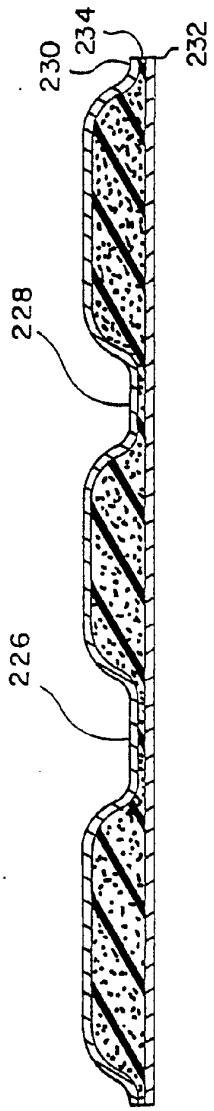


FIG. 27

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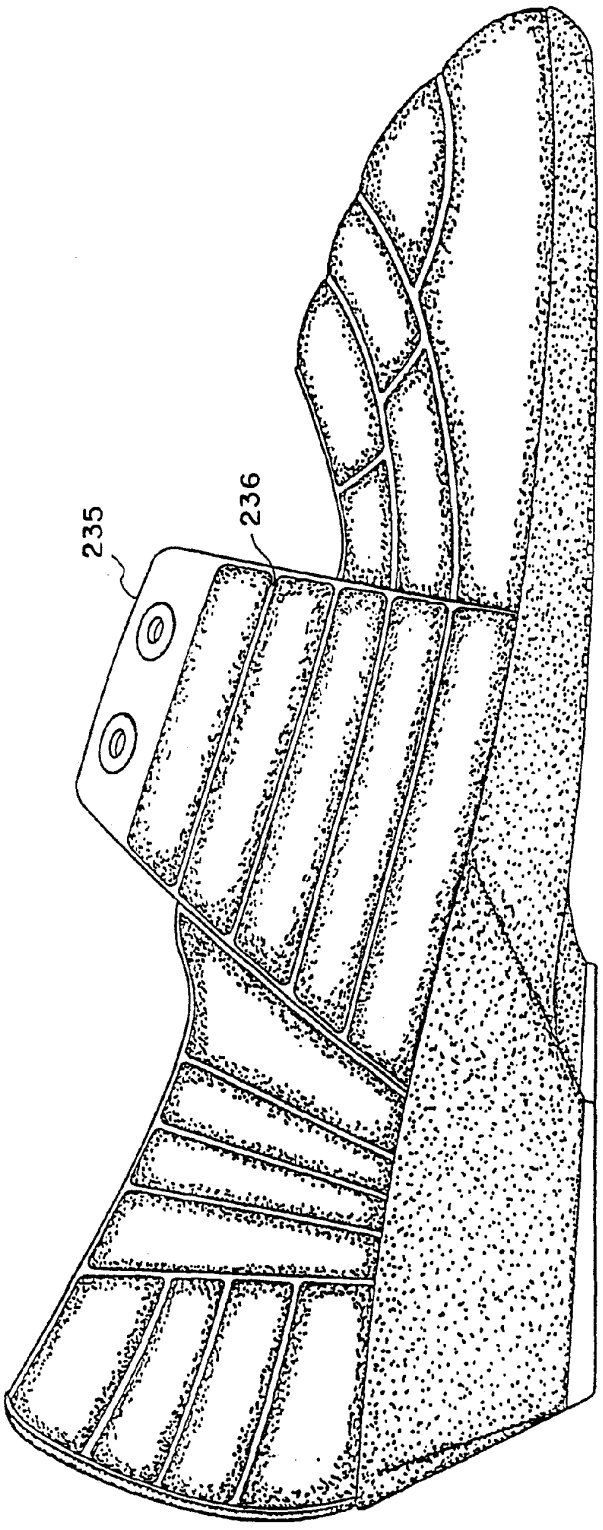


FIG. 29

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 89/04370

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC
IPC5: A 43 D 8/24

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC5	A 43 D; A 43 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	US, A, 2622052 (J.D. CHANDLER) 16 December 1952, see the whole document	1-43
A	US, A, 3130505 (I.I. MARKEVITCH) 28 April 1964, see the whole document	1-43
A	US, A, 3583081 (HIDEO HAYASHI) 8 June 1971, see the whole document	1-43
A	DE, B2, 2235819 (FRITZ WAGNER, MASCHINENFABRIK GMBH & CO KG) 14 February 1974, see the whole document	1-43

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
17th January 1990	12. 02. 90
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	C.D. v.d. Vliet

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO. PCT/US 89/04370

SA 31867

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 08/11/89
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 2622052	16/12/52	NONE	
US-A- 3130505	28/04/64	NONE	
US-A- 3583081	08/06/71	FR-A- 1578531	14/08/69
		GB-A- 1223285	24/02/71
		DE-A- 1785183	04/11/71
		DE-U- 6753371	24/04/69
		DE-U- 6753380	24/04/69
DE-B2- 2235819	14/02/74	DE-A- 2265494	02/12/82

EPO FORM P0479

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

DECLARATION OF DR. EDWARD C. FREDERICK

I. Background and Qualifications

1. I, Dr. Edward C. Frederick, make this declaration in connection with the petition by adidas AG ("adidas") for *Inter Partes* Review of U.S. Patent No. 7,347,011 ("the '011 Patent") owned by Nike, Inc.

2. I make this declaration based upon personal knowledge. I am over age 21 and otherwise competent to make this declaration.

3. The statements herein include my opinions and the bases therefore, which relate to the '011 Patent and various prior art references that disclose features found in the claims of the '011 Patent. Although I am being compensated for my time at a rate of $250 per hour in preparing this declaration, the opinions herein are my own, and I have no stake in the outcome of the review proceeding, My compensation does not depend in any way on the outcome of adidas's petition.

4. I am President of Exeter Research, Inc. in Brentwood, New Hampshire. I have more than thirty years of experience in the sporting goods industry, including extensive experience in footwear design and biomechanics, as well as footwear development and manufacturing. Further, I am an active researcher in footwear biomechanics and have published more than one hundred articles in international journals, books and conference proceedings. In addition, I

am inventor or a co-inventor on 16 issued patents including 10 U.S. utility patents relating to footwear.

5. I have been intimately involved with the creation of more than two-dozen new products over the years and have supervised the design and development of hundreds of new products. This experience encompasses doing the background research to come up with new concepts, developing the product concepts, writing design briefs, creating designs, writing specifications, developing tech packages, managing the step-by-step development of the product, commercializing the product, managing production trials, and hands-on testing as well as managing the testing of the product and its components and materials. The choice of materials, constructions and processes, has been an important part of that experience.

6. A copy of my *curriculum vitae* is attached hereto, and it includes a listing of prior experience as an expert in litigation and patent reexamination matters.

II. Materials Reviewed

7. In forming my opinions, I have reviewed (i) the '011 Patent and its prosecution history that is available on the U.S. Patent Office website; and (ii) prior art to the '011 Patent, including (a) U.S. Patent No. 2,147,197 to Glidden; (b) U.S. Patent No. 2,314,098 to McDonald; (c) U.S. Patent No. 2,641,004 to Whiting;

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(d) U.S. Patent No. 4,785,558 to Shiomura; (e) U.S. Patent No. 5,345,638 to Nishida; (f) PCT International Publication No. WO 90/03744 to Curley; (g) Japanese Patent Publication No. H6-113905 to Osamu Daimaru (including an English translation thereof); and (h) the reference text "Knitting Technology: A comprehensive handbook and practical guide," 3rd edition, by David J. Spencer, published in 2001. I understand the prior art references identified above will be included with the petition for *inter partes* review filed with the U.S. Patent Office.

III. Person of Ordinary Skill in the Art of the '011 Patent

8. Counsel for adidas has informed me that the content of a patent or other printed publication (*e.g.*, prior art reference) should be interpreted the way a person of ordinary skill in the art would have interpreted the reference at the time the application for the '011 Patent was filed in the United States – March 3, 2004.

9. In my opinion, the person of ordinary skill in the art for the '011 Patent would have at least several years' experience with all aspects of shoemaking from the conceptual stage through design, development, commercialization, and manufacturing. The cycle of design and development of a new footwear product takes roughly 18 months and there are seven or more decision points during this cycle where the choice of upper materials and production processes are addressed. The person of ordinary skill has been through many and varied product cycles with projects representing a typical range constructions. In addition, a person of

ordinary skill in the art would have basic knowledge of the functional requirements of footwear and a comprehensive understanding of the range of material choices, as well as construction techniques and processes used to create the various parts of a shoe and to assemble them in a proper manner.

10. I have been asked by adidas's counsel to assume that the person of ordinary skill is a hypothetical person who is assumed to be aware of all the pertinent information that qualifies as prior art. In addition, the person of ordinary skill in the art makes inferences and creative steps. He or she is not an automaton, but has ordinary creativity.

11. Based on my experience, I have an understanding of the capabilities of the skilled person in this field, and my opinions are provided from the perspective of such a person.

IV. Standards for Claim Construction, Anticipation, and Obviousness

12. I understand from counsel for adidas that, in a review proceeding, the claims are to be given their broadest reasonable construction consistent with the patent specification. I also understand that limitations from the specification are not to be read into the claims.

13. Counsel for adidas has informed me that a patent claim is invalid as anticipated (i.e., invalid under 35 U.S.C. § 102) if every limitation of a claim is found identically (either expressly, implicitly, or inherently) in a reference. A

reference inherently discloses the subject matter that a person of ordinary skill in the art would have recognized as necessarily being present in the subject matter disclosed in the reference.

14. Counsel for adidas has also informed me that, by law, a patent may not be obtained though the invention is not identically disclosed or described as set forth in a prior art reference, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious (i.e., invalid under 35 U.S.C. § 103) at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.

15. I have also been informed that, in order for a patent claim to have been obvious, there should be a reasoned explanation as to why collectively the prior art references would have rendered the claimed invention obvious. Depending on the real-world context of the invention described in a patent, various factors or reasons can suffice as a reason to modify or combine the subject matter disclosed in prior art references.

16. These factors and reasons include the following: (a) obvious to try – choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success, (b) common sense, (c) combining or substituting known elements from the prior art to obtain predictable results, (d)

ordinary creativity, (e) whether the need or problem addressed by the patent was known in the prior art, (f) use of known techniques to improve similar devices in the same way, (g) a teaching, suggestion, or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify a reference or combine reference teachings, and (h) when a work is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or a different one. I understand that these factors are identified in the U.S. Supreme Court's decision in *KSR v. Teleflex*.

17. I understand that the Patent Office follows its published guidelines for determining whether a patent claim would have been obvious at the time the invention was made to a person of ordinary skill in the art. Those guidelines are in the Patent Office's "Examination Guidelines for Determining Obviousness Under 35 U.S.C. 103 in View of the Supreme Court Decision in *KSR International Co. v. Teleflex Inc.*" ("*KSR* Guidelines") (http://www.uspto.gov/web/offices/pac/mpep/documents/2100_2141.htm#sect214), and I have read those guidelines and applied them below when I analyze a claim for obviousness.

18. I understand that prior art under 35 U.S.C. § 102(b) includes patents and printed publications that were available more than one year before the

effective filing date of the '011 Patent, i.e. before March 3, 2003. All of the prior art references I discuss in this declaration are prior art under § 102(b).

V. Overview of the '011 Patent

19. The '011 Patent discloses and claims an article of footwear that combines a knitted upper of unitary construction with a sole unit. The upper incorporates a textile element with edges that are joined together to create an upper with an area for receiving a foot. The textile element may also have first and second areas that are parts of a unitary construction. These first and second areas may be made with different stich configurations or different yarns, for example, so that different areas of the upper have different properties (such as, different texture, different elasticity, different breathability, etc.). Various warp knitting or weft knitting processes may be utilized to form the textile element.

20. In the section entitled "Description of Background Art," the '011 Patent explains that the use of various materials for uppers in athletic shoes is well known. For example at 1:44-2:3:

> Various materials may be utilized in manufacturing the upper. The upper of an article of athletic footwear, for example, may be formed from multiple material layers that include an exterior layer, an intermediate layer, and an interior layer. The materials forming the exterior layer of the upper may be selected based upon the properties of wear-resistance, flexibility, and air-permeability, for example. With regard to the exterior layer, the toe area and the heel area may be formed of leather, synthetic leather, or a rubber material to impart a relatively high degree of wear-resistance. Leather, synthetic leather,

> and rubber materials may not exhibit the desired degree of flexibility and air-permeability. Accordingly, various other areas of the exterior layer of the upper may be formed from a synthetic or natural textile. The exterior layer of the upper may be formed, therefore, from numerous material elements that each impart different properties to specific portions of the upper.
>
> An intermediate layer of the upper may be formed from a lightweight polymer foam material that provides cushioning and protects the foot from objects that may contact the upper. Similarly, an interior layer of the upper may be formed of a moisture-wicking textile that removes perspiration from the area immediately surrounding the foot. In some articles of athletic footwear, the various layers may be joined with an adhesive, and stitching may be utilized to join elements within a single layer or to reinforce specific areas of the upper.

21. The '011 Patent explains, however, that textile materials often form at least a portion of the exterior and interior layers of athletic shoes (2:4-14):

> Although the materials selected for the upper vary significantly, textile materials often form at least a portion of the exterior layer and interior layer. A textile may be defined as any manufacture from fibers, filaments, or yarns characterized by flexibility, fineness, and a high ratio of length to thickness. Textiles generally fall into two categories. The first category includes textiles produced directly from webs of filaments or fibers by randomly interlocking to construct non-woven fabrics and felts. The second category includes textiles formed through a mechanical manipulation of yarn, thereby producing a woven fabric, for example.

22. The "Description of Background Art" section then briefly describes the various techniques for mechanically manipulating yarn into textiles, including weaving and knitting (2:36-46):

> The various techniques for mechanically manipulating yarn into a textile include interweaving, intertwining and twisting, and interlooping. Interweaving is the intersection of two yarns that cross

> and interweave at right angles to each other. The yarns utilized in interweaving are conventionally referred to as warp and weft. Intertwining and twisting encompasses procedures such as braiding and knotting where yarns intertwine with each other to form a textile. Interlooping involves the formation of a plurality of columns of intermeshed loops, with knitting being the most common method of interlooping.

23. The '011 Patent explains that using multiple materials to impart different properties to different parts of the upper is an inefficient practice because, for example, materials must often be obtained from multiple suppliers located in different places and different materials may require different machinery or numerous distinct manufacturing steps (2:63-3:8). In addition, the '011 Patent explains that using multiple materials in the upper may detract from breathability of the shoe, and specifically that leather, synthetic leather, and rubber inhibit air flow (3:8-16).

24. Thus, the problems that the '011 Patent identifies are (1) inefficiencies and cost in using multiple materials, and (2) poor breathability of materials like leather (natural or synthetic) and rubber. The proposed solution of the '011 Patent is to make a textile upper as a single material element with a unitary construction.

25. The '011 Patent describes several embodiments of a textile element (40, 40', 40'') in the specification and figures. One embodiment is shown in Fig. 8, and the '011 Patent describes how the parts of the textile element 40 form the upper of the shoe (5:18-34):

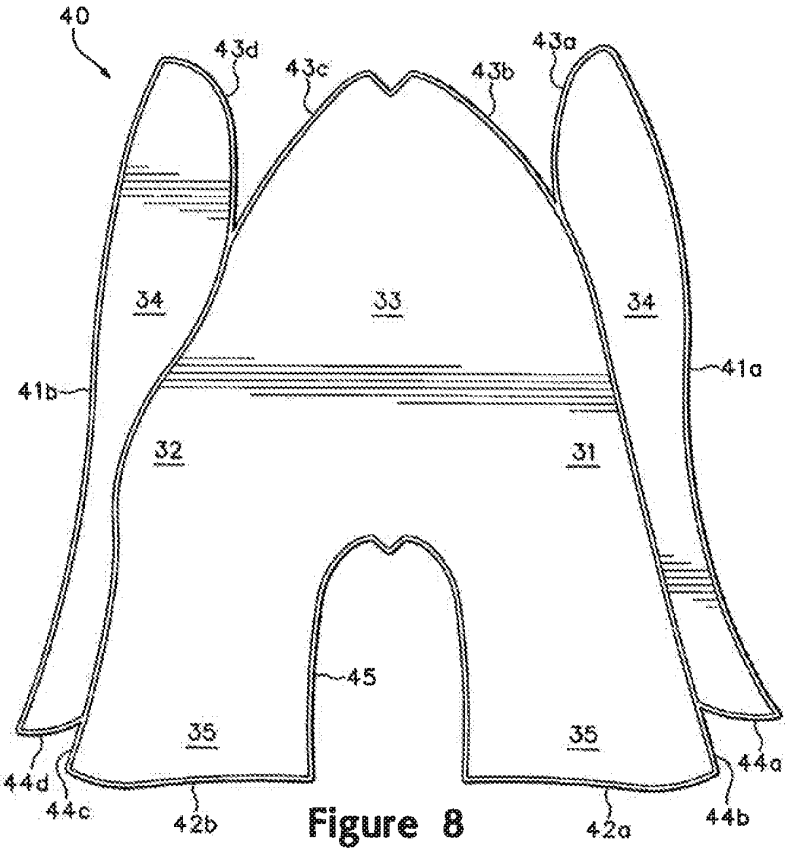


Figure 8

Upper 30 is depicted in FIGS. 2-7 as having a lateral region 31, an opposite medial region 32, an instep region 33, a lower region 34, and a heel region 35. Lateral region 31 extends through a longitudinal length of footwear 10 and is generally configured to contact and cover a lateral side of the foot. Medial region 32 has a similar configuration that generally corresponds with a medial side of the foot. Instep region 33 is positioned between lateral region 31 and medial region 32, and instep region 33 extends over an instep area of the foot. Lower region 34 forms a bottom surface of upper 30 and also extends through the longitudinal length of footwear 10. Heel region 35 forms a rear portion of upper 30 and is generally configured to contact and cover a heel area of the foot. In addition, lateral region 31, medial region 32, instep region 33, and heel region 35 cooperatively define an ankle opening 36 for providing the foot with access to the void within upper 30.

26. The '011 Patent explains how the various edges of the textile element are joined together, forming several seams along the heel, toe, and longitudinal length of the bottom of upper, to make the shape of the upper, and the upper is then secured to the sole. (5:41-6:40)

27. The '011 Patent emphasizes that the textile element is a single material element with unitary construction (6:41-50):

> Textile element 40 is a single material element with a unitary construction, as discussed above. As defined for purposes of the present invention, unitary construction is intended to express a configuration wherein portions of a textile element are not joined together by seams or other connections, as depicted with textile element 40 in FIG. 8. Although the various edges 41a-44d are joined together to form seams 51-54, the various portions of textile element 40 are formed as an unitary element without seams, as discussed below.

28. The '011 Patent describes that the textile element may be formed any number of ways with one or more yarns that are mechanically manipulated using a variety of existing processes (6:51-65):

> Textile element 40 is primarily formed from one or more yarns that are mechanically-manipulated through either an interweaving, intertwining and twisting, or interlooping process, for example. As discussed in the Background of the Invention section above, interweaving is the intersection of two yarns that cross and interweave at right angles to each other. The yarns utilized in interweaving are conventionally referred to as warp and weft. Intertwining and twisting encompasses procedures such as braiding and knotting where yarns intertwine with each other to form a textile. Interlooping involves the formation of a plurality of columns of intermeshed loops, with knitting being the most common method of interlooping. Textile

element 40 may, therefore, be formed from one of these processes for manufacturing a textile.

The '011 Patent continues by identifying several types of knitting and knitting machines that may be used, including a machine from Santoni S.p.A. in Italy that the patent identifies by model number. (6:66-7:27)

29. Fig. 10 from the '011 Patent shows another embodiment of a textile element described therein, where the textile element has different configurations in different areas:

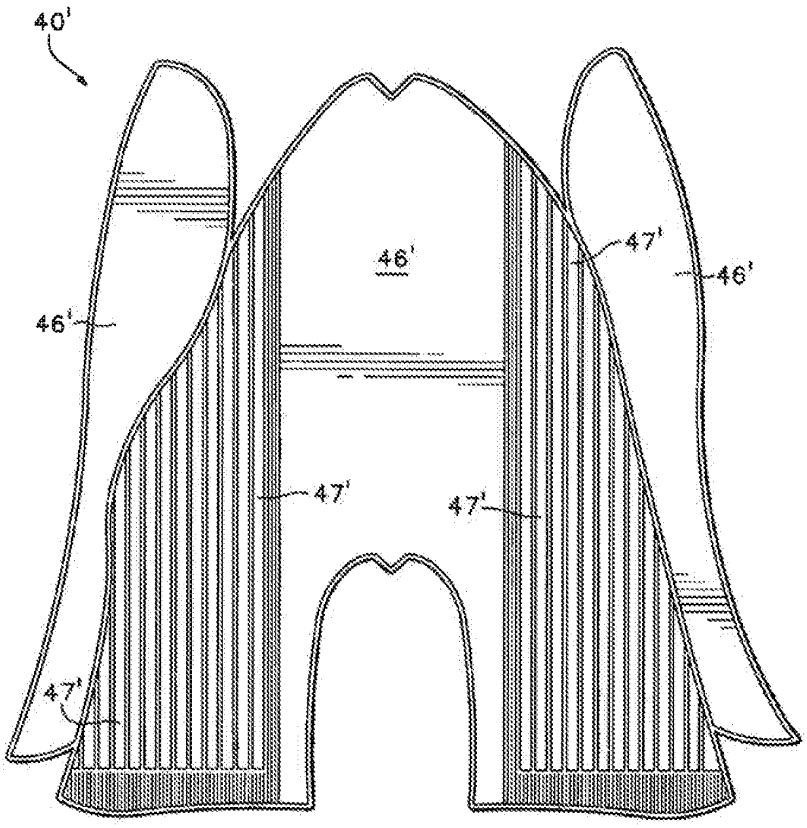


Figure 10

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30. The area that corresponds with the instep region has a first texture 46' that is generally smooth, while the areas that correspond with the lateral and medial regions have a second texture 47' that is a plurality of longitudinal ribs. (9:13-21) The patent states that the ribs may be present for aesthetic purposes or may affect the stretch properties of the upper. (9:21-23) The varying textures may be obtained by varying the stitch types in the different areas or by varying the type of yarn. (9:65-10:1) Changing the yarn type can also be used to impart different properties in different areas, beyond just texture differences. (10:1-14)

31. The '011 Patent explains how the inventors believed this was different from conventional articles of footwear (9:23-35):

> Accordingly, textile element 40' exhibits areas with different textures in a single element of textile material.
>
> Many conventional articles of footwear incorporate uppers with various material elements that each exhibit different properties. For example, a first material element may be smooth, and a second material element may be textured. The first and second material elements are then stitched together to form a portion of the conventional upper. Textile element 40' also exhibits smooth and textured areas. In contrast with the conventional upper, however, first texture 46' and second texture 47' are incorporated into a single, unitary element of textile, rather than two separate elements that are stitched or otherwise joined together.

32. The '011 Patent also discloses an embodiment that has areas with three different textures. (Fig. 11; 9:36-64).

33. The '011 patent includes claims 1-46, of which claims 1, 16, 24, 36 and 44 are the independent claims. All of the independent claims require a sole secured to a knitted upper, with the upper having a plurality of knit constructions (claims 1, 24, 36) or two areas with different constructions or stitch configurations (claims 16, 44). All of the claims are reproduced below:

Nike '011 Patent Claims
1. An article of footwear comprising:
an upper incorporating a weft-knitted textile element having edges that are joined together to define at least a portion of a void for receiving a foot,
wherein the weft-knitted textile element incorporates a single type of textile having a plurality of knit constructions; and
a sole structure secured to the upper.
2. The article of footwear recited in claim 1, wherein the weft-knitted textile element forms at least a portion of a lateral side, a medial side, and an instep region of the upper.
3. The article of footwear recited in claim 1, wherein the edges include a pair of first edges that are joined to form a first seam extending longitudinally along a lower region of the upper.
4. The article of footwear recited in claim 3, wherein the edges include a pair of second edges that are joined to form a second seam extending along a heel region of the upper.
5. The article of footwear recited in claim 4, wherein the second seam extends vertically.
6. The article of footwear recited in claim 4, wherein the edges include at least a pair of third edges that are joined to form a third seam extending through a forefoot area of the upper.

Nike '011 Patent Claims
7. The article of footwear recited in claim 1, wherein the weft-knitted textile element is one of an exterior layer, an intermediate layer, and an interior layer of the upper.
8. The article of footwear recited in claim 1, wherein the upper includes an exterior layer, an intermediate layer, and an interior layer, and the weft-knitted textile element forms at least a portion of the interior layer.
9 The article of footwear recited in claim 1, wherein the weft-knitted textile element forms at least a portion of both an interior surface and an exterior surface of the upper.
10. The article of footwear recited in claim 9, wherein at least one additional element is secured to the exterior surface and forms a portion of the exterior surface.
11. The article of footwear recited in claim 10, wherein the additional element is secured to a forefoot area of the upper.
12. The article of footwear recited in claim 10, wherein the additional element is secured to a heel area of the upper.
13. The article of footwear recited in claim 1, wherein the textile element forms an interior surface of the upper.
14. The article of footwear recited in claim 1, wherein the weft-knitted textile element is created by circular knitting.
15. The article of footwear recited in claim 1, wherein the weft-knitted textile element is created by flat knitting.
16. An article of footwear comprising:
an upper incorporating a weft-knitted textile element, the textile element having a first area and a second area with a unitary construction,
the first area being formed of a first stitch configuration, and the second area being formed of a second stitch configuration that is different from the first stitch configuration to impart varying properties to the textile element; and

Nike '011 Patent Claims
a sole structure secured to the upper.
17. The article of footwear recited in claim 16, wherein the first stitch configuration provides a substantially smooth texture to the first area, and the second stitch configuration provides a texture to the second area that is rougher than the smooth texture.
18. The article of footwear recited in claim 17, wherein the second stitch configuration forms a rib structure in the second area.
19. The article of footwear recited in claim 16, wherein at least one of the first stitch configuration and the second stitch configuration forms an aperture in the weft-knitted textile element.
20. The article of footwear recited in claim 16, wherein the weft-knitted textile element is one of an exterior layer, an intermediate layer, and an interior layer of the upper.
21. The article of footwear recited in claim 16, wherein the upper includes an exterior layer, an intermediate layer, and an interior layer, and the weft-knitted textile element forms at least a portion of the interior layer.
22. The article of footwear recited in claim 16, wherein the textile layer forms at least a portion of both the interior surface and an exterior surface of the upper.
23. The article of footwear recited in claim 16, wherein the weft-knitted textile element forms an interior surface of the upper.
24. An article of footwear comprising:
an upper incorporating a textile element having edges that are joined together to form seams and define at least a portion of a void for receiving a foot,
the seams including a first seam and a second seam, the first seam extending from a heel area to a forefoot area of the footwear along a lower surface of the upper, and the second seam extending vertically in the heel area,
wherein the textile element incorporates a single type of textile having a plurality of knit constructions; and

Nike '011 Patent Claims
a sole structure secured to the upper.
25. The article of footwear recited in claim 24, wherein the footwear includes a third seam extending through the forefoot area of the upper.
26. The article of footwear recited in claim 24, wherein at least one of the knit constructions forms an aperture in the textile element.
27. The article of footwear recited in claim 24, wherein the knit constructions produce varying properties in the textile element including a varying elasticity of the textile element.
28. The article of footwear recited in claim 24, wherein the knit constructions produce varying properties in the textile element including a varying air permeability of the textile element.
29. The article of footwear recited in claim 24, wherein the textile element is one of an exterior layer, an intermediate layer, and an interior layer of the upper.
30. The article of footwear recited in claim 24, wherein the textile element forms at least a portion of both an interior surface and an exterior surface of the upper.
31. The article of footwear recited in claim 24, wherein the textile element forms an interior surface of the footwear, and at least one additional layer forms an exterior surface of the footwear.
32. The article of footwear recited in claim 24, wherein at least a portion of the textile element has a weft knitted construction.
33. The article of footwear recited in claim 32, wherein the weft knitted construction is produced by one of circular knitting and flat knitting.
34. The article of footwear recited in claim 24, wherein the textile element has a warp knitted construction.
35. The article of footwear recited in claim 34, wherein the warp knitted construction is produced by a jacquard double needle-bar raschel.
36. An article of footwear comprising:

Nike '011 Patent Claims
an upper incorporating a knitted textile element formed with a knitting machine, the textile element being removed from a textile structure that includes an outline of the textile element, and
the textile element having edges that are joined together to define at least a portion of a void for receiving a foot,
wherein the textile element incorporates a single type of textile having a plurality of knit constructions; and
a sole structure secured to the upper.
37. The article of footwear recited in claim 36, wherein the knitted textile element has a structure formed by a wide-tube circular knitting machine.
38. The article of footwear recited in claim 36, wherein the knitted textile element has a structure formed by a jacquard double needle-bar raschel knitting machine.
39. The article of footwear recited in claim 36, wherein the edges include a pair of first edges that are joined to form a first seam extending longitudinally along a lower region of the upper.
40. The article of footwear recited in claim 39, wherein the edges include a pair of second edges that are joined to form a second seam extending along a heel region of the upper.
41. The article of footwear recited in claim 40, wherein the edges include at least a pair of third edges that are joined to form a second seam extending through a forefoot area of the upper.
42. The article of footwear recited in claim 36, wherein the knitted textile element is one of an exterior layer, an intermediate layer, and an interior layer of the upper.
43. The article of footwear recited in claim 36, wherein the knitted textile element forms an interior surface of the upper.
44. An article of footwear comprising:

Nike '011 Patent Claims
an upper incorporating a flat-knitted textile element, the flat-knitted textile element having a first area with a first unitary construction and a second area with a second unitary construction different from the first unitary construction,
the first area having a first set of properties, and the second area having a second set of properties that is different from the first set of properties to impart varying characteristics to the textile element; and
a sole structure secured to the upper.
45. The article of footwear recited in claim 44, wherein the first set of properties and the second set of properties are at least one of a stitch configuration and a yarn type.
46. The article of footwear recited in claim 44, wherein the textile element is one of an exterior layer, an intermediate layer, and an interior layer of the upper.

34. Although the '011 Patent has 46 claims, many of the claims recite many of the same features repeatedly, just in slightly different combinations. In other words, the actual subject matter claimed across all 46 claims is not very extensive.

35. For example, all five independent claims have some common features – an upper incorporating a knitted textile element and a sole structure secured to the upper. (Claims 1, 16, 24, 36, 44) Claims 1 and 16 further state that the textile element is "weft-knitted," while claim 44 states it is "flat-knitted." Claims 16 and 44 require the textile element to have a unitary construction with two different areas that have varying characteristics or properties. In claim 16, the two areas

have different stitch configurations to impart the varying properties, while claim 44 requires different constructions in the two areas to impart varying characteristics. Claims 1, 24, and 36 state that the textile element has "edges that are joined together to define at least a portion of a void for receiving a foot" and that "textile element incorporates a single type of textile having a plurality of knit constructions."[1] Claim 24 adds that two seams are formed (one from heel to forefoot, the second vertically in the heel), while claim 36 adds that the textile element is removed from a textile structure that has an outline of the textile element.

36. The dependent claims are likewise repetitive and add minor additional features to what is being claimed as the invention, for example:

- specific seams formed in the upper (claims 3-6, 25, 39-41)
- the textile element forms one of an interior, intermediate, or exterior layer (claims 7, 20, 29, 42, 46)

[1] By "single type of textile," I understand the claims to be saying the textile element is a single material element made with one or more yarns. The '011 Patent states that: (a) "textile element 40 is a single material element that is formed to exhibit a unitary (i.e., one piece) construction" (5:38-39); (b) "textile element 40 is primarily formed from one or more yarns that are mechanically-manipulated through either interweaving, intertwining and twisting, or interloping process for example (6:51-54); (c) "accordingly, textile element 40' exhibits areas with different textures in a single element of textile material" (9:23-24); (d) "in contrast with the conventional upper, however, first texture 46' and second texture 47' are incorporated into a single, unitary element of textile, rather than two separate elements that are stitched or otherwise joined together" (9:32-35).

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- the upper has interior, intermediate, or exterior layers and the textile element forms at least portion of interior layer (claims 8, 21)
- the textile element forms a portion of both interior and exterior surface of upper (claim 9, 22)
- an additional element secured to and forming portion of exterior surface (claims 10-12)
- the textile element forms interior surface of upper (claim 13, 23, 43)
- circular knitting or circular knitting machine is used (claims 14, 33, 37)
- flat knitting is used (claims 15, 33)
- varying stitch configurations, or smooth, rougher/ribbed stitching (claims 17, 18, 45)
- apertures in the textile element (claims 19, 26)
- warp knitting and specific type of machine (claims 24, 35, 38)

VI. Overview of the Prior Art and the Trivial Nature of the Features Claimed in the '011 Patent.

37. The claims of the '011 Patent recite features that were well known in the prior art in March 3, 2004, when the application for the '011 Patent was filed.

38. Knitted uppers of a unitary construction with modifications of stitches, yarn types, patterns, or constructions in different areas for creating various functional regions have been known for decades. For example, such constructions have been described in detail in several U.S. patents, including U.S. Patent No.

5,345,638 to Nishida ("Nishida"), U.S. Patent No. 2,147,197 to Glidden ("Glidden"), and U.S. Patent No. 2,314,098 to McDonald ("McDonald"). Japanese Patent Publication No. H6-113905 to Osamu Daimaru ("Osamu") describes a similar unitary upper made with a woven fabric, instead of a knit.

39. I have reviewed other prior art, some of which is relevant to some of the dependent claims, including U.S. Patent No. 2,641,004 to Whiting ("Whiting"), U.S. Patent No. 4,785,558 to Shiomura ("Shiomura"); and PCT International Publication No. WO 90/03744 to Curley ("Curley"). These prior art references describe additional features of shoe uppers made with knitted fabrics. I also consulted the reference text "Knitting Technology: A comprehensive handbook and practical guide," 3rd edition, by David J. Spencer, published in 2001 ("Spencer"). All of these references are prior art under 35 U.S.C. § 102(b) (mentioned in above in Section IV), as they were all published more than one year before Nike filed the application for the '011 Patent on March 3, 2004.

40. A central teaching of the '011 Patent is that knitting complete uppers is more efficient than joining together separately made pieces of various materials. This is common sense, and it was also taught by Nishida, Glidden, and McDonald well before the '011 Patent application was filed.

41. For example, Nishida states "For production of a shoe upper by cutting out the shoe upper in the form of a layout from a web of material, shaping

of the shoe upper with connection of material parts of the layout with formation of seams, a process is used by which such shoe uppers can be produced in a time saving and efficient manner despite the many individual parts present or to be made visible." (Nishida, Abstract) Glidden discloses that "The principal objects of the present invention are to provide comfort, stretchability, light weight, breathability, and absorption in an article of footwear and to provide for economy of materials and convenience of procedure in the manufacture of same." (Glidden, p.1, 1:25-30) Finally, McDonald explains that "By my improvements, a comfortable and relatively durable and attractive shoe may be produced at a minimum cost by unskilled workers and without any need for the expensive shoe-making machinery ordinarily deemed necessary for economical shoe manufacturing." (McDonald, p. 2, 2:18-23)

42. Indeed, the idea of a unitary construction itself is an ancient idea, harkening back to moccasin construction techniques. Moccasins are made from an upper cut from a single piece of leather and stitched together by joining a limited number of pre-cut edges to form a shoe. This is a most efficient method of shoemaking that is still practiced today, but it has limitations.

43. Because only a single material is used for the upper, it can be challenging to take advantage of what we know and have known for some time about regional functional requirements. Shoe designers and engineers have long

considered uppers as having regionally distinct functional zones. For example, certain areas would be intentionally designed to have more or less stretch, more or less breathability, more or less durability, or, more or less friction. Such regions are designed with different physical properties and for the last 30+ years it has been quite common to use different materials in certain areas to provide the desired properties.

44. However, there is no requirement to use different materials, and it has been known that a single material could be used. With companies more concerned in the last decade with the environment and reducing waste, it is only logical that companies may look to return to uppers made with a single material or a greatly reduced number of materials.

45. From the 1980s until the present, it has been a requirement of running shoes and other sports shoes that these regional upper requirements be addressed. Therefore, it is not novel that knit uppers would be made with specific textile elements that address these requirements. Some of these regional requirements go back even further.

46. For example, shoe designers and engineers have specifically addressed the requirement for breathability since the first Converse Chuck Taylor basketball shoes were made almost 100 years ago with two extra holes in the upper for enhancing breathability. The notion that shoe uppers should be breathable is

quite an old idea and shoes with apertures for enhancing breathability and with special mesh panels incorporated into the upper to increase air exchange have been part of the shoe design for decades. Similarly, wear patches, such as the ankle patches in the early Converse Chuck Taylors have also been used to enhance durability or protection in distinct areas of that upper.

47. Everyone who has worked in the athletic shoe industry for at least a few years over the last 30 years knows about the regional functional requirements of uppers.

48. Further to this point, these specially constructed regions for durability, support, or breathability are described in Nishida and Glidden. For example, Nishida (3:43-48) discloses "Since, generally, toe area 14 is designed to be relatively deformably soft or elastic, and optionally, also permeable to air, the web of material 1, in toe area 14, according to the present invention, is correspondingly designed by suitable selection of the weave pattern, knit pattern and/or material used …." Glidden, in another example, states that "In fabricating the unitary upper, as by knitting, areas thereof which are normally subjected to greater wear and in which a lower degree of elasticity is desired, such as the toe 11 and the heel portion 12, may be more densely fabricated to provide therein heavier weight and less extensibility than in the other parts of the upper, as by changing the type of stitch or amount or thickness of the yarn in the knitting." (Glidden, p.1, 2:33-41)

49. One-piece knitted uppers having areas made differently to address the different functional regions of the upper were well known before March 2004.

50. As noted above, the '011 Patent describes that the one-piece textile element can be made using any number of processes for mechanically manipulating yarns, including weaving and knitting. The claims though often require some specific type of knitting (e.g., "weft" for claims 1 and 16, "flat" for claim 44; many of the dependent claims also require circular, warp, or specific knitting machines). In fact, many of the dependent claims are nothing more than a recitation of one machine or one technique from a laundry list of knitting machines and techniques and appear intended to encompass the widest possible set of options for choosing a knitted material or materials for construction of the upper.

51. These are common design choices that are made everyday by shoemakers. It would have been obvious in March 2004 to the skilled person to select a particular type of knitted upper material from among the long list of options and machines that were known in the art.

52. There is nothing of special significance about weft-knitting from a functional or design point of view. In fact, materials with overlapping functional requirements can be made by either weft or warp knitting. A skilled person would understand that any selection of circular, flat, or warp, or any particular machine that knits textiles in any of these manners, is nothing more than a simple design

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choice from among a number of known, available choices that have been available to the shoe designer and engineer for many years.

53. Indeed the '011 Patent spells this out clearly at the bottom of column 6 and continued in column 7. It describes the use of various processes for forming the necessary textile element of the invention, including interweaving, intertwining or twisting, or interloping processes. ('011 Patent, 6:51-53) In column 7, the '011 Patent goes on to describe the use of warp knitting including the sub-types tricot, racschel, double needle-bar raschel and jacquard double needle-bar raschel, as well as weft knitting and its sub-types described including circular and flat knitting. ('011 Patent, 7:1-10) Significantly, the '011 Patent states that the textile element may be formed through any of the mechanical processes discussed in the specification. ('011 Patent, 6:63-65; 7:11-12)

54. Weft knit describes a type of knitted fabric in which yarns are formed into stitches in widthwise manner. Common examples of weft knits are circular knits and flat knits.

(Fabriclink.com; http://www.fabriclink.com/dictionaries/textile.cfm#W).

Examples of weft knit fabrics used in footwear are: spacer meshes; nylon, polyester, and, cotton meshes; weft-knit polyester suedes; terry; ribbed knits, and jersey. Some jacquard knit are also weft double-knit fabrics.

55. Warp knitting is a type of knitted fabric construction in which the yarns are formed into stitches in a lengthwise manner, i.e., along the length of the fabric. Warp knits are generally less elastic than weft knits. Common examples of warp knits used in footwear uppers are tricot knits and raschel knits.

56. The Spencer reference text mentioned above explains knitting processes and machines in great detail. An excerpt from the reference textbook entitled "Clothing Technology," Third English edition, by Hannelore Eberle (and others) published in 2002 (Beuth-Verlag GmbH) provides a definition and summary graphic showing that knitted fabrics are generally classified as weft or warp, and that weft knits may be made with flat or circular machines. These things were well known to the skilled person decades before March 2004. I understand the "Clothing Technology" excerpt will be included with the petition for *inter partes* review filed with the U.S. Patent Office, but I have also reproduced it below for reference:

3 Textile Fabrics
3.3 Knitted Fabrics

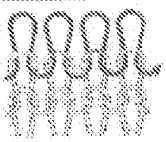
3.3.1 Classification of Knitted Fabrics

Definition after ISO 1806: 1984

Knitted fabrics are made from interlocking loops, formed from a single yarn or from many.
They are classified into weft knitted and warp knitted fabrics.

KNITTED FABRICS

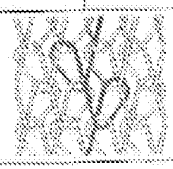
WEFT KNITTED



Characteristics

- May be made from a single yarn.
- The yarn is fed crosswise to the length of the fabric.
- Can be unravelled, may ladder.
- Knitting needles can work sequentially or all together.

WARP KNITTED



Characteristics

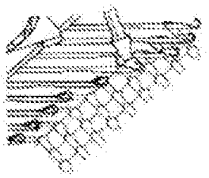
- Requires a full warp sheet.
- The loop-forming yarns are fed in the direction of the length of the fabric.
- Can not be unravelled, usually does not ladder.
- Knitting needles always work together as a unit.

Production

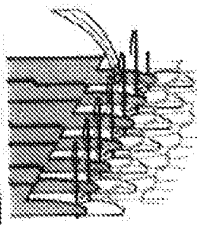
WEFT KNITTED FABRICS

Sequential needles:
Loops are formed in sequence across the width of the fabric. Machines can be flat or circular. Needles are usually of the latch type.

Simultaneous needles:
All of the needles are moved together or the needles are stationary and the fabric is moved. Machines can be flat or circular. Needles are usually of the bearded type.



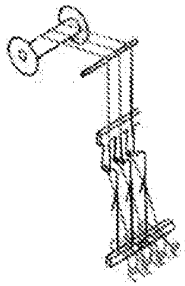
1: Sequential loop formation on a flat machine



2: Simultaneous loop formation

WARP KNITTED FABRICS

Warp knitting:
Warp knitting uses one or more warp sheets. Each yarn is looped around a needle and the needles are all moved together. The needles may be of the bearded, latch, or compound type. Warp knitting machines with latch or compound needles are called raschel machines and the material they make is called raschel fabric.



3: Loop formation on a warp knitting machine

83

57. Although it is possible to make some generalizations about weft versus warp knits, they are just that – generalizations. They do not represent the elucidation of exclusive properties. The more relevant point is that the functional properties of all possible warp-knit and weft-knit fabrics overlap. In other words, it is possible to produce fabrics with a wide range of functional properties such as stretch, breathability, durability, and so on using either technique.

58. The prior art I reviewed shows that both warp knitting and weft knitting, including the various sub-types identified in the '011 Patent, are well known:

- McDonald (p. 1, 2:26-39): "In the embodiment of my invention illustrated in Figs. 1 and 2, a seamless sock is knit on a conventional type of circular knitting machine with a top welt of ribbed fabric having stretchable elastic threads 2 knit circumferentially therein in any usual manner to form a stretchable elastic welt, as for instance in the manner illustrated in Letters Patent Nos. 630,110, 1,883,303, 1,929,006, or any of the other known methods of incorporating in a weft knit fabric stretchable elastic threads composed of wrapped cores of extruded or cut rubber or rubber substitutes of which the stretchable elastic yarns used in my invention are composed."

- Whiting (2:53-56): "It will be realized that the sock may be otherwise produced, whether initially seamless or not, as by knitting the same on flat or circular knitting machines…."

- Curley (pp. 7-8): "In one preferred embodiment, the outer layer is a warp knit fabric classified as 'tricot'….In particular, two bar knits such as full tricot and warp lockknit have shown particularly good characteristics with regard to the molding process as well as end use. In another preferred embodiment, the outer layer is a weft knit fabric of jersey, rib, or purl designation"

- Shiomura (3:4-15): "The above-mentioned shoe upper can be easily knitted using a knitting machine such as a tricot knitting machine or a Raschel knitting machine.... Alternatively, the knitting may be conducted using a double Raschel knitting machine which can knit the shoe upper simply in one step because it can simultaneously conduct the two above mentioned steps." Shiomura 3:4-15.

59. The same statement can be made when comparing knitted fabrics with woven fabrics. It used to be generalized that woven fabrics could be considered less elastic and less breathable than knitted fabrics, but the ability to interweave elastic threads like Spandex and Lycra, and loose weaving techniques with specially treated fibers have changed all that. It is possible to find woven and knit fabrics with identical elasticity and breathability. In fact, shoe designers and engineers are not really required to choose knits if elasticity and breathability are the primary features they are looking for. Instead, they have a wide range of fabrics with different properties from both the knitted and woven families of fabrics.

60. This was well known in the prior art. Curley, for example, states (p. 8):

> In still another embodiment, the outer layer is of the woven classification. In utilizing woven structure fabrics in the fabrication process, success is more dependent on yarn schemes than in knit fabrics. While a characteristic of knitted structures is fabric stretch or elasticity, wovens possess lower stretch values due to the somewhat linear relationship between fabric and yarn width/length. Therefore, in utilizing woven materials in the process, it is necessary to focus on

> yarn elasticity properties. Methods of incorporating elasticity in yarns is well known and may include texturing or using bi-component or bi-constituent yarn or fiber."

61. Nishida, which discloses almost every one of the claimed features in the '011 Patent and is from the early 1990s, explains that "In the production of the web of material, the layouts or the areas in which the layouts are provided are produced in a woven and/or knitted type different from the sole parts or those areas in which these patterns are provided." (Nishida, 1:60-64) Furthermore, Osamu (also from the early 1990s) describes "using both woven fabric and/or knitted fabric as uppers materials for shoes" when describing the related art. (Osamu, paragraph [0002])

62. This broadening of design choice also extends to the essence of the '011 Patent. The core teaching of the '011 Patent is that knitting complete uppers is more efficient than joining together separately made pieces of various materials. But the sophistication of modern computer-controlled Jacquard head looms means that it is also possible to using weaving techniques to produce unitary uppers with a high degree of regionalization of function. Osamu goes into detail on how these weaving techniques can be used to create unitary upper constructions with distinct functional regions.

63. Finally, several of the '011 Patent claims focus on seam location in the upper (e.g., claims 3-6, 24, 25, 39-41). The placement of seams in various

locations is one of the choices made by pattern makers in the shoe industry. Basically, all the seam configurations claimed are simply a few of a limited number of configurations that patternmakers employ to impart various shapes to footwear and to ensure proper fit.

64. Further to this point, the creation of a textile upper for footwear that has edges that are joined together to form seams along the bottom and heel of the upper, as well as in the forefoot area, is a process that has been used to make shoes and slippers for more than 100 years. There is nothing new about the various seam locations described in the '011 Patent.

65. As the prior art Nishida patent clearly shows in Figures 1, 2, 4 and 5, creating a flat layout for a shoe that can be cutout and then folded and stitched to form a three-dimensional shoe upper was well known. In fact, the layout shown in Figure 4 of Nishida is very similar to those shown in the '011 Patent. By constructing the upper from the layout shown in Figure 4 of Nishida, the upper would necessarily have seams in the same places as the upper described and claimed in the '011 patent. Similarly, Osamu shows a very similar layout in its figures which would also create seams in the finished upper.

VII. Claims 1-46 of the '011 Patent Are Anticipated and/or Obvious in View of U.S. Patent No. 5,345,638 to Nishida

66. As further explained in the claim chart below, it is my opinion that claims 1-46 of the '011 patent are invalid in view of the Nishida patent alone or Nishida combined with other prior art.

67. Nishida was issued by the Patent Office on September 13, 1994 and is entitled "Process for Producing a Shoe-Shaped Part from a Web of Material and Resulting Shoe-Shaped Part." The Abstract of Nishida states:

> For the production of a shoe upper by cutting out of the shoe upper in the form of a layout from a web of material, shaping of the shoe upper with connection of material parts of the layout with formation of seams, a process is used by which such shoe uppers can be produced in a timesaving and efficient manner despite the many individual parts present or to be made visible. For this purpose, a web of material (1) is used to produce layouts (2) by different production measures, such as different styles, yarn material, color, material thickness, single layer or multilayer type of material or the like, at the same time with the production of web of material (1), and with a sole part attached to the layout. The layout is cut from the web as a unit with the sole part and processed into a shoe part having an upper and sole part.

68. Nishida explains at 3:6-26:

> In FIGS. 1 and 2, a web of material is identified by 1, and is produced by a conventional textile process, tier example, by weaving and/or knitting and/or embroidering. The web of material 1 can be provided with a single or with a plurality of layouts 2 of the shape of a shoe upper 3, as it is represented from the side, for example, in FIG. 3.
>
> The web of material has a backing 4 that can be a conventionally used material formed, for example, of a warp and filling or a knitted fabric. Layout 2 is divided into different individual parts or areas, which differ from one another, such as by being of another material style

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> and/or by being of different fibers or yarns, for example, from wool, wool with metal yarns, silk, silk with metal yarns, wool with plastic fibers or the like and/or by being formed of different colors, such as from fibers or yarns of different colors, including those of metals, or by different color prints, and/or by being differently designed fiber extrudates or fiber extrudate compositions, such as twisted, processed parallel or the like.

69. Nishida also describes the advantages of multiple configurations or designs and the advantages of his invention, including low weight and reduced costs (4:12-18 and 4:52-60):

> As can be seen, any number of layouts 2 in the most varied configurations and/or designs as well as of different sizes can be produced on a single web of material 1. For this purpose, above all, the use of program-controlled, particularly computer-controlled, production devices is advantageous, so that style, color, design, size or the like can be varied at will.
>
> * * *
>
> As already indicated, any sizes and different upper designs can be produced by computer-controlled programs, starting from corresponding basic patterns. The completed shoe uppers produced from such webs of material are marked by an extremely low weight, for example, between 70 to 80 g in a shoe size of 8. The costs for the production of such uppers are exceptionally low in comparison with previously known processes.

70. In the chart below, all citations are to Nishida, except where I specifically identify that I am citing to another prior art reference. I have included direct quotations from Nishida in some instances.

71. In my opinion, Nishida describes every feature of claims 1-16, 19-34, 36, and 39-46 and therefore anticipates those claims. Even if all of these claims

were not anticipated, they and claims 35, 37, and 38 are obvious based on Nishida alone and the knowledge of the skilled person in the art.

72. I have also cited to other prior art references – McDonald, Glidden Curley, Whiting, and Shiomura – and set forth alternative obviousness grounds for all of claims 1-46 in the chart below.

Nike '011 Patent Claims	Nishida
1. An article of footwear comprising:	Abstract; Fig. 3
an upper incorporating a weft-knitted textile element having edges that are joined together to define at least a portion of a void for receiving a foot,	Abstract; Figs. 2-3 3:6-12: "In FIGS. 1 and 2, a web of material is identified by 1, and is produced by a conventional textile process, tier example, by weaving and/or knitting and/or embroidering. The web of material 1 can be provided with a single or with a plurality of layouts 2 of the shape of a shoe upper 3, as it is represented from the side, for example, in FIG. 3." 3:31-42: "After cutting out layout 2 from the web of material 1, the edges 7 and 8 are stitched together and a heel seam thus is formed. Then, heel counter 9, represented in FIG. 3, is applied, for example, glued and/or stitched, to adjacent areas 5 and 6. Correspondingly, the contours of edges 11 and 12 are stitched together in the form of shoe toe 10, and a seam is formed on the shoe toe. To reduce wear, a toe cap 15, represented in FIG. 3, can be applied, especially glued and/or stitched, on the front area, adjacent to

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Nike '011 Patent Claims	Nishida
	front edge 13 of toe area 14." Nishida discloses producing the material that forms the upper with a "conventional textile process … by weaving and/or knitting …" At the time Nishida was filed in the U.S. (June 17, 1992) the skilled person would have known and understood that "conventional" knitting processes include both warp knitting and weft knitting (and further including both circular and flat knitting), since these knitting processes existed for many decades before 1992 and had been used in the making of shoe uppers for many decades as well. For example, McDonald dates to 1943 and describes a method of making shoes including use of a "conventional type of circular knitting machine" to form a "weft knit fabric" used to make the upper of a shoe. (McDonald, p. 1 at 2:26-39) As another example, Whiting dates to 1953 and describes a method for producing knitted shoe uppers of shrinkable yarn, including knitting the sock-like structure that forms the upper on "flat or circular knitting machines." (Whiting, 2:39-56) As another example, Curley, published in April 1990, describes shoes made with knitted layers in the upper, including both warp and weft knitting. (Curley, p. 7, line 32 – p. 8, line 25) It is my opinion that Nishida discloses both weft (including circular and flat) and warp knitting by disclosing that "conventional" knitting processes can be used for his invention. Even if Nishida was determined not to describe weft-knitting, it would have been obvious to the skilled person to use weft knitting from Nishida's disclosure of using a knitted material for the upper. Weft knitting

Nike '011 Patent Claims	Nishida
	was a well known knitting process in March 2004, when the '011 patent was filed. Weft knitting had been used for years in shoe uppers, as shown by McDonald, Whiting, and Curley, for many years. It would simply have been a matter of design choice from among a finite number of types of knitting processes one could use.
wherein the weft-knitted textile element incorporates a single type of textile having a plurality of knit constructions; and	3:15-4:18; 4:47-60; 5:41-45; 5:63-6:2; 6:4-41 3:15-26: "Layout 2 is divided into different individual parts or areas, which differ from one another, such as by being of another material style and/or by being of different fibers or yarns, for example, from wool, wool with metal yarns, silk, silk with metal yarns, wool with plastic fibers or the like and/or by being formed of different colors, such as from fibers or yarns of different colors, including those of metals, or by different color prints, and/or by being differently designed fiber extrudates or fiber extrudate compositions, such as twisted, processed parallel or the like." 4:12-18: "As can be seen, any number of layouts 2 in the most varied configurations and/or designs as well as of different sizes can be produced on a single web of material 1. For this purpose, above all, the use of program-controlled, particularly computer-controlled, production devices is advantageous, so that style, color, design, size or the like can be varied at will." 5:41-45: "Preferably, each layout 2 has at least five, preferably more than ten, patterns and a tongue 40 has at least

Nike '011 Patent Claims	Nishida
	two, preferably at least three patterns produced or appearing, which are different from one another in each case."
a sole structure secured to the upper.	Abstract; Fig. 3 4:39-46: "Finally, before or after cutting out of layout(s) 2, a tongue 32 (FIG. 3) is applied in the forefoot area. After the production of shoe upper 3, an insole and/or a midsole, optionally, is additionally applied or molded on. Completed shoe upper 3 is then brought into a gluing, injection or casting mold, in which a midsole 33 and an outsole 34 are molded by known measures, as is represented in FIG. 3."
2. The article of footwear recited in claim 1, wherein the weft-knitted textile element forms at least a portion of a lateral side, a medial side, and an instep region of the upper.	Figs. 1-5 3:15-4:46
3. The article of footwear recited in claim 1, wherein the edges include a pair of first edges that are joined to form a first seam extending longitudinally along a lower region of the	Fig. 4 5:3-13: "With the embodiment according to FIG. 4, a sole part section 29.1 that extends over the entire length of the sole is provided on outside contour 31 in the approximate form of a half of sole part 29, and a sole part section 29.2 which forms the remainder of sole part 29 is provided on the outside contour 30. Both sole part sections 29.1 and 29.2 complement each other to

Nike '011 Patent Claims	Nishida
upper.	complete sole part 29. In this case, their outside contours 29.3 and 29.4 are connected with one another, for example stitched and/or glued and/or fused or the like, preferably by a longitudinal seam."
4. The article of footwear recited in claim 3, wherein the edges include a pair of second edges that are joined to form a second seam extending along a heel region of the upper.	Figs. 2, 4 3:31-36: "After cutting out layout 2 from the web of material 1, the edges 7 and 8 are stitched together and a heel seam thus is formed. Then, heel counter 9, represented in FIG. 3, is applied, for example, glued and/or stitched, to adjacent areas 5 and 6." 4:9-11: "A heel counter 28, represented in FIG. 3, is applied on areas 26, 27 after formation of the initially described heel seam."
5. The article of footwear recited in claim 4, wherein the second seam extends vertically.	Figs. 2-4 3:31-36: "After cutting out layout 2 from the web of material 1, the edges 7 and 8 are stitched together and a heel seam thus is formed. Then, heel counter 9, represented in FIG. 3, is applied, for example, glued and/or stitched, to adjacent areas 5 and 6." 4:9-11: "A heel counter 28, represented in FIG. 3, is applied on areas 26, 27 after formation of the initially described heel seam."
6. The article of footwear recited in claim 4, wherein the	Fig. 4 4:19-30:

Nike '011 Patent Claims	Nishida
edges include at least a pair of third edges that are joined to form a third seam extending through a forefoot area of the upper.	"According to an advantageous further development of the invention, an individual part 29 in the form of an insole can be co-produced on layout 2 of shoe upper 3. After being cut out, this individual part 29 remains connected with layout 2, and after or during the shaping and fixing of shoe upper 3 from layout 2, part 29 is folded into the plane of the shoe sole and is fastened to the lower edge zone of the shoe upper 3. This lower edge zone is defined in layout 2 by outside contours 30 and 31, and the manner of its fastening can be, in a way known in the art, for example, by gluing, stitching, tacking or the like."
7. The article of footwear recited in claim 1, wherein the weft-knitted textile element is one of an exterior layer, an intermediate layer, and an interior layer of the upper.	Fig. 3 3:6-9; 3:66-4:1 3:66-4:1: "Optionally, in this case, the material can be woven or knitted in two or more layers or can be especially thick or additionally embroidered."
8. The article of footwear recited in claim 1, wherein the upper includes an exterior layer, an intermediate layer, and an interior layer, and the weft-knitted textile element forms at least a portion of the interior layer.	3:6-9; 3:62-4:1 3:66-4:1: "Optionally, in this case, the material can be woven or knitted in two or more layers or can be especially thick or additionally embroidered." The skilled person would understand that this passage teaches three layers, which means an interior, intermediate (middle), and exterior layer are all present. The skilled person would understand that by cutting out layout 2 and forming it as described in columns 3 and 4 of Nishida, the result is a textile element that forms a

Nike '011 Patent Claims	Nishida
	portion an the interior layer. To the extent that one may suggest that backing 4 described in Nishida is not part of the "textile element" and forms the interior layer of the upper when layout 2 is cut out and shaped to as described in columns 3 and 4 to form the upper such that backing 4 forms an interior layer, Nishida describes that backing 4 is a "conventionally used material formed, for example, of a warp and filling or a knitted fabric." (3:13-15) Thus, a knitted portion still forms an interior layer of the upper. In addition, if it is determined that Nishida does not describe what is recited in claim 8, it would have been obvious to the skilled person to modify the textile element of Nishida to provide multiple layers with the knitted textile element forming a portion of the inner layer. Three-layer constructions with an inner layer of textile were well known in the prior art in March 2004, and it would have been a simple matter of design choice to make any necessary modifications to Nishida to obtain this construction. As the '011 patent describes in the section "Description of Background Art," three-layer upper constructions were well known in the prior art before March 3, 2004, as was using a textile material for the inner layer. The '011 patent explains as background art (1:44-2:6, underlining added): "Various materials may be utilized in manufacturing the upper. <u>The upper of an article of athletic footwear, for example, may be formed from multiple material layers that include an exterior layer, an intermediate layer, and an interior layer.</u> The materials forming the exterior layer of the upper may be selected based upon the properties of wear-resistance, flexibility, and air-permeability, for example. With regard to the exterior

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Nike '011 Patent Claims	Nishida
	layer, the toe area and the heel area may be formed of leather, synthetic leather, or a rubber material to impart a relatively high degree of wear-resistance. Leather, synthetic leather, and rubber materials may not exhibit the desired degree of flexibility and air-permeability. Accordingly, various other areas of the exterior layer of the upper may be formed from a synthetic or natural textile. The exterior layer of the upper may be formed, therefore, from numerous material elements that each impart different properties to specific portions of the upper. An intermediate layer of the upper may be formed from a lightweight polymer foam material that provides cushioning and protects the foot from objects that may contact the upper. Similarly, an interior layer of the upper may be formed of a moisture-wicking textile that removes perspiration from the area immediately surrounding the foot. In some articles of athletic footwear, the various layers may be joined with an adhesive, and stitching may be utilized to join elements within a single layer or to reinforce specific areas of the upper. Although the materials selected for the upper vary significantly, textile materials often form at least a portion of the exterior layer and interior layer." In other prior art references, Curley describes an upper that includes multiple layers preferably three layers (Curley, p. 6, lines 30-32), where a knit textile element forms a portion of an inner layer (Curley, p. 30, claim 34) and an outer layer (Curley, p. 7, line 32 – p. 8, line 5). In another example, Shiomura describes an upper that includes an outer knit fabric layer and an inner knit fabric layer, with a layer of crossing threads between.

Nike '011 Patent Claims	Nishida
	(Shiomura, 2:26-45)
9 The article of footwear recited in claim 1, wherein the weft-knitted textile element forms at least a portion of both an interior surface and an exterior surface of the upper.	Fig. 3; 3:6-4:46 3:66-4:1: "Optionally, in this case, the material can be woven or knitted in two or more layers or can be especially thick or additionally embroidered." The skilled person would understand that by cutting out layout 2 and forming it as described in columns 3 and 4 of Nishida, the result is an exterior surface as shown in Fig. 3 and a corresponding interior surface (i.e. portion facing the foot), both of which are formed by the textile element of Nishida. To the extent that backing 4 described in Nishida is not part of the "textile element" and forms the interior surface of the upper when layout 2 is cut out and shaped to as described in columns 3 and 4 to form the upper such that backing 4 forms an interior surface, Nishida describes that backing 4 is a "conventionally used material formed, for example, of a warp and filling or a knitted fabric." (3:13-15) Thus, a knitted portion still forms an interior surface of the upper. In addition, if it is determined that Nishida does not describe what is recited in claim 9, it would have been obvious to the skilled person to modify the textile element of Nishida to provide one or more layers with the knitted textile element forming a portion of the both the interior surface and the exterior surface of the upper. Upper constructions with an interior and exterior surfaces of knitted textile elements (whether a one layer structure or multiple layer structure) were well known in the prior art in March 2004, and it would have been a simple matter of design choice to make

Nike '011 Patent Claims	Nishida
	any necessary modifications to Nishida. As the '011 patent describes in the section "Description of Background Art," upper constructions with exterior and interior surfaces made of textile elements were well known in the prior art before March 3, 2004. The '011 patent explains as background art (1:44-2:6, underlining added): "Various materials may be utilized in manufacturing the upper. The upper of an article of athletic footwear, for example, may be formed from multiple material layers that include an exterior layer, an intermediate layer, and an interior layer. The materials forming the exterior layer of the upper may be selected based upon the properties of wear-resistance, flexibility, and air-permeability, for example. With regard to the exterior layer, the toe area and the heel area may be formed of leather, synthetic leather, or a rubber material to impart a relatively high degree of wear-resistance. Leather, synthetic leather, and rubber materials may not exhibit the desired degree of flexibility and air-permeability. Accordingly, various other areas of the exterior layer of the upper may be formed from a synthetic or natural textile. The exterior layer of the upper may be formed, therefore, from numerous material elements that each impart different properties to specific portions of the upper. An intermediate layer of the upper may be formed from a lightweight polymer foam material that provides cushioning and protects the foot from objects that may contact the upper. Similarly, an interior layer of the upper may be formed of a moisture-wicking textile that removes perspiration from the area immediately surrounding the foot. In some articles of athletic footwear, the various layers may be joined with an adhesive, and stitching may be utilized to join elements

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	within a single layer or to reinforce specific areas of the upper. Although the materials selected for the upper vary significantly, textile materials often form at least a portion of the exterior layer and interior layer." In other prior art references, Curley describes an upper that includes multiple layers preferably three layers (Curley, p. 6, lines 30-32), where a knit textile element forms a portion of an interior surface (Curley, p. 30, claim 34) and an exterior surface (Curley, p. 7, line 32 – p. 8, line 5). In another example, Shiomura describes an upper that includes an outer knit fabric layer (exterior surface) and an inner knit fabric layer (interior surface), with a layer of crossing threads between. (Shiomura, 2:26-45) In another example, Glidden describes a knitted upper where the knitted material forms a portion of both interior and exterior surfaces of the upper. (Glidden, Figs. 1-2, p. 1, 2:3-32)
10. The article of footwear recited in claim 9, wherein at least one additional element is secured to the exterior surface and forms a portion of the exterior surface.	Fig. 3; 2:37-47; 3:37-42; 3:53-58; 4:9-11 3:37-42: "Correspondingly, the contours of edges 11 and 12 are stitched together in the form of shoe toe 10, and a seam is formed on the shoe toe. To reduce wear, a toe cap 15, represented in FIG. 3, can be applied, especially glued and/or stitched, on the front area, adjacent to front edge 13 of toe area 14."
11. The article of footwear recited in claim 10, wherein the additional element is secured to a forefoot	3:37-42: "Correspondingly, the contours of edges 11 and 12 are stitched together in the form of shoe toe 10, and a seam is formed on the shoe toe. To reduce wear, a toe cap 15,

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area of the upper.	represented in FIG. 3, can be applied, especially glued and/or stitched, on the front area, adjacent to front edge 13 of toe area 14."
12. The article of footwear recited in claim 10, wherein the additional element is secured to a heel area of the upper.	4:9-11: "A heel counter 28, represented in FIG. 3, is applied on areas 26, 27 after formation of the initially described heel seam."
13. The article of footwear recited in claim 1, wherein the textile element forms an interior surface of the upper.	3:6-4:46 The skilled person would understand that by cutting out layout 2 and forming it as described in columns 3 and 4 of Nishida results in the textile element forming an interior surface (i.e. portion facing the foot) of the upper. To the extent that backing 4 described in Nishida is not part of the "textile element" and forms the interior surface of the upper when layout 2 is cut out and shaped to as described in columns 3 and 4 to form the upper such that backing 4 forms an interior surface, Nishida describes that backing 4 is a "conventionally used material formed, for example, of a warp and filling or a knitted fabric." (3:13-15) Thus, a knitted portion still forms an interior surface of the upper. In addition, if it is determined that Nishida does not describe what is recited in claim 13, it would have been obvious to the skilled person to modify the textile element of Nishida to provide one or more layers with the knitted textile element forming a portion of the interior surface of the upper. Upper constructions with an interior surface of a knitted textile element (whether a one layer structure or multiple layer structure) were well known in the prior art in March 2004, and it would have been a simple matter of design choice to make

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	any necessary modifications to Nishida. As the '011 patent describes in the section "Description of Background Art," upper constructions with interior surfaces made of textile elements were well known in the prior art before March 3, 2004. The '011 patent explains as background art (1:44-2:6, underlining added): "Various materials may be utilized in manufacturing the upper. The upper of an article of athletic footwear, for example, may be formed from multiple material layers that include an exterior layer, an intermediate layer, and an interior layer. The materials forming the exterior layer of the upper may be selected based upon the properties of wear-resistance, flexibility, and air-permeability, for example. With regard to the exterior layer, the toe area and the heel area may be formed of leather, synthetic leather, or a rubber material to impart a relatively high degree of wear-resistance. Leather, synthetic leather, and rubber materials may not exhibit the desired degree of flexibility and air-permeability. Accordingly, various other areas of the exterior layer of the upper may be formed from a synthetic or natural textile. The exterior layer of the upper may be formed, therefore, from numerous material elements that each impart different properties to specific portions of the upper. An intermediate layer of the upper may be formed from a lightweight polymer foam material that provides cushioning and protects the foot from objects that may contact the upper. Similarly, an interior layer of the upper may be formed of a moisture-wicking textile that removes perspiration from the area immediately surrounding the foot. In some articles of athletic footwear, the various layers may be joined with an adhesive, and stitching may be utilized to join elements

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	within a single layer or to reinforce specific areas of the upper. Although the materials selected for the upper vary significantly, textile materials often form at least a portion of the exterior layer and interior layer." In other prior art references, Curley describes an upper that includes multiple layers preferably three layers (Curley, p. 6, lines 30-32), where a knit textile element forms a portion of an interior surface (Curley, p. 30, claim 34). In another example, Shiomura describes an upper that includes an outer knit fabric layer (exterior surface) and an inner knit fabric layer (interior surface), with a layer of crossing threads between. (Shiomura, 2:26-45) In another example, Glidden describes a knitted upper where the knitted material forms a portion of the interior surface of the upper. (Glidden, Figs. 1-2, p. 1, 2:3-32)
14. The article of footwear recited in claim 1, wherein the weft-knitted textile element is created by circular knitting.	As discussed above for claim 1, Nishida describes the use of "conventional" knitting processes, as of June 1992, to form the textile element for the upper. Circular knitting was a conventional and well known process for knitting textiles for shoe uppers in 1992. Even if Nishida was determined not to describe circular knitting, it would have been obvious to the skilled person to use circular knitting from Nishida's disclosure of using a knitted material for the upper. Circular knitting was a well known knitting process in March 2004, when the '011 patent was filed. Circular knitting had been used for many years in shoe uppers, as shown, for example, by McDonald and Whiting. It would simply have been a matter of design choice from among a finite number of types of knitting processes

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	one could use to select circular knitting. For example, McDonald dates to 1943 and describes a method of making shoes including use of a "conventional type of circular knitting machine" to form a "weft knit fabric" used to make the upper of a shoe. (McDonald, p. 1 at 2:26-39) As another example, Whiting dates to 1953 and describes a method for producing knitted shoe uppers of shrinkable yarn, including knitting the sock-like structure that forms the upper on "flat or circular knitting machines." (Whiting, 2:39-56)
15. The article of footwear recited in claim 1, wherein the weft-knitted textile element is created by flat knitting.	As discussed above for claim 1, Nishida describes the use of "conventional" knitting processes, as of June 1992, to form the textile element for the upper. Flat knitting was a conventional and well known process for knitting textiles for shoe uppers in 1992. Even if Nishida was determined not to describe flat knitting, it would have been obvious to the skilled person to use flat knitting from Nishida's disclosure of using a knitted material for the upper. Flat knitting was a well known knitting process in March 2004, when the '011 patent was filed. Flat knitting had been used for many years in shoe uppers, as shown, for example, by Whiting. It would simply have been a matter of design choice from among a finite number of types of knitting processes one could use to select flat knitting. As another example, Whiting dates to 1953 and describes a method for producing knitted shoe uppers of shrinkable yarn, including knitting the sock-like structure that forms the upper on "flat or circular knitting machines." (Whiting, 2:39-56)
16. An article of	Fig. 3; Title

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footwear comprising:	
an upper incorporating a weft-knitted textile element, the textile element having a first area and a second area with a unitary construction,	Abstract; Figs. 2-3 3:6-12: "In FIGS. 1 and 2, a web of material is identified by 1, and is produced by a conventional textile process, tier example, by weaving and/or knitting and/or embroidering. The web of material 1 can be provided with a single or with a plurality of layouts 2 of the shape of a shoe upper 3, as it is represented from the side, for example, in FIG. 3." 3:15-26: "Layout 2 is divided into different individual parts or areas, which differ from one another, such as by being of another material style and/or by being of different fibers or yarns, for example, from wool, wool with metal yarns, silk, silk with metal yarns, wool with plastic fibers or the like and/or by being formed of different colors, such as from fibers or yarns of different colors, including those of metals, or by different color prints, and/or by being differently designed fiber extrudates or fiber extrudate compositions, such as twisted, processed parallel or the like." 4:12-18: "As can be seen, any number of layouts 2 in the most varied configurations and/or designs as well as of different sizes can be produced on a single web of material 1. For this purpose, above all, the use of program-controlled, particularly computer-controlled, production devices is advantageous, so that style, color, design, size or the like can be varied at will." Nishida discloses producing the material that forms the

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	upper with a "conventional textile process … by weaving and/or knitting …" At the time Nishida was filed in the U.S. (June 17, 1992) the skilled person would have known and understood that "conventional" knitting processes include both warp knitting and weft knitting (and further including both circular and flat knitting), since these knitting processes existed for many decades before 1992 and had been used in the making of shoe uppers for many decades as well. For example, McDonald dates to 1943 and describes a method of making shoes including use of a "conventional type of circular knitting machine" to form a "weft knit fabric" used to make the upper of a shoe. (McDonald, p. 1 at 2:26-39) As another example, Whiting dates to 1953 and describes a method for producing knitted shoe uppers of shrinkable yarn, including knitting the sock-like structure that forms the upper on "flat or circular knitting machines." (Whiting, 2:39-56) As another example, Curley, published in April 1990, describes shoes made with knitted layers in the upper, including both warp and weft knitting. (Curley, p. 7, line 32 – p. 8, line 25) It is my opinion that Nishida discloses both weft (including circular and flat) and warp knitting by disclosing that "conventional" knitting processes can be used for his invention. Even if Nishida was determined not to describe weft-knitting, it would have been obvious to the skilled person to use weft knitting from Nishida's disclosure of using a knitted material for the upper. Weft knitting was a well known knitting process in March 2004, when the '011 patent was filed. Weft knitting had been used for years in shoe uppers, as shown by McDonald,

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	Whiting, and Curley, for many years. It would simply have been a matter of design choice from among a finite number of types of knitting processes one could use.
the first area being formed of a first stitch configuration, and the second area being formed of a second stitch configuration that is different from the first stitch configuration to impart varying properties to the textile element; and	3:15-4:18; 4:47-60; 5:41-45; 5:63-6:2; 6:4-41 3:15-26: "Layout 2 is divided into different individual parts or areas, which differ from one another, such as by being of another material style and/or by being of different fibers or yarns, for example, from wool, wool with metal yarns, silk, silk with metal yarns, wool with plastic fibers or the like and/or by being formed of different colors, such as from fibers or yarns of different colors, including those of metals, or by different color prints, and/or by being differently designed fiber extrudates or fiber extrudate compositions, such as twisted, processed parallel or the like." 3:43-52: "Since, generally, toe area 14 is designed to be relatively deformably soft or elastic, and optionally, also permeable to air, the web of material 1, in toe area 14, according to the present invention, is correspondingly designed by suitable selection of the weave pattern, knit pattern and/or the material used, such as, for example, Silk or plastic. The type of production can, additionally, insure that the toe area 14 has a good air exchange capability. For example, this can be achieved by a net-like woven or knitted structure." 4:12-18: "As can be seen, any number of layouts 2 in the most

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	varied configurations and/or designs as well as of different sizes can be produced on a single web of material 1. For this purpose, above all, the use of program-controlled, particularly computer-controlled, production devices is advantageous, so that style, color, design, size or the like can be varied at will." 5:41-45: "Preferably, each layout 2 has at least five, preferably more than ten, patterns and a tongue 40 has at least two, preferably at least three patterns produced or appearing, which are different from one another in each case." 5:63-6:2: "As already indicated, the webs of material being used can be produced by program-controlled web material production devices whose programs can be matched almost at will according to the corresponding basic setting with deviations in the size of the layouts of the individual shoe uppers or with changes of the type of weave or knit of individual areas or contours, the type of fiber or yarn and/or the color." The '011 Patent describes varying the "stitch type" as a way to vary the type of texture in different areas, and as separate from varying the type of yarn. ('011 Patent, 9:46-49, 9:65-10:3) Nishida specifically describes using different materials, different compositions (such as twisted or parallel processing or the like), and different knit types or knit patterns, therefore describing for the skilled person using different stitch configurations in different areas. Nishida describes this to give the textile element different properties in different areas. Even if Nishida did not describe using different stitch

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	configurations in different areas to vary the properties of the textile element in those areas, it was well known to skilled persons in the art to do so and it was taught in the prior art. It would have been obvious to vary stitch configurations as one of many ways to impart different properties to two different areas, and it would have been a simple matter of design choice to do so. For example, Glidden describes varying the properties in the toe and heel area of a knitted upper, such "as by changing the type of stitch or amount of thickness in the yarn in the knitting." (Glidden, p. 1, 2:33-44) In another example, McDonald describes knitting an ankle/heel portion, instep, and sole of a knitted upper with "a plain or jersey stitch" in contrast to another area of the upper made with a ribbed knit. (McDonald, p. 1, 2:26-49; Fig. 1)
a sole structure secured to the upper.	Abstract; Fig. 3 4:39-46: "Finally, before or after cutting out of layout(s) 2, a tongue 32 (FIG. 3) is applied in the forefoot area. After the production of shoe upper 3, an insole and/or a midsole, optionally, is additionally applied or molded on. Completed shoe upper 3 is then brought into a gluing, injection or casting mold, in which a midsole 33 and an outsole 34 are molded by known measures, as is represented in FIG. 3."
17. The article of footwear recited in claim 16, wherein the first stitch configuration provides a substantially	Glidden describes a first stitch configuration with a substantially smooth texture for the first area (Glidden, p. 1, 2:35-41, where the toe and heel portions may be more densely fabricated to provide heavier weight and less extensibility) and a second stitch configuration in a

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smooth texture to the first area, and the second stitch configuration provides a texture to the second area that is rougher than the smooth texture.	second area that is rougher than the smooth texture (Glidden, p. 1, 2:41-44, where the ankle portion is made so as to provide softness and elasticity, such as a ribbed construction). In addition, McDonald describes a circular-knitted upper with a first stitch configuration for an ankle/heel, instep, and sole areas of the upper with a substantially smooth texture and a second stitch configuration for a different area that has a rougher, ribbed texture. (McDonald, p. 1, 2:26-49; Fig. 1) It would have been obvious to combine Nishida with Glidden or McDonald to vary the stitch configurations to provide one area with a substantially smooth texture and one are with a rougher or ribbed texture as a simple design choice, for aesthetics, because a ribbed texture may allow for more extensibility or stretchability, or because one may want a smoother interior layer adjacent the foot, for example.
18. The article of footwear recited in claim 17, wherein the second stitch configuration forms a rib structure in the second area.	As explained for claim 17, the second stitch configuration for the second area that forms the rougher texture is ribbed in both Glidden and McDonald, and it would have been obvious to modify Nishida for the same reasons as explained for claim 17.
19. The article of footwear recited in claim 16, wherein at least one of the first stitch configuration and the second stitch configuration forms an aperture in the weft-knitted textile element.	3:43-52; 6:25-31 3:43-52: "Since, generally, toe area 14 is designed to be relatively deformably soft or elastic, and optionally, also permeable to air, the web of material 1, in toe area 14, according to the present invention, is correspondingly designed by suitable selection of the weave pattern, knit pattern and/or the material used,

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	such as, for example, Silk or plastic. The type of production can, additionally, insure that the toe area 14 has a good air exchange capability. For example, this can be achieved by a net-like woven or knitted structure." The '011 Patent describes that "apertures" are formed by omitting stitches to provide air permeability in the knitted textile element. ('011 Patent, 9:57-62) The "net-like" knitted structure described by Nishida has apertures for the same reason, air permeability.
20. The article of footwear recited in claim 16, wherein the weft-knitted textile element is one of an exterior layer, an intermediate layer, and an interior layer of the upper.	Claim 20 adds the same limitation to independent claim 16 as claim 7 added to independent claim 1. Nishida describes the additional limitations of claim 20 – see discussion for claim 7 in chart.
21. The article of footwear recited in claim 16, wherein the upper includes an exterior layer, an intermediate layer, and an interior layer, and the weft-knitted textile element forms at least a portion of the interior layer.	Claim 21 adds the same limitation to independent claim 16 as claim 8 added to independent claim 1. Nishida describes the additional limitations of claim 21 or they are obvious in view of Curley or Shiomura – see discussion for claim 8 in chart.
22. The article of footwear recited in claim 16, wherein the textile layer forms at least a portion of both	Claim 22 adds the same limitation to independent claim 16 as claim 9 added to independent claim 1, except that claim 22 recites "the textile "layer" instead of "textile element." I have assumed this is a typographical error because claim 16 does not otherwise identify a "textile

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the interior surface and an exterior surface of the upper.	layer" and have treated this limitation as if it recited "textile element" as in claim 9. Nishida describes the additional limitations of claim 22 or they are obvious in view of Curley, Shiomura or Glidden – see discussion for claim 9 in chart.
23. The article of footwear recited in claim 16, wherein the weft-knitted textile element forms an interior surface of the upper.	Claim 23 adds the same limitation to independent claim 16 as claim 13 added to independent claim 1. Nishida describes the additional limitations of claim 23 or they are obvious in view of Curley, Shiomura, or Glidden – see discussion for claim 13 in chart.
24. An article of footwear comprising:	Abstract; Fig. 3
an upper incorporating a textile element having edges that are joined together to form seams and define at least a portion of a void for receiving a foot,	Abstract; Figs. 2-3 3:6-12: "In FIGS. 1 and 2, a web of material is identified by 1, and is produced by a conventional textile process, tier example, by weaving and/or knitting and/or embroidering. The web of material 1 can be provided with a single or with a plurality of layouts 2 of the shape of a shoe upper 3, as it is represented from the side, for example, in FIG. 3." 3:31-42: "After cutting out layout 2 from the web of material 1, the edges 7 and 8 are stitched together and a heel seam thus is formed. Then, heel counter 9, represented in FIG. 3, is applied, for example, glued and/or stitched, to adjacent areas 5 and 6. Correspondingly, the contours of edges 11 and 12 are stitched together in the form of shoe toe 10, and a seam

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	is formed on the shoe toe. To reduce wear, a toe cap 15, represented in FIG. 3, can be applied, especially glued and/or stitched, on the front area, adjacent to front edge 13 of toe area 14."
the seams including a first seam and a second seam, the first seam extending from a heel area to a forefoot area of the footwear along a lower surface of the upper, and the second seam extending vertically in the heel area,	Figs. 2, 4; 3:31-36; 4:9-11; 5:3-13 5:3-13: "With the embodiment according to FIG. 4, a sole part section 29.1 that extends over the entire length of the sole is provided on outside contour 31 in the approximate form of a half of sole part 29, and a sole part section 29.2 which forms the remainder of sole part 29 is provided on the outside contour 30. Both sole part sections 29.1 and 29.2 complement each other to complete sole part 29. In this case, their outside contours 29.3 and 29.4 are connected with one another, for example stitched and/or glued and/or fused or the like, preferably by a longitudinal seam." 3:31-36: "After cutting out layout 2 from the web of material 1, the edges 7 and 8 are stitched together and a heel seam thus is formed. Then, heel counter 9, represented in FIG. 3, is applied, for example, glued and/or stitched, to adjacent areas 5 and 6." 4:9-11: "A heel counter 28, represented in FIG. 3, is applied on areas 26, 27 after formation of the initially described heel seam."
wherein the textile element incorporates a single type of textile having a plurality of	3:15-4:18; 4:47-60; 5:41-45; 5:63-6:2; 6:4-41 3:15-26: "Layout 2 is divided into different individual parts or

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knit constructions; and	areas, which differ from one another, such as by being of another material style and/or by being of different fibers or yarns, for example, from wool, wool with metal yarns, silk, silk with metal yarns, wool with plastic fibers or the like and/or by being formed of different colors, such as from fibers or yarns of different colors, including those of metals, or by different color prints, and/or by being differently designed fiber extrudates or fiber extrudate compositions, such as twisted, processed parallel or the like." 4:12-18: "As can be seen, any number of layouts 2 in the most varied configurations and/or designs as well as of different sizes can be produced on a single web of material 1. For this purpose, above all, the use of program-controlled, particularly computer-controlled, production devices is advantageous, so that style, color, design, size or the like can be varied at will." 5:41-45: "Preferably, each layout 2 has at least five, preferably more than ten, patterns and a tongue 40 has at least two, preferably at least three patterns produced or appearing, which are different from one another in each case."
a sole structure secured to the upper.	Abstract; Fig. 3 4:39-46: "Finally, before or after cutting out of layout(s) 2, a tongue 32 (FIG. 3) is applied in the forefoot area. After the production of shoe upper 3, an insole and/or a midsole, optionally, is additionally applied or molded on.

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	Completed shoe upper 3 is then brought into a gluing, injection or casting mold, in which a midsole 33 and an outsole 34 are molded by known measures, as is represented in FIG. 3."
25. The article of footwear recited in claim 24, wherein the footwear includes a third seam extending through the forefoot area of the upper.	Fig. 4 4:19-30: "According to an advantageous further development of the invention, an individual part 29 in the form of an insole can be co-produced on layout 2 of shoe upper 3. After being cut out, this individual part 29 remains connected with layout 2, and after or during the shaping and fixing of shoe upper 3 from layout 2, part 29 is folded into the plane of the shoe sole and is fastened to the lower edge zone of the shoe upper 3. This lower edge zone is defined in layout 2 by outside contours 30 and 31, and the manner of its fastening can be, in a way known in the art, for example, by gluing, stitching, tacking or the like."
26. The article of footwear recited in claim 24, wherein at least one of the knit constructions forms an aperture in the textile element.	3:43-52: "Since, generally, toe area 14 is designed to be relatively deformably soft or elastic, and optionally, also permeable to air, the web of material 1, in toe area 14, according to the present invention, is correspondingly designed by suitable selection of the weave pattern, knit pattern and/or the material used, such as, for example, Silk or plastic. The type of production can, additionally, insure that the toe area 14 has a good air exchange capability. For example, this can be achieved by a net-like woven or knitted structure." The '011 Patent describes that "apertures" are formed by omitting stitches to provide air permeability in the knitted textile element. ('011 Patent, 9:57-62) The

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	"net-like" knitted structure described by Nishida has apertures for the same reason, air permeability.
27. The article of footwear recited in claim 24, wherein the knit constructions produce varying properties in the textile element including a varying elasticity of the textile element.	2:26-37: "It is of further advantage in the process according to the present invention that the individual patterns or partial patterns already can be produced directly in the production of the web of material in the desired shoe size, by which the cutting waste can be still further limited, since the individual patterns or partial patterns in the provided size can directly adjoin one another. Nevertheless, it is possible to configure the individual patterns or partial patterns soft, stiff, elastic, colored differently or the like, corresponding to the later stressing or desired shaping." 3:43-52: "Since, generally, toe area 14 is designed to be relatively deformably soft or elastic, and optionally, also permeable to air, the web of material 1, in toe area 14, according to the present invention, is correspondingly designed by suitable selection of the weave pattern, knit pattern and/or the material used, such as, for example, Silk or plastic. The type of production can, additionally, insure that the toe area 14 has a good air exchange capability. For example, this can be achieved by a net-like woven or knitted structure." 6:16-31: "wherein the layouts of the shoe upper and sole parts are produced by modifying the overall construction of the web of material in the locations of the layouts relative to that in portions thereof where the layouts of the shoe upper and the sole parts are not provided, using one of a different weaving and knitting type for

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	the layouts of the shoe upper than is used for producing the sole parts, said weaving and knitting types being matched to differing requirements for materials of the shoe upper and sole part of a shoe in relation to properties thereof including at least one of the properties of absorptivity, air permeability, softness, extensibility, wear resistance and appearance"
28. The article of footwear recited in claim 24, wherein the knit constructions produce varying properties in the textile element including a varying air permeability of the textile element.	3:43-52: "Since, generally, toe area 14 is designed to be relatively deformably soft or elastic, and optionally, also permeable to air, the web of material 1, in toe area 14, according to the present invention, is correspondingly designed by suitable selection of the weave pattern, knit pattern and/or the material used, such as, for example, Silk or plastic. The type of production can, additionally, insure that the toe area 14 has a good air exchange capability. For example, this can be achieved by a net-like woven or knitted structure." 6:16-31: "wherein the layouts of the shoe upper and sole parts are produced by modifying the overall construction of the web of material in the locations of the layouts relative to that in portions thereof where the layouts of the shoe upper and the sole parts are not provided, using one of a different weaving and knitting type for the layouts of the shoe upper than is used for producing the sole parts, said weaving and knitting types being matched to differing requirements for materials of the shoe upper and sole part of a shoe in relation to properties thereof including at least one of the properties of absorptivity, air permeability, softness, extensibility, wear resistance and appearance"
29. The article of	Claim 29 adds the same limitation to independent claim

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footwear recited in claim 24, wherein the textile element is one of an exterior layer, an intermediate layer, and an interior layer of the upper.	24 as claim 7 added to independent claim 1. Nishida describes the additional limitations of claim 29 – see discussion for claim 7 in chart.
30. The article of footwear recited in claim 24, wherein the textile element forms at least a portion of both an interior surface and an exterior surface of the upper.	Claim 30 adds the same limitation to independent claim 16 as claim 9 added to independent claim 1. Nishida describes the additional limitations of claim 30 or they are obvious in view of Curley, Shiomura or Glidden – see discussion for claim 9 in chart.
31. The article of footwear recited in claim 24, wherein the textile element forms an interior surface of the footwear, and at least one additional layer forms an exterior surface of the footwear.	Claim 31 adds the same limitation to independent claim 24 as claim 13 added to independent claim 1 – the textile element forming an interior surface of the footwear (or upper). Nishida describes this additional limitation of claim 31 or it is obvious in view of Curley, Shiomura, or Glidden – see discussion for claim 13 in chart. Claim 31 also recites an additional limitation – "at least one additional layer forms an exterior surface of the footwear." Nishida discloses this additional limitation. 2:37-39: "Only inside and/or outside stiffening elements, such as inside and/or outside toe caps, heel counters or the like have to be applied later on." 3:29-42:

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	"For example, areas 5 and 6 are provided for applying an inside or outside heel counter 9 (FIG. 3). After cutting out layout 2 from the web of material 1, the edges 7 and 8 are stitched together and a heel seam thus is formed. Then, heel counter 9, represented in FIG. 3, is applied, for example, glued and/or stitched, to adjacent areas 5 and 6. Correspondingly, the contours of edges 11 and 12 are stitched together in the form of shoe toe 10, and a seam is formed on the shoe toe. To reduce wear, a toe cap 15, represented in FIG. 3, can be applied, especially glued and/or stitched, on the front area, adjacent to front edge 13 of toe area 14." 4:9-11: "A heel counter 28, represented in FIG. 3, is applied on areas 26, 27 after formation of the initially described heel seam." In addition, Curley, Shiomura, and Glidden also disclose the limitation of "at least one additional layer forms an exterior surface of the footwear." Curley describes a three layer structure for an upper where there is additional layer other than the inner knit layer that forms an exterior surface of the footwear. (Curley, p. 6, lines 30-32; claim 34) Shiomura describes that wear-resistant leather materials may be added to the toe and heel portions of the shoe. (Shiomura, 2:20-35; Fig. 1) Glidden describes heel reinforcements, counters, and rubber coverings may be added to form an exterior surface of the shoe. (Glidden, p. 2, 1:9-19, 1:68-74; Figs. 1, 6, 8)
32. The article of	As discussed above for claim 1, Nishida describes the

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footwear recited in claim 24, wherein at least a portion of the textile element has a weft knitted construction.	use of "conventional" knitting processes, as of June 1992, to form the textile element for the upper. Weft knitting was a conventional and well known process for knitting textiles for shoe uppers in 1992 – see discussion for claim 1 in chart. Additional prior art, McDonald, Whiting, and Curley, describes weft knitting – see discussion for claim 1 of chart.
33. The article of footwear recited in claim 32, wherein the weft knitted construction is produced by one of circular knitting and flat knitting.	As discussed above for claim 1, Nishida describes the use of "conventional" knitting processes, as of June 1992, to form the textile element for the upper. Both circular and flat knitting were conventional and well known processes for knitting textiles for shoe uppers in 1992 – see discussion for claim 1 in chart. Additional prior art, McDonald and Whiting, describe circular or flat knitting or both – see discussion for claim 1 of chart.
34. The article of footwear recited in claim 24, wherein the textile element has a warp knitted construction.	As discussed above for claim 1, Nishida describes the use of "conventional" knitting processes, as of June 1992, to form the textile element for the upper. Warp knitting was a conventional and well known process for knitting textiles for shoe uppers in 1992 – see discussion for claim 1 in chart. Additional prior art, Curley and Shiomura, describe warp knitting – see discussion for claim 1 of chart. Shiomura describes use tricot knitting machines, Raschel knitting machines, or double Raschel knitting machines, all types of warp knitting, to make the knitted textile elements of its shoe. (Shiomura, 3:4-43)
35. The article of footwear recited in	It would be obvious to the skilled person making a warp knitted textile element to choose from among

Nike '011 Patent Claims	Nishida
claim 34, wherein the warp knitted construction is produced by a jacquard double needle-bar raschel.	available machines that use warp knitting. It is a simple design choice from among available possible machines. Indeed, Nishida discloses using suitable "program-controlled" or "computer-controlled" machines to make knitted uppers, suggesting any number of machines would be suitable for use. (2:40-47, 4:12-18, 4:47-60, 5:63-6:2) In addition, Shiomura describes using a double needle bar raschel knitting machine to make the knitted textile element of its shoe. (Shiomura, 3:4-43; Fig. 5) The '011 Patent describes that a "double needle-bar raschel ([machine] further includes jacquard double needle-bar raschel)." ('011 Patent, 7:4-5) It would have been obvious to the skilled person to use a jacquard double needle-bar raschel machine as described in Shiomura based on Nishida's disclosure of making the knitted uppers using suitable "program-controlled" or "computer-controlled" machines. (2:40-47, 4:12-18, 4:47-60, 5:63-6:2) The type of machine is a simple design choice and the skilled person would have a finite number of types of knitting machines from which to select a desired knitting machine.
36. An article of footwear comprising:	Abstract; Fig. 3
an upper incorporating a knitted textile element formed with a knitting machine, the textile element being removed from a textile structure that includes an outline of the textile element, and	Abstract; Fig. 2; 1:48-2:47; 3:6-12; 4:12-18; 4:31-42; 4:47-55; 5:63-6:2; 6:32-35 2:1-10: "the layouts and the sole parts assigned to one another are not completely separated from one another when cut out of the web of material, and remain connected with one another, as a cut-out unit, by corresponding material sections;

Nike '011 Patent Claims	Nishida
	from the cut-out units, each of which has a layout with an associated sole part, first the layout is connected on the provided seams to a shoe upper, and then, the sole part is stitched or basted to the free outside edge of the corresponding layout." 4:31-42: "In the production of web of material 1 or after its production, and optionally after cutting out of layout(s) 2, layout(s) 2 can be provided with an embroidery, especially with an English embroidery (i.e., the type of embroidery by which a hole pattern is welded and which is commonly used for the sewing of button holes), of a trademark or another mark or identification on suitable or preferred places. Finally, before or after cutting out of layout(s) 2, a tongue 32 (FIG. 3) is applied in the forefoot area. After the production of shoe upper 3, an insole and/or a midsole, optionally, is additionally applied or molded on."
the textile element having edges that are joined together to define at least a portion of a void for receiving a foot,	Abstract; Figs. 2-3 3:6-12: "In FIGS. 1 and 2, a web of material is identified by 1, and is produced by a conventional textile process, tier example, by weaving and/or knitting and/or embroidering. The web of material 1 can be provided with a single or with a plurality of layouts 2 of the shape of a shoe upper 3, as it is represented from the side, for example, in FIG. 3." 3:31-42: "After cutting out layout 2 from the web of material 1, the edges 7 and 8 are stitched together and a heel seam thus is formed. Then, heel counter 9, represented in

Nike '011 Patent Claims	Nishida
	FIG. 3, is applied, for example, glued and/or stitched, to adjacent areas 5 and 6. Correspondingly, the contours of edges 11 and 12 are stitched together in the form of shoe toe 10, and a seam is formed on the shoe toe. To reduce wear, a toe cap 15, represented in FIG. 3, can be applied, especially glued and/or stitched, on the front area, adjacent to front edge 13 of toe area 14."
wherein the textile element incorporates a single type of textile having a plurality of knit constructions; and	3:15-4:18; 4:47-60; 5:41-45; 5:63-6:2; 6:4-41 3:15-26: "Layout 2 is divided into different individual parts or areas, which differ from one another, such as by being of another material style and/or by being of different fibers or yarns, for example, from wool, wool with metal yarns, silk, silk with metal yarns, wool with plastic fibers or the like and/or by being formed of different colors, such as from fibers or yarns of different colors, including those of metals, or by different color prints, and/or by being differently designed fiber extrudates or fiber extrudate compositions, such as twisted, processed parallel or the like." 4:12-18: "As can be seen, any number of layouts 2 in the most varied configurations and/or designs as well as of different sizes can be produced on a single web of material 1. For this purpose, above all, the use of program-controlled, particularly computer-controlled, production devices is advantageous, so that style, color, design, size or the like can be varied at will." 5:41-45: "Preferably, each layout 2 has at least five, preferably

Nike '011 Patent Claims	Nishida
	more than ten, patterns and a tongue 40 has at least two, preferably at least three patterns produced or appearing, which are different from one another in each case."
a sole structure secured to the upper.	Abstract; Fig. 3 4:39-46: "Finally, before or after cutting out of layout(s) 2, a tongue 32 (FIG. 3) is applied in the forefoot area. After the production of shoe upper 3, an insole and/or a midsole, optionally, is additionally applied or molded on. Completed shoe upper 3 is then brought into a gluing, injection or casting mold, in which a midsole 33 and an outsole 34 are molded by known measures, as is represented in FIG. 3."
37. The article of footwear recited in claim 36, wherein the knitted textile element has a structure formed by a wide-tube circular knitting machine.	It would be obvious to the skilled person making a knitted textile element to choose from among available machines, including wide tube circular knitting machines. It is a simple design choice from among available possible machines. Indeed, Nishida discloses using suitable "program-controlled" or "computer-controlled" machines to make knitted uppers, suggesting any number of machines would be suitable for use. (2:40-47, 4:12-18, 4:47-60, 5:63-6:2) McDonald describes using a "conventional type of circular knitting machine" (p. 1, 2:26-30) to form a knitted textile element. The '011 Patent describes a wide tube circular knitting machine from Santoni S.p.A. of Italy that clearly existed before March 2004. ('011 Patent, 7:8-48) It would have been obvious to the skilled person to use a wide tube circular knitting machine based on

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	Nishida's disclosure of making the knitted uppers using suitable "program-controlled" or "computer-controlled" machines. (2:40-47, 4:12-18, 4:47-60, 5:63-6:2) The type of machine is a simple design choice and the skilled person would have a finite number of types of knitting machines from which to select a desired knitting machine. In particular wide tube knitting machine would allow for more material to be processed and more textile elements to be made than some other machines. The skilled person would be motivated to utilize such a machine for large-scale production to increase productivity and throughput.
38. The article of footwear recited in claim 36, wherein the knitted textile element has a structure formed by a jacquard double needle-bar raschel knitting machine.	Claim 38 adds an almost identical limitation to independent claim 36 as claim 35 added to independent claim 24. The additional limitation of claim 38 is obvious in view Nishida alone or Nishida and Shiomura – see discussion for claim 35 in chart.
39. The article of footwear recited in claim 36, wherein the edges include a pair of first edges that are joined to form a first seam extending longitudinally along a lower region of the upper.	Claim 39 adds the same limitation to independent claim 36 as claim 3 added to independent claim 1. Nishida describes the additional limitations of claim 39 – see discussion for claim 3 in chart.
40. The article of footwear recited in claim 39, wherein the edges include a pair of second edges that are	Claim 40 adds the same limitation to independent claim 36 as claim 4 added to independent claim 1. Nishida describes the additional limitations of claim 40 – see discussion for claim 4 in chart.

Nike '011 Patent Claims	Nishida
joined to form a second seam extending along a heel region of the upper.	
41. The article of footwear recited in claim 40, wherein the edges include at least a pair of third edges that are joined to form a second seam extending through a forefoot area of the upper.	Claim 41 adds the same limitation to independent claim 36 as claim 6 added to independent claim 1, except that there appears to be a typographical error referring to the third edges forming a "second seam" extending through the forefoot when the "second seam" was already defined in claim 40 as extending along a heel region. I have assumed this claim limitation meant to recite that the third edges form a "third seam." Nishida describes the additional limitations of claim 41 – see discussion for claim 6 in chart.
42. The article of footwear recited in claim 36, wherein the knitted textile element is one of an exterior layer, an intermediate layer, and an interior layer of the upper.	Claim 42 adds the same limitation to independent claim 36 as claim 7 added to independent claim 1. Nishida describes the additional limitations of claim 42 – see discussion for claim 7 in chart.
43. The article of footwear recited in claim 36, wherein the knitted textile element forms an interior surface of the upper.	Claim 43 adds the same limitation to independent claim 36 as claim 13 added to independent claim 1. Nishida describes the additional limitations of claim 43 or they are obvious in view of Curley, Shiomura, or Glidden – see discussion for claim 13 in chart.
44. An article of footwear comprising:	Abstract; Fig. 3
an upper incorporating a flat-knitted textile element, the flat-knitted textile element having a	The'011 Patent repeatedly describes a textile element with a unitary construction, not multiple unitary constructions. ('011 Patent, 5:38-40; 6:41-42; 9-32-35; 11:14-18) I understand this claim element to mean that

Nike '011 Patent Claims	Nishida
first area with a first unitary construction and a second area with a second unitary construction different from the first unitary construction ,	the textile element is a unitary construction that has two different areas within it that have different constructions. Abstract; Figs. 2-3 3:6-12: "In FIGS. 1 and 2, a web of material is identified by 1, and is produced by a conventional textile process, tier example, by weaving and/or knitting and/or embroidering. The web of material 1 can be provided with a single or with a plurality of layouts 2 of the shape of a shoe upper 3, as it is represented from the side, for example, in FIG. 3." 3:15-26: "Layout 2 is divided into different individual parts or areas, which differ from one another, such as by being of another material style and/or by being of different fibers or yarns, for example, from wool, wool with metal yarns, silk, silk with metal yarns, wool with plastic fibers or the like and/or by being formed of different colors, such as from fibers or yarns of different colors, including those of metals, or by different color prints, and/or by being differently designed fiber extrudates or fiber extrudate compositions, such as twisted, processed parallel or the like." 3:31-42: "After cutting out layout 2 from the web of material 1, the edges 7 and 8 are stitched together and a heel seam thus is formed. Then, heel counter 9, represented in FIG. 3, is applied, for example, glued and/or stitched, to adjacent areas 5 and 6. Correspondingly, the contours of edges 11 and 12 are

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	stitched together in the form of shoe toe 10, and a seam is formed on the shoe toe. To reduce wear, a toe cap 15, represented in FIG. 3, can be applied, especially glued and/or stitched, on the front area, adjacent to front edge 13 of toe area 14." 4:12-18: "As can be seen, any number of layouts 2 in the most varied configurations and/or designs as well as of different sizes can be produced on a single web of material 1. For this purpose, above all, the use of program-controlled, particularly computer-controlled, production devices is advantageous, so that style, color, design, size or the like can be varied at will." Nishida discloses producing the material that forms the upper with a "conventional textile process … by weaving and/or knitting …" At the time Nishida was filed in the U.S. (June 17, 1992) the skilled person would have known and understood that "conventional" knitting processes include both warp knitting and weft knitting (and further including both circular and flat knitting), since these knitting processes existed for many decades before 1992 and had been used in the making of shoe uppers for many decades as well. For example, Whiting dates to 1953 and describes a method for producing knitted shoe uppers of shrinkable yarn, including knitting the sock-like structure that forms the upper on "flat or circular knitting machines." (Whiting, 2:39-56) As another example, Curley, published in April 1990, describes shoes made with knitted layers in the upper, including both warp and weft knitting. (Curley, p. 7, line 32 – p. 8, line 25) It is my opinion that Nishida discloses flat knitting by

Nike '011 Patent Claims	Nishida
	disclosing that "conventional" knitting processes can be used for his invention. Even if Nishida was determined not to describe flat knitting, it would have been obvious to the skilled person to use flat knitting from Nishida's disclosure of using a knitted material for the upper. Flat knitting was a well known knitting process in March 2004, when the '011 Patent was filed. Flat knitting had been used for years in shoe uppers, as shown by Whiting for example. It would simply have been a matter of design choice from among a finite number of types of knitting processes one could use.
the first area having a first set of properties, and the second area having a second set of properties that is different from the first set of properties to impart varying characteristics to the textile element; and	3:15-4:18; 4:47-60; 5:41-45; 5:63-6:2; 6:4-41 3:15-26: "Layout 2 is divided into different individual parts or areas, which differ from one another, such as by being of another material style and/or by being of different fibers or yarns, for example, from wool, wool with metal yarns, silk, silk with metal yarns, wool with plastic fibers or the like and/or by being formed of different colors, such as from fibers or yarns of different colors, including those of metals, or by different color prints, and/or by being differently designed fiber extrudates or fiber extrudate compositions, such as twisted, processed parallel or the like." 3:43-52: "Since, generally, toe area 14 is designed to be relatively deformably soft or elastic, and optionally, also permeable to air, the web of material 1, in toe area 14, according to the present invention, is correspondingly designed by suitable selection of the weave pattern, knit pattern and/or the material used,

Nike '011 Patent Claims	Nishida
	such as, for example, Silk or plastic. The type of production can, additionally, insure that the toe area 14 has a good air exchange capability. For example, this can be achieved by a net-like woven or knitted structure." 4:12-18: "As can be seen, any number of layouts 2 in the most varied configurations and/or designs as well as of different sizes can be produced on a single web of material 1. For this purpose, above all, the use of program-controlled, particularly computer-controlled, production devices is advantageous, so that style, color, design, size or the like can be varied at will." 5:41-45: "Preferably, each layout 2 has at least five, preferably more than ten, patterns and a tongue 40 has at least two, preferably at least three patterns produced or appearing, which are different from one another in each case." 5:63-6:2: "As already indicated, the webs of material being used can be produced by program-controlled web material production devices whose programs can be matched almost at will according to the corresponding basic setting with deviations in the size of the layouts of the individual shoe uppers or with changes of the type of weave or knit of individual areas or contours, the type of fiber or yarn and/or the color." 6:22-31: "using one of a different weaving and knitting type for the layouts of the shoe upper than is used for producing the sole parts, said weaving and knitting types being

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	matched to differing requirements for materials of the shoe upper and sole part of a shoe in relation to properties thereof including at least one of the properties of absorptivity, air permeability, softness, extensibility, wear resistance and appearance"
a sole structure secured to the upper.	Abstract; Fig. 3 4:39-46: "Finally, before or after cutting out of layout(s) 2, a tongue 32 (FIG. 3) is applied in the forefoot area. After the production of shoe upper 3, an insole and/or a midsole, optionally, is additionally applied or molded on. Completed shoe upper 3 is then brought into a gluing, injection or casting mold, in which a midsole 33 and an outsole 34 are molded by known measures, as is represented in FIG. 3."
45. The article of footwear recited in claim 44, wherein the first set of properties and the second set of properties are at least one of a stitch configuration and a yarn type.	3:15-26: "Layout 2 is divided into different individual parts or areas, which differ from one another, such as by being of another material style and/or by being of different fibers or yarns, for example, from wool, wool with metal yarns, silk, silk with metal yarns, wool with plastic fibers or the like and/or by being formed of different colors, such as from fibers or yarns of different colors, including those of metals, or by different color prints, and/or by being differently designed fiber extrudates or fiber extrudate compositions, such as twisted, processed parallel or the like." 3:43-52: "Since, generally, toe area 14 is designed to be relatively deformably soft or elastic, and optionally,

Nike '011 Patent Claims	Nishida
	also permeable to air, the web of material 1, in toe area 14, according to the present invention, is correspondingly designed by suitable selection of the weave pattern, knit pattern and/or the material used, such as, for example, Silk or plastic. The type of production can, additionally, insure that the toe area 14 has a good air exchange capability. For example, this can be achieved by a net-like woven or knitted structure." 5:63-6:2: "As already indicated, the webs of material being used can be produced by program-controlled web material production devices whose programs can be matched almost at will according to the corresponding basic setting with deviations in the size of the layouts of the individual shoe uppers or with changes of the type of weave or knit of individual areas or contours, the type of fiber or yarn and/or the color."
46. The article of footwear recited in claim 44, wherein the textile element is one of an exterior layer, an intermediate layer, and an interior layer of the upper.	Claim 46 adds the same limitation to independent claim 44 as claim 7 added to independent claim 1. Nishida describes the additional limitations of claim 46 – see discussion for claim 7 in chart.

73. As explained in the chart, claims 1-15 are anticipated by Nishida or, alternatively, are obvious in view of Nishida alone. Claims 1-15 are also obvious in view of Nishida combined with other prior art as follows:

- Claim 1 is obvious in view of Nishida and any one of the following: McDonald, Whiting, Curley.

- Claims 2-7 and 10-12 are obvious in view of same.

- Claim 8 is obvious in view of Nishida and one or more of the following: Curley, Shiomura, McDonald, Whiting.

- Claims 9 and 13 are obvious in view of Nishida and one or more of the following: Curley, Shiomura, Glidden, McDonald, Whiting.

- Claim 14 is obvious in view of Nishida and any one of the following: McDonald, Whiting.

- Claim 15 is obvious in view of Nishida and Whiting.

74. Claims 16 and 19-23 are anticipated by Nishida or, alternatively, are obvious in view of Nishida alone. Claims 16-23 are also obvious in view of Nishida combined with other prior art as follows:

- Claim 16 is obvious in view of Nishida and any one of the following: McDonald, Whiting, Curley.

- Claims 19-20 are obvious in view of same.

- Claims 17-18 are obvious in view of Nishida and one or more of the following: McDonald, Whiting, Curley, Glidden.

- Claim 21 is obvious in view of Nishida and one or more of the following: Curley, Shiomura, McDonald, Whiting.

- Claims 22-23 are obvious in view of Nishida and one or more of the following: Curley, Shiomura, Glidden, McDonald, Whiting.

75. Claims 24-34 are anticipated by Nishida or, alternatively, are obvious in view of Nishida alone. Claim 35 is obvious in view of Nishida alone. Claims 30-35 are also obvious in view of Nishida combined with other prior art as follows:

- Claims 30-31 are obvious in view of Nishida and any one of the following: Curley, Shiomura, Glidden.
- Claim 32 is obvious in view of Nishida and any one of the following: McDonald, Whiting, Curley.
- Claim 33 is obvious in view of Nishida and any one of the following: McDonald, Whiting.
- Claim 34 is obvious in view of Nishida and any one of the following: Curley, Shiomura.
- Claim 35 is obvious in view of Nishida and Shiomura.

76. Claims 36 and 39-43 are anticipated by Nishida or, alternatively, are obvious in view of Nishida alone. Claims 37 and 38 are obvious in view of Nishida alone. Claims 37, 38, and 43 are also obvious in view of Nishida combined with other prior art as follows:

- Claim 37 is obvious in view of Nishida and McDonald.
- Claim 38 is obvious in view of Nishida and Shiomura.
- Claim 43 is obvious in view of Nishida and any of the following: Curley, Shiomura, Glidden.

77. Claims 44-46 are anticipated by Nishida or, alternatively, are obvious in view of Nishida alone. Claims 44-46 are also obvious in view of Nishida combined with other prior art as follows:

- Claims 44-46 are obvious in view of Nishida and any one of the following: Whiting, Curley.

VIII. Claims 1, 2, 7-14, and 16-23 Are Anticipated by U.S. Patent No. 2,147,197 to Glidden and/or Obvious

78. As further explained in the chart below, it is my opinion that claims 1, 2, 7-14, and 16-23 of the '011 Patent are invalid in view of the Glidden patent.

79. Glidden was issued by the Patent Office on February 14, 1939 and is entitled "Article of Footwear." Glidden explains (p. 1, 1:4-20, 1:25-32):

> Heretofore shoes for use in playing athletic games and for similar purposes, sometimes called sneakers or tennis shoes, have been manufactured from substantially nonstretchable canvas or similar woven material. It has been the practice to construct the uppers with a fabric lining attached to the upper by an intervening layer of rubber. In the manufacture of such shoes a great amount of waste has been involved in the cutting of the fabric parts, and due to the substantially nonstretchable nature of the textile material comprising the upper difficulty has been experienced in providing the proper shape to such shoes. The resulting shoes are of such a nonabsorbent nature and so impervious to moisture that discomfort has been caused to the wearer by perspiration.
>
> * * *
>
> The principal objects of the present invention are to provide comfort, stretchability, lightweight, breathability and absorption properties in an article of footwear and to provide for economy of materials and convenience of procedure in the manufacture of the same. Other objects will appear from the following description and the accompanying drawings.

80. Glidden further explains at page 1, 2:2-17:

> Referring to the drawings, the invention contemplates the construction of an article of footwear in which an upper of extensible and elastic textile material, such, for example, as knited [sic] material, and of such extent as to form the complete upper including the insole, is

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> fabricated without substantial waste to the desired shape to accommodate the foot without uncomfortable wringles. A reinforcing structure, preferably of rubber is provided on the outer face of the upper in form-fitting contact therewith without wrinkling or buckling of either of the parts, while preferably leaving extensive portions of the textile upper exposed to provide breathability and facility of flexing.

81. Glidden also describes that its unitary knitted upper has different configurations in different areas (p. 1, 2:33-44):

> In fabricating the unitary upper, as by knitting, areas thereof which are normally subjected to greater wear and in which a lower degree of elasticity is desired, such as the toe 11 and the heel portion 12, may be more densely fabricated to provide therein heavier weight and less extensibility than in the other parts of the upper, as by changing the type of stitch or amount or thickness of the yarn in the knitting. Other areas, such as the ankle portion 13, are preferably made so as to provide softness and elasticity, as by making them of ribbed construction, as shown.

82. Glidden summarizes its advantages (p. 2, 2:39-53):

> An article of footwear constructed according to the invention has decided advantages over articles of footwear heretofore produced. Because of the unlined, absorbent nature of the upper perspiration is readily absorbed and evaporated from the foot. The high porosity of the upper provides good ventilation, and the flexibility of the upper and its inherent elasticity provide a degree of comfort comparable to wearing well fitted socks without shoes, while the outsole, which may be of any desired type and may be of crepe soling or may be molded to provide any desired anti-skid surface, provides adequate traction and protects the feet in walking.

83. In the chart below, all citations are to Glidden, except where I specifically identify that I am citing to another prior art reference. I have included direct quotations from Glidden in some instances.

84. Glidden describes every element of claims 1, 2, 7-14, and 16-23, and therefore anticipates those claims. These claims are likewise obvious in view of Glidden combined with either McDonald or Whiting.

Nike '011 Patent Claims	Glidden
1. An article of footwear comprising:	Title; p.1,1:1-4 "This invention relates to articles of footwear and to methods of making the same, and is especially useful in the manufacture of shoes having textile uppers."
an upper incorporating a weft-knitted textile element having edges that are joined together to define at least a portion of a void for receiving a foot,	Figs. 1, 6, 8 p. 1, 2:3-10: "Referring to the drawings, the invention contemplates the construction of an article of footwear in which an upper of extensible and elastic textile material, such, for example, as knited material, and of such extent as to form the complete upper including the insole, is fabricated without substantial waste to the desired shape to accommodate the foot without uncomfortable wringles." p. 1, 2:45-48: "In the embodiment of Fig. 1 the entire upper, preferably including the insole, is fabricated as an integral, shaped, sock-like article although in some cases the insole portion may be omitted if that is desired." The skilled person would know from Glidden's description of fabricating the upper as a shaped, "sock-like" article, as well as the knit patterns in the drawings, that Glidden is describing and showing a weft-knitted textile element. In addition, the skilled person would know that

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Nike '011 Patent Claims	Glidden
	knitting the unitary upper in a "sock-like" fabrication process would have utilized circular knitting, which has been used for making socks for many decades. This would require the edges to be joined, at least in the area of the toe, in order to create a void for receiving the foot (otherwise, it would be an open tube if those edges were not joined) For example, Whiting dates to 1953 and describes a method for producing knitted shoe uppers of shrinkable yarn, including knitting the sock-like structure that forms the upper on "flat or circular knitting machines." (Whiting, 2:39-56) As another example, McDonald dates to 1943 and describes a method of making shoes including use of a "conventional type of circular knitting machine" to form a "weft knit fabric" used to make the upper of a shoe. (McDonald, p. 1 at 2:26-39)
wherein the weft-knitted textile element incorporates a single type of textile having a plurality of knit constructions; and	Fig. 1 p.1, 2:33-44 "In fabricating the unitary upper, as by knitting, areas thereof which are normally subjected to greater wear and in which a lower degree of elasticity is desired, such as the toe 11 and the heel portion 12, may be more densely fabricated to provide therein heavier weight and less extensibility than in the other parts of the upper, as by changing the type of stitch or amount or thickness of the yarn in the knitting. Other areas, such as the ankle portion 13, are preferably made so as to provide softness and elasticity as by making them of ribbed construction, as shown."
a sole structure secured to the upper.	Figs. 1, 6 p. 2, 1:9-19; p. 2, 2:8-15; p. 2, 2:23-30

Nike '011 Patent Claims	Glidden
	p. 2, 1:9-19: "In the embodiment of Fig. 1, after the upper has been applied to the last, the parts, preferably of rubber including a counter 14, heel reinforcement 16, outsole 17 and a blucher saddle 18 having an integral heel strap 19, which encircles the rear of the shoe, are mounted in place upon the upper as illustrated in Fig. 3, and may be cemented thereto in the places where it is desired to attach the parts to the upper, and a foxing 20 is preferably applied around the lower portion of the shoe where it joins the outer sole."
2. The article of footwear recited in claim 1, wherein the weft-knitted textile element forms at least a portion of a lateral side, a medial side, and an instep region of the upper.	Figs. 1-3 p. 1, 2:3-10: "Referring to the drawings, the invention contemplates the construction of an article of footwear in which an upper of extensible and elastic textile material, such, for example, as knited material, and of such extent as to form the complete upper including the insole, is fabricated without substantial waste to the desired shape to accommodate the foot without uncomfortable wringles."
7. The article of footwear recited in claim 1, wherein the weft-knitted textile element is one of an exterior layer, an intermediate layer, and an interior layer of the upper.	Figs. 1-3, 6-8 p. 1, 2:3-23; p. 2, 1:68-74 p. 1, 2:3-23: "Referring to the drawings, the invention contemplates the construction of an article of footwear in which an upper of extensible and elastic textile material, such, for example, as knited material, and of such extent as to form the complete upper including the insole, is fabricated without substantial

Nike '011 Patent Claims	Glidden
	waste to the desired shape to accommodate the foot without uncomfortable wringles. A reinforcing structure, preferably of rubber is provided on the outer face of the upper in form-fitting contact therewith without wrinkling or buckling of either of the parts, while preferably leaving extensive portions of the textile upper exposed to provide breathability and facility of flexing. Referring to the drawings: In proceeding according to the method of this invention a complete and integral, extensible and elastic, unlined shoe upper 10 is formed, preferably by knitting, to final form and without waste, of yarn which may be of any suitable material, …"
8. The article of footwear recited in claim 1, wherein the upper includes an exterior layer, an intermediate layer, and an interior layer, and the weft-knitted textile element forms at least a portion of the interior layer.	Figs. 1-2 p. 1, 2:3-23; p. 2, 1:9-19; p. 2, 1:68-74 p. 2, 1:9-19: "In the embodiment of Fig. 1, after the upper has been applied to the last, the parts, preferably of rubber including a counter 14, heel reinforcement 16, outsole 17 and a blucher saddle 18 having an integral heel strap 19, which encircles the rear of the shoe, are mounted in place upon the upper as illustrated in Fig. 3, and may be cemented thereto in the places where it is desired to attach the parts to the upper, and a foxing 20 is preferably applied around the lower portion of the shoe where it joins the outer sole."
9 The article of footwear recited in claim 1, wherein the weft-knitted textile element forms at least a portion of both an	Figs. 1-3, 6-8 p. 1, 2:3-23; p. 2, 1:68-74 p. 1, 2:3-23:

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Nike '011 Patent Claims	Glidden
interior surface and an exterior surface of the upper.	"Referring to the drawings, the invention contemplates the construction of an article of footwear in which an upper of extensible and elastic textile material, such, for example, as knited material, and of such extent as to form the complete upper including the insole, is fabricated without substantial waste to the desired shape to accommodate the foot without uncomfortable wringles. A reinforcing structure, preferably of rubber is provided on the outer face of the upper in form-fitting contact therewith without wrinkling or buckling of either of the parts, while preferably leaving extensive portions of the textile upper exposed to provide breathability and facility of flexing. Referring to the drawings: In proceeding according to the method of this invention a complete and integral, extensible and elastic, unlined shoe upper 10 is formed, preferably by knitting, to final form and without waste, of yarn which may be of any suitable material, …"
10. The article of footwear recited in claim 9, wherein at least one additional element is secured to the exterior surface and forms a portion of the exterior surface.	Figs. 1-8 p. 2, 1:9-19: "In the embodiment of Fig. 1, after the upper has been applied to the last, the parts, preferably of rubber including a counter 14, heel reinforcement 16, outsole 17 and a blucher saddle 18 having an integral heel strap 19, which encircles the rear of the shoe, are mounted in place upon the upper as illustrated in Fig. 3, and may be cemented thereto in the places where it is desired to attach the parts to the upper, and a foxing 20 is preferably applied around the lower portion of the shoe where it joins the outer sole."

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Nike '011 Patent Claims	Glidden
	p.2, 1:50-55 "A strap 25 may be provided, extending around the back of the foot and secured at its ends to the stays. As shown, the shoe may be of the low type with the strap 25 extending along the top margin of the upper." p.2, 1:64-74: "Other modifications of the invention, in which the rubber portion of the shoe may be detachable from the textile upper to facilitate washing the upper, are illustrated in Figs. 6, 7 and 8. In the embodiment of Figs. 6 and 7, the lower portion of the textile upper 27 is embraced by an integral rubber covering 28 having no lacings or other fastening means, but provided with a sole 29 and formed with ventilating and expansion-facilitating openings 30 which expose the textile upper." p.2, 2:24-26: "The embodiment of Fig. 8 may be constructed in similar manner. Here a sole 32 is provided with a counter 33, toe cap 34, heel straps 35, and sole straps 36, united to each other."
11. The article of footwear recited in claim 10, wherein the additional element is secured to a forefoot area of the upper.	Figs. 6, 8 p.2, 2:24-26: "The embodiment of Fig. 8 may be constructed in similar manner. Here a sole 32 is provided with a counter 33, toe cap 34, heel straps 35, and sole straps 36, united to each other."
12. The article of footwear recited in claim 10, wherein the additional	Figs. 1-6

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Nike '011 Patent Claims	Glidden
element is secured to a heel area of the upper.	p. 2, 1:9-19: "In the embodiment of Fig. 1, after the upper has been applied to the last, the parts, preferably of rubber including a counter 14, heel reinforcement 16, outsole 17 and a blucher saddle 18 having an integral heel strap 19, which encircles the rear of the shoe, are mounted in place upon the upper as illustrated in Fig. 3, and may be cemented thereto in the places where it is desired to attach the parts to the upper, and a foxing 20 is preferably applied around the lower portion of the shoe where it joins the outer sole." p.2, 2:24-26: "The embodiment of Fig. 8 may be constructed in similar manner. Here a sole 32 is provided with a counter 33, toe cap 34, heel straps 35, and sole straps 36, united to each other."
13. The article of footwear recited in claim 1, wherein the textile element forms an interior surface of the upper.	Figs. 1-3 Figs. 1-3, 6-8 p. 1, 2:3-23; p. 2, 1:68-74 p. 1, 2:3-23: "Referring to the drawings, the invention contemplates the construction of an article of footwear in which an upper of extensible and elastic textile material, such, for example, as knited material, and of such extent as to form the complete upper including the insole, is fabricated without substantial waste to the desired shape to accommodate the foot without uncomfortable wringles. A reinforcing structure, preferably of rubber is provided on the outer face of the upper in form-fitting contact therewith without wrinkling or buckling of either of the parts, while preferably leaving extensive portions

Nike '011 Patent Claims	Glidden
	of the textile upper exposed to provide breathability and facility of flexing. Referring to the drawings: In proceeding according to the method of this invention a complete and integral, extensible and elastic, unlined shoe upper 10 is formed, preferably by knitting, to final form and without waste, of yarn which may be of any suitable material, …"
14. The article of footwear recited in claim 1, wherein the weft-knitted textile element is created by circular knitting.	Figs. 1, 6, 8 p. 1, 2:3-10; p. 1, 2:45-48 As discussed above for claim 1, Glidden describes fabricating the unitary knitted upper as a shaped, "sock-like" article, which skilled persons would have known meant circular knitting was used to make the textile element since circular knitting was commonly used in the manufacture of socks. For example, Whiting dates to 1953 and describes a method for producing knitted shoe uppers of shrinkable yarn, including knitting the sock-like structure that forms the upper on "flat or circular knitting machines." (Whiting, 2:39-56) As another example, McDonald dates to 1943 and describes a method of making shoes including use of a "conventional type of circular knitting machine" to form a "weft knit fabric" used to make the upper of a shoe. (McDonald, p. 1 at 2:26-39)
16. An article of footwear comprising:	Title; p.1,1:1-4 "This invention relates to articles of footwear and to methods of making the same, and is especially useful

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Nike '011 Patent Claims	Glidden
	in the manufacture of shoes having textile uppers."
an upper incorporating a weft-knitted textile element, the textile element having a first area and a second area with a unitary construction,	Figs. 1, 6, 8 p. 1, 2:3-10: "Referring to the drawings, the invention contemplates the construction of an article of footwear in which an upper of extensible and elastic textile material, such, for example, as knited material, and of such extent as to form the complete upper including the insole, is fabricated without substantial waste to the desired shape to accommodate the foot without uncomfortable wringles." p.1, 2:33-44: "In fabricating the unitary upper, as by knitting, areas thereof which are normally subjected to greater wear and in which a lower degree of elasticity is desired, such as the toe 11 and the heel portion 12, may be more densely fabricated to provide therein heavier weight and less extensibility than in the other parts of the upper, as by changing the type of stitch or amount or thickness of the yarn in the knitting. Other areas, such as the ankle portion 13, are preferably made so as to provide softness and elasticity as by making them of ribbed construction, as shown." p. 1, 2:45-48: "In the embodiment of Fig. 1 the entire upper, preferably including the insole, is fabricated as an integral, shaped, sock-like article although in some cases the insole portion may be omitted if that is desired." The skilled person would know from Glidden's description of fabricating the upper as a shaped, "sock-like" article, as well as the knit patterns in the

Nike '011 Patent Claims	Glidden
	drawings, that Glidden is describing and showing a weft-knitted textile element. In addition, the skilled person would know that knitting the unitary upper in a "sock-like" fabrication process would have utilized circular knitting, which has been used for making socks for many decades. For example, Whiting dates to 1953 and describes a method for producing knitted shoe uppers of shrinkable yarn, including knitting the sock-like structure that forms the upper on "flat or circular knitting machines." (Whiting, 2:39-56) As another example, McDonald dates to 1943 and describes a method of making shoes including use of a "conventional type of circular knitting machine" to form a "weft knit fabric" used to make the upper of a shoe. (McDonald, p. 1 at 2:26-39)
the first area being formed of a first stitch configuration, and the second area being formed of a second stitch configuration that is different from the first stitch configuration to impart varying properties to the textile element; and	Figs. 1, 2, 6 p.1, 2:33-44: "In fabricating the unitary upper, as by knitting, areas thereof which are normally subjected to greater wear and in which a lower degree of elasticity is desired, such as the toe 11 and the heel portion 12, may be more densely fabricated to provide therein heavier weight and less extensibility than in the other parts of the upper, as by changing the type of stitch or amount or thickness of the yarn in the knitting. Other areas, such as the ankle portion 13, are preferably made so as to provide softness and elasticity as by making them of ribbed construction, as shown."
a sole structure secured to the upper.	Figs. 1, 6 p. 2, 1:9-19; p. 2, 2:8-15; p. 2, 2:23-30

Nike '011 Patent Claims	Glidden
	p. 2, 1:9-19: "In the embodiment of Fig. 1, after the upper has been applied to the last, the parts, preferably of rubber including a counter 14, heel reinforcement 16, outsole 17 and a blucher saddle 18 having an integral heel strap 19, which encircles the rear of the shoe, are mounted in place upon the upper as illustrated in Fig. 3, and may be cemented thereto in the places where it is desired to attach the parts to the upper, and a foxing 20 is preferably applied around the lower portion of the shoe where it joins the outer sole."
17. The article of footwear recited in claim 16, wherein the first stitch configuration provides a substantially smooth texture to the first area, and the second stitch configuration provides a texture to the second area that is rougher than the smooth texture.	Figs. 1, 2, 6 p.1, 2:33-44: "In fabricating the unitary upper, as by knitting, areas thereof which are normally subjected to greater wear and in which a lower degree of elasticity is desired, such as the toe 11 and the heel portion 12, may be more densely fabricated to provide therein heavier weight and less extensibility than in the other parts of the upper, as by changing the type of stitch or amount or thickness of the yarn in the knitting. Other areas, such as the ankle portion 13, are preferably made so as to provide softness and elasticity as by making them of ribbed construction, as shown."
18. The article of footwear recited in claim 17, wherein the second stitch configuration forms a rib structure in the second area.	p.1, 2:33-44: "In fabricating the unitary upper, as by knitting, areas thereof which are normally subjected to greater wear and in which a lower degree of elasticity is desired, such as the toe 11 and the heel portion 12, may be more densely fabricated to provide therein heavier weight and less extensibility than in the other parts of the upper, as by changing the type of stitch or amount or thickness of the yarn in the knitting. Other areas,

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Nike '011 Patent Claims	Glidden
	such as the ankle portion 13, are preferably made so as to provide softness and elasticity as by making them of ribbed construction, as shown."
19. The article of footwear recited in claim 16, wherein at least one of the first stitch configuration and the second stitch configuration forms an aperture in the weft-knitted textile element.	p. 1, 1:25-30; p. 2, 2:40-53; claims 1-5 p. 1, 1:25-30: "The principal objects of the present invention are to provide comfort, stretchability, lightweight, breathability and absorption properties in an article of footwear and to provide for economy of materials and convenience of procedure in the manufacture of the same." p. 2, 2:40-53: "An article of footwear constructed according to the invention has decided advantages over articles of footwear heretofore produced. Because of the unlined, absorbent nature of the upper perspiration is readily absorbed and evaporated from the foot. The high porosity of the upper provides good ventilation, and the flexibility of the upper and its inherent elasticity provide a degree of comfort comparable to wearing well fitted socks without shoes, while the outsole, which may be of any desired type and may be of crepe soling or may be molded to provide any desired anti-skid surface, provides adequate traction and protects the feet in walking." The '011 Patent describes that "apertures" are formed by omitting stitches to provide air permeability in the knitted textile element. ('011 Patent, 9:57-62) The Glidden upper with high porosity has apertures.
20. The article of footwear recited in claim 16, wherein the weft-	Claim 20 adds the same limitation to independent claim 16 as claim 7 added to independent claim 1. Glidden describes the additional limitations of claim

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Nike '011 Patent Claims	Glidden
knitted textile element is one of an exterior layer, an intermediate layer, and an interior layer of the upper.	20 – see discussion for claim 7 in chart.
21. The article of footwear recited in claim 16, wherein the upper includes an exterior layer, an intermediate layer, and an interior layer, and the weft-knitted textile element forms at least a portion of the interior layer.	Claim 21 adds the same limitation to independent claim 16 as claim 8 added to independent claim 1. Glidden describes the additional limitations of claim 21 – see discussion for claim 8 in chart.
22. The article of footwear recited in claim 16, wherein the textile layer forms at least a portion of both the interior surface and an exterior surface of the upper.	Claim 22 adds the same limitation to independent claim 16 as claim 9 added to independent claim 1, except that claim 22 recites "the textile "layer" instead of "textile element." I have assumed this is a typographical error because claim 16 does not otherwise identify a "textile layer" and have treated this limitation as if it recited "textile element" as in claim 9. Glidden describes the additional limitations of claim 22 – see discussion for claim 9 in chart.
23. The article of footwear recited in claim 16, wherein the weft-knitted textile element forms an interior surface of the upper.	Claim 23 adds the same limitation to independent claim 16 as claim 13 added to independent claim 1. Glidden describes the additional limitations of claim 23 – see discussion for claim 13 in chart.

IX. Claims 1-46 Are Obvious in View of Japanese Patent Publication No. H6-113905 to Osamu Daimaru Alone or Combined with Other Prior Art.

85. It is my opinion that Japanese Patent Publication No. H6-113905 to Osamu Daimaru ("Osamu") anticipates and/or renders obvious claims 1-46 of the '011 Patent. The English translation of Osamu indicates Osamu was published on April 26, 1994, almost ten years before the application for the '011 Patent was filed.

86. Osamu describes uppers for shoes, including athletic shoes, that are made from a single woven textile. (paragraph [0001]) Osamu cites efficiency as one of the objectives of his invention (p. 1, Objective and Configuration):

> To develop uppers material for shoes indispensable to manufacturing methods that increase the economic efficiency of production by reducing the quantity of uppers materials for shoes as much as possible thus simplifying the stitching process. The configuration is one sheet of cloth wherein, as uppers material for shoes, all the outlines of the main uppers for the shoe of one foot are continuous and the interiors thereof are woven using Jacquard weave in a variety of weave structures and/or patterns for each location.

87. Similar to the '011 Patent, Osamu describes the inefficiencies associated with conventional shoe manufacturing (paragraph [0004]):

> As mentioned above, with the conventional shoe manufacturing methods based on parts, a variety of materials come to be assembled into the shoe for one foot. To do this, there is the difficulty of procuring each material and losses of each material are large, with the loss having to be borne by the shoe factory. In addition, because the structure is complicated, effort is required for cutting and stitching together and skill-training is required. The actual labor cost,

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> domestically, for cutting and sewing/stitching work has increased by 10 to 100% or more. The trend toward a "parts approach" results in an increase in the component of specialized fabrication work and a steep rise in personnel cost, coupled with the fact that domestic sewing/stitching factories are unprofitable. Thus shoe manufacturing that involves a large number of individual parts has become difficult in practice. Further, in respect to economies of manufacturing, because a process where each part of a shoe is designed and cut and a process where these parts of complicated shapes are stitched together accurately and with uniform elasticity are involved, for mass production, there were the issues that high-level techniques were required and simplification/reduction of the number of process steps was difficult.

88. Osamu explains that solving the problem utilizes a single textile element to form the upper, and that this textile element can have a variety of configurations within it (paragraph [0005]):

> The present invention, by setting up the conventional parts as a single sheet of main uppers materials as much as possible, reduces the number of parts and the number of sewing/stitching operations, thus improving overall efficiency. To sum up, uppers material is provided which, on a single sheet of Jacquard weave cloth, forms an integration of almost all the uppers material for a shoe. The present invention is uppers material configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures, designs and/or patterns.

89. Osamu further explains that (paragraphs [0009] and [0012]):

> Figure 3 shows the main uppers 2 after cutting. Overall they make one sheet of woven fabric and each pattern element 10 through 18 therein is formed of a different weave structure and/or different pattern. For each shoe location, the appropriate weave structure is used. For example, toe cap tip 10 is formed of a weave structure of high yarn count and density, and upper surface 11 is formed of a weave structure with high breathability. Furthermore, by using a weaving yarn materials such as those with nylon fiber blended in and

> cutting the outline lines by thermal cutting, the cut edges melt and will not fray.
>
> * * *
>
> In this connection, the shape of main uppers 2 enables various types of computer-generated designs and patterns to be used, and by designating patterns or other software to weaving machines, this can be applied both to small lot production and to mass production.

90. In the chart below I cite to the English translation of Osamu that counsel provided to me using the paragraph [XXXX] format, except where I specifically identify that I am citing to another prior art reference. I have included direct quotations from Osamu in some instances.

91. Claims 1-46 are obvious in view of Osamu combined with other prior art references as follows:

Nike '011 Patent Claims	Osamu
1. An article of footwear comprising:	Title; paragraphs [0001], [0007] [0001]: "[Field of the Invention] The present invention relates to uppers material for shoes and more particularly that for sport shoes. In particular, the shoe uppers material of the present invention is uppers material comprising one sheet of woven fabric."
an upper incorporating a weft-knitted textile element having edges that are joined together to define at least a portion of a void for receiving a	Figs. 1, 3; paragraphs [0007], [0010], [0011] part of [0007]: "Figure 1 shows an embodiment of uppers material for shoes according to the present invention. The uppers material for shoes is configured of one sheet of cloth wherein, the main uppers material 2 for the

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Nike '011 Patent Claims	Osamu
foot,	shoe of one foot are woven on elongated foundation cloth 1, all the outlines thereof are connected, and within those outlines at each appropriate location 21 through 26 are many kinds of weave structures, designs and patterns." [0009], [0010]: "Figure 3 shows the main uppers 2 after cutting. Overall they make one sheet of woven fabric and each pattern element 10 through 18 therein is formed of a different weave structure and/or different pattern. For each shoe location, the appropriate weave structure is used. For example, toe cap tip 10 is formed of a weave structure of high yarn count and density, and upper surface 11 is formed of a weave structure with high breathability. Furthermore, by using a weaving yarn materials such as those with nylon fiber blended in and cutting the outline lines by thermal cutting, the cut edges melt and will not fray. The main uppers 2, configured in this way, become 3-dimensional shoe uppers by stitching together the parts for joining by stitching 19 at the rear-most part of those main uppers." Osamu describes a woven textile element, rather than a weft-knitted textile element. However, the use of a weft-knitted textile element would have been obvious to the skilled person. Woven and knitted textiles are both suitable for use in uppers and known by the skilled person to be interchangeable. Selection of one versus the other is an obvious design choice. Nishida, for example, recognizes the interchangeability of woven and knitted textiles for use in uppers, repeatedly referring to "woven and/or knitted" fabrics when describing the textile element and configurations in his patent. (Nishida, 1:61-62;

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Nike '011 Patent Claims	Osamu
	1:67-68; 2:42-45; 3:6-10; 3:45-52; 3;66-68; 5:63-6:2; 6:23-25) Osamu itself recognized that the use of a knitted versus a woven textile in the upper was interchangeable and a matter of design choice. Osamu, in describing the prior art in paragraph [0002], states "For example, when using woven fabric and/or knitted fabric as uppers materials for shoes, as shown in Figure 2, the material is made into many parts, such as the tip part A, upper surface part B, edge part C, side surface parts D, E, and F, ankle edge part G, heel parts H and I, and the material and shape of each is selected according to the function of that location. Parts of many types are provided, such as woven fabrics and/or knitted fabrics of various surface structure and design (A, B, I), …" The '011 Patent also describes in the section entitled "Description of Background Art" that textile materials for uppers can be formed by mechanical manipulation of yarns, including weaving and knitting. ('011 Patent, 2:4-46) The '011 Patent makes no suggestion that knitted fabrics are somehow preferable to woven fabrics. In describing its invention, the '011 Patent describes that textile element 40 can be made using any number of processes that mechanically manipulate the yarns ('011 Patent, 6:51-65): "Textile element 40 is primarily formed from one or more yarns that are mechanically-manipulated through either an interweaving, intertwining and twisting, or interlooping process, for example. As discussed in the Background of the Invention section above, interweaving is the intersection of

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Nike '011 Patent Claims	Osamu
	two yarns that cross and interweave at right angles to each other. The yarns utilized in interweaving are conventionally referred to as warp and weft. Intertwining and twisting encompasses procedures such as braiding and knotting where yarns intertwine with each other to form a textile. Interlooping involves the formation of a plurality of columns of intermeshed loops, with knitting being the most common method of interlooping. Textile element 40 may, therefore, be formed from one of these processes for manufacturing a textile." While some in the past may have suggested that woven fabrics are less elastic or less breathable than knitted fabrics, this was not the case in March 2004. The ability to interweave elastic threads, loose weaving techniques, use of specially treated fibers, and selecting yarn with greater elasticity were known by March 2004 to be useful to address any such perceived concern. For example, Curley explains that either knitted fabrics or woven fabrics may be used for the textile layers of the three-layer upper Curley describes, Curley explains that focusing on yarn elasticity properties when utilizing woven fabrics compensates for lower stretch or elasticity that woven fabrics generally possess when compared with knitted fabrics. The selection of a weft-knitted fabric instead of a woven fabric to form the textile element would have been obvious to the skilled person, as the '011 Patent and the prior art references show. Specifically, with respect to weft knitting, several

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Nike '011 Patent Claims	Osamu
	prior art references disclose weft knitting for use in making shoe uppers. Nishida discloses forming the upper with a "conventional textile process … by weaving and/or knitting …" (Nishida, 3:6-12) At the time Nishida was filed in the U.S. (June 17, 1992) the skilled person would have known and understood that "conventional" knitting processes include both warp knitting and weft knitting (and further including both circular and flat knitting), since these knitting processes existed for many decades before 1992 and had been used in the making of shoe uppers for many decades as well. Glidden describes an upper that is "fabricated as an integral, shaped, sock-like article although in some cases the insole portion may be omitted if that is desired." (p. 1, 2:45-48) The skilled person would know from Glidden's description of fabricating the upper as a shaped, "sock-like" article, as well as the knit patterns in the drawings (Figs. 1, 6, 8), that Glidden is describing and showing a weft-knitted textile element. As another example, McDonald dates to 1943 and describes a method of making shoes including use of a "conventional type of circular knitting machine" to form a "weft knit fabric" used to make the upper of a shoe. (McDonald, p. 1 at 2:26-39) As another example, Whiting dates to 1953 and describes a method for producing knitted shoe uppers of shrinkable yarn, including knitting the sock-like structure that forms the upper on "flat or circular knitting machines." (Whiting, 2:39-56) As another example, Curley, published in April 1990, describes shoes made with knitted layers in the upper,

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Nike '011 Patent Claims	Osamu
	including both warp and weft knitting. (Curley, p. 7, line 32 – p. 8, line 25)
wherein the weft-knitted textile element incorporates a single type of textile having a plurality of knit constructions; and	claim 1: "Uppers material for shoes configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures and/or patterns." part of [0005]: "The present invention is uppers material configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures, designs and/or patterns." part of [0007]: "The uppers material for shoes is configured of one sheet of cloth wherein, the main uppers material 2 for the shoe of one foot are woven on elongated foundation cloth 1, all the outlines thereof are connected, and within those outlines at each appropriate location 21 through 26 are many kinds of weave structures, designs and patterns. The weave structure is a comparatively heavy Jacquard weave, the weave structure being changed for each part corresponding to each location on the shoe or being woven in a pattern that changes the design/pattern." [0009]: "Figure 3 shows the main uppers 2 after cutting. Overall they make one sheet of woven fabric and each pattern element 10 through 18 therein is formed of a different weave structure and/or different pattern. For each shoe location, the appropriate weave

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Nike '011 Patent Claims	Osamu
	structure is used. For example, toe cap tip 10 is formed of a weave structure of high yarn count and density, and upper surface 11 is formed of a weave structure with high breathability. Furthermore, by using a weaving yarn materials such as those with nylon fiber blended in and cutting the outline lines by thermal cutting, the cut edges melt and will not fray." [0012]: "In this connection, the shape of main uppers 2 enables various types of computer-generated designs and patterns to be used, and by designating patterns or other software to weaving machines, this can be applied both to small lot production and to mass production."
a sole structure secured to the upper.	paragraphs [0001], [0007], [0013], [0015] Osamu describes that the uppers of his invention are for use with athletic or sports shoes. The skilled person knows athletic shoes have a sole secured to the upper.
2. The article of footwear recited in claim 1, wherein the weft-knitted textile element forms at least a portion of a lateral side, a medial side, and an instep region of the upper.	Figs. 1, 3; paragraphs [0007]-[0010] [0010]: "The main uppers 2, configured in this way, become 3-dimensional shoe uppers by stitching together the parts for joining by stitching 19 at the rear-most part of those main uppers."
3. The article of footwear recited in claim 1, wherein the edges include a pair of first edges that are joined to form a first seam extending longitudinally along a	Fig. 1; paragraph [0007] part of [0007]: "On foundation cloth 1, all of the main uppers material 2 for the shoe of one foot are woven, and continuous thereto middle sheet 3 and, and separated

Nike '011 Patent Claims	Osamu
lower region of the upper.	a little therefrom, shoe tongue flap shaped cover 4, are woven in. Middle sheet 3 is a sole-shape divided in half, roughly diagonally, formed continuous with the edge of the outline of main uppers material 2, to the right and left thereof. Middle sheet 3, formed divided, will become the shape of the sole by being 3-dimensionally folded in and stitched together when main uppers material 2 is formed 3-dimensionally on the shoe mold."
4. The article of footwear recited in claim 3, wherein the edges include a pair of second edges that are joined to form a second seam extending along a heel region of the upper.	Figs. 1, 3; paragraph [0010] [0010]: "The main uppers 2, configured in this way, become 3-dimensional shoe uppers by stitching together the parts for joining by stitching 19 at the rear-most part of those main uppers."
5. The article of footwear recited in claim 4, wherein the second seam extends vertically.	Figs. 1, 3; paragraph [0010] [0010]: "The main uppers 2, configured in this way, become 3-dimensional shoe uppers by stitching together the parts for joining by stitching 19 at the rear-most part of those main uppers."
6. The article of footwear recited in claim 4, wherein the edges include at least a pair of third edges that are joined to form a third seam extending through a forefoot area of the upper.	Fig. 1 When cut out and formed into a 3-dimensional upper, edges of middle sheet 3 that forms the insole must be joined to edges of part 21 in the forefoot area of the upper to complete the upper and will form a seam where joined.
7. The article of footwear recited in claim 1,	[0001]:

Nike '011 Patent Claims	Osamu
wherein the weft-knitted textile element is one of an exterior layer, an intermediate layer, and an interior layer of the upper.	"[Field of the Invention] The present invention relates to uppers material for shoes and more particularly that for sport shoes. In particular, the shoe uppers material of the present invention is uppers material comprising one sheet of woven fabric." claim 1: "Uppers material for shoes configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures and/or patterns." part of [0005]: "The present invention is uppers material configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures, designs and/or patterns." [0010]: "The main uppers 2, configured in this way, become 3-dimensional shoe uppers by stitching together the parts for joining by stitching 19 at the rear-most part of those main uppers."
8. The article of footwear recited in claim 1, wherein the upper includes an exterior layer, an intermediate layer, and an interior layer, and the weft-knitted textile element forms at least a portion of the interior layer.	[0001]: "[Field of the Invention] The present invention relates to uppers material for shoes and more particularly that for sport shoes. In particular, the shoe uppers material of the present invention is uppers material comprising one sheet of woven fabric." claim 1: "Uppers material for shoes configured of one sheet of

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Nike '011 Patent Claims	Osamu
	cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures and/or patterns." part of [0005]: "The present invention is uppers material configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures, designs and/or patterns." [0010]: "The main uppers 2, configured in this way, become 3-dimensional shoe uppers by stitching together the parts for joining by stitching 19 at the rear-most part of those main uppers." [0006]: "Furthermore, the present invention forms the uppers material on one sheet of Jacquard weave cloth, and on top of them other elements can be sewn on, water-proofing material can be applied, decorative elements can be sewn on, and of course water-proofing can be done as a secondary production step." Osamu describes a woven textile element that forms at least a portion of the interior layer and further that additional elements may be sewn on. It would have been obvious to the skilled person to modify the textile element of Osamu to provide multiple layers with the textile element forming a portion of the inner layer. Three-layer constructions with an inner layer of textile were well known in the prior art in March 2004, and it would have been a simple matter of design choice to make any necessary

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Nike '011 Patent Claims	Osamu
	modifications to Osamu to obtain this construction. As the '011 patent describes in the section "Description of Background Art," three-layer upper constructions were well known in the prior art before March 3, 2004, as was using a textile material for the inner layer. The '011 patent explains as background art (1:44-2:6, underlining added): "Various materials may be utilized in manufacturing the upper. The upper of an article of athletic footwear, for example, may be formed from multiple material layers that include an exterior layer, an intermediate layer, and an interior layer. The materials forming the exterior layer of the upper may be selected based upon the properties of wear-resistance, flexibility, and air-permeability, for example. With regard to the exterior layer, the toe area and the heel area may be formed of leather, synthetic leather, or a rubber material to impart a relatively high degree of wear-resistance. Leather, synthetic leather, and rubber materials may not exhibit the desired degree of flexibility and air-permeability. Accordingly, various other areas of the exterior layer of the upper may be formed from a synthetic or natural textile. The exterior layer of the upper may be formed, therefore, from numerous material elements that each impart different properties to specific portions of the upper. An intermediate layer of the upper may be formed from a lightweight polymer foam material that provides cushioning and protects the foot from objects that may contact the upper. Similarly, an interior layer of the upper may be formed of a moisture-wicking textile that removes perspiration from the area immediately surrounding the foot. In some articles of athletic footwear, the various layers

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	may be joined with an adhesive, and stitching may be utilized to join elements within a single layer or to reinforce specific areas of the upper. Although the materials selected for the upper vary significantly, textile materials often form at least a portion of the exterior layer and interior layer." In other prior art references, Curley describes an upper that includes multiple layers preferably three layers (Curley, p. 6, lines 30-32), where a knit textile element forms a portion of an inner layer (Curley, p. 30, claim 34) and an outer layer (Curley, p. 7, line 32 – p. 8, line 5). In another example, Shiomura describes an upper that includes an outer knit fabric layer and an inner knit fabric layer, with a layer of crossing threads between. (Shiomura, 2:26-45)
9 The article of footwear recited in claim 1, wherein the weft-knitted textile element forms at least a portion of both an interior surface and an exterior surface of the upper.	[0001]: "[Field of the Invention] The present invention relates to uppers material for shoes and more particularly that for sport shoes. In particular, the shoe uppers material of the present invention is uppers material comprising one sheet of woven fabric." claim 1: "Uppers material for shoes configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures and/or patterns." part of [0005]: "The present invention is uppers material configured of one sheet of cloth wherein all the outlines of the

Nike '011 Patent Claims	Osamu
	main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures, designs and/or patterns." [0010]: "The main uppers 2, configured in this way, become 3-dimensional shoe uppers by stitching together the parts for joining by stitching 19 at the rear-most part of those main uppers."
10. The article of footwear recited in claim 9, wherein at least one additional element is secured to the exterior surface and forms a portion of the exterior surface.	[0006]: "Furthermore, the present invention forms the uppers material on one sheet of Jacquard weave cloth, and on top of them other elements can be sewn on, water-proofing material can be applied, decorative elements can be sewn on, and of course water-proofing can be done as a secondary production step."
11. The article of footwear recited in claim 10, wherein the additional element is secured to a forefoot area of the upper.	[0006]: "Furthermore, the present invention forms the uppers material on one sheet of Jacquard weave cloth, and on top of them other elements can be sewn on, water-proofing material can be applied, decorative elements can be sewn on, and of course water-proofing can be done as a secondary production step." To the extent that Osamu is considered not to disclose securing the additional element that forms a portion of the exterior surface to a forefoot area, it would have been obvious to do so as a design choice or to reinforce the exterior of the forefoot area. For example, Nishida describes a toe cap applied to the forefoot area of the upper. (Nishida, 3:37-42) As another example, Glidden describes a toe cap applied to the forefoot area of the upper. (Glidden,

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Nike '011 Patent Claims	Osamu
	Figs. 6, 8; p. 2, 2:24-26) The '011 Patent also explains in the section entitled "Description of Background Art" that leather, synthetic leather, and rubber materials are often used for the exterior layer in the toe and heel areas to impart additional wear-resistance. ('011 Patent, 1:44-54)
12. The article of footwear recited in claim 10, wherein the additional element is secured to a heel area of the upper.	[0006]: "Furthermore, the present invention forms the uppers material on one sheet of Jacquard weave cloth, and on top of them other elements can be sewn on, water-proofing material can be applied, decorative elements can be sewn on, and of course water-proofing can be done as a secondary production step." To the extent that Osamu is considered not to disclose securing the additional element that forms a portion of the exterior surface to a heel area, it would have been obvious to do so as a design choice or to reinforce the exterior of the heel area. For example, Nishida describes a heel counter applied to the heel area. (Nishida, Fig. 3; 4:9-11) As another example, Glidden describes a counter and heel reinforcement structure applied in the heel area of the upper. (Glidden, Figs. 1-6; p. 2, 1:9-19; p. 2, 2:24-26) The '011 Patent also explains in the section entitled "Description of Background Art" that leather, synthetic leather, and rubber materials are often used for the exterior layer in the toe and heel areas to impart additional wear-resistance. ('011 Patent, 1:44-54)

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Nike '011 Patent Claims	Osamu
13. The article of footwear recited in claim 1, wherein the textile element forms an interior surface of the upper.	[0001]: "[Field of the Invention] The present invention relates to uppers material for shoes and more particularly that for sport shoes. In particular, the shoe uppers material of the present invention is uppers material comprising one sheet of woven fabric." claim 1: "Uppers material for shoes configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures and/or patterns." part of [0005]: "The present invention is uppers material configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures, designs and/or patterns." [0010]: "The main uppers 2, configured in this way, become 3-dimensional shoe uppers by stitching together the parts for joining by stitching 19 at the rear-most part of those main uppers."
14. The article of footwear recited in claim 1, wherein the weft-knitted textile element is created by circular knitting.	As discussed above for claim 1, the use of a weft-knitted textile element instead of the woven textile element of Osamu would have been obvious. The use of a particular sub-type of weft knitting, such as circular knitting would likewise have been obvious to a skilled person as it is a mere design choice or selection from among a finite number of weft-knitting techniques and one that was known for decades

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Nike '011 Patent Claims	Osamu
	before the March 2004 filing of the '011 Patent. For example, Whiting dates to 1953 and describes a method for producing knitted shoe uppers of shrinkable yarn, including knitting the sock-like structure that forms the upper on "flat or circular knitting machines." (Whiting, 2:39-56) As another example, McDonald dates to 1943 and describes a method of making shoes including use of a "conventional type of circular knitting machine" to form a "weft knit fabric" used to make the upper of a shoe. (McDonald, p. 1 at 2:26-39)
15. The article of footwear recited in claim 1, wherein the weft-knitted textile element is created by flat knitting.	As discussed above for claim 1, the use of a weft-knitted textile element instead of the woven textile element of Osamu would have been obvious. The use of a particular sub-type of weft knitting, such as flat knitting would likewise have been obvious to a skilled person as it is a mere design choice or selection from among a finite number of weft-knitting techniques and one that was known for decades before the March 2004 filing of the '011 Patent. For example, Whiting dates to 1953 and describes a method for producing knitted shoe uppers of shrinkable yarn, including knitting the sock-like structure that forms the upper on "flat or circular knitting machines." (Whiting, 2:39-56)
16. An article of footwear comprising:	Title; paragraphs [0001], [0007] [0001]: "[Field of the Invention] The present invention relates to uppers material for shoes and more particularly that for sport shoes. In particular, the shoe uppers material of the present invention is uppers material comprising one sheet of woven fabric."

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Nike '011 Patent Claims	Osamu
an upper incorporating a weft-knitted textile element, the textile element having a first area and a second area with a unitary construction,	Figs. 1, 3; claim 1; paragraphs [0005], [0007], [0009]-[0012] claim 1: "Uppers material for shoes configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures and/or patterns." part of [0005]: "The present invention is uppers material configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures, designs and/or patterns." part of [0007]: "Figure 1 shows an embodiment of uppers material for shoes according to the present invention. The uppers material for shoes is configured of one sheet of cloth wherein, the main uppers material 2 for the shoe of one foot are woven on elongated foundation cloth 1, all the outlines thereof are connected, and within those outlines at each appropriate location 21 through 26 are many kinds of weave structures, designs and patterns. The weave structure is a comparatively heavy Jacquard weave, the weave structure being changed for each part corresponding to each location on the shoe or being woven in a pattern that changes the design/pattern." [0009], [0010]: "Figure 3 shows the main uppers 2 after cutting. Overall they make one sheet of woven fabric and each pattern element 10 through 18 therein is formed

Nike '011 Patent Claims	Osamu
	of a different weave structure and/or different pattern. For each shoe location, the appropriate weave structure is used. For example, toe cap tip 10 is formed of a weave structure of high yarn count and density, and upper surface 11 is formed of a weave structure with high breathability. Furthermore, by using a weaving yarn materials such as those with nylon fiber blended in and cutting the outline lines by thermal cutting, the cut edges melt and will not fray. The main uppers 2, configured in this way, become 3-dimensional shoe uppers by stitching together the parts for joining by stitching 19 at the rear-most part of those main uppers." [0012]: "In this connection, the shape of main uppers 2 enables various types of computer-generated designs and patterns to be used, and by designating patterns or other software to weaving machines, this can be applied both to small lot production and to mass production." Osamu describes a woven textile element, rather than a weft-knitted textile element. However, the use of a weft-knitted textile element would have been obvious to the skilled person. Woven and knitted textiles are both suitable for use in uppers and known by the skilled person to be interchangeable. Selection of one versus the other is an obvious design choice. Nishida, for example, recognizes the interchangeability of woven and knitted textiles for use in uppers, repeatedly referring to "woven and/or knitted" fabrics when describing the textile element and configurations in his patent. (Nishida, 1:61-62; 1:67-68; 2:42-45; 3:6-10; 3:45-52; 3;66-68; 5:63-6:2;

Nike '011 Patent Claims	Osamu
	6:23-25) Osamu itself recognized that the use of a knitted versus a woven textile in the upper was interchangeable and a matter of design choice. Osamu, in describing the prior art in paragraph [0002], states "For example, when using woven fabric and/or knitted fabric as uppers materials for shoes, as shown in Figure 2, the material is made into many parts, such as the tip part A, upper surface part B, edge part C, side surface parts D, E, and F, ankle edge part G, heel parts H and I, and the material and shape of each is selected according to the function of that location. Parts of many types are provided, such as woven fabrics and/or knitted fabrics of various surface structure and design (A, B, I), …" The '011 Patent also describes in the section entitled "Description of Background Art" that textile materials for uppers can be formed by mechanical manipulation of yarns, including weaving and knitting. ('011 Patent, 2:4-46) The '011 Patent makes no suggestion that knitted fabrics are somehow preferable to woven fabrics. In describing its invention, the '011 Patent describes that textile element 40 can be made using any number of processes that mechanically manipulate the yarns ('011 Patent, 6:51-65): "Textile element 40 is primarily formed from one or more yarns that are mechanically-manipulated through either an interweaving, intertwining and twisting, or interlooping process, for example. As discussed in the Background of the Invention section above, interweaving is the intersection of two yarns that cross and interweave at

Nike '011 Patent Claims	Osamu
	right angles to each other. The yarns utilized in interweaving are conventionally referred to as warp and weft. Intertwining and twisting encompasses procedures such as braiding and knotting where yarns intertwine with each other to form a textile. Interlooping involves the formation of a plurality of columns of intermeshed loops, with knitting being the most common method of interlooping. Textile element 40 may, therefore, be formed from one of these processes for manufacturing a textile." While some in the past may have suggested that woven fabrics are less elastic or less breathable than knitted fabrics, this was not the case in March 2004. The ability to interweave elastic threads, loose weaving techniques, use of specially treated fibers, and selecting yarn with greater elasticity were known by March 2004 to be useful to address any such perceived concern. For example, Curley explains that either knitted fabrics or woven fabrics may be used for the textile layers of the three-layer upper Curley describes, Curley explains that focusing on yarn elasticity properties when utilizing woven fabrics compensates for lower stretch or elasticity that woven fabrics generally possess when compared with knitted fabrics. The selection of a weft-knitted fabric instead of a woven fabric to form the textile element would have been obvious to the skilled person, as the '011 Patent and the prior art references show. Specifically, with respect to weft knitting, several prior art references disclose weft knitting for use in

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Nike '011 Patent Claims	Osamu
	making shoe uppers. Nishida discloses forming the upper with a "conventional textile process … by weaving and/or knitting …" (Nishida, 3:6-12) At the time Nishida was filed in the U.S. (June 17, 1992) the skilled person would have known and understood that "conventional" knitting processes include both warp knitting and weft knitting (and further including both circular and flat knitting), since these knitting processes existed for many decades before 1992 and had been used in the making of shoe uppers for many decades as well. Glidden describes an upper that is"fabricated as an integral, shaped, sock-like article although in some cases the insole portion may be omitted if that is desired." (p. 1, 2:45-48) The skilled person would know from Glidden's description of fabricating the upper as a shaped, "sock-like" article, as well as the knit patterns in the drawings (Figs. 1, 6, 8), that Glidden is describing and showing a weft-knitted textile element. As another example, McDonald dates to 1943 and describes a method of making shoes including use of a "conventional type of circular knitting machine" to form a "weft knit fabric" used to make the upper of a shoe. (McDonald, p. 1 at 2:26-39) As another example, Whiting dates to 1953 and describes a method for producing knitted shoe uppers of shrinkable yarn, including knitting the sock-like structure that forms the upper on "flat or circular knitting machines." (Whiting, 2:39-56) As another example, Curley, published in April 1990, describes shoes made with knitted layers in the upper, including both warp and weft knitting. (Curley, p. 7,

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	line 32 – p. 8, line 25)
the first area being formed of a first stitch configuration, and the second area being formed of a second stitch configuration that is different from the first stitch configuration to impart varying properties to the textile element; and	claim 1: "Uppers material for shoes configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures and/or patterns." part of [0005]: "The present invention is uppers material configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures, designs and/or patterns." part of [0007]: "Figure 1 shows an embodiment of uppers material for shoes according to the present invention. The uppers material for shoes is configured of one sheet of cloth wherein, the main uppers material 2 for the shoe of one foot are woven on elongated foundation cloth 1, all the outlines thereof are connected, and within those outlines at each appropriate location 21 through 26 are many kinds of weave structures, designs and patterns. The weave structure is a comparatively heavy Jacquard weave, the weave structure being changed for each part corresponding to each location on the shoe or being woven in a pattern that changes the design/pattern." [0009]: "Figure 3 shows the main uppers 2 after cutting. Overall they make one sheet of woven fabric and each pattern element 10 through 18 therein is formed of a different weave structure and/or different pattern.

Nike '011 Patent Claims	Osamu
	For each shoe location, the appropriate weave structure is used. For example, toe cap tip 10 is formed of a weave structure of high yarn count and density, and upper surface 11 is formed of a weave structure with high breathability. Furthermore, by using a weaving yarn materials such as those with nylon fiber blended in and cutting the outline lines by thermal cutting, the cut edges melt and will not fray." The '011 Patent describes varying the "stitch type" as a way to vary the type of texture in different areas, and as separate from varying the type of yarn. ('011 Patent, 9:46-49, 9:65-10:3) Osamu specifically describes varying the weave structure or pattern, and the skilled person would know and understand that using different stitch configurations is one way to vary the weave structure or pattern. Osamu describes this to give the textile element different properties in different areas. Even if Osamu did not describe using different stitch configurations in different areas to vary the properties of the textile element in those areas, it was well known to skilled persons in the art to do so and it was taught in the prior art. It would have been obvious to vary stitch configurations as one of many ways to impart different properties to two different areas or t vary the structure or pattern, and it would have been a simple matter of design choice to do so. For example, Glidden describes varying the properties in the toe and heel area of a knitted upper, such "as by changing the type of stitch or amount of thickness in the yarn in the knitting." (Glidden, p. 1, 2:33-44) In another example, McDonald describes knitting an ankle/heel portion, instep, and sole of a knitted upper with "a plain or jersey stitch" in contrast to another

Nike '011 Patent Claims	Osamu
	area of the upper made with a ribbed knit. (McDonald, p. 1, 2:26-49; Fig. 1) Nishida also describes using different materials, different compositions (such as twisted or parallel processing or the like), and different knit types or knit patterns, therefore describing for the skilled person using different stitch configurations in different areas. Nishida describes this to give the textile element different properties in different areas. (Nishida, 3:15-26, 3:43-52, 5:41-45)
a sole structure secured to the upper.	paragraphs [0001], [0007], [0013], [0015] Osamu describes that the uppers of his invention are for use with athletic or sports shoes. The skilled person knows athletic shoes have a sole secured to the upper.
17. The article of footwear recited in claim 16, wherein the first stitch configuration provides a substantially smooth texture to the first area, and the second stitch configuration provides a texture to the second area that is rougher than the smooth texture.	Glidden describes a first stitch configuration with a substantially smooth texture for the first area (Glidden, p. 1, 2:35-41, where the toe and heel portions may be more densely fabricated to provide heavier weight and less extensibility) and a second stitch configuration in a second area that is rougher than the smooth texture (Glidden, p. 1, 2:41-44, where the ankle portion is made so as to provide softness and elasticity, such as a ribbed construction). In addition, McDonald describes a circular-knitted upper with a first stitch configuration for an ankle/heel, instep, and sole areas of the upper with a substantially smooth texture and a second stitch configuration for a different area that has a rougher, ribbed texture. (McDonald, p. 1, 2:26-49; Fig. 1) It would have been obvious to combine Osamu with Glidden or McDonald to vary the stitch configurations to provide one area with a

Nike '011 Patent Claims	Osamu
	substantially smooth texture and one are with a rougher or ribbed texture as a simple design choice, for aesthetics, because a ribbed texture may allow for more extensibility or stretchability, or because one may want a smoother interior layer adjacent the foot, for example.
18. The article of footwear recited in claim 17, wherein the second stitch configuration forms a rib structure in the second area.	As explained for claim 17, the second stitch configuration for the second area that forms the rougher texture is ribbed in both Glidden and McDonald, and it would have been obvious to modify Nishida for the same reasons as explained for claim 17.
19. The article of footwear recited in claim 16, wherein at least one of the first stitch configuration and the second stitch configuration forms an aperture in the weft-knitted textile element.	[0009]: "Figure 3 shows the main uppers 2 after cutting. Overall they make one sheet of woven fabric and each pattern element 10 through 18 therein is formed of a different weave structure and/or different pattern. For each shoe location, the appropriate weave structure is used. For example, toe cap tip 10 is formed of a weave structure of high yarn count and density, and upper surface 11 is formed of a weave structure with high breathability. Furthermore, by using a weaving yarn materials such as those with nylon fiber blended in and cutting the outline lines by thermal cutting, the cut edges melt and will not fray." The '011 Patent describes that "apertures" are formed by omitting stitches to provide air permeability in the knitted textile element. ('011 Patent, 9:57-62) The weave structure with high breathability for upper surface 11 described by Osamu necessarily has apertures.
20. The article of footwear recited in claim 16, wherein the weft-	Claim 20 adds the same limitation to independent claim 16 as claim 7 added to independent claim 1.

Nike '011 Patent Claims	Osamu
knitted textile element is one of an exterior layer, an intermediate layer, and an interior layer of the upper.	Osamu describes the additional limitations of claim 20 – see discussion for claim 7 in chart.
21. The article of footwear recited in claim 16, wherein the upper includes an exterior layer, an intermediate layer, and an interior layer, and the weft-knitted textile element forms at least a portion of the interior layer.	Claim 21 adds the same limitation to independent claim 16 as claim 8 added to independent claim 1. Osamu describes the additional limitations of claim 21 or they are obvious in view of Curley or Shiomura – see discussion for claim 8 in chart.
22. The article of footwear recited in claim 16, wherein the textile layer forms at least a portion of both the interior surface and an exterior surface of the upper.	Claim 22 adds the same limitation to independent claim 16 as claim 9 added to independent claim 1, except that claim 22 recites "the textile "layer" instead of "textile element." I have assumed this is a typographical error because claim 16 does not otherwise identify a "textile layer" and have treated this limitation as if it recited "textile element" as in claim 9. Osamu describes the additional limitations of claim 22 – see discussion for claim 9 in chart.
23. The article of footwear recited in claim 16, wherein the weft-knitted textile element forms an interior surface of the upper.	Claim 23 adds the same limitation to independent claim 16 as claim 13 added to independent claim 1. Osamu describes the additional limitations of claim 23 – see discussion for claim 13 in chart.
24. An article of footwear comprising:	Title; paragraphs [0001], [0007]

Nike '011 Patent Claims	Osamu
	[0001]: "[Field of the Invention] The present invention relates to uppers material for shoes and more particularly that for sport shoes. In particular, the shoe uppers material of the present invention is uppers material comprising one sheet of woven fabric."
an upper incorporating a textile element having edges that are joined together to form seams and define at least a portion of a void for receiving a foot,	Figs. 1, 3; paragraphs [0007], [0009], [0010] part of [0007]: "Figure 1 shows an embodiment of uppers material for shoes according to the present invention. The uppers material for shoes is configured of one sheet of cloth wherein, the main uppers material 2 for the shoe of one foot are woven on elongated foundation cloth 1, all the outlines thereof are connected, and within those outlines at each appropriate location 21 through 26 are many kinds of weave structures, designs and patterns." [0009], [0010]: "Figure 3 shows the main uppers 2 after cutting. Overall they make one sheet of woven fabric and each pattern element 10 through 18 therein is formed of a different weave structure and/or different pattern. For each shoe location, the appropriate weave structure is used. For example, toe cap tip 10 is formed of a weave structure of high yarn count and density, and upper surface 11 is formed of a weave structure with high breathability. Furthermore, by using a weaving yarn materials such as those with nylon fiber blended in and cutting the outline lines by thermal cutting, the cut edges melt and will not fray. The main uppers 2, configured in this way, become 3-dimensional shoe uppers by stitching together the

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Nike '011 Patent Claims	Osamu
	parts for joining by stitching 19 at the rear-most part of those main uppers."
the seams including a first seam and a second seam, the first seam extending from a heel area to a forefoot area of the footwear along a lower surface of the upper, and the second seam extending vertically in the heel area,	0010 Figs. 1, 3; paragraph [0007], [0010] part of [0007]: "On foundation cloth 1, all of the main uppers material 2 for the shoe of one foot are woven, and continuous thereto middle sheet 3 and, and separated a little therefrom, shoe tongue flap shaped cover 4, are woven in. Middle sheet 3 is a sole-shape divided in half, roughly diagonally, formed continuous with the edge of the outline of main uppers material 2, to the right and left thereof. Middle sheet 3, formed divided, will become the shape of the sole by being 3-dimensionally folded in and stitched together when main uppers material 2 is formed 3-dimensionally on the shoe mold." [0010]: "The main uppers 2, configured in this way, become 3-dimensional shoe uppers by stitching together the parts for joining by stitching 19 at the rear-most part of those main uppers."
wherein the textile element incorporates a single type of textile having a plurality of knit constructions; and	claim 1: "Uppers material for shoes configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures and/or patterns." part of [0005]: "The present invention is uppers material configured

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Nike '011 Patent Claims	Osamu
	of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures, designs and/or patterns." part of [0007]: "The uppers material for shoes is configured of one sheet of cloth wherein, the main uppers material 2 for the shoe of one foot are woven on elongated foundation cloth 1, all the outlines thereof are connected, and within those outlines at each appropriate location 21 through 26 are many kinds of weave structures, designs and patterns. The weave structure is a comparatively heavy Jacquard weave, the weave structure being changed for each part corresponding to each location on the shoe or being woven in a pattern that changes the design/pattern." [0009]: "Figure 3 shows the main uppers 2 after cutting. Overall they make one sheet of woven fabric and each pattern element 10 through 18 therein is formed of a different weave structure and/or different pattern. For each shoe location, the appropriate weave structure is used. For example, toe cap tip 10 is formed of a weave structure of high yarn count and density, and upper surface 11 is formed of a weave structure with high breathability. Furthermore, by using a weaving yarn materials such as those with nylon fiber blended in and cutting the outline lines by thermal cutting, the cut edges melt and will not fray." [0012]: "In this connection, the shape of main uppers 2 enables various types of computer-generated designs and patterns to be used, and by designating patterns or

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Nike '011 Patent Claims	Osamu
	other software to weaving machines, this can be applied both to small lot production and to mass production." Osamu describes a woven textile element with a plurality of weave structures, rather than a knitted textile element with a plurality of knit constructions. However, the use of a knitted textile element, including weft-knitted and warp-knitted elements, would have been obvious to the skilled person. Woven and knitted textiles are both suitable for use in uppers and known by the skilled person to be interchangeable. Selection of one versus the other is an obvious design choice. Nishida, for example, recognizes the interchangeability of woven and knitted textiles for use in uppers, repeatedly referring to "woven and/or knitted" fabrics when describing the textile element and configurations in his patent. (Nishida, 1:61-62; 1:67-68; 2:42-45; 3:6-10; 3:45-52; 3;66-68; 5:63-6:2; 6:23-25) Osamu itself recognized that the use of a knitted versus a woven textile in the upper was interchangeable and a matter of design choice. Osamu, in describing the prior art in paragraph [0002], states "For example, when using woven fabric and/or knitted fabric as uppers materials for shoes, as shown in Figure 2, the material is made into many parts, such as the tip part A, upper surface part B, edge part C, side surface parts D, E, and F, ankle edge part G, heel parts H and I, and the material and shape of each is selected according to the function of that location. Parts of many types are provided, such as woven fabrics and/or knitted fabrics of various surface structure and design (A, B, I), …" The '011 Patent also describes in the section entitled

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	"Description of Background Art" that textile materials for uppers can be formed by mechanical manipulation of yarns, including weaving and knitting. ('011 Patent, 2:4-46) The '011 Patent makes no suggestion that knitted fabrics are somehow preferable to woven fabrics. In describing its invention, the '011 Patent describes that textile element 40 can be made using any number of processes that mechanically manipulate the yarns ('011 Patent, 6:51-65): "Textile element 40 is primarily formed from one or more yarns that are mechanically-manipulated through either an interweaving, intertwining and twisting, or interlooping process, for example. As discussed in the Background of the Invention section above, interweaving is the intersection of two yarns that cross and interweave at right angles to each other. The yarns utilized in interweaving are conventionally referred to as warp and weft. Intertwining and twisting encompasses procedures such as braiding and knotting where yarns intertwine with each other to form a textile. Interlooping involves the formation of a plurality of columns of intermeshed loops, with knitting being the most common method of interlooping. Textile element 40 may, therefore, be formed from one of these processes for manufacturing a textile." While some in the past may have suggested that woven fabrics are less elastic or less breathable than knitted fabrics, this was not the case in March 2004.

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	The ability to interweave elastic threads, loose weaving techniques, use of specially treated fibers, and selecting yarn with greater elasticity were known by March 2004 to be useful to address any such perceived concern. For example, Curley explains that either knitted fabrics or woven fabrics may be used for the textile layers of the three-layer upper Curley describes, Curley explains that focusing on yarn elasticity properties when utilizing woven fabrics compensates for lower stretch or elasticity that woven fabrics generally possess when compared with knitted fabrics. The selection of a weft-knitted fabric instead of a woven fabric to form the textile element would have been obvious to the skilled person, as the '011 Patent and the prior art references show. Specifically, with respect to weft knitting, several prior art references disclose weft knitting for use in making shoe uppers. Nishida discloses forming the upper with a "conventional textile process … by weaving and/or knitting …" (Nishida, 3:6-12) At the time Nishida was filed in the U.S. (June 17, 1992) the skilled person would have known and understood that "conventional" knitting processes include both warp knitting and weft knitting (and further including both circular and flat knitting), since these knitting processes existed for many decades before 1992 and had been used in the making of shoe uppers for many decades as well. Glidden describes an upper that is"fabricated as an integral, shaped, sock-like article although in some cases the insole portion may be omitted if that is desired." (p. 1, 2:45-48) The skilled person would know from Glidden's description of fabricating the

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	upper as a shaped, "sock-like" article, as well as the knit patterns in the drawings (Figs. 1, 6, 8), that Glidden is describing and showing a weft-knitted textile element. As another example, McDonald dates to 1943 and describes a method of making shoes including use of a "conventional type of circular knitting machine" to form a "weft knit fabric" used to make the upper of a shoe. (McDonald, p. 1 at 2:26-39) As another example, Whiting dates to 1953 and describes a method for producing knitted shoe uppers of shrinkable yarn, including knitting the sock-like structure that forms the upper on "flat or circular knitting machines." (Whiting, 2:39-56) As another example, Curley, published in April 1990, describes shoes made with knitted layers in the upper, including both warp and weft knitting. (Curley, p. 7, line 32 – p. 8, line 25)
a sole structure secured to the upper.	paragraphs [0001], [0007], [0013], [0015] Osamu describes that the uppers of his invention are for use with athletic or sports shoes. The skilled person knows athletic shoes have a sole secured to the upper.
25. The article of footwear recited in claim 24, wherein the footwear includes a third seam extending through the forefoot area of the upper.	Fig. 1 When cut out and formed into a 3-dimensional upper, edges of middle sheet 3 that forms the insole must be joined to edges of part 21 in the forefoot area of the upper to complete the upper and will form a seam where joined.
26. The article of footwear recited in claim 24, wherein at least one	[0009]: "Figure 3 shows the main uppers 2 after cutting.

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of the knit constructions forms an aperture in the textile element.	Overall they make one sheet of woven fabric and each pattern element 10 through 18 therein is formed of a different weave structure and/or different pattern. For each shoe location, the appropriate weave structure is used. For example, toe cap tip 10 is formed of a weave structure of high yarn count and density, and upper surface 11 is formed of a weave structure with high breathability. Furthermore, by using a weaving yarn materials such as those with nylon fiber blended in and cutting the outline lines by thermal cutting, the cut edges melt and will not fray." The '011 Patent describes that "apertures" are formed by omitting stitches to provide air permeability in the knitted textile element. ('011 Patent, 9:57-62) The weave structure with high breathability for upper surface 11 described by Osamu necessarily has apertures.
27. The article of footwear recited in claim 24, wherein the knit constructions produce varying properties in the textile element including a varying elasticity of the textile element.	[0008]: "For weaving yarn, material is selected that is outstanding in terms of wear resistance, weather resistance, elasticity, and flexibility. By 'punch-out' cutting of main uppers 2, middle sheet 3, and tongue flap shaped cover 4, parts are made in the least number possible." [0009]: "Figure 3 shows the main uppers 2 after cutting. Overall they make one sheet of woven fabric and each pattern element 10 through 18 therein is formed of a different weave structure and/or different pattern. For each shoe location, the appropriate weave structure is used. For example, toe cap tip 10 is formed of a weave structure of high yarn count and density, and upper surface 11 is formed of a weave structure with high breathability. Furthermore, by

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	using a weaving yarn materials such as those with nylon fiber blended in and cutting the outline lines by thermal cutting, the cut edges melt and will not fray."
28. The article of footwear recited in claim 24, wherein the knit constructions produce varying properties in the textile element including a varying air permeability of the textile element.	[0009]: "Figure 3 shows the main uppers 2 after cutting. Overall they make one sheet of woven fabric and each pattern element 10 through 18 therein is formed of a different weave structure and/or different pattern. For each shoe location, the appropriate weave structure is used. For example, toe cap tip 10 is formed of a weave structure of high yarn count and density, and upper surface 11 is formed of a weave structure with high breathability. Furthermore, by using a weaving yarn materials such as those with nylon fiber blended in and cutting the outline lines by thermal cutting, the cut edges melt and will not fray."
29. The article of footwear recited in claim 24, wherein the textile element is one of an exterior layer, an intermediate layer, and an interior layer of the upper.	Claim 29 adds the same limitation to independent claim 24 as claim 7 added to independent claim 1. Osamu describes the additional limitations of claim 29 – see discussion for claim 7 in chart.
30. The article of footwear recited in claim 24, wherein the textile element forms at least a portion of both an interior surface and an exterior surface of the upper.	Claim 30 adds the same limitation to independent claim 16 as claim 9 added to independent claim 1. Osamu describes the additional limitations of claim 30 – see discussion for claim 9 in chart.
31. The article of footwear recited in claim 24, wherein the textile element forms an interior	Claim 31 adds the same limitation to independent claim 24 as claim 13 added to independent claim 1 – the textile element forming an interior surface of the

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surface of the footwear, and at least one additional layer forms an exterior surface of the footwear.	footwear (or upper). Osamu describes this additional limitation of claim 31 – see discussion for claim 13 in chart. Claim 31 also recites an additional limitation – "at least one additional layer forms an exterior surface of the footwear." Osamu discloses this additional limitation. [0006]: "Furthermore, the present invention forms the uppers material on one sheet of Jacquard weave cloth, and on top of them other elements can be sewn on, water-proofing material can be applied, decorative elements can be sewn on, and of course water-proofing can be done as a secondary production step."
32. The article of footwear recited in claim 24, wherein at least a portion of the textile element has a weft knitted construction.	As discussed for claim 24, it would have been obvious to use a weft-knitted textile element instead of the woven textile element of Osamu. McDonald, Whiting, Curley, Nishida, and Glidden describe weft knitting – see discussion for claim 24 of chart.
33. The article of footwear recited in claim 32, wherein the weft knitted construction is produced by one of circular knitting and flat knitting.	McDonald and Whiting describe circular or flat knitting or both – see discussion for claim 24 of chart.
34. The article of footwear recited in claim 24, wherein the textile element has a warp	As discussed for claim 24, it would have been obvious to use a warp-knitted textile element instead of the woven textile element of Osamu.

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knitted construction.	Curley, Shiomura, and Nishida describe warp knitting – see discussion for claim 24 of chart. Shiomura describes use tricot knitting machines, Raschel knitting machines, or double Raschel knitting machines, all types of warp knitting, to make the knitted textile elements of its shoe. (Shiomura, 3:4-43)
35. The article of footwear recited in claim 34, wherein the warp knitted construction is produced by a jacquard double needle-bar raschel.	It would be obvious to the skilled person making a warp knitted textile element to choose from among available machines that use warp knitting. It is a simple design choice from among available possible machines. Shiomura describes using a double needle bar raschel knitting machine to make the knitted textile element of its shoe. (Shiomura, 3:4-43; Fig. 5) The '011 Patent describes that a "double needle-bar raschel ([machine] further includes jacquard double needle-bar raschel)." ('011 Patent, 7:4-5) Osamu describes using a jacquard weave (paragraph [0005]) rather than a jacquard knit. It would have been obvious to the skilled person to use a jacquard double needle-bar raschel machine as described in Shiomura based on Osamu's disclosure of making the woven uppers in such a way that allows "various types of computer-generated designs and patterns to be used, and by designating patterns or other software to weaving machines … for small lot production and to mass production" and using "a computer connected to a weaving machine." (paragraphs [0012], [0014]) The type of machine is a simple design choice and the skilled person would have a finite number of types of knitting machines from which to select a desired knitting machine.

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36. An article of footwear comprising:	Title; paragraphs [0001], [0007] [0001]: "[Field of the Invention] The present invention relates to uppers material for shoes and more particularly that for sport shoes. In particular, the shoe uppers material of the present invention is uppers material comprising one sheet of woven fabric."
an upper incorporating a knitted textile element formed with a knitting machine, the textile element being removed from a textile structure that includes an outline of the textile element, and	paragraphs [0005], [0007]-[0009], [0012], [0014] part of [0007]: "The uppers material for shoes is configured of one sheet of cloth wherein, the main uppers material 2 for the shoe of one foot are woven on elongated foundation cloth 1, all the outlines thereof are connected, and within those outlines at each appropriate location 21 through 26 are many kinds of weave structures, designs and patterns." [0008]: "For weaving yarn, material is selected that is outstanding in terms of wear resistance, weather resistance, elasticity, and flexibility. By 'punch-out' cutting of main uppers 2, middle sheet 3, and tongue flap shaped cover 4, parts are made in the least number possible." [0012]: "In this connection, the shape of main uppers 2 enables various types of computer-generated designs and patterns to be used, and by designating patterns or other software to weaving machines, this can be applied both to small lot production and to mass production."

Nike '011 Patent Claims	Osamu
	Osamu describes a woven textile element with a plurality of weave structures, rather than a knitted textile element with a plurality of knit constructions. However, the use of a knitted textile element, including weft-knitted and warp-knitted elements, would have been obvious to the skilled person. Woven and knitted textiles are both suitable for use in uppers and known by the skilled person to be interchangeable. Selection of one versus the other is an obvious design choice. Nishida, for example, recognizes the interchangeability of woven and knitted textiles for use in uppers, repeatedly referring to "woven and/or knitted" fabrics when describing the textile element and configurations in his patent. (Nishida, 1:61-62; 1:67-68; 2:42-45; 3:6-10; 3:45-52; 3;66-68; 5:63-6:2; 6:23-25) Osamu itself recognized that the use of a knitted versus a woven textile in the upper was interchangeable and a matter of design choice. Osamu, in describing the prior art in paragraph [0002], states "For example, when using woven fabric and/or knitted fabric as uppers materials for shoes, as shown in Figure 2, the material is made into many parts, such as the tip part A, upper surface part B, edge part C, side surface parts D, E, and F, ankle edge part G, heel parts H and I, and the material and shape of each is selected according to the function of that location. Parts of many types are provided, such as woven fabrics and/or knitted fabrics of various surface structure and design (A, B, I), …" The '011 Patent also describes in the section entitled "Description of Background Art" that textile materials for uppers can be formed by mechanical manipulation of yarns, including weaving and

Nike '011 Patent Claims	Osamu
	knitting. ('011 Patent, 2:4-46) The '011 Patent makes no suggestion that knitted fabrics are somehow preferable to woven fabrics. In describing its invention, the '011 Patent describes that textile element 40 can be made using any number of processes that mechanically manipulate the yarns ('011 Patent, 6:51-65): "Textile element 40 is primarily formed from one or more yarns that are mechanically-manipulated through either an interweaving, intertwining and twisting, or interlooping process, for example. As discussed in the Background of the Invention section above, interweaving is the intersection of two yarns that cross and interweave at right angles to each other. The yarns utilized in interweaving are conventionally referred to as warp and weft. Intertwining and twisting encompasses procedures such as braiding and knotting where yarns intertwine with each other to form a textile. Interlooping involves the formation of a plurality of columns of intermeshed loops, with knitting being the most common method of interlooping. Textile element 40 may, therefore, be formed from one of these processes for manufacturing a textile." While some in the past may have suggested that woven fabrics are less elastic or less breathable than knitted fabrics, this was not the case in March 2004. The ability to interweave elastic threads, loose weaving techniques, use of specially treated fibers, and selecting yarn with greater elasticity were known

Nike '011 Patent Claims	Osamu
	by March 2004 to be useful to address any such perceived concern. For example, Curley explains that either knitted fabrics or woven fabrics may be used for the textile layers of the three-layer upper Curley describes, Curley explains that focusing on yarn elasticity properties when utilizing woven fabrics compensates for lower stretch or elasticity that woven fabrics generally possess when compared with knitted fabrics. The selection of a weft-knitted fabric instead of a woven fabric to form the textile element would have been obvious to the skilled person, as the '011 Patent and the prior art references show. Specifically, with respect to weft knitting, several prior art references disclose weft knitting for use in making shoe uppers. Nishida discloses forming the upper with a "conventional textile process … by weaving and/or knitting …" (Nishida, 3:6-12) At the time Nishida was filed in the U.S. (June 17, 1992) the skilled person would have known and understood that "conventional" knitting processes include both warp knitting and weft knitting (and further including both circular and flat knitting), since these knitting processes existed for many decades before 1992 and had been used in the making of shoe uppers for many decades as well. Glidden describes an upper that is"fabricated as an integral, shaped, sock-like article although in some cases the insole portion may be omitted if that is desired." (p. 1, 2:45-48) The skilled person would know from Glidden's description of fabricating the upper as a shaped, "sock-like" article, as well as the knit patterns in the drawings (Figs. 1, 6, 8), that Glidden is describing and showing a weft-knitted

Nike '011 Patent Claims	Osamu
	textile element. As another example, McDonald dates to 1943 and describes a method of making shoes including use of a "conventional type of circular knitting machine" to form a "weft knit fabric" used to make the upper of a shoe. (McDonald, p. 1 at 2:26-39) As another example, Whiting dates to 1953 and describes a method for producing knitted shoe uppers of shrinkable yarn, including knitting the sock-like structure that forms the upper on "flat or circular knitting machines." (Whiting, 2:39-56) As another example, Curley, published in April 1990, describes shoes made with knitted layers in the upper, including both warp and weft knitting. (Curley, p. 7, line 32 – p. 8, line 25)
the textile element having edges that are joined together to define at least a portion of a void for receiving a foot,	Figs. 1, 3; paragraphs [0009], [0010] [0009], [0010]: "Figure 3 shows the main uppers 2 after cutting. Overall they make one sheet of woven fabric and each pattern element 10 through 18 therein is formed of a different weave structure and/or different pattern. For each shoe location, the appropriate weave structure is used. For example, toe cap tip 10 is formed of a weave structure of high yarn count and density, and upper surface 11 is formed of a weave structure with high breathability. Furthermore, by using a weaving yarn materials such as those with nylon fiber blended in and cutting the outline lines by thermal cutting, the cut edges melt and will not fray. The main uppers 2, configured in this way, become 3-dimensional shoe uppers by stitching together the parts for joining by stitching 19 at the rear-most part

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	of those main uppers."
wherein the textile element incorporates a single type of textile having a plurality of knit constructions; and	claim 1: "Uppers material for shoes configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures and/or patterns." part of [0005]: "The present invention is uppers material configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures, designs and/or patterns." part of [0007]: "The uppers material for shoes is configured of one sheet of cloth wherein, the main uppers material 2 for the shoe of one foot are woven on elongated foundation cloth 1, all the outlines thereof are connected, and within those outlines at each appropriate location 21 through 26 are many kinds of weave structures, designs and patterns. The weave structure is a comparatively heavy Jacquard weave, the weave structure being changed for each part corresponding to each location on the shoe or being woven in a pattern that changes the design/pattern." [0009]: "Figure 3 shows the main uppers 2 after cutting. Overall they make one sheet of woven fabric and each pattern element 10 through 18 therein is formed of a different weave structure and/or different pattern. For each shoe location, the appropriate weave structure is used. For example, toe cap tip 10 is

Nike '011 Patent Claims	Osamu
	formed of a weave structure of high yarn count and density, and upper surface 11 is formed of a weave structure with high breathability. Furthermore, by using a weaving yarn materials such as those with nylon fiber blended in and cutting the outline lines by thermal cutting, the cut edges melt and will not fray." [0012]: "In this connection, the shape of main uppers 2 enables various types of computer-generated designs and patterns to be used, and by designating patterns or other software to weaving machines, this can be applied both to small lot production and to mass production."
a sole structure secured to the upper.	paragraphs [0001], [0007], [0013], [0015] Osamu describes that the uppers of his invention are for use with athletic or sports shoes. The skilled person knows athletic shoes have a sole secured to the upper.
37. The article of footwear recited in claim 36, wherein the knitted textile element has a structure formed by a wide-tube circular knitting machine.	It would be obvious to the skilled person making a knitted textile element to choose from among available machines, including wide tube circular knitting machines. It is a simple design choice from among available possible machines. McDonald describes using a "conventional type of circular knitting machine" (p. 1, 2:26-30) to form a knitted textile element. The '011 Patent describes a wide tube circular knitting machine from Santoni S.p.A. of Italy that clearly existed before March 2004. ('011 Patent, 7:8-48) It would have been obvious to the skilled person to use a wide tube circular knitting machine based on

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	Osamu's disclosure of making the woven uppers in such a way that allows "various types of computer-generated designs and patterns to be used, and by designating patterns or other software to weaving machines … for small lot production and to mass production" and using "a computer connected to a weaving machine." (paragraphs [0012], [0014]) The type of machine is a simple design choice and the skilled person would have a finite number of types of knitting machines from which to select a desired knitting machine. In particular wide tube knitting machine would allow for more material to be processed and more textile elements to be made than some other machines. The skilled person would be motivated to utilize such a machine for large scale production to increase productivity and throughput.
38. The article of footwear recited in claim 36, wherein the knitted textile element has a structure formed by a jacquard double needle-bar raschel knitting machine.	Claim 38 adds an almost identical limitation to independent claim 36 as claim 35 added to independent claim 24. The additional limitation of claim 38 is obvious in view of the above art in claim 36 or Shiomura – see discussion for claim 35 in chart.
39. The article of footwear recited in claim 36, wherein the edges include a pair of first edges that are joined to form a first seam extending longitudinally along a lower region of the upper.	Claim 39 adds the same limitation to independent claim 36 as claim 3 added to independent claim 1. Osamu describes the additional limitations of claim 39 – see discussion for claim 3 in chart.
40. The article of footwear recited in claim	Claim 40 adds the same limitation to independent claim 36 as claim 4 added to independent claim 1.

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39, wherein the edges include a pair of second edges that are joined to form a second seam extending along a heel region of the upper.	Osamu describes the additional limitations of claim 40 – see discussion for claim 4 in chart.
41. The article of footwear recited in claim 40, wherein the edges include at least a pair of third edges that are joined to form a second [third?] seam extending through a forefoot area of the upper.	Claim 41 adds the same limitation to independent claim 36 as claim 6 added to independent claim 1, except that there appears to be a typographical error referring to the third edges forming a "second seam" extending through the forefoot when the "second seam" was already defined in claim 40 as extending along a heel region. I have assumed this claim limitation meant to recite that the third edges form a "third seam." Osamu describes the additional limitations of claim 41 – see discussion for claim 6 in chart.
42. The article of footwear recited in claim 36, wherein the knitted textile element is one of an exterior layer, an intermediate layer, and an interior layer of the upper.	Claim 42 adds the same limitation to independent claim 36 as claim 7 added to independent claim 1. Osamu describes the additional limitations of claim 42 – see discussion for claim 7 in chart.
43. The article of footwear recited in claim 36, wherein the knitted textile element forms an interior surface of the upper.	Claim 43 adds the same limitation to independent claim 36 as claim 13 added to independent claim 1. Osamu describes the additional limitations of claim 43 – see discussion for claim 13 in chart.
44. An article of footwear comprising:	Title; paragraphs [0001], [0007] [0001]:

Nike '011 Patent Claims	Osamu
	"[Field of the Invention] The present invention relates to uppers material for shoes and more particularly that for sport shoes. In particular, the shoe uppers material of the present invention is uppers material comprising one sheet of woven fabric."
an upper incorporating a flat-knitted textile element, the flat-knitted textile element having a first area with a first unitary construction and a second area with a second unitary construction different from the first unitary construction,	The'011 Patent repeatedly describes a textile element with a unitary construction, not multiple unitary constructions. ('011 Patent, 5:38-40; 6:41-42; 9-32-35; 11:14-18) I understand this claim element to mean that the textile element is a unitary construction that has two different areas within it that have different constructions. Figs. 1, 3; claim 1; paragraphs [0005], [0007], [0009]-[0012] claim 1: "Uppers material for shoes configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures and/or patterns." part of [0005]: "The present invention is uppers material configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures, designs and/or patterns." part of [0007]: "Figure 1 shows an embodiment of uppers material for shoes according to the present invention. The uppers material for shoes is configured of one sheet of cloth wherein, the main uppers material 2 for the shoe of one foot are woven on elongated foundation

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	cloth 1, all the outlines thereof are connected, and within those outlines at each appropriate location 21 through 26 are many kinds of weave structures, designs and patterns. The weave structure is a comparatively heavy Jacquard weave, the weave structure being changed for each part corresponding to each location on the shoe or being woven in a pattern that changes the design/pattern." [0009], [0010]: "Figure 3 shows the main uppers 2 after cutting. Overall they make one sheet of woven fabric and each pattern element 10 through 18 therein is formed of a different weave structure and/or different pattern. For each shoe location, the appropriate weave structure is used. For example, toe cap tip 10 is formed of a weave structure of high yarn count and density, and upper surface 11 is formed of a weave structure with high breathability. Furthermore, by using a weaving yarn materials such as those with nylon fiber blended in and cutting the outline lines by thermal cutting, the cut edges melt and will not fray. The main uppers 2, configured in this way, become 3-dimensional shoe uppers by stitching together the parts for joining by stitching 19 at the rear-most part of those main uppers." [0012]: "In this connection, the shape of main uppers 2 enables various types of computer-generated designs and patterns to be used, and by designating patterns or other software to weaving machines, this can be applied both to small lot production and to mass production." Osamu describes a woven textile element, rather than

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	a flat-knitted textile element. However, the use of a flat-knitted textile element would have been obvious to the skilled person. Woven and knitted textiles are both suitable for use in uppers and known by the skilled person to be interchangeable. Selection of one versus the other, including a fat-knitted textile element, is an obvious design choice. Nishida, for example, recognizes the interchangeability of woven and knitted textiles for use in uppers, repeatedly referring to "woven and/or knitted" fabrics when describing the textile element and configurations in his patent. (Nishida, 1:61-62; 1:67-68; 2:42-45; 3:6-10; 3:45-52; 3;66-68; 5:63-6:2; 6:23-25) Osamu itself recognized that the use of a knitted versus a woven textile in the upper was interchangeable and a matter of design choice. Osamu, in describing the prior art in paragraph [0002], states "For example, when using woven fabric and/or knitted fabric as uppers materials for shoes, as shown in Figure 2, the material is made into many parts, such as the tip part A, upper surface part B, edge part C, side surface parts D, E, and F, ankle edge part G, heel parts H and I, and the material and shape of each is selected according to the function of that location. Parts of many types are provided, such as woven fabrics and/or knitted fabrics of various surface structure and design (A, B, I), …" The '011 Patent also describes in the section entitled "Description of Background Art" that textile materials for uppers can be formed by mechanical manipulation of yarns, including weaving and knitting. ('011 Patent, 2:4-46) The '011 Patent makes no suggestion that knitted fabrics are somehow preferable to woven fabrics. In describing its

Nike '011 Patent Claims	Osamu
	invention, the '011 Patent describes that textile element 40 can be made using any number of processes that mechanically manipulate the yarns ('011 Patent, 6:51-65): "Textile element 40 is primarily formed from one or more yarns that are mechanically-manipulated through either an interweaving, intertwining and twisting, or interlooping process, for example. As discussed in the Background of the Invention section above, interweaving is the intersection of two yarns that cross and interweave at right angles to each other. The yarns utilized in interweaving are conventionally referred to as warp and weft. Intertwining and twisting encompasses procedures such as braiding and knotting where yarns intertwine with each other to form a textile. Interlooping involves the formation of a plurality of columns of intermeshed loops, with knitting being the most common method of interlooping. Textile element 40 may, therefore, be formed from one of these processes for manufacturing a textile." While some in the past may have suggested that woven fabrics are less elastic or less breathable than knitted fabrics, this was not the case in March 2004. The ability to interweave elastic threads, loose weaving techniques, use of specially treated fibers, and selecting yarn with greater elasticity were known by March 2004 to be useful to address any such perceived concern. For example, Curley explains that either knitted fabrics or woven fabrics may be used

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Nike '011 Patent Claims	Osamu
	for the textile layers of the three-layer upper Curley describes, Curley explains that focusing on yarn elasticity properties when utilizing woven fabrics compensates for lower stretch or elasticity that woven fabrics generally possess when compared with knitted fabrics. The selection of a flat-knitted fabric instead of a woven fabric to form the textile element would have been obvious to the skilled person, as the '011 Patent and the prior art references show. Specifically, with respect to flat knitting, several prior art references disclose flat knitting for use in making shoe uppers. Nishida discloses forming the upper with a "conventional textile process … by weaving and/or knitting …" (Nishida, 3:6-12) At the time Nishida was filed in the U.S. (June 17, 1992) the skilled person would have known and understood that "conventional" knitting processes include both warp knitting and weft knitting (and further including both circular and flat knitting), since these knitting processes existed for many decades before 1992 and had been used in the making of shoe uppers for many decades as well. As another example, Whiting dates to 1953 and describes a method for producing knitted shoe uppers of shrinkable yarn, including knitting the sock-like structure that forms the upper on "flat or circular knitting machines." (Whiting, 2:39-56) As another example, Curley, published in April 1990, describes shoes made with knitted layers in the upper, including both warp and weft (which includes flat) knitting. (Curley, p. 7, line 32 – p. 8, line 25)

Nike '011 Patent Claims	Osamu
the first area having a first set of properties, and the second area having a second set of properties that is different from the first set of properties to impart varying characteristics to the textile element; and	claim 1: "Uppers material for shoes configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures and/or patterns." part of [0005]: "The present invention is uppers material configured of one sheet of cloth wherein all the outlines of the main uppers materials for the shoe of one foot are continuous and the interiors therein are woven in a variety of weave structures, designs and/or patterns." part of [0007]: "Figure 1 shows an embodiment of uppers material for shoes according to the present invention. The uppers material for shoes is configured of one sheet of cloth wherein, the main uppers material 2 for the shoe of one foot are woven on elongated foundation cloth 1, all the outlines thereof are connected, and within those outlines at each appropriate location 21 through 26 are many kinds of weave structures, designs and patterns. The weave structure is a comparatively heavy Jacquard weave, the weave structure being changed for each part corresponding to each location on the shoe or being woven in a pattern that changes the design/pattern." [0009]: "Figure 3 shows the main uppers 2 after cutting. Overall they make one sheet of woven fabric and each pattern element 10 through 18 therein is formed of a different weave structure and/or different pattern. For each shoe location, the appropriate weave

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Nike '011 Patent Claims	Osamu
	structure is used. For example, toe cap tip 10 is formed of a weave structure of high yarn count and density, and upper surface 11 is formed of a weave structure with high breathability. Furthermore, by using a weaving yarn materials such as those with nylon fiber blended in and cutting the outline lines by thermal cutting, the cut edges melt and will not fray."
a sole structure secured to the upper.	paragraphs [0001], [0007], [0013], [0015] Osamu describes that the uppers of his invention are for use with athletic or sports shoes. The skilled person knows athletic shoes have a sole secured to the upper.
45. The article of footwear recited in claim 44, wherein the first set of properties and the second set of properties are at least one of a stitch configuration and a yarn type.	paragraphs [0007], [0009] The '011 Patent describes varying the "stitch type" as a way to vary the type of texture in different areas, and as separate from varying the type of yarn. ('011 Patent, 9:46-49, 9:65-10:3) Osamu specifically describes varying the weave structure or pattern , and the skilled person would know and understand that using different stitch configurations is one way to vary the weave structure or pattern. Osamu describes this to give the textile element different properties in different areas. Even if Osamu did not describe using different stitch configurations or different yarn types in different areas to vary the properties of the textile element in those areas, it was well known to skilled persons in the art to do so and it was taught in the prior art. It would have been obvious to vary stitch configurations or yarn types as one of many ways to impart different properties to two different areas or to vary the structure or pattern, and it would have been a simple matter of design choice to do so.

Nike '011 Patent Claims	Osamu
	For example, Glidden describes varying the properties in the toe and heel area of a knitted upper, such "as by changing the type of stitch or amount of thickness in the yarn in the knitting." (Glidden, p. 1, 2:33-44) In another example, McDonald describes knitting an ankle/heel portion, instep, and sole of a knitted upper with "a plain or jersey stitch" in contrast to another area of the upper made with a ribbed knit. (McDonald, p. 1, 2:26-49; Fig. 1) Nishida also describes using different materials, different compositions (such as twisted or parallel processing or the like), and different knit types or knit patterns, therefore describing for the skilled person using different stitch configurations in different areas. Nishida describes this to give the textile element different properties in different areas. (Nishida, 3:15-26, 3:43-52, 5:41-45)
46. The article of footwear recited in claim 44, wherein the textile element is one of an exterior layer, an intermediate layer, and an interior layer of the upper.	Claim 46 adds the same limitation to independent claim 44 as claim 7 added to independent claim 1. Osamu describes the additional limitations of claim 46 – see discussion for claim 7 in chart.

92. As explained in the chart, claims 1-15 are obvious in view of Osamu alone. Claims 1-15 are also obvious in view of Osamu combined with other prior art as follows:

- Claim 1 is obvious in view of Osamu and any one of the following: McDonald, Whiting, Curley, Nishida, Glidden.

- Claims 2-7, 9-10, and 13 are obvious in view of same.

- Claim 8 is obvious in view of Osamu and one or more of the following: Curley, Shimoura, McDonald, Whiting, Nishida, Glidden.

- Claims 11-12 are obvious in view of Osamu and one or more of the following: Nishida, Glidden, Curley, Shimoura, McDonald, Whiting.

- Claim 14 is obvious in view of Osamu and any one of the following: McDonald, Whiting.

- Claim 15 is obvious in view of Osamu and Whiting.

93. Claims 16 and 19-23 are obvious in view of Osamu alone. Claims 16-23 are also obvious in view of Osamu combined with other prior art as follows:

- Claim 16 is obvious in view of Osamu and any one of the following: McDonald, Whiting, Curley, Nishida, Glidden.

- Claims 19-20, 22, and 23 are obvious in view of same.

- Claims 17-18 are obvious in view of Osamu and any one of the following: McDonald, Glidden.

- Claim 21 is obvious in view of Osamu and one or more of the following: Curley, Shiomura, McDonald, Whiting, Nishida, Glidden.

94. Claims 24-35 are obvious in view of Osamu alone. Claims 24-35 are also obvious in view of Osamu combined with other prior art as follows:

- Claim 24 is obvious in view of Osamu and any of the following: McDonald, Whiting, Curley, Nishida, Glidden.

- Claims 25-32 are obvious in view of same.

- Claim 33 is obvious in view of Osamu and any one of the following: McDonald, Whiting.

- Claims 34-35 are obvious in view of Osamu and one or more of the following: Shiomura, Curley, Nishida, McDonald, Whiting, Glidden.

95. Claims 36-43 are obvious in view of Osamu alone. Claims 36-43 are also obvious in view of Osamu combined with other prior art as follows:

- Claim 36 is obvious in view of Osamu and any one of the following: McDonald, Whiting, Curley, Nishida, Glidden.

- Claims 39-43 are obvious in view of same.

- Claim 37 is obvious in view of Osamu and McDonald.

- Claim 38 is obvious in view of Osamu and one or more of the following: Shiomura, Curley, Nishida, McDonald, Whiting, Glidden.

96. Claims 44-46 are obvious in view of Osamu alone. Claims 44-46 are also obvious in view of Osamu combined with other prior art as follows:

- Claim 44 is obvious in view of Osamu and any of the following: Whiting, Curley, Nishida.

- Claim 46 is obvious in view of same.

- Claim 45 is obvious in view of Osamu and one or more of the following: Nishida, McDonald, Glidden, Whiting, Curley.

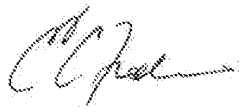
X. Conclusion

97. In signing this declaration, I recognize that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be

subject to cross examination in the case and that cross examination will take place within the United States. If cross examination is required of me, I will appear for cross examination within the United States during the time allotted for cross examination.

98. I reserve the right to supplement my opinions in the future to respond to any arguments raised by the owner of the '011 Patent and to take into account new information as it becomes available to me.

99. I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.



Dated: November 28, 2012 Edward C. Frederick, Ph.D.

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mailto:ned@exeter-research.com

Edward C. Frederick

Objective

To contribute to the research, design and development of innovative and functional products. To consult on Product Design & Development and Advanced Product Development and Research.

Career Summary

Over thirty years experience in the sporting goods industry. Extensive experience in footwear design, development and manufacturing, expert in footwear biomechanics research and advanced product development.

Work experience

Dec. 99-present — Exeter Research, Inc. — Brentwood, NH

President

- Research and development services for the sports and fitness industries
- Consultation on new product development, advanced concepts and, biomechanics research and functional testing of new products
- Design, manufacture and sales of special test equipment and software for traction, impact shock attenuation, and shoe flexibility testing

Jun 08 -present — Footwear Science — Abingdon, Oxford, UK

Editor-in-Chief

- Responsible for the scientific quality and content of the Journal
- Official representative of the journal in external matters
- Manages the peer review process and editing of all manuscripts
- Overseas issue planning and the work of the editorial board
- Responsible for implementing and applying the Journal's editorial policies

Feb 96-Dec. 99 — **Converse, Inc.** — N. Reading, MA & Taiwan

Senior Vice-President, Research, Design and Development (97-99)

Chief Product Executive (96-97)

- Responsible for all aspects of new product research, design and development for Converse.
- Research and Development facilities in US, China, and Taiwan
- Responsible for staff of 50 people in US and 26 in Taiwan
- Creation and management of $6.5 Million budget
- Managed introduction of new Helium technology

June 87-April 97 **Exeter Research, Inc** Exeter, NH - USA

President

- Research and development services for the sports and fitness industries. New product development, advanced concepts and, biomechanics research and functional testing to a wide range of companies including: Nike, adidas, Converse, Fila, Sole Technology, Rollerblades, Asolo, Lotto, Rossignol, Avia, Dr. Scholls, Nordica, Timberland, Inc., Wilson SG, Inc., Spenco Medical Corp., Sorbothane, Inc., Li Ning, & the US Biathlon Team.
- Design, manufacture and sales of special test equipment and software for traction, impact shock attenuation, force measurement, ski glide performance testing, and shoe flexibility testing
- Recruited, trained and managed a staff of biomechanists, industrial designers, testing engineers, and footwear developers.

Sept.86-June 87 **Penn State University** University Park, PA

Associate Professor of Locomotion Studies

- Research & graduate instruction: locomotion studies and biomechanics
- Consultant to Nike, Inc. on new technologies, research and testing.

Aug.80-Sept.86 **Nike, Inc** Exeter, NH & Beaverton, OR

Director of Research; Director of Research and Development

- Responsible for creating an advanced products research and development program at Nike. The Nike Sports Research Laboratory was established in 1980. The NSRL remains a viable part of Nike's extensive R&D efforts.
- Director of Research (1980-82). Established NSRL, responsible for recruiting and managing 12 scientists, engineers, and technicians.
- Director of Research & Development (1982-83): administrative and fiscal responsibility for the 150 plus employees and $8 million budget of all research and new product development programs at Nike. Established processes and scheduling procedures that improved R&D typical timelines from 2 years to an average of less than 9 months. Expanded R&D efforts into outdoor, cleated and court sports.
- Director of Research (1983-86). Responsible for research and development aspects of new corporate ventures, as well as advanced research on new product concepts.

Aug. 79-Aug. 80 **University of Montana** Missoula, MT

Assistant Professor of Zoology

- Major teaching responsibilities: Human Anatomy and Physiology, Comparative Anatomy, and Vertebrate Functional Morphology.
- Research on footwear biomechanics and functional morphology
- Consultant to Nike, Inc. on conceptualization, design, development and testing of new technologies, including Nike Air®.

Aug. 77-Aug 79 **University of Tennessee** Knoxville, TN
Assistant Professor of Zoology

- Major teaching responsibilities: Human Anatomy and Physiology, Comparative Anatomy, and Comparative Physiology.
- Research on footwear biomechanics and functional morphology
- Consultant to Nike, Inc. on conceptualization, design, development and testing of new technologies, including Nike Air®. (1978 on)

Jun. 76-Aug 77 **Museum of Northern Arizona** Flagstaff, AZ
Head, Publications Department; Research Biologist

- Directed production of museum publications
- Managed Staff of five producing 12 books and 2 periodicals per year
- Research on muscle design.

Aug. 73-Aug 76 **Northern Arizona University** Flagstaff, AZ
Instructor of Biology

- Courses taught: General Biology and Cell Physiology
- Research on muscle design

Special Academic Appointments

Sept. 95-present **University of Massachusetts** Amherst, MA
Adjunct Professor, Dept of Kinesiology, School of Public Health & Health Sciences

- Research collaboration, participation in advising graduate students, occasional lectures on sports biomechanics

Sept. 88 –Aug 90 **University of New Hampshire** Durham, NH
Adjunct Associate Professor, Dept of Phys. Ed., College of Health Sciences

- Research collaboration, participation in advising graduate students, occasional lectures on sports biomechanics and physiology

Education

1970 **B.A. in Zoology**, California State University at Humboldt
Areas of emphasis: general zoology and marine biology.

1973 **M.A. in Biology**, California State University at Humboldt
Areas of emphasis: neurophysiology, general physiology.

1977 **Ph.D. in Zoology**, Northern Arizona University
Areas of emphasis: vertebrate functional morphology, neural control of locomotion, locomotion biomechanics and muscle biology.

Editorships & Professional Service

1973-83 Founder, Science Editor and columnist for *Running* magazine.

1976-77 Editor *Plateau*, a natural & cultural history magazine.

1977 Editor, Journal *of the Arizona Academy of Sciences*.

1983-88 Associate Editor, Biomechanics, *Medicine & Science in Sports and Exercise*, Journal of the American College of Sports Medicine

1982-91 Technical Advisor and contributor, *American Health* magazine

1988-91 Editorial Board, *International Journal of Sports Biomechanics*,

1989-92 Editorial Board, *Cycling Science*

1989-93 Board Member, *Cycling Research Association*

1988-94 Board member, *United States Biathlon Association*,

1984-94 Sports Medicine Director, *U. S. Biathlon Association*. Coordination of medical care and all scientific services.

2008- present - Editor-in-Chief, *Footwear Science* a international, peer-reviewed journal published by Taylor & Francis.

Honors

1996 Jury, IOC Olympic Prize. *International Olympic Committee*. Member of six person international jury that chose the winner of this prestigious $250,000 prize for excellence in science applied to sport.

2000 AAKPE, elected to the American Academy of Kinesiology and Physical Education

2005-2007 elected Chairperson of the 500 member International Society of Biomechanics *Footwear Biomechanics Group*

2007 Co-Chaiperson of the *VIIIth Footwear Biomechanics Symposium*, Taipei, Taiwan

2009 – honored by the creation of the biennial, *E. C. "Ned" Frederick Young Investigator Award* of the Footwear Biomechanics Group

Additional Comments on Professional Service

In addition to service to the U.S.B.A. Sports Medicine Council and the International Olympic Committee, I was a consultant to the USOC Ski Project, and I have tested and counseled over 60 Olympic and professional athletes since 1975. This list includes a variety of track and field athletes, rowers, baseball, basketball and football players. Six have since won medals in Olympic competition and one was voted National League MVP.

My services as a reviewer have been used by: *Nature*, *Journal of the American Medical Association*, *Medicine and Science in Sports and Exercise*, *Research Quarterly*, *Journal of Biomechanics*, *International Journal of Sports Medicine, Journal of Applied Biomechanics,* Journal *of Theoretical Biology*, *Journal of Sports Science*, *Clinical Journal Of Sport Medicine, Clinical Biomechanics*, and the *Canadian Journal of Applied Sports Science*. I have reviewed abstracts for numerous scientific meetings. I have chaired sessions at the annual meetings of the American College of Sports Medicine, American Society of Biomechanics, Canadian Society of Biomechanics, International Society of Biomechanics, Commonwealth Games Conference 86 in Glasgow, several sessions for the ISB Footwear Biomechanics Group, and the IOC World Congress on Sports Science. I have been the external examiner for the doctoral dissertations of students at the University of Calgary, Canada, and Chalmers University of Technology, Göteborg, Sweden. I have been a graduate committee member for students pursuing advanced degrees at the University of Tennessee, the University of Montana, Penn State University, and The University of Massachusetts.

Since 2005 I have been invited annually to act as an External Reviewer for the Hong Kong Research Grants Council (RGC). I have reviewed Competitive Earmarked Research Grants and other RGC proposals.

Seminars, Keynote Lectures, and Papers Presented

I have had the pleasant experience of being an invited speaker at over 50 sports clinics and running camps including those associated with the Honolulu Marathon, the Phidippides Marathon in Athens, the Rotterdam Marathon, New York Marathon, Atlanta Marathon, and the Boston Marathon. Those speaking engagements are not listed in this vita because they were not formal research presentations, even though they are certainly a form of professional service. Research seminars, invited keynote lectures and papers read at meetings and special colloquia are included below.

Seminars

1976 Northern Arizona University, Department of Biological Science
"Selected physiological properties of the ankle extensor muscles of Mephitis mephitis "

1977 Museum of Northern Arizona, Department of Biology, "How animals move"

1977 University of Tennessee, Department of Zoology, "Why big animals? Being a discussion of size limits in mammals"

1979 University of Montana, Department of Zoology
"Muscle design in an endurance walker, the Striped Skunk"

1979 New England College of Osteopathic Medicine, Physiology Department "The concept of muscle design"

1979 Colorado State University, Department of Anatomy, "Muscle fiber type compartmentalization in mammals"

1979 Portland State University, Department of Biology
"Muscle design in the Striped Skunk"

1979 University of North Carolina, Charlotte, Department of Biology
"Analysis of muscle design in mammals"

1982 University of Calgary, Faculty of Physical Education
"The resolving power of oxygen uptake measurements"

1982 Johns Hopkins University, Department of Mechanical Engineering
"Running shoe biomechanics: Myth versus fact"

1983 Baldwin-Wallace College, Department of Biology, "Zoolympics"

1983 Simon Fraser University, Department of Kinesiology,
"Studying the economy of movement"

1983 University of Tennessee, Departments of Zoology and Physical Education, "Running shoe biomechanics: Myth versus fact"

1983 Oregon Museum of Science and Industry, "What a difference a shoe makes"

1984 Liverpool Polytechnic, Department of Sport & Rec. Study, "Mythology in sports biomechanics"

Seminars (CONTINUED)

1986 Pennsylvania State University, Center for Locomotion Studies
"Kinematically mediated effects on the economy of movement"

1987 University of Calgary, Biomechanics Laboratory "Biomechanical aspects of ski skating"

1992 University of Massachussetts, Department of Exercise Science, "Biomechanical Aspects of Sport Shoe Biomechanics

2002 University of Massachusetts, Department of Exercise Science, "Big Ideas in Biomechanics"

Keynote Lectures

1978 Atlanta, Georgia State University, AMA Symposium, "Controversies in Sports Medicine "

1978 Honolulu, AMJA Sports Medicine Symposium,
"How high, how far, how fast: Human performance potential"

1979 Boston, Symposium on Medical Care in Road Racing
"Role of environmental factors in planning medical care"

1979 Honolulu, AMJA Sports Medicine Symposium, "Heat injury in marathon running"

1979 Provo, Utah, Brigham Young University, Distinguished University Lecturer, "Human anatomical and physiological potential"

1981 New York, American Academy of Podiatric Sports Medicine
"Myth and fact in sport shoe biomechanics"

1981 Minneapolis, ACSM, Symposium on Ergogenic Aids
"Extrinsic biomechanical aids to performance"

1981 Boxborough, MA American College of Sports Medicine- New England Chapter, "Body size and biomechanical consequences"

1982 Seattle, American Society of Biomechanics
"The role of biomechanics in sports equipment design"

1982 Nanjing, Shanghai and Beijing, All-China Sports Federation Lecture Series, "Myth and fact in modern sports science" and "Using sports science to enhance performance"

1982 Boston, St. Elizabeth's Hospital Sportsmedicine Symposium
"Biomechanical aspects of running shoe design"

1982 Nijmegen, Netherlands, Symposium on Sport Shoes and Playing Surfaces,
"The effect of shoe design on shock attenuation"

1983 Boston, American Podiatric Association
"Myth and fact in sport shoe biomechanics"

Keynote Lectures (Continued)

1983 New York, John Marshall Memorial Symposium
"In search of the perfect marathon"

1983 Cleveland, Baldwin-Wallace College Special Event Lecturer
"Human running"

1983 Calgary, Symposium, Biomechanical Aspects of Sports Shoes & Playing Surfaces,
"Measuring the effects of shoes and surfaces on the economy of locomotion"

1984 Orelia, Ontario, Ontario Exercise Physiology Group
"Factors affecting the economy of movement"

1984 Brussels, Belgian Society of Kinestherapy (ABKS)
"Myth and fact in sport shoe biomechanics"

1984 Munich, Symposium- Der Schuh im Sport
"Dilemmas and Dichotomies in sport shoe design"

1984 Hanover, Dartmouth Medical School Sportsmedicine Symposium
"In pursuit of the perfect marathon: Using sport science to improve performance"

1984 Iowa City, Hawkeye Sports Medicine Symposium, "Running shoe biomechanics"

1986 Glasgow, Commonwealth & International Conference on H.P.E.R.D.
"Kinematically mediated consequences of sport shoe design"

1986 Edinburgh, Exercise-Benefits, Limits & Adaptations, symposium
"Biomechanical aspects of endurance"

1986 Burlington, VT. Univ. of Vermont, Biathlon Conference, "Using Biomechanics to Ski Faster"

1987 Calgary, Alberta. Biomechanical Aspects of Sports Surfaces, Intl. Symposium
"Performance aspects of sports surfaces"

1987 Burlington, VT. University of Vermont, Biathlon Training Conference
"Putting Technique Improvements into Perspective"

1987 Manchester, NH. Elliot Hospital, "Truth or Consequences in Sports Medicine"

1988 Anaheim CA. I.D.E.A. Convention, " Fitness Tools for CrossTraining"

1988 Calgary, Alberta, 2nd Annual Symposium on Sports Surfaces
"Citius, Altius, Fortius: Performance Enhancement through Sport Surface Design"

1988 Calgary, Alberta, 2nd Annual Symposium on Sports Surfaces
"Marketing Technical Concepts to the Sports & Fitness Community"

1988 Chicago, IRSA Fall Conference, " Integrating Safe, Effective CrossTraining Programs"

1988 Washington, DC. IDEA Convention, "Fitness Tools for CrossTraining"

Keynote Lectures (Continued)

1988 Tokyo & Osaka, Japan, NIJAC Sports Forum, "CrossTraining: Fitness tools for a better life"

1989 Aspen, Colorado, Aspen Sportsmedicine Conference,
"Fitness tools for CrossTraining" & "Sport Shoe Biomechanics for the Practitioner"

1991 Orlando Florida, American College of Sports Medicine - Annual Meeting
Guest Clinical Lecture " Biomechanical Mechanisms of Sports Injury"

1991 Orlando Florida, American College of Sports Medicine Annual Meeting
Symposium keynote: " Mechanical Constraints on Nordic Ski Performance"

1991 Chicago, IL, Sensors Expo
"Harnessing Local Pressures: A New Tool for Sports Performance Enhancement."

1992 Calgary. Alberta, International Sports Surfaces Symposium
" Biomechanical Underpinnings of Sports Surface Standards"

1992 Colorado Springs, CO USOC Sports Equipment and Technology Conference
"Measuring Nordic Ski Glide Performance" (w/ J. Healy & A. Vangura)

1993 Falun, Sweden, International Nordic Skiing Symposium, " Finding Faster Skis"

1993 Amherst, MA Intl Soc. Biomechanics in Sports Symposium, "Slipping and Sliding in Sports"

1994 Calgary, Alberta Canadian Soc. of Biomechanics Functional Footwear Symposium
" Footwear and Performance- Is there a link?"

1994 Boston, The Boston Foot Course, "Biomechanical Consequences of Sports Shoe Design"

1995 Göteborg, Sweden Chalmers University Biomechanics Seminar
" Biomechanical Demands of Court Sports"

1995 Köln, Germany ISB - Working Group on Functional Footwear Symposium on Footwear Biomechanics, " Biomechanical Requirements of Basketball Shoes"

2001 Washington, DC Prescription Footwear Association Symposium on Footwear Biomechanics, "Pedicentric Footwear Design"

2003 Queenstown, New Zealand, *Foot in Sport* conference of New Zealand Society of Podiatrists " Pedicentric Shoe Design: a Critical Dissection of Footwear R&D"

2003 Queenstown, New Zealand 6th *Symposium on Footwear Biomechanics* of the ISB-Technical Group on Footwear Biomechanics, "A Peak Down Under the Rug".

2004 Hong Kong, Chinese University Hong Kong, Workshop: Application of Science in Footwear Design, Development and Manufacture, 2004, "Application of Science in Footwear Design"

2005 Dongguan City, People's Republic of China. Workshop "Application of Biomechanics in Footwear Design".

Keynote Lectures (Continued)

2008 Stoke on Trent, UK, 6th Staffordshire Conference on Clinical Biomechanics, " The Pedicentric Cure for What Ails the Footwear Industry"

2008 Stoke on Trent, UK, 6th Staffordshire Conference on Clinical Biomechanics, " Biomechanics of Skateboarding "

2009 Atlanta, GA, PFOLA 2009 12th Annual International Conference on Foot Biomechanics & Orthotic Therapy, " Kinetics of Skateboarding: Footwear Considerations"

Research Papers Presented

1975 Society for Neurosciences- Arizona Chapter, "Histochemical properties of Hindlimb muscles of the striped skunk"

1976 Arizona Academy of Sciences,"Adaptations for saltation in pocket mice and kangaroo rats"

1976 American Society of Zoologists,"Histochemical properties of the primary ankle extensors of the Striped Skunk, Mephitis mephitis"

1977 American Soc. of Zoologists,"Muscle design in the ankle extensors of M. mephitis"

1980 Am College of Sports Med., "Lower oxygen cost while running in air cushion type shoes"

1980 American Society of Biomechanics, "The prediction of vertical impact force during running"

1981 Am College of Sports Medicine, "Consequences of scaling on impact loading in running"

1982 World Congress Sports Med,"The effect of shoe weight on the aerobic demands of running"

1983 American College of Sports Medicine, "Shoe design and rearfoot control in running"

1983 Symposium on Biomechanical Properties of Sport Shoes and Playing Surfaces, "The effects of shoe cushioning on the oxygen demands of running"

1983 International Society of Biomechanics, "A model of the energy cost of load carriage on the feet during running"

1984 American College of Sports Medicine, "Ventilatory contributions to shock attenuation"

1985 International Society of Biomechanics, "Rearfoot kinematics and ground reaction forces in elite caliber twin runners"

1985 New England Physiologists, "Performance Limits"

1987 International Society of Biomechanics, "Double peaks in impact force during running"

1989 International Society of Biomechanics, "Scaling of Foot Dimensions" w/ J. Robinson

1989 IOC World Congress on Sports Science, "Reliability and validity of tests of ski sliding friction". w/ P. Hoag. (Poster)

1995 ISB - Working Group on Functional Footwear Symposium on Footwear Biomechanics, "Determining the cushioning characteristics of replacement insoles" w/ Craig Wojcieszak

1997 ISB Technical Group on Footwear Biomechanics, 3rd Symposium on Footwear Biomechanics, "A Comparison of Two Friction Measuring Methods", w/ C Wojcieszak, P. Jiang

2003 ISB-Technical Group on Footwear Biomechanics 6th Symposium on Footwear Biomechanics, "Biomechanics of Skateboarding: Kinetics of the 'Ollie'". w/ J. J. Determan, S. N. Whittlesley, and J. Hamill

Research Papers Presented (Continued)

2004 CSB Symposium w/ J Determan and J. Cox." Impact Forces During Skateboarding Landings".Thirteenth Biennial Conference, Canadian Society for Biomechanics. Halifax, Nova Scotia, Canada. 2004

2006 World Congress of Biomechanics w/ J Determan, J. Cox, and M Nevitt, "Kinetics of the Skateboarding Kick Flip" Fifth World Congress of Biomechanics, Munich

2007 VIIIth Footwear Biomechanics Symposium, Taipei, Taiwan, w/ J. Determan, J. Cox, and M Nevitt, "Reporting Shear Ground Reaction Forces During Skateboard Landings" Footwear Biomechanics Group

2008 North American Congress on Biomechanics *(NACOB, Ann Arbor (USA) w/* Matthew Nevitt, Jeremy Determan, Joseph Cox & Edward Frederick. "Ground Reaction Forces in Skateboarding: The Ollie"

2009 IXth Bienniel Footwear Biomechanics Symposium, South Africa, w/ J. Determan and M Nevitt, "Measuring the Shock Attenuation Properties of Skateboarding Shoes"

2009 IXth Biennial Footwear Biomechanics Symposium, South Africa, w/ J. Determan, J. Cox, and M Nevitt, "Tibial Accelerations During Snowboarding Jump Landings: A Pilot Study"

Publications:

Books, Audio, Internet, and Video Tapes & Dissertaion

1973 Frederick, E.C. *The Running Body*, World Publications, Palo Alto, CA.-the physiology of running for lay readers.

1977 Frederick, E.C. *An Analysis of Muscle Design in the Primary Ankle Extensors of Mephitis mephitis*. Unpublished doctoral dissertation, Northern Arizona University

1984 Frederick, E.C. (Editor), *Sport Shoes and Playing Surfaces: Their Biomechanical Properties*, Human Kinetics Publishers,Champaign, IL- a collection of scholarly reviews on the biomechanics of sport shoes and surfaces.

1986 Kiesling, Stephen & E.C. Frederick, *Walk On: A Toolkit for Building Your Own Walking Fitness Program*. Rodale Press

1988 Kiesling, Stephen & E.C. Frederick, (ghost authors) *HealthWalking*, Nike & SyberVision, Newark, CA - a complete fitness system based on walking - 60 min Video, booklet, 4 audio tapes.

1988 Kiesling, Stephen & E.C. Frederick, *Nike CrossTraining System,* Nike Fitness Information, Beaverton, OR - 4 audio tapes and a 64 page book on CrossTraining

2007 Frederick, E. C. & S. W. Yang (eds) *Proceedings: VIIIth Footwear Biomechanics Symposium, Taipei 2007,* Footwear Biomechanics Group, pp 160.

2008 Ruan Mianfang & E. C. Frederick, *Li Ning Glossary of Footwear and Biomechanics Terminology: English and Chinese*. http://exeter-research.com/indexGlossary.html

Papers, Reviews, Chapters & Abstracts

Out of a fondness for teaching and new ideas, I have given my non-technical writing skills regular exercise. This has led to more than 70 articles in lay publications such as *American Health*, *Runner's World*, *Modern Athlete & Coach*, *Track Technique*, *Running, The Washington Post*, *Walking*, and so on. These articles have covered a range of subjects, but the majority have been about scientific topics related to health and fitness. The above-mentioned articles are intentionally *not* listed in this vita, because they are not strictly the product of my professional labors. I must confess, though, that this writing, along with what little teaching I have had time for, has helped me accept life without students and blackboards, one of the most difficult adjustments to working in research and administration. The publications listed below are technical, research publications. (NB: "A" following the date indicates an abstract. "CH" indicates a chapter in a book)

Research Publications:

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E. C. Frederick, Starting Over, *Footwear Science* Vol 3, Issue 2, p 69-70, 2011

Patents:

"Athletic shoe with heel stabilizer" US Patent No. 4354318

"Shock absorbing sole layer", US Patent No. 4535553

"Sole with V-Oriented Flex Groove" US Patent No. 4562651

"Electronic device for determining the speed, distance traversed, elapsed time and calories expended by a person while running", US Patent No. 4578769

"Shoe Insole With Bottom Pattern", US Patent D-341023

"Finger Watch", US Patent D-498425

"Finger Watch", US Patent D-501412

"Finger Watch", US Patent D-501144

"Housing for electronic device wearable on user's finger", European Patent EP1462880A2

"Housing for electronic device wearable on user's finger" US Patent, US2004/190383 (application)

"Footwear with Enhanced Impact Protection" US Patent, 7,020,988

"Footwear with Enhanced Impact Protection" US Patent, 7,278,226

"一种鞋的可调节的减震装置"("Adjustable Shock Attenuating Means for Footwear") Chinese Patent, CN 2930368Y

"Dynamically moderated shock attenuation system for footwear" US Patent, 7,788,826

""Footwear with Enhanced Impact Protection" US Patent, 7,832,118

"Adjustable Shock Attenuating Means for Footwear and Footwear Using the Same" US Patent, 8,166,671

"Dynamically moderated shock attenuation system" US Patent, 8,276,296

Litigation Support:

Selected Experience as Expert or Consultant in Litigation or Patent Reexamination Matters

1996 or later

AlpineStars S.P.A. v. United States, No. 09-00271. I have been engaged as an expert by the Commercial Litigation Branch of the US Department of Justice in a customs dispute. I have written two expert reports and have been deposed. This case is ongoing.

Pashamova vs. New Balance Athletic Shoe, Inc. and New Balance, Inc., Case No. 11-cv-10001-NG (D. Mass.). I am currently serving as an expert in support of New Balance. I filed a preliminary expert report in 2011. (2011- ongoing)

Request for Reexamination by K-Swiss Inc. of U.S. Patent No. 7,181,866. I provided a declaration in support of K-Swiss. Concluded in 2010.

Masai Marketing & Trading AG (MBT) v. Ryn Korea Co. LTD. Provided expert support including several reports in support of MBT's infringement case. Concluded in 2009.

Hockerson-Halberstadt, Inc. and Standon, LLC v. New Balance Athletic Shoe, Inc. Serving as an expert in support of New Balance. Last active in 2009.

Cushion Technologies, LLC v. adidas America, Inc., New Balance Athletic Shoe, Inc. , et al. Served as an expert in this case for New Balance and filed two expert reports. Concluded in 2008.

H. J. Dananberg v. Payless Shoe Source, Inc. Two depositions as an expert as well as couple of reports for Payless. Case concluded in 2006.

Akeva L.L.C. v. New Balance Athletic Shoes, Inc. Retained as an expert by New Balance. Case concluded in 2004.

Sole Technology v. Pegasus. Filed Expert Report in Sydney, Australia for Sole Technology. 2002.

adidas v. Minor. Testified in arbitration hearing in Geneva, Switzerland in November 1996 on behalf of adidas. 1995-97.

Prior to 1996 (underlining indicates party I worked with)

Purpora v. Brown Univ./Mondo: Report and Deposition

Sherkin v. Avia/Reebok. Two Expert Reports

Kalotkin v Nike slip and fall (S&F) case in Boston as expert for Nike. Expert Report, Deposition, Testimony at trial

Danielson v. Puma in Albuquerque, NM as expert for Puma. Expert Report, Deposition and Testimony at trial. Personal Injury case (PI)

Mehl v. Monsanto/Converse. I was deposed as an expert for the plaintiff and wrote two reports. (PI)

Cipolloni v. adidas. I was deposed as an expert for adidas and wrote a couple of reports,1993. (PI)

Cicci/Gaudreau v. Hyde. Expert Report (IP)

Helbig v. Nike. Expert Report (PI, S&F)

Pollack v. Pony. Expert Report. (cleat design)

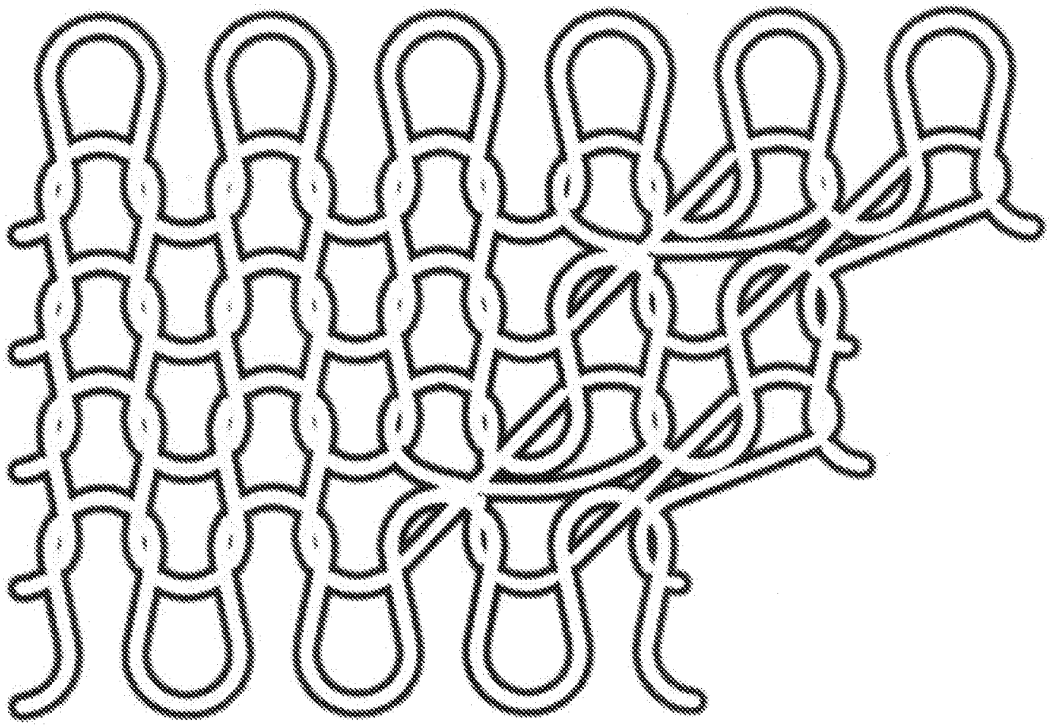
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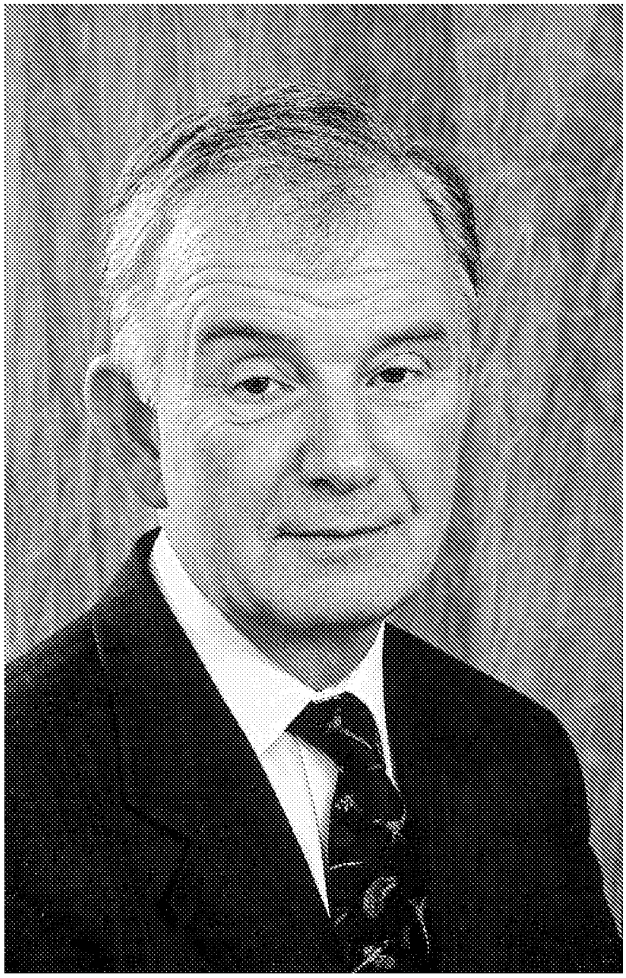
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The author, David J Spencer, C Text, FTI, ACFI, recently retired as a senior lecturer in Textile and Knitting Technology at De Montfort University, Leicester. He has been an examiner and moderator in the Manufacture of Hosiery and Knitted Goods for the City and Guilds of London Institute. He has written numerous technical articles and is Technical Editor of the journal *Knitting International* and is Contributing Editor of *ATA Journal* and *China Textile Journal*. He is Chairman of The Textile Institute Knitting Terms and Definitions Committee. He obtained his initial industrial experience with Corah of Leicester, who were then world leaders in the application of knitting technology. [*Photo by Oakham Photographic.*]

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To my wife,
SHIRLEY ANN

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Preface

The aim of this book is to combine in a single volume the fundamental principles of weft and warp knitting in such a manner that its contents are useful to readers in education, industry or commerce. It thus fulfils the long felt need for a comprehensive up-to-date textbook explaining this important sector of textile technology. Aspects covered include flat, circular, full fashioned, hosiery, Raschel, tricot and crochet production. The inclusion of the historical development of the types of machines, their actions and mechanisms as well as the construction, properties and end used of the products which they manufacture, make the book acceptable as a set text for Textile courses from technician to degree and Textile Institute examination level. It will also prove particularly suitable for professionals wishing to update or broaden their understanding of knitting.

The contents have been arranged for the convenient use of different levels of readership with the text gradually progressing from an explanation of basic terminology and principles to eventually encompass the most advanced aspects of the technology including the application of microprocessor controls and developments in knitting science. Care has been taken where possible to emphasise fundamental rules and principles which are less likely to be drastically altered by developments in later technology.

The indexed and referenced format of the text is supplemented by labelled diagrams and photographs so that the book may also serve as a handy reference work for study and business purposes. Terminology is defined either according to Textile Institute terms and definitions or current usage in the industry and is supplemented as necessary by American or continental terminology. Internationally accepted methods of notation help to clarify explanations of fabric structures. Although SI units and the tex yarn count system have been explained and used in the text, other systems of measurement and yarn count systems have also been employed wherever it has been considered that their usage is still of importance. A number of worked calculations have been included in certain chapters to further clarify explanations and assist students.

It is hoped that the inclusion of a number of fashion photographs will encourage

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design and sales personnel to come to terms with technology whilst emphasizing the importance of end-product design to technologists.

This edition includes developments in electronic control and selection in warp and weft knitting. Basic software programming is covered with particular reference to shaping and integral knitting of complete garments. New information regarding the historical development of knitting techniques has also been included.

An additional chapter has been added to cover the rapidly expanding sector of technical textiles. Chapter 30 deals with the exacting requirements and end-uses of technical textiles and the type of knitted structures that can meet these conditions.

It is particularly satisfying that this book has proved useful in education, industry and commerce throughout the world. I hope the above mentioned additions will further increase its usefulness.

Knossington
Leicestershire

DAVID J. SPENCER

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First and second editions

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1

An introduction to textile technology

1.1 The evolution of textiles

Although man's first articles of clothing and furnishing were probably animal skin wraps, sometimes stitched together using bone needles and animal sinews, he soon attempted to manipulate fibrous materials into textile fabrics, encouraged by experience gained from interlacing branches, leaves and grasses in the production of primitive shelters.

The word '*textile*' originates from the Latin verb *texere* – to weave – but, as the Textile Institute's Terms and Definitions Glossary explains, it is now 'a general term applied to any manufacture from fibres, filaments or yarns characterised by flexibility, fineness and high ratio of length to thickness'.

1.2 Textile fabrics

Textile fabrics can be produced directly from webs of fibres by bonding, fusing or interlocking to make non-woven fabrics and felts, but their physical properties tend to restrict their potential end-usage. The mechanical manipulation of yarn into fabric is the most versatile method of manufacturing textile fabrics for a wide range of end-uses.

There are three principal methods of mechanically manipulating yarn into textile fabrics: interweaving, intertwining and interlooping. All three methods have evolved from hand-manipulated techniques through their application on primitive frames into sophisticated manufacturing operations on automated machinery.

1. *Interweaving* (Fig. 1.1) is the intersection of two sets of straight threads, warp and weft, which cross and interweave at right angles to each other. Weaving is by far the oldest and most common method of producing continuous lengths of straight-edged fabric.
2. *Intertwining and twisting* (Fig. 1.2) includes a number of techniques, such as braiding and knotting, where threads are caused to intertwine with each other

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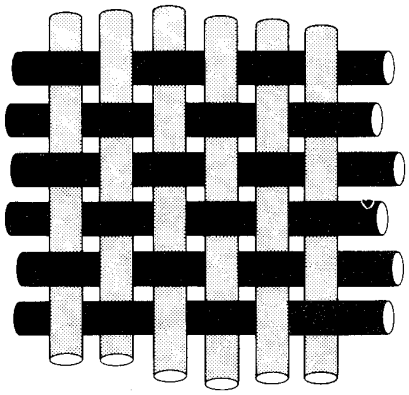


Fig. 1.1 Interweaving.

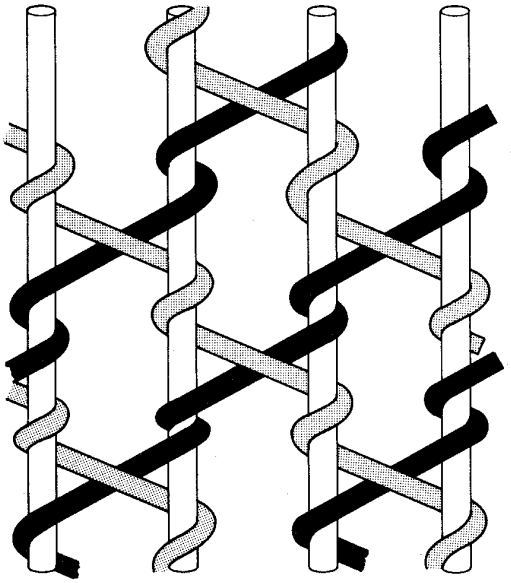


Fig. 1.2 Intertwining and twisting.

at right angles or some other angle. These techniques tend to produce special constructions whose uses are limited to very specific purposes.

3 *Interlooping* (Fig. 1.3) consists of forming yarn(s) into loops, each of which is typically only released after a succeeding loop has been formed and intermeshed with it so that a secure ground loop structure is achieved. The loops are also held together by the yarn passing from one to the next. (In the simplified illustration this effect is not illustrated.)

Knitting is the most common method of interlooping and is second only to weaving as a method of manufacturing textile products. It is estimated that over 7 million

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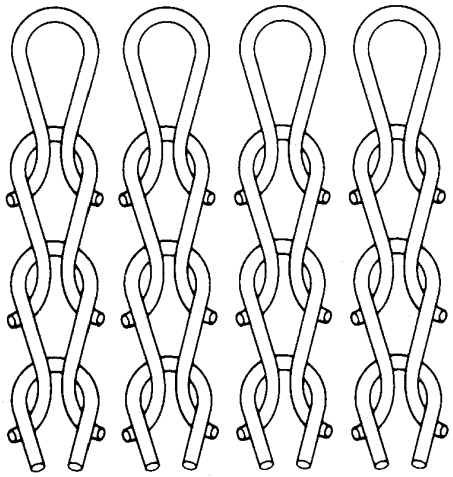


Fig. 1.3 Interlooping.

tons of knitted goods are produced annually throughout the world. Although the unique capability of knitting to manufacture shaped and form-fitting articles has been utilised for centuries, modern technology has enabled knitted constructions in shaped and unshaped fabric form to expand into a wide range of apparel, domestic and industrial end-uses.

1.3 Textile yarns and fibres

Yarns are the raw materials manipulated during knitting. A *yarn* is defined as 'an assembly, of substantial length and relatively small cross-section, of fibres or filaments, with or without twist'. The term '*thread*' is loosely used in place of yarn and does not imply that it is as smooth, highly twisted and compact as a sewing thread.

Textile fibres are the raw materials of the yarns into which they are spun. There are two configurations of fibres: staple fibres and filament fibres.

- *Staple fibres* are of comparatively short length – for example, cotton and wool fibres, which require spinning and twisting together in order to produce a satisfactory length of yarn of suitable strength.
- A *filament* is a fibre of indefinite length – for example silk, which requires combining with other filaments, usually with some twist, in order to produce a yarn of sufficient bulk.

Originally, all textile fibres occurred naturally – for example, animal fibres such as wool and silk, and vegetable fibres such as cotton and flax. The first artificially-produced fibres were the *rayons*, developed by the regeneration of long-chain cellulose polymers that occur naturally in wood pulp and cotton linters. Derivatives such as cellulose acetate and triacetate were later produced by the acetylation of cellulose polymers. *Nylon*, the first truly synthetic fibre, was invented by

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Wallace H. Carothers in 1938. It is based on a synthetically-built, long-chain polyamide polymer that previously did not occur naturally. A wide range of synthetic fibre polymers, including polyesters and polyacrylics, has since been developed. Many of the synthetic polymers may be converted into yarns in continuous filament form (in which state they were extruded during manufacturing). The filaments may also be cut or broken into staple fibre form, to be later spun on systems originally developed for natural fibres such as wool or cotton.

The properties of more than one type of fibre may be incorporated into a fabric as the result of blending the fibres during spinning, or by knitting two or more types of yarn.

Knitting requires a relatively fine, smooth, strong yarn with good elastic recovery properties. The worsted system has proved particularly suitable for spinning yarns used for knitwear, outerwear and socks, and the combed cotton system for underwear, sportswear and socks.

The introduction of synthetic fibres, which can be heat set in a permanent configuration, has led to the development of *texturing processes* that directly convert these filaments into *bulked yarns*, thus bypassing the staple fibre spinning process. During texturing, the filaments are disturbed from their parallel formation and are permanently set in configurations such as crimps or coils that help to entrap pockets of air and confer properties such as bulkiness, soft handle, porosity, drape, cover, opacity and (if necessary) elasticity to the resultant yarn. Examples of yarns of this type include *false twist nylon* and *Crimplene*, the latter being a registered trade name for a technique whereby the properties of the textured polyester yarn are modified during a second heat-setting operation so that the stitch clarity, handle and stability of the fabric are improved.

The development of synthetic fibres and of their texturing processes has proved particularly beneficial to the knitting industry and has resulted in a close association between the two industries. The most recent development is the widespread use of the elastane fibre *Lycra* to support the elastic properties of knitted garments. The period from the mid-1960s to 1973 is often regarded by knitters as a 'golden age' because fashionable demand for textiles composed of synthetic fibres reached a peak during that period [1,2].

1.4 Yarn count numbering systems

A *yarn count* number indicates the *linear density* (yarn diameter or fineness) to which that particular yarn has been spun. An important consideration in choosing a yarn count is the *machine gauge* which defines the spacing of the needles in the needle bed (usually as *needles per inch*).

Obviously, the finer the machine gauge, the finer the required yarn count. Choice of yarn count is also restricted by the type of knitting machine employed and the knitting construction.

The count, in turn, influences the cost, weight, opacity, handle and drapability of the resultant structure. In general, staple spun yarns tend to be comparatively more expensive the finer their count because finer fibres and a more exacting spinning process are necessary in order to prevent the yarn from showing an irregular appearance.

Unfortunately, a number of differently based count numbering systems are still currently in use. Historically, most systems are associated with particular yarn-

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spinning systems. Thus, a yarn spun on the worsted system from acrylic fibres may be given a worsted count number.

The *worsted count system* is of the *indirect* type based on *length per fixed unit mass*, i.e. the higher the count number, the finer the yarn. The weight is fixed (1 lb) and the length unit (number of 560-yard hanks) varies. A 1/24's worsted yarn (24 × 560-yard hanks weighing 1 lb) will be twice the cross-sectional area of a 1/48's worsted yarn (48 × 560-yard hanks weighing 1 lb).

The designation 2/24's worsted indicates that the yarn contains two ends of 1/24's so that the resultant count is twice the cross-sectional area (24/2 = 12's).

The denier system is used in continuous filament silk spinning, and when the silk throwsters began to process textured synthetic continuous filament yarns, these nylon and polyester yarns were given denier count numbers.

The *denier system* is of the *direct* type based on *mass per fixed unit length*, i.e. the lower the number, the finer the yarn. The length unit is fixed (9000 metres) and the weight unit (in grams) is variable. A 70 denier yarn (9000 metres weigh 70 g) will be twice as fine as a 140 denier yarn (9000 metres weigh 140 g). A 2/70 denier yarn will give a resultant count of 140 denier.

The *tex system* was introduced as a universal system to replace all the existing systems. As tex sometimes produces a count number having a decimal point, it has been found more satisfactory to multiply the count number by 10 to give a *deci-tex* number. The tex system has not been universally accepted, particularly for spun yarns, and on the continent of Europe the metric system is used for these yarns.

In this book, common commercial practice has been followed, with decitex being used for filament yarn counts and the metric system for spun staple yarn counts.

The main count systems, with their continental abbreviations, are as follows:

Indirect Systems

Bradford Worsted System (NeK) – the number of 560-yard hanks that weigh 1 lb (453.6 g).

English Woollen System (NeW) (Yorkshire Skeins) – the number of 256-yard hanks that weigh 1 lb.

English Cotton System (NeB) – the number of 840-yard hanks that weigh 1 lb.

Continental Metric System (Nm) (Cotton System) – the number of 1000-metre hanks that weigh 1000 g (1 kg).

Direct Systems

Denier System (Td) – the weight in grams of 9000 metres.

Tex System (Tt) – the weight in grams of a 1000 metres.

Decitex System (dtex) – the weight in grams of 10000 metres.

1.5 Conversion formulae

Tex counts may be obtained from count numbers in other systems by using one of the following formulae:

$$\frac{886}{\text{NeK}} \quad \frac{1938}{\text{NeW}} \quad \frac{591}{\text{NeB}} \quad \frac{1000}{\text{Nm}} \quad \frac{\text{Td}}{9}$$

(To obtain the decitex count, multiply the tex result by ten.)

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Example: An interlock underwear fabric is weft knitted from 1/40's NeB at a weight of 5 ounces per square yard. Convert the yarn count to decitex and the fabric weight to grams per square metre.

(a) The conversion for Tex is 591/NeB so it is necessary to also multiply by 10 to obtain decitex.

The *decitex* count therefore $= (591/40) \times 10 = 148$ dtex

(b) $1\,\text{oz} = 28.35\,\text{g}$ and $1\,\text{yd}^2 = 0.836\,\text{m}^2$.

Therefore $5\,\text{oz/yd}^2 = (5 \times 28.35) = 142\,\text{g} \times 1/0.836 = 170\,\text{g/m}^2$.

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2

From hand knitting to hand frame knitting

2.1 The evolution of hand knitting

The term *knitting* describes the technique of constructing textile structures by forming a continuous length of yarn into columns of vertically intermeshed loops.

It relies heavily on the availability of fine, strong, uniformly spun yarn. The term 'knitting' dates from the mid-sixteenth century, earlier words such as the Saxon 'cnyttan' and the Sanskrit 'nahyat' being less precise, indicating that knitting probably evolved from sources such as the experience gained by knotting and Coptic knitting.

In *Coptic knitting* or *Nalbinding*, an upside-down looped structure is produced using a single-eyed needle (like a sewing needle) containing a short length of yarn. Normally, crossed loops are formed. The technique can achieve fashioning, closing, circular knitting and stitch patterning. Leicester's Jewry Wall Museum possesses a sock of cross stitch construction from the Antinoe site in Roman Egypt dating from the fifth century AD [1].

2.2 The spread of knowledge of hand pin knitting

Weft knitting, using the fingers to produce open loop structures, may well have been practised long before the use of hand-held pins. Hand pin knitting was first recorded in religious paintings in 1350 in Northern Italy. It then spread through the rest of Europe [2]. Maitre Bertram's painting of Mary knitting Christ's seamless garment (Fig. 2.1) is dated to just before 1400. Unfortunately, Christ's garment is more likely to have been made by the 'sprang' or braiding technique, in a similar manner to the vestments of Saint Cuthbert [3].

Cap knitting was established as a technique in Britain by 1424, and by 1488 Parliament controlled the price of knitted caps. Coarse woollen stockings may have been worn prior to 1600 but they were not as fine as woven cloth stockings cut on the bias to give greater extensibility. Henry VIII (1509–1547) was the first British

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Fig. 2.1 The Madonna knitting Christ's seamless garment. The earliest recorded illustration of a knitted garment. Part of a church architectural painting by Maitre Bertram (1345–1415) [Hamburg Kunsthalle Museum].

monarch to wear fine expensive knitted silk stockings. Queen Elizabeth I wore them in about 1561 and was so impressed by their elasticity and fineness that she never again wore cut and sewn woven hose [4]. In 1564 William Rider knitted a pair of worsted stockings by copying a pair knitted in Italy.

2.3 The principles of hand knitting using two pins

In Fig. 2.2a, the left-hand pin A is retaining the previously formed row of loops (course). The right-hand pin B is being used to draw through and retain the next course of loops, one at a time.

In Fig. 2.2b, pin B has drawn the newly formed loop 2 through loop 1 of the previous course. Pin A then releases loop 1, which hangs from loop 2, which itself is hanging from pin B. (Note that loop 1 has been drawn under the head of the lower loop and that loop 2 has been drawn over the head of loop 1.)

At the start of the next row (course), the pins may be changed hands and the action continued. If this happens, the fabric will be turned around and the next course of loops will mesh through from the opposite side of the fabric. Each course

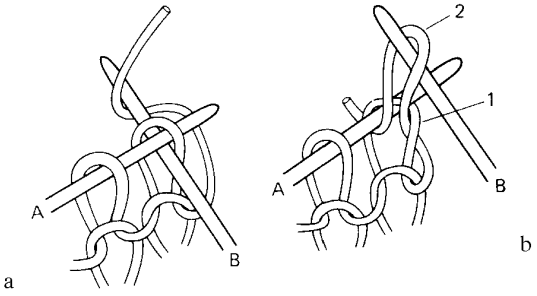


Fig. 2.2 Hand pin knitting.

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of loops will be drawn through the heads of the previous course of loops, in the *same direction* in the fabric. As the pins are straight and pointed, skill is required to ensure that the loops do not slip off the end and cause *drop stitches*.

2.4 The invention of the stocking hand frame

'The Reverend' William Lee 'of Calverton in Nottinghamshire' is generally credited with inventing the stocking hand frame in 1589. 'The advance it represented, by mechanising complex hand movements at a single stroke, was 150–200 years in advance of its time.' [5]

The concept of its operation was so brilliant that, through an evolutionary process of technical refinement, modification and innovation by many inventors throughout the world over the succeeding centuries, it laid the foundations for today's weft and warp knitting and machine lace industries.

Unfortunately there is no dated documentary evidence concerning Lee's life, efforts and achievements prior to 1589 [6]. Imaginative descriptions and paintings from a much later period provide a mythical and confusing back-cloth to the event. The first extant illustrations of a frame were drawn for *Colbert* by the French spy *Hindret* in 1656, and the earliest existing stocking frames appear to date from about 1750.

Lee's original frame was undoubtedly crude, and knitted poor quality woollen stockings with a gauge of only 8 needles per inch (25 mm). It required two men to operate it. Not until 1750 were frame knitted stockings accepted as comparable in quality to those knitted with pins. Lee is believed to have knitted a pair of silk stockings in 1596/7 [7], although a reported gauge of 20 needles per inch seems to be too fine for that period. A gauge of 16 needles per inch was only commercially attained after 1620, when *Aston* applied lead *sinkers* (dividers) in the hand-frame.

Frustrated in his attempts to obtain a patent from either Elizabeth I or James I by the fear of unemployment amongst hand pin knitters, William Lee and his brother James took their nine machines and knitters to France at the invitation of Henry IV in 1609. Lee set up a workshop in Rouen and signed a partnership agreement with Pierre de Caux in 1611, with a further agreement in 1614.

The protection of Protestant workers in France ended when Henry IV was assassinated in 1610 and it is believed that (at an unspecified date) James brought most of the machines and knitters back to London and that William died in poverty in Paris whilst hiding from persecution. England then prohibited the export of stocking frames, but Hindret's accurate drawings and knowledge enabled frames to be built in Paris from 1656 onwards and thus the knowledge of their operation spread across Europe.

Gradually London declined as the centre of frame-work knitting and, by 1750, the major areas could be broadly classified as Derby for silk, Nottingham for cotton and Leicester for wool knitting.

Improvements in the spinning of cotton yarns led particularly to an increase in knitted underwear and open-work point lace fabrics, in addition to cotton hose. The knitting industry then expanded rapidly until 1810 when over-production resulted in stagnation, unemployment and the Luddite riots. It was not until conditions improved in the second half of the century that new innovations and inventions in knitting technology received encouragement and practical application.

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2.5 The bearded needle

From a logical viewpoint, Lee's hand frame has more in common with a knitting *peg frame* (Stuhl) than with a pair of hand-held pins. There is evidence of a prior art of peg frame knitting dating back at least to 1535 in Strasbourg [8].

Lee quickly discarded the idea of trying to imitate hand-held circular knitting. His brilliance lay in his adaptation and integration of the straight peg frame with the foot- and hand-controls of the hand-operated weaving loom, and with the employment of a hooked loop holder (*the bearded needle*) for loop intermeshing.

The bearded needle has an extended hook or beard that is pressed to enclose the newly-formed loop so that this loop can be drawn through the previously-formed loop as the latter is being released.

Lee set the needles in a row across the width of the frame, whose working parts were more intricate than that of the existing hand-weaving loom. Skilled hand knitters could only form up to 100 loops per minute whereas Lee's first frame could achieve 500 to 600 loops per minute, and the later silk hose frame could produce 1000 to 1500 loops per minute.

2.6 The principles of frame knitting

Figure 2.3 shows a side view of the knitting elements. After the weft yarn has been laid by hand across the horizontally-mounted needle bed, thin metal sinkers descend

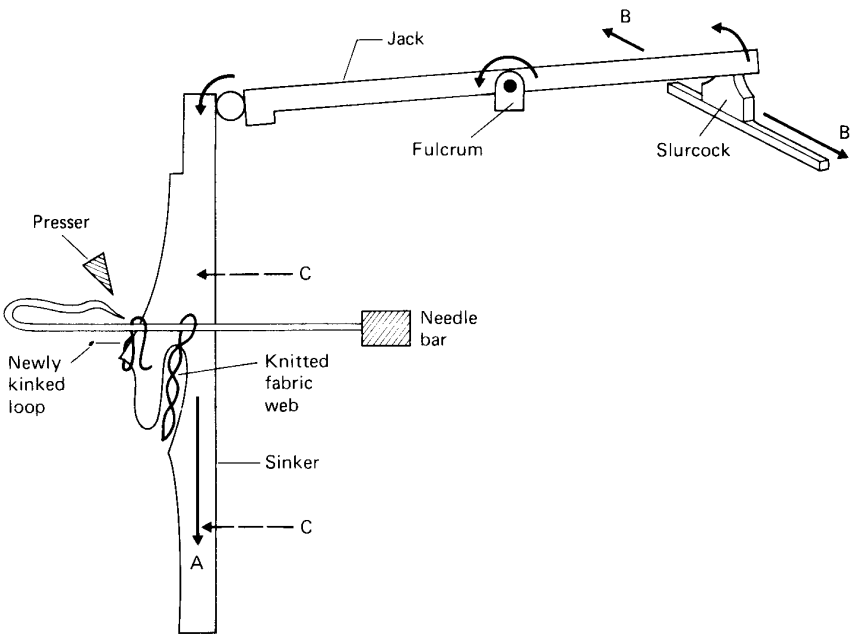


Fig. 2.3 The action of frame knitting.

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(in direction A) individually between each pair of adjacent needles to kink or sink it into a loop shape around each needle stem. Each sinker is caused to descend because it is hinged at its upper end to a pivoted jack that is lifted at its outer end by a wedge-shaped piece of iron termed a *slurcock*.

The slurcock is traversed backwards and forwards (direction B) across the needle bed width by a rope. A forward motion of the sinkers (in direction C) takes the new loops under the beards. The beard is then closed by the presser bar.

Figure 2.4 shows a general view of the hand frame. There are three foot-pedals. After the weft yarn has been laid across, the right pedal is pressed down causing the rope attached to it to turn the wheel clockwise and draw the slurcock from left to

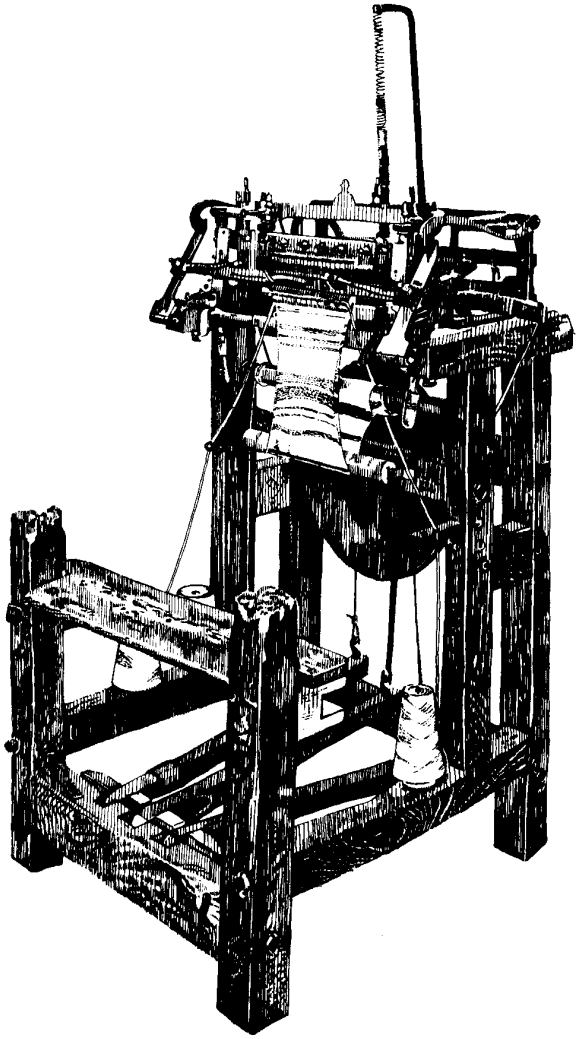


Fig. 2.4 Hand frame (c. 1820) [Copyright: Leicestershire Museums, Art Galleries and Record Service].

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right. For the next row of loops, the slurcock is traversed across from right to left by pressing down the left foot-pedal after the yarn has been laid across. This turns the wheel in the opposite direction. The middle pedal causes the presser bar to be lowered to press and close the needle beards.

2.7 The evolution of other weft knitting machines

The fineness of the needles and sinkers relied heavily on the developing skills of English mechanics, a skill which was lacking on the continent of Europe at that time. Lee's original invention, although workable, was not economically viable as it required two men to operate it. Improvements were carried out and by 1620, *Aston*, a former apprentice of Lee's, had arranged the sinkers into alternating sets and thus, with skill and precision, had obtained better uniformity of loop length, much finer machine gauges (24 gauge) and easier operation of a frame consisting of 2000 parts.

The jack sinkers continued to be individually raised and lowered but the lead or dividing sinkers were afterwards moved down *en bloc* to equalise the loop lengths. The principle of sinkers and dividers is still employed on fine gauge Cotton's patent straight bar frames. Other improvements were trucks (wheels bearing the weight of the mechanism), sley castor backs and front stops.

These developments led to attempts to prevent the export of the improved British frames and to the growth of framework knitting in the second half of the seventeenth century, but a hundred years passed before further significant developments occurred. Strutt's *Derby Rib* attachment dates from 1759 (see Section 7.3). In 1769 the frame was successfully adapted to rotary drive (Section 17.1). It was not until the second half of the nineteenth century that vertical needle bars began to be employed or circular frames became viable (Section 8.4.3), despite earlier circular-machine patents ranging from Decroix's in 1798 to Brunel's in 1816.

It was the invention of Cotton's straight bar frame that automated the production of fashion shaped articles and developed the full potential of loop transfer shaping (Section 17.1).

Matthew Townsend's versatile latch needle (Section 3.14), however, mounted a challenge to the monopoly of the bearded needle frame and, with the later support of precision engineering techniques, it paved the way for electronically-controlled individual needle selection (Sections 11.13 and 12.6) on V-bed and circular machines.

2.8 The development of warp knitting

Warp knitting, the second and smaller section of machine knitting, was never a hand-manipulated craft. It was first developed by Crane and Porter in 1769 as a method of embroidery plating, by means of multiple warp thread guides, onto stocking fabric as it was being knitted on the hand frame.

As the technique improved, purely warp intermeshed loop structures without the weft knitted ground began to be knitted and *Crane* patented his warp loom in 1775. Tarrat is credited with developing the first efficient treadle-operated warp knitting frame in 1785. Two important later developments were *Dawson*'s wheels for shogging the guide bars, and *Brown*'s use of two separately-controlled, warp-supplied guide bars. In 1807, another Nottingham frame-smith, *S. Orgill*, introduced the

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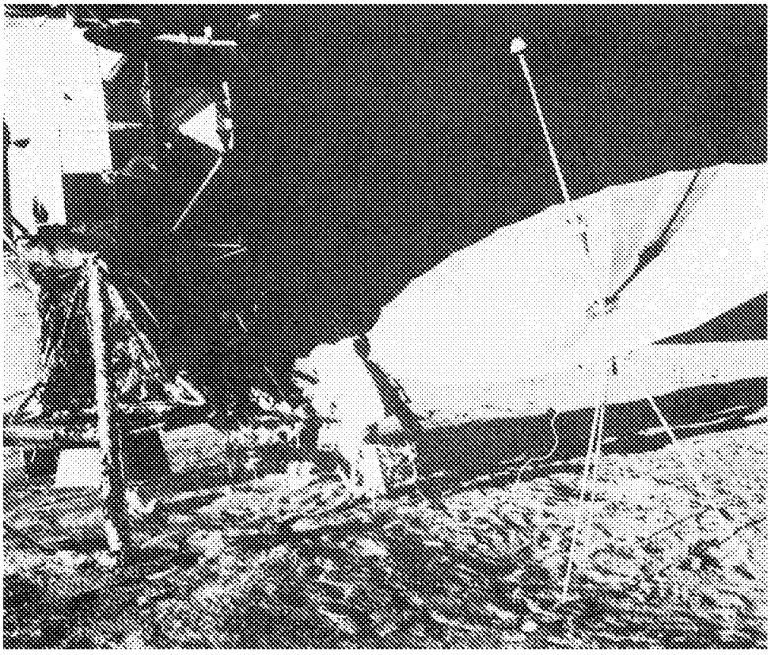


Fig. 2.5 Warp knitted fabric on the moon [Photo credit NASA]. The photograph, taken during the Apollo 12 mission, shows the warp knitted antenna which transmitted the television pictures of the lunar landing back to Earth. The two-bar mesh fabric, weighing less than one ounce per square yard, was warp knitted from gold plated metallic yarn. [*Knit O'wr Times*, July 7, 1969, 34–7].

rotary shaft driven knitting frame, having a width up to 72 inches (1.8 m) and cam-controlled knitting motions capable of knitting up to 30 rows (courses) of loops per minute.

The German warp knitting industry developed in Chemnitz and Apolda, after *Reichel* brought a British hand warp loom to Berlin in 1795.

During the Napoleonic wars, 500 hand warp looms were producing woollen uniform fabric for the British forces. However, the power-driven weaving loom was soon to out-produce the warp loom in plain fabric and, by the 1840s, the fancy lace market was lost to the patterning capabilities of the Leaver's lace machine.

The ingenuity of machine builders and warp knitters, and a combination of modern engineering technology and the advent of new yarns and finishing processes, have at last enabled warp knitting to realise the potential it first demonstrated in its early years of development (Fig. 2.5).

2.9 The potential of knitting technology

The unique loop structure of knitting provides opportunities for

- using a minimum number of yarns.
- easy flow of yarn from one loop to another under tension.
- varying the size of loops.

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- loop distortion when under tension.
- loop transfer.
- knitting single face, double face, open-work and surface interest structures.
- increasing or decreasing the number of loops in width or depth.
- knitting to shape either fabric pieces or separate articles.
- knitting from a selection of yarns.
- engineering extensibility or stability.
- introducing (by inlay) yarns unsuitable for knitting.

2.10 Meeting the challenge of new markets

Today, knitting machines can manufacture most previously hand-knitted designs and structures in a fraction of the time as well as knitting structures that are too fine, intricate or complex to be attempted with hand-held pins. The manufacture of textiles is a highly competitive industry requiring the harnessing of the very latest technology to meet the instant demands of fashion and changing end-use requirements.

Fortunately the unique properties of knitted constructions, their ability to be engineered to exacting requirements and their potential for producing shaped articles as well as fabrics, enables knitting technology to rapidly respond to requirements in non-apparel areas whilst retaining its traditional markets in sweaters, hosiery, jersey and tricot fabrics, and raschel lace [9].

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3

General terms and principles of knitting technology

3.1 Machine knitting

Knitted structures are progressively built-up from row after row of intermeshed loops. The newly-fed yarn is converted into a new loop in each needle hook. The needle then draws the new loop head first through the old (fabric) loop, which it has retained from the previous knitting cycle. The needles, at the same time, release, (*cast-off* or *knock-over*) the old loops so that they hang suspended by their heads from the feet of the new loops whose heads are still held in the hooks of the needles.

A cohesive knitted loop structure is thus produced by a combination of the intermeshed needle loops and yarn that passes from needle loop to needle loop.

3.2 The knitted loop structure

The knitted loop structure may not always be noticeable because of the effect of structural fineness, fabric distortion, additional pattern threads or the masking effect of finishing processes. However, unless the intermeshing of the loops is securely achieved by the needles receiving new loops of yarn into their hooks before the old loops are 'cast-off', and the ground structure is not fractured during finishing or wear, a breakdown or separation of the structure will result.

The properties of a knitted structure are largely determined by the interdependence of each stitch to its neighbours on either side and above and below it.

Knitted loops are arranged in rows, roughly equivalent to the weft and warp of woven structures. These are termed '*courses*' and '*wales*' respectively.

3.3 A course

A *course* is a predominantly horizontal row of needle loops (in an upright fabric as knitted) produced by adjacent needles during the same knitting cycle. (The

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last five words help to prevent confusion when describing complex weft knitted fabrics).

3.3.1 A course length

In weft knitted fabrics (with the exception of structures such as jacquard, intarsia and warp insertion), a course of loops is composed of a single length of yarn termed *a course length*. Weft knitted structures will *unrove* from the course knitted last unless it is secured, for example, by binding-off.

3.3.2 A pattern row

A *pattern row* is a horizontal row of needle loops produced by adjacent needles in one needle bed. In plain weft knitted fabric this is identical to a course but in more complex fabrics a pattern row may be composed of two or more course lengths. In warp knitting, every loop in a course is usually composed of a separate yarn.

3.4 A wale

A *wale* is a predominantly vertical column of intermeshed needle loops generally produced by the same needle knitting at successive (not necessarily all) knitting cycles. A wale commences as soon as an empty needle starts to knit.

- When loop transfer occurs it is possible to transfer a wale of loops from one needle A to another B and to recommence knitting with the second needle, in which case more than one needle will have produced intermeshed loops in the same wale. (If needle B knits continuously, the wale knitted by needle A will merge into it).
- In warp knitting a wale can be produced from the same yarn if the same warp guide laps the same needle at successive knitting cycles.
- Wales are connected together across the width of the fabric by sinker loops (weft knitting) or underlaps (warp knitting).
- Wales show most clearly on the technical face and courses on the technical back of single needle bed fabric.

3.5 Stitch density

Stitch density refers to the total number of loops in a measured area of fabric and not to the length of yarn in a loop (*stitch length*). It is the total number of needle loops in a given area (such as a square inch, or three square centimetres). The figure is obtained by counting the number of courses or pattern rows in one inch (or three centimetres) and the number of wales in one inch (or three centimetres), then multiplying the number of courses by the number of wales. (Using a measurement of three centimetres rather than one, is preferable for accuracy in counting).

Stitch density gives a more accurate measurement than does a linear measurement of only courses or only wales. Tension acting in one direction might produce

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a low reading for the courses and a high reading for the wales; when they are multiplied together this effect is cancelled out. Pattern rows rather than courses may be counted when they are composed of a constant number of courses.

3.6 Technically upright

A knitted fabric is *technically upright* when its courses run horizontally and its wales run vertically, with the heads of the needle loops facing towards the top of the fabric and the course knitted first situated at the bottom of the fabric.

3.7 Design appearance requirements

The terms *technical face*, *technical back*, and *upright* are purely technically descriptive terms. They do not necessarily indicate the orientation of the fabric from the designer's viewpoint.

For example:

- Socks and ladies hosiery are usually worn upside-down compared to their sequence of production.
- The technical back of structures is often used for *plush* and *pile* effects.
- Curtains may be hung sideways compared to the wales.
- Diagonal stripes may be achieved for dress-wear by cutting the fabric at an angle.

3.8 The main features of the knitting machine

Originally, the term '*machine*' used to refer to a mechanism on a bearded needle frame such as the fashioning mechanism on the straight bar frame. Today, it refers to the complete assembly.

A *knitting machine* is thus an apparatus for applying mechanical movement, either hand or power derived, to primary knitting elements, in order to convert yarn into knitted loop structures.

The machine incorporates and co-ordinates the action of a number of mechanisms and devices, each performing specific functions that contribute towards the efficiency of the knitting action.

The main features of a knitting machine (see Fig. 13.12) are as follows:

1 *The frame* or *carcass*, normally free standing and either circular or rectilinear according to needle bed shape, provides the support for the majority of the machine's mechanisms.
2 *The machine control* and *drive system* co-ordinates the power for the drive of the devices and mechanisms.
3 *The yarn supply* consists of the yarn package or beam accommodation, tensioning devices, yarn feed control and yarn feed carriers or guides.
4 *The knitting system* includes the knitting elements, their housing, drive and control, as well as associated pattern selection and garment-length control device (if equipped).

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5 *The fabric take-away mechanism* includes fabric tensioning, wind-up and accommodation devices.
6 *The quality control system* includes stop motions, fault detectors, automatic oilers and lint removal systems.

Machines may range from high-production, limited-capability models to versatile, multi-purpose models having extensive patterning capabilities. The more complex the structure being knitted, the lower the knitting speed and efficiency. The simplest of the knitting machines would be hand-powered and manipulated whereas power-driven machines may be fully automatically-programmed and controlled from a computer system.

3.9 The needle

The hooked metal needle is the principal knitting element of the knitting machine.

Prior to yarn feeding, the needle is raised to clear the old loop from the hook and to receive the new loop above it on the needle stem. The new loop is then enclosed in the needle hook as the needle starts to descend. The hook then draws the new loop down through the old loop as the latter slides over the outside of the descending bridge of the closed hook. All needles must therefore have some method of closing the needle hook to retain the new loop and exclude the old loop.

3.10 Fabric draw-off

The fabric loops are always drawn from the needles on the side remote from their hooks. When two sets of needles are employed, either arranged vertically back-to-back or at some other angle to each other, each set of hooks will face away from the other set and the fabric will be produced and drawn away in the gap between the two sets.

3.11 The front of rectilinear needle bar machines

All rectilinear needle bar machines have a front and a back. The front of the machine is the side to which the fabric is drawn away, removed and inspected during knitting.

If the machine has a single vertical needle bar, its hooks will face towards the back. If the machine has two vertical needle bars, the fabric will be drawn down between them and will then pass underneath one needle bar (the front bar) and will be removed from that side of the machine.

On warp knitting machines, the guide bars and their corresponding warp beams are numbered and described according to their position in relation to the front and back of the machine.

On circular machines, there is no front or back as the fabric is drawn towards the centre, usually below the needle circle. The cylinder face loops show on the outside of the fabric tube as it is drawn downwards during knitting.

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3.12 The basic knitting action of a needle

Figure 3.1 (1–7) illustrates the basic action of a needle. Except for the manner in which the hook is closed (in this case by pressing the beard), the knitting action is similar for all needles. The arrows indicate the relative movement of the loops along the needles. (Whether the needle moves through the loops or the loops are moved over the needle by some other elements depends upon the machine design.)

1 The needle is in the (so-called) *rest position*, with the previously formed loop (a) held on its stem and covered by the hook.
2 The loop is *cleared* from the needle hook to a lower position on the needle stem.
3 The new yarn (b) is *fed* to the needle hook at a higher position on the needle stem than the position of the previous ('old') loop.
4 The yarn is *formed* into a 'new' loop.
5 The hook is *closed*, enclosing the new loop and excluding and *landing* the old loop onto the outside of the closed hook.
6 The new loop (b) is *drawn through* the head of the old loop (a). Simultaneously the old loop slides off the closed hook of the needle and is *cast-off* or *knocked-over*.
7 The old loop now hangs from the feet of the fully formed new loop and the knitting cycle starts again.

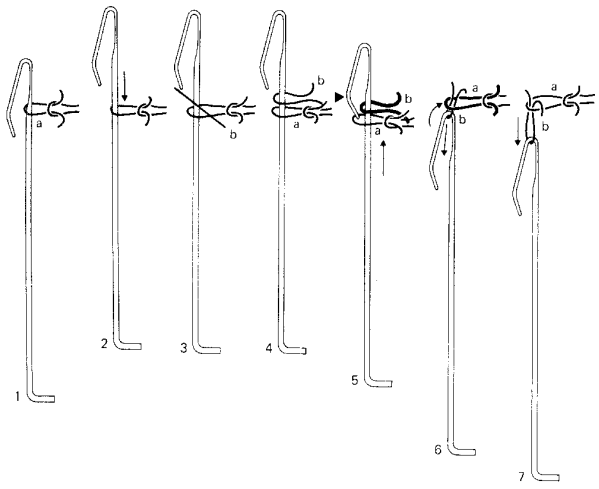


Fig. 3.1 Basic knitting action of a needle.

3.13 The bearded needle

As mentioned previously (Section 2.5), the *bearded* or *spring needle* was the first type of needle to be produced. It is the cheapest and simplest type to manufacture as it is made from a single piece of metal, in machine gauges as fine as 60 needles per inch, with the needles being pliered to ensure accurate needle spacing.

The bearded needle is essentially a *frame needle*, the needles being fixed to move

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collectively with the straight needle bar or being attached to a circular frame and revolving with it.

When bearded needles are reciprocated in their bed, the action is a collective one because of the problems of individual pressing and needle movement. The serial action of weft knitting is thus achieved by other loop-forming and controlling knitting elements that form the yarn into new loops and may (on sinker wheel and loop wheel frames) move the loops along the needle stems. A knitting section occupies a considerable amount of space on bearded needle circular machines, thus limiting productivity. Selective beard pressing facilities used to be provided on some weft and warp knitting machines.

In weft knitting, accurate control of the loops throughout the knitting sequence made the bearded needle *sinker wheel* and *loop wheel* frames particularly suitable for the production of plush and inlay, whilst the ease of flexing and deflection of the bearded needle made the sinker wheel and straight bar frames useful for loop transfer effects. However, bearded needle technology was unable to meet the challenging requirements of modern knitting machinery, such as individual needle selection of stitches, use of two needle beds and high productivity. Once fine-gauge latch needle machines could knit, to a consistently high quality, structures that were previously only knitted on bearded needle machines, the latter were no longer competitive.

3.13.1 The main parts of the bearded needle

There are five main parts of the bearded needle (Fig. 3.2):

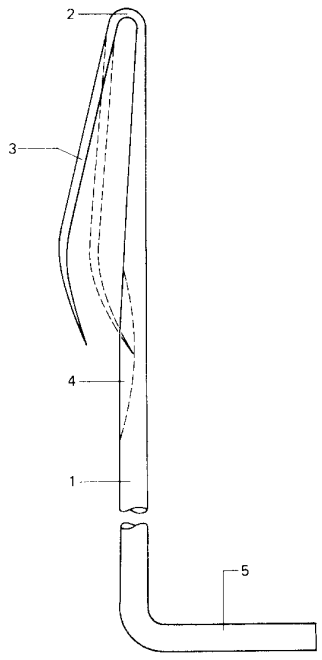


Fig. 3.2 Main parts of the bearded needle.

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1 The *stem*, around which the needle loop is formed.
2 The *head*, where the stem is turned into a hook to draw the new loop through the old loop.
3 The *beard*, which is the curved downwards continuation of the hook that is used to separate the trapped new loop inside from the old loop as it slides off the needle beard.
4 The *eye*, or groove, cut in the stem to receive the pointed tip of the beard when it is pressed, thus enclosing the new loop.
5 The *shank*, which may be bent for individual location in the machine or cast with others in a metal 'lead'.

3.13.2 The knitting action of the bearded needle

The knitting action of the bearded needle has been illustrated in Fig. 3.1. Depending upon the machine, the needles are set vertically or horizontally. The needle has the disadvantage of requiring a pressing edge to close the bearded hook and enclose the new loop. The presser may be in the form of a bar, blade, verge or wheel, with either the presser or the needle remaining stationary whilst the other element moves towards it.

Another feature of bearded needle knitting is that individual loop formation has to be achieved by a *loop forming element*. This leads to a more complicated knitting action but also provides for a more gentle and careful loop formation.

3.14 The latch needle

3.14.1 The history and development of the latch needle

Fact and fiction envelopes the invention of the *latch needle* in a similar manner to that of the bearded needle. *Pierre Jeandeau* patented the first latch needle (also known as the *tumbler needle*) in 1806 but there is no evidence of its practical use [1,2]. There is also no evidence that the pivoting of a broken pocket knife blade led to the development of the latch spoon.

However, it was *Townsend* and *Moulden's* practical patents applying the use of this *self-acting* needle that, in 1849, began the challenge to the 260-year reign of the bearded needle.

Matthew Townsend was a Leicester fancy hosier who was searching for a simpler method of knitting purl fabrics than using a frame with two sets of bearded needles and pressers. Townsend not only realised that a latch needle, which dispensed with the need for a presser, could be employed in a double-headed form to knit purl, he also foresaw the use of single-headed latch needles in plain and rib circular machines, flat machines and single and double needle bar warp knitting machines, as well as the use of holding-down sinkers for single needle bed knitting.

Although the first needles were crude, a *Mr. D. Fitchett* used them to knit borders for cravats which he exhibited at the Great Exhibition of 1851. Townsend, who lacked engineering skill and financial backing, sold the rights of his latch needle to *Joseph Pool* of Leicester and *Hine Mundella* of Nottingham, and emigrated to Canton, Massachusetts in 1858. In 1865 he was successfully sued for infringing the American latch needle patent of *James Hibbert*, which pre-dated his own by a mere

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month and four days. In his defence, Townsend stated that latch needles had been in use in France for many years, but he was unable to provide evidence. He died in 1879.

The latch needle was a more expensive and intricate needle to manufacture than the bearded needle. It was more prone to making needle lines as it slides in its trick, particularly if the latch was damaged or there was dirt in the trick. However, the latch needle was quickly employed by the newly emerging American knitting machine industry, whilst British companies preferred the bearded needle. The latter believed the bearded needle, which could be more precisely manufactured, had a knitting action which produced a better quality knitted structure.

It is now accepted that precision-manufactured latch needles can knit structures of the highest quality.

3.14.2 The features of the latch needle

The latch needle has nine main features (Fig. 3.3):

1 The *hook*, which draws and retains the new loop.
2 The *slot* or *saw cut*, which receives the latch-blade (not illustrated).
3 The *cheeks* or *slot walls*, which are either punched or riveted to fulcrum the latch-blade (not illustrated).
4 The *rivet*, which may be plain or threaded. This has been dispensed with on most plate metal needles, by pinching in the slot walls to retain the latch blade.
5 The *latch-blade*, which locates the latch in the needle.

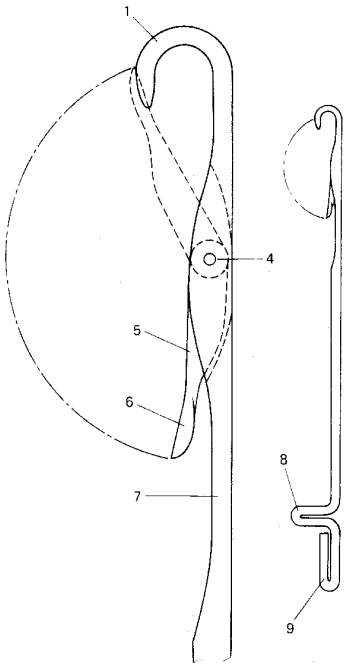


Fig. 3.3 Main features of the latch needle.

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6 The *latch spoon*, which is an extension of the blade, and bridges the gap between the hook and the stem covering the hook when closed, as shown in broken lines.
7 The *stem*, which carries the loop in the clearing or rest position.
8 The *butt*, which enables the needle to be reciprocated when contacted by cam profiles on either side of it, forming a track. Double-ended purl type needles have a hook at each end; whilst one hook knits, the inactive hook is controlled as a butt by a cam-reciprocated element called a *slider*.
9 The *tail*, which is an extension below the butt, giving additional support to the needle and keeping the needle in its trick.

3.14.3 The knitting action of the latch needle

Figure 3.4 shows the position of a latch needle as it passes through the cam system, completing one knitting cycle or course as it moves up and in its trick or slot.

1 *The rest position.* The head of the needle hook is level with the top of the verge of the trick. The loop formed at the previous feeder is in the closed hook. It is prevented from rising as the needle rises, by *holding-down sinkers* or web holders that move forward between the needles to hold down the sinker loops.
2 *Latch opening.* As the needle butt passes up the incline of the clearing cam, the old loop, which is held down by the sinker, slides inside the hook and contacts the latch, turning and opening it.
3 *Clearing height.* When the needle reaches the top of the cam, the old loop is cleared from the hook and latch spoon on to the stem. At this point the feeder guide plate acts as a guard to prevent the latch from closing the empty hook.
4 *Yarn feeding and latch closing.* The needle starts to descend the stitch cam so that its latch is below the verge, with the old loop moving under it. At this point the new yarn is fed through a hole in the feeder guide to the descending needle hook, as there is no danger of the yarn being fed below the latch. The old loop contacts the underside of the latch, causing it to close on to the hook.
5 *Knocking-over and loop length formation.* As the head of the needle descends below the top of the trick, the old loop slides off the needle and the new loop is drawn through it. The continued descent of the needle draws the loop length, which is approximately twice the distance the head of the needle descends, below the surface of the sinker or trick-plate supporting the sinker loop. The distance is determined by the depth setting of the stitch cam, which can be adjusted.

The *rest position* actually occurs between positions 1 and 2, when the open needle hook just protrudes above the needle trick verge. In this position, a feeder would be passed without the needle receiving a new loop and the old loop would not be cast off, so that a float stitch would be produced. The *tucking in the hook position* occurs between positions 2 and 3, when the needle can receive the new yarn but the old loop has not been cleared from the open latch.

The latch needle used on the *Stoll* CMS V-bed flat machine has a spring-loaded latch so that it fully opens and fully closes. Also, the latch spoon does not project beyond the needle head. Loops thus slide easily over the hook and latch, the yarn is less likely to be split, and there is greater security for the knitted loops.

NB: Although the above knitting action is described assuming the needle to be moving through the knitted loops, the movement is relative and the same effect can be achieved by moving the loops over a stationary needle. Similarly, the knock-over

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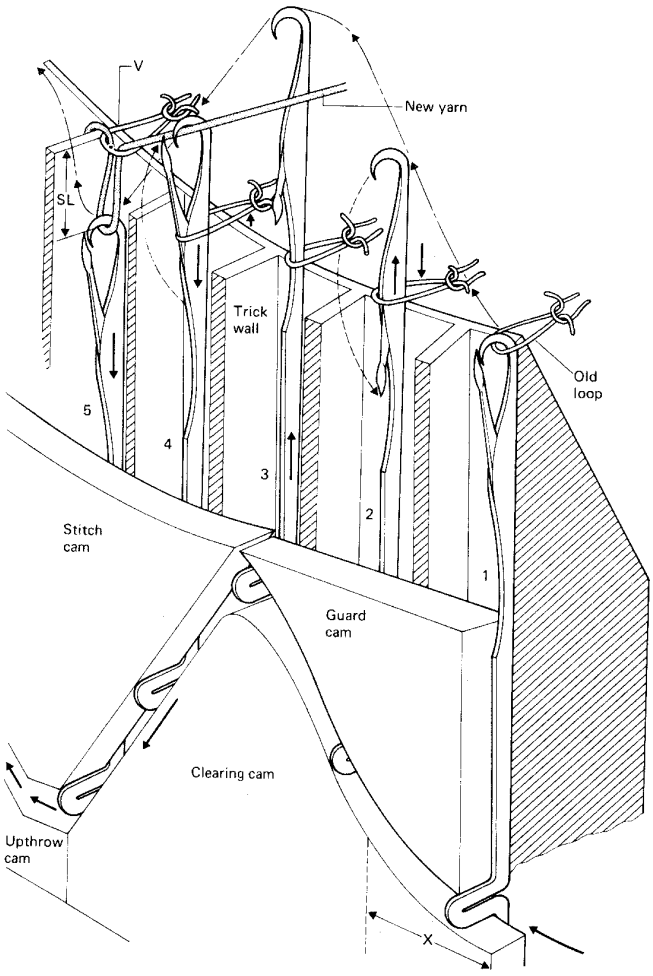


Fig. 3.4 Knitting action of the latch needle.

surface can be moved in opposition to the needle movement. (see *Relanit*, Chapter 13; and *Shima* contra sinkers, Chapter 19).

3.14.4 The advantages of the latch needle

The latch needle has the major advantage of being self-acting or loop-controlled, so that individual movement and control of the needle enables stitch selection to be achieved. It is ideally suited for use with computer-controlled electronic selection devices. For that reason, it is the most widely used needle in weft knitting and is sometimes termed the *'automatic' needle* (provided there are loops on the needle).

The old loop is cleared from the hook automatically when the needle is lifted because the loop slides down inside the hook and contacts the latch or tumbler,

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causing it to pivot open allowing the loop to slide off the latch down onto the stem. The hook is closed automatically after yarn feeding by lowering the needle because the old loop, which was on the stem, slides upwards contacting and pivoting the latch tightly closed and drawing and enclosing the newly fed loop inside the hook.

Latch needles thus knit automatically as they are reciprocated and draw the length of the new loop as they descend to knock-over. Except in raschel warp knitting machines, they are arranged to move independently in their tricks or grooves. They can operate at any angle but often require a latch-guard or latch-opening facilities as there is a tendency for latches to spring closed as tightly-knitted loops are cleared from the open latches.

Individually moving latch needles can draw and form their own needle loops in succession across the needle bed, unlike bearded needles and needles in warp knitting machines which move as a unit and thus require sinkers or guides to form the loops around their stems. The Germans classify the first method as '*Strickerei*' or *loop drawing* and the second method as '*Wirkerei*' or *loop forming*.

Variation of the height of vertical reciprocation of a latch needle at a feeder can produce either missing, tucking or knitting, and depth of descent normally determines loop length. Specially designed latch needles are capable of facilitating rib loop transference by selective lifting to a height above clearing height. Double-ended purl needles can slide through the old loops in order to knit from an opposing bed and thus draw a loop from the opposite direction to the previously knitted loop.

3.15 Friction and frictionless needles

There are two types of latch needle – friction and frictionless. *Friction needles* have a slight flex, crimp or bend in the tails so that they contact the side-walls of the tricks in which they are housed. They are used in open-cam systems, where cams may be introduced or taken out of action to divert the needle path. *Frictionless needles* are employed in closed cam-tracks that have guard or safety cams on the opposite side to the knitting cams to produce a completely enclosed track, through which the needles run (otherwise the freely-moving needles would be thrown out of their tricks at high knitting speeds).

3.16 The bi-partite compound needle

Compound needles (Fig. 3.5) consist of two separately-controlled parts – the *open hook* and the *sliding closing element* (tongue, latch, piston, plunger). The two parts rise and fall as a single unit but, at the top of the rise, the hook moves faster to open the hook and at the start of the fall the hook descends faster to close the hook. It is easier to drive the hooks and tongues collectively from two separate bars in warp knitting than to move each hook and tongue individually, as in weft knitting.

A compound needle with a sliding latch was first patented by *Jeacock* of Leicester in 1856. It now dominates the warp knitting industry after suffering a set-back against high-speed bearded needle machines in the 1960s. However, in weft knitting, where versatility and needle selection are as important as knitting speed, it has only made limited inroads in certain specialist or prototype areas.

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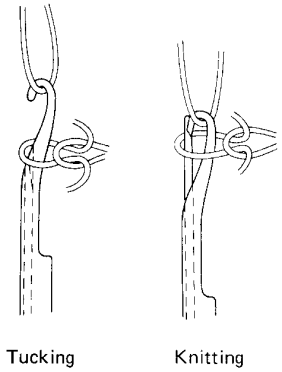


Fig. 3.5 Compound needle.

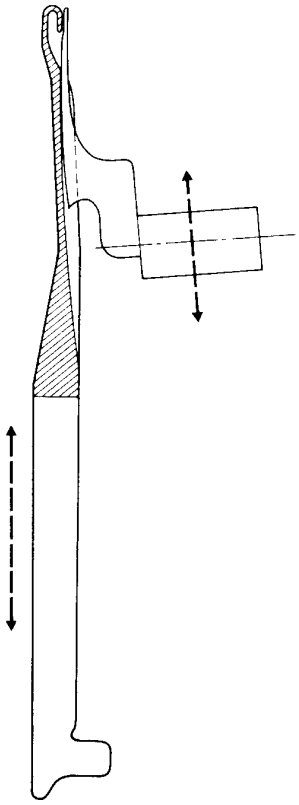


Fig. 3.6 Open-stem slide needle.

Two types of compound needle have been employed in warp knitting machines. *The tubular pipe needle* has its tongue sliding inside the tube of the open hook. It was successfully employed in *Sir James Morton's* high-speed *FNF tricot warp knitting machine* during the late 1940s and 50s. Development then ceased and bearded needle tricot machines recaptured their market with higher speeds, only to be later outpaced by a more efficient type of compound needle, *the slide compound needle.*

The *open-stem 'pusher type'* or *slide needle* (Fig. 3.6) has a closing wire or tongue that slides externally along a groove on the edge of the flat hook member. This needle is now preferred because it is simpler, cheaper, more compact and each of the two parts can be separately replaced.

3.17 A comparison of latch and compound needles

Compared with the latch needle, the compound needle is more intricate and expensive to manufacture. Each of its two parts must be separately and precisely controlled during knitting. In circular knitting, yarn feeding is very critical because, if the yarn lands on the tongue, it will not enter the open hook, whereas in latch needle

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knitting the closing latch will flick the yarn into the hook. It is particularly a problem when knitting multiple tucks. Adjustment of a machine setting is therefore a very skilled operation. Lifting of the tongue out of its guide groove at high speeds or as the result of dirt or fly can also be a problem, particularly if it splits filament yarns. In addition, differential heat expansion between the hook and its closer can cause problems.

On the other hand, the vertical clearing height for the compound needle is not so high because only the open hook and not an open latch spoon has to be cleared. The shorter vertical stroke can be achieved with a smaller cam system in V-bed flat knitting.

Also, when clearing, the compact head of the compound needle does not cause stretching of needle loops and robbing of yarn from adjacent sinker loops as the needle rises to clear or descends to knock-over, as is the case with the latch needle. The needle can knit tight, uniform stitches that tend to be rounder than the long, narrow loops produced by latch needles.

The compound needle has a short, smooth, simple harmonic movement without latch and beard inertia problems, so there is less vibration. Also, there is no stress on needle loops to open and close latches. The hook of the compound needle does not have to withstand the shock of a latch spoon hitting it. It can therefore be tapered to a slimmer diameter, producing a larger area inside the hook that can accommodate thicker yarns. This is particularly useful in the case of fine gauge, V-bed flat machinery.

Its slim construction and short hook make it particularly suitable for knitting fine warp knitted structures at high speed. It can knit chain stitches without the loops rising up the needles, and its sturdy construction resists the deflection generated by elastic yarns or thick places in yarns. Accumulations of lint are pushed out of the hook by the action of the closing element.

It is now employed in all types of warp knitting machines apart from double needle bar raschels and raschel simplex machines. Horizontal yarn tension between front and back needle bars can cause the two sets of needle hooks to be drawn towards each other and away from contact with their hook-closing sliders.

The compound needle has not lived up to its earlier promise in circular weft knitting. It has failed to gain a foothold in hosiery and even in simple plain knit single jersey. *Vignoni* are now the only circular machine builder to continue to include it as an option.

In V-bed flat knitting, *Shima Seiki* are successfully employing an open-slot compound needle in their coarse gauge (3 to 5 gauge) V-bed flat machines, resulting in a more compact cam box and reduced width of machine. The needle has conventional knit, tuck, miss and rib loop transfer facilities. The closing element passes through a slot in the hook element to the back, so that the two elements are held in contact with each other. Stop ledges on the two elements engage so that, after a certain distance, the individual movement of the element is converted into a collective movement of the two elements together.

Shima Seiki also used compound needles in their prototype four needle bed model SWG-X *WholeGarment* machine because the four needle beds are so close to each other that there is no space for latches to turn-over. Shima, again employ compound needles in their *model FIRST* machine. These ascend during knitting to only half the height of latch needles. They have a uniquely designed hook closer whose leading-end shoulder can project across to receive or transfer a loop from a

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needle in the opposite bed. This closing element also has a small cut-away section on its outward surface that can be used for retaining loops separately from those inside the hook. On the Shima machine, the slide needles are centre-mounted, minimising yarn stress and damage.

3.18 Machine gauge

Normally, all primary elements (those directly involved in the knitting action) in the same machine are set to the same gauge. It should be noted that the gauge is measured on one needle bed, so a machine of the same gauge but with two needle beds will have a total of twice as many needles as a machine with one bed. The gauge measured at the point of needle location is the same as that at the point of loop formation.

The *pitch*, or distance between one needle and another, is proportional to the needle gauge or thickness. The space available, which determines the maximum thickness of the yarn (i.e. the yarn count) that may be knitted, is the gap between the side of the needle and the trick wall as the needle descends to draw a new loop.

Machine gauge can be calculated by dividing the total number of needles into the length of the needle bed. The figure is rounded to the nearest whole number. For example, a 4-inch diameter sock machine has 168 needles. The circumference of a circle is πd where $\pi = 22/7$ and d = the diameter. The circumference is therefore $4 \times 22/7 = 12.57$ inches. The gauge is 168/12.57 = approximately 14 needles per inch. This may be expressed as 'E 14', E being the number of needles per inch.

The diameter of a yarn is proportional to its count, so a relationship exists between the range of optimum counts of yarn that may be knitted on a particular machine and its gauge. Machine gauge thus influences choice of yarn count and affects fabric properties such as appearance and weight.

For a given machine diameter or width, finer gauge machines tend to knit a wider fabric because more wales are involved. Loop sizes will naturally be smaller so more courses of loops will be required per centimetre of fabric knitted and production rates in linear metres of fabric will be less than for a coarser gauge machine.

Also, with more and finer needles there is a higher machine cost and a greater potential for needle damage to occur. A 30-inch diameter single jersey circular machine might have 1716 needles in E 18 and 1872 in E 20.

Coarse gauge machines have needles with larger dimensions and larger needle movements. The knitting cam systems are correspondingly larger, so coarse gauge machines tend to have larger cam boxes and less feed systems around their cylinder than finer gauge machines. It can thus be assumed that machines at the coarse and fine ends of gauge ranges are more expensive to build and operate than machines in the middle of the gauge range.

Originally, needles were cast in small metal blocks termed *leads*, which were then fitted into a needle bar. In the bearded needle straight bar frame, needles were cast two to a lead and gauged in the number of leads per 3 inches of the needle bar, which is equivalent to a gauge of the number of needles in $1\frac{1}{2}$ inches. In bearded needle warp knitting machines, needles were cast three to a lead, giving a gauge directly in needles per inch. In the raschel warp knitting machine, the needles were cast in 2-inch leads giving a raschel gauge of needles per 2 inches. Latch needle weft knitting machines normally have a gauge expressed in needles per inch, which in

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the USA is referred to as 'cut', being short for the phrase 'tricks cut per inch'. As mentioned previously, there is an increasing universal use of the symbol 'E' in warp and weft knitting – for example, raschel E 28 which is 28 needles per inch (25.4 mm). If two needle beds are employed (e.g. V-bed or double-jersey circular machines), the gauge is measured on one bed since the needles in the other bed are to the same gauge unless stated. Also, small diameter single- and double-cylinder hosiery machines have a gauge expressed in the form diameter multiplied by total number of needles, because the number of double-headed needles in a particular cylinder of the double-cylinder machine varies according to the rib set-out.

On some machines it is possible to change the needle beds and camming, and therefore the gauge. The extra spare parts can, however, cost about one third of the cost of a machine. It is also sometimes possible to employ finer or coarser needles than the machine gauge, thus producing finer or coarser knitted stitches. One well-known technique used on the V-bed flat machine is to *half-gauge* the needle bed by taking every other needle out of action. Thus a machine with 10 needles per inch would become twice as coarse, with only 5 needles per inch. Increasing or decreasing the number of ends of a particular count of yarn will also produce the appearance of a heavier or finer gauge.

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4

Basic mechanical principles of knitting technology

4.1 The sinker

The sinker is the second primary knitting element (the needle being the first). It is a thin metal plate with an individual or a collective action operating approximately at right angles from the hook side of the needle bed, between adjacent needles. It may perform one or more of the following functions, dependent upon the machine's knitting action and consequent sinker shape and movement:

Loop formation
Holding-down
Knocking-over

(It is always advisable to use one or more of the above terms as adjectives when referring to a sinker, in order to avoid confusion.)

On bearded needle weft knitting machines of the straight bar frame and sinker-wheel type (as on Lee's hand frame), the main purpose of a sinker is to *sink* or kink the newly laid yarn into a *loop* (Fig. 4.1) as its forward edge or catch (C) advances between the two adjacent needles. On the bearded needle loopwheel frame, the blades of burr wheels perform this function, whereas on latch needle weft knitting machines (Fig. 4.2) and warp knitting machines (Fig. 4.3), loop formation is not a function of the sinkers.

(NB: On the European mainland, particularly in Germany, the term *couliering* is used to describe the presentation of a yarn, the kinking of it into a needle loop and the knock-over of the old loop. Also the term 'sinker' often refers confusingly to a jack or other element (that can be sunk into a trick so that its butt is no longer in action.)

The *second* and more common function of sinkers on modern machines is *to hold down the old loops* at a lower level on the needle stems than the new loops that are being formed, and to prevent the old loops from being lifted as the needles rise to clear them from their hooks.

In Fig. 4.1, the protruding *nib* or nose of sinker (N) is positioned over the sinker

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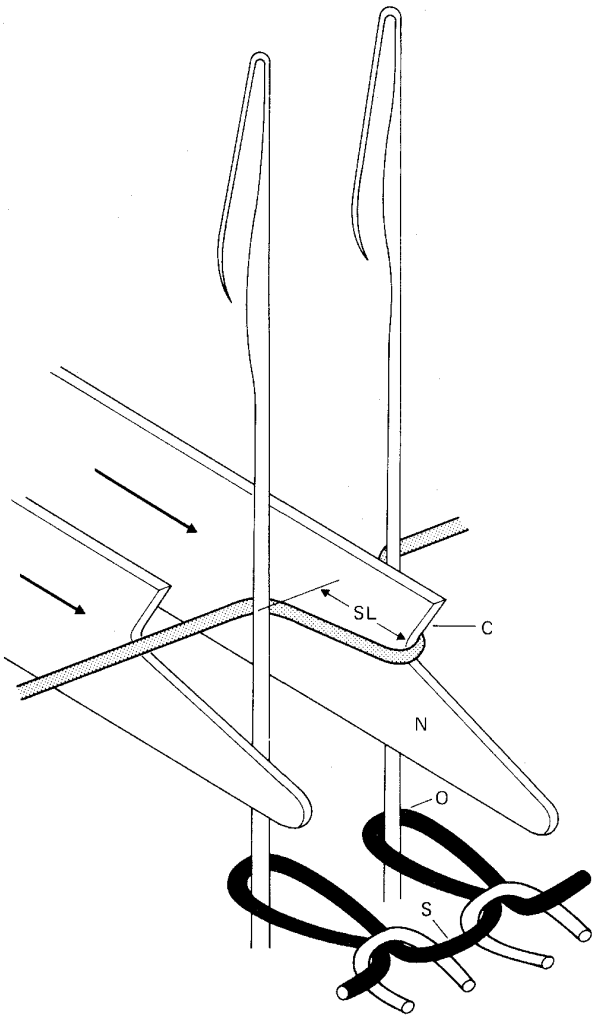


Fig. 4.1 Action of the loop-forming sinker.

loop of the old loop (O), preventing it from rising with the needle. On tricot warp knitting machines and single bed weft knitting machines, a *slot* or *throat* (T in Fig. 4.2) is cut to hold and control the old loop.

The sole function of' the sinker may be to act as a *web holder* or *stitch comb* as on the raschel warp knitting machine, in which case only the underside of the nose performs this function. On single cylinder latch needle weft knitting machines the holding-down sinkers have a rectangular gap cut into their upper surface, remote from the nose, into which the *sinker cam race* fits, to positively control the sinker's movement.

Holding-down sinkers enable tighter structures with improved appearance to be obtained, the minimum draw-off tension is reduced, higher knitting speeds are

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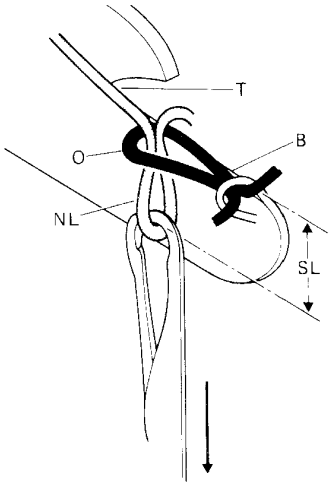


Fig. 4.2 Action of the knock-over sinker.

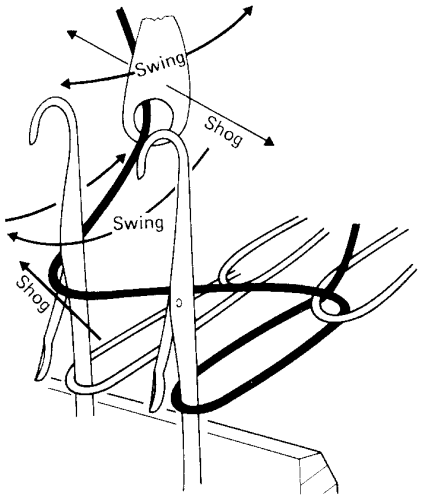


Fig. 4.3 Loop forming by warp guides.

possible and knitting can be commenced on empty needles. Holding-down sinkers are often unnecessary when knitting with two needle bed machines as the second bed restrains the fabric loops whilst the other set of needles moves. However, if single bed knitting or held loop structure is knitted, a form of holding-down element may still be required (as is the case with some V-bed flat knitting machines).

The *third function* of the sinker – as a *knock-over surface* – is illustrated in Fig. 4.2 where its upper surface or *belly* (B) supports the old loop (O) as the new loop (NL) is drawn through it. On tricot warp knitting machines the sinker belly is specially shaped to assist with *landing* as well as knock-over. On raschel warp knitting machines, many V-bed flats, and cylinder and dial circular machines, the verge or upper surface of the trick-plate (V in Fig. 3.4) serves as the knock-over surface.

On some machines, the knock-over surface moves in opposition to the descent of the needle (see *Relanit*, Chapter 13; and *Shima* contra sinkers, Chapter 19).

4.2 The jack

The jack is a secondary weft knitting element which may be used to provide versatility of latch needle selection and movement. It is placed below and in the same trick as the needle and has its own operating butt and cam system.

4.3 Cams

All needles have a reciprocating action either *en masse* or serially (except on now obsolete bearded needle sinkerwheel and loopwheel frames, where the circle of fixed bearded needles merely revolves). Cams are the devices which convert the rotary machine drive into a suitable reciprocating action for the needles and other elements. The cams are carefully profiled to produce precisely-timed movement and

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dwell periods and are of two types, *engineering cams* and *knitting cams*. The movements may be represented in the form of a time-displacement graph.

4.3.1 Engineering cams

Circular engineering cams or high speed eccentrics control the motion of bars of elements which move *en masse* as single units in Cottons Patent and warp knitting machines. They are attached to a rotary drive shaft situated parallel to, and below, the needle bar. A number of identical cams are positioned along the shaft to ensure correctly aligned movement. The drive is transmitted and adapted via cam-followers, levers, pivots and rocker shafts. One complete 360-degree revolution of the drive shaft is equivalent to one knitting cycle, and it produces all the required movements of the elements in their correctly-timed relationship.

In warp knitting machines, four types of cam drive have been employed: single acting cams, cam and counter cam, box cams and contour cams. The first type requires a powerful spring to negatively retain the cam truck or follower in contact with the cam surface, where bounce and excessive wear occur at speed. The cam and counter cam arrangement provides a cam and its follower in each direction of movement, but is obviously more expensive to manufacture. The box or enclosed cam employs a single cam follower, which is guided by the two cam races of a groove on the face of the cam. However, change of contact from one face to the other causes the follower to turn in the opposite direction, producing wear which cannot be compensated. The contour, ring or pot cam is the reverse of the box cam as the cam profile projects out from one face of the cam in the form of a lip with a cam-follower placed on either side of it. This is a popular and easily adaptable arrangement. Although cams are comparatively cheap, simple and accurate, at speeds above 800 courses per minute they are subject to excessive vibration. For this reason, at speeds in excess of that, eccentric drive is now employed.

The *eccentric* is a form of crank which provides a simple harmonic movement with smooth acceleration and deceleration. Its widespread use is the result of adapting this simple motion and modifying it to the requirements of the warp knitting machine, so that even dwell (stationary periods) in the element cycle can be achieved. On the *FNF compound needle machine*, the movements of two eccentric drive shafts, one turning twice as fast as the other, were superimposed on each other. Now, however, the simpler, single eccentric drive is successfully driving element bars at speeds in excess of 3000 courses per minute.

4.3.2 Knitting cams

The other type of cam, the angular *knitting cam* (see Fig. 3.4), acts directly onto *the butts* of needles or other elements to produce individual or serial movement in the tricks of a latch needle weft knitting machine.

Two arrangements exist:

(a) Revolving cylinder machines – the needle butts pass through the stationary cam system and the fabric hanging from the needles revolves with them.

(b) Reciprocating cam-carriage flat machines or rotating cam-box circular machines – the cams with the yarn feeds pass across the stationary needle beds.

In weft knitting, the yarn feed position is fixed in relation to the cam system (Fig. 3.4). The yarn feed moves with or remains stationary with the cam system, as do the

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yarn packages and tackle (except in the case of flat machines where the cam-carriage only reciprocates away from and towards the stationary yarn packages and does not revolve).

In the past, most *garment-length* knitwear and underwear machines have had revolving cam boxes because changes to the cam settings during the garment sequence can be initiated from a single control position as the cam-boxes pass by; also the garment lengths are stationary and may be inspected or removed whilst the machine is knitting. Now, most new electronically-controlled garment-length machines are of the revolving cylinder type as electronics have removed the need for the complex arrangement of rods and levers found, for example, on mechanically-controlled half-hose machines (Fig. 21.3.)

All hosiery machines and all fabric-producing machines are revolving cylinder machines because the weight of revolving multi-feeder yarn packages and tackle creates inertia problems that reduce efficiency and knitting speeds.

Knitting cams are attached, either individually or in unit form, to a cam-plate and, depending upon machine design, are fixed, exchangeable or adjustable. In the last case, on garment-length machines this might occur whilst the machine is in operation. Elements such as holding-down sinkers and pelerine (loop-transfer) points are controlled by their own arrangement of cams attached to a separate cam-plate.

At each yarn feed position there is a set of cams consisting of at least a raising cam, a stitch cam and an upthrow cam (Fig. 3.4.), whose combined effect is to cause a needle to carry out a knitting cycle if required. On circular machines there is a removable cam section or door so that knitting elements can be replaced.

The *raising cam* causes the needles to be lifted to either tuck, clearing, loop transfer or needle transfer height, depending upon machine design.

The *swing cam* is fulcrummed so that the butts will be unaffected when it is out of the track and it may also be swung into the track to raise the butts.

The *bolt cam* can be caused to descend into the cam track to control the element butts or be withdrawn out of action so that the butts pass undisturbed across its face; it is mostly used on garment-length machines to produce changes of rib set-outs.

The *stitch cam* controls the depth to which the needle descends, thus controlling the amount of yarn drawn into the needle loop; it also functions simultaneously as a *knock-over cam*.

The *upthrow* or counter cam takes the needles back to the rest position and allows the newly-formed loops to relax. The stitch cam is normally adjustable for different loop lengths and it may be attached to a slide together with the upthrow cam, so that the two are adjusted in unison. In Fig. 3.4 there is no separate upthrow cam; section X of the raising cam is acting as the upthrow cam.

The *guard cams* are often placed on the opposite side of the cam-race to limit the movement of the butts and to prevent needles from falling out of track.

Separate cam-boxes are required for each needle bed or associated element bed and they must be linked together or co-ordinated. If the cam-box itself is moving from right-to-left, the needle butts will pass through in a left-to-right direction.

On circular fabric machines, the cams are designed to act in only one direction, but on flat and circular leg-wear machines, the cams are symmetrically arranged to act in both directions of cam-box traverse, with only the leading edges of certain cams in action. All cam systems are a compromise between speed, variety, needle control and selection systems [1].

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4.4 The two methods of yarn feeding

As mentioned in Section 4.3.2, yarn feeding involves either (a) moving the needles past the stationary yarn feed or (b) moving the yarn past the stationary needle bed.

When the yarn moves past the needles, the fabric will be stationary because the loops hang from the needles. This arrangement exists on all warp knitting machines, and on weft knitting machines with straight beds and circular machines with stationary cylinders and dials.

On straight machines of both weft and warp type, the yarn-carrier or guide has a reciprocating traversing movement that takes it towards and away from a suitably-placed yarn supply. On stationary cylinder and dial machines, however, the yarn supply packages must rotate in order to keep with the continuously revolving yarn feeds.

Because the latch needle beds of these flat and circular weft knitting machines are thus stationary, it is necessary to reciprocate the cam-carriage and revolve the cam-boxes so that the needle butts of the stationary tricks pass through. The needles are thus reciprocated to rise and receive the yarn at the exact moment when the traversing yarn feed is passing by (Fig. 4.4).

Most circular weft knitting machines have revolving needle cylinders and stationary cams, feeders and yarn packages. In this case, the fabric tube must revolve with the needles, as must the fabric rollers and take-up mechanism.

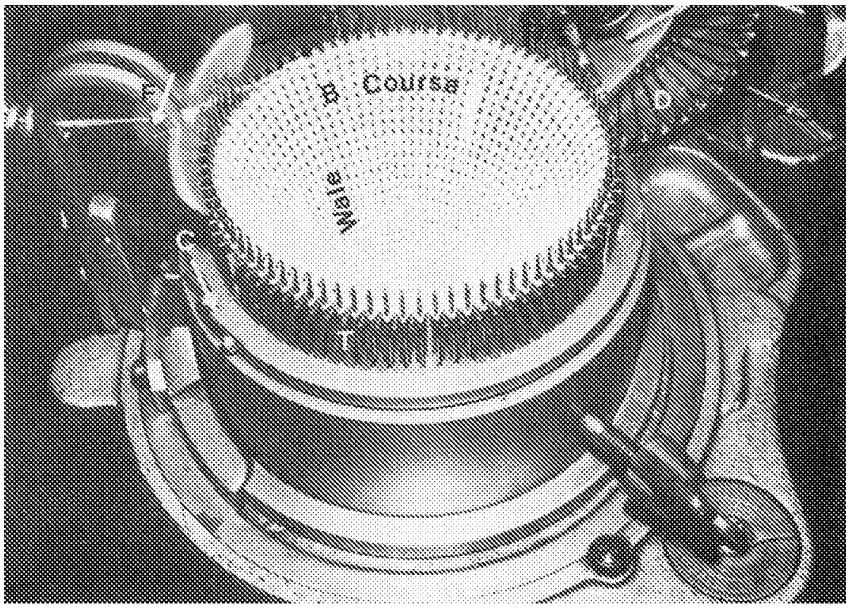


Fig. 4.4 Simple hand-turned Griswold type machine [Walter Bulwer, Leicestershire Polytechnic]. T = stationary needle tricks; C = revolving cam-box; F = revolving feeder; D = replaceable dial and needles; B = technical back of plain fabric.

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4.5 The three methods of forming yarn into needle loops

There are three methods of forming the newly-fed yarn into the shape of a needle loop:

1 (Fig. 4.1) – by sinking the yarn into the space between adjacent needles using loop forming sinkers or other elements which approach from the beard side. The action of a straight bar frame is illustrated. (Other obsolete circular bearded needle machines such as the sinkerwheel and loopwheel frame employ the same technique.) The distance SL, which the catch of the sinker moves past the beard side of the needle, is approximately half the stitch length,
2 (Fig. 4.2) – by causing latch needles to draw their own needle loops down through the old loops as they descend, one at a time, down the stitch cam. This method is employed on all latch needle weft knitting machines. The distance SL that the head of the latch needle descends below the knock-over surface (in this case, the belly of the knock-over sinker) is approximately half the stitch length, and
3 (Fig. 4.3) – by causing a warp yarn guide to wrap the yarn loop around the needle.

The lapping movement of the guide is produced from the combination of two separate guide bar motions:

- A swinging motion which occurs between the needles from the front of the machine to the hook side and return.
- A lateral shogging (or racking) motion parallel to the needle bar on the hook side and also on the front of the machine.

The swinging motion is fixed, but the direction and extent of the shogging motion may or may not be varied from a pattern mechanism. This method is employed on all warp knitting machines and for wrap patterning on weft knitting machines (when a fixed wrapping movement is used). The length of yarn per stitch unit is generally determined by the rate of warp yarn feed.

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5

Elements of knitted loop structure

5.1 The needle loop

The needle loop (H + L in Fig. 5.1) is the basic unit of knitted structure. When tension in the fabric is balanced and there is sufficient take-away tension during knitting, it is an upright noose formed in the needle hook. It consists of a *head* (H) *and two side limbs* or *legs* (L). At the base of each leg is a foot (F), which meshes through the head of the loop formed at the previous knitting cycle, usually by that needle. The yarn passes from the foot of one loop into the foot and leg of the next loop formed by it.

(NB: If the loop is the first loop knitted on that needle, its feet and legs will not be restricted and it will open out to give the appearance of a tuck loop. If the loops are knitted on a flat machine with a pressing down device and no take-down tension, the loops will be more rounded and will tend to incline due to the traversing movement of the presser.)

In warp knitting the feet may be *open* or *closed* at the base of the loop. In the latter case, the yarn guide has passed across the back of the needle across whose hook it has previously formed a loop.

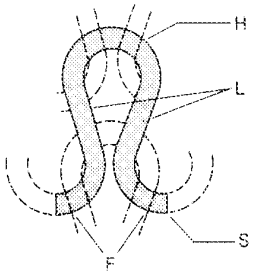


Fig. 5.1 Intermeshing points of a needle loop.

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In weft knitting, the feet are normally open because the yarn continues to be supplied in one direction (except at the selvedges of straight knitting machines). Exceptionally, closed loops have occasionally been produced in the past on the bearded needle sinkerwheel machine, by twisting a loop over as it is transferred to another needle, or by using a twizzle beard which closes onto the back of the needle so that, as the loop is cast-off, it twists over itself.

5.2 The sinker loop

The sinker loop (S in Fig. 5.1) is the piece of yarn that joins one weft knitted needle loop to the next. On bearded needle weft knitting machines, *loop-forming sinkers* form the sinker loops in succession between the needles – hence the origin of the term sinker loop. On latch needle weft knitting machines, however, the sinker loops are automatically formed as the needles, in succession, draw their new loops.

Sinker loops show on the opposite side of the fabric to the needle loops because the needle loop is drawn onto the opposite side from which the yarn was originally fed. The terms 'sinker loop' and 'needle loop' are convenient descriptive terms but their precise limits within the same loop length are impossible to exactly define.

5.3 Warp knitted laps

Loops are termed '*laps*' in warp knitting because the warp guides lap their yarn around the needles in order to form the loop structure. The loops (overlaps) may be open or closed.

On the original warp frame (as on many present-day crochet machines), the needle bar was in a horizontal and not a vertical position, with its beards facing upwards (Fig. 5.2). To produce a needle loop it was thus necessary to swing the guide upwards and shog it over the needle hook; hence the term '*overlap*' which refers both to the movement and the loop which it forms. Similarly, the guide was shogged under the needles to a new starting position for the next overlap. This movement and the lapped thread it produces is still termed an '*underlap*'. In the warp knitting cycle, it is always understood that the overlap precedes the underlap.

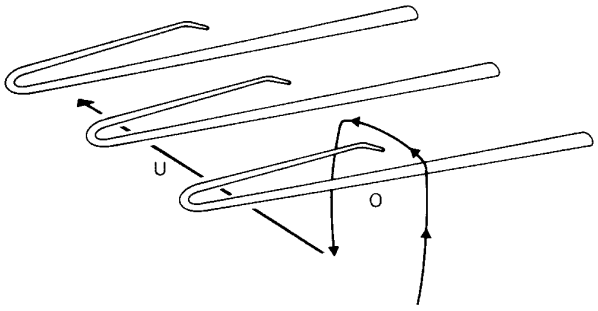


Fig. 5.2 Overlapping and underlapping (warp knitting).

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5.4 The overlap

The *overlap* (Fig. 4.3) is a shog, usually across one needle hook, by a warp guide (at the back of a single needle bar machine) which forms the warp yarn into the head of a needle loop. Every needle on a conventional warp knitting machine must receive an overlapped loop from at least one guide at every knitting cycle, otherwise it will press-off the fabric.

The swinging movement of the guide to the hook side and the return swing after the overlap, produce the two side limbs of the loop which give a similar appearance on the face side of warp knitted fabric to a weft knitted needle loop.

Very rarely are overlap shogs across two needle hooks, as this produces severe tension on the warp yarn and knitting elements because the needles knock-over in unison and the needles are sharing yarns (unlike in single needle overlap warp knitted structures). Two needle overlaps also generally have a poor appearance and physical characteristics because the first overlap of the two will have a different configuration of underlap to that of the second. In the former, the underlap will be passing along the course to the second overlap in a similar manner to a sinker loop. However, the underlap from the second overlap will lap upwards to the next course in the manner of a normal underlap.

5.5 The underlap

The *underlap* shog occurs across the side of the needles remote from the hooks on the front of single-needle bar, and in the centre of double-needle bar, warp knitting machines. It supplies the warp yarn between one overlap and the next (Fig. 5.3). The underlap shog generally ranges from 0 to 3 needle spaces, but it might be 14 needle spaces or more depending upon the design of the machine and the fabric structure

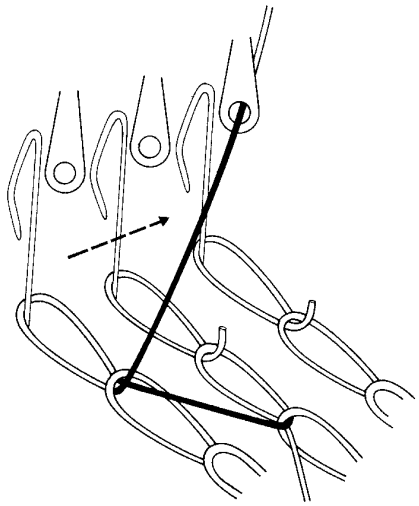


Fig. 5.3 The underlap shog.

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(although efficiency and production speed will be correspondingly reduced with long underlaps).

Underlaps as well as overlaps are essential in warp knitted structures in order to join the wales of loops together but they may be contributed by different guide bars.

5.6 The closed lap

A *closed lap* is produced when a subsequent underlap shogs in the opposite direction to the preceding overlap, thus lapping the same yarn around the back as well as around the front of the needle (Fig. 5.4).

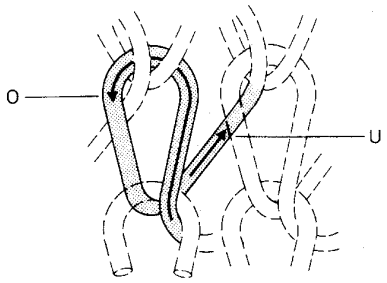


Fig. 5.4 The closed lap.

5.7 The open lap

An *open lap* is produced either when a subsequent underlap is in the same direction as the preceding overlap (Fig. 5.5) or an underlap is omitted so that the overlap of the next knitting cycle commences in the needle space where the previous overlap finished. Closed laps are heavier, more compact, more opaque, and less extensible than open laps produced from the same yarn at a comparable knitting quality.

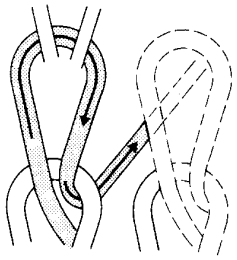


Fig. 5.5 The open lap.

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5.8 Wrapping

Wrapping is a method of producing vertically-orientated patterning with warp threads on a single jersey weft knitted base structure. Specially controlled warp thread guides are used which make unidirectional warp knitted overlaps into selected needle hooks. If selected empty needle hooks rise to receive the warp yarn (as is the case on a few single jersey machines), *pure wrapping* or *warp insertion* is produced. If, however, wrapping takes place on needles, all of which already hold a ground yarn at that knitting cycle, *embroidery plating* or *wrap striping* is produced; this is a technique occasionally used on some half-hose machines.

5.9 The knitted stitch

The *knitted stitch* is the basic unit of intermeshing. It usually consists of three or more intermeshed needle loops (Fig. 5.6). The centre loop has been drawn through the head of the lower previously-formed loop and is, in turn, intermeshed through its head by the loop above it.

The *repeat unit* of a stitch is the minimum repeat of intermeshed loops that can be placed adjoining other repeat units in order to build up an unbroken sequence in width and depth.

A needle loop only has its characteristic appearance because its legs are prevented from spreading outwards by being intermeshed through the head of the loop below it. If there is no previous loop to mesh through, the legs of the new loop will spread outwards.

The term stitch is unfortunately sometimes used to refer to a single needle loop.

Stitch length is a length of yarn which includes the needle loop and half the sinker loop on either side of it. Generally, the larger the stitch length, the more extensible and lighter the fabric and the poorer the cover, opacity and bursting strength.

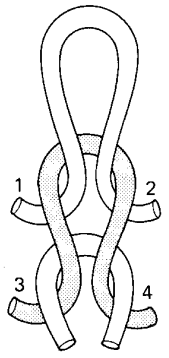


Fig. 5.6 The knitted stitch.

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5.10 The intermeshing points of a needle loop

All needle loops or overlaps have four possible intermeshing points (Fig. 5.6) – 1 and 2 at the head, where the next new loop will be drawn through by the needle, and 3 and 4 at the base, where the loop has intermeshed with the head of the previously formed loop. The intermeshings at 1 and 2 are always identical with each other as are intermeshings 3 and 4 with each other. It is impossible to draw a new loop through the old loop so that its two feet are alternately intermeshed (Fig. 5.7). This could only be achieved by taking the yarn package through the old loop. Although this would produce a locked loop, the package used would not be large enough to provide a continuous supply.

A *new loop* can thus only be intermeshed through the head of the old loop in a manner that will show a face loop stitch on one side and a reverse loop stitch on the other side. This is because the needle hook is uni-directional and can only draw a new loop down through an old loop.

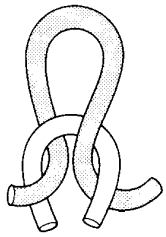


Fig. 5.7 An impossible intermeshing.

5.11 The face loop stitch

The *face side* of the stitch (Fig. 5.8) shows the new loop coming towards the viewer as it passes over and covers the head of the old loop. It is referred to as the *right side* in mainland Europe.

Face loop stitches tend to show the side limbs of the needle loops or overlaps as a series of interfitting 'V's. The face loop-side is the underside of the stitch on the needle.

5.12 The reverse loop stitch

This is the opposite side of the stitch to the face loop-side and shows the new loop meshing away from the viewer as it passes under the head of the old loop. It is referred to as the *left side* on the mainland of Europe. Reverse stitches show the sinker loops in weft knitting and the underlaps in warp knitting most prominently on the surface. The reverse loop side is the nearest to the head of the needle because the needle draws the new loop downwards through the old loop (Figures 4.4 and 5.8).

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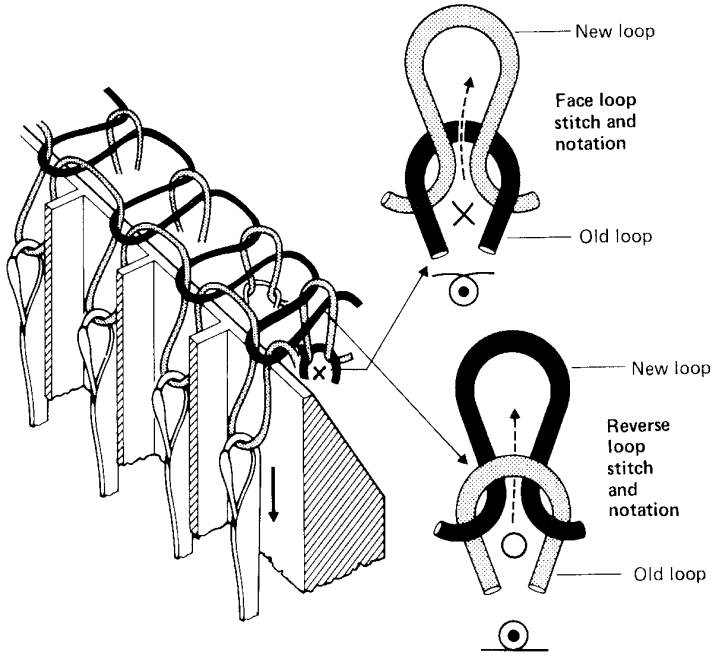


Fig. 5.8 Face- and reverse-meshed loops.

5.13 Single-faced structures

Single-faced structures are produced in warp and weft knitting by the needles (arranged in either a straight line or a circle, with their hooks facing outwards) operating as a single set. Adjacent needles will thus have their hooks facing towards the same direction and the heads of the needles will always draw the new loops downwards through the old loops in the same direction so that intermeshing points 1 and 2 will be identical with intermeshing points 3 and 4.

The under-surface of the fabric on the needles (termed the *technical face* or *right side*) will thus only show the face stitches in the form of the side limbs of the loops or overlaps as a series of interfitting 'V's. The upper surface of the fabric on the needles (termed the *technical back* or *left side*) will show reverse stitches in the form of sinker loops or underlaps as well as the heads of the loops.

5.14 Double-faced structures

Double-faced structures are produced in weft and warp knitting when two sets of independently-controlled needles are employed with the hooks of one set knitting or facing in the opposite direction to the other set. The two sets of needles thus draw their loops from the same yarn in opposite directions, so that the fabric, formed in the gap between the two sets, shows the face loops of one set on one side and the face loops of the other set on the opposite side.

The two faces of the fabric are held together by the sinker loops or underlaps,

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which are inside the fabric so that the reverse stitches tend to be hidden. The two faces may be knitted from different yarns and the two fabrics thus formed may only occasionally be joined together. Sometimes the two faces are cohesively produced and are far enough apart for the connecting sinker loops or underlaps to be severed in order to produce two single-faced fabrics.

5.15 A balanced structure

A *balanced structure* is a double-faced structure that has an identical number of each type of stitch produced on each needle bed which therefore show on each fabric surface, usually in the same sequence. Balanced structures need not, however, have the same design in coloured yarn on either surface. Such structures do not normally show curling at their edges.

5.16 Face and reverse stitches in the same wale

Face and reverse stitches in the same wale are normally produced on purl weft knitting machines that have double-headed needles capable of drawing a face stitch with one hook and a reverse stitch with the other, so that intermeshing points 1 and 2 will not always be identical with intermeshing points 3 and 4. Transfer of a wale of loops from a needle knitting face loops to one knitting reverse loops (or vice-versa) will produce the same result.

5.17 Selvedged fabric

A *selvedged fabric* is one having a '*self-edge*' to it and can only be produced on a straight machine whose yarn carrier reciprocates backwards and forwards across the needle bed so that a selvedged edge is formed as the yarn rises up to the next course at either edge of the fabric.

5.18 Cut edge fabric

A *cut edge fabric* is usually produced by slitting open a tube of fabric knitted on a circular machine. A slit tube of fabric from a 30-inch (76 cm) diameter machine will have an open width of 94 inches (2.38 m) ($\pi\, d$) at knitting and before relaxation.

5.19 Tubular fabric

Tubular fabric may be produced in double-faced or single-faced structures on circular machines; or in a single-faced form on straight machines with two sets of needles, provided each needle set only knits at alternate cycles and the yarn only passes across from one needle bed to the other at the two selvedge needles at each end, thus closing the edges of the tube by joining together the two single-faced fabrics produced on each needle set.

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Tubular double faced fabrics can be produced on straight machines with two sets of needles, needle bed racking and transfer facilities, provided empty complimentary needles are always available to receive and transfer loops.

5.20 Upright loop structures

Structures with upright loops in straight wales are produced only if the tension on the yarn on either side of the needle loop head is balanced. This condition often exists in weft knitted structures because balanced sinker loops enter from either side of the needle head, but it may be disturbed by racking, by knitting twist lively yarn or by traversing pressing-down elements.

Warp knitted structures, however, seldom have perfectly upright overlaps because the underlaps, even if they enter from either side of the overlap head, rarely balance each other. When closed laps are produced, both underlaps will be on one side of the previous overlap head, causing it to incline towards that direction. Even a progressive open lap will not produce a balanced loop structure, because the underlap entering the overlap head from below will not balance the effect of the underlap on the opposite side as it leaves for the course above.

Single guide bar fabrics are thus very unstable structures. This is one of the reasons why most warp knitted structures are produced from two or more sets of warp threads. Often the guide bars supply yarn to each needle but lap in opposite directions, so that the tensions of their underlaps tend to balance each other.

5.21 Knitting notations

A *knitting notation* is a simple, easily-understood, symbolic representation of a knitting repeat sequence and its resultant fabric structure that eliminates the need for time-consuming and possibly confusing sketches and written descriptions. Figure 5.8 gives the symbols used in the two types of notation system. A method universally recognised for warp knitting lapping diagrams and which is also popular for weft knitting running thread path notations requires the use of point paper.

Each point represents a needle in plan view from above and, after the thread path has been drawn, it also represents its stitch.

Each horizontal row of points thus represents adjacent needles during the same knitting cycle and the course produced by them.

The lowest row of points represents the starting course in knitting but it must be understood that, when analysing structures, the courses are normally unroved in a reverse order to the knitting sequence.

When knitting with a single set of needles, each vertical column of points represents the same needle at successive knitting cycles or a wale in the resultant structure. For double needle bar knitting, every second row represents the back needle bar and its wales with all needle hooks facing towards the top of the paper to facilitate the drawing of a continuous lapping movement. For weft knitting with two sets of needles, it is assumed that the lower row of points represent needles whose hooks face towards the bottom of the paper and the upper row, needles whose hooks face towards the top of the paper.

A second notation method is that developed by the Leicester School of Textiles

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for weft knitting only. In this method squared paper instead of point paper is employed, with each square representing a needle or stitch. An 'X' symbol is placed in a square where a face stitch occurs and an 'O' where there is a reverse stitch.

When notating each stitch, it is necessary to examine the intermeshing direction *at the base of the loop* because the intermeshing at its head determines the direction of the intermeshing of the new loop formed above it.

Computer-aided design systems have their own methods of notation which may involve realistic appearance and the use of colour.

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6

Comparison of weft and warp knitting

6.1 Yarn feeding and loop formation

In a *weft knitting* machine, even when the needles are fixed or are caused to act collectively, yarn feeding and loop formation will occur at each needle in succession across the needle bed during the same knitting cycle (Fig. 6.1). All, or a number of, the needles (A, B, C, D) are supplied in turn with the same weft yarn during the same knitting cycle so that the yarn path (in the form of a course length) will follow a course of the fabric passing through each needle loop knitted from it (E, F, G, H).

In a *warp knitting* machine there will be a simultaneous yarn-feeding and loop-forming action occurring at every needle in the needle bar during the same knitting cycle (Fig. 6.2). All needles (A, B, C, D) in the needle bar are simultaneously lapped

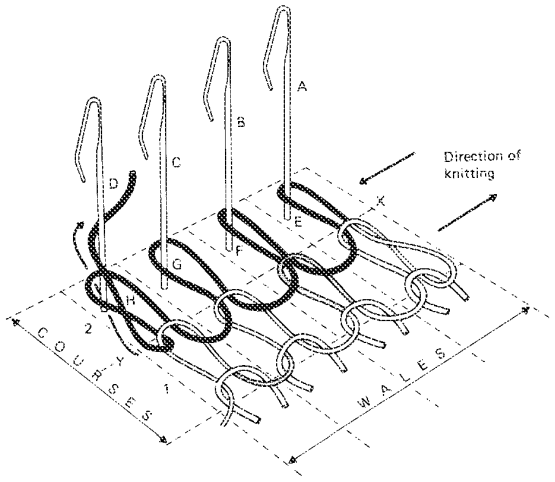


Fig. 6.1 Weft knitting.

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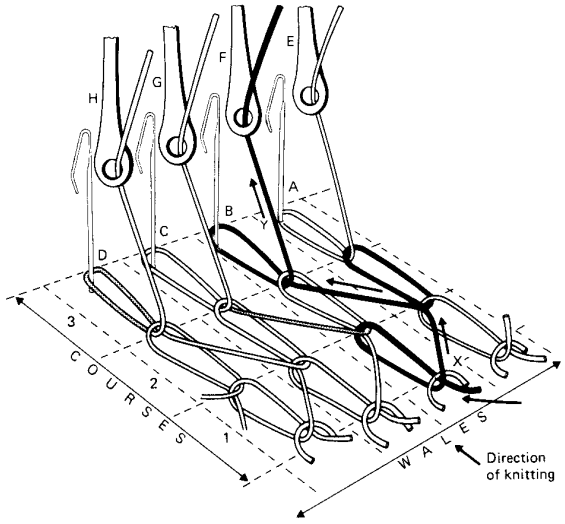


Fig. 6.2 Warp knitting.

by separate warp guides (E, F, G, H). As all needles receive their overlaps simultaneously, a guide underlapping from one needle to another will be passing from one knitting cycle or course to the next. Thus, the warp yarn passes from an overlap produced in one course to an overlap produced in the succeeding course (for example, guide F underlapping from needle B to needle A).

6.2 The two industries

Occasionally parts of both knitting techniques are combined in a single machine; generally, however, the techniques have tended to diverge to produce entirely separate industries each having its own specialist technology, machine builders, fabric characteristics and end-uses.

6.2.1 Weft knitting

Weft knitting is the more diverse, widely spread and larger of the two sectors, and accounts for approximately one quarter of the total yardage of apparel fabric compared with about one sixth for warp knitting. Weft knitting machines, particularly of the garment-length type, are attractive to small manufacturers because of their versatility, relatively low total capital costs, small floor space requirements, quick pattern and machine changing facilities, and the potential for short production runs and low stock-holding requirements of yarn and fabric.

A major part of the weft knitting industry is directly involved in the assembly of garments using operations, such as overlocking (Fig. 6.3), cup seaming (Fig. 6.4), and linking, that have been specifically developed to produce seams with compatible properties to those of weft knitted structures. There are, however, production units

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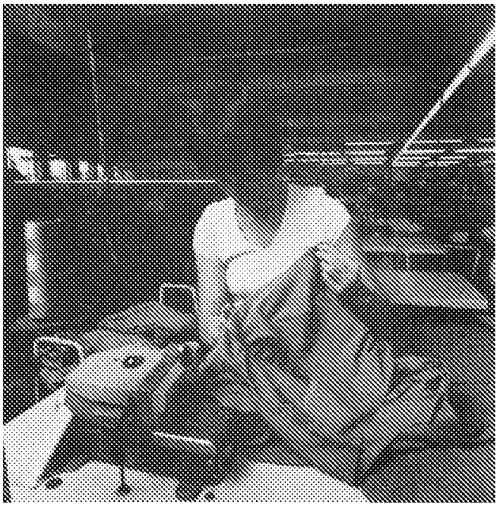


Fig. 6.3 Overlock seaming [Corah].



Fig. 6.4 Cup-seaming.

that concentrate on the knitting of continuous lengths of weft knitted fabric for apparel, upholstery and furnishings, and certain industrial end-uses.

6.2.2 Warp knitting

Warp knitted fabric is knitted at a constant continuous width, although it is possible to knit a large number of narrow width fabrics within a needle bed width, usually separating them after finishing. There is considerable potential for changing fabric properties during the finishing process, as well as during knitting.

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It is also possible to produce length sequences such as scarves with fringed ends, articles produced on double needle bar raschels based on the tubular knitting principle, and scalloped shaping of net designs by cutting around the outline after finishing.

British Celanese set the trend for the establishment of large, vertically-organized warp knitting plants self-sufficient in beaming, and in dyeing and finishing operations. During the 1930s they installed large plants with a total of 600 two-guide bar locknit machines, in order to convert their acetate and viscose rayon yarn into lingerie, shirting, blouse and dress fabrics. The much later introduction of continuous filament nylon and polyester yarn provided ideal raw materials for high-speed conversion into fine-gauge warp knitted fabrics.

From the mid 1950s, the patterning potential of multi-guide bar raschels has been progressively improved, based particularly on the conversion of nylon and polyester filament yarns. Thus, the lace and curtain net trade taken from warp knitting during the 1820s by twist, bobbinet and Leaver's lace machines has been extensively regained [1]. Warp knitting suffered in the swing of fashion away from continuous filament synthetic yarns towards blended spun yarns in solid fabrics, so there has been a tendency for the industry to seek new markets in household furnishings, car upholstery (Fig. 6.5) and industrial cloths.

Staple fibre spun yarns and textured continuous filament yarns create major difficulties for warp knitters. The precise setting of the elements, their fine gauge, the plating of two yarns in a needle hook, and the supply of parallel ends of yarn necessitate the use of fine and therefore expensive yarns. Problems can be caused by lint accumulation or filamentation, and the increased cross-sectional area caused by these seriously reduces the total length of warp yarn that can be accommodated on a specific warp beam flange diameter, thus increasing handling costs and machine down-time. For example, increasing the warp beam diameter from 21 to 40 inches (53 to 100 cm) enables the total length of accommodated warp to be quadrupled, but changing the yarn from 30 denier nylon to 150 denier textured polyester decreases the total length of accommodated warp ten-fold.



Fig. 6.5 Warp-knitted car upholstery [Karl Mayer].

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6.3 Productivity

Productivity (P) is expressed in pattern rows per minute. In warp knitting this is the same as courses, but in weft knitting a pattern row may be composed of more than one course (feed).

In warp knitting, $P = R \times E$, where R is the number of camshaft revolutions per minute and E is the machine efficiency.

In weft knitting, $P = F \times R$ or $T \times (E/C)$, where F is the number of active yarn feeds, R or T the number of machine revolutions or cam-carriage traverses per minute, and C the number of courses or colours which comprise one pattern row.

6.4 Machine design

In warp knitting machines, all elements of the same type (needles or sinkers or guides of one guide bar) act as a single unit and are therefore fitted into, and controlled from, an element bar. Each guide in the same (conventional) guide bar requires the same warp-yarn feed rate and tension. This is most conveniently achieved by supplying a large number of parallel ends of warp yarn to the guide bar from a *warp beam*.

The shogging movement of the guide bars is controlled from one end of the machine. All these factors tend to restrict warp knitting machines to *rectilinear frames* and *straight needle bars*.

In weft knitting machines there are only a limited number of yarn feed positions, often requiring different rates of yarn feed, so these are supplied from yarn packages such as cones. Since the needles knit in serial formation, the weft knitting machine frame may be arranged with either a circular or a straight needle bed, depending upon end-use requirements.

6.5 Comparison of patterning and fabric structures

Individual element movement (particularly of latch needles) enables weft knitting machines to produce designs and structures based upon needle selection for loop intermeshing and transfer. This also facilitates the production of garment parts shaped on the knitting machine. Weft knitted loops tend to distort easily under tension and yarn can freely flow from one loop to another that is under greater tension, a characteristic which aids form-fitting and elastic recovery properties (Figures 6.6, 6.7 and 6.8). Change of yarn by horizontal striping is another major weft knitting patterning technique.

Weft knitted structures can generally be unroved, a course at a time, from the end of the fabric knitted last and this, together with a tendency for loop breakdown to cause laddering, can create problems.

Most patterning on warp knitting machines is based on selective control over guide bar lapping movements (i.e. the direction and extent of the overlap and underlap movements) and on the threading of the individual guides of each guide bar (i.e. with or without warp threads or with different types or colours of yarn). Yarn change by striping is not available on warp threads.

Warp knitted threads tend to have an approximately vertical path through the

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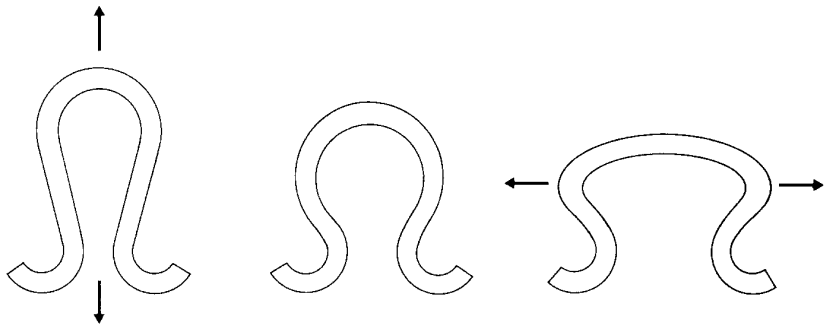


Fig. 6.6 Loop extension and recovery.

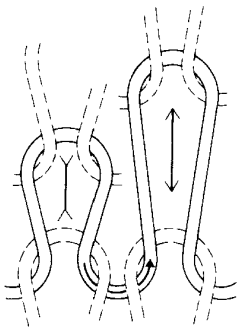


Fig. 6.7 Yarn flow in knitted structure.

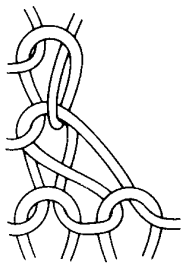


Fig. 6.8 Weft knitted loop transfer.

structure, which makes the warp threads less likely to fray or unrove and, in the absence of weft threads allows almost any width up to the full knitting width to be achieved. Effects in open work and colour can be obtained without the use of special mechanisms, and lapping movements can be arranged to produce fabrics ranging from dimensionally stable to highly elastic without necessarily changing the type of yarn.

6.6 Course length and run-in per rack

In weft knitting, the term '*course length*' refers to the measurement of a straight length of yarn knitted by all or a fraction of the needles in the production of a particular course. It consists of the stitch length multiplied by the number of needles knitting that stitch length. It may be measured at a yarn feed during knitting or after unroving the yarn from a knitted fabric, either as a complete course length or from the counted wales between two vertical cuts in the fabric. In Fig. 6.1, the length of black yarn between X and Y would be the course length.

In warp knitting, *run-in per rack* is equivalent to course length in weft knitting and is measured in inches or millimetres. All threads from the same warp are supplied from the same beam-shaft under identical conditions of yarn feed and tension,

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so it is only necessary to measure the length of one representative runner from each warp. The *rack* is an internationally recognized unit of 480 courses or knitting cycles. For fabric weight calculations, the threading arrangement of each bar must also be taken into consideration.

The simplest method of measuring run-in is to divert one thread through two guide eyes so that it runs at right-angles to the rest of the warp sheet at that point. It is then marked and, after the machine has been run for 480 cam-shaft revolutions, the distance the mark has moved towards the needles is measured. The length of yarn in an average stitch unit can be calculated by dividing the run-in by 480.

In Fig. 6.2, the length of black warp thread between *X* and *Y* would be the run-in if the measurement was multiplied by 160, giving a total of 480 courses.

6.7 Fabric quality

The term fabric '*quality*' is sometimes used when referring to wales and courses per inch or centimetre, either in a knitted or a finished relaxed state. As knitted loops tend to assume a recognizable configuration, the results can give an indication of the approximate stitch length and possible machine gauge used in knitting the structure, provided the state of relaxation and type of structure is taken into consideration. Generally, the higher the figure for a given linear measurement of wales, the finer the machine gauge and the smaller the stitch length.

6.8 Structural modifications commonly used in weft and warp knitting

Certain techniques are possible during the knitting action that can radically change the physical appearance and properties of a knitted construction without seriously affecting the cohesive nature of the loop structure. These techniques may be broadly divided into four groups – laying-in, plating, open-work and plush/pile. Although these techniques can be achieved on most knitting machines, slight modifications are often necessary and the more sophisticated versions of these techniques may require specially-designed knitting machines.

6.8.1 Laying-in

Inlaid (or laid-in) *fabric* consists of a ground structure of knitted or overlapped (warp knitted) threads that hold in position other non-knitted threads which were incorporated (laid-in) into the structure during the same knitting cycle.

An inlaid yarn is never formed into a knitted loop, although in weft knitting, when using only one bed of needles, it is necessary to form the inlay yarn into occasional tuck stitches in order to hold it in the technical back of the structure.

When weft knitting with two sets of needles, or when overlapping on the front guide bar of a warp knitting machine, it is possible to introduce the inlaid yarn into the structure merely by supplying the yarn across the backs of the needles (the front of the machine) in order to trap the yarn in the fabric.

Inlaid yarns are trapped inside double needle bed fabrics by the loops or

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overlaps; and towards the back of single needle bed fabrics by the sinker loops or underlaps.

Dependent upon the fabric construction and the types of yarns employed, laying-in may be used to modify one or more of the following properties of a knitted structure: stability, elastic stretch and recovery, handle, weight, surface 'interest', and visual appearance.

Laying-in offers the possibility of introducing fancy, unusual, and/or inferior or superior yarns whose physical properties such as thickness (linear density, count), low strength, irregular surface or cross-sectional area, elasticity or lack of elasticity render them difficult to knit into intermeshed loops. An inlay yarn may have a yarn count that is 6–8 times heavier than the optimum count for that machine type and gauge when operating under normal knitting conditions.

Laying-in yarn carriers or feeder guides may be of the conventional type or they may be specially designed for their function and the type of yarn; the ground yarn is knitted normally as for any structure. An inlay yarn normally assumes a relatively straight configuration, with hardly any reserve of yarn to distort or flow towards an area of the fabric under tension. It therefore requires less yarn than for knitted loops and tends to confer stability unless an elastomeric yarn is used, in which case the elastic stretch and recovery properties of the fabric will be improved.

6.8.2 Weft insertion

Weft insertion is a special type of laying-in where the yarn is laid onto special elements that, in turn, introduce it to the needles at the correct moment during the knitting cycle, instead of the yarn guide laying the yarn directly into the needles.

Although the possibility exists for introducing both weft and warp threads into either weft knitted or warp knitted fabrics during knitting, many attempts at this technique have failed to produce viable alternative structures as regards cost, design or end-use properties to effectively compete against woven structures [2–5].

In warp knitting, laying-in is achieved even on single needle bar machines by omitting the overlap movement and merely underlapping on the inlay guide bar. Provided the inlay guide bar is always behind a guide bar that is overlapping the front guide bar, overlaps and underlaps will trap the inlay underlaps into the technical back of the structure (Fig. 27.1).

When weft knitting with one set of needles, it is not possible to lay-in a yarn by merely traversing a yarn carrier across the backs of the needles because the yarn will not be trapped by the sinker loops of the knitted loops. The inlaid yarn must occasionally pass across the hooks of a needle to form a tuck stitch and thus hold itself into the structure.

6.8.3 Plating

A *plated structure* contains loops composed of two (or more) yarns, usually with differing physical properties. Each has been separately supplied through its own guide or guide hole to the needle hook, in order to influence its respective position relative to the surface (technical face and technical back of the fabric).

Plating (as an all-over effect or on selected stitches) may be used to produce surface interest, coloured patterns, open-work lace or to modify the wearing properties of the structure.

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Perfect plating, so that the underneath yarn does not show or 'flash' onto the surface, is difficult to achieve with yarns that have a circular cross-section and variable physical properties. It is essential to control yarn tension, angle of feed and the already-formed loops throughout the whole knitting cycle. If the two yarns are of similar count, they should be approximately half the normal yarn count for that gauge of machine.

As the yarns slide along the underside of a normally-curved needle hook, they may roll over each other and thus destroy their plating relationship; for this reason, needles with specially shaped hooks for plating are often employed.

The basic rule of plating is that the yarn positioned nearest to the needle head shows on the reverse side of the needle loop and therefore shows on the surface of the technical back (Fig. 6.9). The second yarn is in a lower position and tends to show on the face stitches of weft- and warp-knitted structures (Figures 6.10 and 6.11). The second yarn will be prominent on the surface of face loops on both sides of rib fabrics unless it is tucked ('tuck plated') by the second set of needles. In purl fabrics, face stitches will show the second yarn and reverse stitches the first yarn.

In single jersey plating, the yarn for the technical back is fed at a low angle across the open latches from a hole drilled vertically in the feeder guide. The face yarn is fed at a sharp angle above it into the open hooks from a hole drilled horizontally into the side of the guide. As the latches close, the back yarn is lifted into the hook above the face yarn, thus ensuring the correct plating relationship in the fabric.

In tricot warp knitting, many fabrics are knitted where two guide bars simultaneously overlap the same needle in opposite directions and thus produce a plated structure. The front guide bar threads strike the needle stems first and at a lower

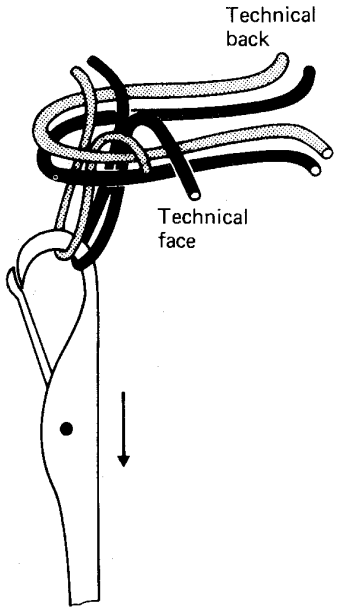


Fig. 6.9 The plating relationship of two yarns.

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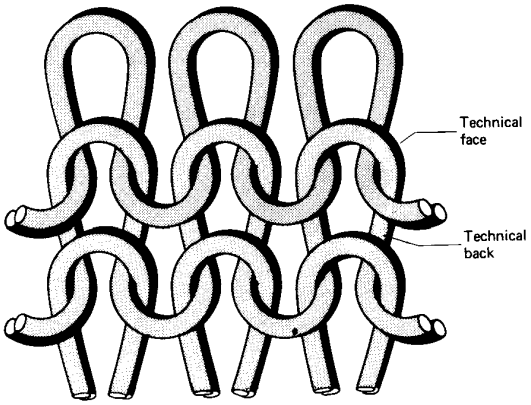


Fig. 6.10 Plating in weft knitting.

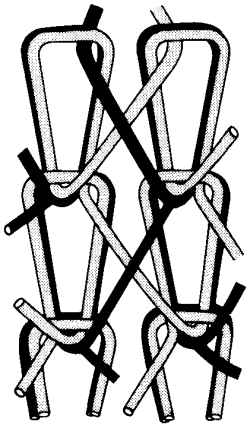


Fig. 6.11 Plating in warp knitting.

level during the return swing after the overlap, so they tend to plate on top on the technical face.

This relationship may, however, be upset if the two guide bars overlap in the same direction, because the back guide bar threads then tend to slide over the front bar threads and thus assume a lower position on the needle.

Normally the front guide threads also show on the technical back, as well as the front, because, as the underlaps emerge from out of the head of the previous loop, they are laid on top of the new overlaps in turn and the front bar underlap (black) is laid down last (Fig. 6.11).

6.8.4 Open-work structures

Knitting is noted for its production of open-work as well as close structures.

A close structure is one where the stitches provide a uniform cover across the fabric and hold the wales securely together. An *open-work structure* has normal securely-intermeshed loops but it contains areas where certain adjacent wales are not as directly joined to each other by underlaps or sinker loops as they are to the wales on their other side. The unbalanced tension causes them to move apart, producing apertures at these points. The arrows in Fig. 6.12 indicate the movement of adjacent wales towards each other at points where they are most securely joined together, thus producing an aperture on the other side of the wale.

Semi-transparent structures are produced in a similar manner but, instead of having apertures, there is less yarn crossing between the wales than elsewhere and this provides less cover at these points ('float plating', Section 9.5).

Semi-breakthrough or honeycomb structures have certain yarns that produce an open-work effect whilst others produce an all-over close structure, so that the aperture is closed on one side of the fabric.

Open-work apertures may be a number of courses in depth and, as a result of tension distortion within the structure, they may cause adjacent wales to be considerably further apart than the actual distance between two adjacent needles during knitting.

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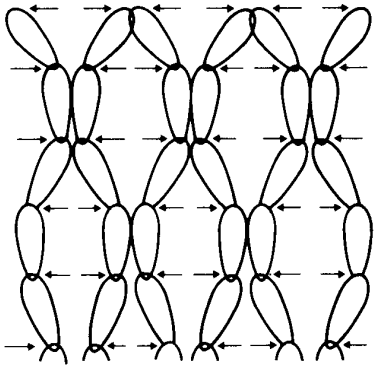


Fig. 6.12 The movement of loops to form open work.

In weft knitting only, open-work structures may be produced by the introduction of empty needles and/or by using special elements to produce loop displacement. An alternative technique is by selective press-off of fabric loops.

Open-work structures are used for fancy laces and nets for dresswear, underwear (Fig. 6.13), nightwear, lingerie, sportswear, linings, blouses and shirts, drapes and curtains, and industrial fabrics.

6.8.5 Plush and pile constructions

Although the terms 'plush' and 'pile' originally referred to specific woven structures, they are often used synonymously today in referring to a very wide range of weft and warp knitted constructions.

The essential difference between a plush and pile structure is that the *pile* is normally composed of a different type of yarn and should stand out almost at right angles from the knitted ground surface whereas the *plush* has neither of these characteristics. Both plush and pile surfaces may consist of either cut or uncut loops of yarn and, in the case of *high pile*, slivers of fibres instead of yarns are used. Generally, the production of pile fabrics tends to be a very specialized technique for both knitting and finishing. One or more of the following techniques is normally involved in the production of the two types of fabric – special points or other elements in the knitting machine, excess feeding of the pile yarn, and raising or brushing of the pile surface during finishing.

Although a certain amount of double-faced pile fabric is produced, the majority of plush and pile fabric has its surface effect on the technical back of single-faced constructions, with the sinker loops or underlaps being used to produce the effect. A variation of this technique is to use a double needle bar machine, pressing off on the second set of needles to produce the pile surface. Yet another method is to employ a double needle bar raschel to knit two separate ground constructions, one on each needle bar, each with its own yarns, and to supply a pile yarn across between the needle bars. The pile is later cut to separate the two ground fabrics and thus produce two single-sided cut pile fabrics.

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Fig. 6.13 Bra and briefs made from elastic raschel lace fabric. Note also the scalloped, elasticated edge trimmings [Dupont 'Lycra'].

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7

The four primary base weft knitted structures

7.1 Introduction

Four primary structures – plain, rib, interlock and purl – are the base structures from which all weft knitted fabrics and garments are derived. Each is composed of a different combination of face and reverse meshed stitches, knitted on a particular arrangement of needle beds. Each primary structure may exist alone, in a modified form with stitches other than normal cleared loops, or in combination with another primary structure in a garment-length sequence.

All weft knitted fabric is liable to unrove (unravel), or ladder, from the course knitted last, unless special 'locking courses' are knitted, or unless it is specially seamed or finished.

Plain is produced by the needles knitting as a single set, drawing the loops away from the technical back and towards the technical face side of the fabric.

Rib requires two sets of needles operating in between each other so that wales of face stitches and wales of reverse stitches are knitted on each side of the fabric.

Interlock was originally derived from rib but requires a special arrangement of needles knitting back-to-back in an alternate sequence of two sets, so that the two courses of loops show wales of face loops on each side of the fabric exactly in line with each other, thus hiding the appearance of the reverse loops.

Purl is the only structure having certain wales containing both face and reverse meshed loops. A garment-length sequence, such as a ribbed half-hose, is defined as purl, whereas smaller sections of its length may consist of plain and rib sections.

Although in the past structures of this type were knitted only on flat bed and double cylinder purl machines employing double-ended latch needles, electronically-controlled V-bed flat machines with rib loop transfer and racking facilities are now used.

- Single-jersey machines can only produce one type of base structure.
- Rib machines, particularly of the garment-making type, can produce sequences of plain knitting by using only one bed of needles.
- Interlock machines can sometimes be changed to rib knitting.

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- Purl machines are capable of producing rib or plain knitting sequences by retaining certain needle arrangements during the production of a garment or other knitted article.

7.2 Plain structure

Plain (the stocking stitch of hand knitting) is the base structure of ladies' hosiery, fully fashioned knitwear and single-jersey fabrics. Its use in ladies' suiting was popularised by Lily Langtry (1852–1929), known as the 'Jersey Lily' after her island birthplace. Other names for plain include *stockinette*, whilst in the USA the term '*shaker stitch*' is applied to it when knitted in a coarse gauge of about $3\frac{1}{2}$ needles per inch (25 mm). The term '*plain knit*' may be used instead of just 'plain', particularly when the structure has a surface design.

Its technical face (Fig. 7.1) is smooth, with the side limbs of the needle loops having the appearance of columns of V's in the wales. These are useful as basic units of design when knitting with different coloured yarns.

On the technical back, the heads of the needle loops and the bases of the sinker loops form columns of interlocking semi-circles (Fig. 7.2), whose appearance is sometimes emphasised by knitting alternate courses in different coloured yarns.

Plain can be unroved from the course knitted last by pulling the needle loops through from the technical back, or from the course knitted first by pulling the sinker loops through from the technical face side. Loops can be prevented from unroving by binding-off.

If the yarn breaks, needle loops successively unmesh down a wale and sinker loops unmesh up a wale; this structural breakdown is termed *laddering* after 'Jacob's Ladder' [1].

Laddering is particularly prevalent in ladies' hosiery, where loops of fine smooth filaments are in a tensioned state; to reduce this tendency, certain ladder-resist structures have been devised. The tendency of the cut edges of plain fabric to unrove

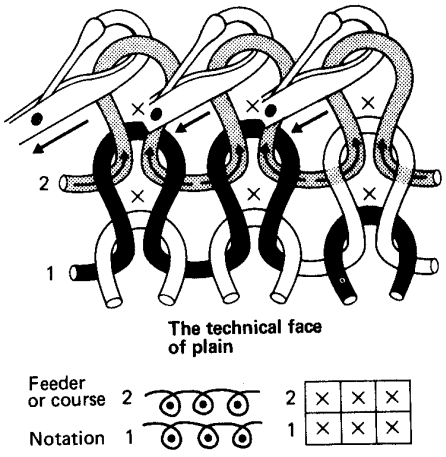


Fig. 7.1 The technical face of plain weft knitted fabric.

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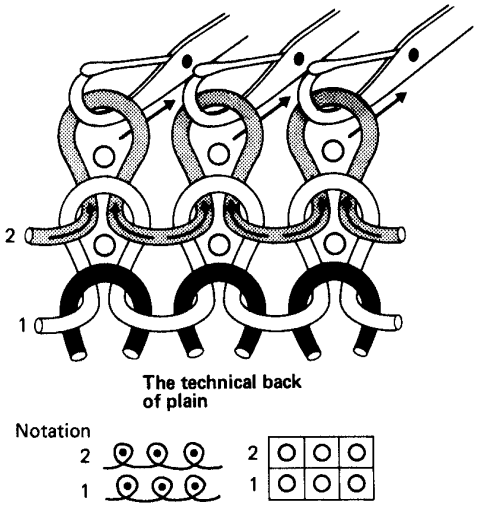


Fig. 7.2 The technical back of plain weft knitted fabric.

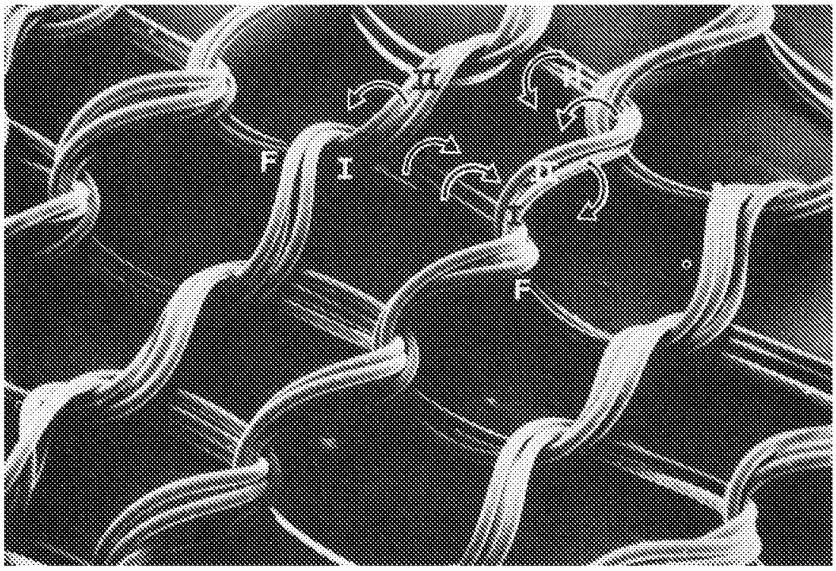


Fig. 7.3 The three-dimensional structure of plain weft knitting [Milliken AGILON] magnified ×130 by a stereoscan electron microscope. The arrows indicate the direction in which the fabric will tend to curl if it is cut. [By permission of *Knitting Times*, official publication of NKSA USA].

and fray when not in tubular or flat selvedged form can be overcome by securing them during seaming.

Knitted structures have a three-dimensional structure as shown in Fig. 7.3. At the point where the new needle loop is drawn through the old loop (I), the structure is

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composed of two yarn thicknesses (diameters) instead of one. The needle loop is therefore held down, both at its head (H) and its feet (F), by loops in the same wale, but its side limbs tend to curve upwards at (II).

When the fabric is cut, the loops are no longer held in this configuration so that the fabric curls towards the face at the top and bottom and towards the back at the sides. The same configuration causes face meshed wales of loops to be prominent in rib fabrics and the heads of loops and the sinker loops to be prominent in wales of purl stitches.

Plain is the simplest and most economical weft knitted structure to produce and has the maximum covering power. It normally has a potential recovery of 40% in width after stretching.

7.2.1 Production of single-jersey fabric on a circular latch needle machine

Most single-jersey fabric is produced on circular machines whose latch needle cylinder and sinker ring revolve through the stationary knitting cam systems that, together with their yarn feeders, are situated at regular intervals around the circumference of the cylinder. The yarn is supplied from cones, placed either on an integral overhead bobbin stand or on a free-standing creel, through tensioners, stop motions and guide eyes down to the yarn feeder guides.

The fabric, in tubular form, is drawn downwards from inside the needle cylinder by tension rollers and is wound onto the fabric-batching roller of the winding-down frame. The winding-down mechanism revolves in unison with the cylinder and fabric tube and is rack-lever operated via cam-followers running on the underside of a profiled cam ring. As the sinker cam-plate is mounted outside on the needle circle, the centre of the cylinder is open and the machine is referred to as an *open top* or *sinker top* machine.

Compared with a rib machine, a plain machine is simpler and more economical, with a potential for more feeders, higher running speeds and knitting a wider range of yarn counts. The most popular diameter is 26 inches (66 cm) giving an approximate finished fabric width of 60–70 inches (152–178 cm). An approximately suitable count may be obtained using the formula $NeB = G^2/18$ or $NeK = G^2/15$, where NeB = cotton spun count, NeK = worsted spun count, G = gauge in npi. For fine gauges, a heavier and stronger count may be necessary.

Examples of typical metric cotton counts for machine gauges are:

E 18 Nm1/24–1/32,
E 20 Nm1/28–1/40,
E 22 Nm1/32–1/44,
E 24 Nm1/34–1/48,
E 28 Nm1/50–1/70

7.2.1.1 The knitting head

Figure 7.4 shows a cross section of the knitting head all of whose stationary parts are shaded.

1 Yarn feeder guide, which is associated with its own set of knitting cams.
2 Latch needle.
3 Holding-down sinker – one between every needle space.
4 Needle cylinder (in this example, revolving clockwise).
5 Cylinder driving wheel.

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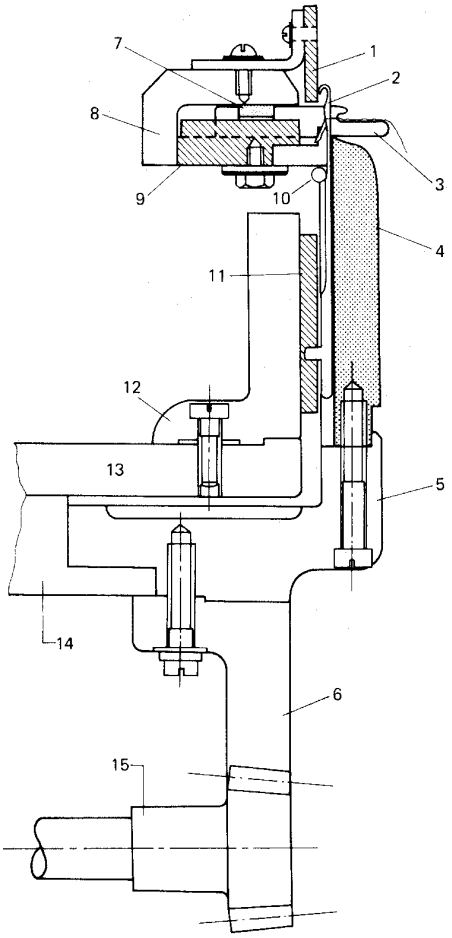


Fig. 7.4 Cross-section of knitting head of a single jersey machine.

6 Cylinder driving gear.
7 Sinker-operating cams, which form a raised track operating in the recess of the sinker.
8 Sinker cam-cap.
9 Sinker trick ring, which is simply and directly attached to the outside top of the needle cylinder thus causing the sinkers to revolve in unison with the needles.
10 Needle-retaining spring.
11 Needle-operating cams which, like the sinker cams, are stationary.
12 Cam-box.
13 Cam-plate.
14 Head plate.
15 Cylinder driving pinion attached to the main drive shaft.

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7.2.1.2 The knitting action

Figure 7.5(a–e) shows the knitting action of a latch needle and holding-down sinker during the production of a course of plain fabric.

(a) *Tucking in the hook or rest position.* The sinker is forward, holding down the old loop whilst the needle rises from the rest position.
(b) *Clearing.* The needle has been raised to its highest position clearing the old loop from its latch.
(c) *Yarn feeding.* The sinker is partially withdrawn allowing the feeder to present its yarn to the descending needle hook and also freeing the old loop so that it can slide up the needle stem and under the open latch spoon.
(d) *Knock-over.* The sinker is fully withdrawn whilst the needle descends to knock-over its old loop on the sinker belly.
(e) *Holding-down.* The sinker moves forward to hold down the new loop in its throat whilst the needle rises under the influence of the upthrow cam to the rest position where the head of the open hook just protrudes above the sinker belly.

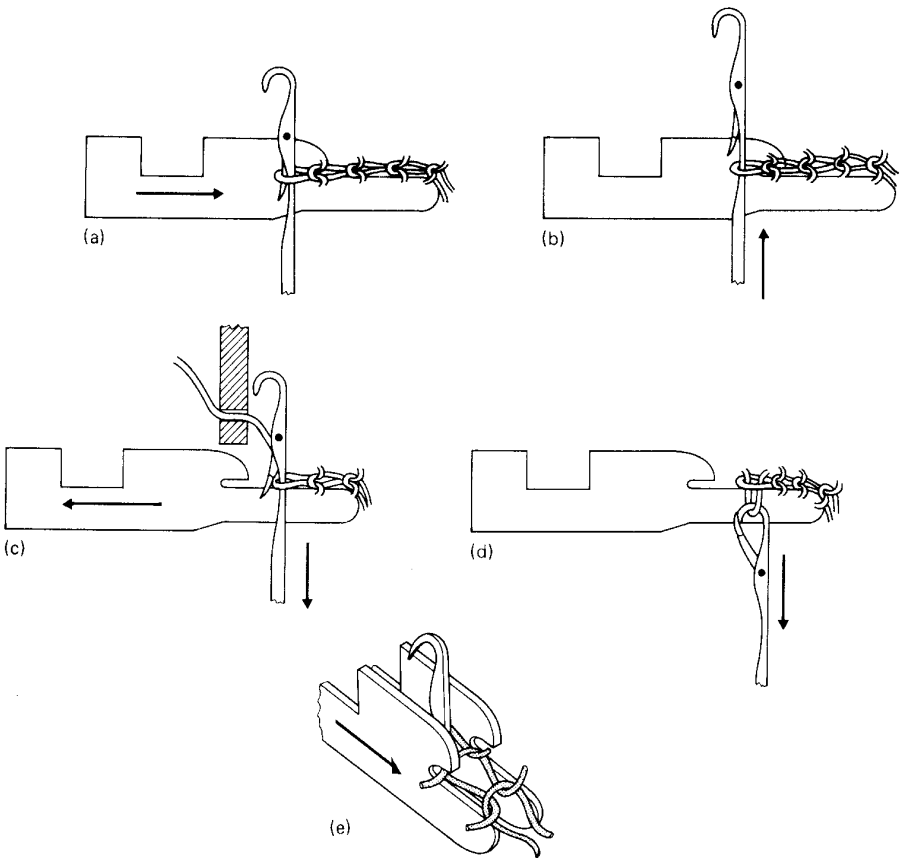


Fig. 7.5 Knitting cycle of a single jersey latch needle machine.

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7.2.1.3 The cam system

Figure 7.6 shows the arrangement and relationship between the needle and sinker cams as the elements pass through in a left to right direction with the letters indicating the positions of the elements at the various points in the knitting cycle. The needle cam race consists of the following: the clearing cam (1) and its guard cam (4), the stitch cam (2) and upthrow cam (3) which are vertically adjustable together for alteration of stitch length, and the return cam (5) and its guard cam (6).

The three sections of the sinker cam race are the race cam (7), the sinker-withdrawing cam (8) and the sinker-return cam (9) which is adjustable in accordance with the stitch length.

7.2.1.4 Sinker timing

The most forward position of the sinker during the knitting cycle is known as the *push point* and its relationship to the needles is known as the *sinker timing*. If the sinker cam-ring is adjusted so that the sinkers are advanced to the point where they rob yarn from the new stitches being formed, a lighter-weight fabric with oversized sinker loops and smaller needle loops is produced. If the ring is moved in the oppo-

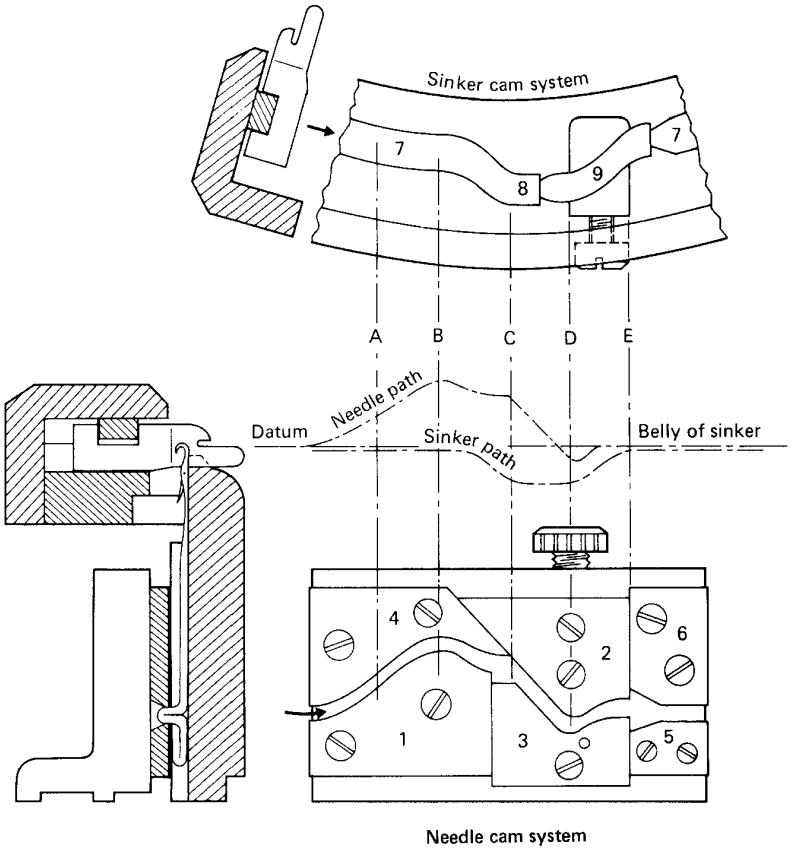


Fig. 7.6 Sinker timing on a single jersey machine.

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site direction, a tighter, heavier fabric is produced having smaller sinker loops and larger needle loops. The timing is normally set between the two extremes.

7.2.2 The 'contra' knitting technique

The '*contra*', *relative* or *shared loop* knitting technique is used on some modern circular single-jersey fabric machines. The sinkers move vertically, to positively assist in holding-down and knocking-over the fabric loops so that they move in opposition to both the rise and the fall of the needles, as well as having the normal radial movement between the needles. The contra movement of the fabric loops considerably reduces the extent of the needle movement.

As on the old bearded needle sinker-wheel machines, one loop is almost fully formed before the next loop is commenced. There are thus less metal/yarn contact points (each of which doubles the tension of the previous point). Contra knitting therefore reduces the tendency to 'rob back', produces less knitting element stress, improves fabric quality, 'handles' yarns more gently, and enables weaker and lower quality yarns to be knitted. The smaller needle movement enables cam angles to be employed so that speeds up to 1.4 m/sec can be achieved. (See also Section 13.10.)

7.3 Rib structure

The simplest rib fabric is 1×1 rib. The first rib frame was invented by *Jedediah Strutt* of Derby in 1755, who used a second set of needles to pick up and knit the sinker loops of the first set. It is now normally knitted with two sets of latch needles (Figures 7.7, 7.8).

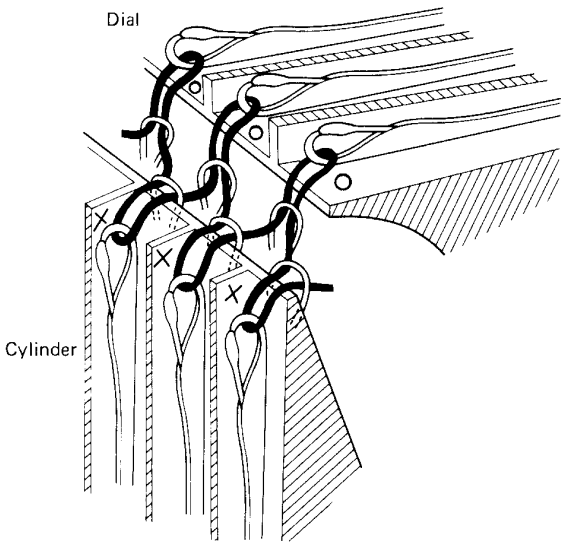


Fig. 7.7 Structure of 1×1 rib.

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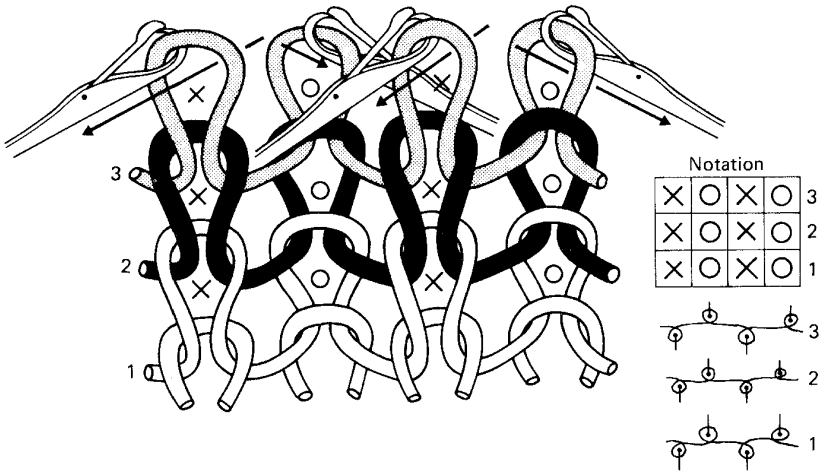


Fig. 7.8 Face and reverse loop wales in 1 × 1 rib.

Rib has a vertical cord appearance because the face loop wales tend to move over and in front of the reverse loop wales. As the face loops show a reverse loop intermeshing on the other side, 1 × 1 rib has the appearance of the technical face of plain fabric on both sides until stretched to reveal the reverse loop wales in between.

1 × 1 rib is production of by two sets of needles being alternately set or gated between each other. Relaxed 1 × 1 rib is theoretically twice the thickness and half the width of an equivalent plain fabric, but it has twice as much width-wise recoverable stretch. In practice, 1 × 1 rib normally relaxes by approximately 30 per cent compared with its knitting width.

1 × 1 rib is balanced by alternate wales of face loops on each side; it therefore lies flat without curl when cut. It is a more expensive fabric to produce than plain and is a heavier structure; the rib machine also requires finer yarn than a similar gauge plain machine. Like all weft-knitted fabrics, it can be unroved from the end knitted last by drawing the free loop heads through to the back of each stitch. It can be distinguished from plain by the fact that the loops of certain wales are withdrawn in one direction and the others in the opposite direction, whereas the loops of plain are always withdrawn in the same direction, from the technical face to the technical back.

Mock Rib is plain fabric knitted on one set of needles, with an elastic yarn inlaid by tucking and missing so that the fabric concertinas and has the appearance of 1 × 1 rib. It is knitted at the tops of plain knit socks and gloves.

Rib cannot be unroved from the end knitted first because the sinker loops are securely anchored by the cross-meshing between face and reverse loop wales. This characteristic, together with its elasticity, makes rib particularly suitable for the extremities of articles such as tops of socks, cuffs of sleeves, rib borders of garments, and stolling and strapping for cardigans. Rib structures are elastic, form-fitting, and retain warmth better than plain structures.

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7.3.1 Rib set-outs

There is a range of rib set-outs apart from 1 × 1 rib. The first figure in the designation indicates the number of adjacent plain wales and the second figure, the number of adjacent rib wales. *Single* or *simple ribs* have more than one plain wale but only one rib wale, such as 2/1, 3/1, etc. *Broad ribs* have a number of adjacent rib as well as plain wales, for example, 6/3 *Derby Rib* (Fig. 7.9). Adjacent wales of the same type are produced by adjacent needles in the same bed, without needles from the other bed knitting in between them at that point.

The standard procedure for rib set-outs is to take out of action in one bed, one less needle than the number of adjacent needles required to be working in the other bed (Fig. 7.9).

In the case of purl machines, the needles knit either in one bed or the other, so there are theoretically the same number of needles out of action in the opposite bed as are knitting in the first. In the case of 2/2 rib, *Swiss rib* (Fig. 7.9), this is produced on a rib machine by taking one needle out of action opposite the two needles knitting.

Swiss rib is sometimes confusingly termed 2/3 rib because 2 out of 3 needles in each bed are knitting. It is not possible to commence knitting on empty needles with the normal 2 × 2 arrangement because the two needles in each bed will not form individual loops – they will make one loop across the two hooks. One needle bed must be racked by one needle space so that the 2 × 2 needle set-out is arranged for 1 × 1 rib; this is termed '*skeleton 1 × 1*'; after knitting the set-up course, the bed is racked back so that 2 × 2 rib knitting can commence.

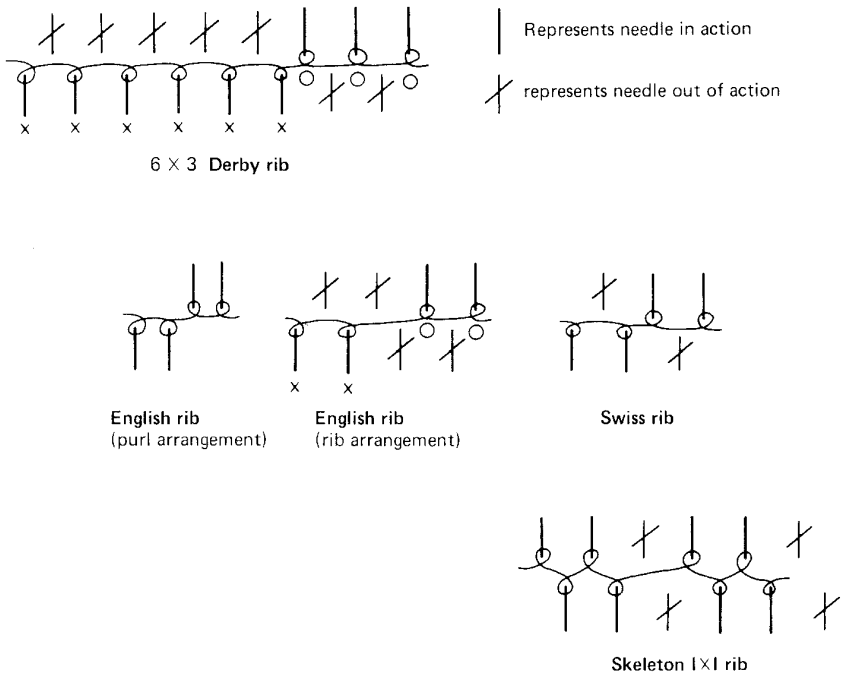


Fig. 7.9 Rib set-outs.

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English rib is produced on a purl machine (or rib machine) with two empty tricks opposite to the two needles knitting; this type of rib is less elastic than Swiss rib.

In garment-length knitting, a direct change of knitting from 2 × 2 to 1 × 1 rib brings every third needle into action. At the first course, the limbs of the loops knitted on these formerly empty needles open out, producing apertures between every two wales that spoil the appearance of the structure. This problem is overcome by knitting a tubular *cover course* of plain on all needles in one bed, then on all needles in the other bed. On each side, the sinker loops draw the wales together and prevent the loops on the newly-introduced needles from forcing the wales apart.

7.3.2 The knitting action of the circular rib machine

The knitting action of a circular rib machine is shown in Fig. 7.10:

(a) *Clearing.* The cylinder and dial needles move out to clear the plain and rib loops formed in the previous cycle.
(b) *Yarn Feeding.* The needles are withdrawn into their tricks so that the old loops are covered by the open latches and the new yarn is fed into the open hooks.
(c) *Knocking-over.* The needles are withdrawn into their tricks so that the old loops are cast off and the new loops are drawn through them.

In a gauge range from 5 to 20 npi, an approximately suitable count may be obtained using the formula $NeB = G^2/8.4$, where NeB = cotton count and G = gauge in npi.

For underwear fabric, a popular gauge is E 14 with a count of 1/30's.

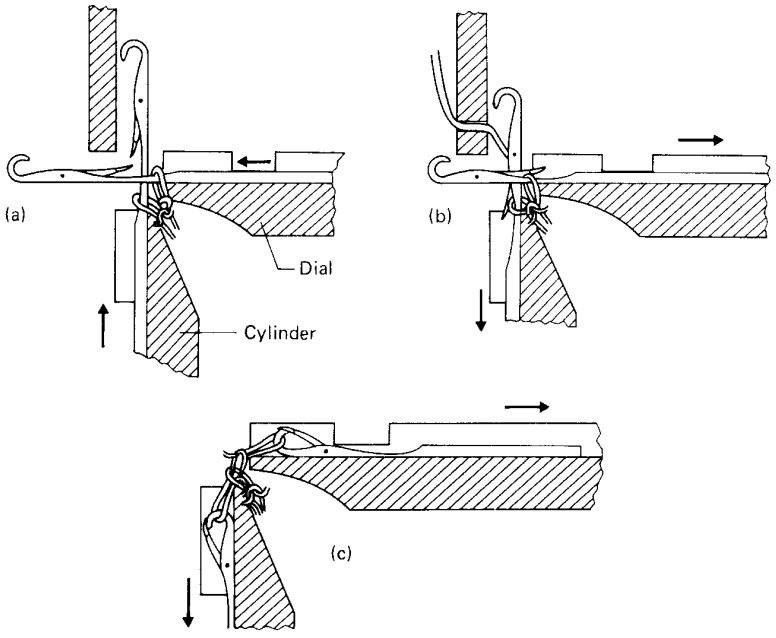


Fig. 7.10 Knitting action of a circular rib machine.

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7.3.3 Needle timing

Needle timing (Fig. 7.11) is the relationship between the loop-forming positions of the dial and cylinder needles measured as the distance in needles between the two stitch cam knock-over points. Collective timing adjustment is achieved by moving the dial cam-plate clockwise or anti-clockwise relative to the cylinder; individual adjustment at particular feeders (as required) is obtained by moving or changing the stitch cam profile.

Synchronized timing (Fig. 7.12), also known as *point*, *jacquard* and *2 × 2 timing*, is the term used when the two positions coincide with the yarn being pulled in an alternating manner in two directions by the needles, thus creating a high tension during loop formation.

With *delayed timing*, also called *rib* or *interlock timing* (Fig. 7.13) the dial knock-over occurs after about four cylinder needles have drawn loops and are rising

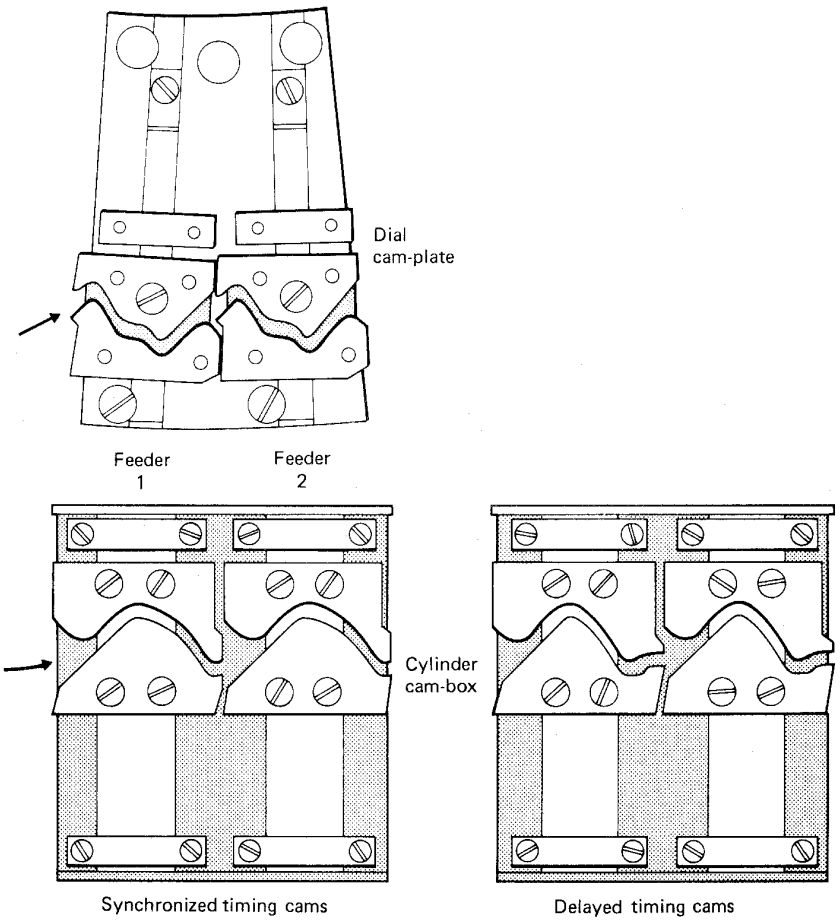


Fig. 7.11 Needle cam timing for a circular rib machine.

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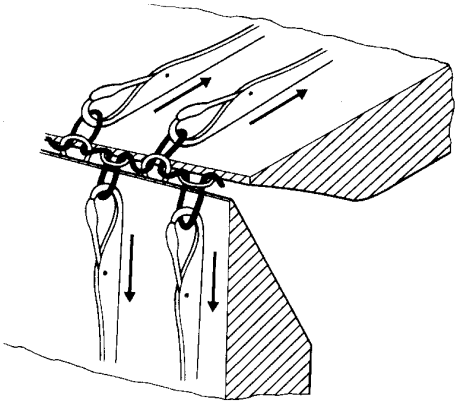


Fig. 7.12 Synchronised timing.

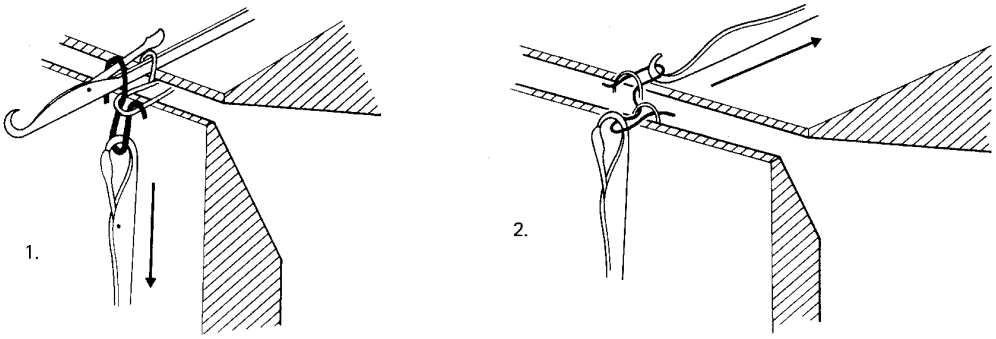


Fig. 7.13 Delayed timing.

slightly to relieve the strain. The dial loops are therefore composed of the extended loops drawn over the dial needle stems during cylinder knock-over, plus a little yarn robbed from the cylinder loops. The dial loops are thus larger than the cylinder loops and the fabric is tighter and has better rigidity; it is also heavier and wider, and less strain is produced on the yarn.

Rib jacquard or broad ribs cannot be produced in delayed timing because there will not always be cylinder needles knitting either side of the dial needles from which to draw yarn. Although the dial knock-over is delayed, it is actually achieved by advancing the timing of the cylinder knock-over (Fig. 7.11).

Advanced timing is the reverse of delayed timing. The cylinder loops rob from the dial, producing tighter dial loops; advancement can only be about one needle. This type of timing is sometimes used in the production of figured ripple double-jersey fabrics, where selected cylinder needles can rob from the all knitting dial needles [2].

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7.4 Interlock structure

Although the American *Scott and Williams* Patent of 1908 for interlock was extended for 20 years, underwear manufacturers found the needles expensive, especially on the larger 20 inch (51 cm) diameter model. Suitable hosiery twist cotton yarn only became available in 1925, and the first stationary cam-box machine appeared in 1930.

Originally, interlock was knitted almost solely in cotton on 20 gauge (needles per inch) machines for underwear, a typical weight being 5 oz per square yard (170 g per square metre) using 1/40's s cotton, but from the 1950s onwards, 18 gauge machines were developed for knitting double-jersey for semi-tailored suiting because the open-width fabric could be finished on existing equipment. As the machines became more versatile in their capabilities, the range of structures became greater.

Interlock has the technical face of plain fabric on both sides, but its smooth surface cannot be stretched out to reveal the reverse meshed loop wales because the wales on each side are exactly opposite to each other and are locked together (Fig. 7.14). Each interlock pattern row (often termed an '*interlock course*') requires two feeder courses, each with a separate yarn that knits on separate alternate needles, producing two half-gauge 1×1 rib courses whose sinker loops cross over each other. Thus, odd feeders will produce alternate wales of loops on each side and even feeders will produce the other wales.

Interlock relaxes by about 30–40 per cent or more, compared with its knitted width, so that a 30-inch (76 cm) diameter machine will produce a tube of 94-inch (2.4 m) open width which finishes at 60–66 inches (1.5–1.7 m) wide. It is a balanced, smooth, stable structure that lies flat without curl. Like 1×1 rib, it will not unrove from the end knitted first, but it is thicker, heavier and narrower than rib of equivalent gauge, and requires a finer, better, more expensive yarn.

As only alternate needles knit at a feeder, interlock machines can be produced in finer gauges than rib, with less danger of press-offs. Interlock knitting is, however, more of a problem than rib knitting, Because productivity is half, less feeders can be accommodated, and there are finer tolerances. When two different-coloured

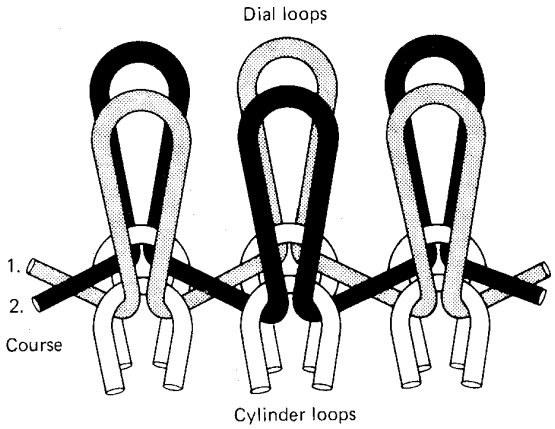


Fig. 7.14 Interlock fabric structure.

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yarns are used, horizontal stripes are produced if the same colour is knitted at two consecutive feeders, and vertical stripes if odd feeders knit one colour and even feeders knit the other colour. The number of interlock pattern rows per inch is often double the machine gauge in needles per inch.

The interlock structure is the only weft knitted base not normally used for individual needle selection designs, because of the problems of cylinder and dial needle collision. However, selection has, in the past, been achieved by using four feeder courses for each pattern row of interlock, long and short cylinder needles not selected at the first two feeder courses for colour A being selected at the second two feeders for colour B. This knitting sequence is not cost effective.

Eightlock is a 2×2 version of interlock that may be produced using an arrangement of two long and two short needles, provided all the tricks are fully cut through to accommodate them and knock-over bits are fitted to the verges to assist with loop formation on adjacent needles in the same bed.

It was first produced on double-system V-bed flat machines having needles with two butt positions, each having its own cam system. This involved a total of eight locks, four for each needle bed, making one complete row per traverse. Set-outs for 4×4 and 3×3 can also be produced.

It is a well-balanced, uniform structure with a softer, fuller handle, greater widthwise relaxation, and more elasticity than interlock. Simple geometric designs with a four wale wide repeat composed of every two loops of identical colour, can be achieved with careful arrangement of yarns.

7.4.1 Production of interlock fabric

Interlock is produced mainly on special cylinder and dial circular machines and on some double-system V-bed flat machines (Fig. 7.15). An interlock machine must have the following:

1 *Interlock gating*, the needles in two beds being exactly opposite each other so that only one of the two can knit at any feeder.
2 *Two separate cam systems in each bed, each controlling half the needles in an alternate sequence*, one cam system controlling knitting at one feeder, and the other at the next feeder.
3 *Needles set out alternately, one controlled from one cam system, the next from the other*; diagonal and not opposite needles in each bed knit together.

Originally, the interlock machine had needles of two different lengths, long needles knitting in one cam-track and short needles knitting in a track nearer to the needle heads. Long needle cams were arranged for knitting at the first feeder and short needle cams at the second feeder. The needles were set out alternately in each bed, with long needles opposite to short needles. At the first feeder, long needles in cylinder and dial knit, and at the second feeder short needles knit together; needles not knitting at a feeder follow a run-through track. On modern machines the needles are of the same length.

Typical cotton counts for particular gauges would be:

E 16 Nm 1/28–1/50, E 22 Nm 1/50–1/80,
E 18 Nm 1/34–1/60, E 24 Nm 1/56–1/90,
E 20 Nm 1/40–1/70, E 28 Nm 1/60–1/100.

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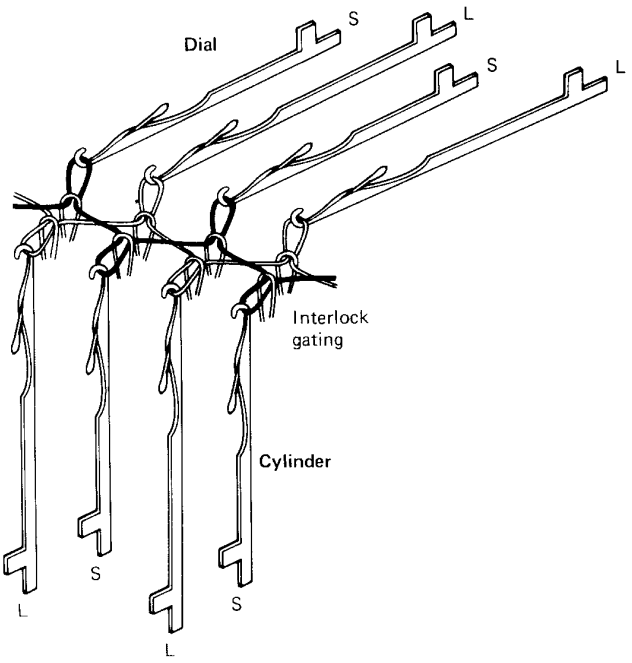


Fig. 7.15 Knitting interlock.

A 30-inch (76cm) diameter E 28 machine running at 28rpm and 85% efficiency, knitting 38 courses/in (15 courses/cm) from Nm 1/70 yarn would produce 34.4lb/hr (15.6kg/hr) of 4.45oz/yd^2 (151g/m^2) interlock fabric.

7.4.2 Example of an interlock cam system

Figure 7.16 shows the cylinder and dial needle camming to produce one course of ordinary interlock fabric, which is actually the work of two knitting feeders. In this example, the dial has a swing tuck cam that will produce tucking if swung out of the cam-track and knitting if in action.

The cylinder cam system

A Clearing cam which lifts the needle to clear the old loop.
B, C Stitch and guard cams respectively, both vertically adjustable for varying stitch length.
D Upthrow cam, to raise the cylinder needle whilst dial needle knocks-over.
E, F Guard cams, to complete the track.
G, H Guide cams that provide the track for the idling needles.

The dial cam system

1 Raising cam to tuck position only.
2, 3 Dial knock-over cams (adjustable).
4 Guard cam to complete the track.
5 Auxiliary knock-over cam to prevent the dial needle re-entering the old loop.

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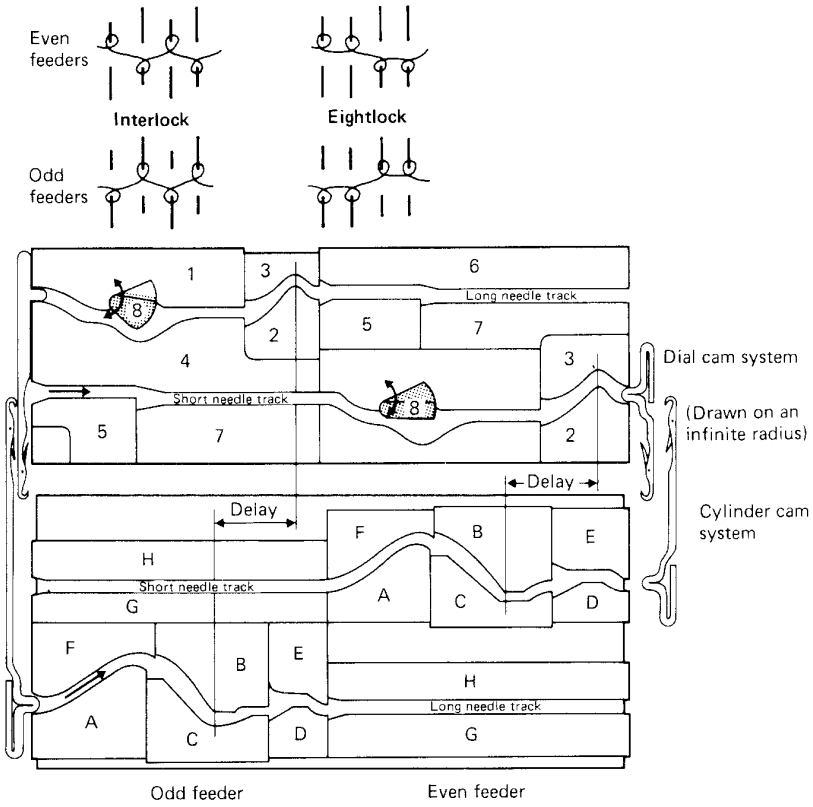


Fig. 7.16 Interlock cam system.

6, 7 Guide cams that provide the track for the idling needles.
8 Swing type clearing cam, which may occupy the knitting position as shown at feeder 1 or the tuck position as shown at feeder 2.

Interlock thus requires eight cam systems or locks in order to produce one complete course, two cam systems for each feeder in each needle bed. Basic cylinder and dial machines and flat-machines having this arrangement are often referred to as *eightlock machines*.

7.5 Purl structure

Purl was originally spelt 'pearl' and was so named because of its similar appearance to pearl droplets.

Purl structures have one or more wales which contain both face and reverse loops. This can be achieved with double-ended latch needles or by rib loop transfer from one bed to the other, combined with needle bed racking.

The semi-circles of the needle and sinker loops produced by the reverse loop intermeshing tend to be prominent on both sides of the structure and this has led

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to the term '*links-links*' being generally applied to purl fabrics and machines. Links is the German word for left and it indicates that there are *left* or *reverse* loops visible on each side of the fabric [3]. In a similar manner, the German term for rib is rechts-rechts (right-right).

The tricks of the two needle beds in purl machines are exactly opposite to each other and in the same plane, so that the single set of purl needles, each of which has a hook at either end, can be transferred across to knit outwards from either bed (Fig. 7.17). Knitting outwards from one bed, the needle will produce *a face meshed* needle loop with the newly-fed yarn whilst the same needle knitting outwards with its other hook from the opposite bed will produce *a reverse meshed* needle loop (Fig. 7.18).

As the needle moves across between the two needle beds, the old loop slides off the latch of the hook that produced it and moves along the needle towards the other hook. It cannot enter because it will pivot the latch closed (an action that must not occur until the new yarn has been fed to that hook).

The needle hook that protrudes from the bed knits with the yarn whilst the hook in the needle trick acts as a butt and is controlled by an element termed a *slider* (Fig. 7.19). There is a complete set of sliders with their noses facing outwards from each bed. It is the sliders whose butts are controlled by the knitting and needle transfer cam systems in each bed and they, in turn, control the needles.

Each slider is normally provided with two butts – a *knitting butt* (K) near to its head and the needle hook that is connected to it, and a *transfer butt* (T) near to its tail. Each butt has its own cam system and track.

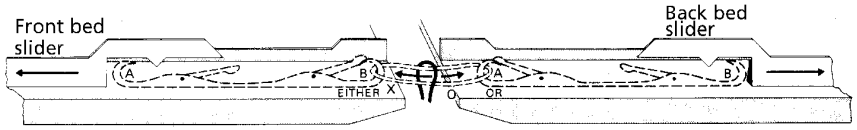


Fig. 7.17 Purl knitting using sliders.

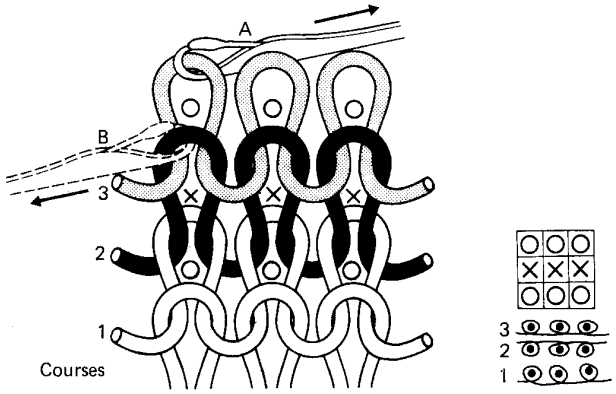


Fig. 7.18 Purl fabric structure.

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There are two types of purl needle bed machine – *flat bed purls*, which have two horizontally opposed needle beds and *circular purls (double cylinder machines)*, which have two superimposed cylinders one above the other. Both types of machine generally produce garment lengths.

Flat bed purls are no longer built because electronically-controlled V-bed flat machines can now knit types of links-links designs. Small diameter (6 inch/15 cm or less) double cylinder machines are used to knit broad rib socks, whereas larger diameter machines produce knitwear.

V-bed rib machines will knit purl stitch designs if rib loops are transferred across to empty needles in the opposing bed, which then begin to knit in the same wales.

The simplest purl is *1 × 1 purl*, which is the garter stitch of hand knitters and consists of alternate courses of all face and all reverse loops and is produced by the needles knitting in one bed and then transferring over to the other bed to knit the next course (Fig. 7.18). Its lateral stretch is equal to plain, but its length-wise elasticity is almost double. When relaxed, the face loop courses cover the reverse loop courses, making it twice as thick as plain. It can be unroved from both ends because the free sinker loops can be pulled through at the bottom of the fabric. In the USA, 1×1 purl is sometimes made up at right angles to the knitting sequence and is then termed '*Alpaca stitch*'.

Another simple purl is *moss stitch*, which consists of face and reverse loops in alternate courses and wales (Fig. 7.20). *Basket purls* consist of rectangular areas of all X or all O loops, which alternate with each other. Examples include 5×3 (Fig. 7.21), 7×3, 4×4 (Fig. 7.22). On some of the older machines, a collecting row with all needles knitting in one bed making a plain course is necessary before needles change over beds [4].

The reverse stitches of purl give it the appearance of hand knitting and this is enhanced by using softly spun yarns. It is particularly suitable for baby wear, where width and length stretch is required, and also for adult knitwear.

The double-cylinder half-hose machine is actually a small diameter purl machine that produces ribs by retaining needles in the same set-out for a large number of successive courses.

7.5.1 Purl needle transfer action

The following conditions are necessary in order to achieve the transference of a purl needle from the control of a slider in one bed into the control of a slider in the opposite bed (Fig. 7.19):

1 Engagement of the head of the receiving slider with the needle hook that was originally knitting from the opposing bed.
2 Cam action causing the head of the delivering slider to pivot outwards from the trick and thus disengage itself from the other hook of the needle.
3 Sufficient free space to allow the heads of the sliders to pivot outwards from their tricks during engagement and disengagement of the needles.
4 A positive action which maintains the engagement of the head of a slider with a needle hook throughout its knitting cycle by ensuring that it is pressed down into the trick.

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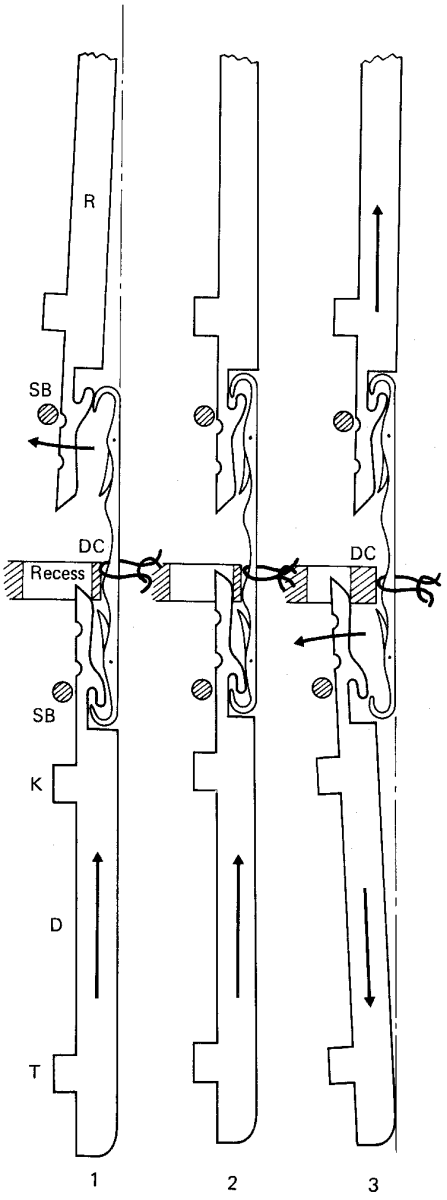


Fig. 7.19 Purl needle transfer action.

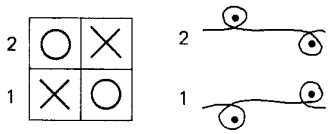


Fig. 7.20 Purl notation.

7.5.2 The use of dividing cams

Figure 7.19 illustrates the transfer action using *dividing cams*, on a revolving double-cylinder machine with internal holding-down sinkers and stationary cam-boxes. The dividing cam principle for slider disengagement was, until recently, in widespread use on half-hose machines, although it had already been replaced on the double-

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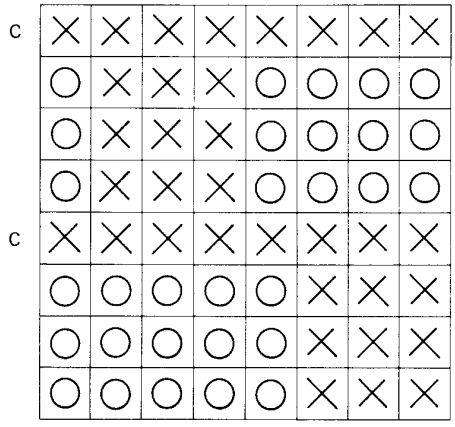


Fig. 7.21 Basket purl with a collecting course.

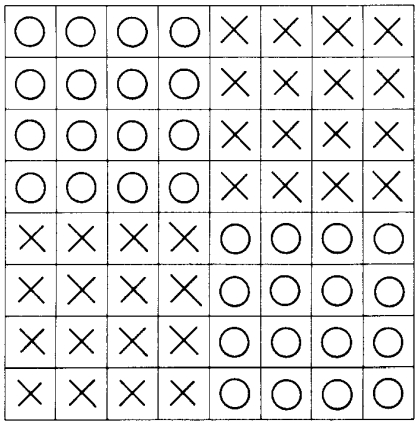


Fig. 7.22 Basket purl without a collecting course.

cylinder garment-length purl machines that succeeded the original Spensa purl machine.

The dividing cam is an internally-profiled, cut-through recess in a flat plate, attached horizontally and externally to the cylinders at a position half-way between them. There is a recess cam position for the top cylinder and another for the bottom cylinder in a different position in the same plate. The principle of the dividing cam operation is that it forms a wedge shape of increasing thickness between the upper surface of the needle hook and the under surface of the extended nose of the delivering slider, pivoting it away from the cylinder so that it disengages from the needle hook.

1 The delivering slider (D) advances with the needle so that the nose of the slider, which is extended into a latch guard, penetrates the profiled recess of the dividing cam. The outer hook of the needle contacts the hook underneath the head of the receiving slider (R), pivoting it out of the cylinder, but it immediately returns and –
2 engages with the needle hook under the influence of a coil spring band (SB) that surrounds each cylinder and ensures that the slider heads are depressed into contact with the needle hooks.
3 As slider D revolves with the cylinder, it passes along the wall of the dividing cam (DC), which increases in thickness so that the slider is pivoted outwards and disengages from the needle hook. Slider D then returns to its cylinder whilst slider R retires into its cylinder, taking the needle with it, ready for the next knitting feed.

7.5.3 The use of spring-loaded cams

Figure 7.23 illustrates the *spring-loaded cam method of slider disengagement*, used in the SPJ type machine, which is the successor of the Spensa purl but has stationary cylinders (without internal sinkers) and revolving cam-boxes. A similar

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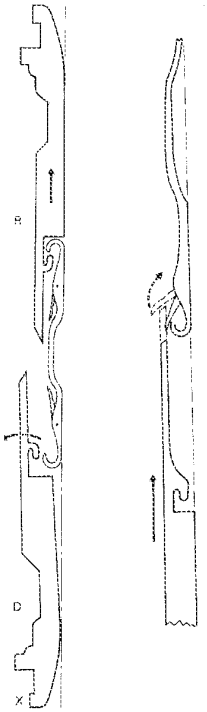


Fig. 7.23 Purl needle transfer using spring loaded cams.

technique is being generally introduced into double-cylinder half-hose machines, although these have revolving cylinders. At the moment of disengagement, the spring-loaded cam presses onto the tail of the delivering slider (D), causing its head to swing away from the cylinder and to disengage itself from the needle hook. The action is made possible by the tapering under-surface of the slider tail.

This method is simpler and safer and operates well at high speeds. The latch guard nose of the slider is extended and pointed to act as a latch-opener as the receiving slider meets the approaching head of the needle, whose latch is specially shaped to facilitate the action. This action reduces the danger of press-offs occurring through latches closing onto empty hooks. (On the *Spensa* purl, two ends of yarn were knitted so that yarn breakage and a subsequent press-off were less likely to occur).

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8

The various types of weft knitting machines

8.1 Fabric machines and garment-length machines

Weft knitting machines may be broadly grouped according to end product as either:

- *circular machines*, knitting *tubular fabric* in a continuous uninterrupted length of constant width, or
- *flat* and *circular machines*, knitting *garment-length sequences*, which have a timing or counting device to initiate an additional garment-length programming ('machine control') mechanism. This co-ordinates the knitting action to produce a garment-length structural repeat sequence in a wale-wise direction. The garment width may or may not vary within the garment length.

The difference between fabric and garment-length knitting is best understood in terms of hand flat knitting. If the knitter merely traverses the cam carriage backwards and forwards across the needle bed, a continuous fabric length will be knitted. However, if the knitter counts the traverses and alters the cam box settings at predetermined traverses, a garment-length sequence can be knitted.

Underwear may be knitted either in garment-length or fabric form, whereas *knitwear* is normally in garment-length form, usually knitted in machine gauges coarser than E 14. *Jersey wear* is cut and made-up from fabric usually knitted on large circular machines (26-inch or 30-inch diameter), although there are larger and smaller diameter machines used. Generally, gauges are finer than E 14.

8.1.1 Fabric machines

Large diameter, circular, latch needle machines (also known as *yardgoods* or *piece goods*, machines) knit fabric, at high speed, that is manually cut away from the machine (usually in roll form) after a convenient length has been knitted. Most fabric is knitted on circular machines, either single-cylinder (*single jersey*) or cylinder and dial (*double jersey*), of the revolving needle cylinder type, because of their high speed and productive efficiency.

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Circular machines employing bearded needles are now obsolete. Although sinkerwheel and loopwheel frames could knit high quality speciality fabrics, their production rates were uncompetitive.

Unless used in tubular body-width, the fabric tube requires splitting into open-width. It is finished on continuous finishing equipment and is cut-and-sewn into garments, or it is used for household and technical fabrics. The productivity, versatility and patterning facilities of fabric machines vary considerably. Generally, cam settings and needle set-outs are not altered during the knitting of the fabric (see also Chapter 13, *The production of weft knitted fabric*).

8.1.2 Garment-length machines

Garment-length machines include straight bar frames, most flats, hosiery, legwear and glove machines, and circular garment machines including *sweater strip* machines, producing knitwear, outerwear and underwear. On these machines, the garment sequence control with the timing/counting device, collectively termed '*the machine control*', automatically initiates any alteration to the other facilities on the machine needed to knit a garment-length construction sequence instead of a continuous fabric.

This machine control may have to initiate correctly-timed changes in some or all of the following: cam-settings, needle set-outs, feeders and machine speeds. It must be able to override and cancel the effect of the patterning mechanism in rib borders and be easily adjustable for different garment sizes.

Also the *fabric take down* mechanism must be more sophisticated than for continuous fabric knitting. It has to adapt to varying rates of production during the knitting of the sequence and, on some machines, be able to assist both in the setting-up on empty needles and the take away of separate garments or pieces on completion of the sequence.

Garments may be knitted to size either in tubular or open-width; in the latter case more than one garment panel may be knitted simultaneously across the knitting bed. Large-diameter circular machines and wide V-bed flat machines can knit garment blanks that are later split into two or more garment widths (*blanket-width* knitting) (see also Chapter 20, *Circular garment-length machines*).

8.2 Knitting welts and rib borders

Garment-length knitting sequences vary considerably. The simplest circular garment machines knit repeat sequences of rib borders and body panels in a continuous structure at high speed. This structure requires cutting into garment lengths and seaming to produce a secure welt edge.

Most garment machines knit some form of secure welt edge at the start of the garment sequence and either a 'knitted-in' separation course (draw-thread or dissolving thread) or 'press-off' separation between each garment piece. In the latter case, the machine must be capable of commencing knitting of the next garment length on empty needles.

Shaping of flat garment panels is either in the form of cut edges or in the form of knitted selvedges (in the case of reciprocating knitting on a flat machine). The amount of shape introduced into the garment also varies; in some cases this is

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achieved entirely by the cutting and making-up operation, in others it is by stitch shaping, stitch length variation, loop transfer and fashioning, held stitches or reciprocation.

8.3 Integral knitting

Whereas garments cut from fabric are completely assembled during seaming, others require varying amounts of making-up. *Integrally knitted* articles or '*whole garments*' are completely assembled on the knitting machine and require no further making-up operations off the machine.

Some V-bed glove knitting machines are of this type, as are some hosiery machines with integral toe-closing facilities. Some V-bed flat machines can knit complete garments in tubular form [1].

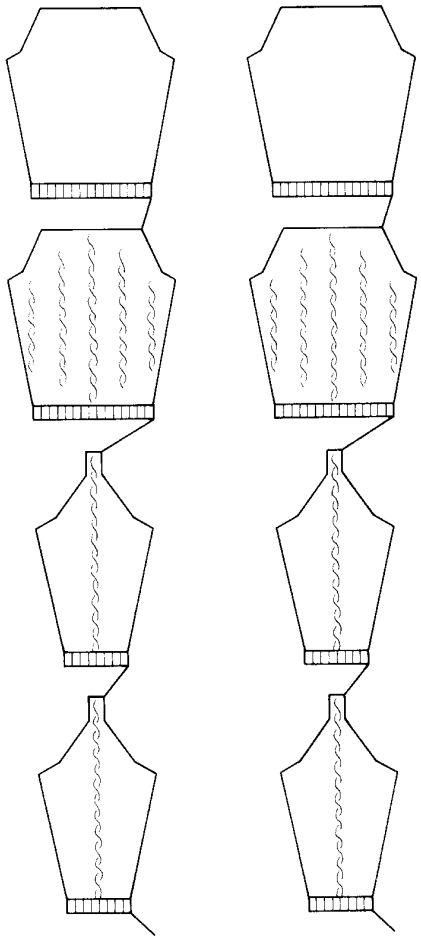


Fig. 8.1 Sequential knitting.

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The advantages of this technique include savings in making-up machinery, space and labour, and reductions in the production sequence. Disadvantages include increased costs and complexity of the knitting machine and a possible reduction in its versatility and flexibility.

Certain electronically-controlled straight bar and V-bed flat machines can now be programmed to carry out a sequence of knitting a front, a back and two sleeves in turn thus using the same yarn and stitch lengths. Programming *sequential knitting* requires adequate computer memory and gives the advantages of quick response, less work in progress and better matching of component panels (Fig. 8.1).

8.4 The three classes of weft knitting machines

The three main groups of weft knitting machinery may broadly be classified as either straight bar frames, flats, or circulars, according to their frame design and needle bed arrangement.

8.4.1 Straight bar frame machines

Straight bar frames are a specific type of machine having a vertical bar of bearded needles whose movement is controlled by circular engineering cams attached to a revolving cam-shaft in the base of the machine. The length of the machine is divided into a number of knitting heads ('*sections*' or '*divisions*') and each head is capable of knitting a separate but identically-dimensioned fashion-shaped garment panel.

The needles press their beards against a fixed pressing edge; loop formation prior to intermeshing is achieved by individually horizontally-moving loop-forming sinkers, and knock-over occurs when the needles descend below the knock-over bits.

At either edge of each knitting head, a group of rackably-controlled points transfer loops to fashion shape the garment panel at the selvedges by widening or narrowing the knitting width. On completion of the garment panel, it is *pressed-off* the needles.

As straight bar frames have a single needle bar, they are unable to knit rib welts. A few rib frames (with a horizontal as well as a vertical needle bar) were built, but they were too slow and complex to become accepted. The same situation arose with the *rib-to-plain frame*, which had an auxiliary needle bed and was designed to knit a rib border after which only the vertical needle bar continued knitting for the plain knit body panel.

The welt and border sequence at the beginning of the panel was achieved by one of the two following methods:

1 Knitting a rib border fabric and welt on a separate V-bed flat machine, running it onto the empty needles of the frame and then commencing to knit the body panel onto the rib.
2 Employing a welt-turning device on the frame to produce a double thickness plain fabric. This method is more popular in the USA. It is the only method of knitting welts on fully-fashioned stockings.

Straight bar frames are long, capital-expensive machines that, because of their multi-sections and in spite of their intermittent knitting action, are highly productive in a very narrow sphere of garment manufacture. The knitting width is rather restricted

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and fashion tends not to encourage full exploitation of the fashion shaping and stitch-transfer patterning potential of the machines.

The machines are noted for their production of high-quality garments as a result of the gentle knitting action, low fabric tension and fashion shaping, which reduces the waste of expensive yarn during cutting and is emphasised on the garments by carefully-positioned fashion marks.

The straight bar frame is the only bearded needle weft knitting machine that is still commercially viable, although it now faces serious competition from electronically-controlled V-bed flat machines (see also Chapter 17).

8.4.2 Flat machines

The typical flat machine has two stationary beds arranged in an inverted V formation. Latch needles and other elements slide in the tricks during the knitting action. Their butts project and are controlled as they pass through the tracks formed by the angular cams of a bi-directional cam system. It is attached to the underside of a carriage that, with its selected yarn carriers, traverses in a reciprocating manner across the machine width (Fig. 8.2).

The machines range from hand-propelled and -manipulated models to automated, electronically-controlled, power-driven machines.

The classes of flat machines are:

1 the V-bed flat machines, which form by far the largest class;
2 the flat-bed purl machines, which employ double-headed needles;

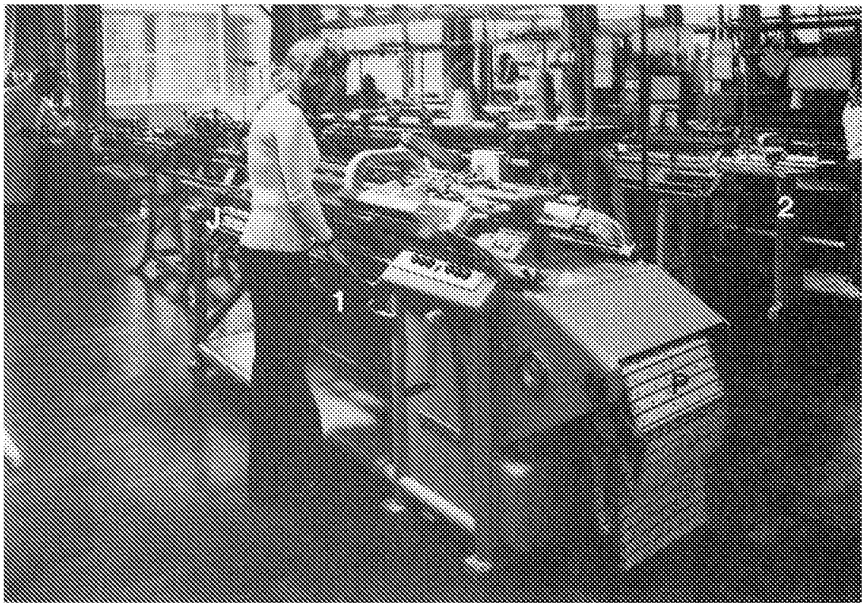


Fig. 8.2 Mechanically controlled flat knitting machines. 1 = jacquard power flat; 2 = hand flat; J = jacquard selection steels; P = paste board movement cards.

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3 machines having a single bed of needles, which include domestic models and a few hand-manipulated intarsia machines; and
4 the unidirectional, multi-carriage ('Diamant') machines, which are no longer built.

As with all knitting machines, there is a separate cam system for each bed; the two systems are linked together by a bow, or bridge, that passes across from one needle bed to the other. The systems for each needle bed are symmetrically arranged so that knitting, and in some cases loop transfer, may be achieved in either direction of carriage traverse.

The intermittent action of the carriage traverse and its low number of knitting heads (one to four) and cam systems (often only two to six, with a maximum of eight) reduces productivity but enables major cam changes to occur when the carriage is clear of the active needles.

The flat machine is the most versatile of the weft knitting machines; its stitch potential includes needle selection on one or both beds, racked stitches, needle-out designs, striping, tubular knitting, changes of knitting width, and loop transfer; a wide range of yarn counts may be knitted for each machine gauge, including a number of ends of yarn at each knitting system; the stitch length range is also wide; and there is the possibility of changing the machine gauge. The operation and supervision of the machines of the simpler type are less arduous than for other weft knitting machines. The number of garments or panels knitted across the machine depends upon the knitting width, yarn carrier arrangement, yarn path and yarn package accommodation.

Articles knitted on flat machines range from trimmings, edgings and collars, to shaped panels, integrally-knitted garment pieces, integrally-knitted complete garments and other articles. (see also Chapter 19, *Automatic power flat knitting*).

8.4.3 Circular machines

The term 'circular' covers all those weft knitting machines whose needle beds are arranged in circular cylinders and/or dials, including latch, bearded, or (very occasionally) compound needle machinery, knitting a wide range of fabric structures, garments, hosiery and other articles in a variety of diameters. Circular garment-length machines are either of body size or larger (Fig. 8.3), having a cylinder and dial arrangement, single cylinder or double cylinder, as is also the case with small diameter machines for hosiery (Fig. 8.4).

During the last 200 years, numerous inventors have assisted the development of circular weft knitting technology towards its present state of sophistication and diversity [2]. Whilst *Decroix's* patent of 1798 has been considered to be the first for a circular frame, *Marc Brunel's* 'tricoteur' of 1816 is probably the first practical working example of such a frame. Efforts were concentrated during the subsequent 30 years on improving the knitting action of this frame, with its revolving dial of fixed bearded needles radiating horizontally outwards and having their beards uppermost.

In 1845, *Fouquet* applied his '*Stuttgarter Mailleuse*' wheels to the frame and their individually moving, loop-forming sinkers provided the sinker frame with the capability of knitting high-quality fabric, a possibility later exploited by *Terrot* who improved the frame's patterning facilities and marketed it throughout the world.

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