



(86) Date de dépôt PCT/PCT Filing Date: 2005/01/19  
(87) Date publication PCT/PCT Publication Date: 2005/08/18  
(85) Entrée phase nationale/National Entry: 2006/07/25  
(86) N° demande PCT/PCT Application No.: EP 2005/050203  
(87) N° publication PCT/PCT Publication No.: 2005/075737  
(30) Priorité/Priority: 2004/01/30 (US10/768,550)

(51) Cl.Int./Int.Cl. *D21F 11/00* (2006.01),  
*D21F 9/00* (2006.01), *D21F 11/14* (2006.01)  
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(54) Titre : APPAREIL ET PROCEDE DE FORMATION D'UNE BANDE DE MATIERE SUR UN TISSU STRUCTURE  
DANS UNE MACHINE A PAPIER  
(54) Title: APPARATUS FOR AND PROCESS OF MATERIAL WEB FORMATION ON A STRUCTURED FABRIC IN A  
PAPER MACHINE

(57) **Abrégé/Abstract:**

A method of forming a structured web including the steps of providing a fiber slurry through a headbox (22) to a nip formed by a structured fabric (28) and a forming fabric (26) and collecting fibers from the fiber slurry in at least one valley of the structured fabric.



## (12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
18 August 2005 (18.08.2005)

PCT

(10) International Publication Number  
**WO 2005/075737 A1**

(51) International Patent Classification<sup>7</sup>: **D21F 11/00**,  
11/14, 9/00

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(21) International Application Number:  
PCT/EP2005/050203

(22) International Filing Date: 19 January 2005 (19.01.2005)

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(25) Filing Language: English

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(26) Publication Language: English

(30) Priority Data:  
10/768,550 30 January 2004 (30.01.2004) US

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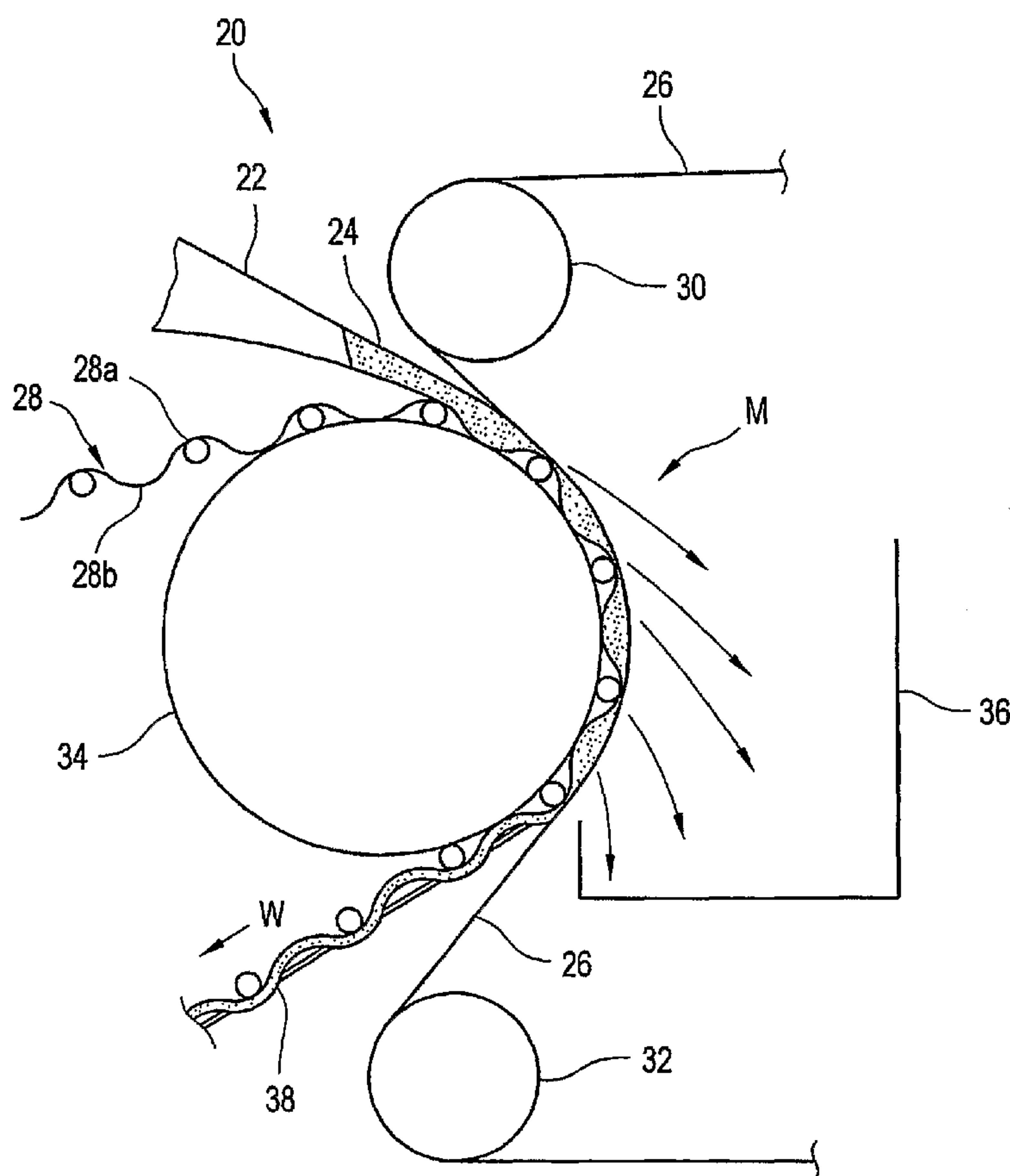
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(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH,

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[Continued on next page]

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WO 2005/075737 A1

**WO 2005/075737 A1**

GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Published:**

— *with international search report*

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

**APPARATUS FOR AND PROCESS OF MATERIAL WEB FORMATION ON A  
STRUCTURED FABRIC IN A PAPER MACHINE**

**BACKGROUND OF THE INVENTION**

**5    1. Field of the invention.**

The present invention relates to a method of forming a structured fiber web on a paper machine, and, more particularly, to a method and apparatus of forming a structured fiber web on a structured fabric in a paper machine.

**10    2. Description of the related art.**

In a wet molding process, a structured fabric in a Crescent Former configuration impresses a three dimensional surface on a web while the fibrous web is still wet. Such an invention is disclosed in International Publication No. WO 03/062528 A1. A suction box is disclosed for the purpose of shaping the fibrous web while wet to generate the three dimensional structure by removing air through the structural fabric. It is a physical displacement of portions of the fibrous web that leads to the three dimensional surface. Similar to the aforementioned method, a through air drying (TAD) technique is disclosed in U.S. Patent No. 4,191,609. The TAD technique discloses how an already formed web is transferred and molded into an impression fabric. The transformation takes place on a web having a sheet solids level greater than 15%. This results in a low density pillow area in the fibrous web. These pillow areas are of a low basis weight since the already formed web is expanded to fill the valleys thereof. The impression of the fibrous web into a pattern, on an impression fabric, is carried out by passing a vacuum through the impression fabric to mold the fibrous web.

What is needed in the art is a method to produce a fibrous web with a high basis weight pillow area of low density to thereby increase the absorption and bulk characteristics of the finished fibrous web.

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### **SUMMARY OF THE INVENTION**

The present invention provides a method of producing a structured fibrous web having a high basis weight pillow area of low density on a paper machine using a structured fabric.

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The invention comprises, in one form thereof, a method of forming a structured web including the steps of providing a fiber slurry through a headbox to a nip formed by a structured fabric and a forming fabric and collecting fibers from the fiber slurry in at least one valley of the structured fabric.

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An advantage of the present invention is that the low density pillow areas have a relatively higher fiber basis weight than that provided with other methods.

Another advantage is that the ratio of the uncompressed fiber mass to the compressed fiber mass is much higher, with the same overall basis weight than was achievable in the prior art.

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Yet another advantage is that the fibrous web formed by the method of the present invention allows for a superior transfer of the web to a Yankee drying surface.

Still yet another advantage of the present invention is that hood associated with the Yankee dryer can utilize a higher temperature for drying the pillow portions of the fibrous web, without burning the pillow portions.

5 An additional advantage of the present invention is that the structured fabric can have deeper valleys or pockets than a prior art fabric, since the pillow portions of the fibrous web are thicker and have a higher basis weight, eliminating the pin hole problems associated with prior art methods, which results in a thicker more absorbent web.

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### **BRIEF DESCRIPTION OF THE DRAWINGS**

The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings, wherein:

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Fig. 1 is a cross-sectional schematic diagram illustrating the formation of a structured web using an embodiment of a method of the present invention;

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Fig. 2 is a cross-sectional view of a portion of a structured web of a prior art method;

Fig. 3 is a cross-sectional view of a portion of the structured web of an embodiment of the present invention as made on the machine of Fig. 1;

Fig. 4 illustrates the web portion of Fig. 2 having subsequently gone through a press drying operation;

Fig. 5 illustrates a portion of the fiber web of the present invention of Fig. 3 having subsequently gone through a press drying operation;

5 Fig. 6 illustrates a resulting fiber web of the forming section of the present invention;

Fig. 7 illustrates the resulting fiber web of the forming section of a prior art method;

Fig. 8 illustrates the moisture removal of the fiber web of the present invention;

10 Fig. 9 illustrates the moisture removal of the fiber web of a prior art structured web;

Fig. 10 illustrates the pressing points on a fiber web of the present invention;

Fig. 11 illustrates pressing points of prior art structured web;

15 Fig. 12 illustrates a schematical cross-sectional view of an embodiment of a papermaking machine of the present invention;

Fig. 13 illustrates a schematical cross-sectional view of another embodiment of a papermaking machine of the present invention;

Fig. 14 illustrates a schematical cross-sectional view of another embodiment of a papermaking machine of the present invention;

20 Fig. 15 illustrates a schematical cross-sectional view of another embodiment of a papermaking machine of the present invention;

Fig. 16 illustrates a schematical cross-sectional view of another embodiment of a papermaking machine of the present invention;

Fig. 17 illustrates a schematical cross-sectional view of another embodiment of a papermaking machine of the present invention; and

Fig. 18 illustrates a schematical cross-sectional view of another embodiment of a papermaking machine of the present invention.

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Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate one preferred embodiment of the invention, in one form, and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

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#### **DETAILED DESCRIPTION OF THE INVENTION**

Referring now to the drawings, and more particularly to Fig. 1, there is a fibrous web machine 20 including a headbox 22 that discharges a fibrous slurry 24 between a forming fabric 26 and a structured fabric 28. Rollers 30 and 32 direct fabric 26 in such a manner that tension is applied thereto, against slurry 24 and structured fabric 28.

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Structured fabric 28 is supported by forming roll 34 which rotates with a surface speed that matches the speed of structured fabric 28 and forming fabric 26. Structured fabric 28 has peaks 28a and valleys 28b, which give a corresponding structure to web 38 formed thereon. Structured fabric 28 travels in direction W, and as moisture M is driven from fibrous slurry 24, structured fibrous web 38 takes form. Moisture M that leaves slurry 24 travels through forming fabric 26 and is collected in sash 36. Fibers in fibrous slurry 24 collect predominately in valleys 28b as web 38 takes form.

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Structured fabric 28 includes warp and weft yarns interwoven on a textile loom. Structured fabric 28 may be woven flat or in an endless form. The final mesh count of structured fabric 28 lies between 95 x 120 and 26 x 20. For the manufacture of toilet tissue, the preferred mesh count is 51 x 36 or higher and more preferably 58 x 44 or higher. For the manufacturer of paper towels, the preferred mesh count is 42 x 31 or lower, and more preferably 36 x 30 or lower. Structured fabric 28 may have a repeated pattern of 4 shed and above repeats, preferably 5 shed or greater repeats. The warp yarns of structured fabric 28 have diameters of between 0.12 mm and 0.70 mm, and weft yarns have diameters of between 0.15 mm and 0.60 mm. The pocket depth, which is the offset between peak 28a and valley 28b is between approximately 0.07 mm and 0.60 mm. Yarns utilized in structured fabric 28 may be of any cross-sectional shape, for example, round, oval or flat. The yarns of structured fabric 28 can be made of thermoplastic or thermoset polymeric materials of any color. The surface of structured fabric 28 can be treated to provide a desired surface energy, thermal resistance, abrasion resistance and/or hydrolysis resistance. A printed design, such as a screen printed design, of polymeric material can be applied to structured fabric 28 to enhance its ability to impart an aesthetic pattern into web 38 or to enhance the quality of web 38. Such a design may be in the form of an elastomeric cast structure similar to the Spectra<sup>®</sup> membrane described in another patent application. Structured fabric 28 has a top surface plane contact area at peak 28a of 10% or higher, preferably 20% or higher, and more preferably 30% depending upon the particular product being made. The contact area on structured web 28 at peak 28a can be increased by abrading the top surface of structured fabric 28 or an elastomeric cast structure can be formed thereon

having a flat top surface. The top surface may also be hot calendered to increase the flatness.

Forming roll 34 is preferably solid. Moisture travels through forming fiber 26 but  
5 not through structured fabric 28. This advantageously forms structured fibrous web 38 into a more bulky or absorbent web than the prior art.

Prior art methods of moisture removal, remove moisture through a structured fabric by way of negative pressure. It results in a cross-sectional view as seen in Fig. 2.  
10 Prior art structured web 40 has a pocket depth D which corresponds to the dimensional difference between a valley and a peak. The valley occurring at the point where measurement C occurs and the peak occurring at the point where measurement A is taken. A top surface thickness A is formed in the prior art method. Sidewall dimension B and pillow thickness C of the prior art result from moisture drawn through a structured  
15 fabric. Dimension B is less than dimension A and dimension C is less than dimension B in the prior art structure.

In contrast, structured web 38, as illustrated in Figs. 3 and 5, have for discussion purposes, a pocket depth D that is similar to the prior art. However, sidewall thickness  
20 B' and pillow thickness C' exceed the comparable dimensions of web 40. This advantageously results from the forming of structural web 38 on structured fabric 28 at low consistency and the removal of moisture is an opposite direction from the prior art. This results in a thicker pillow dimension C'. Even after fiber web 38 goes through a drying press operation, as illustrated in Fig. 5, dimension C' is substantially greater than

A<sub>p</sub>'. Advantageously, the fiber web resulting from the present invention has a higher basis weight in the pillow areas as compared to prior art. Also, the fiber to fiber bonds are not broken as they can be in impression operations, which expand the web into the valleys.

5

According to prior art an already formed web is vacuum transferred into a structured fabric. The sheet must then expand to fill the contour of the structured fabric. In doing so, fibers must move apart. Thus the basis weight is lower in these pillow areas and therefore the thickness is less than the sheet at point A.

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Now, referring to Fig's 6 to 11 the process will be explained by simplified schematic drawings.

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As shown in Fig. 6, fibrous slurry 24 is formed into a web 38 with a structure inherent in the shape of structured fabric 28. Forming fabric 26 is porous and allows moisture to escape during forming. Further, water is removed as shown in Fig. 8, through dewatering fabric 82. The removal of moisture through fabric 82 does not cause a compression of pillow areas C' in the forming web, since pillow areas C' reside in the structure of structured fabric 28.

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The prior art web 40 shown in Fig. 7, is formed with a conventional forming fabric as between two conventional forming fabrics in a twin wire former and is characterized by a flat uniform surface. It is this fiber web that is given a three-dimensional structure by a wet shaping stage, which results in the fiber web that is shown in Fig. 2. A

conventional tissue machine that employs a conventional press fabric will have a contact area approaching 100%. Normal contact area of the structured fiber, as in this present invention, or as on a TAD machine, is typically much lower than that of a conventional machine, it is in the range of 15 to 35% depending on the particular pattern of the product being made.

In Figs. 9 and 11 a prior art web structure is shown where moisture is drawn through a structured fabric 33 causing the web, as shown in Fig. 7, to be shaped and causing pillow area C to have a low basis weight as the fibers in the web are drawn into the structure. The shaping can be done by performing pressure or underpressure to the web 40 forcing the web 40 to follow the structure of the structured fabric 33. This additionally causes fiber tearing as they are moved into pillow area C. Subsequent pressing at the Yankee dryer 52, as shown in Fig. 11, further reduces the basis weight in area C. In contrast, water is drawn through dewatering fabric 82 in the present invention, as shown in Fig. 8, preserving pillow area C'. Pillow areas C' of Fig. 10, is an unpressed zone, which is supported on structured fabric 28, while pressed against Yankee 52. Pressed zone A' is the area through which most of the pressure applied is transferred. Pillow area C' has a higher basis weight than that of the illustrated prior art structures.

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The increased mass ratio of the present invention, particularly the higher basis weight in the pillow areas carries more water than the compressed areas, resulting in at least two positive aspects of the present invention over the prior art, as illustrated in Figs. 10 and 11. First, it allows for a good transfer of the web to the Yankee surface 52,

since the web has a relatively lower basis weight in the portion that comes in contact with the Yankee surface 52, at a lower overall sheet solid content than had been previously attainable, because of the lower mass of fibers that comes in contact with the Yankee dryer 52. The lower basis weight means that less water is carried to the contact points with the Yankee dryer 52. The compressed areas are dryer than the pillow areas, thereby allowing an overall transfer of the web to another surface, such as a Yankee dryer 52, with a lower overall web solids content. Secondly, the construct allows for the use of higher temperatures in the Yankee hood 54 without scorching or burning of the pillow areas, which occurs in the prior art pillow areas. The Yankee hood 54 temperatures are often greater than 350° C and preferably greater than 450° C and even more preferably greater than 550° C. As a result the present invention can operate at lower average pre-Yankee press solids than the prior art, making more full use of the capacity of the Yankee Hood drying system. The present invention can allow the solids content of web 38 prior to the Yankee dryer to run at less than 40%, less than 35% and even as low as 25%.

Due to the formation of the web 38 with the structured fabric 28 the pockets of the fabric 28 are fully filled with fibres.

Therefore, at the Yankee surface 52 the web 38 has a much higher contact area, up to approx. 100 %, as compared to the prior art because the web 38 on the side contacting the Yankee surface 52 is almost flat. At the same time the pillow areas C' of the web 38 maintain unpressed, because they are protected by the valleys of the

structured fabric 28 (Fig. 10). Good results in drying efficiency were obtained only pressing 25 % of the web.

As can be seen in Fig. 11 the contact area of the prior art web 40 to the Yankee surface 52 is much lower as compared to the one of the web 38 manufactured according to the invention.

The lower contact area of the prior art web 40 results from the shaping of the web 40 that now follows the structure of the structured fabric 33.

Due to the less contact area of the prior art web 40 to the Yankee surface 52 the drying efficiency is less.

Now, additionally referring to Fig. 12, there is shown an embodiment of the process where a structured fiber web 38 is formed. Structured fabric 28 carries a three dimensional structured web 38 to an advanced dewatering system 50, past suction box 67 and then to a Yankee roll 52 where the web is transferred to Yankee roll 52 and hood section 54 for additional drying and creping before winding up on a reel (not shown).

A shoe press 56 is placed adjacent to structured fabric 28, holding it in a position proximate Yankee roll 52. Structured web 38 comes into contact with Yankee roll 52 and transfers to a surface thereof, for further drying and subsequent creping.

A vacuum box 58 is placed adjacent to structured fabric 28 to achieve a solids level of 15-25% on a nominal 20 gsm web running at -0.2 to -0.8 bar vacuum with a preferred operating level of -0.4 to -0.6 bar. Web 38, which is carried by structured fabric 28, contacts dewatering fabric 82 and proceeds toward vacuum roll 60. Vacuum roll 60 operates at a vacuum level of -0.2 to -0.8 bar with a preferred operating level of at least -0.4 bar. Hot air hood 62 is optionally fit over vacuum roll 60 to improve dewatering. If for example, a commercial Yankee drying cylinder with 44 mm steel thickness and a conventional hood with an air blowing speed of 145 m/s is used production speeds of 1400 m/min or more for towel paper and 1700 m/min or more for toilet paper are used.

Optionally a steam box can be installed instead of the hood 62 supplying steam to the web 38. Preferably the steam box has a sectionalized design to influence the moisture re-dryness cross profile of the web 38. The length of the vacuum zone inside the vacuum roll 60 can be from 200 mm to 2,500 mm, with a preferable length of 300 mm to 1,200 mm and an even more preferable length of between 400 mm to 800 mm. The solids level of web 38 leaving suction roll 60 is 25% to 55% depending on installed options. A vacuum box 67 and hot air supply 65 can be used to increase web 38 solids after vacuum roll 60 and prior to Yankee roll 52. Wire turning roll 69 can also be a suction roll with a hot air supply hood. Roll 56 includes a shoe press with a shoe width of 80 mm or higher, preferably 120 mm or higher, with a maximum peak pressure of less than 2.5 MPa. To create an even longer nip to facilitate the transfer of web 38 to Yankee 52, web 38 carried on structured fabric 28 can be brought into contact with the

surface of Yankee roll 52 prior to the press nip associated with shoe press 56. Further, the contact can be maintained after structured fabric 28 travels beyond press 56.

Dewatering fabric 82 may have a permeable woven base fabric connected to a  
5 batt layer. The base fabric includes machine direction yarns and cross -directional  
yarns. The machine direction yarn is a 3 ply multifilament twisted yarn. The cross -  
direction yarn is a monofilament yarn. The machine direction yarn can also be a  
monofilament yarn and the construction can be of a typical multilayer design. In either  
case, the base fabric is needled with a fine batt fiber having a weight of less than or  
10 equal to 700 gsm, preferably less than or equal to 150 gsm and more preferably less  
than or equal to 135 gsm. The batt fiber encapsulates the base structure giving it  
sufficient stability. The needling process can be such that straight through channels are  
created. The sheet contacting surface is heated to improve its surface smoothness.  
The cross-sectional area of the machine direction yarns is larger than the cross -  
15 sectional area of the cross -direction yarns. The machine direction yarn is a  
multifilament yarn that may include thousands of fibers. The base fabric is connected to  
a batt layer by a needling process that results in straight through drainage channels.

In another embodiment of dewatering fabric 82 there is included a fabric layer, at  
20 least two batt layers, an anti-rewetting layer and an adhesive. The base fabric is  
substantially similar to the previous description. At least one of the batt layers include a  
low melt bi-compound fiber to supplement fiber to fiber bonding upon heating. On one  
side of the base fabric, there is attached an anti -rewetting layer, which may be attached  
to the base fabric by an adhesive, a melting process or needling wherein the material

contained in the anti-rewet layeris connected to the base fabric layer and a batt layer.

The anti-rewetting layer is made of an elastomeric material thereby f orming elastomeric membrane , which has openings therethrough.

5           The batt layers are needed to thereby hold dewatering fabric 82 together. This advantageously leaves the batt layers with many needled holes therethrough. The anti -rewetting layer is porous having water channels or straight through pores therethrough.

          In yet an other embodiment of dewatering fabric 82, there is a construct  
10   substantially similar to that previously discussed with an addition of a hydrophobic layer to at least one side of de-watering fabric 82. The hydrophobic layer does not absorb water, but it does direct water through pores therein.

          In yet another embodiment of dewatering fabric 82, the base fabric has attached  
15   thereto a lattice grid made of a polymer, such as polyurethane, that is put on top of the base fabric. The grid may be put on to the base fabric by utilizing various known procedures, such as, for example, an extrusion technique or a screen -printing technique. The lattice grid may be put on the base fabric wit h an angular orientation relative to the machine direction yarns and the cross direction yarns. Although this  
20   orientation is such that no part of the lattice is aligned with the machine direction yarns, other orientations can also be utilized. The lattic e can have a uniform grid pattern, which can be discontinuous in part. Further, the material between the interconnections of the lattice structure may take a circuitous path rather than being substantially straight.

The lattice grid is made of a synthetic, such as a polymer or specifically a polyurethane, which attaches itself to the base fabric by its natural adhesion properties.

In yet another embodiment of dewatering fabric 82 there is included a permeable  
5 base fabric having machine direction yarns and cross-direction yarns, that are adhered to a grid. The grid is made of a composite material that may be the same as that discussed relative to a previous embodiment of dewatering fabric 82. The grid includes machine direction yarns with a composite material formed therearound. The grid is a composite structure formed of composite material and machine direction yarns. The  
10 machine direction yarns may be pre-coated with a composite before being placed in rows that are substantially parallel in a mold that is used to reheat the composite material causing it to re-flow into a pattern. Additional composite material may be put into the mold as well. The grid structure, also known as a composite layer, is then connected to the base fabric by one of many techniques including laminating the grid to  
15 the permeable fabric, melting the composite coated yarn as it is held in position against the permeable fabric or by re-melting the grid onto the base fabric. Additionally, an adhesive may be utilized to attach the grid to permeable fabric.

The batt fiber may include two layers, an upper and a lower layer. The batt fiber  
20 is needled into the base fabric and the composite layer, thereby forming a dewatering fabric 82 having at least one outer batt layer surface. Batt material is porous by its nature, additionally the needling process not only connects the layers together, it also creates numerous small porous cavities extending into or completely through the structure of dewatering fabric 82.

Dewatering fabric 82 has an air permeability of from 5 to 100 cubic feet/minute preferably 19 cubic feet/minute or higher and more preferably 35 cubic feet/minute or higher. Mean pore diameters in dewatering fabric 82 are from 5 to 75 microns, preferably 25 microns or higher and more preferably 35 microns or higher. The hydrophobic layers can be made from a synthetic polymeric material, a wool or a polyamide, for example, nylon 6. The anti-rewet layer and the composite layer may be made of a thin elastomeric permeable membrane made from a synthetic polymeric material or a polyamide that is laminated to the base fabric.

The batt fiber layers are made from fibers ranging from 0.5 d-tex to 22 d-tex and may contain a low melt bi-compound fiber to supplement fiber to fiber bonding in each of the layers upon heating. The bonding may result from the use of a low temperature meltable fiber, particles and/or resin. The dewatering fabric can be less than 2.0 millimeters, or less than 1.50 millimeters, or less than 1.25 millimeters or less than 1.0 millimeter thick.

Preferred embodiments of the dewatering fabric 82 are also described in the PCT/EP2004/053688 and PCT/EP2005/050198 which are herewith incorporated by reference.

Now, additionally referring to Fig. 13, there is shown yet another embodiment of the present invention, which is substantially similar to the invention illustrated in Fig. 12, except that instead of hot air hood 62, there is a belt press 64. Belt press 64 includes a

permeable belt 66 capable of applying pressure to the non-sheet contacting side of structured fabric 28 that carries web 38 around suction roll 60. Fabric 66 of belt press 64 is also known as an extended nip press belt or a link fabric, which can run at 60 KN/m fabric tension with a pressing length that is longer than the suction zone of roll 60.

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Preferred embodiments of the fabric 66 and the required operation concillation are also described in PCT/EP2004/053688 and PCT/EP2005/050198 which are herewith incorporated by reference.

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The above mentioned references are also fully applicable for dewatering fabrics 82 and press fabrics 66 described in the further embodiments.

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While pressure is applied to structured fabric 28, the high fiber density pillow areas in web 38 are protected from that pressure as they are contained within the body of structured fabric 28, as they are in the Yankee nip.

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Belt 66 is a specially designed Extended Nip Press Belt 66, made of, for example reinforced polyurethane and/or a spiral link fabric. Belt 66 is permeable thereby allowing air to flow therethrough to enhance the moisture removing capability of belt press 64. Moisture is drawn from web 38 through dewatering fabric 82 and into vacuum roll 60.

Belt 66 provides a low level of pressing in the range of 50-300 KPa and preferably greater than 100 KPa. This allows a suction roll with a 1.2 meter diameter to have a fabric tension of greater than 30 KN/m and preferably greater than 60 KN/m.

The pressing length of permeable belt 66 against fabric 28, which is indirectly supported by vacuum roll 60, is at least as long as a suction zone in roll 60. Although the contact portion of belt 66 can be shorter than the suction zone.

5            Permeable belt 66 has a pattern of holes therethrough, which may, for example, be drilled, laser cut, etched formed or woven therein. Permeable belt 66 may be monoplanar without grooves. In one embodiment, the surface of belt 66 has grooves and is placed in contact with fabric 28 along a portion of the travel of permeable belt 66 in belt press 64. Each groove connects with a set of the holes to allow the passage  
10           and distribution of air in belt 66. Air is distributed along the grooves, which constitutes an open area adjacent to contact areas, where the surface of belt 66 applies pressure against web 38. Air enters permeable belt 66 through the holes and then migrates along the grooves, passing through fabric 28, web 38 and fabric 82. The diameter of the holes may be larger than the width of the grooves. The grooves may have a cross-  
15           section contour that is generally rectangular, triangular, trapezoidal, semi-circular or semi-elliptical. The combination of permeable belt 66, associated with vacuum roll 60, is a combination that has been shown to increase sheet solids by at least 15%.

            An example of another structure of belt 66 is that of a thin spiral link fabric, which  
20           can be a reinforcing structure within belt 66 or the spiral link fabric will itself serve as belt 66. Within fabric 28 there is a three dimensional structure that is reflected in web 38. Web 38 has thicker pillow areas, which are protected during pressing as they are within the body of structured fabric 28. As such the pressing imparted by belt press

assembly 64 upon web 38 does not negatively impact web quality, while it increases the dewatering rate of vacuum roll 60.

Now, additionally referring to Fig. 14, which is substantially similar to the embodiment shown in Fig. 13 with the addition of hot air hood 68 placed inside of belt press 64 to enhance the dewatering capability of belt press 64 in conjunction with vacuum roll 60.

Now, additionally referring to Fig. 15, there is shown yet another embodiment of the present invention, which is substantially similar to the embodiment shown in Fig. 13, but including a boost dryer 70, which encounters structured fabric 28. Web 38 is subjected to a hot surface of boost driver 70, structure web 38 rides around boost driver 70 with another woven fabric 72 riding on top of structured fabric 28. On top of woven fabric 72 is a thermally conductive fabric 74, which is in contact with both woven fabric 72 and a cooling jacket 76 that applies cooling and pressure to all fabrics and web 38. Here again, the higher fiber density pillow areas in web 38 are protected from the pressure as they are contained within the body of structured fabric 28. As such, the pressing process does not negatively impact web quality. The drying rate of boost dryer 70 is above  $400 \text{ kg/hrm}^2$  and preferably above  $500 \text{ kg/hrm}^2$ . The concept of boost dryer 70 is to provide sufficient pressure to hold web 38 against the hot surface of the dryer thus preventing blistering. Steam that is formed at the knuckle points fabric 28 passes through fabric 28 and is condensed on fabric 72. Fabric 72 is cooled by fabric 74 that is in contact with the cooling jacket, which reduces its temperature to well below that of the steam. Thus the steam is condensed to avoid a pressure build up to thereby avoid

blistering of web 38. The condensed water is captured in woven fabric 72, which is dewatered by dewatering device 75. It has been shown that depending on the size of boost dryer 70, the need for vacuum roll 60 can be eliminated. Further, depending upon the size of boost dryer 70, web 38 may be creped on the surface of boost dryer 70, thereby eliminating the need for Yankee dryer 52.

Now, additionally referring to Fig. 16, there is shown yet another embodiment of the present invention substantially similar to the invention disclosed in Fig. 13 but with an addition of an air press 78, which is a four roll cluster press that is used with high temperature air and is referred to as an HPTAD for additional web drying prior to the transfer of web 38 to Yankee 52. Four roll cluster press 78 includes a main roll and a vented roll and two cap rolls. The purpose of this cluster press is to provide a sealed chamber that is capable of being pressurized. The pressure chamber contains high temperature air, for example, 150°C or higher and is at a significantly higher pressure than conventional TAD technology, for example, greater than 1.5psi resulting in a much higher drying rate than a conventional TAD. The high pressure hot air passes through an optional air dispersion fabric, through web 38 and fabric 28 into a vent roll. The air dispersion fabric may prevent web 38 from following one of the four cap rolls. The air dispersion fabric is very open, having a permeability that equals or exceeds that of fabric 28. The drying rate of the HPTAD depends on the solids content of web 38 as it enters the HPTAD. The preferred drying rate is at least 500 kg/hr/m<sup>2</sup>, which is a rate of at least twice that of conventional TAD machines.

Advantages of the HPTAD process are in the areas of improved sheet dewatering without a significant loss in sheet quality, compactness in size and energy efficiency. Additionally, it enables higher pre-Yankee solids, which increase the speed potential of the invention. Further, the compact size of the HPTAD allows for easy retrofit to an existing machine. The compact size of the HPTAD and the fact that it is a closed system means that it can be easily insulated and optimized as a unit to increase energy efficiency.

Now, additionally referring to Fig. 17, there is shown another embodiment of the present invention. This is significantly similar to Fig. 13 and 16 except for the addition of a two-pass HPTAD 80. In this case, two vented rolls are used to double the dwell time of structured web 38 relative to the design shown in Fig. 16. An optional coarse mesh fabric may be used as in the previous embodiment. Hot pressurized air passes through web 38 carried on fabric 28 and onto the two vent rolls. It has been shown that depending on the configuration and size of the HPTAD, that more than one HPTAD can be placed in series, which can eliminate the need for roll 60.

Now, additionally referring to Fig. 18, a conventional Twin Wire Former 90 may be used to replace the Crescent Former shown in previous examples. The forming roll can be either a solid or open roll. If an open roll is used, care must be taken to prevent significant dewatering through the structured fabric to avoid losing basis weight in the pillow areas. The outer forming fabric 93 can be either a standard forming fabric or one such as that disclosed in U.S. Patent No. 6,237,644. The inner forming fabric 91 must be a structured fabric 91 that is much coarser than the outer forming fabric. A vacuum

box 92 may be needed to ensure that the web stays with structured wire 91 and does not go with outer wire 90. Web 38 is transferred to structured fabric 28 using a vacuum device. The transfer can be a stationary vacuum shoe or a vacuum assisted rotating pick-up roll 94. The second structured fabric 28 is at least the same coarseness and preferably courser than first structured fabric 91. The process from this point is the same as one of the previously discussed processes. The registration of the web from the first structured fabric to the second structured fabric is not perfect, as such some pillows will lose some basis weight during the expansion process, thereby losing some of the benefit of the present invention. However, this process option allows for running a differential speed transfer, which has been shown to improve some sheet properties. Any of the arrangements for removing water discussed above as may be used with the Twin Wire Former arrangement and a conventional TAD.

The fiber distribution of web 38 in this invention is opposite that of the prior art, which is a result of removing moisture through the forming fabric and not through the structured fabric. The low density pillow areas are of relatively higher basis weight than the surrounding compressed zones, which is opposite of conventional TAD paper. This allows a high percentage of the fibers to remain uncompressed during the process. The sheet absorbency capacity as measured by the basket method, for a nominal 20 gsm web is equal to or greater than 12 grams water per gram of fiber and often exceeds 15 grams of water per gram fiber. The sheet bulk is equal to or greater than  $10 \text{ cm}^3/\text{gm}$  and preferably greater than  $13 \text{ cm}^3/\text{gm}$ . The sheet bulk of toilet tissue is expected to be equal to or greater than  $13 \text{ cm}^3/\text{gm}$  before calendering.

With the basket method of measuring absorbency, five (5) grams of paper are placed into a basket. The basket containing the paper is then weighted and introduced into a small vessel of water at 20°C for 60 seconds. After 60 seconds of soak time, the basket is removed from the water and allowed to drain for 60 seconds and then  
5 weighted again. The weight difference is then divided by the paper weight to yield the grams of water held per gram of fibers being absorbed and held in the paper.

Web 38 is formed from fibrous slurry 24 that headbox 22 discharges between forming fabric 26 and structured fabric 28. Roll 34 rotates and supports fabrics 26 and  
10 28 as web 38 forms. Moisture M flows through fabric 26 and is captured in save all 36. It is the removal of moisture in this manner that serves to allow pillow areas of web 38 to retain a greater basis weight and therefore thickness than if the moisture were to be removed through structured fabric 28. Sufficient moisture is removed from web 38 to allow fabric 26 to be removed from web 38 to allow web 38 to proceed to a drying stage.  
15 Web 38 retains the pattern of structured fabric 28 and any zonal permeability effects from fabric 26 that may be present.

While this invention has been described as having a preferred design, the present invention can be further modified within the spirit and scope of this disclosure.  
20 This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.

**WHAT IS CLAIMED IS:**

1. A method of forming a structured web with a paper machine, comprising the steps of:  
  
providing a fiber slurry through a headbox to a nip formed by a structured fabric and a forming fabric; and  
  
5 collecting fibers from said fiber slurry predominately in a plurality of valleys of said structured fabric.
2. The method of claim 1, further comprising the step of dewatering said fiber slurry through said forming fabric and not through said structured fabric.
3. The method of claim 1, wherein said forming fabric has a zonally different fabric permeability.
4. The method of claim 1, wherein said structured fabric includes a plurality of peaks each of said peaks associated with at least one of said plurality of valleys.
5. The method of claim 4, wherein said fiber slurry substantially covers a portion of a surface of said structured fabric including at least one of said plurality of valleys and at least one adjacent peak.

6. The method of claim 5, wherein said fiber slurry becomes the structured web by way of said collecting step.
7. The method of claim 6, wherein the structured web has a pillow thickness associated with the structured web formed in said valleys, the structured web having a top surface thickness associated with the structured web formed on said peaks, said pillow thickness being one of equal to and greater than said top surface thickness.
8. The method of claim 6, wherein the structured web has a pillow basis weight associated with the structured web formed in said valleys, the structured web having a top surface basis weight associated with the structured web formed on said peaks, said pillow basis weight being one of equal to and greater than said top surface basis weight.
9. The method of claim 6, further comprising the steps of:  
removing said forming fabric from the structured web;  
contacting the structured web with a dewatering fabric; and  
applying pressure to the structured web through said dewatering fabric.
10. The method of claim 9, further comprising the step of applying a negative air pressure against a portion of a surface of said dewatering fabric thereby removing moisture from the structured web through said dewatering fabric.

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11. The method of claim 6 , further comprising the steps of:  
transferring the structured web to a Yankee dryer at a transfer point; and  
retaining the structured web with said structured fabric until reaching said  
transfer point.

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12. The method of claim 11, wherein the structured web remains on said  
structured fabric until said transfer point thereby ensuring that pillow  
areas of the structured web formed in said valleys have a higher basis  
weight than the rest of the structured web and said pillow areas stay  
impressed.

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13. A structured fibrous web, comprising:  
a plurality of pillow portions each having a first basis weight property; and  
a plurality of connection portions each having a second basis weight  
property, each of said connection portions connecting at least two of said  
plurality of pillow portions, said first basis weight being greater than said  
second basis weight.

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14. The structured fibrous web of claim 13 , wherein said plurality of pillow  
portions have a first thickness and said plurality of connection portions  
have a second thickness, said first thickness greater than said second  
thickness.

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15. A method of forming a structured web in a papermaking machine,  
comprising the steps of:  
supplying a fiber slurry to a nip, said nip formed by a structured fabric and  
a forming fabric;  
5 dewatering said fiber slurry through said forming fabric, thereby creating  
the web; and  
retaining the web with said structured fabric through at least one  
dewatering process.
16. The method of claim 15, further comprising the step of transferrin g the  
web from said structured fabric to a Yankee dryer.
17. The method of claim 15, wherein said structured fabric includes peaks and  
valleys.
18. The method of claim 17, wherein said valleys form pillows in the web and  
said peaks form pressin g points in the web.
19. The method of claim 18, wherein said pillows have a first thickness and  
said pressing points have a second thickness, said first thickness greater  
than said second thickness.

20. The method of claim 18, wherein said pillows have a first basis weight and said pressing points have a second basis weight, said first basis weight greater than said second basis weight.
21. The method of claim 18, wherein said pillows have a first moisture content and said pressing points have a second moisture content, said first moisture content greater than said second moisture content prior to a drying process.
- 5
22. A structured fabric for use in a paper machine, comprising:  
a plurality of yarns woven together having a mesh count and a weave pattern, said weave pattern including valleys of from approximately 0.07 mm to approximately 0.60 mm deep.
- 5
23. The structured fabric of claim 22, wherein said mesh count is between 95 x 120 and 26 x 20.
24. The structured fabric of claim 22, wherein said mesh count is one of greater than and equal to 51 x 36.
25. The structured fabric of claim 24, wherein said mesh count is one of greater than and equal to 58 x 44.

26. The structured fabric of claim 22 , wherein said mesh count is one of less than and equal to 42 x 31.
27. The structured fabric of claim 26, wherein said mesh count is one of less than and equal to 36 x 30.
28. The structured fabric of claim 22, wherein said weave pattern includes one of greater than and equal to 4 shed repeats.
29. The structured fabric of claim 28, wherein said weave pattern includes one of greater than and equal to 5 shed repeats.
30. The structured fabric of claim 22 , wherein said plurality of yarns include a plurality of warp yarns and a plurality of weft yarns.
31. The structured fabric of claim 30, wherein said warp yarns each have a diameter of between approximately 0.12 mm and 0.70 mm.
32. The structured fabric of claim 30 , wherein said weft yarns each have a diameter of between approximately 0.15 mm and 0.60 mm.
33. The structured fabric of claim 22 , wherein said plurality of yarns each have a cross-sectional shape, said cross-sectional shape including at least one of round, ovate and flat.

34. The structured fabric of claim 22, wherein said plurality of yarns are made of at least one of thermoplastic and thermoset polymeric materials.
35. The structured fabric of claim 22, wherein said plurality of yarns woven together form a surface, said surface being treated to alter a characteristic of said surface, said characteristic including at least one of surface energy, thermal resistance, abrasion resistance and hydrolysis resistance.
36. The structured fabric of claim 22, further comprising a polymeric material applied to a surface of said plurality of yarns woven together.
37. The structured fabric of claim 36, wherein said polymeric material is applied in a pattern.
38. The structured fabric of claim 22, wherein said plurality of yarns woven together form a surface, a portion of said surface being a top contact plane, said top contact plane being one of greater than and equal to approximately 10% of the area of said surface.
39. The structured fabric of claim 38, wherein said top contact plane is one of greater than and equal to approximately 20% of the area of said surface.
40. The structured fabric of claim 39, wherein said top contact plane is one of greater than and equal to approximately 30% of the area of said surface.

41. The structured fabric of claim 3 8, wherein said top contact plane is formed by abrading said surface.
42. A structured element for use in a paper machine, comprising:  
An elastomeric cast structure including valleys of from approximately 0.07 mm to approximately 0.60 mm deep and a surface.
43. The structured element of claim 4 2, wherein said elastomeric cast structure is made of at least one of thermoplastic and thermoset polymeric materials.
44. The structured element of claim 42, wherein a portion of said surface is a top contact plane, said top contact plane being one of greater than and equal to approximately 10% of the area of said surface.
45. The structured element of claim 4 4, wherein said top contact plane is one of greater than and equal to approximately 20% of the area of said surface.
46. The structured element of claim 45, wherein said top contact plane is one of greater than and equal to approximately 30% of the area of said surface.

47. A fiber web forming apparatus, comprising:

a headbox;

a forming roll;

a structured fabric;

5 a forming fabric, a portion of one of said structured fabric and said forming fabric in contact with a portion of said forming roll, a side of said structured fabric and a side of said forming fabric becoming proximate to each other thereby forming a nip, said headbox discharging a fibrous slurry directed at said nip, said fibrous slurry losing moisture through said forming fabric and not through said structured fabric.

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48. The apparatus of claim 47, wherein said forming fabric includes a surface having a zonally different fabric permeability.

49. The apparatus of claim 47, wherein said structured fabric includes a plurality of valleys and a plurality of peaks.

50. The apparatus of claim 49, wherein said fiber slurry substantially covers a portion of a surface of said structured fabric including at least one of said plurality of valleys and at least one adjacent peak.

51. The apparatus of claim 50, wherein said fiber slurry becomes a fiber web after said moisture is removed through said forming fabric.

52. The apparatus of claim 51, wherein said fiber web has a pillow thickness associated with said fiber web formed in said valleys, said fiber web having a top surface thickness associated with said fiber web formed on said peaks, said pillow thickness being one of equal to and greater than said top surface thickness.
53. The apparatus of claim 51, further comprising a press section including:  
a dewatering fabric, said forming fabric being removed from said fiber web and said dewatering fabric contacting said fiber web; and  
a pressure device applying pressure to a surface of said dewatering fabric, a portion of said pressure being transferred to a portion of said fiber web.
54. The apparatus of claim 53, further comprising a vacuum device applying a negative air pressure against a portion of a surface of said dewatering fabric thereby removing moisture from said fiber web through said dewatering fabric.
55. The apparatus of claim 54, wherein said vacuum device is a vacuum roll.
56. The apparatus of claim 47, further comprising an extended nip press belt in partial contact with an other side of said structured fabric.
57. The apparatus of claim 56, further comprising an airflow device additionally passing air through said extended nip press belt.

58. The apparatus of claim 47, further comprising at least one of a Yankee roll, a suction roll, a hot air hood, a boost dryer, an air press, an HPTAD and a two pass HPTAD, said fibrous web conveyed in a machine direction, said at least one of a Yankee roll, a suction roll, a hot air hood, a boost dryer, an air press, a single pass HPTAD and a two pass HPTAD being downstream in said machine direction from said nip.
59. A method of drying a fibrous web in a paper machine, comprising the steps of:  
forming a structured web between a structured fabric and a forming fabric;  
and  
removing moisture from the structured web through said forming fabric and not through said structured fabric.
60. The method of claim 59, further comprising the steps of:  
removing said forming fabric from said structured web;  
contacting the structured web with a dewatering fabric; and  
applying pressure to the structured web through said dewatering fabric.
61. The method of claim 60, wherein said step of applying pressure comprises applying a low pressure in an extended nip press.

62. The method of claim 60 , further comprising the step of applying a negative air pressure against a portion of a surface of said dewatering fabric thereby removing moisture from the structured web through said dewatering fabric.
63. A method of forming a structured web with a Twin Wire paper machine, comprising the steps of:  
providing a fiber slurry to a nip formed by a first structured fabric and a forming fabric;  
dewatering said fiber slurry through said forming fabric and not through said structured fabric, thereby forming the structured web; and  
transferring the structured web to a second structured fabric .
64. The method of claim 63, wherein said first structured fabric has a first coarseness and said second structured fabric has a second coarseness , said second coarseness being one of greater than and equal to said first coarseness .

1/8

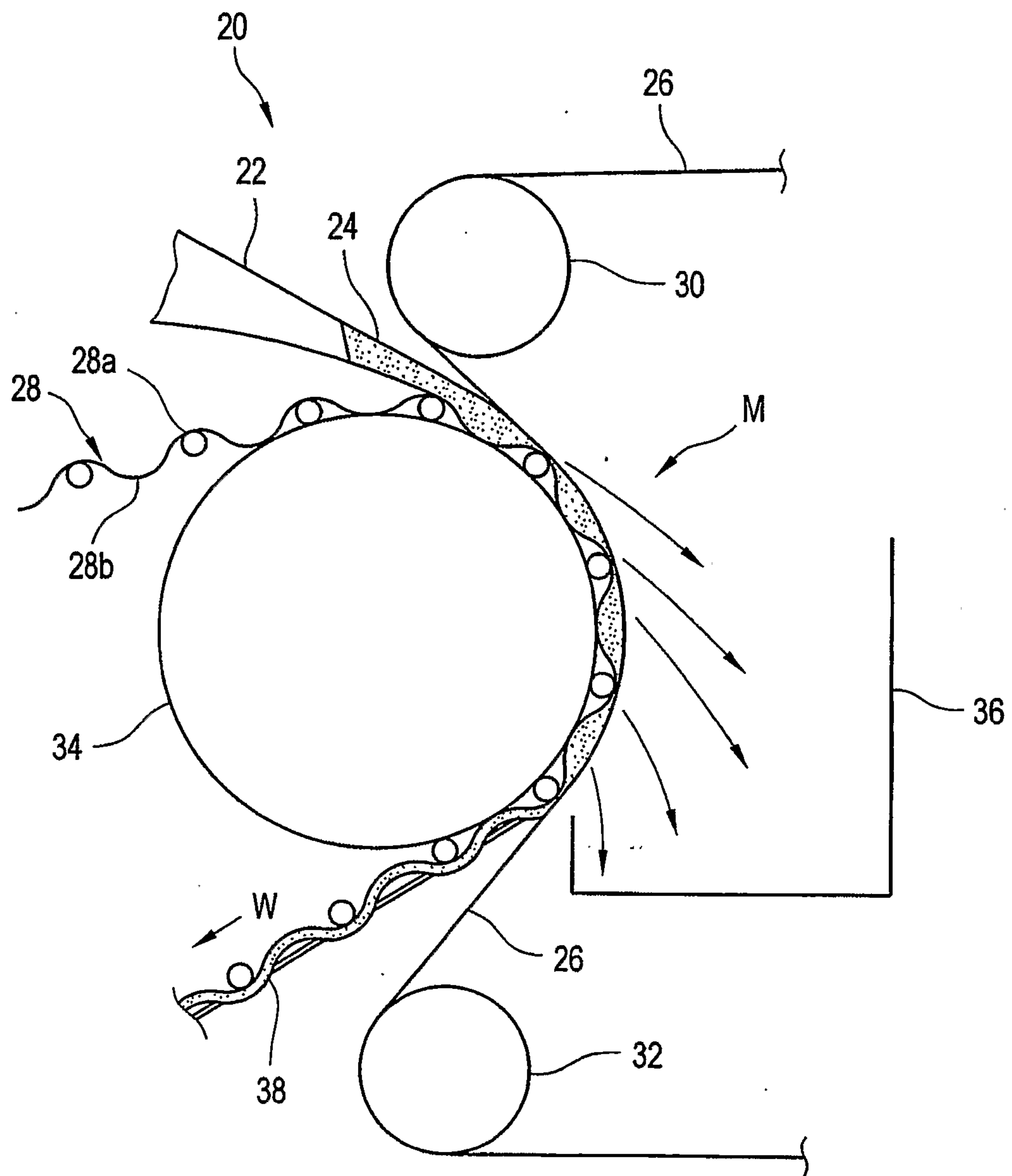


Fig.1

2/8

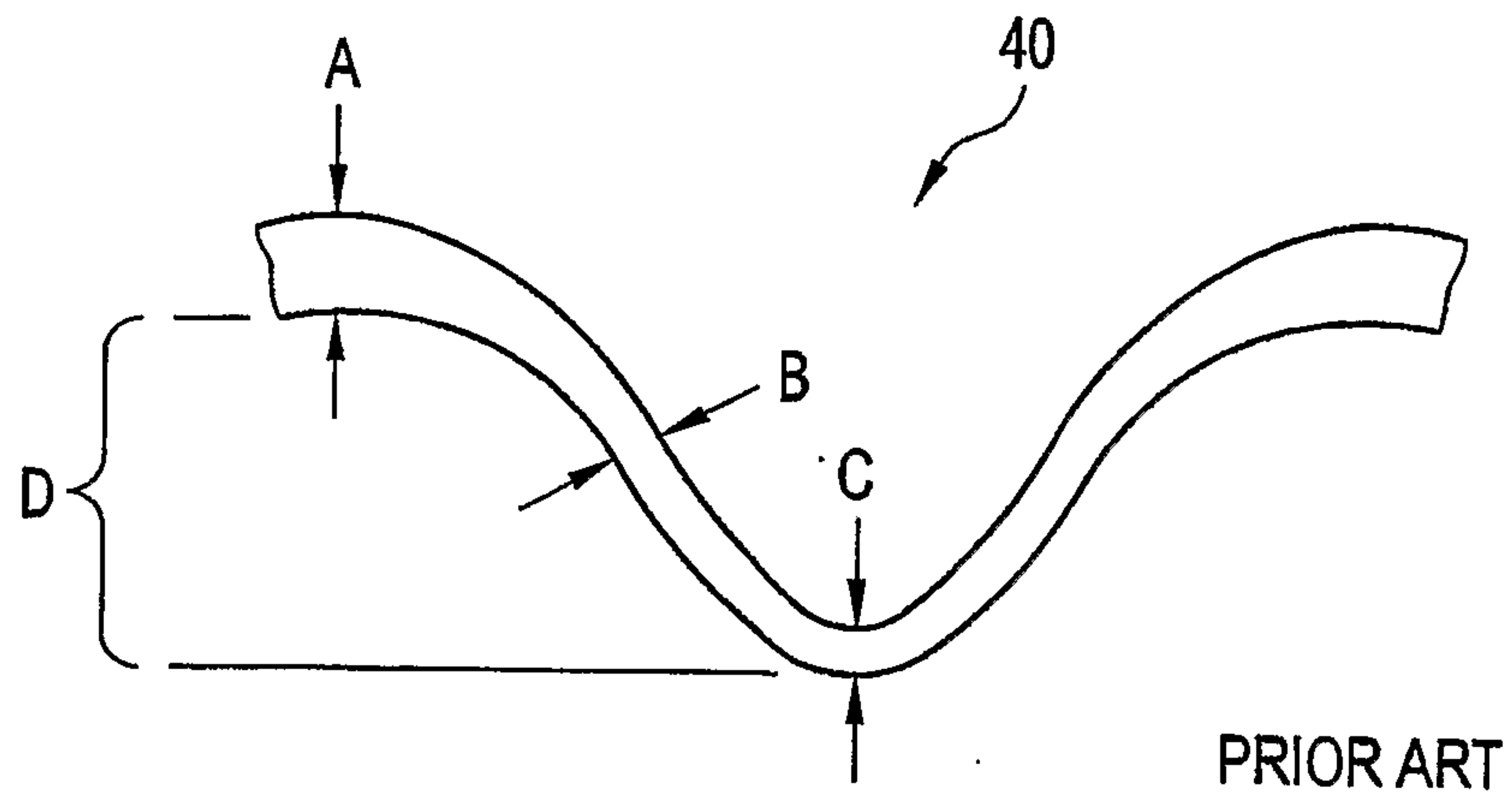


Fig. 2

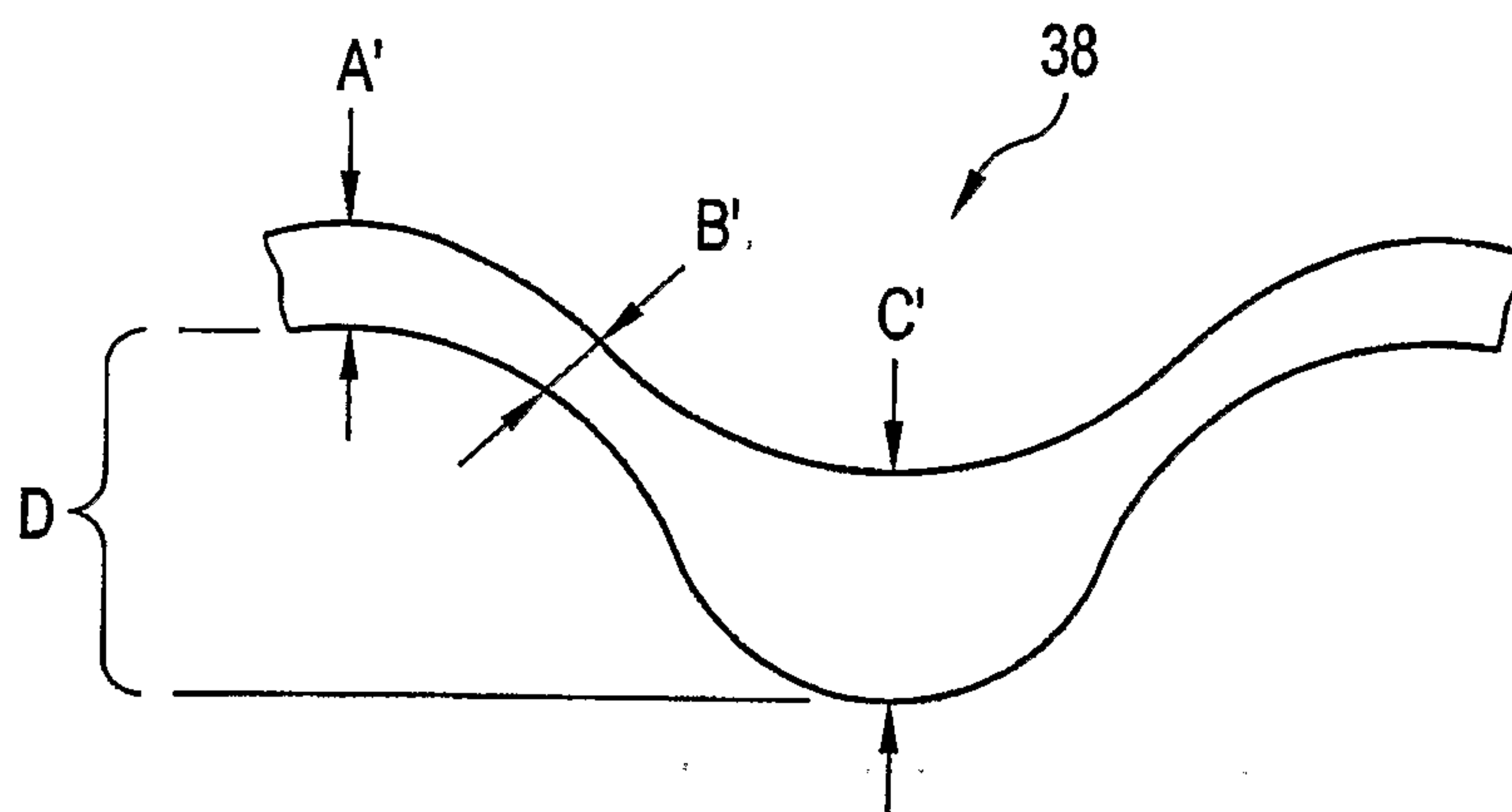


Fig. 3

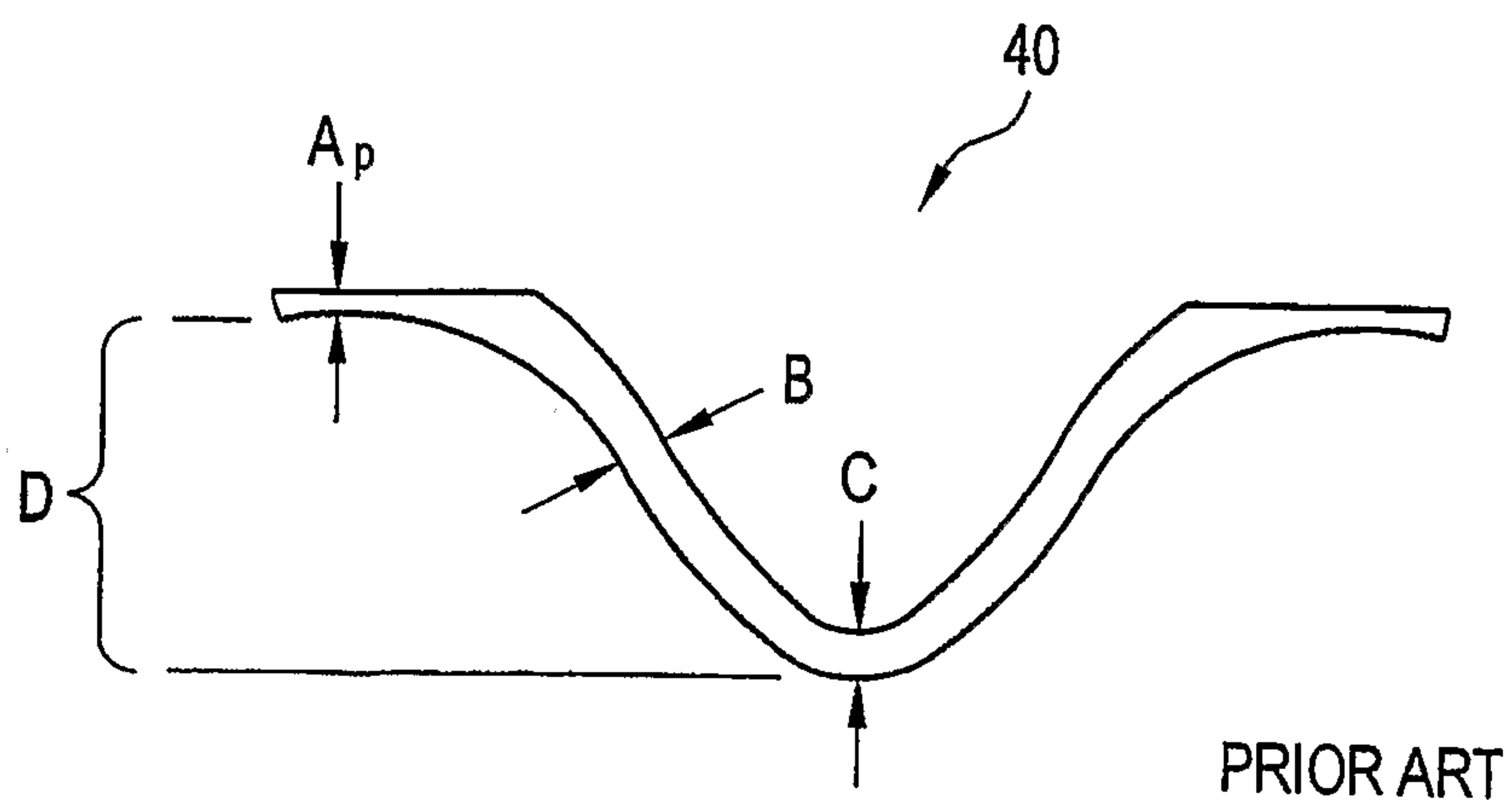


Fig. 4

3/8

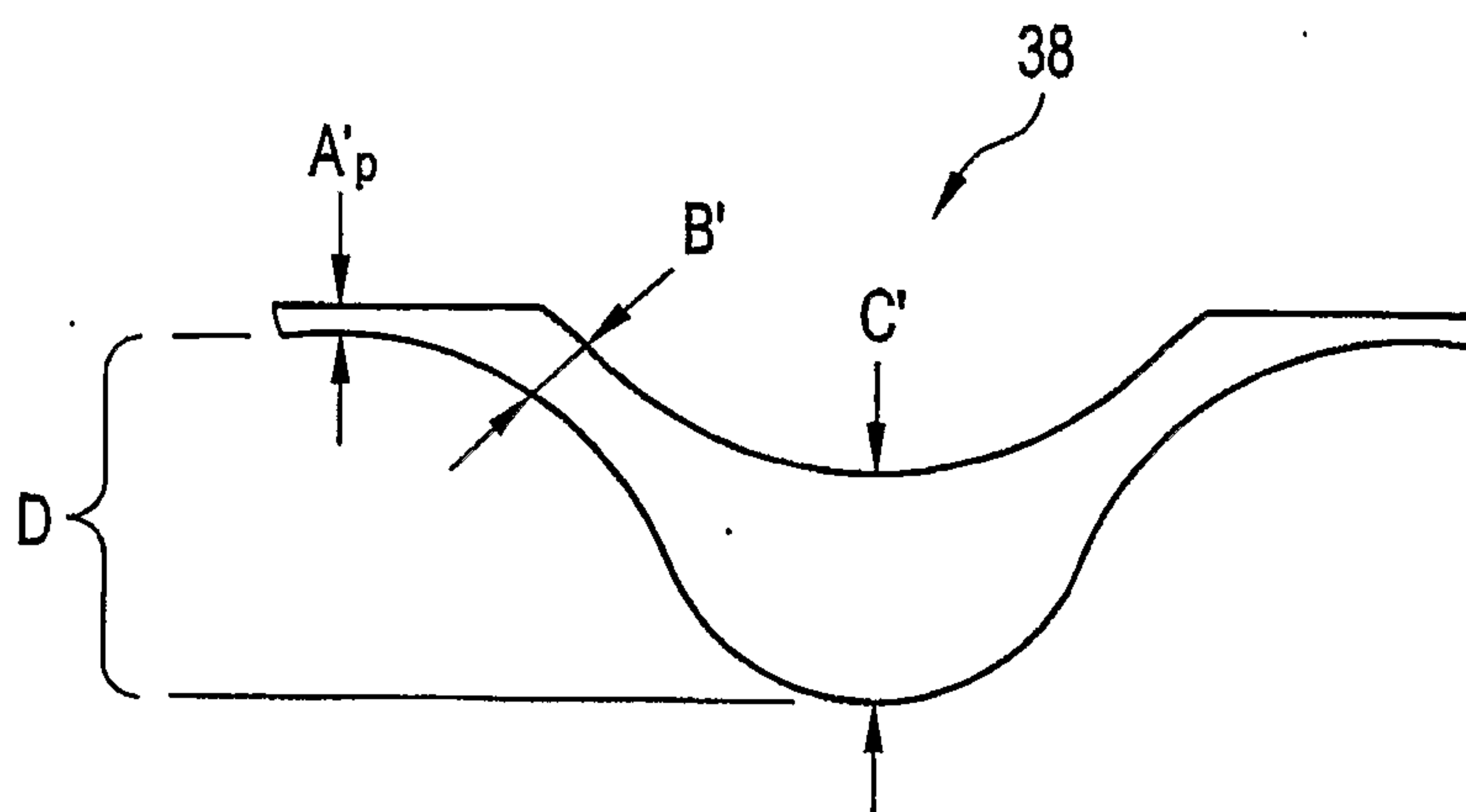


Fig. 5

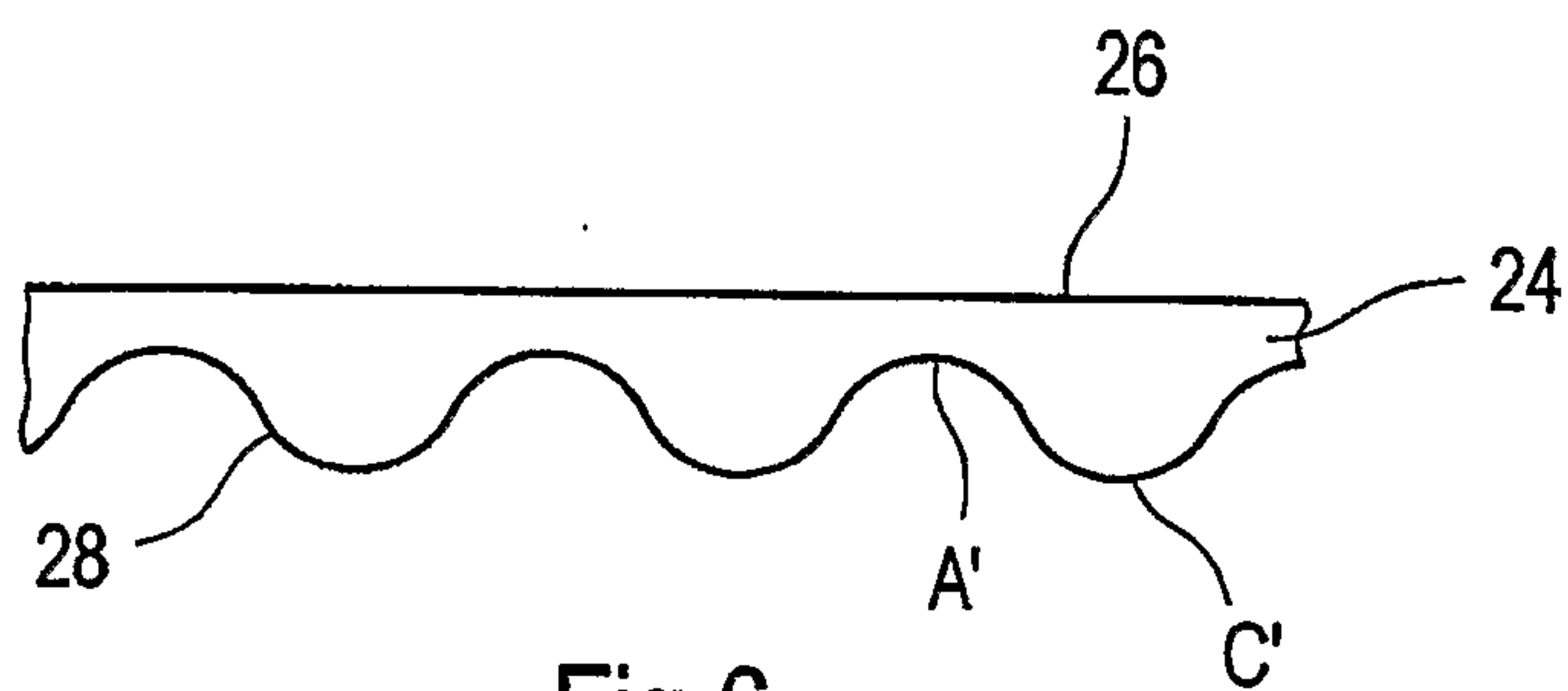


Fig. 6



Fig. 7

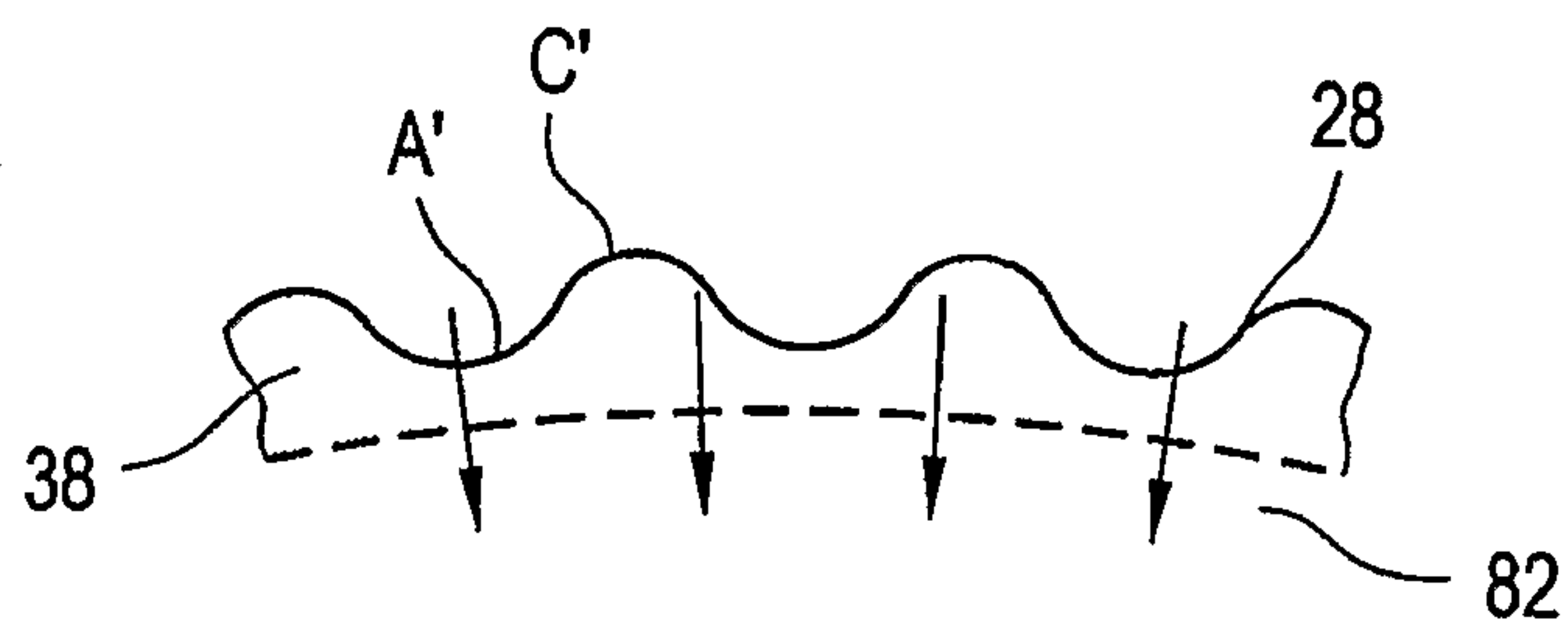


Fig. 8

4/8

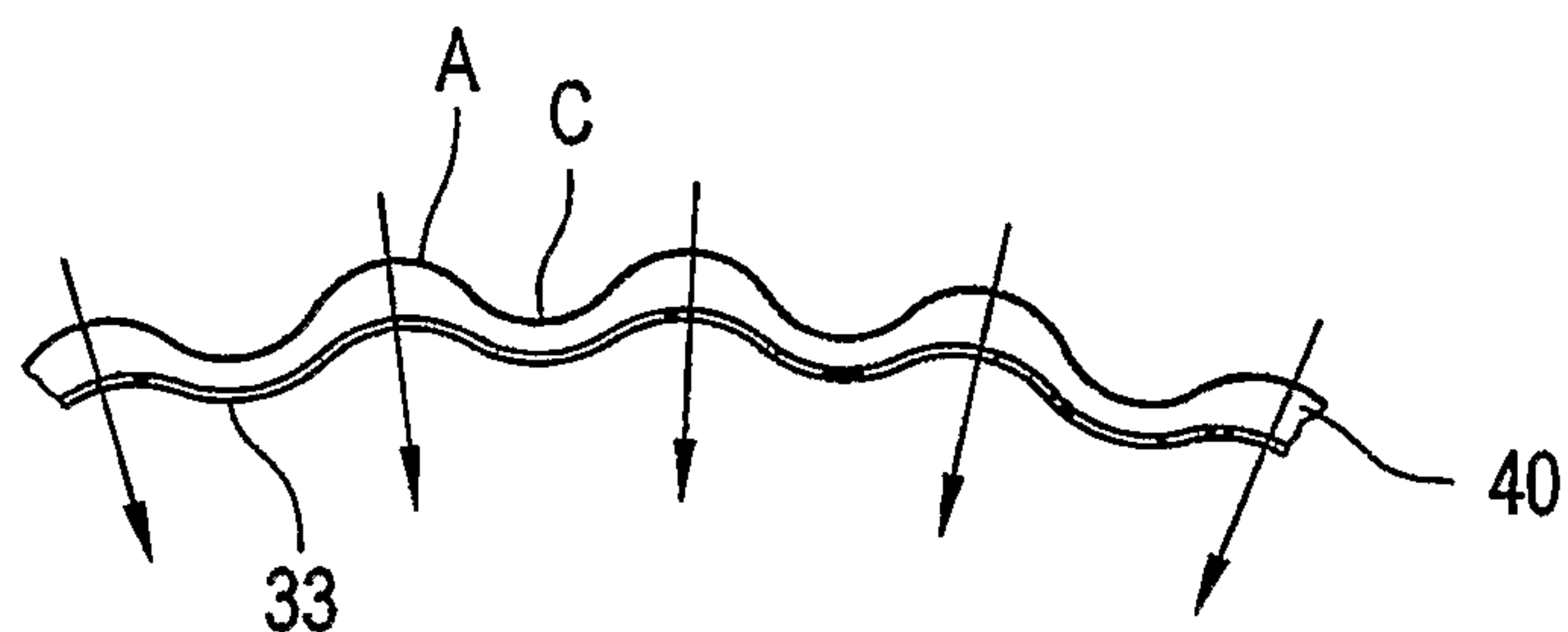


Fig. 9

PRIOR ART

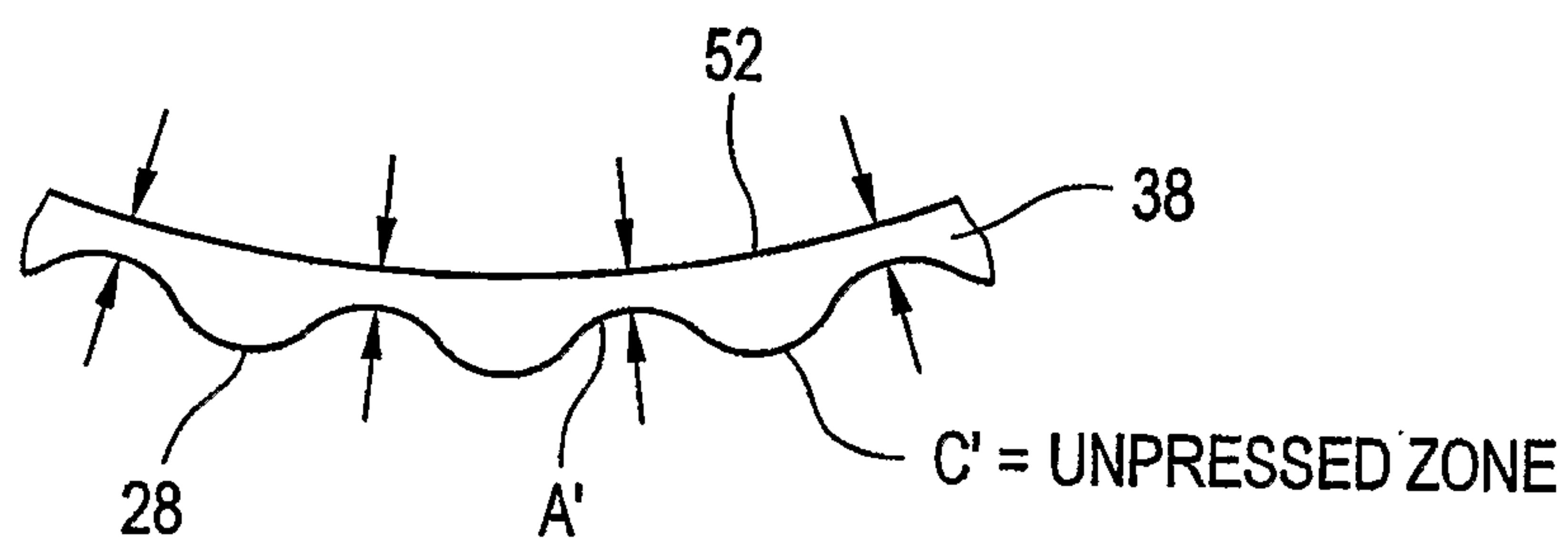


Fig. 10

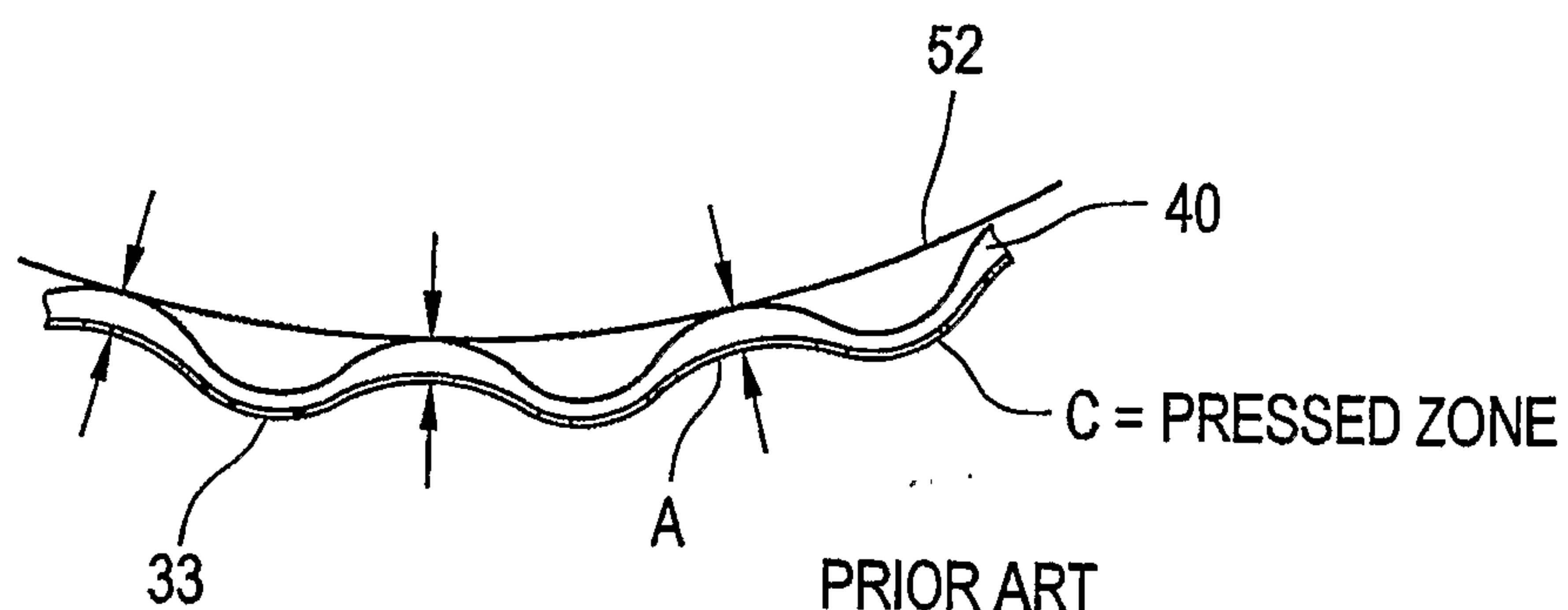


Fig. 11

PRIOR ART

5/8

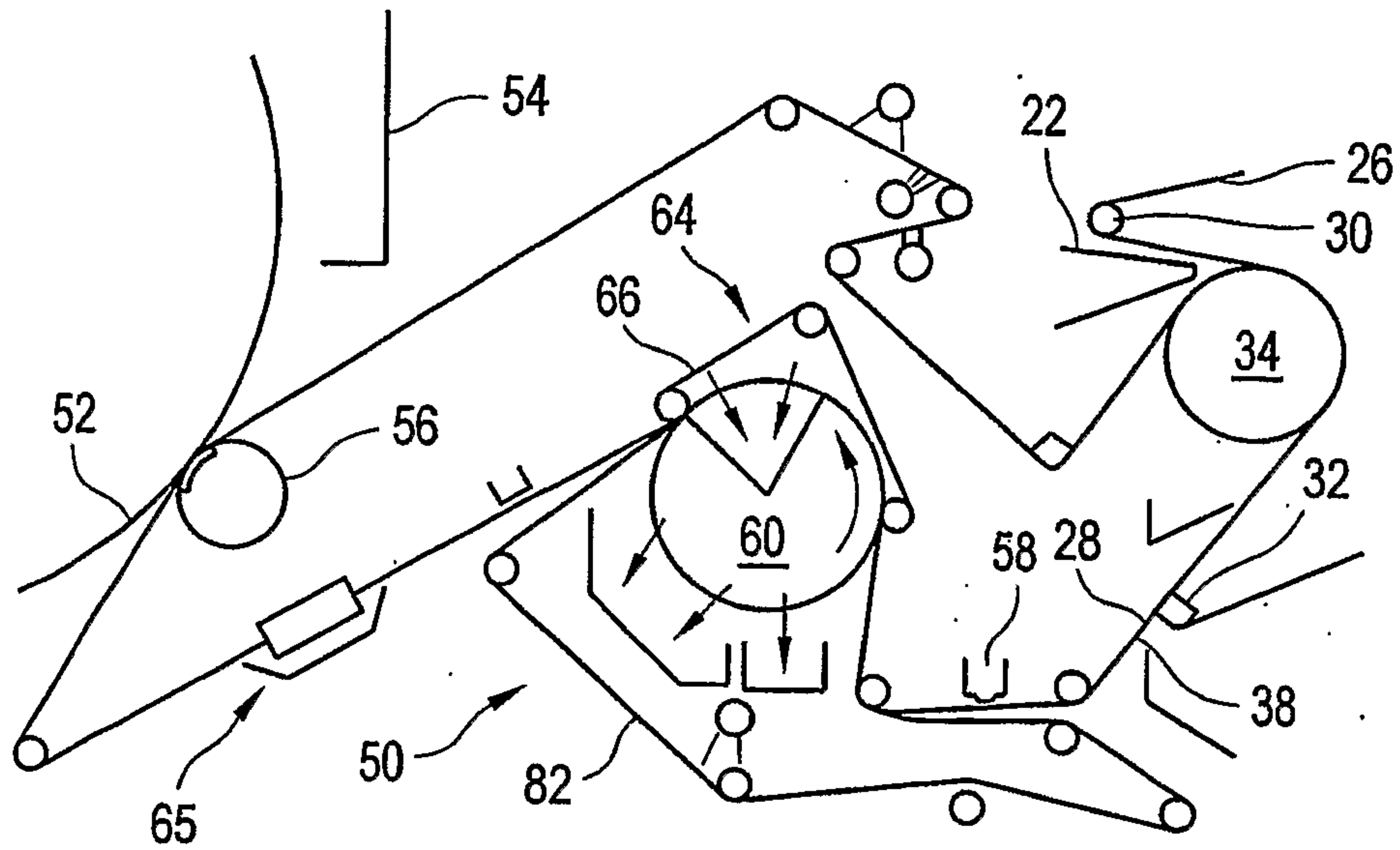


Fig.13

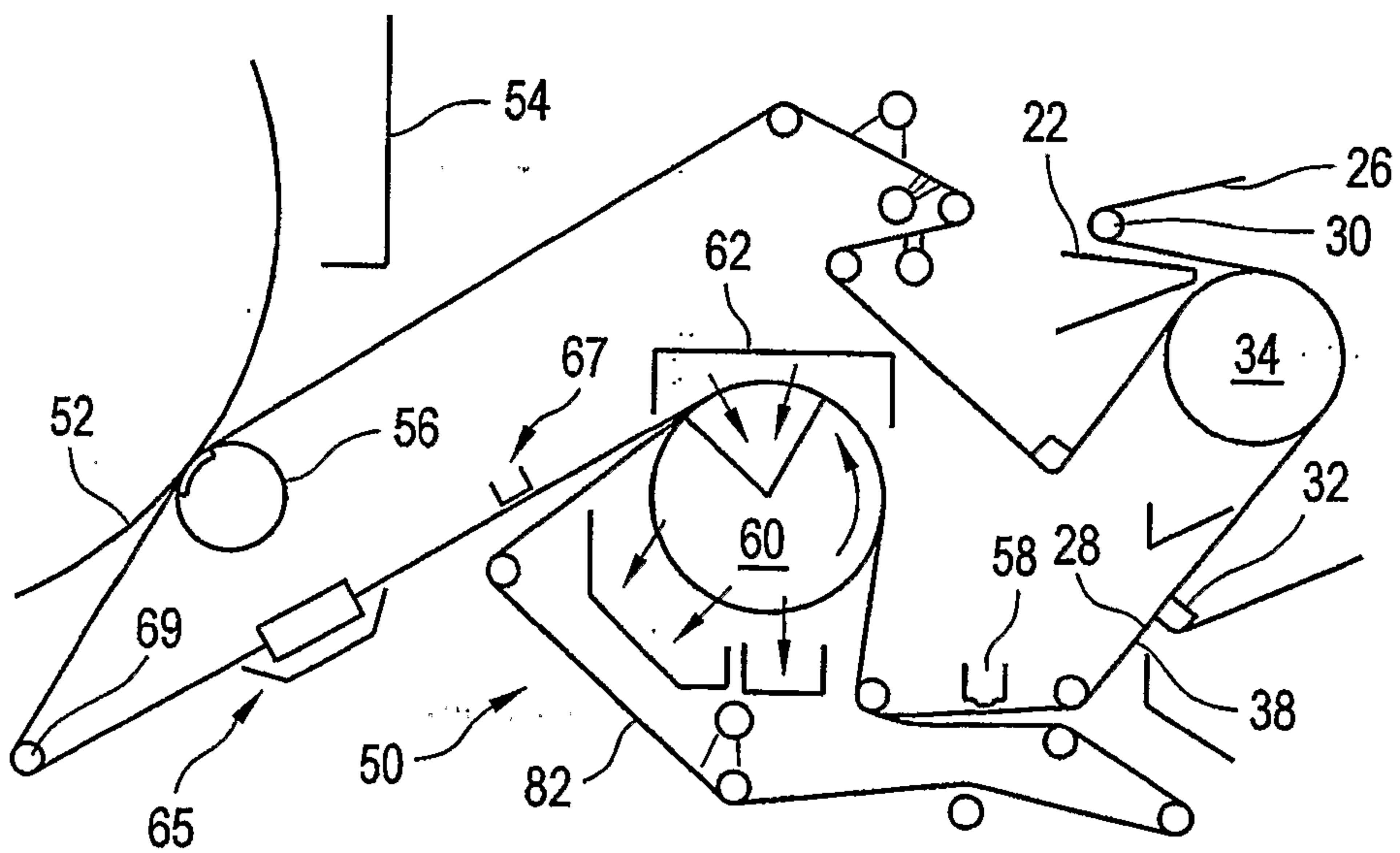


Fig.12

6/8

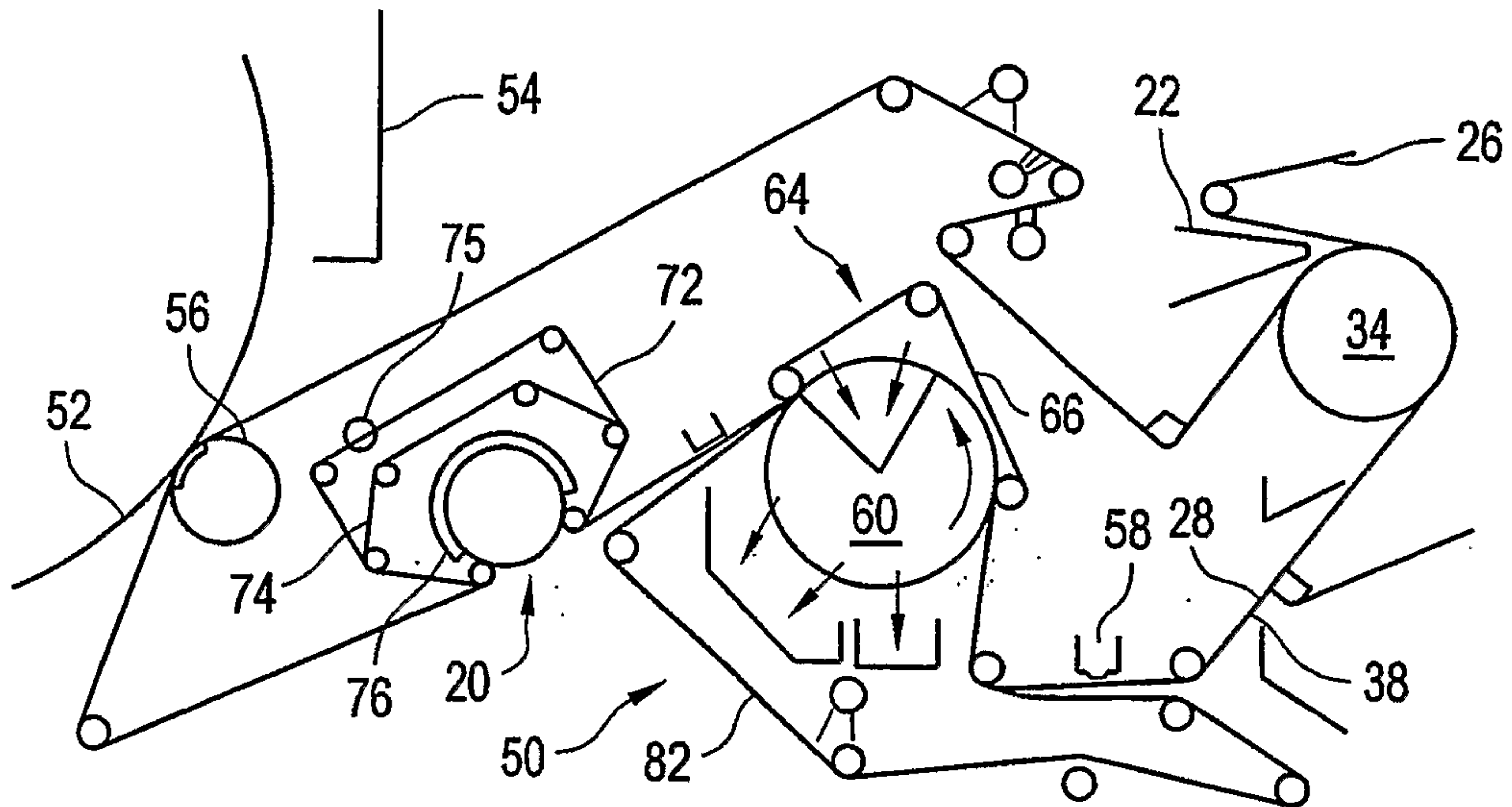


Fig.15

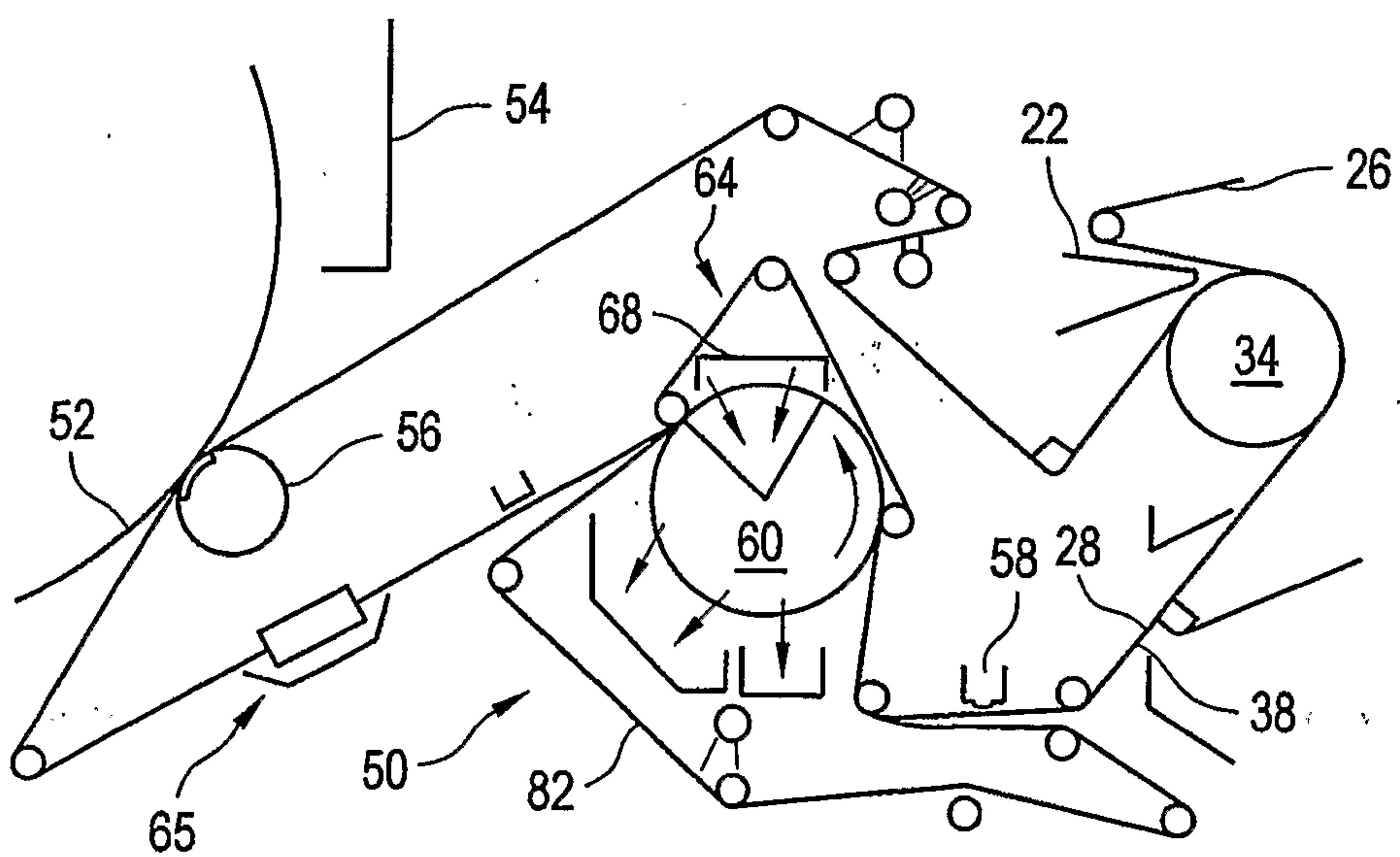


Fig.14

7/8

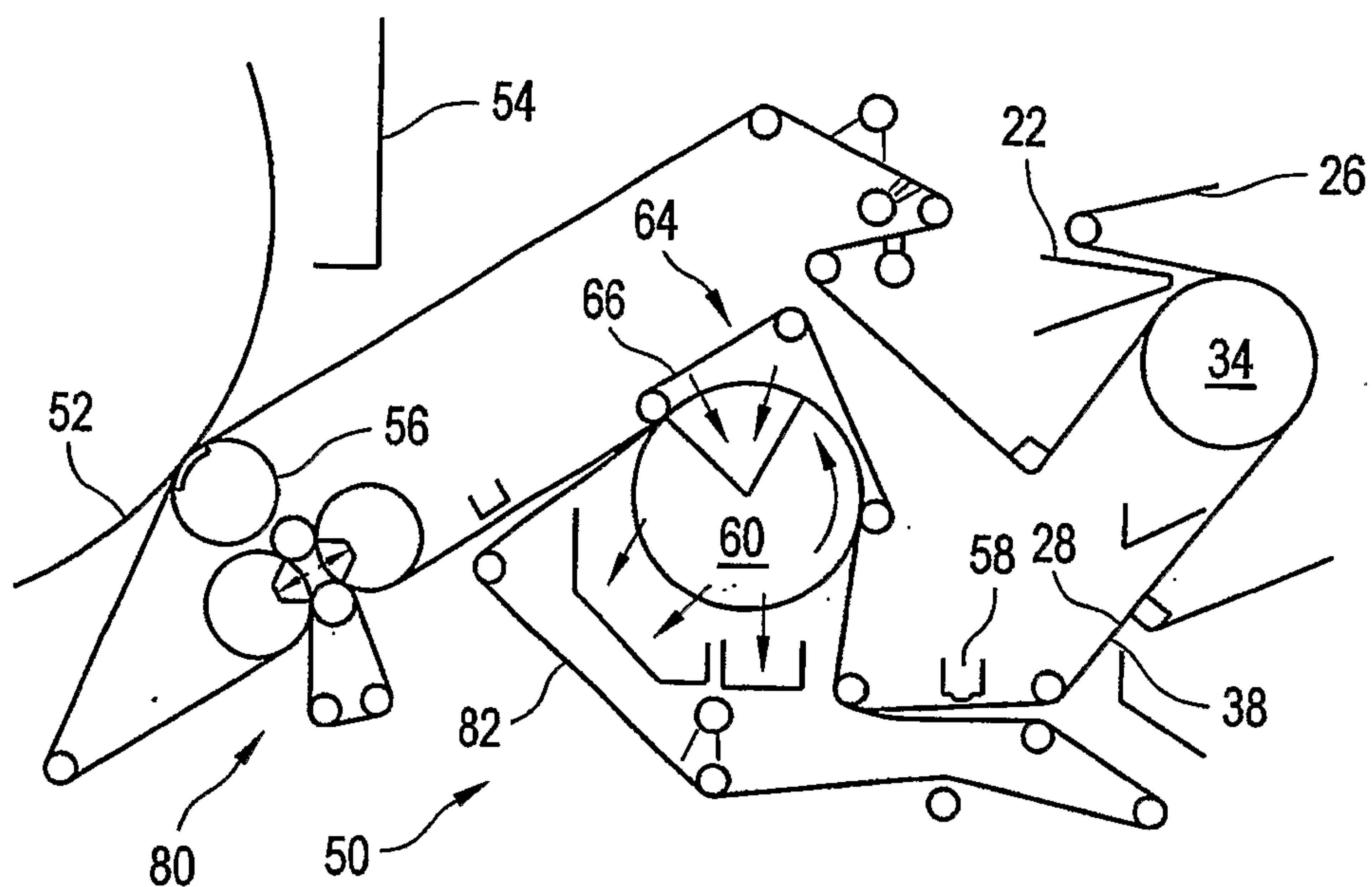


Fig. 17

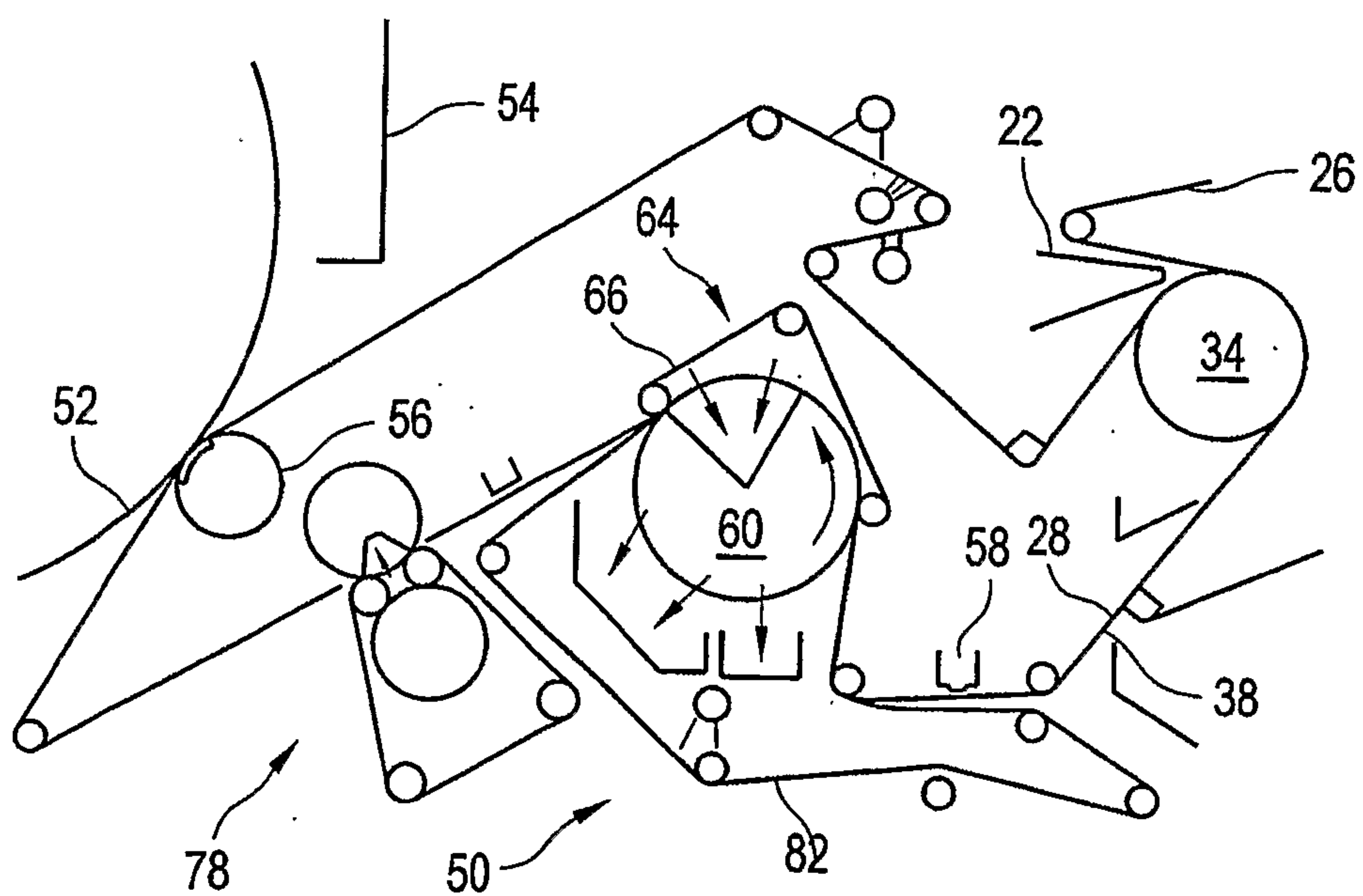


Fig. 16

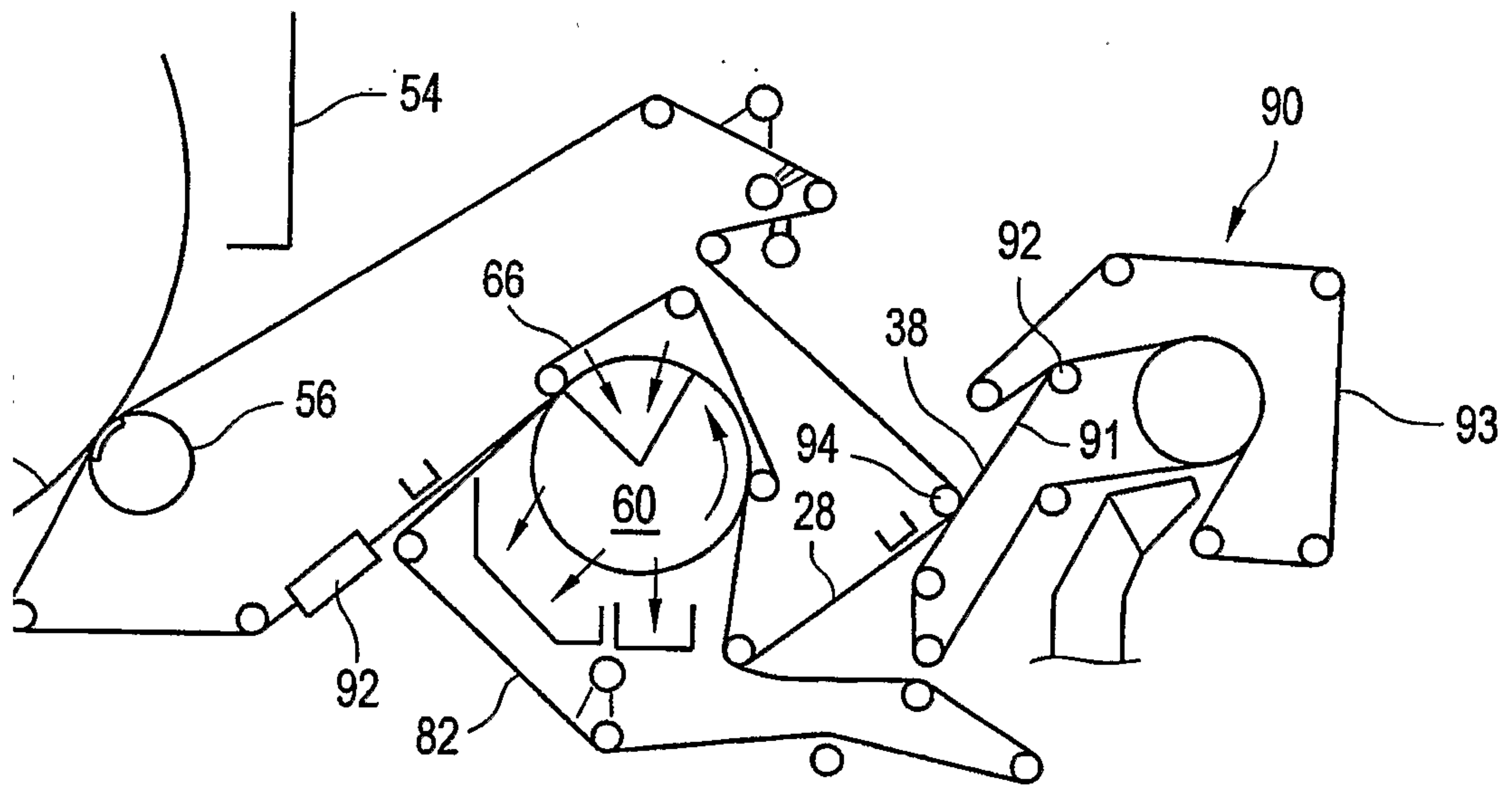


Fig.18