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(54) COMPOSITE FOOTWEAR UPPER AND METHOD OF MANUFACTURING A COMPOSITE FOOTWEAR UPPER

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Publication Classification

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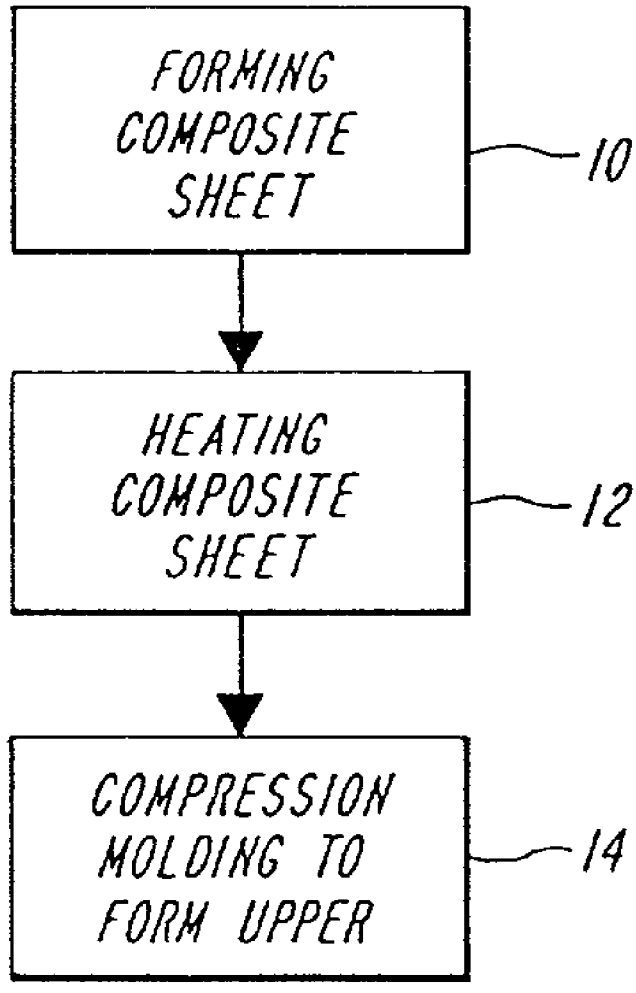
(52) **U.S. Cl.** **428/304.4**

(57) **ABSTRACT**

A method of manufacturing a multi-layer, composite footwear upper having a three-dimensional geometry includes forming a substantially planar composite sheet from two or more layers, heating the composite sheet, and shaping the composite sheet into the three-dimensional geometry of the footwear upper. The composite sheet can be formed by laminating a first layer of thermoplastic foam to a second layer of thermoplastic urethane (TPU). A third layer of mesh fabric can be interposed between the first and second layers. The composite sheet can be shaped by compression molding in a mold cavity or by lasting to achieve the desired three-dimensional geometry.



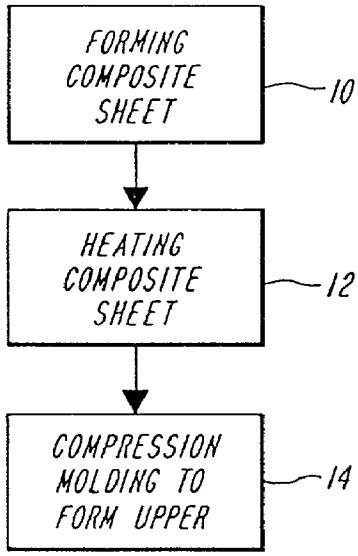

FORMING COMPOSITE SHEET
10
HEATING COMPOSITE SHEET
12
COMPRESSION MOLDING TO FORM UPPER
14

FIG. 1

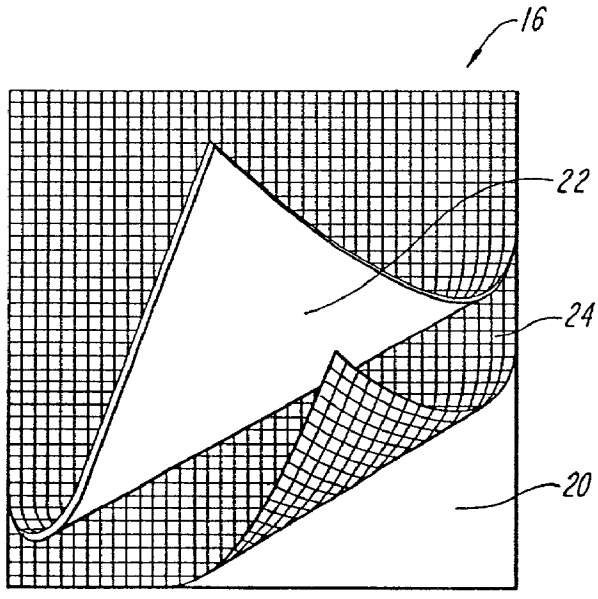

16
22
24
20

FIG. 2

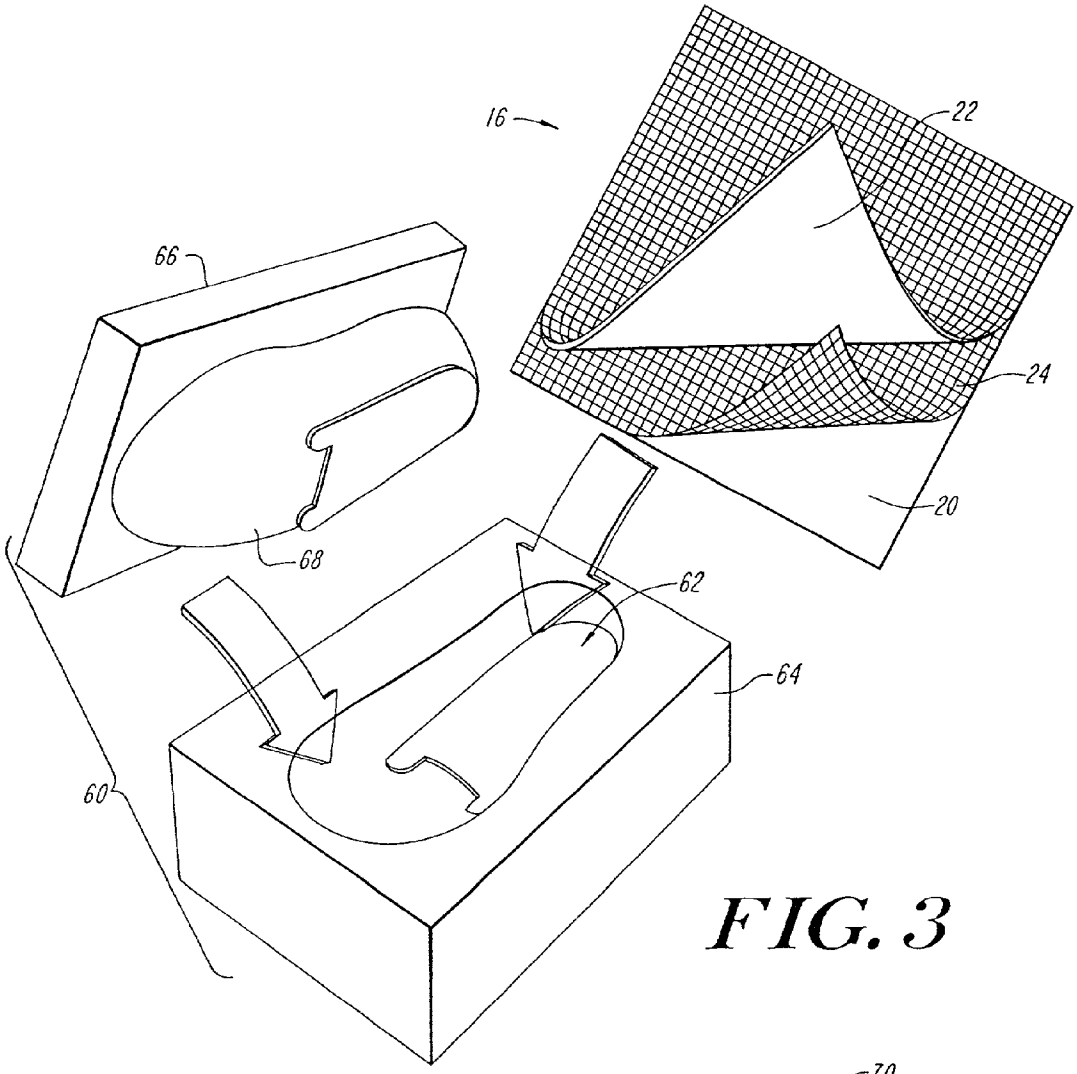


FIG. 3

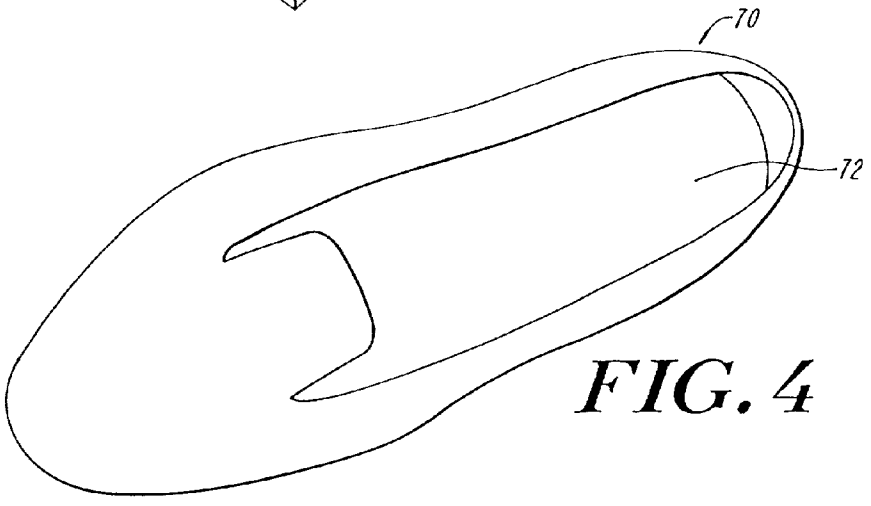


FIG. 4

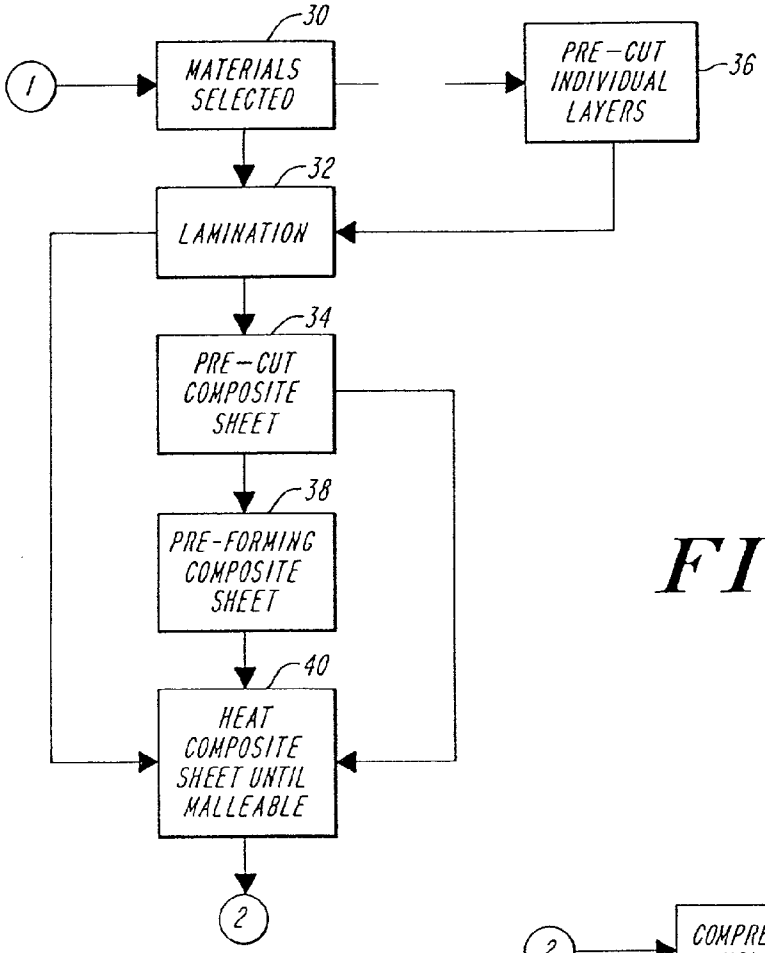

1
30
MATERIALS SELECTED
PRE-CUT INDIVIDUAL LAYERS
36
32
LAMINATION
34
PRE-CUT COMPOSITE SHEET
38
PRE-FORMING COMPOSITE SHEET
40
HEAT COMPOSITE SHEET UNTIL MALLEABLE
2

FIG. 5A

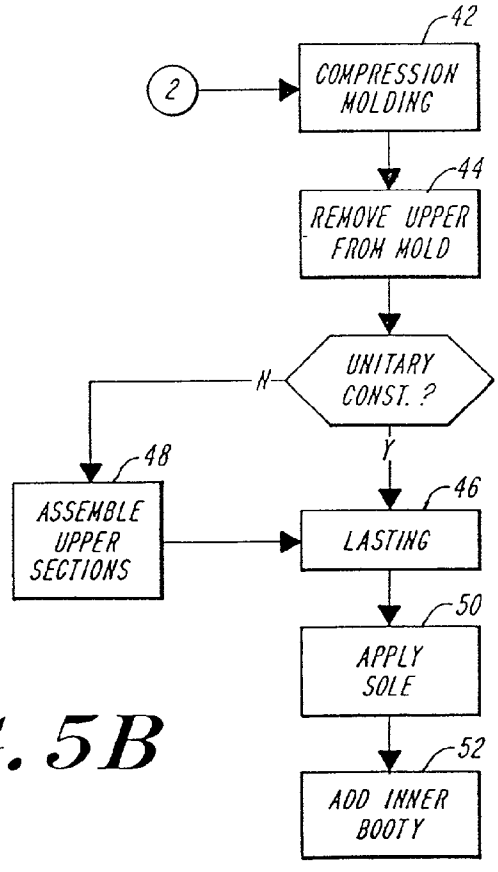

2
42
COMPRESSION MOLDING
44
REMOVE UPPER FROM MOLD
UNITARY CONST. ?
N
Y
48
ASSEMBLE UPPER SECTIONS
46
LASTING
50
APPLY SOLE
52
ADD INNER BOOTY

FIG. 5B

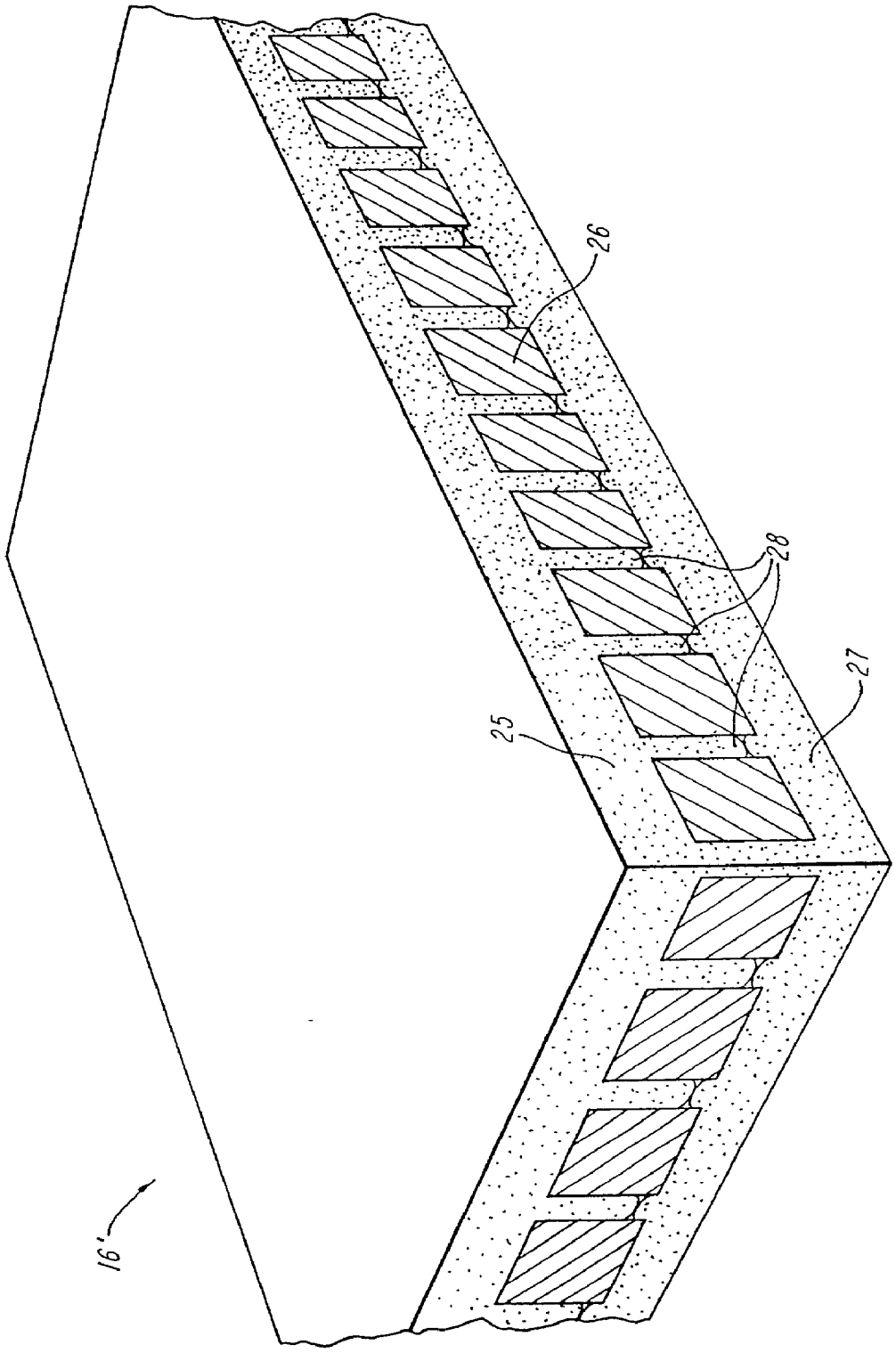


FIG. 6

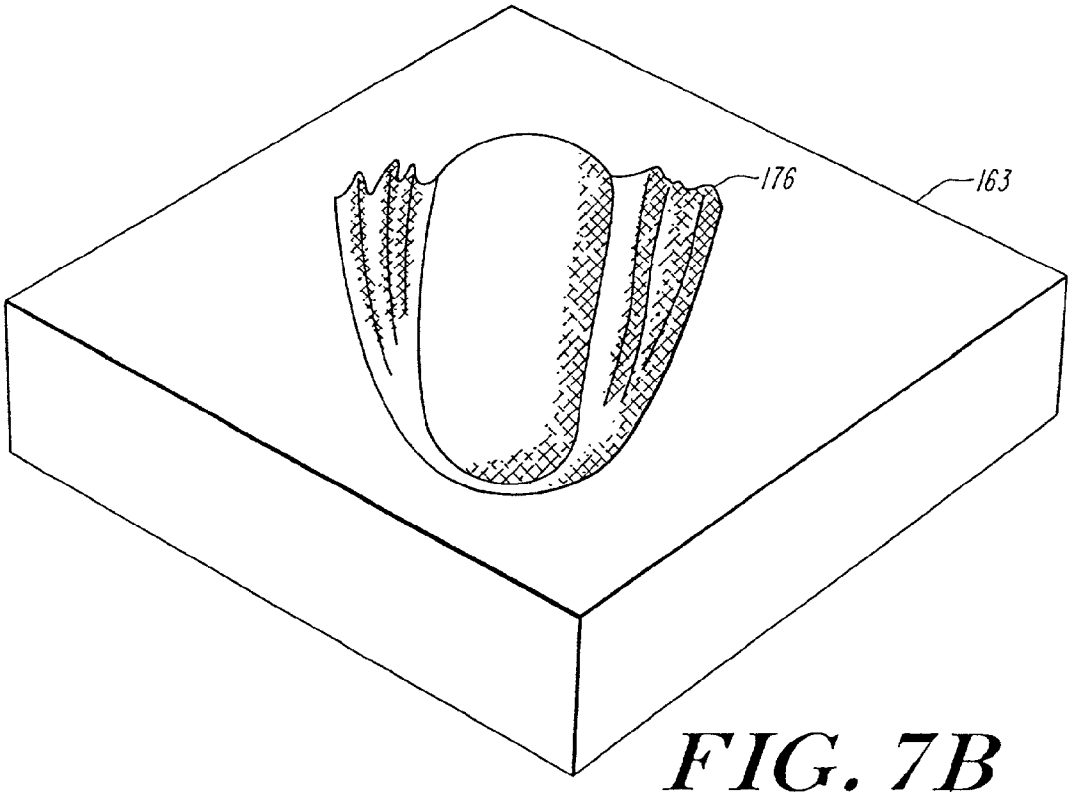


FIG. 7B

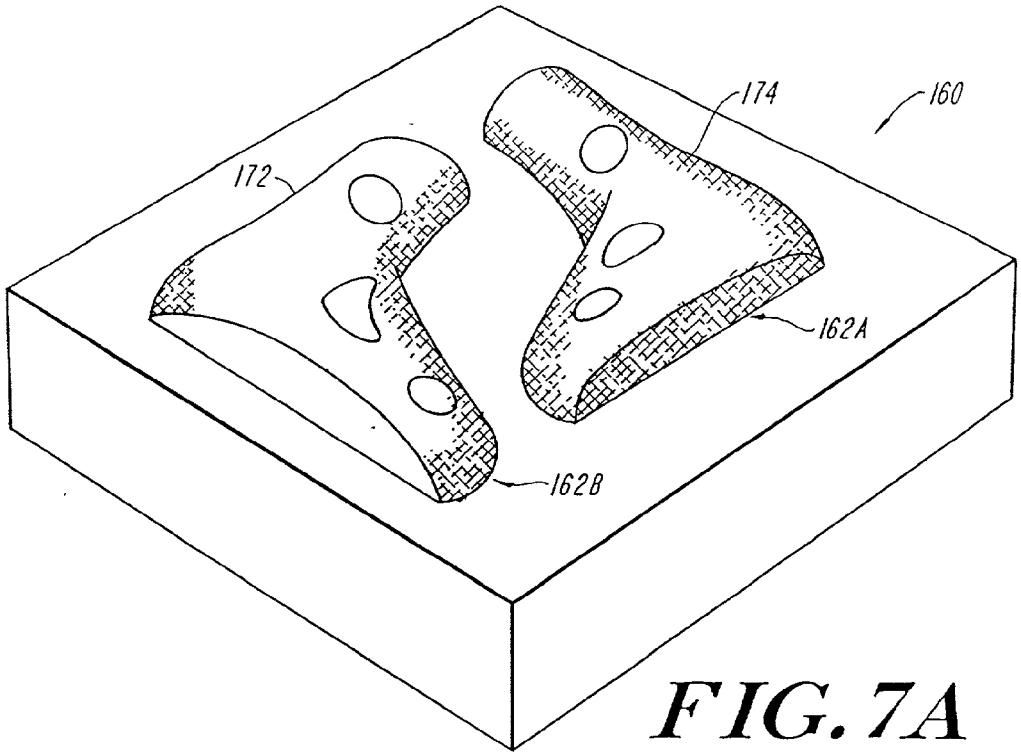


FIG. 7A

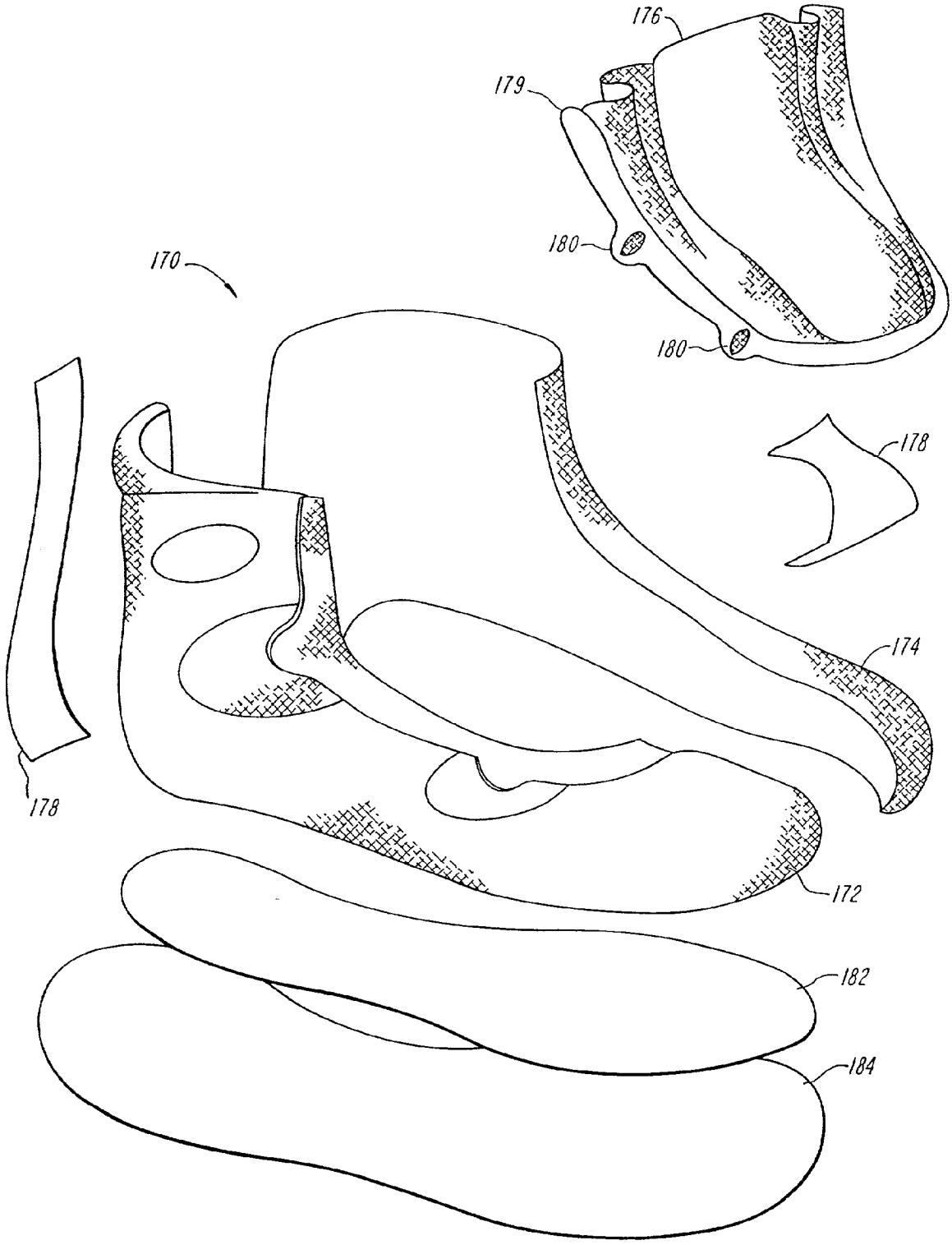


FIG. 7C

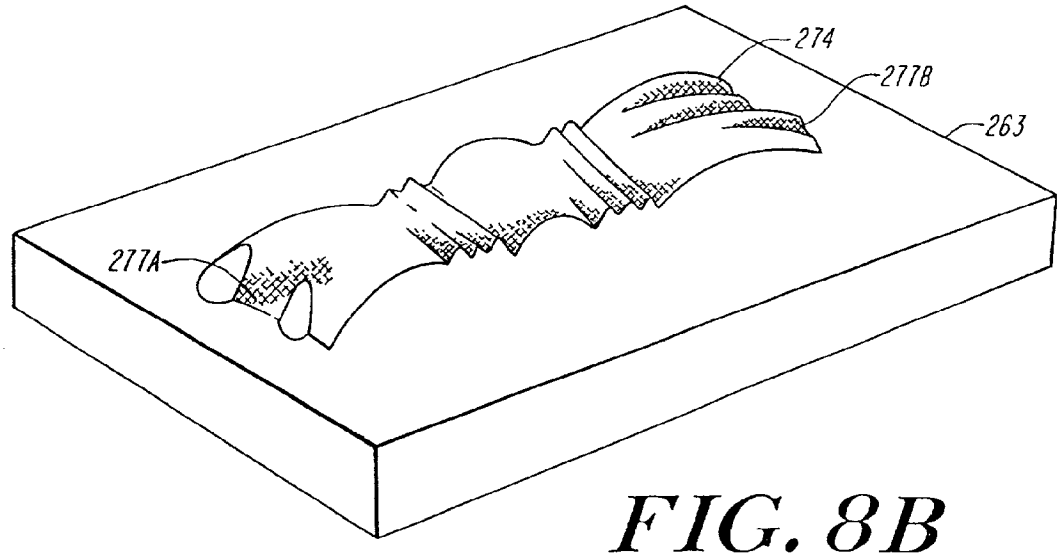


FIG. 8B

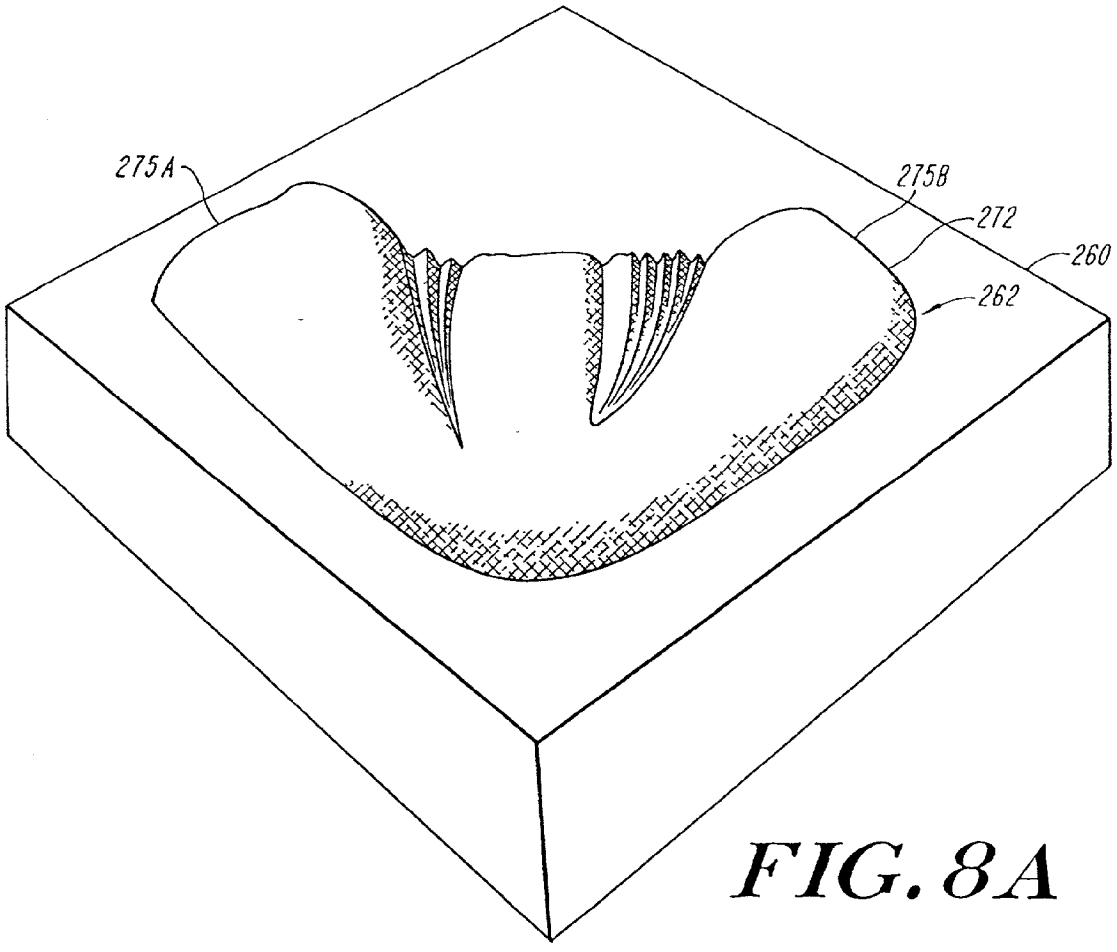


FIG. 8A

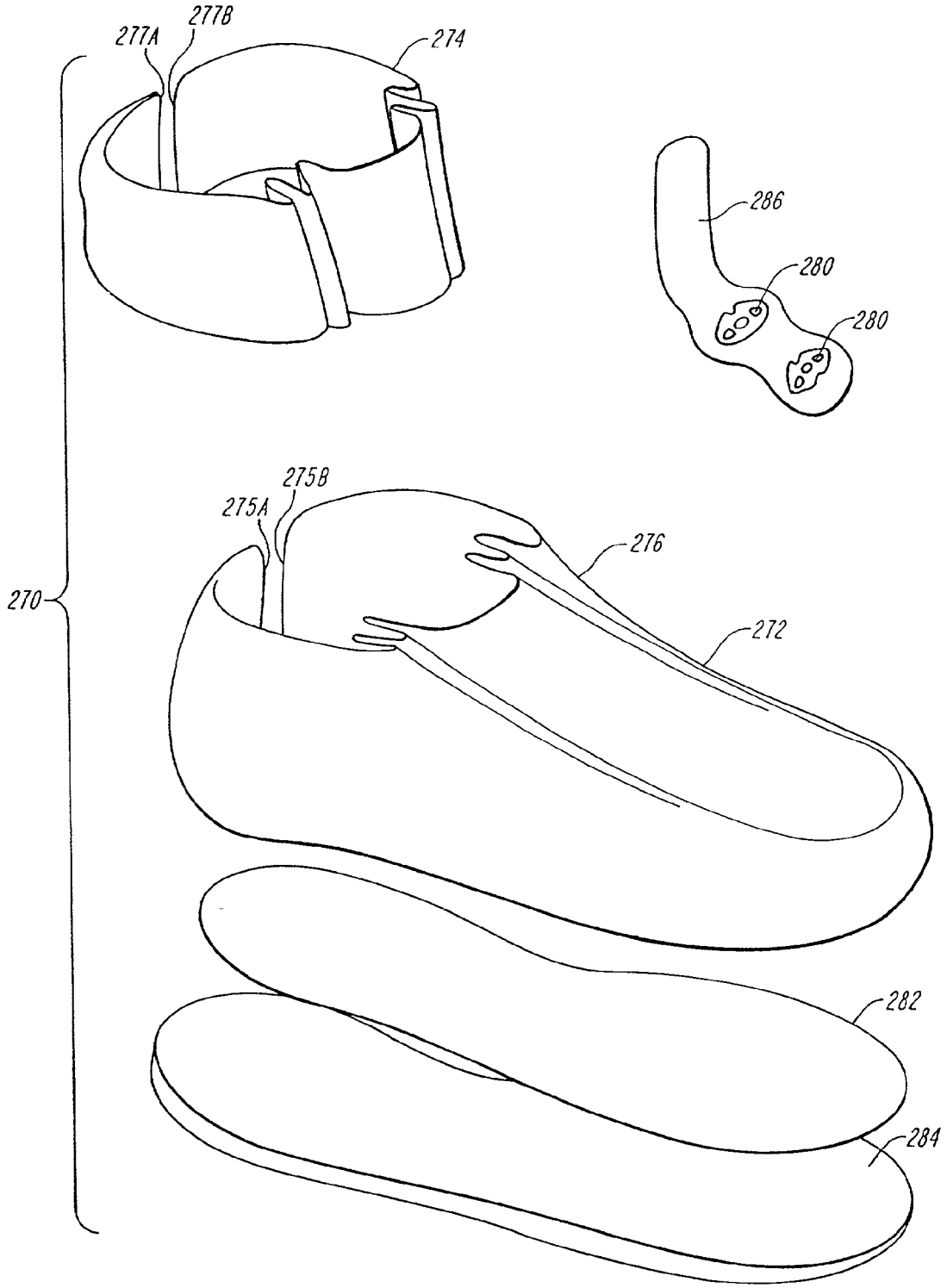


FIG. 8C

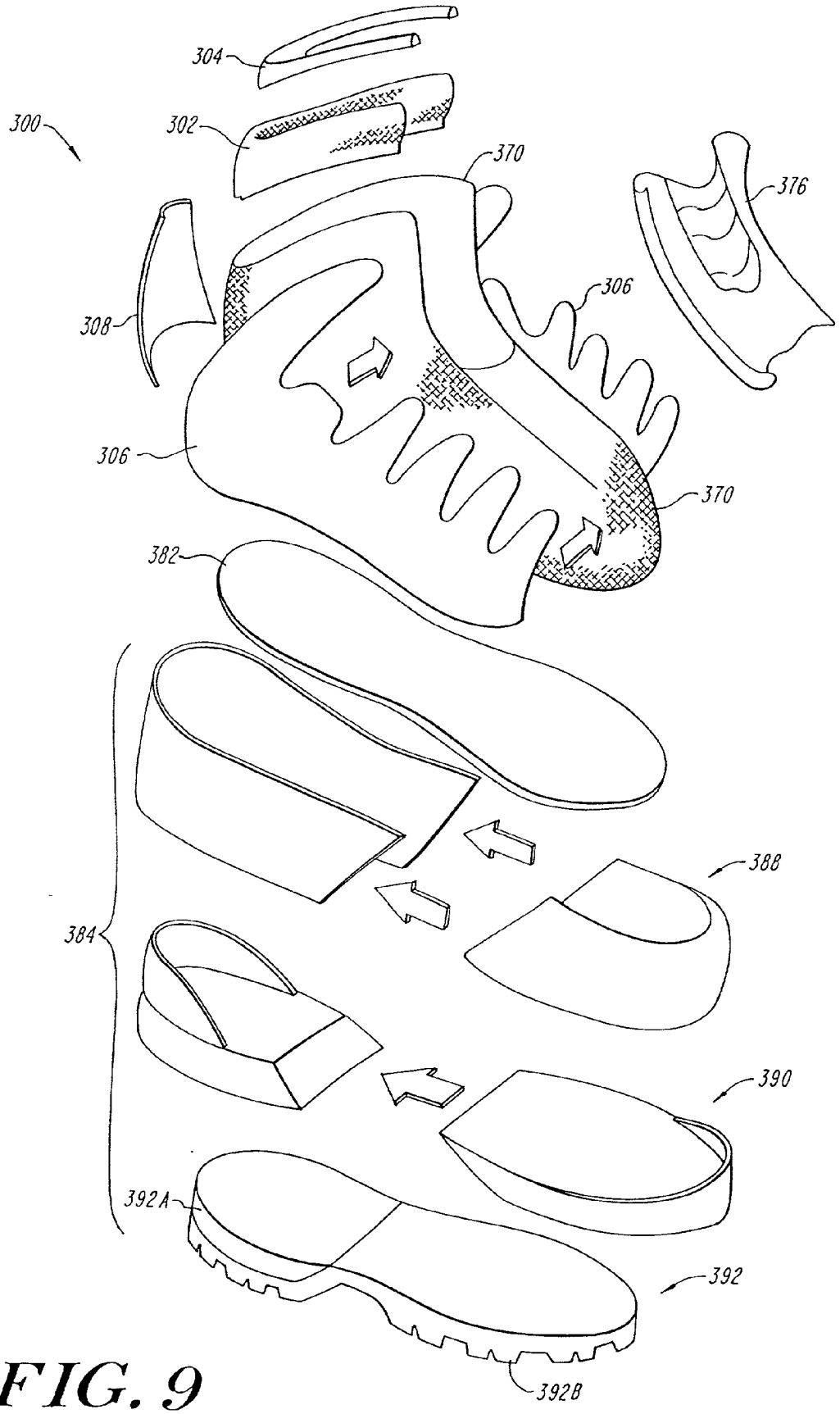

304
300
302
370
376
306
308
306
370
382
388
384
390
392A
392
392B

FIG. 9

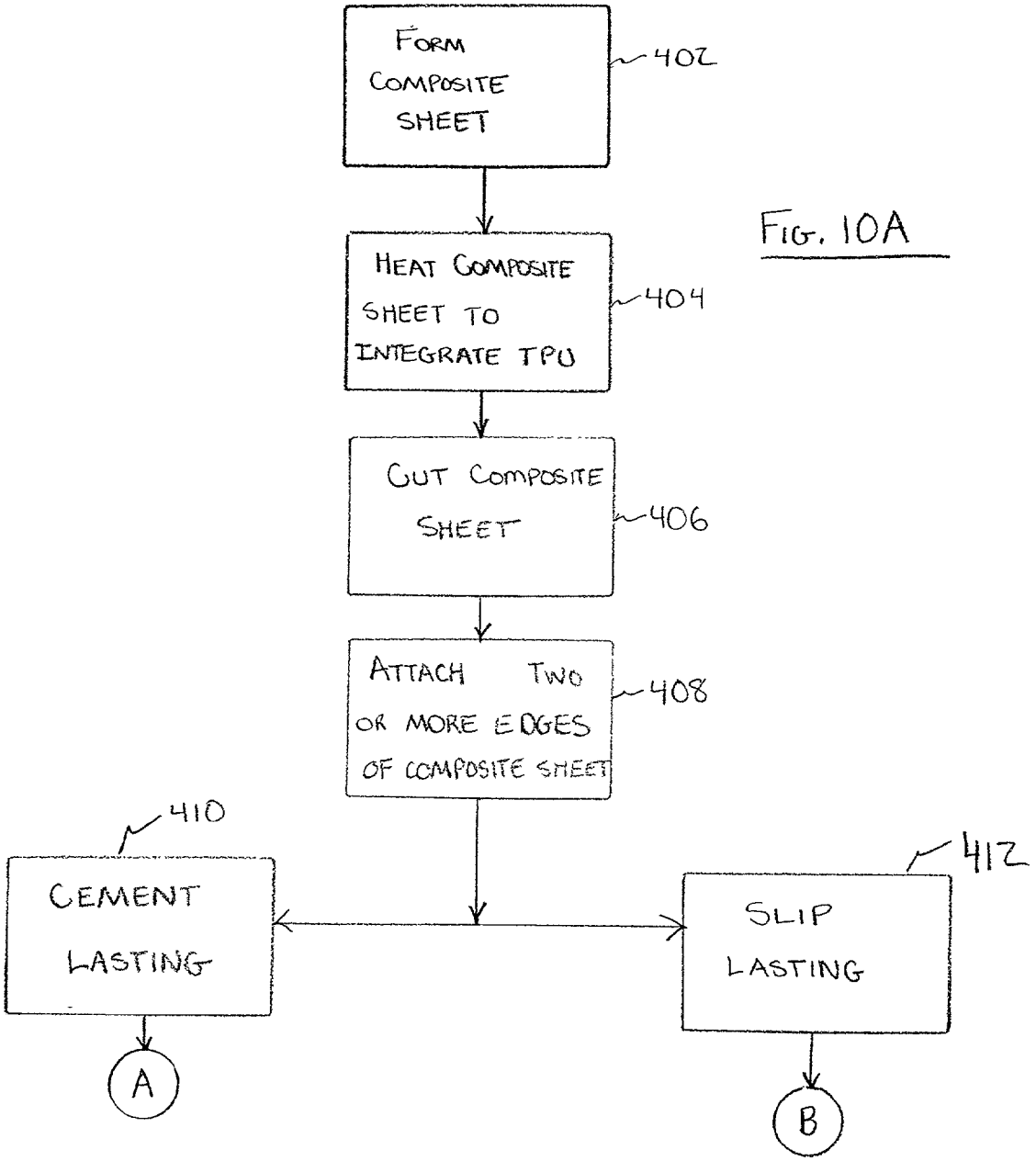

FORM COMPOSITE SHEET
402
HEAT COMPOSITE SHEET TO INTEGRATE TPU
404
CUT COMPOSITE SHEET
406
ATTACH TWO OR MORE EDGES OF COMPOSITE SHEET
408
410
CEMENT LASTING
412
SLIP LASTING
A
B

FIG. 10A

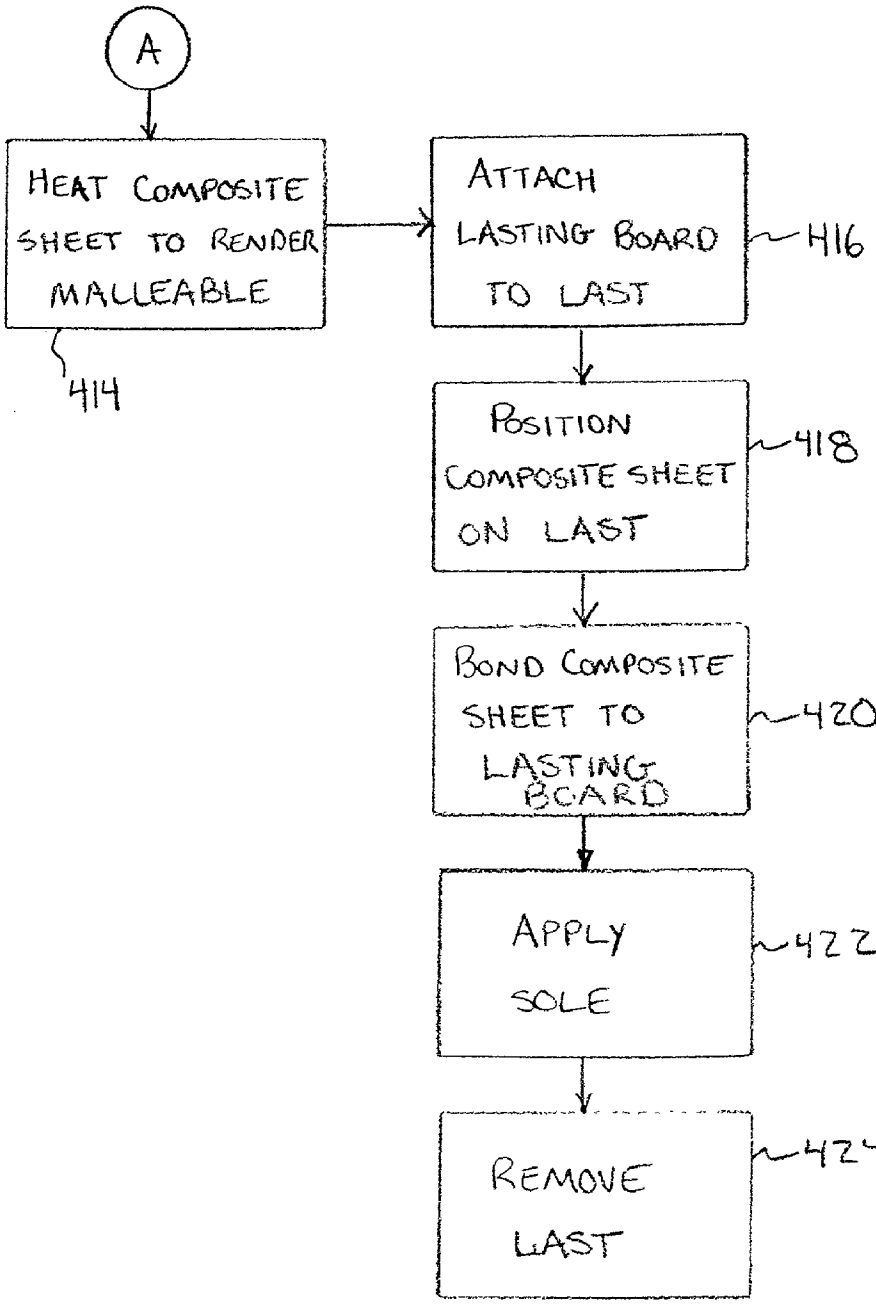

A
HEAT COMPOSITE SHEET TO RENDER MALLEABLE
414
ATTACH LASTING BOARD TO LAST
416
POSITION COMPOSITE SHEET ON LAST
418
BOND COMPOSITE SHEET TO LASTING BOARD
420
APPLY SOLE
422
REMOVE LAST
424

FIG. 10B

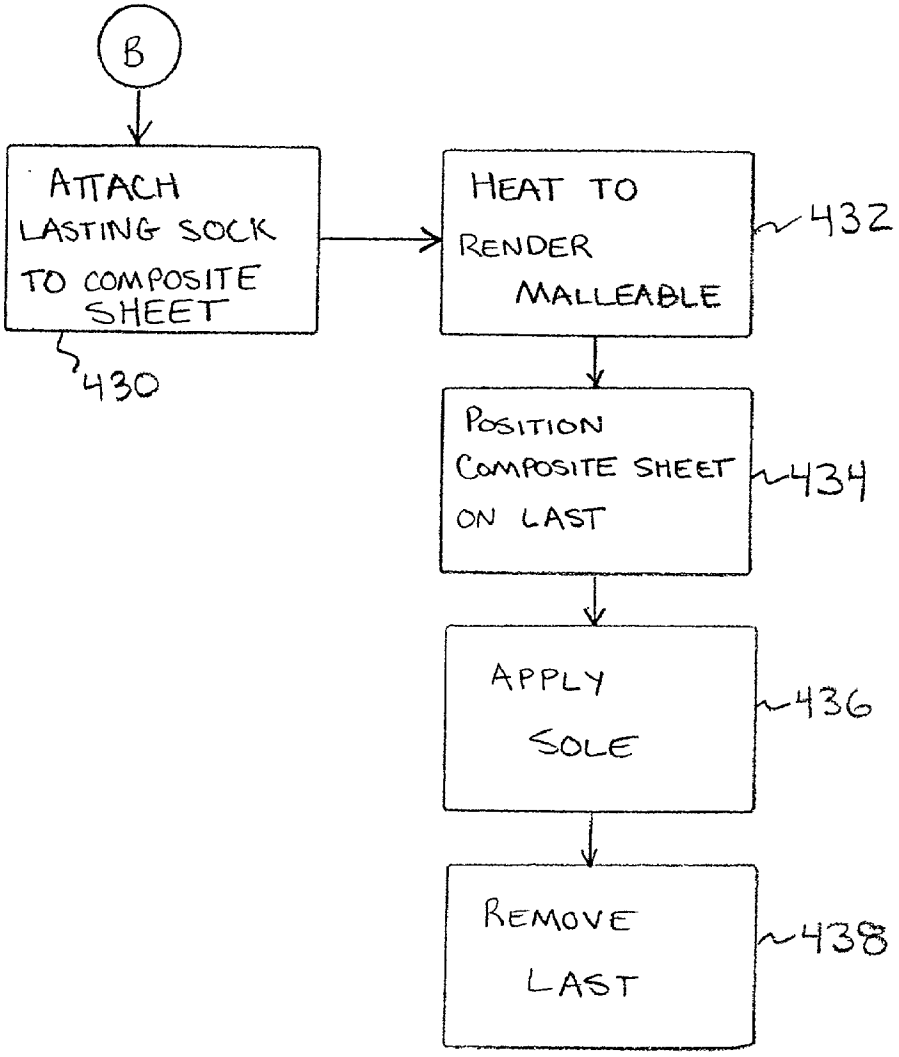

B
ATTACH LASTING SOCK TO COMPOSITE SHEET
430
HEAT TO RENDER MALLEABLE
432
POSITION COMPOSITE SHEET ON LAST
434
APPLY SOLE
436
REMOVE LAST
438

FIG. 10C

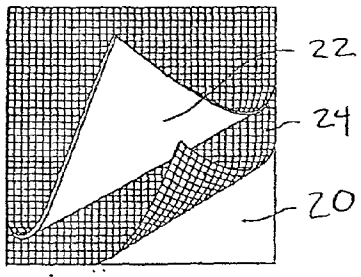


FIG. 11A

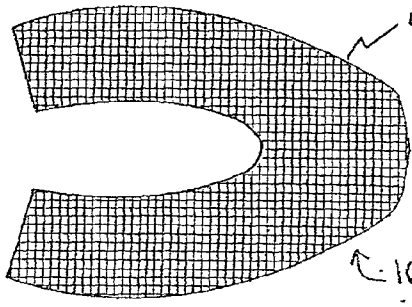


FIG. 11B

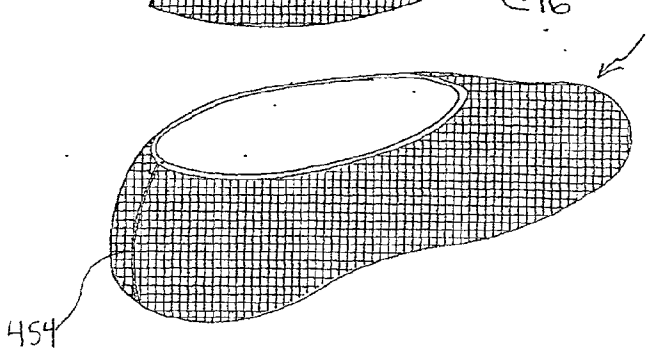


FIG. 11C

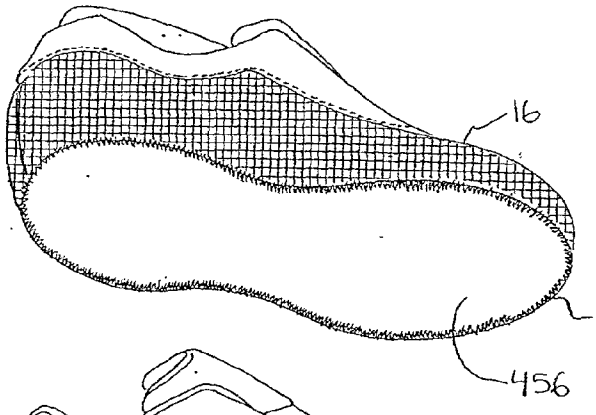


FIG. 11D

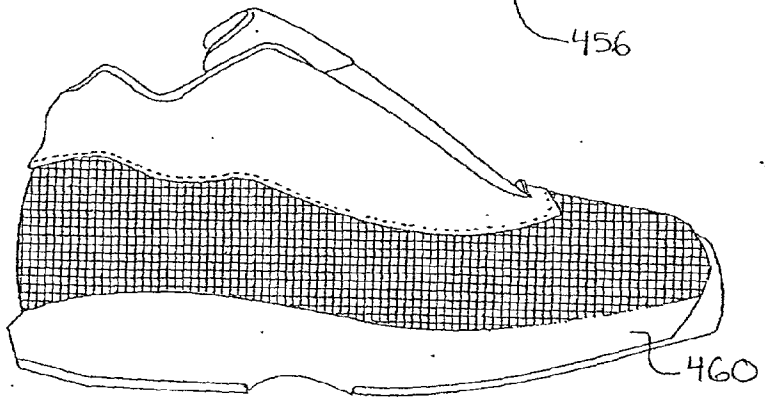


FIG. 11E

COMPOSITE FOOTWEAR UPPER AND METHOD OF MANUFACTURING A COMPOSITE FOOTWEAR UPPER

REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a continuation-in-part of U.S. patent application Ser. No. 09/514,419, filed Feb. 28, 2000, which claims priority to U.S. Provisional Application No. 60/122,351, filed Mar. 2, 1999. Each of the aforementioned patent applications is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] Many outdoor activities require performance footwear designed for use in extreme conditions. Performance footwear such as hiking boots, ski boots, snowboard boots, mountaineering boots, etc., can provide the wearer with protection from extreme temperatures, from moisture, and from foot injuries due to difficult terrain. To provide such protection, performance footwear is typically constructed from a material or a combination of materials having insulative, moisture resistant, and abrasion resistant characteristics.

[0003] The processes for constructing performance footwear can be labor intensive and costly and often require sophisticated and expensive molding and stitching equipment. For example, constructing performance footwear from leather requires hand cutting and hand stitching of the leather. Likewise, constructing performance footwear from plastic materials necessitates the use of expensive and complicated high-pressure injection equipment and molds.

[0004] In addition, the construction of performance boots often necessitates multiple layers of materials to be applied in sequence to one another to provide the desired insulative, moisture resistant, and abrasion resistant properties. This can result in bulky and heavy footwear that is uncomfortable to wear and difficult and time consuming to manufacture.

SUMMARY OF THE INVENTION

[0005] The present invention provides methods of manufacturing footwear and footwear uppers that simplifies the footwear manufacturing process, reduces manufacturing costs, and results in the construction of comfortable footwear having the properties necessary for use in extreme conditions. Moreover, the methods of the present invention provide the flexibility to vary the properties of the resultant footwear, allowing the footwear to be specifically tailored to the environment in which it is designed to be used, without the need for multiple sets of molds or manufacturing equipment.

[0006] In accordance with one aspect, the present invention provides a method of manufacturing a footwear upper having a three-dimensional geometry. The method includes the steps of forming a composite sheet from two or more layers and shaping the composite sheet into the three-dimensional geometry of the footwear upper. The composite sheet can be formed by the lamination of two or more layers. The layers can be bonded together by a bonding agent, can be heat bonded, or can be laminated together by other means. The composite sheet can be shaped by compression molding in a mold cavity or by lasting to achieve the desired three-dimensional geometry.

[0007] It is preferable that one or more of the layers forming the composite sheet includes a thermoformable material. In one preferred embodiment, the composite sheet comprises a first layer of thermoplastic foam and a second layer of thermoplastic urethane (TPU), preferably in the form of a TPU film. The thermoplastic foam can be, for example, ethylene vinyl acetate (EVA) foam. A third layer of fabric can be interposed between the first and second layers. Suitable fabrics can include a mesh fabric formed from nylon, polyester, polycotton, cotton, acetate, or acrylic.

[0008] In accordance with a further aspect of the present invention, the composite sheet can be compression molded into the three-dimensional geometry of the footwear upper. Compression molding can include positioning the composite sheet in a first mold member having a mold cavity and compressing the composite sheet in the mold cavity with a second mold member. The composite sheet can be heated prior to positioning the composite sheet into the first mold member or after the composite sheet is positioned in the first mold member, for example when the composite sheet is positioned in the mold cavity of the first mold member. The composite sheet can be compression molded into separate sections that are assembled after molding to form the footwear upper. Alternatively, the composite sheet can be compression molded into a seamless, unitary footwear upper that requires minimal, if any, assembly for completion.

[0009] In accordance with another aspect of the present invention, the composite sheet can be cement lasted into the three-dimensional geometry of the footwear upper. Cement lasting, also referred to as flat lasting, can include positioning the composite sheet on a last to shape the composite sheet into the three-dimensional geometry of the footwear upper and attaching a lasting board to the composite sheet. The lasting board is preferably attached to the last prior to positioning the composite sheet on the last and is preferably attached to the composite sheet after positioning the composite sheet on the last. The lasting board can be bonded to the composite sheet with cement or another bonding agent. The composite sheet can be optionally heated to a temperature sufficient to render the composite sheet malleable. The composite sheet can optionally be pre-formed into a non-planar configuration by, for example, cutting the composite sheet into a desired shape and attaching two or more edges of the composite sheet to provide a preliminary three-dimensional geometry to the composite sheet.

[0010] In accordance with another aspect of the present invention, the composite sheet can be slip lasted into the three-dimensional geometry of the footwear upper. Slip lasting can include positioning the composite sheet on a last to shape the composite sheet into the three-dimensional geometry of the footwear upper and attaching a lasting sock to the composite sheet. The lasting sock is preferably attached to the composite sheet before positioning the composite sheet on the last. The lasting sheet is preferably stitched to the composite sheet. The composite sheet can be optionally heated to a temperature sufficient to render the composite sheet malleable. The composite sheet can optionally be pre-formed into a non-planar configuration by, for example, cutting the composite sheet into a desired shape and attaching two or more edges of the composite sheet to provide a preliminary three-dimensional geometry to the composite sheet.

[0011] A method of manufacturing footwear in accordance with the present invention includes the steps of constructing an upper by forming a substantially planar composite sheet from two or more layers and shaping the composite sheet into the three-dimensional geometry of the upper. The upper then can be attached to a sole. The upper can be attached to the sole by stitching a sock into the upper, placing the upper on a last, attaching the upper to the sole, and removing the last from the upper after attaching the sole to the upper.

[0012] In accordance with another aspect of the present invention, an inner liner can be assembled within the upper. The inner liner can be a fabric or composite booty that can be stitched to the upper or can be separate and removable from the upper. In the alternative, a layer forming the inner liner can be attached to the composite sheet prior to the step of compression molding the composite sheet.

[0013] A multi-layer composite footwear upper in accordance with one aspect of the present invention can include a first layer of thermoplastic foam and a second layer of thermoplastic urethane (TPU), preferably in the form of a TPU film, attached to the first layer. The composite upper is preferably of unitary, seamless construction. A third layer of fabric can be interposed between the first and second layers. The thermoplastic foam can be, for example, ethylene vinyl acetate (EVA) foam. The fabric is preferably a mesh fabric formed from, for example, nylon, polyester, polycotton, cotton, acetate, or acrylic.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] These and other features and advantages of the present invention will be more fully understood by reference to the following detailed description in conjunction with the attached drawings in which like reference numerals refer to like elements through the different views. The drawings illustrate principles of the invention and, although not to scale, show relative dimensions.

[0015] **FIG. 1** is a flow chart illustrating a method of manufacturing a footwear upper according to the teachings of the present invention;

[0016] **FIG. 2** is a multi-layer composite sheet used to construct a footwear upper according to the teachings of the present invention;

[0017] **FIG. 3** is a schematic illustration of a method of manufacturing a footwear upper according to the teachings of the present invention;

[0018] **FIG. 4** is a perspective view of a footwear upper constructed in accordance with the teachings of the present invention;

[0019] **FIGS. 5A and 5B** are flow charts illustrating a method of manufacturing footwear according to the teachings of the present invention;

[0020] **FIG. 6** is a perspective view of an alternative embodiment of a multi-layer composite sheet used to construct a footwear upper according to the teachings of the present invention;

[0021] **FIG. 7A** is a perspective view of a mold for forming a footwear upper according to the teachings of the present invention;

[0022] **FIG. 7B** is a perspective view of a mold used to form a footwear tongue according to the teachings of the present invention;

[0023] **FIG. 7C** is an exploded view of the components of a footwear upper constructed in accordance with a method of manufacturing footwear of the present invention;

[0024] **FIG. 8A** is a perspective view of a mold for forming the lower portion of a footwear upper according to the teachings of the present invention;

[0025] **FIG. 8B** is a perspective view of a mold used to form an upper shaft according to the teachings of the present invention;

[0026] **FIG. 8C** is an exploded view of the components of a footwear constructed in accordance with a method of manufacturing footwear of the present invention;

[0027] **FIG. 9** is an exploded view of a boot constructed in accordance with a method of manufacturing footwear of the present invention;

[0028] FIGS. **10A-10C** are flow charts illustrating alternative methods of manufacturing footwear according to the teachings of the present invention; and

[0029] FIGS. **11A-11E** are schematic illustrations of alternative methods of manufacturing a footwear upper according to the teachings of the present invention;

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0030] The present invention provides methods for manufacturing footwear uppers and, in general, footwear in which a multi-layer composite sheet is heat activated to become malleable and than placed in a mold. The mold is used to compress the composite sheet into a desired three-dimensional geometry to form the composite upper. The resultant composite upper can be joined to a sole, as well as other footwear components, to complete the construction of the footwear. The manufacturing methods of the present invention simplify footwear construction, reduce manufacturing costs, and provide the flexibility to construct a footwear upper, and thus footwear, have a variety of different properties.

[0031] A method of manufacturing a footwear upper in accordance with the present invention is generally illustrated in the flowchart of **FIG. 1**. A substantially planar composite sheet is formed from two or more layers of material, step **10**. The substantially planar sheet is heat activated to become malleable, step **12**. Once heated, the substantially planar composite sheet is compression molded into the desired three-dimensional geometry of the footwear upper, step **14**.

[0032] **FIG. 2** illustrates an exemplary substantially planar composite sheet **16**. It is preferable for one of the layers forming the composite sheet **16** to include a thermo-formable material that becomes malleable (formable) when heated above a specific temperature. The thermo-formable material can be, for example, a thermoplastic material, although other thermo-formable materials may be used. Thermoplastic materials are desirable because, when heated above a characteristic activation temperature, thermoplastic materials become malleable and, upon cooling below the activation temperature, thermoplastic materials set and

maintain the desired form and shape. Exemplary thermoplastic materials include, but are not limited to, thermoplastic urethanes and polyurethanes, ethylene vinyl acetate (EVA).

[0033] Continuing to refer to **FIG. 2**, the exemplary composite sheet **16** comprises a first layer **20** of thermoplastic foam, such as EVA foam, and a second layer **22** of thermoplastic urethane (TPU). Other thermoplastic foams include, but are not limited to, polyethylene foam and polypropylyene foam. In a preferred embodiment, a third layer **24** of fabric can be interposed between the first layer **20** and the second layer **22**. The fabric is preferably a mesh material formed from fabrics such as nylon, polyester, polycotton, cotton, acetate, or acrylic. Although a woven fabric can be employed, a non-woven or knit fabric is preferred for the third layer **24** because of the increased stretchability provided. The second layer **22** of TPU and the underlying third layer **24** of mesh fabric are selected to provide the upper, as well as the resultant footwear, with a moisture and wear resistant outer layer. The first layer **20** of thermoplastic foam is selected to provide the upper, as well as the resultant footwear, with an insulative inner layer. The amount of insulation can depend of the thickness and density of the thermoplastic foam selected. Thus, the combination of layers forming the composite sheet **16** provide the composite sheet, as well as the upper formed therefrom and the resultant footwear, with a variety of properties.

[0034] One skilled in the art will appreciate that the composite sheet **16** is not limited to three layers as illustrated in **FIG. 2** and described above. Any number of layers can be used, depending on the desired properties of the footwear being constructed. For example, the thickness, hardness, density, or color, etc. of the composite sheet **16** can be varied by changing, adding, removing, or moving layers of the composite sheet **16**. Likewise, the degree of water resistance, thermal protection, and abrasion and wear resistance can be varied.

[0035] For example, in an alternative embodiment, the composite sheet can include an additional layer of a thermoset material, such as a thermoset urethane, over the second layer **22** of TPU. The additional layer of thermoset material can provide increased abrasion resistance and increased flexibility to the composite sheet and the molded composite upper.

[0036] **FIG. 6** illustrates an alternative embodiment of the composite sheet **16'** having a first layer **25** of cloth material, a second layer **26** of thermoplastic foam, and a third layer **27** of cloth material. The cloth material forming the first and third layers **25**, **27** is preferably felt. The term "felt" used herein includes, but is not limited to, cloth constructed from woven or non-woven synthetic or natural fibers. Other suitable cloth materials for the first and third layers include, but are not limited to, wool, fur, hair, polyester, nylon, cotton, acetate, and acrylic. The cloth material of the first layer **25** can be the same or different than the cloth material of the third layer **27**. The first, second, and third layer can be bonded together with a bonding agent or attached by other means. In addition, the first, second, and third layers **25**, **26**, **27** are preferably connected by forcing fibers of either the first or third layer through the second layer of thermoplastic foam. For example, the first layer **25** of cloth material can be needle punched to drag fibers **28** through the thermoplastic foam of the second layer **26**. The needle-punched fibers **28** are interweaved or interconnected with the fibers forming the third layer **27** of cloth material to thereby connect the three layers.

[0037] Referring to **FIGS. 3, 4**, and **5A**, a method of manufacturing a composite upper having a seamless, unitary construction will be described. To begin with, the materials are selected for forming the composite sheet **16**, step **30**, based on the desired properties of the composite upper. For purposes of the present description the three layer composite sheet described above will be used, however, one skilled in the art will recognize that any number of layers and a range of materials may be used to form the substantially-planar composite sheet. The materials selected can then be laminated together, for example, by bonding with an adhesive or by heat bonding, to form the substantially planar composite sheet **16**, step **32**.

[0038] The composite sheet **16** can be optionally pre-cut to the general shape of the composite upper to facilitate placement within the mold cavity **62** of the mold **60** used to form the composite upper, step **34**. This step of pre-cutting is generally referred to as "die-cutting." As best illustrated in **FIG. 3**, the mold **60** comprises a first mold member **64** that includes the mold cavity **62** and a second mold member **66** having a "male" projection **68** analogous in shape to the mold cavity **62**. The mold cavity **62** and the corresponding projection **68** are sized and shaped to form a unitary, i.e. single piece, footwear upper **70**, as illustrated in **FIG. 4**. In this regard, the mold cavity **62** defines a three-dimensional shape having a length, a width, and a depth or height corresponding, i.e., equal to, to the length, width, and depth or height of the footwear upper **70**.

[0039] Alternatively, the individual layers of materials can be pre-cut to the general shape of the mold cavity **62** prior to the step of laminating the layers together to form the composite sheet **16**, step **36**.

[0040] The die-cut composite sheet **16** can optionally be rough-formed prior to molding such that the composite sheet **16** better conforms to the geometry of the mold cavity **62**, step **38**. Rough forming can include providing a preliminary three-dimensional geometry to the composite sheet **16**. This can be accomplished, for example, by removing a section of the die-cut composite sheet and then attaching the cut edges such that the composite sheet is no longer substantially planar. Rough forming can also include forming score lines at predetermined locations on the composite sheet **16** to facilitate cutting and removal of material from the footwear upper after molding.

[0041] Although it is preferably that the composite sheet be die-cut and rough formed prior to molding, it should be understood that the die-cutting step and the rough forming step are optional steps, as illustrated by the flowchart of **FIG. 5A**. In other words, once the composite sheet is formed, the composite sheet can be immediately heated and compressed, without proceeding with either or both of these steps.

[0042] Prior to or during the step of compression molding the composite sheet, the composite sheet is preferably heated so that composite sheet becomes malleable or formable, step **40**. Heating of the composite sheet can occur within the mold **60** by, for example, heating the mold cavity

62 and/or the projection 68. Alternatively, the composite sheet can heated prior to placement within the mold cavity 62 by other heating means. In the case of a composite sheet formed using thermoplastic materials, the composite sheet is heated to or above the heat activation temperature of the thermoplastic material.

[0043] Referring to FIG. 5B, the heated composite sheet is compression molded within the mold 60, step 42. Compression molding can occur by pressing or forcing the projection 68 into contact with the composite sheet within the mold cavity 62. Alternative compression molding techniques can also be used. For example, a vacuum source can be coupled to the mold cavity 62 to apply a vacuum force to the under side of the composite sheet. Likewise, positive fluid pressure can be used independently or in cooperation with the compression provided by projection 68 to compress the composite sheet.

[0044] After compression molding, the molded composite upper is cooled to allow the materials forming the upper to set in the molded shape. After cooling, the composite upper is removed from the mold cavity 62, step 44. Compression molding of the composite sheet results in single piece footwear upper 70 that does not require further assembly, such as stitching, and, thus, is completely seamless, as illustrated in FIG. 4. Any excess material can be trimmed from the molded upper and the collar and throat area 72 can be punched-out, cut away, or otherwise removed from the upper. Eyelets holes or loops for laces, a collar, and a tongue can be added to the composite upper 70 if desired.

[0045] Continuing to refer to the FIG. 5B, the completed composite upper can be assembled with other footwear components to form an article of footwear, e.g., a shoe or a boot, etc. The general steps for assembling the upper and other footwear components into footwear are set forth in the flow-chart of FIG. 5B. One skilled in the art will appreciate that additional or fewer steps may be necessary depending on the footwear being manufactured.

[0046] The unitary composite upper can be lasted according to known lasting methods, step 46. As discussed in greater detail below, the method of forming a composite upper of the present invention is not limited to the formation of a single piece, seamless footwear upper. By changing the geometry of the mold cavity, a multi-section composite upper can be manufactured. In the case of a multi-section composite upper, the sections of the upper are assembled prior to lasting, step 48.

[0047] An exemplary lasting procedure involves stitching a bottom, generally referred to as a sock, to the bottom peripheral edge of the composite footwear upper. The sock can be made from a fabric material or any other soft, flexible, stitchable material. The upper and the sock are then placed on a last or foot form. Prior to adding the sole unit, the portions of the lasted upper which will contact the sole can be prepared by roughing, priming, and/or cementing the contact points. The sole unit is then applied to the lasted upper, step 50. The sole unit can be applied by any known method including, for example, by bonding the sole unit to the lasted upper or by injecting the material forming the sole unit onto the upper. It is preferable to prepare the sole unit for assembly to the upper in the same manner as with the upper, by roughing, priming, and/or cementing the contact points of the sole unit. Any type of sole unit can be applied to the composite upper depending of the type of footwear being manufactured. Once the sole unit is bonded to the composite upper the last is removed from the upper.

[0048] An inner liner, generally referred to as an inner booty, can be optionally assembled within the composite upper depending on the type of footwear being manufactured, step 52. The inner liner can be inserted into the lasted upper before or, preferably, after the sole unit is applied. The inner liner can be constructed of a fabric material or a composite material that can be stitched into the composite upper or attached by other means to the composite upper. It is not necessary, however, for the inner liner to be attached to the composite upper. Instead, the inner liner can be separate and removable from the composite upper. Alternatively, the inner liner can be assembled with the layers forming the composite sheet prior to compression molding the composite sheet into the composite upper. In this manner, the inner liner is an integral layer of the composite sheet and the resultant composite upper.

[0049] The methods of manufacturing a footwear upper in accordance with the present invention provide numerous advantages over conventional footwear manufacturing methods. The manufacturing methods of the present invention permit the construction of a seamless composite upper of unitary construction. This results in a reduction of manufacturing costs by minimizing assembly steps and reducing cutting and stitching time significantly. The compression molding processes of the present invention permit the creation of more comfortable, better fitting footwear by allowing anatomically correct contours to be formed in the mold cavity, and, thus, the molded composite upper. Surface variances can molded into either side, i.e., inside or outside, of the composite upper to enhance the aesthetic appearance and the functionality of the composite upper. For example, grooves or channels can be molded into the inner surface of the composite upper to create a space or spaces between the composite boot and the foot and thereby enhance the breathability of the composite upper. Protrusions can be molded into the outer surface of the composite upper to create initial contact points that can protect recessed regions of the outer surface of the composite upper from abrasion. Additionally, grooves can be molded into the outer surface of the composite upper to provide increased bendability or flexibility to the composite upper at the locations of the grooves.

[0050] Additionally, the compression molding processes of the present invention allow many different composite upper types to be created from a single compression mold by varying the materials use to form the composite sheet. A wide range of properties, such as weight, breathability, water resistance, insulation, flexibility, durability, rigidity, etc. can be imparted to the molded composite upper and the resultant footwear singularly or in combination depending on the materials used to form the composite sheet.

[0051] As discussed above, the composite upper can be compression molded into multiple sections which are assembled post-molding to form the composite upper. FIGS. 7A-C and 8A-C illustrate exemplary multi-section composite uppers formed according to the methods of the present invention. Referring to FIG. 7A-7C, a multi-section composite upper 170 is compression molded into two separate sections, 172 and 174, each representing a longitudinal half

of the assembled upper **170**. A mold **160** having two mold cavities, a first mold cavity **162**B corresponding in size and shape to one longitudinal half of the upper and a second mold cavity **162**B corresponding in size and shape to the other longitudinal half of the upper, is used to compression mold the composite sheet. A second mold **163** can be used to form a composite tongue **176** for the composite upper **170** in a manner analogous to the method of creating the composite upper.

[**0052**] **FIG. 7C** illustrates the components of the composite upper **170** formed according to the manufacturing methods of the present invention. After molding, the composite sections **172** and **174** are assembled by stitching, by bonding, or by other conventional methods. Seam covers **176** in the form of rubber strips can be placed over the seam or junction between the sections **172** and **174**. The composite tongue **176** can be provided with a leather or synthetic eyestay **179** having eyelets **180** for laces and is assembled to the upper **170**. A sock **182** for lasting is stitched to the lower peripheral edge of the composite upper **170**. A rubber outsole **184** is applied to the sock **182**.

[**0053**] Referring to FIGS. **8**A-**8**C, a multi-section composite upper **270** is compression molded into two separate sections, a lower section **272** and a shaft section **274**. The composite sheet is compression molded in a mold **260** having a butterfly-shaped mold cavity **262** corresponding in size and shape to the lower section of the upper. A separate second mold **263** is used to form the shaft section **274** for the composite upper **270** in a manner analogous to the method of creating the composite upper.

[**0054**] **FIG. 8C** illustrates the components of the composite upper **270** formed according to the manufacturing methods of the present invention. After compression molding, the butterfly-shaped lower section **272** is folded and assembled along edges **275**A and **275**B by stitching, by bonding, or by other means. Likewise, the shaft section **274** is folded and assembled along edges **277**A and **277**B. The shaft section **274** can then be attached to the lower section **272**. An integral, gusseted tongue **276** is compression molded into the lower section **272** of the upper **270**. A tongue inlay **286**, preferably constructed from leather, is positioned within the gusset formed on the tongue **276**. The tongue inlay **286** includes eyelets **280** or the like for laces. A sock **282** for lasting is stitched to the lower peripheral edge of the lower section **272** of the composite upper **270**. A rubber outsole **284** is applied to the sock **282**.

[**0055**] A exemplary article of footwear, in the form of a mountain boot **300**, is illustrated in **FIG. 9**. The mountain boot **300** includes a composite upper **370** of seamless, unitary construction. An upper composite collar **302** and binding **304** is assembled to the top peripheral edge of the composite upper **370**. A tongue **376** is assembled to the upper **370**. A pair of molded support plates **306** provide lateral support to the upper **370**. Rubbing foxing **308** is provided at the rear of the upper **370**. A sock **382** for lasting is stitched to the lower peripheral edge of the composite upper **370**. A multi-layer sole unit **384** is applied to the upper **370**. The sole unit **384** includes a two-part rubber foxing layer **388**, a two-piece TPU frame or flat **390**, and a rubber outsole **392**. The rubber outsole **392** includes a heel section **392**A and a front section **392**B, each constructed from rubber having a different density.

[**0056**] In some cases, it may be desirable to construct a composite footwear upper without the use of the compression molding. Referring to FIGS. **10**A-**10**C and **11**A-**11**E, exemplary alternative non-molding methods of manufacturing a composite upper will be described. The exemplary non-molding methods described below employ lasting methods to shape the composite sheet into the three-dimensional geometry of the footwear upper, however, other footwear manufacturing methods may be used to shape the composite sheet into the three-dimensional geometry of the footwear upper without departing from the present invention. For purposes of the present description the three layer composite sheet described above will be used, however, one skilled in the art will recognize that a different number of layers and a range of materials may be used to form the substantially-planar composite sheet. One skilled in the art will appreciate that additional or fewer steps may be necessary depending on the footwear being manufactured. Moreover, one skilled in the art will appreciate that the order of the steps illustrated in the flowcharts **10**A-**10**C is for illustrative purposes only and that the order may be varied without departing from the scope of the present invention.

[**0057**] The composite sheet may be formed, **402**, in the accordance with the methods described above. In the case of the composite sheet **16** including a first layer **20** of thermoplastic foam, a second layer **22** of TPU, and a third layer **24** of fabric, as illustrated in **FIG. 11**A, the composite sheet **16** can be optionally heated, **404**, to integrate the TPU of the first layer **22** into the third layer **24** of fabric. Pressure may also be applied during heating to improve integration. For example, the composite sheet can be heated to a temperature, for example 125° C. to 270° C., sufficient to soften the TPU. The integration of the TPU into the fabric layer can improve the abrasion resistance of the composite upper.

[**0058**] The composite sheet **16** can be optionally pre-cut to the general shape of the composite upper, **406**. This pre-cutting is generally referred to as "die-cutting." Alternatively, as discussed above, the individual layers of materials forming the composite sheet can be pre-cut prior to laminating the layers together to form the composite sheet.

[**0059**] The die-cut composite sheet **452**, **FIG. 11**B, can optionally be rough-formed, **408**, to provide a preliminary three-dimensional geometry to the die-cut composite sheet **452**. Rough forming, also referred to as pre-forming, can be accomplished, for example, by removing a section of the die-cut composite sheet **452** and then attaching two or more of the cut edges such that the composite sheet is no longer substantially planar. For example, the die-cut sheet **452** can be stitched, welded, and/or bonded (e.g., cemented) along the heel **454** of the sheet **452**, as illustrated in **FIG. 11C**.

[**0060**] The composite sheet can be shaped into the three-dimensional geometry of the footwear upper by lasting methods such as cement lasting, **410**, slip lasting, **412**, or other lasting methods. Referring to **FIG. 10**B, an exemplary cement lasting process will be described. Cement lasting, also known as flat lasting, employs a generally flat lasting board that is attached to bottom of the composite upper, typically by cementing the lasting board to the composite sheet. The lasting board provides a platform for attaching the sole to the upper and can also form an inner, bottom surface of the resultant footwear. Cement lasting can optionally include heating the composite sheet to render the sheet malleable or formable, **414**, as in the case of the compression molding processes described above. Heating facilitates positioning the composite sheet on the last and can allow the composite sheet to more readily adopt and maintain the shape of the last. Heating can occur, for example, prior to

positioning the composite sheet on the last and/or after positioning the composite sheet on the last by heating the last and the composite upper. The lasting board is preferably attached to the last prior to positioning the composite sheet on the last, **416**. Typically, the lasting board is tacked to the bottom of the last, however other attachment mechanisms may be employed. The composite sheet can be positioned on the last, **418**, and the composite sheet then can be attached to the lasting board by cement or other bonding agents, **420**. A sole unit can then be secured to the lasted upper, **422**, as described above. Once the sole unit is secured to the composite upper the last is removed from the upper, **424**. Other components of the footwear, such as an inner booty, a liner, a collar, and/or a tongue, can also be added to the footwear as described above.

[**0061**] Referring to **FIGS. 10C and 11D**, an exemplary slip lasting process will be described. Slip lasting employs a generally flat fabric lasting sock **456** that is attached to bottom of the composite upper, typically by stitching the lasting sock to the composite sheet. **FIG. 11D** illustrates an exemplary stitch line **458** about the circumference of the bottom of the composite sheet. The lasting sock **456** provides a platform for attaching the sole to the upper and can also form an inner, bottom surface of the resultant footwear. The lasting sock **456** is preferably attached to the composite sheet prior to positioning the composite sheet on the last, **430**. The composite sheet can be optionally heated to render the sheet malleable or formable, **432**, as in the case of the compression molding processes described above. Heating facilitates positioning the composite sheet on the last and can allow the composite sheet to more readily adopt and maintain the shape of the last. Heating can occur, for example, prior to positioning the composite sheet on the last and/or after positioning the composite sheet on the last by heating the last and the composite upper. The composite sheet can be positioned on the last, **434**. A sole unit **460**, **FIG. 11**E, can then be secured to the lasted upper, **436**, as described above. Once the sole unit is secured to the composite upper the last is removed from the upper, **438**. Other components of the footwear, such as an inner booty, a liner, a collar, and/or a tongue, can also be added to the footwear as described above.

[**0062**] Since certain changes may be made in the above constructions without departing from the scope of the invention. It is intended that all matter contained in the above description or shown in the accompanying drawings be interpreted as illustrative and not in a limiting sense.

[**0063**] It is also to be understood that the following claims are to cover all generic and specific features of the invention described herein, and all statements of the scope of the invention which, as a matter of language, might be the to fall therebetween.

Having described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. A method of manufacturing a footwear upper having a three-dimensional geometry, the method comprising:

forming a composite sheet from two or more layers; and

shaping the composite sheet into the three-dimensional geometry of the footwear upper.

2. The method of claim 1, wherein forming the composite sheet comprises the step of laminating the two or more layers to form the composite sheet.

3. The method of claim 2, wherein the two or more layers are bonded together by a bonding agent.

4. The method of claim 2, wherein the two or more layers are heat bonded.

5. The method of claim 1, wherein one of the layers of the composite sheet includes a thermoformable material.

6. The method of claim 1, wherein the composite sheet comprises

a first layer of thermoplastic foam, and

a second layer of thermoplastic urethane (TPU).

7. The method of claim 6, wherein the thermoplastic foam is ethylene vinyl acetate (EVA) foam.

8. The method of claim 6, wherein the second layer is a TPU film.

9. The method of claim 8, wherein the TPU film comprises

a top layer of formed of a thermoset urethane and a bottom layer formed of a thermoplastic urethane, the bottom layer being proximate the first layer of thermoplastic foam.

10. The method of claim 6, wherein the composite sheet further comprises

a third layer of fabric interposed between the first and second layers.

11. The method of claim 10, wherein the fabric is a mesh fabric formed from nylon, polyester, polycotton, cotton, acetate, or acrylic.

12. The method of claim 1, wherein shaping comprises compression molding the composite sheet.

13. The method of claim 12, wherein compression molding comprises

positioning the composite sheet in a first mold member having a mold cavity, and

compressing the composite sheet in the mold cavity with a second mold member.

14. The method of claim 1, further comprising heating the composite sheet.

15. The method of claim 1, wherein shaping comprises compression molding the composite sheet into separate sections of the upper and assembling the sections to form the footwear upper.

16. The method of claim 1, wherein shaping comprises compression molding the composite sheet into a seamless, unitary footwear upper.

17. The method of claim 1, wherein the composite sheet is substantially planar.

18. The method of claim 1, wherein shaping comprises lasting the composite sheet into the three-dimensional geometry of the footwear upper.

19. The method of claim 18, wherein lasting comprises

pre-forming the composite sheet into a non-planar configuration,

positioning the composite sheet on a last, and

attaching a lasting board to the composite sheet.

20. The method of claim 19, wherein the pre-forming comprises

cutting the composite sheet into a desired shape,

attaching two or more edges of the composite sheet to provide a preliminary three-dimensional geometry to the composite sheet.

21. The method of claim 19, wherein the lasting board is bonded to the composite sheet.

22. The method of claim 19, further comprising heating the composite sheet.

23. The method of claim 18, wherein lasting comprises

pre-forming the composite sheet into a non-planar configuration,

positioning the composite sheet on a last, and

attaching a lasting sock to the composite sheet.

24. The method of claim 23, wherein the pre-forming comprises

cutting the composite sheet into a desired shape,

attaching two or more edges of the composite sheet to provide a preliminary three-dimensional geometry to the composite sheet.

25. The method of claim 23, wherein the lasting sock is stitched to the composite sheet.

26. The method of claim 23, further comprising heating the composite sheet.

27. A method of manufacturing a footwear upper having a three-dimensional geometry, the method comprising:

forming a composite sheet from two or more layers;

positioning the composite sheet on a last to shape the composite sheet into the three-dimensional geometry of the footwear upper, and

attaching a lasting board to the composite sheet.

28. The method of claim 27, further comprising attaching the lasting board to the last prior to positioning the composite sheet on the last.

29. The method of claim 27, wherein the lasting board is attached to the composite sheet after positioning the composite sheet on the last.

30. The method of claim 27, wherein the lasting board is bonded to the composite sheet.

31. The method of claim 27, further comprising heating the composite sheet to a temperature sufficient to render the composite sheet malleable.

32. The method of claim 27, further comprising

cutting the composite sheet into a desired shape,

attaching two or more edges of the composite sheet to provide a preliminary three-dimensional geometry to the composite sheet.

33. The method of claim 27, wherein the composite sheet comprises

a first layer of thermoplastic foam, and

a second layer of thermoplastic urethane (TPU).

34. The method of claim 33, further comprising heating the composite sheet to a temperature sufficient to integrate second layer of TPU into the first layer of thermoplastic foam.

35. The method of claim 33, wherein the thermoplastic foam is ethylene vinyl acetate (EVA) foam.

36. The method of claim 34, wherein the second layer is a TPU film.

37. The method of claim 33, wherein the composite sheet further comprises

a third layer of fabric interposed between the first and second layers.

38. The method of claim 37, wherein the fabric is a mesh fabric formed from nylon, polyester, polycotton, cotton, acetate, or acrylic.

39. A method of manufacturing footwear comprising the steps of:

constructing an upper having a three-dimensional geometry by forming composite sheet from two or more layers,

positioning the composite sheet on a last to shape the composite sheet into the three-dimensional geometry of the footwear upper, and

attaching a lasting board to the composite sheet, and attaching the upper to a sole.

40. The method of claim 39, wherein the upper is bonded to the sole.

41. The method of claim 40, further comprising assembling an inner liner within the upper.

42. The method of claim 39, wherein the composite sheet comprises

a first layer of thermoplastic foam, and

a second layer of thermoplastic urethane (TPU).

43. The method of claim 42, wherein the composite sheet further comprises

a third layer of fabric interposed between the first and second layers.

44. A method of manufacturing a footwear upper having a three-dimensional geometry, the method comprising:

forming a composite sheet from two or more layers;

positioning the composite sheet on a last to shape the composite sheet into the three-dimensional geometry of the footwear upper, and

attaching a lasting sock to the composite sheet.

45. The method of claim 44, further comprising attaching the lasting sock to the composite sheet prior to positioning the composite sheet on the last.

46. The method of claim 44, wherein the lasting sock is stitched to the composite sheet.

47. The method of claim 44, further comprising heating the composite sheet to a temperature sufficient to render the composite sheet malleable.

48. The method of claim 44, further comprising

cutting the composite sheet into a desired shape,

attaching two or more edges of the composite sheet to provide a preliminary three-dimensional geometry to the composite sheet.

49. The method of claim 27, wherein the composite sheet comprises

a first layer of thermoplastic foam, and

a second layer of thermoplastic urethane (TPU).

50. The method of claim 49, further comprising heating the composite sheet to a temperature sufficient to integrate second layer of TPU into the first layer of thermoplastic foam.

51. The method of claim 49, wherein the thermoplastic foam is ethylene vinyl acetate (EVA) foam.

52. The method of claim 49, wherein the second layer is a TPU film.

53. The method of claim 49, wherein the composite sheet further comprises

a third layer of fabric interposed between the first and second layers.

54. The method of claim 53, wherein the fabric is a mesh fabric formed from nylon, polyester, polycotton, cotton, acetate, or acrylic.

55. A method of manufacturing footwear comprising the steps of:

constructing an upper having a three-dimensional geometry by forming composite sheet from two or more layers,

positioning the composite sheet on a last to shape the composite sheet into the three-dimensional geometry of the footwear upper, and

attaching a lasting sock to the composite sheet, and attaching the upper to a sole.

56. The method of claim 55, wherein the upper is bonded to the sole.

57. The method of claim 55, further comprising assembling an inner liner within the upper.

58. The method of claim 55, wherein the composite sheet comprises

a first layer of thermoplastic foam, and

a second layer of thermoplastic urethane (TPU).

59. The method of claim 55, wherein the composite sheet further comprises

a third layer of fabric interposed between the first and second layers.

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