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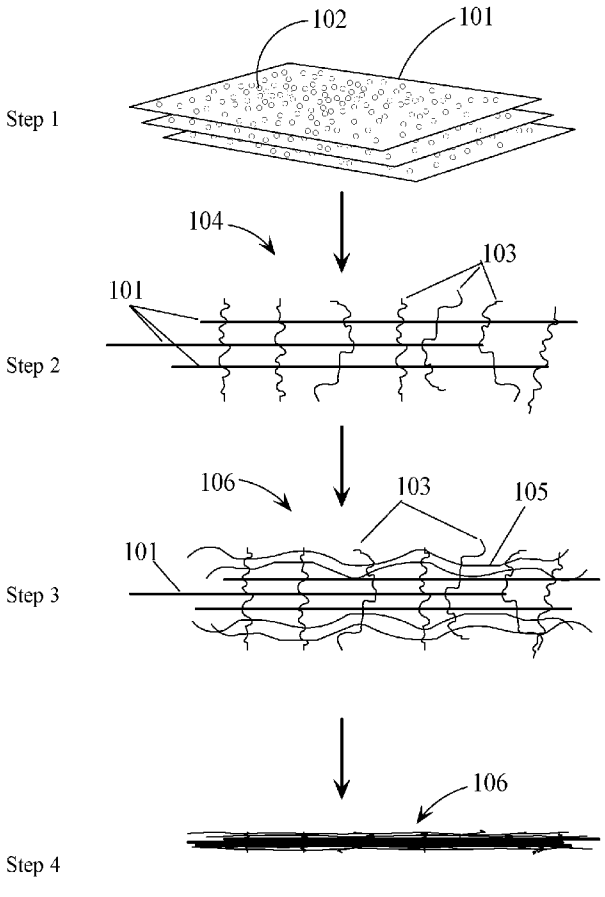
(54) **Title:** METHOD TO PRODUCE SYNTHETIC NON-WOVEN REINFORCED NATURAL FIBER SUBSTRATES



(57) **Abstract:** An improved paper (106) comprises two or more layers of porous non-woven material (101) overlaid to form a web. Pulp fibers (103) disposed through the pores of the non-woven material (101), wherein the pulp fibers (103) are entangled and act to hold the two or more porous non-woven material layers (101) together forming a substrate (104). A layer of paper pulp (105) disposed on both sides of the substrate (104) forming a composite (106) that is compressed, dried and heated to form the improved paper. In one embodiment, the non-woven material substrate (101) of the improved paper is a synthetic polymer material. The pulp fibers (103) may be disposed through the pores (102) of the non-woven material (101) using the process of sonication.

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METHOD TO PRODUCE SYNTHETIC NON-WOVEN REINFORCED NATURAL FIBER SUBSTRATES

REFERENCE TO RELATED APPLICATIONS

This application claims benefit of filing date of Provisional U.S. Patent Applications Nos. 60/819,309 filed July 7, 2006 and 60/819,575 filed July 10, 2006.

TECHNICAL FIELD

The present invention relates in general to manufacture of flexible substrates, and in particular, to the manufacture of paper products.

BACKGROUND INFORMATION

As part of the paper making process, it is desirable to make a natural or synthetic fiber (or combination of both) substrate that is stronger and lasts longer, while exhibiting similar printing characteristics as typical paper substrates. Such substrates are useful in many markets, including the currency market. The inclusion of a synthetic cross-linked component (such as a non-woven) within a natural fiber matrix augments an ability to incorporate more advanced security features to thwart counterfeiting efforts, both foreign and domestic. It also enables the inclusion of anti-bacterial components to sustain cleanliness, if so desired.

It is also desirable to make a normal substrate but with non-woven synthetic planchettes. Planchettes are security devices that are incorporated into the substrate of a security paper. This incorporation allows the otherwise standard paper new and interesting features such as tactile feel, novel optical features and even other, more covert security features.

Currently, attempts have been made to produce this type of improved substrate. The two main methods include gluing and incorporating loose fibers.

The gluing method essentially brings the paper/non-woven/paper "sandwich" together either by adhesives or by utilizing a non-woven that is made up of bi-component fibers, whereas the sheath of the fibers are comprised of a low melt polymer that can be heated to melt and adhere the two individual paper substrates together.

Others incorporate loose reinforcing fibers into the pulp that are then formed into the substrate. It is important to note that these loose fibers are not cross-linked with themselves, and hence only have a limited ability to catch and prevent tearing.

In regard to the embedded planchettes, they too may be formed of the same non-woven materials as used in the substrate. However, there are a number of methods of forming them from the substrates. They include:

Die cutting them from a continuous web. This inexpensive process produces many individual planchettes for incorporation into the paper. However, care must now be taken in order for them to be correctly placed within the substrate, if that is so desired.

Forming daisy-chain lengths of planchettes by die-cutting. This is accomplished by cutting away unwanted areas of the continuous non-woven web, leaving the planchettes connected in a tenuous manner. This allows for easier handling and ensures that the planchettes are positioned relative to each other corrected.

Forming daisy-chain lengths of planchettes by insertion of obstacles. During the original formation of the continuous non-woven web, pointed-obstacles are placed upon the surface of formation. The non-woven web cannot form on those obstacles, leaving user-defined "holes". This is a very efficient method and does not require a large amount of cutting. It is also a standard industry process.

Therefore, there is a need for a process for producing paper using an improved substrate that is stronger and lasts longer. Further, there is a need for a substrate that can easily incorporate planchettes for improved function, characteristics and security features.

SUMMARY

An improved paper comprises two or more layers of porous non-woven material overlaid to form a web. Pulp fibers disposed through the pores of the non-woven material, wherein the pulp fibers are entangled and act to hold the two or more porous non-woven material layers together forming a substrate. A layer of paper pulp disposed on both sides of the substrate forming a composite and the composite is compressed, dried and heated to form the improved paper. In one embodiment, the non-woven material substrate of the improved paper is a synthetic polymer material. The pulp fibers may be disposed through the pores of the non-woven material using the process of sonication.

In another embodiment, the porous non-woven layers of the improved paper include a multiplicity of planchettes configured to have security features that may be used for authentication and against counterfeiting. In one embodiment, the planchettes are linked together and in another the planchettes are loose and unattached. The security feature of the planchettes may reside in their unique shape(s) or lack thereof. In another embodiment, the security feature of planchettes comprises a visual effect such as iridescence or fluorescence. In yet another embodiment, the planchettes are configured to impart a tactile feel to the improved paper. The planchettes used in the improved paper may have sizes in the range of 2-4 mm.

In the above embodiments, the porous non-woven material may include a bi-component spun-bond material having a specific ratio of lower melt temperature polymer such as polylactide, poly vinyl acetate or ethylene vinyl acetate.

The foregoing has outlined rather broadly the features and technical advantages of the present invention in order that the detailed description of the invention that follows may be better understood. Additional features and advantages of the invention will be described hereinafter which form the subject of the claims of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

FIG. 1 illustrates process steps for making paper according to one embodiment;

FIG. 2A illustrates an apparatus for making paper according to one embodiment;

FIG. 2B illustrates an apparatus for making paper according to another embodiment;

FIG. 3 illustrates an inner layer of paper made according to one embodiment; and

FIG. 4 illustrates a patterned inner layer of paper made according to another embodiment.

DETAILED DESCRIPTION

In the following description, numerous specific details are set forth to provide a thorough understanding of the present invention. However, it will be obvious to those skilled in the art that the present invention may be practiced without such specific details. In other

instances, well-known circuits may be shown in block diagram form in order not to obscure the present invention in unnecessary detail. For the most part, details concerning timing and the like have been omitted inasmuch as such details are not necessary to obtain a complete understanding of the present invention and are within the skills of persons of ordinary skill in the relevant art.

Refer now to the drawings wherein depicted elements are not necessarily shown to scale and wherein like or similar elements are designated by the same reference numeral through the several views.

FIG. 1 illustrates steps for producing paper according to an embodiment of the present invention. Step 1 shows layers of porous non-woven material (synthetic) 101 with distributed pores 102. In step 2, the synthetic web material (or substrate) 101 may be exposed to sonication in the presence of some amount of paper slurry. Sonication is the act of applying sound (usually ultrasound) energy to agitate particles in a sample, for various purposes. This process forces some of the slurry into the open pores 102 of the substrate 101, mechanically entangling fibers 103 of the paper slurry within the synthetic web 101. In step 3, normal paper pulp 105 is introduced above and below composite 104 forming composite 106. Entangled fibers 103 engage the encapsulating paper pulp 105 thereby increasing the bonding between the encapsulating paper 105 and the internal non-woven materials 101. In step 4, the composite 106 is compressed to produce flat, smooth paper that looks and feels like regular paper but has in internal core of non-woven material that makes the improved paper strong.

FIG. 2A illustrates an apparatus suitable for producing improved paper according to process steps recited in FIG. 1. A roll of non-woven substrate 101, along with entangled fibers 103, is fed into a headbox 201. The function of a headbox 201 is to deliver a uniform jet of furnish (mix of pulp, fiber, etc.) having essentially the same width as the paper web to be produced. Redistribution of furnish and break-up of flocs is achieved with banks of tubes, expansion areas, and changes of flow direction. A flocculent mass (floc) is formed in a fluid through precipitation or aggregation of suspended particles.

Synthetic web 101 is evenly distributed or fed into the headbox 201 in such a way that paper slurry 103 can migrate underneath and above the synthetic substrate 101. This allows the natural fibers to become entangled with the synthetic fibers of the non-woven substrate 101 (step 3 of FIG. 1), as well as web entrained paper fibers 103, which may be located or placed in the top, middle or bottom of the final natural/synthetic product. As the substrate composite 104 progresses through the process, water is removed from the paper pulp slurry 105 by

vacuum boxes (not shown) located downstream. This vacuum process draws the natural fibers into the synthetic web and cause even further entanglement. Roller 108 is used to compress composite 105 to form flat, smooth paper 106.

FIG. 2B shows an alternate apparatus suitable for forming paper according to the process steps of FIG. 1. In this embodiment, a "split" headbox 202 may also be used. Split headbox 202 allows the paper pulp slurry 103 to be separately applied to the top and bottom of synthetic web 101. Rollers 108 are used to compress composite 105 and downstream vacuum and drying units (not shown) are used to produce the final paper product 106.

FIG. 3 illustrates a substrate manufactured in accordance with an embodiment of the present invention. The substrate is shown in a cut-away view where the top natural paper layer 301 is shown cut away to expose the non-woven synthetic core 302 disposed in between. The substrate corresponds to the finished product 106.

FIG 4 is an illustration of a different embodiment of an improved paper. In this embodiment, large planchettes 303 are incorporated into the substrate (e.g., 104) where these planchettes 303 may support many security features. The planchettes 303 may be loose from each other, or only connected in a very tenuous manner in the form of a daisy-chain. Planchettes are typically security devices that are incorporated into the substrate of a security paper. Planchettes may be polymer cut outs, possibly 2-4 mm in diameter. They may have some visual effect such as iridescence, fluorescence, etc. The incorporation of the planchettes into the paper may also occur during the wet paper pulp stage. This incorporation allows the otherwise standard paper new and interesting features such as tactile feel, novel optical features and even other, more covert security features.

In regard to the substrate, embodiments of the present invention produce a natural or synthetic fiber (or combination of both) substrate that is stronger and lasts longer, while exhibiting similar printing characteristics as typical paper substrates. Such substrates are useful in many markets, including the currency market. The inclusion of a synthetic cross-linked component (such as a non-woven) within a natural fiber matrix augments an ability to incorporate more advanced security features to thwart counterfeiting efforts, both foreign and domestic. It also enables the inclusion of anti-bacterial components to sustain cleanliness, if so desired.

Further, the synthetic web 104 may be produced as a bi-component spun-bond web in which the sheath is comprised of a specific ratio of a lower melt temperature polymer such as PLA (polylactide), PVA (Poly(vinyl acetate)), or EVA (Ethylene vinyl acetate). This allows

for even further adhesion when subjected to a roll heat source that is set at or above the sheath polymer melt temperature. Further, a chemical reaction between non-woven sheath material and pulp may further increase bonding.

United States Patent Application Serial No. 11/266,475 discloses a process which takes a synthetic web roll, two cotton/paper rolls where the three separate rolls are evenly fed together through a series of heated rolls or a heated press which melts the sheath material and essentially glues the three separate substrates together. Although this is an improvement over plain natural fiber substrates, this process does not solve problems with de-lamination.

Embodiments of the present invention solve the delaminating problems as the synthetic substrate 101 and natural fibers 103 essentially become a single substrate 106 that will look and feel like normal paper/cotton substrate but will possess strength properties associated with the polymer core of the substrate. This strength enhancement will undoubtedly produce a stronger substrate product that will exhibit longevity as a superior selling point.

The synthetic non-woven has the capability of being printed or modified (such as die cut) prior to being incorporated into the natural fiber slurry. This capability will enable a clear and recognizable overt security feature to be incorporated within the natural substrate and cannot be duplicated. Further, existing security features could be deployed within the fibers of the non-woven itself. These features might not be able to be implemented into the paper itself.

WHAT IS CLAIMED IS:

1. An improved paper comprising:

two or more layers of porous non-woven material (101) overlaid to form a web;

pulp fibers (103) disposed through pores (102) of the two or more layers of porous non-woven material (101), wherein the pulp fibers (103) are entangled and act to hold the two or more layers of porous non-woven material (101) together forming a substrate (104); and

a layer of paper pulp (105) disposed on a side of the substrate (104) forming a composite (106), wherein the composite (106) is compressed and dried to form the improved paper.

2. The improved paper of claim 1, wherein the non-woven material is a synthetic polymer material.

3. The improved paper of claim 1, wherein the pulp fibers are disposed through the pores of the non-woven material by sonication.

4. The improved paper of claim 1, wherein the two or more layers of porous non-woven material include a multiplicity of planchettes configured to have security features against counterfeiting.

5. The improved paper of claim 4, wherein the planchettes are linked together.

6. The improved paper of claim 4, wherein a shape of the planchettes provides the security feature.

7. The improved paper of claim 4, wherein a visual effect such as iridescence or fluorescence of the planchettes provide the security feature.

8. The improved paper of claim 4, wherein the planchettes provide a tactile feel to the improved paper.

9. The improved paper of claim 4, wherein the planchettes have a size in the range of 2-4 mm.

10. The improved paper of claim 1, wherein the two or more layers of porous non-woven material includes a bi-component spun-bond material having a specific ratio of lower melt temperature polymer such as polylactide, poly vinyl acetate or ethylene vinyl acetate.

11. A method of producing paper comprising:

forming a web of two or more layers of porous non-woven material (101);

disposing paper pulp fibers (103) through pores (102) of the two or more layers of non-woven material (101) such that the pulp fibers (103) entangle the non-woven material and act to hold the two or more layers of porous non-woven material (101) together forming a substrate (104);

disposing a layer of paper pulp (105) on a side of the substrate (104) forming a composite (106) ; and

compressing, dehydrating, and heating the composite (106) to form the improved paper.

12. The method of claim 11, wherein the non-woven material is a synthetic polymer material.

13. The method of claim 11, wherein the pulp fibers are disposed through the pores of the non-woven material by sonication.

14. The method of claim 11, wherein the two or more layers of porous non-woven material include a multiplicity of planchettes configured to have security features against counterfeiting.

15. The method of claim 14, wherein the planchettes are linked together.

16. The method of claim 14, wherein a shape of the planchettes provides the security feature.

17. The method of claim 14, wherein a visual effect such as iridescence or fluorescence of the planchettes provide the security feature.

18. The method of claim 14, wherein the planchettes provide a tactile feel to the improved paper.

19. The method of claim 14, wherein the planchettes have a size in the range of 2-4 mm.

20. The method of claim 11, wherein the two or more layers of porous non-woven material includes a bi-component spun-bond material having a specific ratio of lower melt temperature polymer such as polylactide, poly vinyl acetate or ethylene vinyl acetate.

21. An apparatus for making an improved paper comprising:

a roll dispensing a web (104) formed of two or more layers of porous non-woven material (101);

a single headbox for applying a layer of paper pulp (105) on a side of the web (104) thereby forming a composite (106) by having pulp fibers (103) disposed through the pores (102) of the non-woven material (101) to entangle and hold the layer of paper pulp (105) and the two or more porous non-woven material layers (101) together; and

a series of stations for compressing, dehydrating and heating the composite (106) to form the improved paper.

22. The apparatus of claim 21, wherein the non-woven material is a synthetic polymer material.

23. The apparatus of claim 21, wherein the pulp fibers are disposed through the pores of the non-woven material by sonication.

24. The apparatus of claim 21, wherein the two or more porous non-woven layers include a multiplicity of planchettes configured to have security features against counterfeiting.

25. The apparatus of claim 24, wherein characteristics of the planchettes provides the security feature.

26. The improved paper of claim 21, wherein the porous non-woven material includes a bi-component spun-bond material having a specific ratio of lower melt temperature polymer such as polylactide, poly vinyl acetate or ethylene vinyl acetate.

27 An apparatus for making an improved paper comprising:

a roll dispensing a web (104) formed of two or more layers of porous non-woven material (101);

a split headbox for applying a layer of paper pulp (105) to both sides of the web (104) thereby forming a composite (106) by having pulp fibers (103) disposed through the pores (102) of the non-woven material (101) to entangle and hold the layers of paper pulp (105) and the two or more porous non-woven material layers (101) together; and

a series of stations for compressing, dehydrating and heating the composite (106) to form the improved paper.

28. The apparatus of claim 27, wherein the non-woven material is a synthetic polymer material.

29. The apparatus of claim 21, wherein the pulp fibers are disposed through the pores of the non-woven material by sonication.

30. The apparatus of claim 27, wherein the two or more porous non-woven layers include a multiplicity of planchettes configured to have security features against counterfeiting.

31. The apparatus of claim 30, wherein characteristics of the planchettes provides the security feature.

32. The improved paper of claim 27, wherein the porous non-woven material includes a bi-component spun-bond material having a specific ratio of lower melt temperature polymer such as polylactide, poly vinyl acetate or ethylene vinyl acetate.

33. An improved paper comprising:

a layer of porous non-woven material (101) forming a web;

pulp fibers (103) disposed through the pores (102) of the layer of porous non-woven material (101), wherein the pulp fibers (103) are entangled with the layer of porous non-woven material forming a substrate (104); and

a layer of paper pulp (105) disposed on a side of the substrate (104) forming a composite (106), wherein the composite (106) is compressed and dried to form the improved paper.

34. The improved paper of claim 33 further comprising a second layer of paper pulp (105) disposed on a second side of the substrate forming the composite.

35. The improved paper of claim 33, wherein the non-woven material is a synthetic polymer material.

36. The improved paper of claim 33, wherein the pulp fibers are disposed through the pores of the non-woven material by sonication.

37. The improved paper of claim 33, wherein the layer of porous non-woven material include a multiplicity of planchettes configured to have security features against counterfeiting.

38. The improved paper of claim 37, wherein a shape of the planchettes provides the security feature.

39. The improved paper of claim 37, wherein a visual effect such as iridescence or fluorescence of the planchettes provide the security feature.

40. The improved paper of claim 37, wherein the planchettes provide a tactile feel to the improved paper.

41. The improved paper of claim 37, wherein the planchettes have a size in the range of 2-4 mm.

42. The improved paper of claim 33, wherein the layer of porous non-woven material includes a bi-component spun-bond material having a specific ratio of lower melt temperature polymer such as polylactide, poly vinyl acetate or ethylene vinyl acetate.

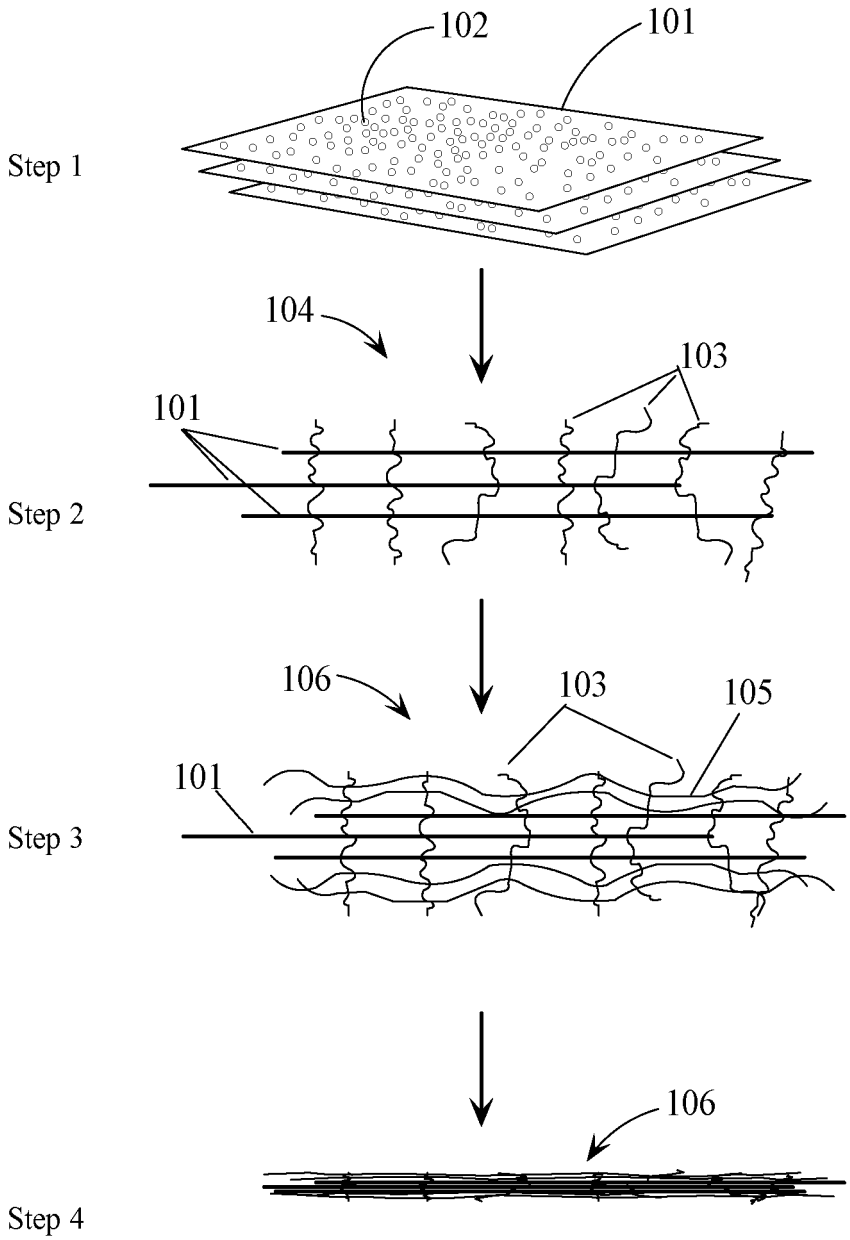
Step 1
102
101
104
103
101
Step 2
106
103
105
101
Step 3
106
Step 4

FIG. 1

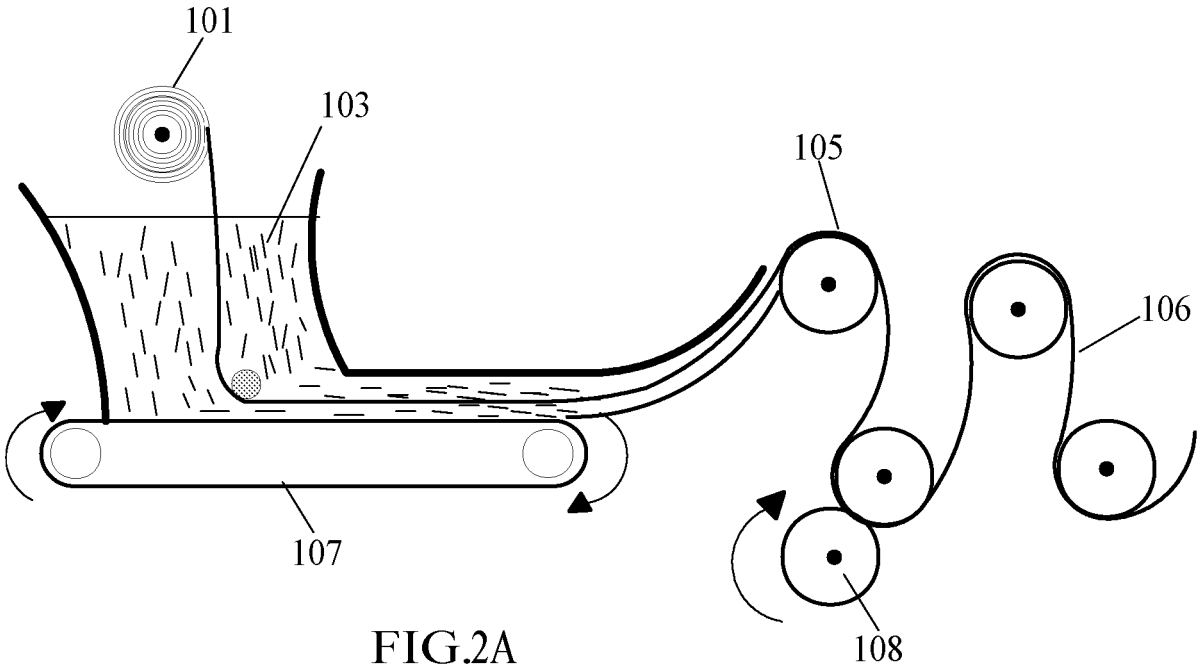

FIG.2A

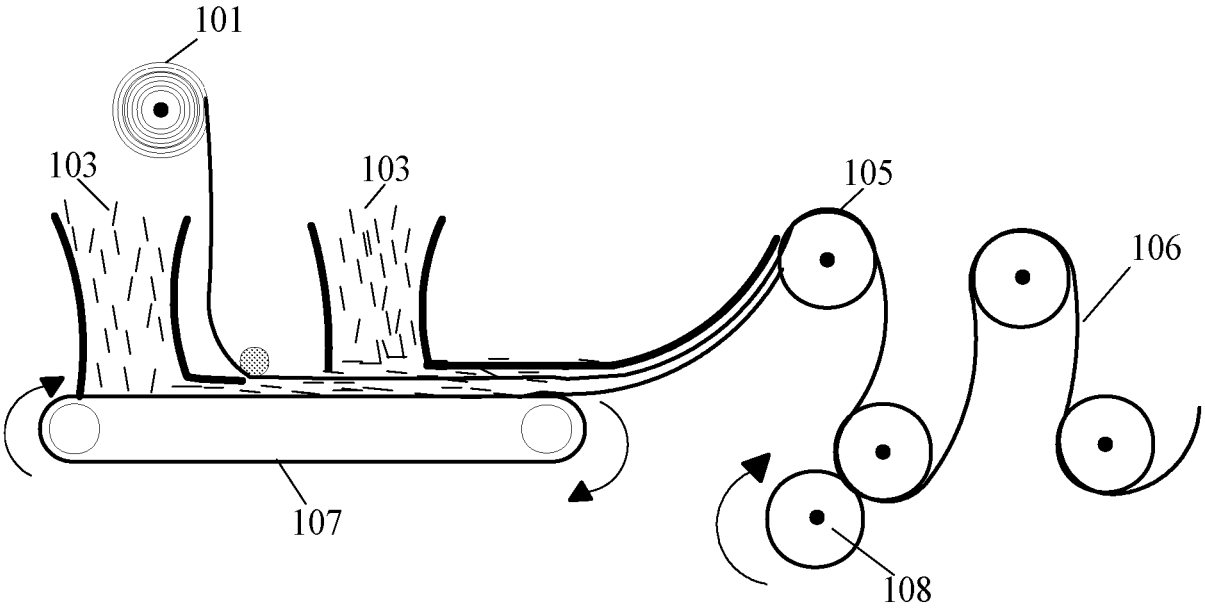

FIG.2B

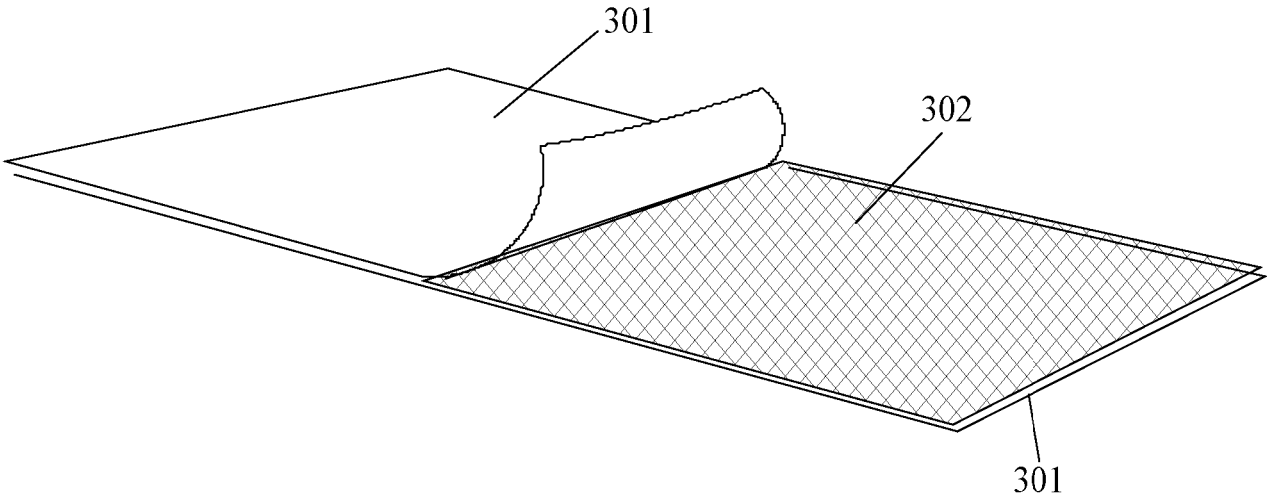

FIG. 3

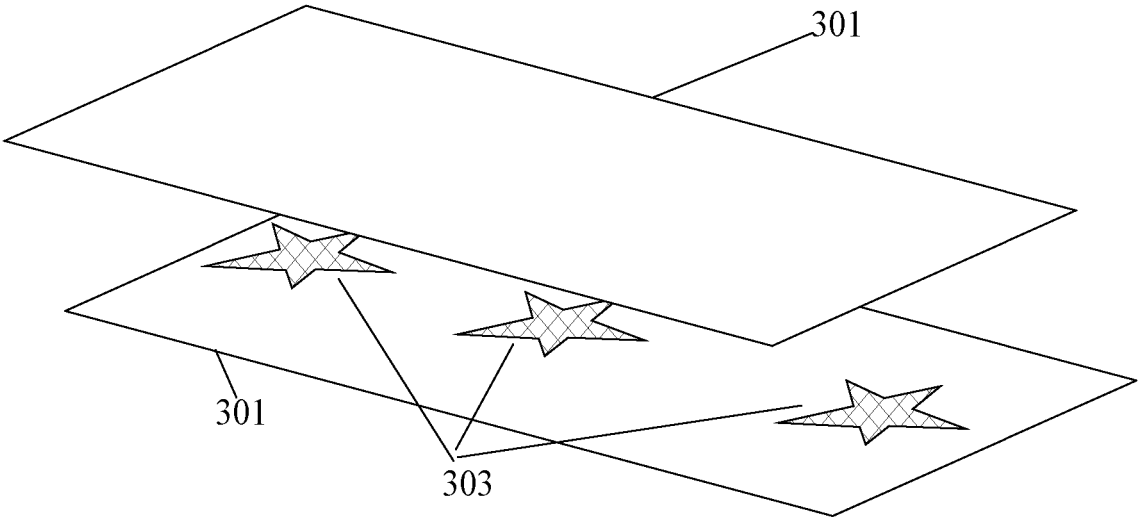

FIG. 4