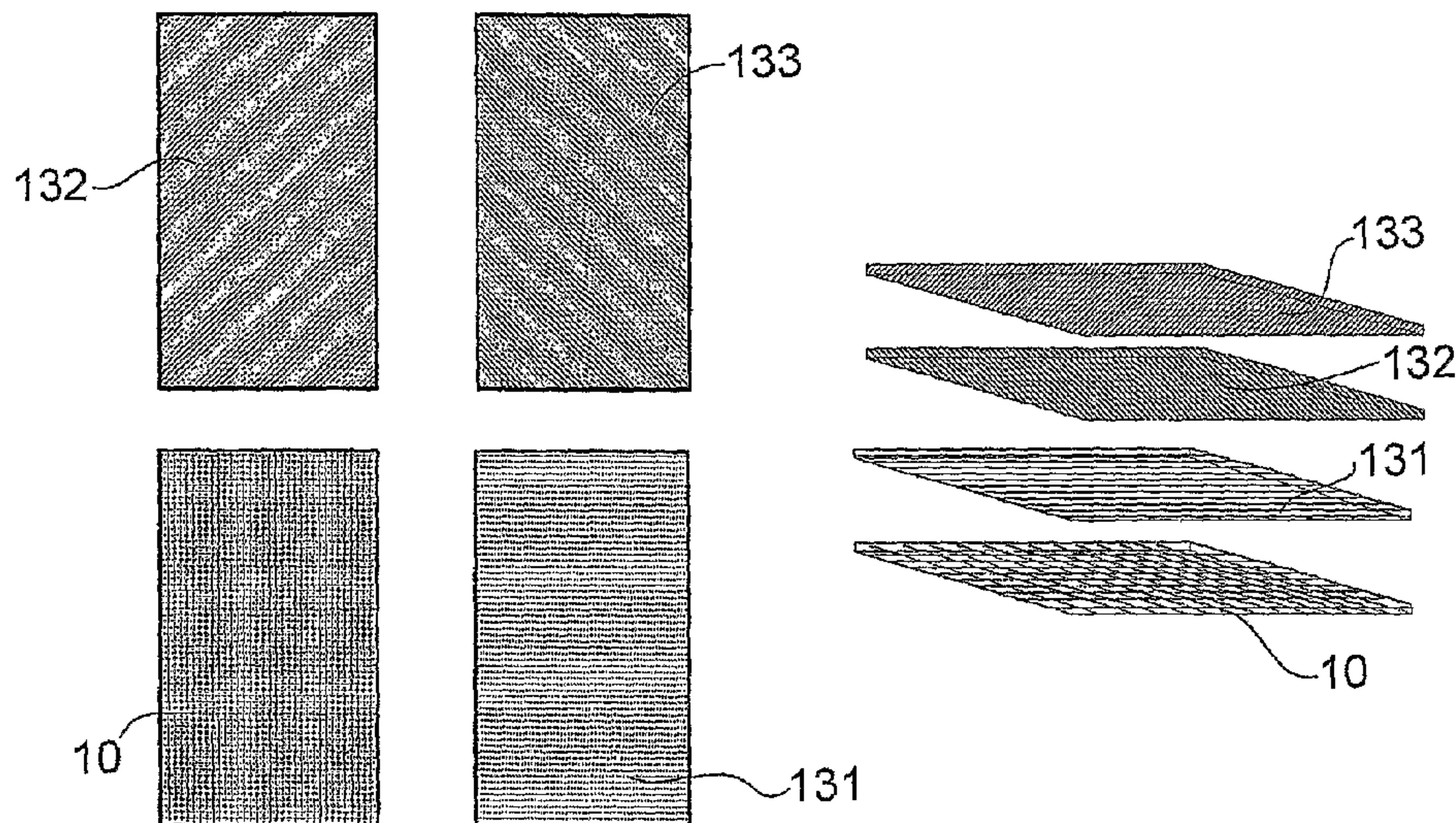




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(57) **Abrégé/Abstract:**

A conveying belt suitable for power turn conveying applications has a multi-layer structure with layers of parallel laid yarns (131, 132, 133) disposed in various angles relative to the machine direction. The parallel yarns (131, 132, 133) are stitchbonded to a multiply interwoven scrim (10) to form a subassembly. A batt of staple fibers is needled to the scrim and the batt and subassembly are encapsulated by a polymer.

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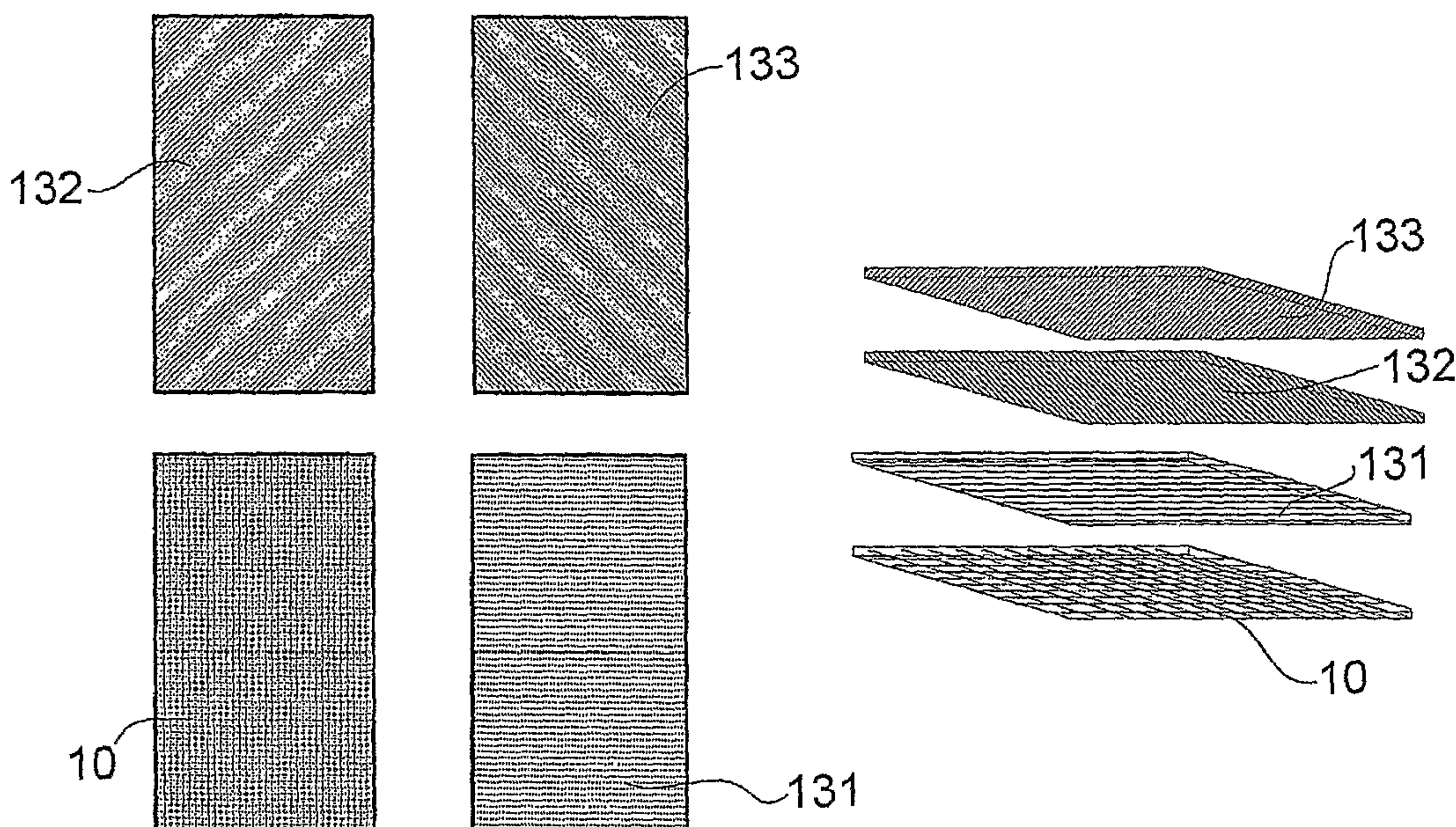
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(57) Abstract: A conveying belt suitable for power turn conveying applications has a multi-layer structure with layers of parallel laid yarns (131, 132, 133) disposed in various angles relative to the machine direction. The parallel yarns (131, 132, 133) are stitch-bonded to a multiply interwoven scrim (10) to form a subassembly. A batt of staple fibers is needled to the scrim and the batt and subassembly are encapsulated by a polymer.

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COMPOSITE CONVEYING BELT**FIELD OF THE INVENTION**

[0002] The present invention relates to conveyor belt applications and specifically, powerturn conveyor belt applications.

BACKGROUND OF THE INVENTION

[0003] Powerturn conveyor belt applications have the following characteristics. The movement of the endless belt around the conveying path includes a curvilinear path with conveying angles ranging from approximately 30° to 180°. As the belt rounds the curve, the principal load axes change continuously and there is no well defined machine direction ("MD") axis. Also, the surface velocity of the belt varies along the radial direction as the belt travels around the curvilinear path. To achieve dimensional stability in powerturn conveyors, certain belt characteristics are desirable such as low to moderate stretch, isotropy in tensile moduli and flexural rigidity within the 2-D belt plane. Accordingly, there is a need for a stronger, lighter belt for powerturn conveyor belt applications.

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US 5 495 935 A discloses a conveyor belting having two woven
scrims connected by staple fibers. In one embodiment, a non-
woven web of staple fibers is needled to the outer surfaces
5 of the scrims and the thusly formed belting is completely
encapsulated in a matrix of elastomeric material.

In US 2 377 650 A, a conveyor belt is shown which comprises a
fabric or cord body and three layers with parallel cords. The
10 parallel cords of the three layers are arranged at different
angles. The cords are all separated from each other by rubber
composition.

EP 0 989 078 A discloses a conveyor belt with reinforcement
15 layers with cords which are connected together through cured
rubbers.

Another conveyor belt of stretchable elastomeric material
reinforced by layers of cords is disclosed in EP 0 046 690 A.
20 The belt is designed with special edges that curl-up under
longitudinal tensile stresses.

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SUMMARY OF THE INVENTION**[0004]**

[0005] The belt design according to the invention enables
5 control of desired directional belting properties, imparts
exceptionally high tear strength, enables lower belt weight,
and enables thinner designs for conveyor belts.

[0006] The conveyor belt includes a scrim having a first
side and a second side. A first plurality of parallel laid
10 yarns are arranged at a first angle relative to a machine
direction. The first yarns overlay on one of the first and
second sides of the scrim. A second plurality of parallel
laid yarns are arranged at a second angle relative to the
machine direction. The second angle is different than the
15 first angle, and the second yarns are disposed in a layer on
top of the first yarns. A third plurality of parallel laid
yarns are arranged at a third angle relative to the machine
direction. The third angle is different from the first and
second angles. The third yarns are disposed in a layer on top
20 of the second yarns. The first, second, and third yarns are
attached to at least one of the first and second sides of the
scrim to form a subassembly having a first and second side. A
fibrous material, in the form of discrete staple fibers
consolidated together through entanglement of the individual
25 fibers, is attached to at least one of the first and second
sides of the subassembly. A polymeric material encapsulates

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the subassembly and the fibrous material to form a conveying belt.

[0007] The modulus and tear strength in multiple directions for the conveying belt of the present invention is superior to
5 conventional belts.

[0007a] In accordance with another aspect of the invention, there is provided a conveyor belting, comprising: a subassembly having a first side and a second side, wherein the subassembly comprises a scrim having a first side and a second
10 side; a batt attached to at least one of the first and second sides of the subassembly; and, a polymeric material encapsulating the subassembly and the batt, wherein the subassembly further comprises a first plurality of parallel laid yarns arranged at a first angle relative to a machine
15 direction, the first yarns overlaid on one of the first and second sides of the scrim; a second plurality of parallel laid yarns arranged at a second angle relative to the machine direction, the second angle being different than the first angle, the second yarns being disposed in a layer on top of the
20 first yarns; a third plurality of parallel laid yarns arranged at a third angle relative to the machine direction, the third angle being different from the first and second angles, the third yarns being disposed in a layer on top of the second yarns; wherein the first, second, and third yarns are attached
25 to at least one of the first and second sides of the scrim.

[0007b] In accordance with another aspect of the invention, there is provided a method for manufacturing a conveyor belting, comprising: providing a scrim having a first side and a second side; overlaying a first plurality of parallel laid

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yarns on at least one of the first and second sides of the scrim, the first yarns being arranged at a first angle relative to a machine direction; placing a second plurality of parallel laid yarns on the first yarns, the second yarns being arranged
5 at a second angle relative to the machine direction; the second angle being different than the first angle; placing a third plurality of parallel laid yarns on the second yarns, the third yarns being arranged at a third angle relative to the machine direction; the third angle being different than the first and
10 second angles; attaching the first, second, and third yarns to at least one of the first and second side of the scrim to form a subassembly having a first side and a second side; attaching a batt to at least one of the first and second side of the subassembly; encapsulating the subassembly and the batt with a
15 polymeric material to form a conveying belt.

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[0008] The present invention may be used in many conveying belt applications including but not limited to powerturn conveying belting applications.

BRIEF DESCRIPTION OF THE DRAWINGS

5 [0009] The invention is illustrated in the drawings in which like reference characters designate the same or similar parts throughout the figures of which:

Fig. 1 is a schematic illustration of the composite showing the layered composition of the present invention;

10 Fig. 2 is a table showing example test results for a powerturn belting made using a reinforcement constructed of a woven scrim stitchbonded to triaxial yarns;

Fig. 3 is a table comparing test results of conventional belting used in powerturn applications against a powerturn
15 belting made using a reinforcement constructed of a woven scrim stitchbonded to triaxial yarns;

Fig. 4 is a radial graph showing tensile moduli at 45° intervals of belt made using conventional woven biaxial reinforcement;

20 Fig. 5 is a radial graph showing the tensile moduli at 45° intervals of a belt made using a balanced conventional woven biaxial reinforcement;

Fig. 6 is a radial graph showing the tensile moduli at 45° intervals of a belt according to the present invention;

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Fig. 7 is an elevational view illustrating the needling of a non-woven web of staple fibers to a scrim;

Fig. 8 is an elevational view illustrating the subassembly moving through a bath of elastomeric material;

5 Fig. 9 is a schematic diagram illustrating a top coat step;

Fig. 10 is a schematic diagram showing the subassembly passing through a heated platen press;

Fig. 11 is a partial plan view of a scrim;

10 Fig. 12 is a cross-sectional view of an interwoven two-ply fabric;

Fig. 13 is a diagrammatic view of a multi-axial yarn feed device;

15 Fig. 14 is a perspective view showing the orientation of the yarns in the woven scrim and parallel laid yarns; and,

Fig. 15 is a side elevational view of one embodiment of the composite belt of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0010] Referring to Fig. 1, the base fabric for the
20 present invention may be a conventional woven scrim 10
(strength member made of woven machine direction yarns and cross-machine direction yarns) or an interwoven design as discussed below. The machine direction yarns and the cross-machine direction yarns are provided in an open weave cloth
25 as the scrim. Any weave may be used including a plain weave as shown in Fig. 11. The weave in Fig. 11 includes machine direction warp yarns 110 and cross machine direction weft yarns 113. The yarn selection, the weave selection and the yarn density of warp and weft yarns is selected so as to
30 achieve a balanced fabric structure of the stitchbonded

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composite. Low thermal shrinkage behavior in yarns is desirable in selection of yarns. Choice between spun, filament or other yarn types is made based on the belt design constraints. Also, the yarns may be selected from a wide
5 variety of synthetic yarns, such as polyester, polyamide, cotton, silk, viscose, rayon and like yarns.

[0011] The nature of the cross-machine direction yarns is as critical as the machine direction yarns, and the yarns may comprise any conventional synthetic yarns. The denier of the
10 machine direction and cross-machine direction yarns can be between 400 denier and 4000 denier without limitation. The density of the weave is selected to provide a scrim weight of from between about 271 g/m² (8 ounces per square yard) to about 814 g/m² (24 ounces per square yard) for optimum
15 strength. The results with a woven scrim and triaxial stitchbonded yarns are discussed below in connection with Fig. 2.

[0012] The woven scrim for the present invention comprises an interwoven multi-ply synthetic fabric shown in Fig. 12.
20 The weave design change from a plain woven scrim to a multi-ply interwoven design allows for increased density in fabric cover resulting from increase in the yarn density in warp and weft yarns. The weave change also facilitates ease of penetration of stitch needles when forming the weft knit
25 stitchbonded composite as described below. As shown there are multiple plies of machine direction warp yarns 150 interwoven with cross machine direction weft yarns 153.

[0013] A plurality of parallel laid yarns 13 having a denier of 400-4000 typical are overlaid on the base fabric or
30 scrim 10 by means of a multiaxial yarn feed device 14 (Fig.

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13). The yarns may be arranged in multiple layers separately at orientation angles from 0° to 180° with respect to the machine direction (0°). An example of an arrangement with triaxial parallel laid yarns 131, 132 and 133 on the scrim 10 is provided in Fig. 14. Other arrangements of the yarns such as quad-axial may also be suitable.

[0014] The parallel laid yarn in multiple layers 13 at different orientation angles may be stitched and/or bonded to the base fabric 10 by means of weft knitting stitch-bonding machines or fused/bonded by other means (i.e., thermal bonding, epoxy adhesives). The bonding between the base fabric and the parallel laid yarn layers in weft knitting technology is achieved by forming stitches using synthetic textured yarns. The resulting composite textile yarn assembly thus may have yarns oriented in many independent directions (formed i.e., 0° , 90° , $+45^{\circ}$, and -45°) and the assembly thus formed acts as the reinforcement member within the textile composite.

[0015] Batts 16, 19 of staple synthetic fibers may be needled to either or both faces of the subassembly 20 created by stitchbonding the parallel laid yarns 13 to the scrim 10. As shown in Fig. 7, the subassembly 20 may be conveyed from a roll 39 onto a conventional conveyor 40 rotating in a clockwise direction, as shown with respect to the orientation of Fig. 1 moving the subassembly 20 from left to right. Discrete staple fibers 42, such as are provided in a non-woven web of fibrous batt may be spread in a generally uniform distribution over the upper surface of the subassembly 20 from a web laying mechanism 44. Multiple layers of fibrous web (batt) are laid onto subassembly 20 in a reciprocating manner to obtain desirable batt fiber weight.

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A needling apparatus 46 serves to consolidate the staple fibers 42 through entanglement and to thereby integrate the staple fibers 42 to the subassembly 20. The batt 16, 19 may be of randomly oriented synthetic carded fibers. As an
5 alternative, the fibers may be directionally oriented within the batt by methods known to those of ordinary skill in the art. The batt of staple synthetic fibers may have an overall weight from between about 67 g/m^2 (2 oz. per square yard) to 3391 g/m^2 (100 oz. per square yard). The staple fibers may
10 have different fineness (denier/dtex) and a range of denier, which is preferred for the yarns in the scrim, may be selected. The batt may be pre-needled using conventional techniques to obtain some integrity of the staple fibers prior to needling the batt to the subassembly. The technique
15 of needling is well-known and the details need not be recited here: see for example U.S. Patent No. 2,059,132 describing conventional needling operations.

The coarseness of the belting needles used, the barb configurations, number, size, and other
20 variables are dependent somewhat on the degree of openness between the textile yarns, so as to avoid rupture of the textile yarns. In general, but not limited to a No. 32 gauge needle is preferred, with the barbs oriented so as not to tear the machine direction yarns. Needling is carried out to
25 produce a needled subassembly. The resulting nonwoven composite is comprised of a reinforcement member made of yarns, sandwiched on both sides by fiber batting 16, 19 where the fiber to fiber entanglement and the fiber to yarn entanglements resulting from the needle-punching process
30 maintains the integrity of the nonwoven composite structure.

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[0016] The needled subassembly 50 may be heat set in an oven (not shown) to thermally stabilize the stitchbonded composite fabric comprising the woven scrim before the nonwoven is subject to the saturation step. During heat setting, the fabric may be tensioned in the machine direction under from between 8.9 kg/m to 393 kg/m (0.5 to 22 lbs per inch). The tensioning obviates wrinkles across the width and along the length of the belting. Heat setting is carried out under hot air temperatures or other methods dependent on the nature of the fibers and yarns employed in the subassembly. Those skilled in the art will know which temperatures to select depending on the materials.

[0017] A wide range of liquid polymeric saturants may be employed for saturation of the belting including acrylonitrile butadiene rubber, styrene-butadiene polymer, poly-butadiene, EPDM, polyurethane, silicone rubber etc. The saturation of the heat set needled subassembly will provide high loading of elastomer, substantially penetrating the stitchbonded base fabric so as to impregnate the fibrous layer. The majority of voids in the stitchbonded base fabric and in the fibrous layer are filled with the elastomeric material so that the elastomer is distributed throughout the body of the final product. The heat set needled subassembly 56 may be calendared by rollers 58 and 60 prior to being guided by rollers 62, 64 and 66 in and out of a vessel or tank 68 containing a solution of the polymerical elastomer material 70. The depth of roller 64 below the level of liquid elastomer 70 may control the exposure time of subassembly 56 to the elastomeric material 70. The subassembly 56 leaving container 68 is now saturated with the liquid elastomeric material 70 and if needed, a fourth roller 72 can be provided

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in conjunction with roller 66 to squeegee or wipe excess liquid elastomer from the belting. It will be appreciated that a single trip through tank 68 may suffice for saturating some beltings, while multiple saturation steps with intermediate squeegeeing or partial drying steps may be required to fully saturate dense fibrous layers in other needed beltings. Curing may be affected by any means appropriate for the polymeric saturant. For example, the belting may be cured by heat for heat curable elastomers. In Fig. 9, a thin topcoat 90 of thermoset acrylic, silicone, polyolefin, polypropylene, polyethylene, PVC, polyurethane, etc., cover may be applied to the top side of the composite assembly to enhance cut and scratch resistance, modify CoF or reduce noise, for example. As shown in Fig. 10, the saturated belting 75 can be passed through a heated platen press 80 at a temperature sufficient to cure the elastomer. Pressures from between about 35153 kg/m² to 140613 kg/m² (50 lbs. per square inch to about 200 lbs per square inch) are practical and illustrative of pressures that may be employed. The saturated belting 75 may be pressed between a top platen 83 and a bottom platen 86 and cured under pressures of from between about 63276 kg/m² to 91399 kg/m² (90 lbs per square inch to 130 lbs per square inch). The addition of the elastomers will further consolidate the non-woven batt and add abrasion resistance. By using a patterned surface impression medium, the belting is molded during curing to mold the impregnated material so as to form at least one plane surface and one surface patterned or with raised portions, i.e., an impression surface. The impression surface is molded to provide a similar appearance and function as the surface of a traditional woven synthetic belt. The raised impression may be of any geometric configuration such as

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semi-hemispheres, bars, grooves etc. and is raised above off the lower portions of the top surface of the belting.

[0018] Turning to Fig. 15, one embodiment of the present invention is shown. The woven substrate 200 is disposed
5 between parallel laid multiaxial yarns 210 and a fibrous batt 220 is needled to both faces. The assembly is encapsulated in an elastomeric material 230.

[0019] Returning to Fig. 2, the physical properties of a composite belt according to the present invention made using
10 an interwoven scrim stitchbonded to triaxial yarns as reinforcement are shown.

[0020] In Fig. 3, a table comparing belting with a 2-ply interwoven polyester fabric stitchbonded to triaxial yarns according to the present invention to two prior art belts A
15 and B is shown. Belt "A" is a conventional plied belting product made of plain woven reinforcement on one face and two-ply interwoven fabric impregnated with elastomer on the other face. Belt "B" is a nonwoven belting product that uses a conventional biaxial woven reinforcement. As shown, the
20 modulus and tear strength in multiple directions is superior for the belt of the present invention considering the reduction in weight and thickness.

[0021] In Fig. 4, a graph shows the tensile moduli (N/mm) at three different extensions for a belt made with
25 conventional woven biaxial reinforcement. The tensile moduli are highest in the machine direction and are far lower in the other directions.

[0022] In Fig. 5, a graph shows the tensile moduli (N/mm) at varying extensions for a belt made with balanced weave

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woven reinforcement. The tensile moduli are balanced in the machine and the cross machine directions, whereas the tensile moduli are much smaller in the bias ($\pm 45^\circ$) directions.

[0023] Fig. 6 illustrates the tensile moduli (N/mm) at
5 varying extensions for a belt according to the present invention. As shown the belt according to the present invention demonstrates significant improvement in isotropy in tensile moduli in 0° , 90° , $+45^\circ$ and -45° directions.

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CLAIMS:

1. Conveyor belting, comprising:

a subassembly having a first side and a second side,
wherein the subassembly comprises a scrim having a first side
5 and a second side;

a batt attached to at least one of the first and
second sides of the subassembly; and,

a polymeric material encapsulating the subassembly
and the batt,

10 wherein the subassembly further comprises

a first plurality of parallel laid yarns arranged at
a first angle relative to a machine direction, the first yarns
overlaid on one of the first and second sides of the scrim;

a second plurality of parallel laid yarns arranged at
15 a second angle relative to the machine direction, the second
angle being different than the first angle, the second yarns
being disposed in a layer on top of the first yarns;

a third plurality of parallel laid yarns arranged at
a third angle relative to the machine direction, the third
20 angle being different from the first and second angles, the
third yarns being disposed in a layer on top of the second
yarns;

wherein the first, second, and third yarns are
attached to at least one of the first and second sides of the
25 scrim.

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2. Conveyor belting according to claim 1, wherein the first plurality of parallel laid yarns have a denier of 400-4000.

3. Conveyor belting according to claim 1 or 2, wherein
5 the scrim has a weight between 271 g/m² and 814 g/m².

4. Conveyor belting according to any one of claims 1 to 3, wherein the first angle is 0°, +45°, -45° or 90°.

5. Conveyor belting according to any one of claims 1 to 3, wherein the first, second, and third angles are +45°,
10 -45° and 90° respectively.

6. Conveyor belting according to any one of claims 1 to 5, wherein the parallel laid yarns are stitch bonded to the scrim.

7. Conveyor belting according to any one of claims 1
15 to 6, wherein the scrim is plain woven.

8. Conveyor belting according to any one of claims 1 to 6, wherein the scrim is a multi-ply interwoven scrim.

9. Conveyor belting according to any one of claims 1 to 8, wherein the batt has a weight between about 67 g/m²
20 to 3391 g/m².

10. Conveyor belting according to any one of claims 1 to 9, wherein the parallel laid yarns are attached to at least one of the first and second sides of the scrim.

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11. Conveyor belting according to any one of claims 1 to 10, wherein the batt is needled to both sides of the subassembly.

12. Conveyor belting according to any one of claims 1 to 11, wherein the parallel laid yarns are triaxial.

13. Conveyor belting according to any one of claims 1 to 11, further comprising a fourth plurality of parallel laid yarns arranged at a fourth angle between 0° and 180° relative to the machine direction, the fourth angle being different from the first, second, and third angles.

14. Conveyor belting according to any one of claims 1 to 13, wherein the batt is formed by staple fibers consolidated together through entanglement of the individual fibers.

15. Method for manufacturing a conveyor belting, comprising:

providing a scrim having a first side and a second side;

overlaying a first plurality of parallel laid yarns on at least one of the first and second sides of the scrim, the first yarns being arranged at a first angle relative to a machine direction;

placing a second plurality of parallel laid yarns on the first yarns, the second yarns being arranged at a second angle relative to the machine direction; the second angle being different than the first angle;

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placing a third plurality of parallel laid yarns on the second yarns, the third yarns being arranged at a third angle relative to the machine direction; the third angle being different than the first and second angles;

5 attaching the first, second, and third yarns to at least one of the first and second side of the scrim to form a subassembly having a first side and a second side;

 attaching a batt to at least one of the first and second side of the subassembly;

10 encapsulating the subassembly and the batt with a polymeric material to form a conveying belt.

16. Method according to claim 15, wherein the scrim is plain woven.

17. Method according to claim 15, wherein the scrim is
15 multi-ply interwoven.

18. Method according to any one of claims 15 to 17, wherein the fibrous materials are attached to the subassembly by needling.

19. Method according to any one of claims 15 to 18,
20 wherein the subassembly and the batt are heat set.

20. Method according to claim 19, wherein the heat set subassembly and batt are encapsulated by saturation with a liquid polymer to form a saturated belting.

21. Method according to claim 20, wherein the heat set
25 subassembly and batt are calendered.

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22. Method according to claim 20 or 21, wherein the saturated belting is passed through a heated platen press at a temperature sufficient to cure the elastomer.

23. Method according to any one of claims 15 to 22,
5 wherein the conveying belt is provided with a conveying surface having at least one plane surface with discontinuities disposed thereon to emulate the appearance of the surface of a woven synthetic belt.

24. Method according to any one of claims 15 to 23,
10 wherein the first, second, and third yarns are attached to at least one of the first and second sides of the scrim.

25. Method according to any one of claims 15 to 24, wherein the batt is attached to both sides of the subassembly.

26. Method according to any one of claims 15 to 25,
15 wherein the first, second, and third angles are $+45^\circ$, -45° , and 90° respectively.

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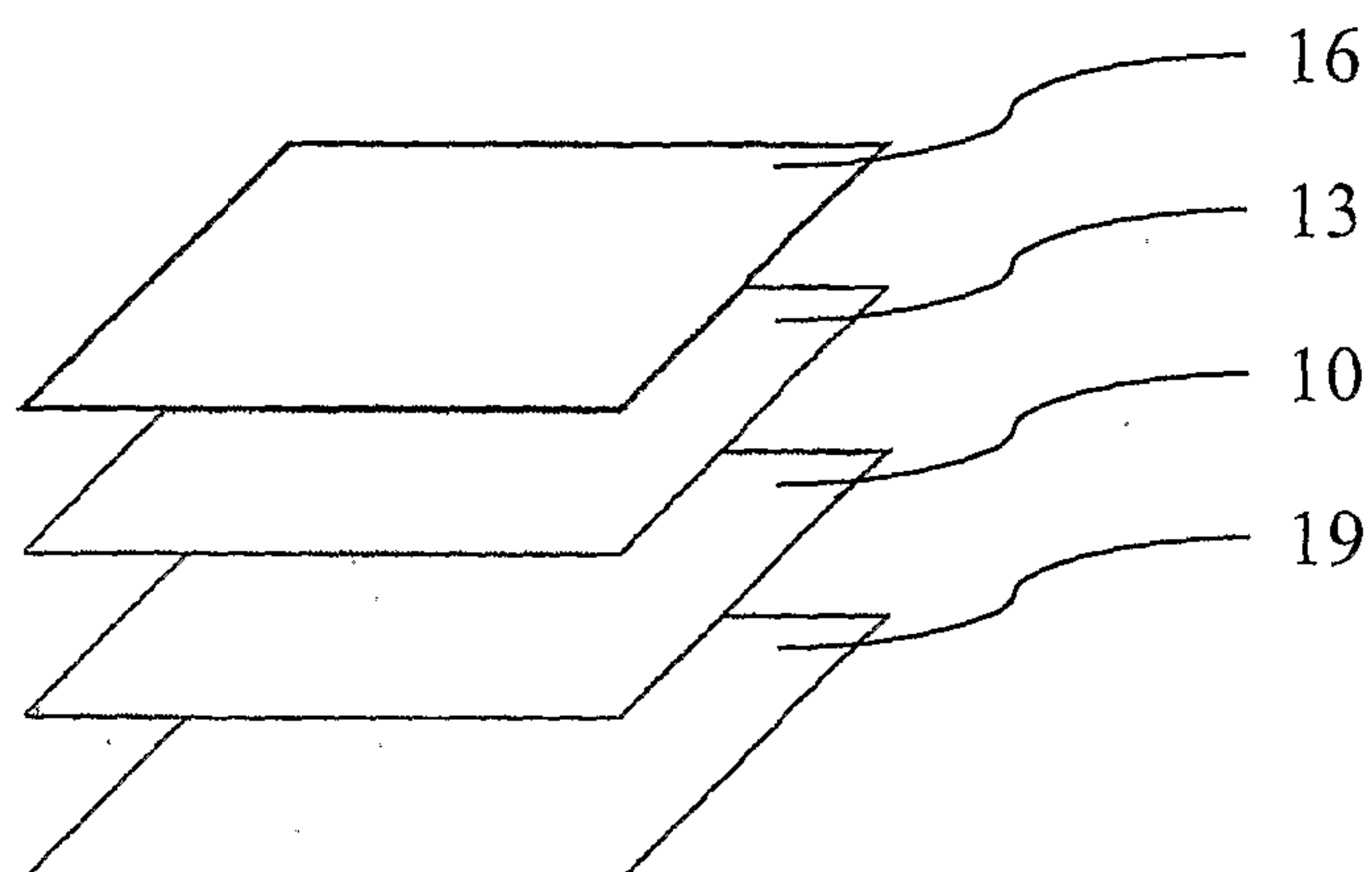


Fig. 1

Orientation Angles (MD = 0°)	0°	90°	-45°	+45°
Belt Weight	0.55 oz/ft ² , 2.7 kg/m ²			
Belt Thickness	0.110 inch, 2.8 mm			
Coefficient of Friction – Top Surface	0.45			
Coefficient of Friction – Bottom Surface	0.22			
Tear Resistance (lbf)	334	203	278	227
Tear Resistance (N)	1516	922	1262	1030
Load @1.5% extension (lbf/inch)	140	101	60	65
Load @1.5% extension (N/mm)	25	18	10.7	11.6

Fig. 2

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	Present Invention	Prior Art "A"	Prior Art "B"					
Belt Weight (oz/ft ² ; kg/m ²)	0.55, 2.7	1.05, 5.1	0.93, 4.5					
Belt Thickness (inch, mm)	0.110, 2.8	0.180, 4.6	0.150, 3.8					
Coefficient of Friction – Top Surface	0.45	0.22	0.30					
Coefficient of Friction – Bottom Surface	0.22	0.19	0.29					
	Tear Resistance (N)				Load @1.5% extension (N/mm)			
Orientation Angles (MD = 0°)	0°	90°	+ 45°	- 45°	0°	90°	+ 45°	- 45°
Present Invention	1516	922	1262	1030	25	18	10.7	11.6
Prior Art "A"	2286	1321	1422	1448	20	8.8	4.5	3.8
Prior Art "B"	244	401	249	323	12	1.9	2.3	2.3

Fig. 3

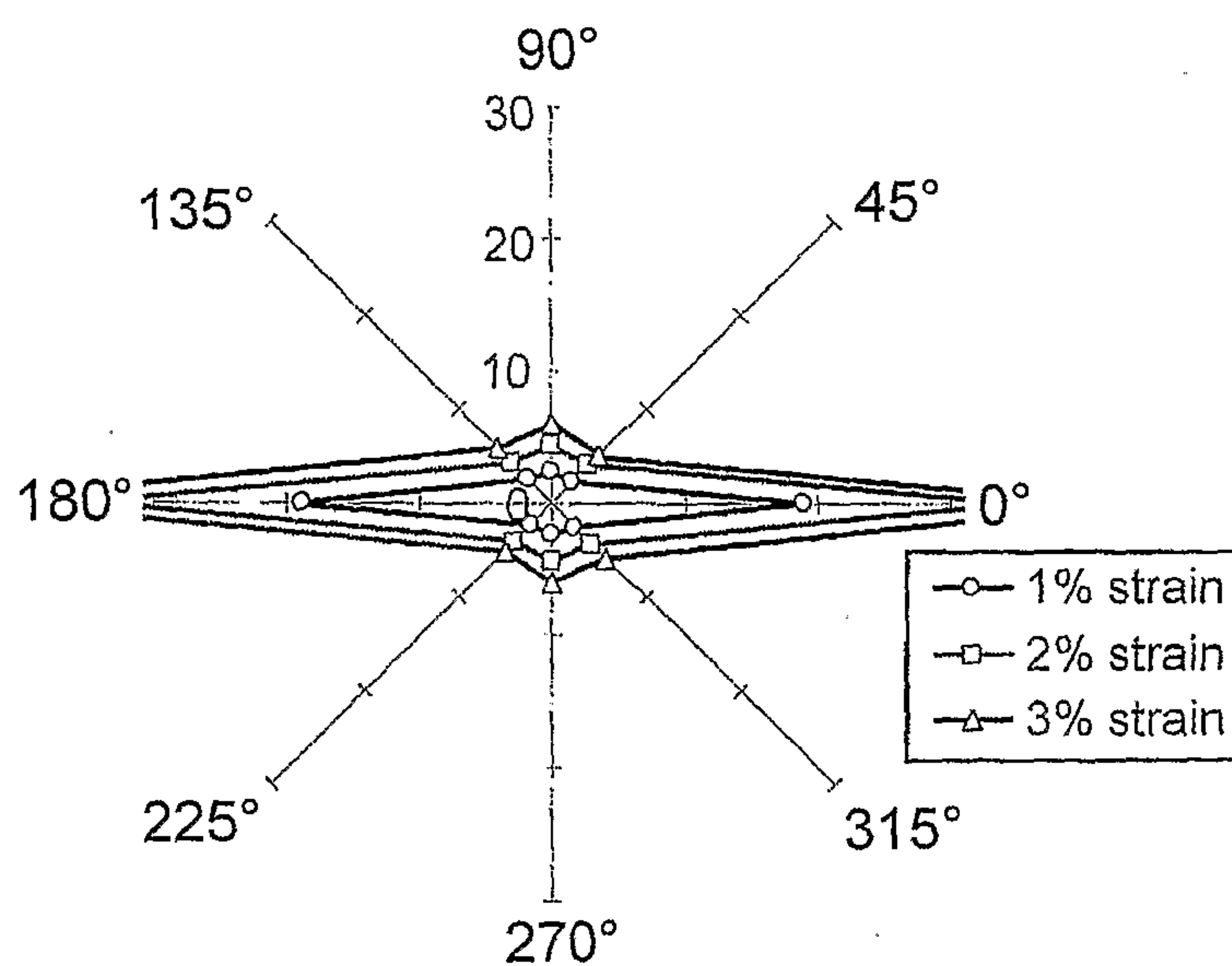


Fig. 4

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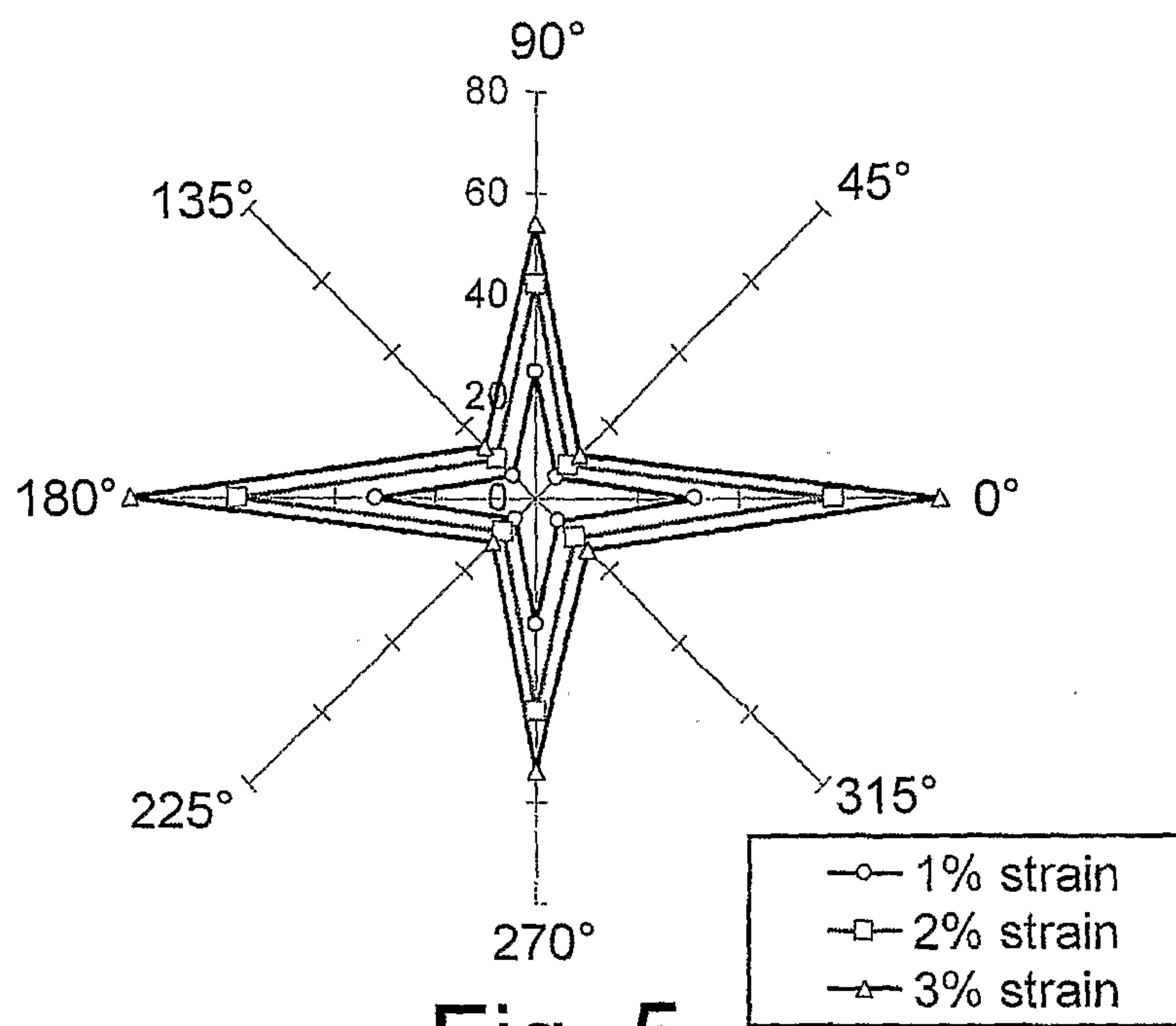


Fig. 5

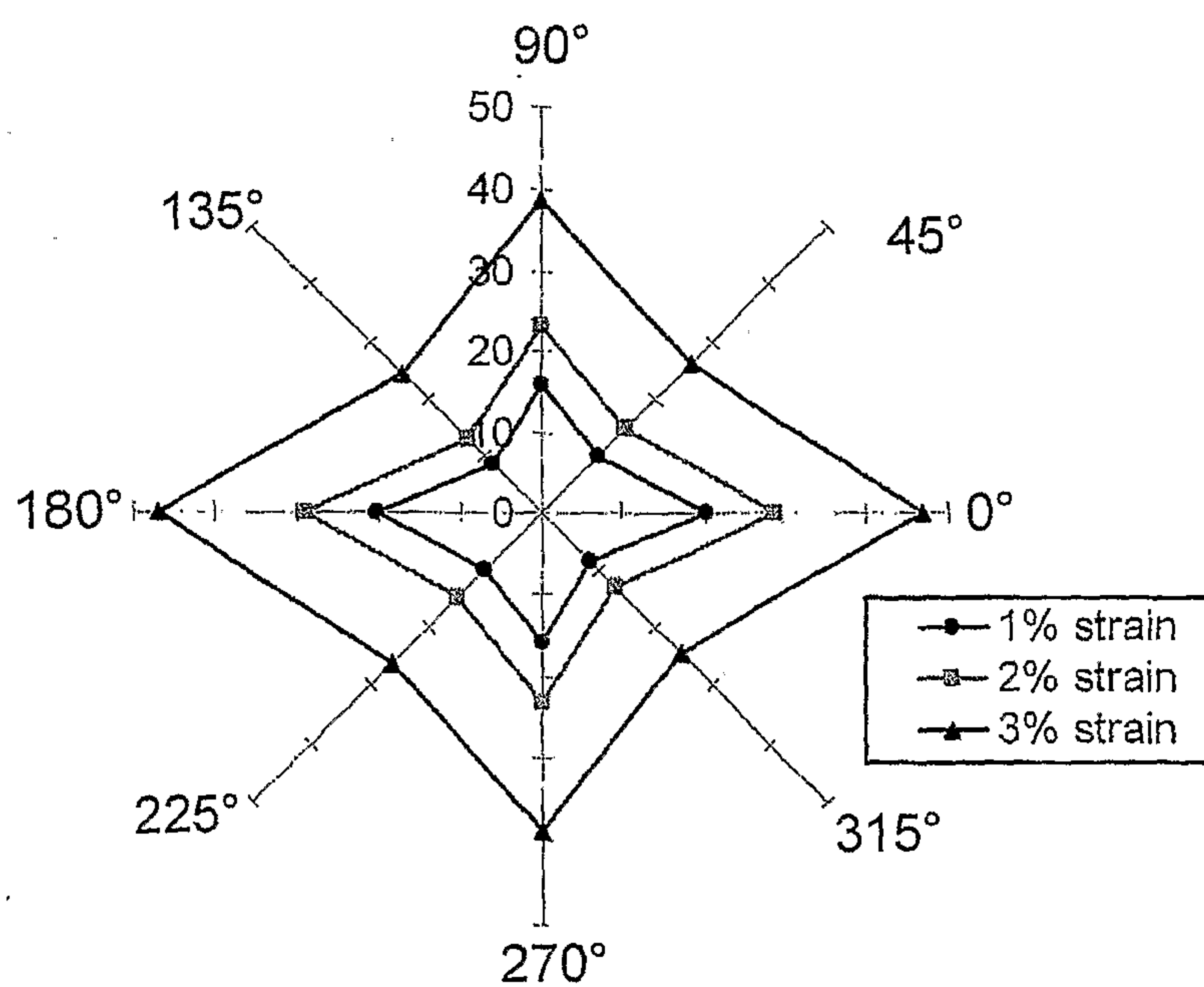
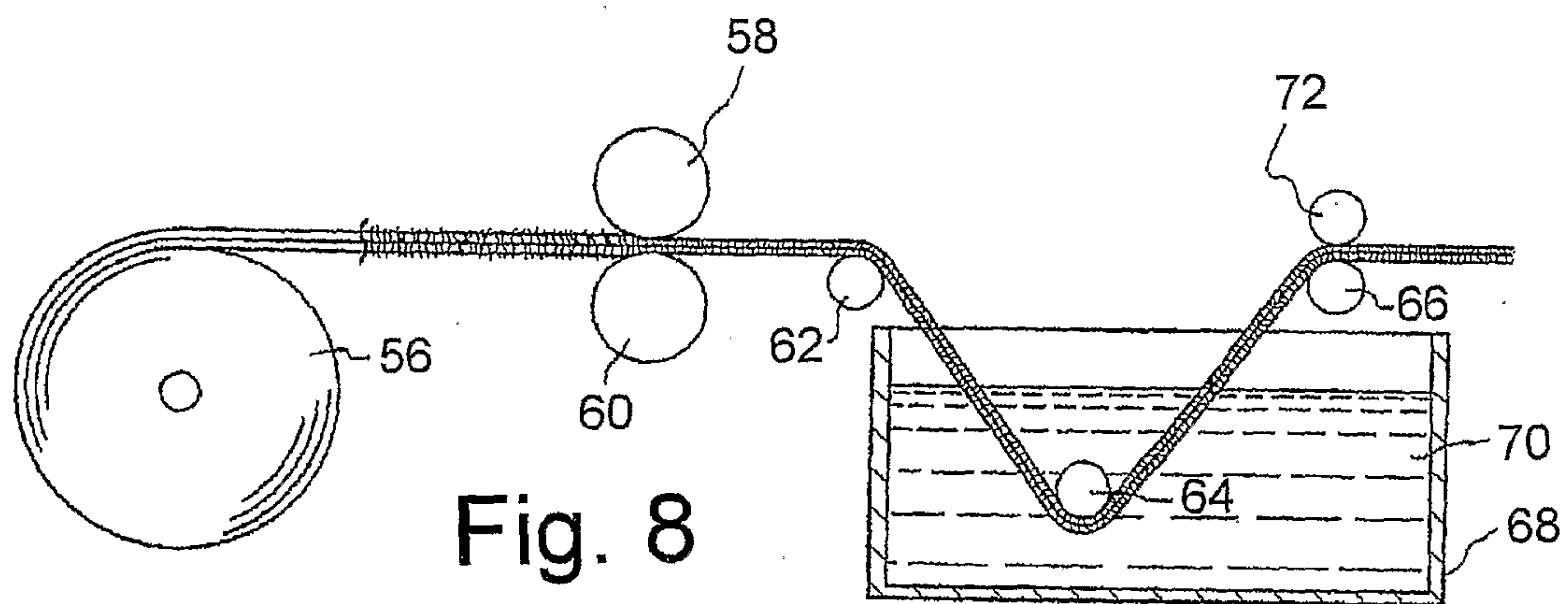
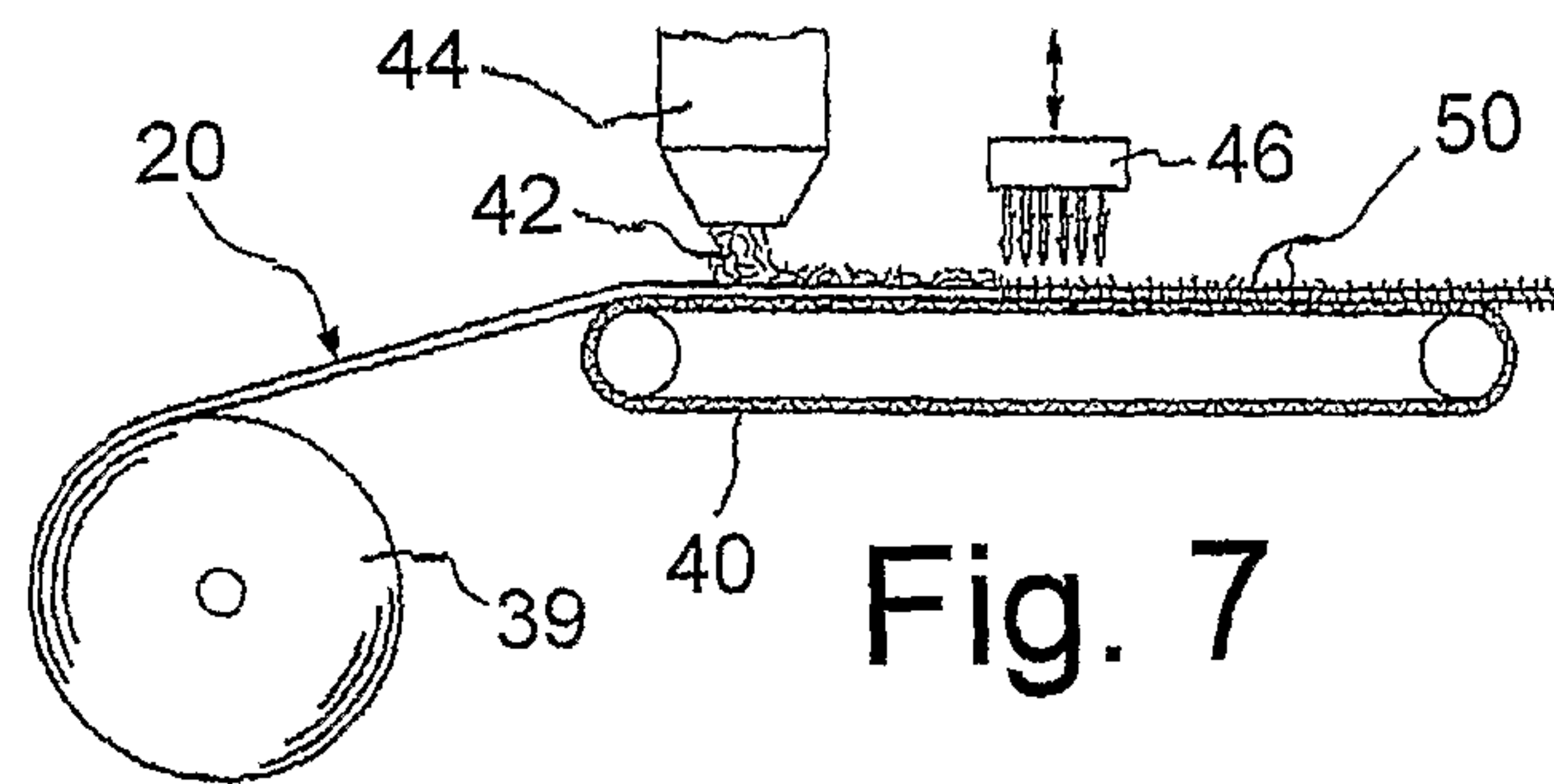


Fig. 6

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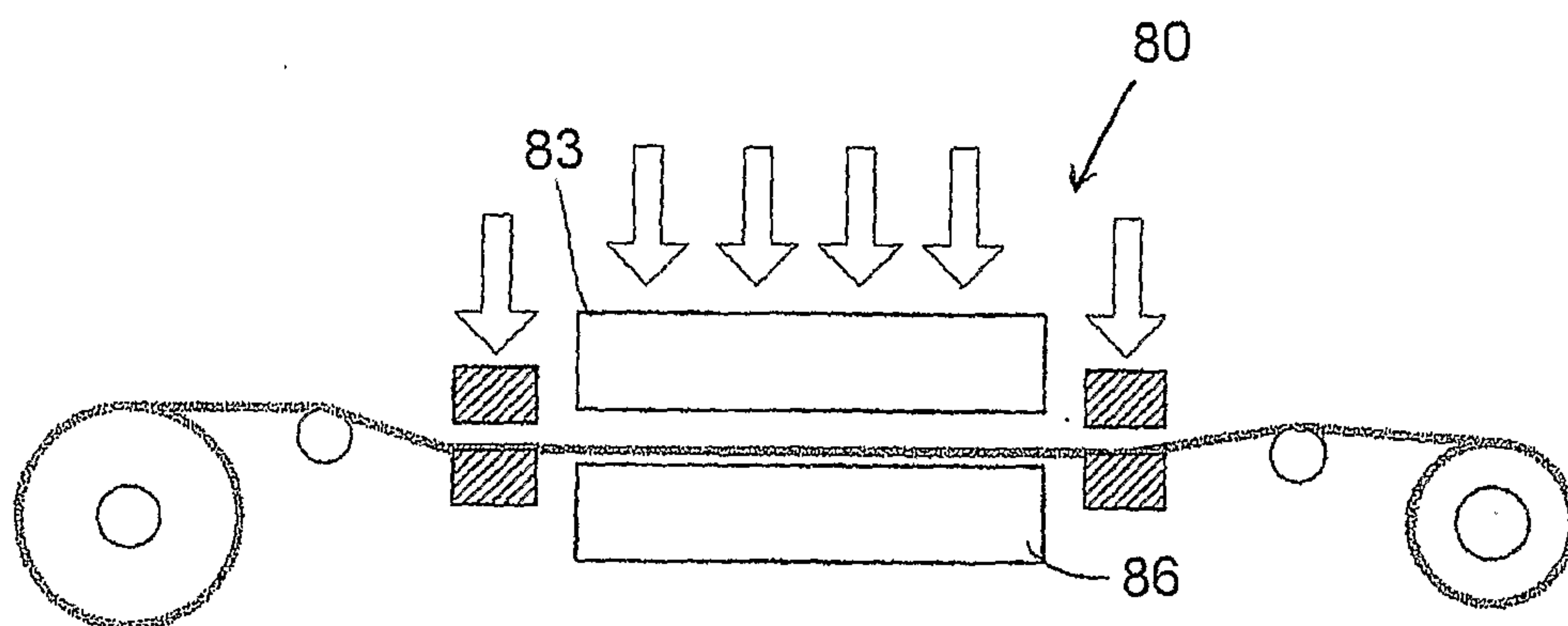


Fig. 10

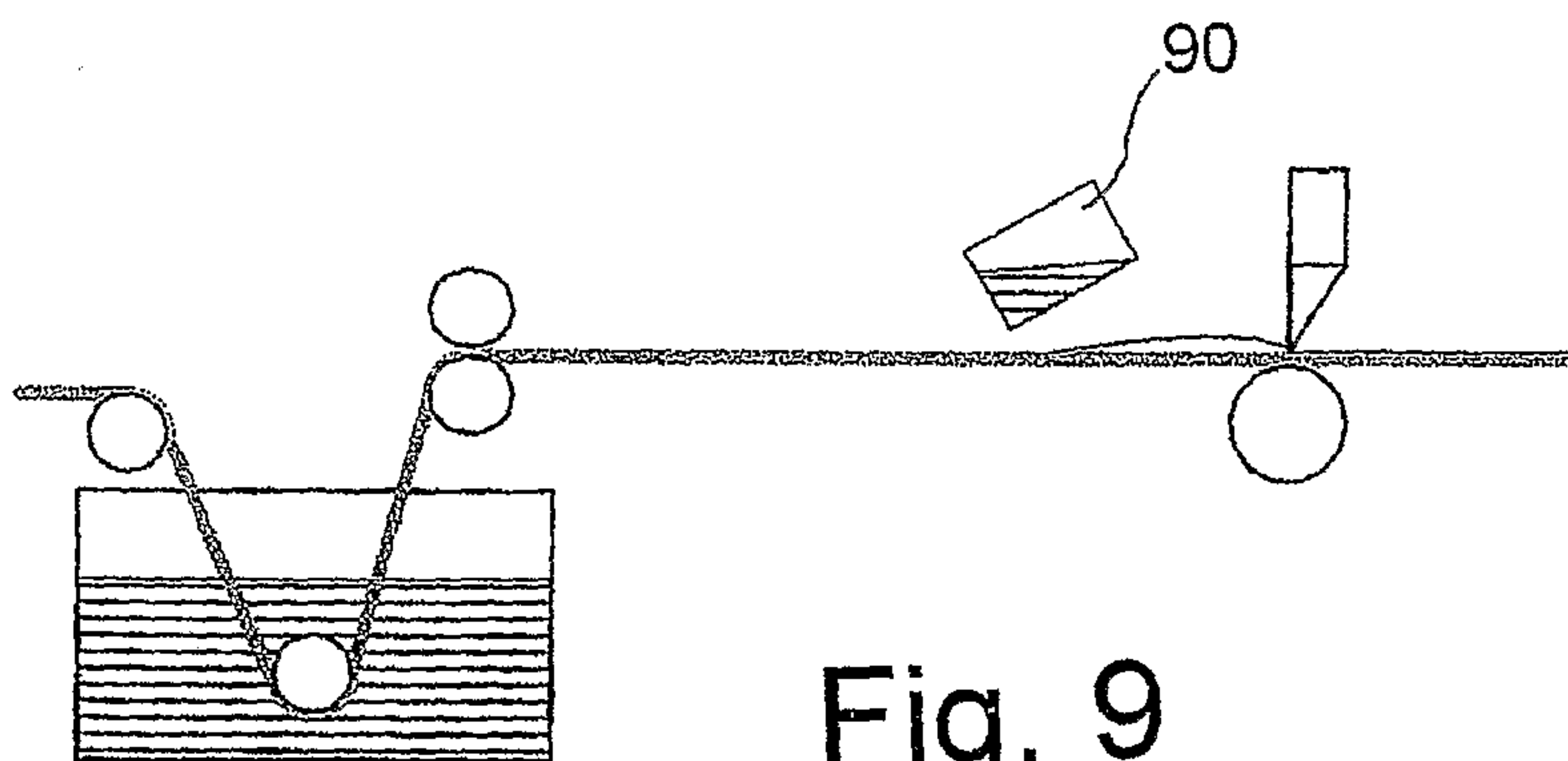


Fig. 9

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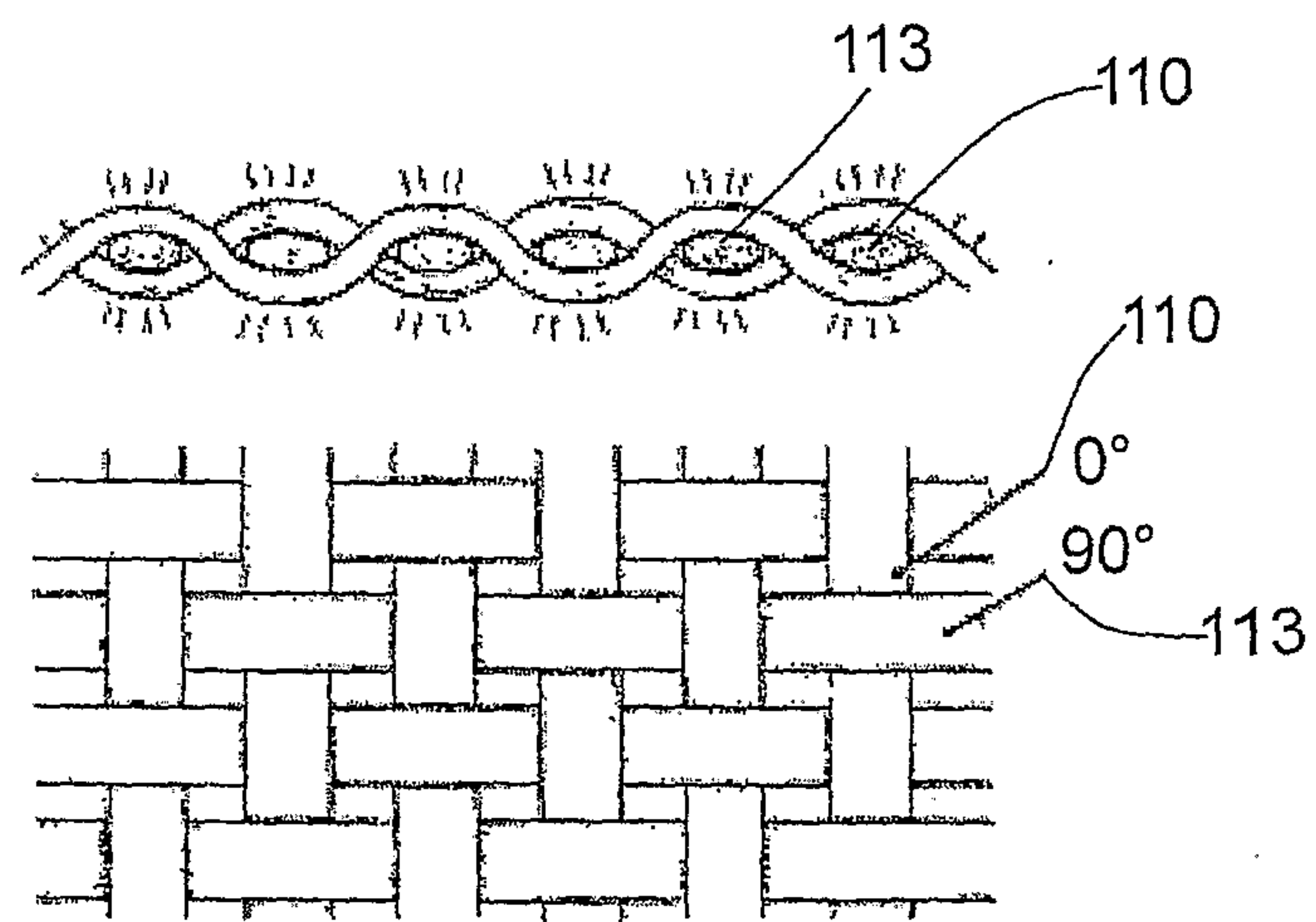


Fig. 11

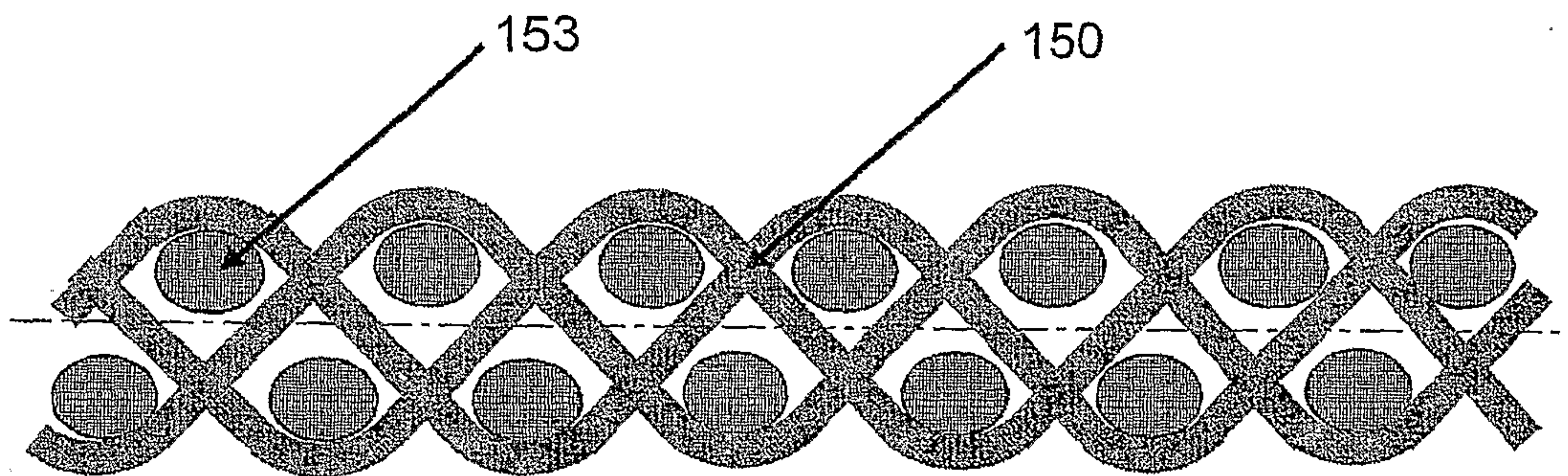


Fig. 12

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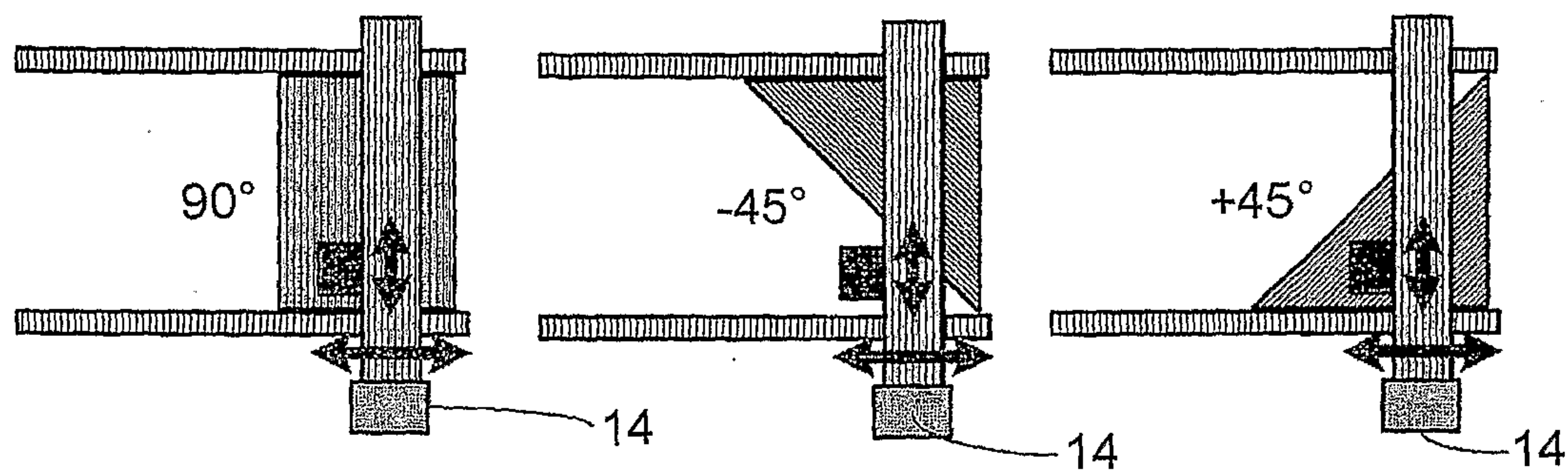


Fig. 13

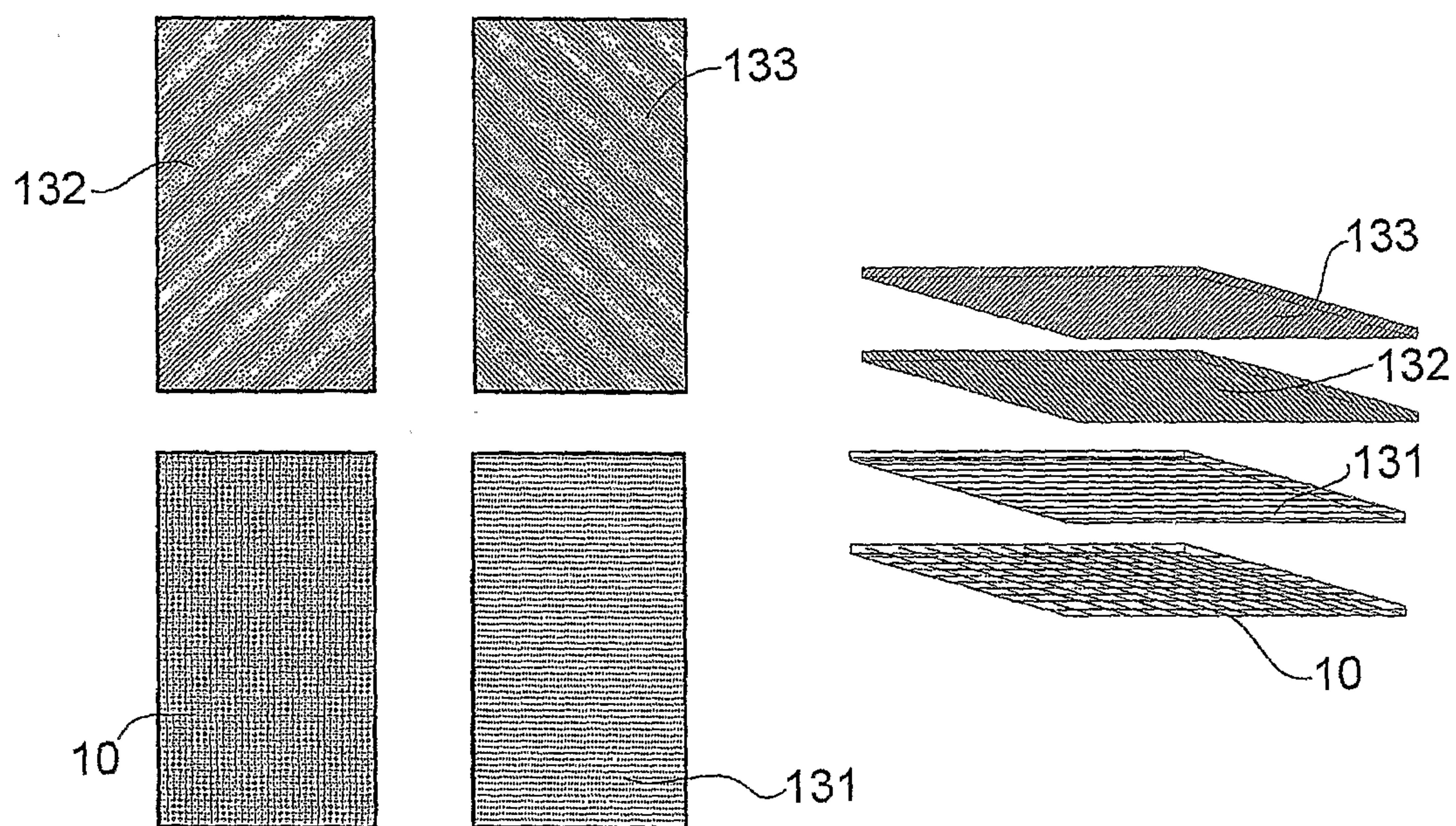


Fig. 14

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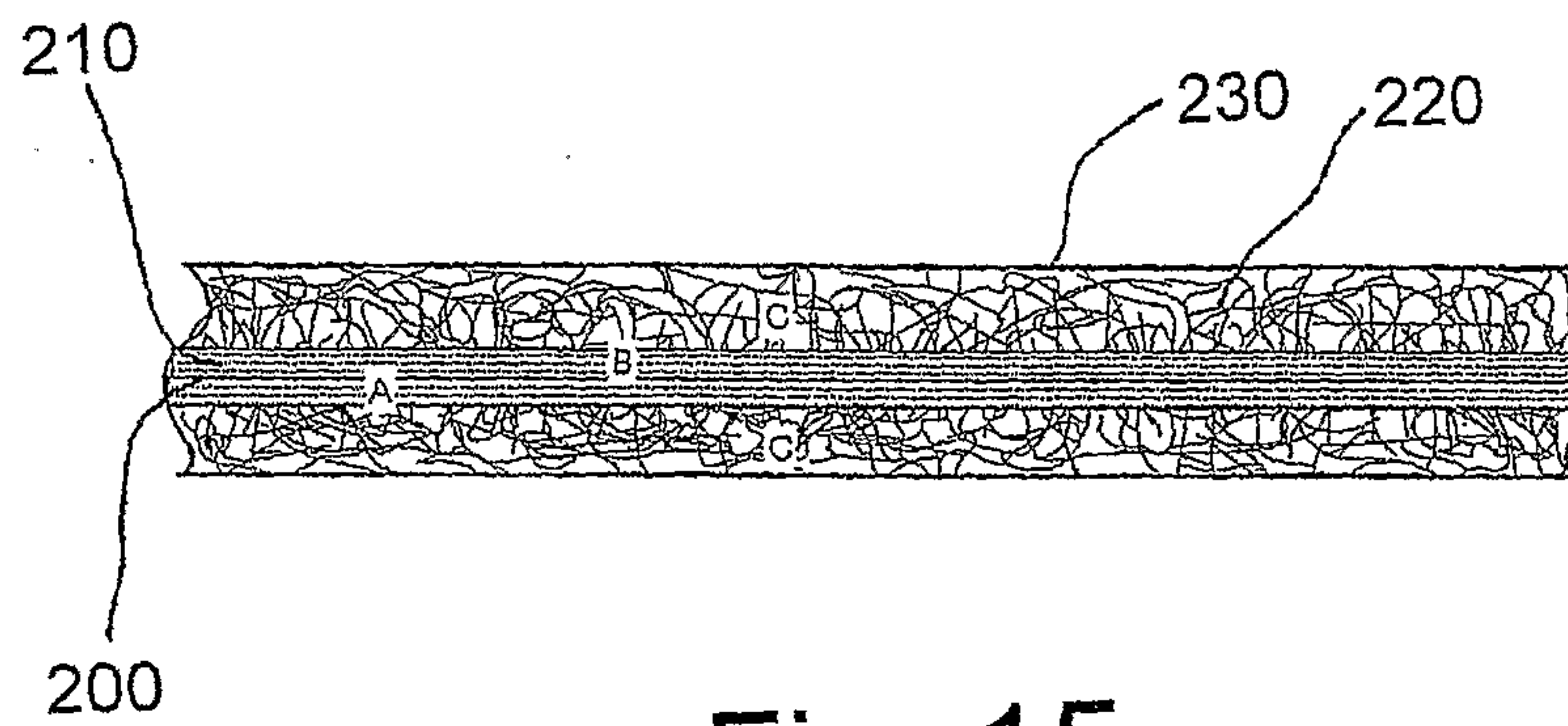


Fig. 15

