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(54) POLYURETHANE FIBER AND SPINNERET THEREFOR AND MANUFACTURING METHOD THEREOF

(57) A polyurethane fiber (700) and a manufacturing method thereof are provided. The manufacturing method includes the following steps. A polyurethane material (70) is provided. Then a melt extrusion process is carried out on the polyurethane material (70) through a spinneret (400). The spinneret (400) includes at least one spinneret orifice unit (410) embedded in a spinneret body (402). Wherein, the spinneret orifice unit (410) includes a plurality of spinneret sub-orifices (412), and each spinneret sub-orifice (412) penetrates through the spinneret body (402). Each spinneret sub-orifice (412) has a sub-orifice diameter (D_H) ranging from 0.07 mm to 0.12 mm, and there is a sticking space (S_H) between every two adjacent spinneret sub-orifices ranging from 0.01 mm to 0.05 mm. Then the polyurethane material (70) passes through the spinneret sub-orifices (412) and is sticked together to form the polyurethane fiber (700).

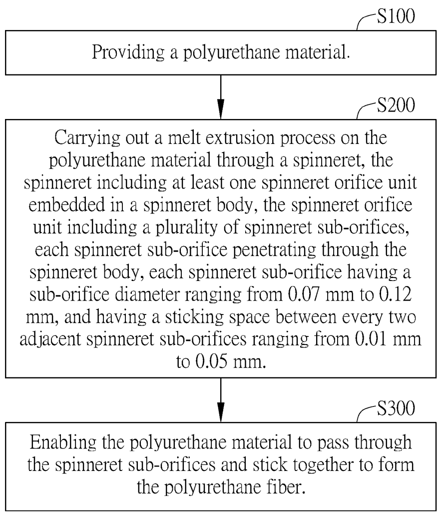

FIG. 1

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a type of polyurethane fiber and a manufacturing method thereof, and particularly relates to a type of polyurethane fiber with a profiled cross-section and a manufacturing method thereof.

2. Description of the Related Art

[0002] Because of the invention of artificial polymer fiber, textile products now have more of a diversity of characteristics such as high elasticity, high breathability, and high moisture-guiding capability, etc. to meet the needs of consumers. Through air intermingling or co-twisting techniques, different artificial polymer fibers may be combined and made into modified textured yarn, such as combining polyester fibers, polyamide fibers, polypropylene fibers, and the like into composite yarns to produce textile products having composite characteristics. However, because composite yarns have two or more components of fibers, the difficulty increases for the subsequent environmentally-friendly recycling of the textile products made of the composite yarns, which makes it difficult to achieve the separation and reproduction of recycled materials.

[0003] In addition, since users demand more and more functions of textile products, they expect textile products to have high scalability, moisture-guiding capability and high breathability at the same time. At present, for high-elasticity fibers, Lycra yarns of Dupont and Roica yarns of Asahi Kasei are the main products. They mainly use polyurethane fibers. Due to their composition of molecular structures, polyurethane fibers have the function of high extension (or stretching) and can be stretched to the maximum extent of eight times. Therefore, polyurethane fibers have high resilience that is far superior to other types of high polymer fibers.

[0004] Although polyurethane fibers have the advantage of high stretchability, in the aspects of moisture-guiding capability and breathability, polyurethane fibers have a natural hygroscopicity of about 1%, and thus can naturally capture water molecules in the air, which in turn affects the moisture-guiding capability and breathability performance target of the final fabric product, and the requirement of the user for moisture-guiding capability and breathability is difficult to meet. In addition, because of the high elasticity characteristic of the polyurethane fiber, the polyurethane fiber can more easily flow into grooves or holes compared with other types of polymer fibers, and a stable deformation structure is difficult to manufacture. Therefore, it is not easy to improve the moisture-guiding capability and breathability performance of the polyurethane fiber.

[0005] Therefore, how to manufacture a polyurethane fiber with a highly stable deformation structure having high stretch recovery, flexibility, high moisture-guiding capability, and breathability, and how to increase the manufacture of a single-component finished fabric of the polyurethane fiber and improve the recycling and regeneration of the finished fabric of the polyurethane fiber have become problems to be solved urgently by a person skilled in the art.

SUMMARY OF THE INVENTION

[0006] One objective of the present invention is to provide a polyurethane fiber and a manufacturing method thereof, wherein the polyurethane fiber has a profiled cross-section and a highly stable deformation structure. The polyurethane fiber with a profiled cross-section and the manufacturing method thereof in the present invention can provide a highly stable deformation structure and solve the problem caused by the high elasticity of the polyurethane fiber in manufacturing a highly moisture-guiding and breathable structure. The polyurethane fiber with a profiled cross-section in the present invention has high resilience and flexibility and also high moisture-guiding capability and breathability. The polyurethane fiber with a profiled cross-section in the present invention can increase the application of the polyurethane fiber in a single-component finished fabric and improve the recycling and regeneration of the finished fabrics of polyurethane fiber.

[0007] One embodiment of the present invention provides a manufacturing method of a polyurethane fiber, which includes the following steps. A polyurethane material is provided. Then, a melt extrusion process is carried out on the polyurethane material through a spinneret. The spinneret includes at least one spinneret orifice unit embedded in a spinneret body. The spinneret orifice unit includes a plurality of spinneret sub-orifices, and each spinneret sub-orifice penetrates through the spinneret body. Each spinneret sub-orifice has a sub-orifice diameter ranging from 0.07 mm to 0.12 mm, and has a sticking space between every two adjacent spinneret sub-orifices ranging from 0.01 mm to 0.05 mm. Then, the polyurethane material passes through the spinneret sub-orifices and is sticked together to form the polyurethane fiber.

[0008] Another embodiment of the present invention provides a spinneret which is suitable for manufacturing the polyurethane fiber. The spinneret includes a spinneret body and at least one spinneret orifice unit. The spinneret body includes a first surface and a second surface which are opposite to each other. The at least one spinneret orifice unit is embedded in the spinneret body. The spinneret orifice unit includes a plurality of spinneret sub-orifices, and each spinneret sub-orifice penetrates through the spinneret body. The two ends of each spinneret sub-orifice are connected to the first surface and the second surface respectively. Each spinneret sub-orifice has a sub-orifice diameter ranging from 0.07 mm to 0.12 mm and has a sticking space between every two adjacent spinneret sub-orifices ranging from 0.01 mm and 0.05 mm.

[0009] Another embodiment of the present invention provides a polyurethane fiber which includes a plurality of sub-fiber parts and a plurality of sticking parts. The sub-fiber parts are arranged in parallel. Each sticking part is positioned between every two adjacent sub-fiber parts and connects the adjacent two sub-fiber parts. Each sub-fiber part has a sub-fiber diameter ranging from 0.07 mm to 0.12 mm, and each sticking part has a sticking width ranging from 0.01 mm to 0.05 mm.

[0010] Compared with conventional technologies, the polyurethane fiber and the manufacturing method thereof in the present invention use spinnerets having sticking spaces between the spinneret sub-orifices, and polyurethane material passing through the spinneret sub-orifices is then sticked together to form a polyurethane fiber with a profiled cross-section. Thus, excessive deformation of the polyurethane material due to high-temperature flowing can be reduced, and the polyurethane fiber can have a high-stability deformation structure. According to the present invention, the polyurethane fiber with a profiled cross-section has a high-stability deformation structure, which makes it possible to make a deep groove in the polyurethane fiber with a profiled cross-section to improve its moisture-guiding capability and breathability. The polyurethane fiber with a profiled cross-section in the present invention can increase the application of the polyurethane fiber in a single-component finished fabric and improve the recycling and regeneration of the finished fabrics of polyurethane fiber.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

FIG. 1 shows a manufacturing method of a polyurethane fiber according to one embodiment of the present invention.
FIG. 2 is a schematic structural diagram of a spinning machine according to one embodiment of the present invention.
FIG. 3 is a schematic top view of a spinneret according to one embodiment of the present invention.
FIG. 4A is a schematic top view of a spinneret orifice unit according to one embodiment of the present invention.
FIG. 4B is a schematic structural diagram of the cross section of a spinneret orifice unit according to one embodiment of the present invention.
FIG. 5A to FIG. 5D are respectively schematic top views of a spinneret orifice unit according to another embodiment of the present invention.
FIG. 6A is a schematic structural diagram of the cross section of a polyurethane fiber according to one embodiment of the present invention.
FIG. 6B is a schematic three-dimensional view of a polyurethane fiber according to one embodiment of the present invention.
FIG. 6C is a schematic structural diagram of the cross section of a polyurethane fiber according to one embodiment of the present invention.
FIGS. 7A to 7D are respectively schematic three-dimensional views of a polyurethane fiber according to another embodiment of the present invention.
FIG. 8 is a schematic three-dimensional view of a polyurethane multifilament fiber according to one embodiment of the present invention.
FIG. 9 is a schematic three-dimensional view of a filament yarn fabric using a polyurethane multifilament fiber according to one embodiment of the present invention.
FIG. 10 is a schematic three-dimensional view of a filament yarn fabric using a polyurethane multifilament fiber according to another embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0012] In various embodiments of the present invention, the terms used herein are only for the purpose of describing specific embodiments and are not limiting. As used herein, the singular forms "a", "an" and "the" are intended to include plural forms including "at least one" unless the context clearly indicates. As used herein, the term "a" includes any and all combinations of one or more related listed items.

[0013] In various embodiments of the present invention, "up", "down", "left", "right", "front" or "back" used herein are to describe the relationship between one element and another element, and are only to illustrate the orientation presented in the drawings, but not to limit its actual position. For apparatuses in the accompanying drawings, the orientation or direction of components of the apparatuses will not be limited by apparatus flipping.

[0014] FIG. 1 shows a manufacturing method of a polyurethane fiber according to one embodiment of the present invention. FIG. 2 is a schematic structural diagram of a spinning machine according to one embodiment of the present invention. As shown in FIG. 1 and FIG. 2, a spinning machine 10 of the present invention is used for illustrative purposes only. The spinning machine 10 of the present invention is at least provided with a spinneret 400. The spinning machine 10 and the spinneret 400 of the present invention are used for illustrative purposes only and do not represent their actual size and configuration. In order to highlight the technology and advantages of the present invention, the size, proportion and structural representation in the figures are properly adjusted, and therefore the objectives and advantages of the present invention can be understood more easily. A person skilled in the art can properly modify the structural design of the spinning machine 10 and the spinneret 400 without departing from the spirit and range of the present invention to achieve the effects of the present invention.

[0015] As shown in FIG. 1 and FIG. 2, the spinning machine 10 of the present invention at least includes the spinneret 400 which is configured to manufacture a polyurethane fiber 700 with a profiled cross-section. According to the present invention, the polyurethane fiber 700 can be manufactured by a melt extrusion process. As shown in FIG. 1, a polyurethane material 70 is provided first (step S100). The polyurethane material 70 (for example, including a poly-carbamate material) generally refers to a high polymer material containing a carbamate characteristic unit in the main chain. The polyurethane material 70 may be a polyurethane raw material or a polyurethane recycled material or a mixture thereof. The polyurethane raw material may be polymerized from, for example, polyisocyanate and polyol. The polyurethane recycled material may be recycled and regenerated from, for example, a finished fabric with the polyurethane fiber or an article containing a polyurethane component. The polyurethane recycled material may be manufactured into, for example, polyurethane powder, polyurethane particles or polyurethane staple fiber yarns, and proper particle sizes can be selected according to the conditions of the melt extrusion process. A dye material may be selectively added into the polyurethane material 70 to manufacture a polyurethane fiber with a specific color. The dye material may be pigments with different particle sizes or chemical colorants. By mixing in different proportions, a yarn-dyed colored polyurethane fiber can be manufactured, and different gloss effects such as bright light, full dull or matte can be achieved. The type of the added dye material is well known by a person skilled in the art, so it will not be described herein.

[0016] As shown in FIG. 1, FIG. 2 and FIG. 3, the spinneret 400 is configured to carry out the melt extrusion process on the polyurethane material 70. The spinneret 400 includes at least one spinneret orifice unit 410 embedded in a spinneret body 402. The at least one spinneret orifice unit 410 includes a single or a plurality of spinneret orifice units 410. The single spinneret orifice unit 410 may be configured to, for example, manufacture a polyurethane monofilament fiber. The number of the plurality of spinneret orifice units 410 may be 2 to 452, but it is not limited thereto. The plurality of spinneret orifice units 410 can be configured to, for example, manufacture a polyurethane multifilament fiber, but it is not limited thereto. The spinneret orifice unit 410 includes a plurality of spinneret sub-orifices 412. Each spinneret sub-orifice 412 penetrates through a spinneret body 402. Each spinneret sub-orifice 412 has a sub-orifice diameter D_H ranging from about 0.07 millimeter (mm) to 0.12 mm. There is a sticking space S_H between every two adjacent spinneret sub-orifices 412 ranging from about 0.01 mm to 0.05 mm (step S200). According to the present invention, with the proper sticking space S_H designed between every two adjacent spinneret sub-orifices 412 of the spinneret 400, in combination with the proper sub-orifice diameter D_H of the two adjacent spinneret sub-orifices 412, a profiled cross-section structure with high stability can be manufactured.

[0017] As shown in FIG. 1, FIG. 2, FIG. 3 and FIG. 6B, the polyurethane material 70 is heated and pressurized in the melt extrusion process, and then the polyurethane material 70 flows through the spinneret sub-orifices 412 and is sticked together to form the polyurethane fiber 700 (step S300). Because the polyurethane material 70 can flow through the spinneret sub-orifices 412 to form strip-shaped sub-fiber parts 710, and the adjacent strip-shaped sub-fiber parts 710 can be sticked to each other under high temperature in the process, the polyurethane fiber 700 with a profiled cross-section can be formed. According to the present invention, the sticking space S_H between the spinneret sub-orifices 412 ranges from about 0.01 mm to 0.05 mm, so that the sub-fiber parts 710 can be sticked to each other at the process temperature, and excessive deformation of the polyurethane fiber 700 can be reduced. Therefore, a deep groove 730 can be manufactured in the polyurethane fiber 700 with a profiled cross-section to improve the moisture-guiding capability and breathability, and a good profiled cross-section structure is maintained without worrying about the problem that the opening of the groove is easily filled and becomes deformed due to the inflow of the material.

[0018] As shown in FIG. 2, FIG. 3 and FIG. 6B, the spinning machine 10 of the present invention can carry out the manufacturing steps as shown in FIG. 1 through, for example, the following mechanisms. The spinning machine 10 includes a raw material tank 100 which can be filled with the polyurethane material 70. The polyurethane material 70 can be heated to reach a melt extrusion temperature by an extrusion system 200 so as to form molten fluid, and the molten fluid is pressurized to flow to the spinneret 400 for melt extrusion. According to the types of material, a glass transition temperature (Tg) and a melting temperature (Tm) of the polyurethane material 70 can be measured, for example, by using a differential scanning calorimeter (DSC). For example, a glass transition temperature is measured to be about -50°C to 120°C, and a melting temperature is about 180°C. A proper heating process is designed according to the measured thermal properties of the material. For example, having the heating temperature ranging from 140 °C to 250 °C allows the polyurethane material 70 to flow to the spinneret 400 at a proper temperature and flow rate. A metering pump 300 may be arranged in front of the spinneret 400 to measure the flow velocity or flow amount of the polyurethane material 70 reaching the spinneret 400. In addition, the temperature of the polyurethane material 70 reaching the spinneret 400 can be measured, thereby stably manufacturing the polyurethane fiber 700 with a profiled cross-section. The polyurethane material 70 passes through the plurality of spinneret sub-orifices 412 of the spinneret orifice unit 410 in the spinneret 400 under a molten state to form a plurality of strip-shaped sub-fiber parts 710. Due to the thermal expansion characteristic of the polyurethane material 70, adjacent sub-fiber parts 710 which just flow out of the spinneret 400 can swell and be sticked to each other at the process temperature, and then form the polyurethane fiber 700 with a profiled cross-section. According to the present invention, because the sticking space S_H is designed between every two adjacent spinneret sub-orifices 412, the sub-fiber parts 710 have enough buffering space, the purpose of mutual sticking can be achieved, and excessive deformation of the sub-fiber parts 710 due to thermal expansion can be avoided. The polyurethane fiber 700 with a profiled cross-section manufactured through the spinneret 400 can maintain a good cross-section shape and prevent the undesirable situation that, due to flow velocity difference and thermal expansion of the conventional profiled opening design with a groove, materials can easily flow into and fully fill the groove, resulting in a polyurethane fiber that is deformed to a nearly cylindrical shape.

[0019] As shown in FIG. 2, the polyurethane fiber 700 manufactured by the spinneret 400 is gradually cooled and molded in a spinning channel 600. An auxiliary cooling module 500, such as an air-cooled cooling module, may be selectively arranged near an outlet of the spinneret 400 to assist in accelerating the proper cooling of the polyurethane fiber 700. According to the product requirement, a plurality of spinneret orifice units 410 may be designed on the spinneret 400 of the spinning machine 10 to manufacture a plurality of polyurethane fibers 700 at the same time. The polyurethane fiber 700 may be a monofilament fiber, and a drafting module 800 is matched with a winding machine 900 to draft the polyurethane fiber 700 to the winding machine 900. The plurality of polyurethane fibers 700 can be twisted into a polyurethane multifilament fiber 1700 and can also be twisted into a wound package for spinning at the same time. The winding speed of the winding machine 900 may range from 1,200 m/min to 6,500 m/min. According to the present invention, the design of the spinning machine 10 with the spinneret 400 can produce polyurethane fiber 700 that is difficult to break. It can also increase the winding speed of the winding machine 900 to a high drafting and winding speed and greatly increase the production speed of the polyurethane fiber 700 without affecting the quality of the produced polyurethane multifilament fiber 1700, realizing excellent performance of both high productivity and high quality and alleviating the problem of insufficient production speed of the conventional spinning machine.

[0020] FIG. 3 is a schematic top view of a spinneret according to one embodiment of the present invention. FIG. 4A is a schematic top view of a spinneret orifice unit according to one embodiment of the present invention. FIG. 4B is a schematic structural diagram of the cross section of a spinneret orifice unit according to one embodiment of the present invention. As shown in FIG. 3, FIG. 4A and FIG. 4B, the spinneret 400 of the present invention includes the spinneret body 402, and has a first surface 404 and a second surface 406 which are opposite to each other. The spinneret body 402 is, for example, a circular plate, as shown in FIG. 3, but it is not limited thereto. The spinneret 400 includes at least one spinneret orifice unit 410. One spinneret orifice unit 410 or a plurality of spinneret orifice units 410 may be configured as required. The number of a plurality of spinneret orifice units 410 may be 2 to 452, but it is not limited thereto. A plurality of spinneret orifice units 410 may be arranged into a plurality of circles concentrically, as shown in FIG. 3, but it is not limited thereto. The spinneret body 402 may be made of, for example, metal materials, such as stainless steel, tungsten, copper, zinc, iron, nickel, titanium and aluminum or alloy and lamination thereof. The spinneret orifice unit 410 is embedded in the spinneret body 402, and may be made of a material the same as or different from the spinneret body 402. The spinneret orifice unit 410 may be a part of the spinneret body 402 or may be an additionally manufactured and embedded part in the spinneret body 402. The spinneret orifice unit 410 includes a plurality of spinneret sub-orifices 412. Each spinneret sub-orifice 412 penetrates through the spinneret body 402. Each spinneret sub-orifice 412 may be manufactured by, for example, a drilling process with a rotating speed of more than 60,000 rpm, but it is not limited thereto. The spinneret orifice unit 410 includes, for example, 3 to 30 spinneret sub-orifices 412, but it is not limited thereto. The spinneret orifice unit 410 may be, for example, a spinneret orifice unit 410A. The spinneret sub-orifices 412 may be arranged in an approximate cross shape. The two ends of each spinneret sub-orifice 412 are connected to the first surface 404 and the second surface 406 respectively. That is, a sub-orifice inner wall 4122 of each spinneret sub-orifice 412 is connected to the first surface 404 and the second surface 406 respectively. Each spinneret sub-orifice 412 is, for example, circular. Each spinneret sub-orifice 412 has a sub-orifice diameter D_H ranging from about 0.07 mm to 0.12 mm, and has a sticking space S_H between every two adjacent spinneret sub-orifices 412 ranging from about 0.01 mm to 0.05 mm. The sticking space S_H is less than or equal to the swelling scale S_{SWELL}, namely, $S_H \leq S_{SWELL}$, so the sub-fiber parts 710 formed by melt extrusion through the spinneret sub-orifices 412 can achieve mutual sticking. Meanwhile, the sub-fiber parts 710 have enough buffering space, so that excessive deformation of the sub-fiber parts 710 due to thermal expansion can be avoided. The polyurethane fiber 700 with a profiled cross-section manufactured by the spinneret 400 can maintain a good cross-section shape. In a variation embodiment, each spinneret sub-orifice 412 can be, for example, elliptical, triangular, quadrangular, pentagonal, hexagonal, and octagonal, but is not limited thereto. The quadrangle is, for example, square, rectangular, and rhombic, but is not limited thereto. Each spinneret sub-orifice 412 can be properly modified as required, and the equivalent effective sub-orifice diameter and the equivalent effective sticking space can be properly adjusted.

[0021] As shown in FIG. 4A, in this embodiment, the spinneret orifice unit 410A is designed to have 5 spinneret sub-orifices 412, including spinneret sub-orifices 412a, 412b, 412c, 412d and 412e which are arranged in an approximate cross shape. Each spinneret sub-orifice 412 is, for example, a circular hole and has the sub-orifice diameter D_H and a sub-orifice radius R_H. The distance between geometric centers of every two adjacent spinneret sub-orifices 412 (for example, the spinneret sub-orifices 412a and 412b) is a sub-orifice distance T_H. That is, the sticking space S_H is equal to the difference of the sub-orifice distance T_H and the sub-orifice radius R_H of the spinneret sub-orifices 412a and 412b, namely $S_H = T_H\text{-}2R_H$. The sticking space S_H between the spinneret sub-orifices 412 is designed to range from about 0.01 mm to 0.05 mm to achieve a good sticking effect. The sub-orifice diameter D_H of the spinneret sub-orifices 412 is designed to range from 0.07 mm to 0.12 mm corresponding to the sticking space S_H to achieve a good swelling scale S_{SWELL}, thereby realizing a good comprehensive effect.

[0022] As shown in FIG. 4A and FIG. 4B, the polyurethane material 70 flows to the first surface 404 of the spinneret 400 after being properly heated and pressurized. An auxiliary plate (not shown) may be selectively arranged on the first surface 404 to increase the strength of the spinneret 400. An auxiliary hole (not shown) may be formed in the auxiliary plate on the spinneret orifice unit 410 to adjust the velocity of the polyurethane material 70 flowing to the spinneret 400. The polyurethane material 70 is melted and extruded through the melt extrusion process. Then the polyurethane material 70 passes through the spinneret sub-orifices 412 of the spinneret 400 to form the sub-fiber parts 710 on the second surface 406 of the spinneret 400, and the sub-fiber parts are sticked together to form the polyurethane fiber 700. Since the adjustable ranges for the viscosity and temperature of the polyurethane material 70 melt are very small, in order to avoid shear thinning of the polyurethane material 70 melt in micro-flow tubes of the spinneret sub-orifices 412, the spinneret sub-orifices 412 may be designed to have tube wall characteristics, so that the polyurethane material 70 melt in the spinneret sub-orifices 412 can pass through the spinneret sub-orifices 412 at the shear rate of less than or equal to 2,000 s^{-1}. Preferably, the shear rate may range from 200 s^{-1} to 2,000 s^{-1}. For example, by selectively utilizing a chemical micro-etching or chemical micro-polishing technology, the inner surface roughness of the sub-orifice inner walls 4122 of the spinneret sub-orifices 412 can be adjusted, and the allowable value for tube wall friction can be adjusted, so that the polyurethane material 70 melt can pass through the spinneret sub-orifices 412 at an ideal shear rate. Preferably, each spinneret sub-orifice 412 can be designed into the same size (including diameter and length), and thus the polyurethane material 70 melt has no differential pressure in the micro-flow tubes and no outlet speed difference at an outlet in the melt extrusion process. As a result, the defect factor of uneven drafting is avoided. The "same size" design of the spinneret sub-orifices 412 can reduce errors in the sub-fiber parts 710 because of the same memory effect and the swelling phenomenon. For example, the profiling degree of lower than 0.5 after extrusion and cooling forming can be avoided. Therefore, the polyurethane fiber 700 can have uniform quality after cooling forming, and polyurethane filament fibers with good quality can be formed. In addition, polyurethane staple fibers can be manufactured if the product design requires it, and the staple fibers are well known by a person skilled in the art and will not be described herein.

[0023] FIG. 5A to FIG. 5D are respectively schematic top views of a spinneret orifice unit according to another embodiment of the present invention. According to the present invention, the spinneret sub-orifices 412 in the spinneret orifice unit 410 may also be arranged in other shapes according to the product design requirements in addition to an approximate cross shape (as shown in FIG. 4A) in the spinneret orifice unit 410A. As shown in FIG. 5A, in this embodiment, a spinneret orifice unit 410B is designed to have 5 spinneret sub-orifices 412 which are arranged in an approximate straight-line shape. Each spinneret sub-orifice 412 is, for example, a circular hole and has a sub-orifice diameter D_H. There is a sticking space S_H between every two adjacent spinneret sub-orifices 412. Each spinneret sub-orifice 412 has a sub-orifice diameter D_H ranging from about 0.07 mm to 0.12 mm. There is a sticking space S_H between every two adjacent spinneret sub-orifices 412 ranging from about 0.01 mm to 0.05 mm. The purpose of mutually sticking the sub-fiber parts 710 formed by melt extrusion through the spinneret sub-orifices 412 can then be achieved, and the sub-fiber parts 710 can have enough buffering space at the same time, so that the sub-fiber parts 710 can be prevented from being excessively deformed because of thermal expansion. The polyurethane fiber 700 with an approximate straight-line-shaped cross-section can be generated by melt extrusion through the spinneret orifice unit 410B, and can be applied to the polyurethane multifilament fiber 1700 according to product requirements.

[0024] As shown in FIG. 5B, in this embodiment, a spinneret orifice unit 410C is designed to have 9 spinneret sub-orifices 412 which are arranged in an approximate W shape. Each spinneret sub-orifice 412 is, for example, a circular hole and has a sub-orifice diameter D_H. There is a sticking space S_H between every two adjacent spinneret sub-orifices 412. Each spinneret sub-orifice 412 has a sub-orifice diameter D_H ranging from about 0.07 mm to 0.12 mm. There is a sticking space S_H between every two adjacent spinneret sub-orifices 412 ranging from about 0.01 mm to 0.05 mm. In this arrangement, the goal of mutually sticking the sub-fiber parts 710 formed by melt extrusion through the spinneret sub-orifices 412 can be achieved, and, at the same time, the sub-fiber parts 710 can be prevented from being excessively deformed because of thermal expansion. The polyurethane fiber 700 with an approximate W-shaped cross-section can be generated by melt extrusion through the spinneret orifice unit 410C, and can be applied to the polyurethane multifilament fiber 1700 according to product requirements.

[0025] As shown in FIG. 5C, in this embodiment, a spinneret orifice unit 410D is designed to have 17 spinneret sub-orifices 412 which are arranged in an approximate asterisk shape. Each spinneret sub-orifice 412 is, for example, a circular hole and has a sub-orifice diameter D_H. There is a sticking space S_H between every two adjacent spinneret sub-orifices 412. Each spinneret sub-orifice 412 has a sub-orifice diameter D_H ranging from about 0.07 mm to 0.12 mm. There is a sticking space S_H between every two adjacent spinneret sub-orifices 412 ranging from about 0.01 mm to 0.05 mm. In this arrangement, the goal of mutually sticking the sub-fiber parts 710 formed by melt extrusion through the spinneret sub-orifices 412 can be achieved, and, at the same time, the sub-fiber parts 710 can be prevented from being excessively deformed because of thermal expansion. The polyurethane fiber 700 with an approximate asterisk-shaped cross-section can be generated by melt extrusion through the spinneret orifice unit 410D, and can be applied to the polyurethane multifilament fiber 1700 according to product requirements.

[0026] As shown in FIG. 5D, in this embodiment, a spinneret orifice unit 410E is designed to have 12 spinneret sub-orifices 412 which are arranged in an approximate ring shape, which may also be referred to as a circular ring shape or an O shape. Besides being arranged in a circular ring shape, the spinneret sub-orifices 412 may also be arranged in a triangular ring shape, a quadrangular ring shape, a pentagonal ring shape, a hexagonal ring shape or an octagonal ring shape and the like, but it is not limited thereto. In the spinneret orifice unit 410E, each spinneret sub-orifice 412 is, for example, a circular hole and has a sub-orifice diameter D_H. There is a sticking space S_H between every two adjacent spinneret sub-orifices 412. Each spinneret sub-orifice 412 has a sub-orifice diameter D_H ranging from about 0.07 mm to 0.12 mm. There is a sticking space S_H between every two adjacent spinneret sub-orifices 412 ranging from about 0.01 mm to 0.05 mm. In this arrangement, the goal of mutually sticking the sub-fiber parts 710 formed by melt extrusion through the spinneret sub-orifices 412 can be achieved, and, at the same time, the sub-fiber parts 710 can be prevented from being excessively deformed because of thermal expansion. The polyurethane fiber 700 with an approximate circular ring-shaped cross-section can be generated by melt extrusion through the spinneret orifice unit 410E, and can be applied to the polyurethane multifilament fiber 1700 according to product requirements.

[0027] According to the present invention, the spinneret 400 may be provided with a plurality of spinneret orifice units 410. The spinneret sub-orifices 412 of the spinneret orifice units 410 may be arranged in the same uniform arrangements, or in two or more different non-uniform arrangements. For example, the spinneret 400 may entirely use uniform arrangements of the spinneret orifice units 410 in a single configuration, e.g., a spinneret entirely consisting of the spinneret orifice units 410A in an approximate cross-shaped arrangement. The spinneret 400 may also consist of other spinneret orifice units 410 in a single configuration arrangement, e.g., a spinneret consisting entirely of the spinneret orifice units 410B in an approximate straight-line-shaped arrangement or the spinneret orifice units 410C in an approximate W-shaped arrangement or the spinneret orifice units 410D in an approximate asterisk-shaped arrangement or the spinneret orifice units 410E in an approximate ring-shaped arrangement.

[0028] According to the present invention, the spinneret 400 may also use non-uniform arrangements of two or more different spinneret orifice units 410. According to the present invention, the spinneret 400 may consist of the two different spinneret orifice units 410 above, e.g., spinneret orifice units 410B arranged in an approximate straight-line shape and spinneret orifice units 410C arranged in an approximate W shape, or the spinneret 400 may consist of other two different spinneret orifice units 410, but it is not limited thereto. According to the present invention, the spinneret 400 may also use non-uniform arrangements of three, four or five different spinneret orifice units 410 above, but it is not limited thereto.

[0029] According to the present invention, the spinneret sub-orifices 412 of the spinneret orifice units 410 may be arranged into other arrangements according to requirements, such as various English letter shapes, the * shape, the 卍 shape or the like, in addition to the cross shape, the straight-line shape, the W shape, the asterisk shape or the ring shape above, and the arrangement is not limited thereto. A person skilled in the art can make equivalent arrangement changes within the spirit and the range of the present invention.

[0030] FIG. 6A is a schematic structural diagram of the cross section of a polyurethane fiber according to one embodiment of the present invention. FIG. 6B is a schematic three-dimensional view of a polyurethane fiber according to one embodiment of the present invention. FIG. 6C is a schematic structural diagram of the cross section of a polyurethane fiber according to one embodiment of the present invention. As shown in FIG. 6A and FIG. 6B, in this embodiment, the polyurethane fiber 700 is formed corresponding to the spinneret orifice units 410 as shown in FIG. 4A and FIG. 4B. The polyurethane fiber 700 is, for example, a polyurethane fiber 700A which has an approximate cross-shaped cross-section. The polyurethane fiber 700 includes a plurality of sub-fiber parts 710 which are arranged in parallel, as shown in FIG. 6B. Each sub-fiber part 710 is in a shape of an approximate cylindrical strip. The polyurethane fiber 700 includes, for example, 3 to 30 sub-fiber parts 710. The sub-fiber parts 710 are formed corresponding to the spinneret sub-orifices 412 as shown in FIG. 4A and FIG. 4B. The adjacent sub-fiber parts 710 are expanded and sticked to each other at a process temperature, and the sticking parts 720 are formed between the adjacent sub-fiber parts 710 so that the polyurethane fiber 700 with a profiled cross-section is formed. A plurality of sticking parts 720 are formed between a plurality of sub-fiber parts 710, and each sticking part 720 is in a strip shape, for example. Each sticking part 720 is positioned between two adjacent sub-fiber parts 710, and each sticking part 720 connects the two adjacent sub-fiber parts 710. Each sub-fiber part 710 has a sub-fiber diameter D_{SF} ranging from about 0.07 mm to 0.12 mm. The sub-fiber part 710 approximately corresponds to the sub-orifice diameter D_H of the spinneret sub-orifice 412 under low expansion and shrinkage rate. If the sub-fiber part 710 has a slight deformation, the equivalent effective sub-fiber diameter D_{SF} can be measured and calculated from the geometric center of a radial cross-section. Each sticking part 720 has a sticking width W_{SF} ranging from about 0.01 mm to 0.05 mm. The sticking width W_{SF} can be slightly adjusted according to the process conditions, the swelling scale S_{SWELL}, the sticking characteristics and the sticking space S_H. For example, the polyurethane fiber 700 can be manufactured to have a monofilament specification with a denier number (den) ranging from 1 den to 3.5 den. A dye material may be selectively added into the polyurethane fiber 700 so that the polyurethane fiber 700 has a specific color. The dye material may be pigments of different particle sizes or chemical pigments. By blending in different proportions, a yarn-dyed colored polyurethane fiber can be manufactured, and different gloss effects such as bright light, full dull or matte can be achieved.

[0031] In this embodiment, the polyurethane fiber 700 is, for example, a polyurethane fiber 700A, which is designed to have 5 sub-fiber parts 710, including sub-fiber parts 710a, 710b, 710c, 710d and 710e in an approximate cross-shaped cross-section arrangement. Each sub-fiber part 710 is, for example, in a shape of an approximate cylindrical strip, and has a sub-fiber diameter D_{SF} and a sub-fiber radius R_{SF} in the radial cross-section. The distance between the geometric centers of the radial cross-sections of two adjacent sub-fiber parts 710 (for example, the sub-fiber parts 710a and 710b) is a sub-fiber distance T_{SF}. That is, the sticking width W_{SF} is approximately equal to the sub-fiber radius R_{SF} of the sub-fiber parts 710a and 710b minus the sub-fiber distance T_{SF}, namely $W_{SF} = 2R_{SF} - T_{SF}$. Each sticking part 720 has a sticking width W_{SF} ranging from about 0.01 mm to 0.05 mm.

[0032] FIG. 6C is an illustration of the polyurethane fiber 700A with a profiled cross-section as shown in FIG. 6A, with a strip-shaped groove 730 in the radial direction. As shown in FIG. 6B and FIG. 6C, the fiber radius R_F of the polyurethane fiber 700A is from the geometric center of the radial cross-section of the polyurethane fiber 700A with a cross-shaped cross-section to the boundary of the farthest sub-fiber part 710. Since the polyurethane fiber 700A has a stable cross-shaped cross-section, a strip-shaped groove 730 is formed between the peripheral sub-fiber parts 710b and 710e. The groove 730 has a groove depth G_F which is approximately equal to 2/3 of the fiber radius R_F. That is, the groove depth G_F can approximately reach 66% of the fiber radius R_F. Since the groove depth G_F is deep enough, the polyurethane fiber 700A can effectively achieve the effects of moisture-guiding and breathability by utilizing the strip-shaped groove 730. In a variation embodiment, if necessary, the sub-fiber parts which are coupled can be additionally arranged on the outer sides of the sub-fiber parts 710b, 710b, 710d and 710e respectively, thereby increasing the groove depth G_F which can approximately reach 4/5 of the fiber radius R_F. That is, the groove depth G_F can approximately reach 80% of the fiber radius R_F. Compared with the related art using a cross-shaped spinneret orifice, since the flow velocity of the polyurethane material in the center of a cross-shaped spinneret orifice is higher than that of the peripheral part, the polyurethane material in the center can flow and diffuse to the outer side very easily, and fill the space near the center. And since polyurethane material has the characteristic of high elasticity, the polyurethane fiber is thus deformed into an approximate cylindrical shape, which makes it difficult to form grooves with deep enough depth on the side surface of a polyurethane fiber manufactured with a cross-shaped spinneret orifice by the related art, making the goal of improving the moisture-guiding capability and the breathability difficult to achieve.

[0033] Table 1 shows ideal results which can be achieved in an experimental example of the present invention according to the design of the present invention. Using the same spinneret orifice unit 410 of the spinneret 400, the spinneret sub-orifices 412 are arranged in the same way, such as the aforementioned approximately cross-shaped arrangement, but different sub-orifice diameters D_H and sticking spaces S_H of the spinneret sub-orifices 412 are used to obtain the test results. From the test results, one can know whether the polyurethane fiber 700 manufactured under different experimental conditions meets the product requirements. From the test results, it can be known that, when the sticking space S_H between the spinneret sub-orifices 412 is designed to range from 0.01 mm to 0.05 mm and the sub-orifice diameter D_H of the spinneret sub-orifices 412 is designed to range from 0.07 mm to 0.12 mm corresponding to the sticking spaces S_H, good swelling and sticking effects can be obtained, and thus a good polyurethane fiber 700 can be obtained. Therefore, the ideal polyurethane fiber 700 structure with a profiled cross-section can be obtained with the sticking space S_H and the sub-orifice diameter D_H in the above ranges.

Table 1

Sticking space S_H (Unit: mm)	Sub-orifice diameter D_H (Unit: mm)	Swelling and sticking (Good: O. General: V. Poor: X.)
0.01	0.07	V

(continued)

Sticking space S_H (Unit: mm)	Sub-orifice diameter D_H (Unit: mm)	Swelling and sticking (Good: O. General: V. Poor: X.)
0.01	0.08	O
0.01	0.09	O
0.01	0.10	O
0.01	0.11	O
0.01	0.12	O
Sticking space S_H (Unit: mm)	Sub-orifice diameter D_H (Unit: mm)	Swelling and sticking (Good: O. General: V. Poor: X.)
0.02	0.07	O
0.02	0.08	O
0.02	0.09	O
0.02	0.10	O
0.02	0.11	O
0.02	0.12	O
Sticking space S_H (Unit: mm)	Sub-orifice diameter D_H (Unit: mm)	Swelling and sticking (Good: O. General: V. Poor: X.)
0.03	0.07	O
0.03	0.08	O
0.03	0.09	O
0.03	0.10	O
0.03	0.11	O
0.03	0.12	O
Sticking space S_H (Unit: mm)	Sub-orifice diameter D_H (Unit: mm)	Swelling and sticking (Good: O. General: V. Poor: X.)
0.04	0.07	X
0.04	0.08	X
0.04	0.09	V
0.04	0.10	O
0.04	0.11	O
0.04	0.12	O
Sticking space S_H (Unit: mm)	Sub-orifice diameter D_H (Unit: mm)	Swelling and sticking (Good: O. General: V. Poor: X.)
0.05	0.07	X
0.05	0.08	X
0.05	0.09	X
0.05	0.10	X
0.05	0.11	V
0.05	0.12	V

[0034] FIGS. 7A to 7D are respectively schematic three-dimensional views of a polyurethane fiber according to another embodiment of the present invention. The polyurethane fiber 700 may be manufactured into a polyurethane fiber 700A (as shown in FIGS. 6A to 6C) with an approximately cross-shaped cross-section, and may also be manufactured into cross-sections with other shapes according to product requirements. Polyurethane fibers 700B to 700E as shown in FIGS. 7A to 7D are manufactured corresponding to spinneret orifice units 410B to 410E as shown in FIGS. 5A to 5D.

[0035] As shown in FIG. 7A, in this embodiment, the polyurethane fiber 700B as shown in FIG. 7A is formed corresponding to the spinneret orifice unit 410B as shown in FIG. 5A. The polyurethane fiber 700B has an approximate straight-line-shaped cross-section, and the polyurethane fiber 700B includes 5 sub-fiber parts 710 which are arranged in parallel, as shown in FIG. 7A. The sub-fiber parts 710 which are arranged in a straight-line shape as shown in FIG.7A are formed corresponding to the spinneret sub-orifices 412 which are arranged in a straight-line shape as shown in FIG. 5A. The adjacent sub-fiber parts 710 expand at a process temperature and are sticked to each other, and the sticking parts 720 are formed between adjacent sub-fiber parts 710, so that the polyurethane fiber 700B with a straight-line-shaped cross-section is formed. Each sticking part 720 is positioned between two adjacent sub-fiber parts 710, and each sticking part 720 connects the two adjacent sub-fiber parts 710.

[0036] In this embodiment, the polyurethane fiber 700B includes 5 sub-fiber parts 710. Each sub-fiber part 710 is, for example, in the shape of an approximately cylindrical strip and has a sub-fiber diameter D_{SF} in the radial cross-section. Each sticking part 720 has a sticking width W_{SF}. The sub-fiber diameter D_{SF} of each sub-fiber part 710 ranges from about 0.07 mm to 0.12 mm. The sub-fiber part 710 approximately corresponds to the sub-orifice diameter D_H of the spinneret sub-orifice 412 under low expansion and shrinkage rate. The sticking width W_{SF} of each sticking part 720 ranges from about 0.01 mm to 0.05 mm. The sticking width W_{SF} can be slightly adjusted according to the process conditions, the swelling scale S_{SWELL}, the sticking characteristics and the sticking space S_H. As shown in FIG. 7A, for the polyurethane fiber 700B with a straight-line-shaped cross-section, the fiber radius R_F of the polyurethane fiber 700B is from the geometric center of the radial cross-section to the boundary of the farthest sub-fiber part 710. Since the polyurethane fiber 700B has a stable straight-line-shaped cross-section, strip-shaped grooves 730 are formed on two sides of the sticking part 720, and the polyurethane fiber 700B can still achieve the effect of assisting in moisture-guiding and breathability by utilizing the strip-shaped grooves 730.

[0037] As shown in FIG. 7B, in this embodiment, the polyurethane fiber 700C as shown in FIG. 7B is formed corresponding to the spinneret orifice unit 410C as shown in FIG. 5B. The polyurethane fiber 700C has an approximate W-shaped cross-section, and the polyurethane fiber 700C includes 9 sub-fiber parts 710 which are arranged in parallel, as shown in FIG. 7B. The sub-fiber parts 710 arranged in a W shape as shown in FIG. 7B are formed corresponding to the spinneret sub-orifices 412 arranged in a W shape as shown in FIG. 5B. The adjacent sub-fiber parts 710 expand at the process temperature and are sticked to each other, and the sticking parts 720 are formed between the adjacent sub-fiber parts 710 so that the polyurethane fiber 700C with a W-shaped cross-section is formed. Each sticking part 720 is positioned between two adjacent sub-fiber parts 710, and each sticking part 720 connects the two adjacent sub-fiber parts 710.

[0038] In this embodiment, the polyurethane fiber 700C includes 9 sub-fiber parts 710. Each sub-fiber part 710 is in the shape of an approximately cylindrical strip and has a sub-fiber diameter D_{SF} in the radial cross-section. Each sticking part 720 has a sticking width W_{SF}. The sub-fiber diameter D_{SF} of each sub-fiber part 710 ranges from about 0.07 mm to 0.12 mm. The sub-fiber part 710 approximately corresponds to the sub-orifice diameter D_H of the spinneret sub-orifice 412 under low expansion and shrinkage rate. The sticking width W_{SF} of each sticking part 720 ranges from about 0.01 mm to 0.05 mm. The sticking width W_{SF} can be slightly adjusted according to the process conditions, the swelling scale S_{SWELL}, the sticking characteristics and the sticking space S_H. As shown in FIG. 7B, for the polyurethane fiber 700C with a W-shaped cross-section, the fiber radius R_F of the polyurethane fiber 700C is from the geometric center of the radial cross-section to the boundary of the farthest sub-fiber part 710. Since the polyurethane fiber 700C has a stable W-shaped cross-section, three strip-shaped grooves 730 are formed in the polyurethane fiber 700C, and the polyurethane fiber 700C can still achieve the effect of improving moisture-guiding capability and breathability by utilizing the strip-shaped grooves 730.

[0039] As shown in FIG. 7C, in this embodiment, the polyurethane fiber 700D as shown in FIG. 7C is formed corresponding to the spinneret orifice unit 410D as shown in FIG. 5C. The polyurethane fiber 700D has an approximately asterisk-shaped cross-section, and the polyurethane fiber 700D includes 17 sub-fiber parts 710 which are arranged in parallel, as shown in FIG. 7C. The sub-fiber parts 710 arranged in an asterisk shape as shown in FIG. 7C are formed corresponding to the spinneret sub-orifices 412 arranged in an asterisk shape as shown in FIG. 5C. The adjacent sub-fiber parts 710 expand at the process temperature and are sticked to each other, and the sticking parts 720 are formed between adjacent sub-fiber parts 710 so that the polyurethane fiber 700D with an approximately asterisk-shaped cross-section is formed. Each sticking part 720 is positioned between two adjacent sub-fiber parts 710, and each sticking part 720 connects the two adjacent sub-fiber parts 710.

[0040] In this embodiment, the polyurethane fiber 700D includes 17 sub-fiber parts 710. Each sub-fiber part 710 is in the shape of an approximately cylindrical strip and has a sub-fiber diameter D_{SF} in the radial cross-section. Each sticking part 720 has a sticking width W_{SF}. The sub-fiber diameter D_{SF} of each sub-fiber part 710 ranges from about 0.07 mm to 0.12 mm. The sub-fiber part 710 approximately corresponds to the sub-orifice diameter D_H of the spinneret sub-orifice 412 under low expansion and shrinkage rate. The sticking width W_{SF} of each sticking part 720 ranges from about 0.01 mm to 0.05 mm. The sticking width W_{SF} can be slightly adjusted according to the process conditions, the swelling scale S_{SWELL}, the sticking characteristics and the sticking space S_H. As shown in FIG. 7C, for the polyurethane fiber 700D with an asterisk-shaped cross-section, the fiber radius R_F of the polyurethane fiber 700D is from the geometric center of the radial cross-section to the boundary of the farthest sub-fiber part 710. Since the polyurethane fiber 700D has a stable asterisk-shaped cross-section, eight strip-shaped grooves 730 are formed in the polyurethane fiber 700D, and the polyurethane fiber 700D can achieve the effect of improving moisture-guiding capability and breathability by utilizing the strip-shaped grooves 730.

[0041] As shown in FIG. 7D, in this embodiment, the polyurethane fiber 700E as shown in FIG. 7D is formed corresponding to the spinneret orifice unit 410E as shown in FIG. 5D. The polyurethane fiber 700E has an approximately O-shaped cross-section, and the polyurethane fiber 700E includes 12 sub-fiber parts 710 which are arranged in parallel, as shown in FIG. 7D. The sub-fiber parts 710 arranged in a ring shape as shown in FIG. 7D are formed corresponding to the spinneret sub-orifices 412 arranged in a ring shape as shown in FIG. 5D. The adjacent sub-fiber parts 710 expand at the process temperature and are sticked to each other, and the sticking parts 720 are formed between adjacent sub-fiber parts 710 so that the polyurethane fiber 700E with an approximately ring-shaped cross-section is formed. Each sticking part 720 is positioned between two adjacent sub-fiber parts 710, and each sticking part 720 connects the two adjacent sub-fiber parts 710.

[0042] In this embodiment, the polyurethane fiber 700E includes 12 sub-fiber parts 710. Each sub-fiber part 710 is in the shape of an approximately cylindrical strip and has a sub-fiber diameter D_{SF} in the radial cross-section. Each sticking part 720 has a sticking width W_{SF}. The sub-fiber diameter D_{SF} of each sub-fiber part 710 ranges from about 0.07 mm to 0.12 mm. The sub-fiber part 710 approximately corresponds to the sub-orifice diameter D_H of the spinneret sub-orifice 412 under low expansion and shrinkage rate. The sticking width W_{SF} of each sticking part 720 ranges from about 0.01 mm to 0.05 mm. The sticking width W_{SF} can be slightly adjusted according to the process conditions, the swelling scale S_{SWELL}, the sticking characteristics and the sticking space S_H. As shown in a reference figure 7D, for the polyurethane fiber 700E with a ring-shaped cross-section, the fiber radius R_F of the polyurethane fiber 700E is from the geometric center of the radial cross-section to the boundary of the farthest sub-fiber part 710. Since the polyurethane fiber 700E has a stable ring-shaped cross-section, 12 strip-shaped grooves 730 are formed on the outer sides of the sticking parts 720, and the polyurethane fiber 700E can still achieve the effects of assisting in moisture-guiding and ventilation by utilizing the strip-shaped grooves 730. In addition, strip-shaped fiber inner holes 740 are formed in the polyurethane fiber 700E, and because the radius of each inner hole 740 is smaller than the fiber radius R_F, the effects of moisture-guiding and breathability can be improved by using the capillary tube phenomenon of the inner holes 740. Therefore, moisture generated by a user's body can be discharged to the outside in an accelerated manner by using the capillary tube effect of the groove 730 and the inner hole 740, and the refreshing effect after moisture discharge is improved.

[0043] According to the present invention, in addition to the cross-shaped cross-section, the straight-line-shaped cross-section, the W-shaped cross-section, the asterisk-shaped cross-section and the ring-shaped cross-section, the sub-fiber parts 710 of the polyurethane fiber 700 can be arranged into other arrangements such as various English-letter-shaped cross-sections, the 米 -shaped cross-section, the 卍 -shaped cross-section or the like according to requirements, and the arrangement is not limited thereto. A person skilled in the art can make equivalent arrangement changes within the spirit and the scope of the present invention.

[0044] FIG. 8 is a schematic three-dimensional view of a polyurethane multifilament fiber according to one embodiment of the present invention. As shown in FIG. 8, the polyurethane multifilament fiber 1700 can be formed by, for example, twisting a plurality of polyurethane fibers 700, wherein the polyurethane fiber 700 is a polyurethane monofilament fiber. As shown in FIG. 8, the polyurethane multifilament fiber 1700 may consist of, for example, five polyurethane fibers 700 with different profiled cross-sections, compounding the characteristics of the five polyurethane fibers 700 with different profiled cross-sections to make the required polyurethane multifilament fiber 1700.

[0045] According to the present invention, the polyurethane multifilament fiber 1700 may also consist entirely of polyurethane fibers 700 in a single configuration arrangement. For example, it may consist entirely of polyurethane fibers 700A with cross-shaped cross-sections. The polyurethane multifilament fiber 1700 may also consist entirely of other polyurethane fibers 700 in a single configuration arrangement. For example, it may consist entirely of polyurethane fibers 700B with straight-line-shaped cross-sections, or polyurethane fibers 700C with W-shaped cross-sections, polyurethane fibers 700D with asterisk-shaped cross-sections or polyurethane fibers 700E with ring-shaped cross-sections. Therefore, according to the present invention, the polyurethane multifilament fiber 1700 with different required characteristics can be manufactured.

[0046] According to the present invention, the polyurethane multifilament fiber 1700 may also consist of two types of polyurethane fibers 700 above. For example, it may consist of the polyurethane fiber 700B with a straight-line-shaped cross-section and the polyurethane fiber 700C with a W-shaped cross-section, or polyurethane fibers 700 with two other types of cross-sections, but it is not limited thereto. According to the present invention, the polyurethane multifilament fiber 1700 may also consist of three types of polyurethane fibers 700 above, for example, the polyurethane fiber 700A with a cross-shaped cross-section, the polyurethane fiber 700B with a straight-line-shaped cross-section and the polyurethane fiber 700C with a W-shaped cross-section, or polyurethane fibers 700 with three other types of cross-sections, but it is not limited thereto. The polyurethane multifilament fiber 1700 may also consist of four types of polyurethane fibers 700 above, for example, the polyurethane fiber 700B with a straight-line-shaped cross-section, the polyurethane fiber 700C with a W-shaped cross-section, the polyurethane fiber 700D with an asterisk-shaped cross-section and the polyurethane fiber 700E with a ring-shaped cross-section, or polyurethane fibers 700 with four other types of sections, but it is not limited thereto. Therefore, according to the present invention, the polyurethane multifilament fiber 1700 with different required characteristics can be manufactured, and the polyurethane multifilament fiber 1700 can easily achieve excellent performances such as high elasticity, high moisture-guiding capability and high breathability, and can meet the requirements of product design.

[0047] According to the present invention, the polyurethane multifilament fiber 1700 can be manufactured into different multifilament specifications according to product requirements. For example, the polyurethane multifilament fiber 1700 may have different numbers of filaments, such as 2 (f) to 452 (f) filaments, and different fiber specifications, such as texture having a denier number (den) ranging from 30 den to 600 den, and can be adjusted according to the product requirements without limitation.

[0048] FIG. 9 is a schematic three-dimensional view of a filament yarn fabric using a polyurethane multifilament fiber according to one embodiment of the present invention. According to the present invention, the polyurethane multifilament fiber 1700 can be made into various filament yarn fabrics 2700 or filament fabric product. For example, the polyurethane fiber can be woven into a filament yarn fabric 2710 entirely made of polyurethane, which has excellent performances such as high elasticity, high moisture-guiding capability and high breathability, and can be made into, for example, clothes, as shown in FIG. 9, or other products such as trousers, skirts and various other clothing, but it is not limited thereto. The filament yarn fabrics 2700 are all made of single-component polyurethane multifilament fibers 1700, so the single-component filament yarn fabric 2700 can be easily recycled and regenerated after being used and made into a polyurethane recycled material, achieving the goals of environmental protection and waste material reduction.

[0049] FIG. 10 is a schematic three-dimensional view of a filament yarn fabric using a polyurethane multifilament fiber according to another embodiment of the present invention. According to the present invention, the polyurethane multifilament fiber 1700 can be adopted, for example, to manufacture a sports shoe 2800, a leisure shoe or other different shoes. A sole 2830 of the sports shoe 2800 can be made of polyurethane material, which has high elasticity and thus can meet the requirement of cushioning force. A vamp 2820 of the sports shoe 2800 can be made of single-component polyurethane multifilament fibers 1700, and can achieve excellent performance of high elasticity, high moisture-guiding capability, high breathability and the like by mixing the polyurethane fibers 700 with different profiled cross-sections. A shoelace 2810 of the sports shoe 2800 can also be made of single-component polyurethane multifilament fibers 1700. The shoelace 2810, the vamp 2820 and the sole 2830 of the sports shoe 2800 can all be made of a single-component polyurethane material, without other types of high polymer materials, so that the convenience in overall recycling and regeneration of the sports shoe 2800 is improved, the environmental friendliness is enhanced, and waste is reduced.

[0050] In conclusion, the polyurethane fiber and the manufacturing method thereof of the present invention use spinnerets with sticking spaces between the spinneret sub-orifices and the adjustment of the sizes of the spinneret sub-orifices and the sticking spaces to form polyurethane fibers with a profiled cross-section by passing the polyurethane material through the spinneret sub-orifices and sticking the sub-fiber parts. According to the design of the present invention, the sub-fiber parts of the polyurethane fiber can be stably formed and the adjacent sub-fiber parts are sticked to each other to form the polyurethane fiber with a profiled cross-section. According to the present invention, deep grooves can be manufactured in the polyurethane fiber with a profiled cross-section, thus improving the moisture-guiding capability and breathability. According to the present invention, the polyurethane fiber with a profiled cross-section can be twisted to manufacture polyurethane multifilament fibers and the polyurethane multifilament fibers can be spun to manufacture filament yarn fabrics. The filament yarn fabrics so made can increase the application of polyurethane fiber in a single-component finished fabric, and further improve the recycling and regeneration of the finished fabrics of polyurethane fiber.

[0051] The present invention is described by the above-mentioned related embodiments, but the above-mentioned embodiments are only examples for implementing the present invention. It is to be pointed out that the disclosed embodiments do not limit the scope of the present invention. On the contrary, modifications and equal arrangements within the spirit and scope of the patent application are included in the scope of the present invention.

Claims

1. A manufacturing method of a polyurethane fiber, comprising:

   providing a polyurethane material;
   carrying out a melt extrusion process on the polyurethane material through a spinneret, the spinneret including at least one spinneret orifice unit embedded in a spinneret body, the spinneret orifice unit including a plurality of spinneret sub-orifices, each spinneret sub-orifice penetrating through the spinneret body, each spinneret sub-orifice having a sub-orifice diameter ranging from 0.07 mm to 0.12 mm, and having a sticking space between every two adjacent spinneret sub-orifices ranging from 0.01 mm to 0.05 mm; and
   enabling the polyurethane material to pass through the spinneret sub-orifices and stick together to form the polyurethane fiber.

2. The manufacturing method according to claim 1, wherein the spinneret body comprises a circular plate.

3. The manufacturing method according to claim 1, wherein the spinneret orifice unit includes 3 to 30 spinneret sub-orifices.

4. The manufacturing method according to claim 1, wherein the at least one spinneret orifice unit comprises a plurality of spinneret orifice units, and the number of the spinneret orifice units includes 2 to 452.

5. The manufacturing method according to claim 1, wherein the spinneret sub-orifices have tube wall characteristics through which the polyurethane material passes through the spinneret sub-orifices at a shear rate less than or equal to 2,000 s^{-1}.

6. The manufacturing method according to claim 1, wherein the spinneret sub-orifices of the spinneret orifice unit are arranged into a straight-line shape, a cross shape, a W shape, an asterisk shape or a ring shape.

7. The manufacturing method according to claim 1, further comprises stretching the polyurethane fiber to a winding machine, which has a winding speed ranging from 1,200 m/min to 6,500 m/min.

8. The manufacturing method according to claim 1, further comprises adding a dye material in the polyurethane material.

9. A spinneret suitable for manufacturing a polyurethane fiber, comprising:

   a spinneret body having a first surface and a second surface opposite to each other; and
   at least one spinneret orifice unit embedded in the spinneret body, the spinneret orifice unit including a plurality of spinneret sub-orifices, each spinneret sub-orifice penetrating through the spinneret body, two ends of each spinneret sub-orifice being connected to the first surface and the second surface respectively, each spinneret sub-orifice having a sub-orifice diameter ranging from 0.07 mm to 0.12 mm, and having a sticking space between every two adjacent spinneret sub-orifices ranging from 0.01 mm to 0.05 mm.

10. A polyurethane fiber, comprising:

    a plurality of sub-fiber parts being arranged in parallel; and
    a plurality of sticking parts, each sticking part being positioned between every two adjacent sub-fiber parts and connecting the two adjacent sub-fiber parts, each sub-fiber part having a sub-fiber diameter ranging from 0.07 mm to 0.12 mm, and each sticking part having a sticking width ranging from 0.01 mm to 0.05 mm.

11. The polyurethane fiber according to claim 10, wherein the shape of each sub-fiber part comprises a strip shape.

12. The polyurethane fiber according to claim 10, wherein the number of the sub-fiber parts includes 3 to 30.

13. The polyurethane fiber according to claim 10, wherein the radial cross-sections of the sub-fiber parts are arranged into a straight-line shape, a cross shape, a W shape, an asterisk shape or a ring shape.

14. The polyurethane fiber according to claim 10, further comprising a groove which is formed adjacent to the sticking part and positioned between two adjacent sub-fiber parts.

15. The polyurethane fiber according to claim 10, wherein the polyurethane fiber has a denier number (den) of 1 den and 3.5 den.

16. The polyurethane fiber according to claim 10, wherein the polyurethane fiber further comprises a dye material.

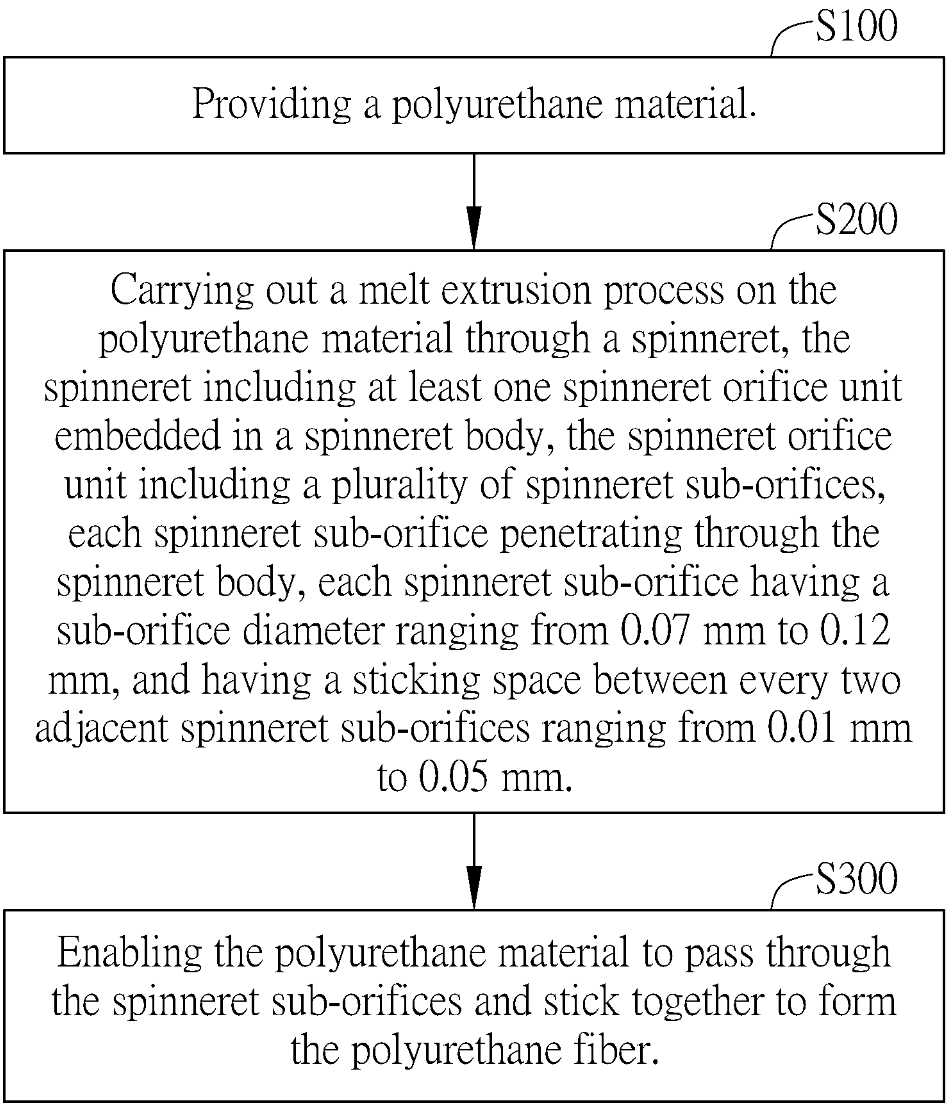

S100
Providing a polyurethane material.
S200
Carrying out a melt extrusion process on the polyurethane material through a spinneret, the spinneret including at least one spinneret orifice unit embedded in a spinneret body, the spinneret orifice unit including a plurality of spinneret sub-orifices, each spinneret sub-orifice penetrating through the spinneret body, each spinneret sub-orifice having a sub-orifice diameter ranging from 0.07 mm to 0.12 mm, and having a sticking space between every two adjacent spinneret sub-orifices ranging from 0.01 mm to 0.05 mm.
S300
Enabling the polyurethane material to pass through the spinneret sub-orifices and stick together to form the polyurethane fiber.

FIG. 1

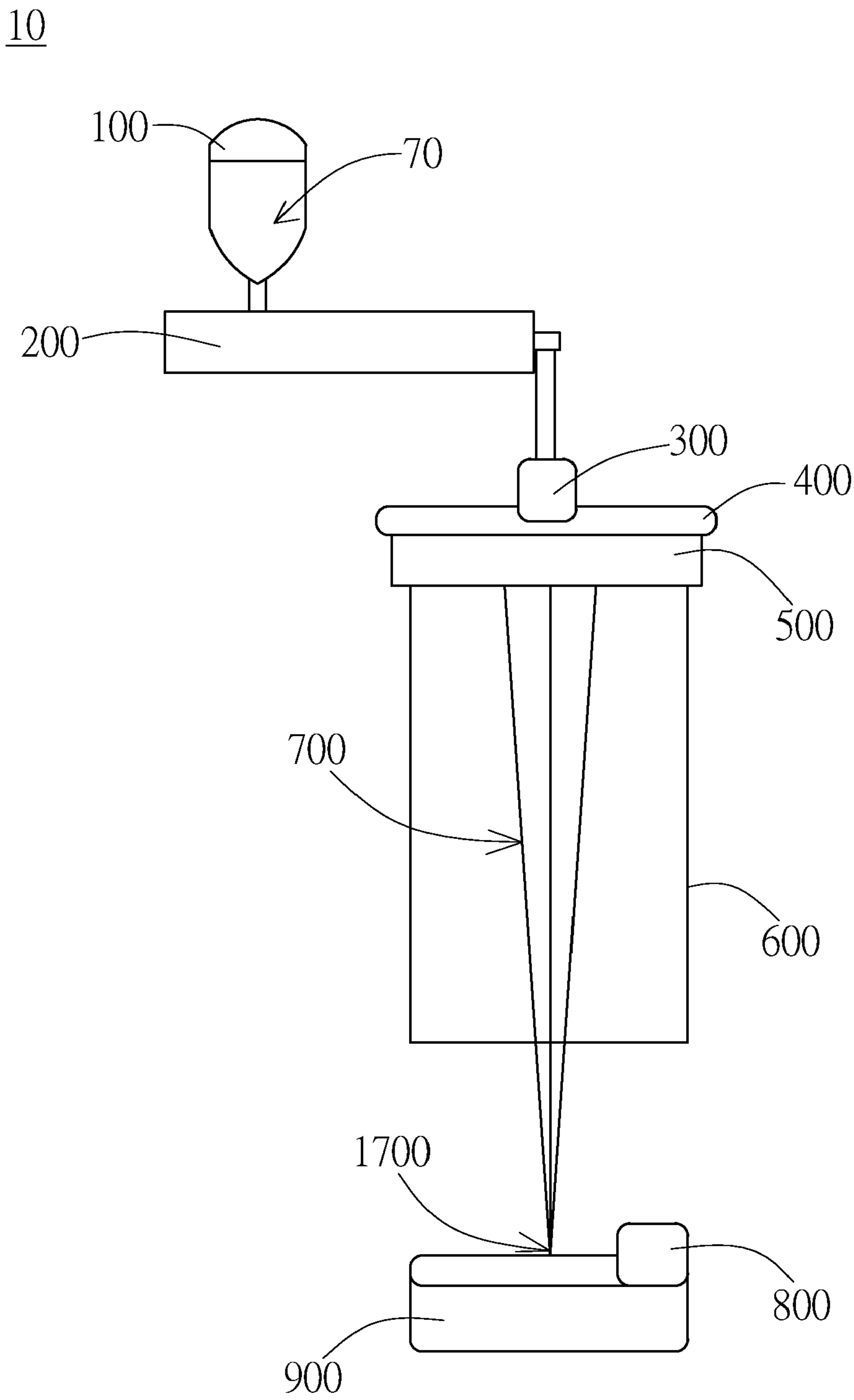


FIG. 2

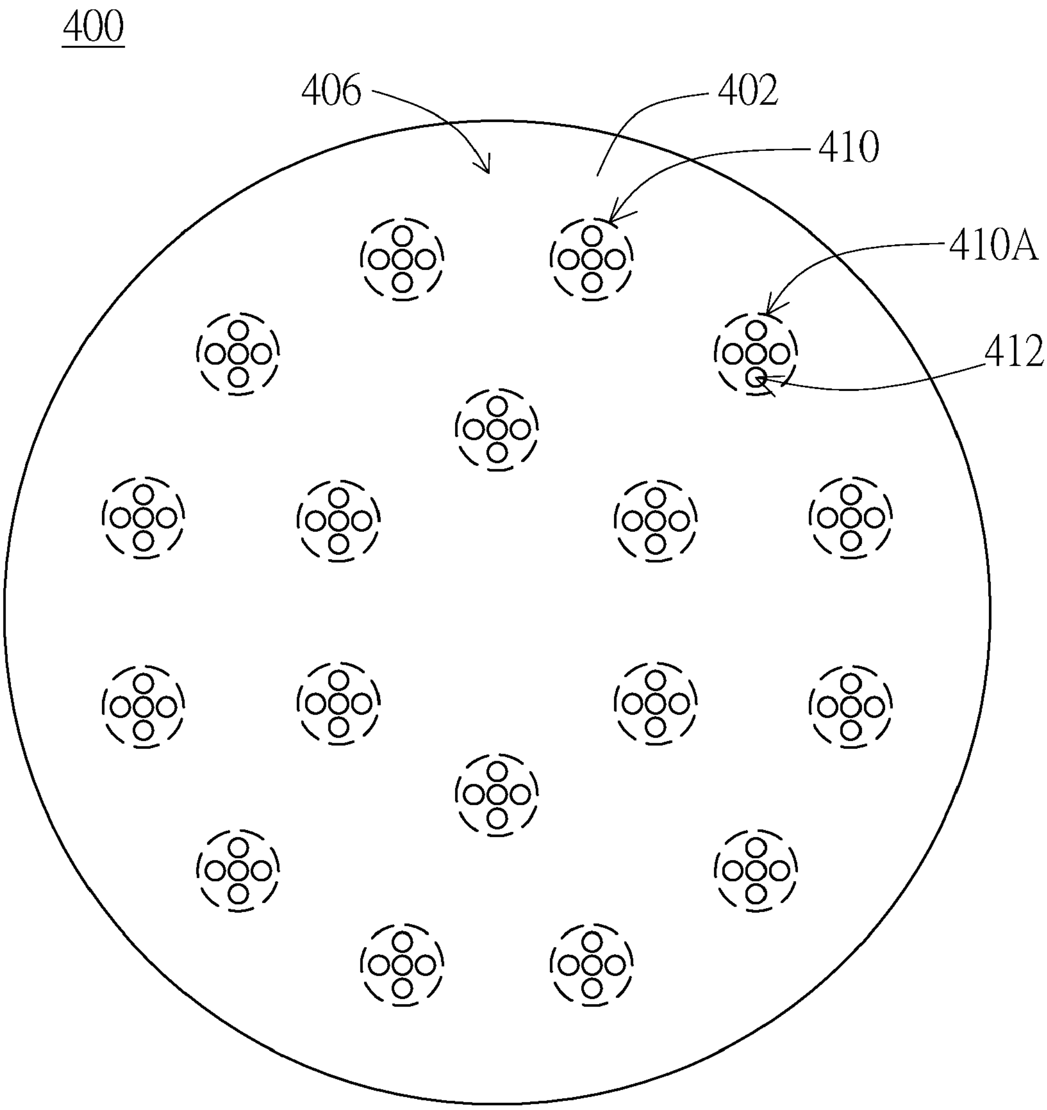
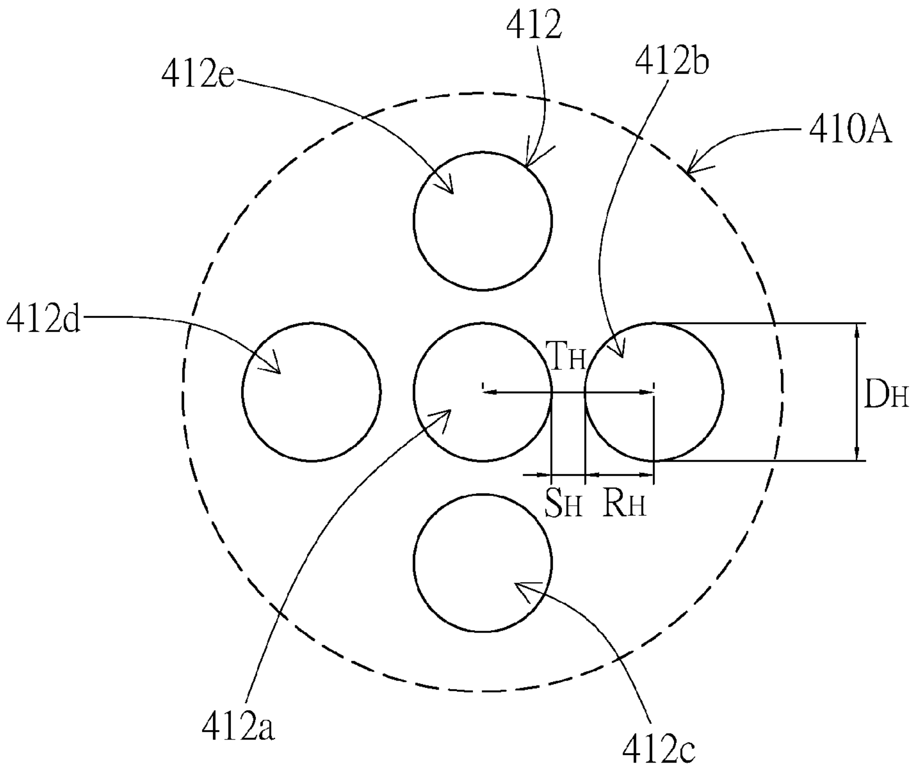


FIG. 3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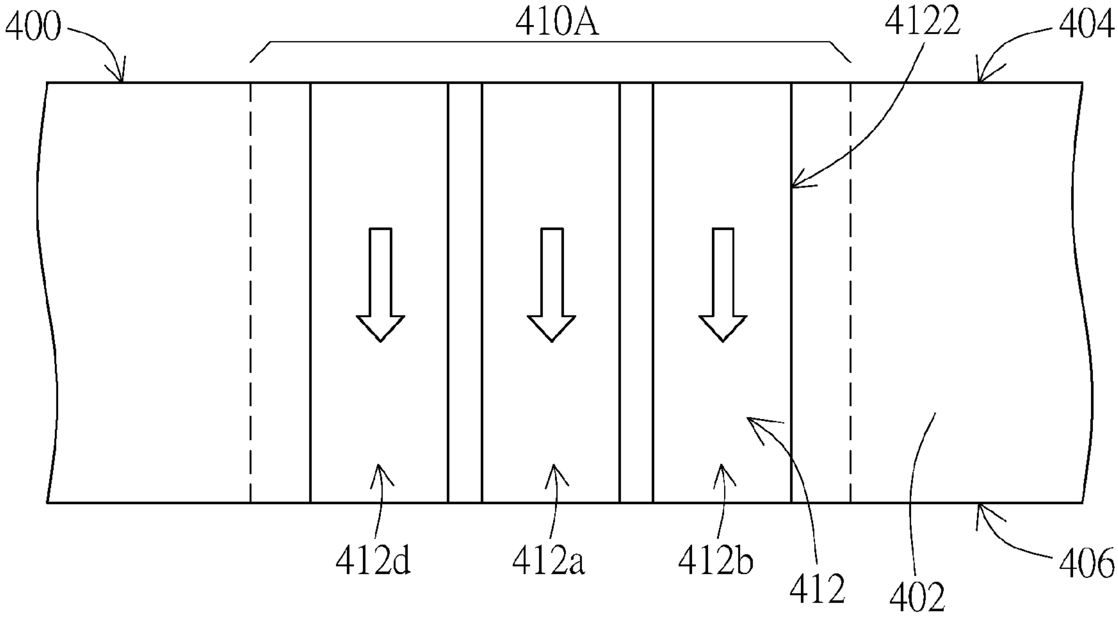
412b
410A
412d
TH
DH
SH
RH
412a
412c

FIG. 4A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402
406

FIG. 4B

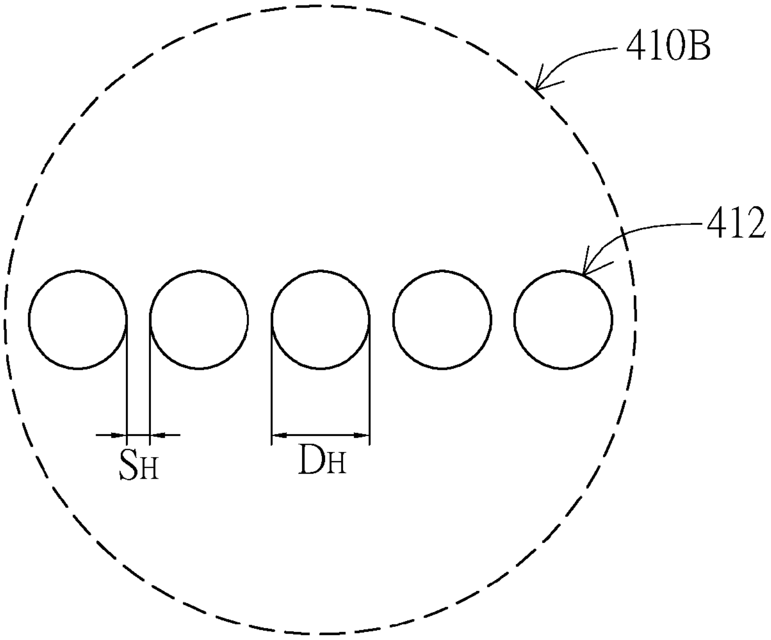


FIG. 5A

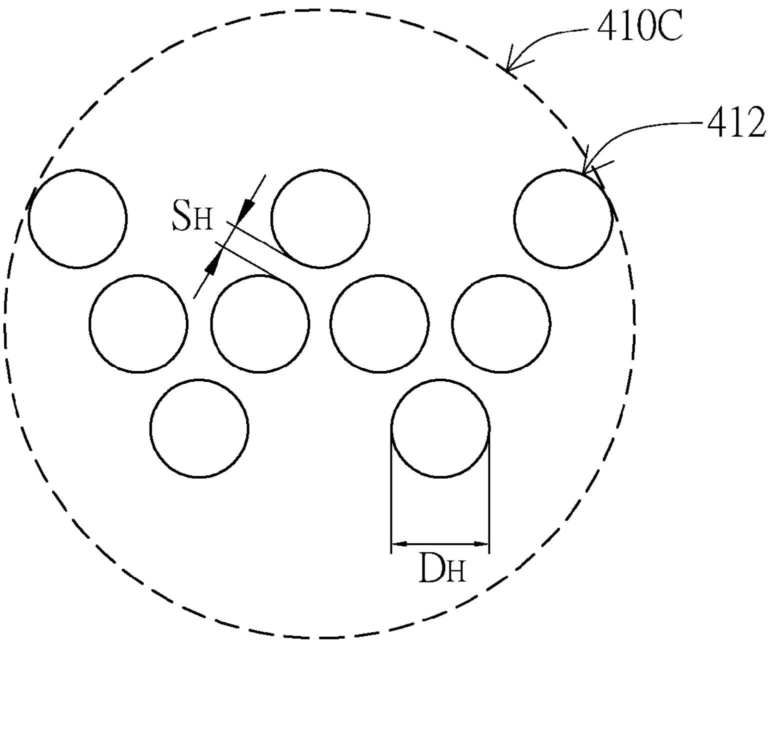


FIG. 5B

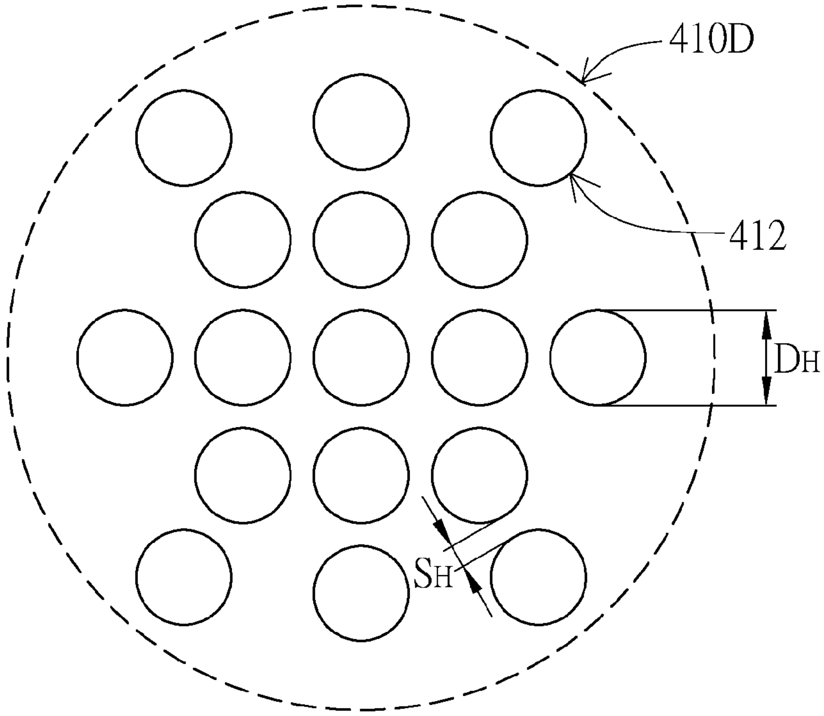


FIG. 5C

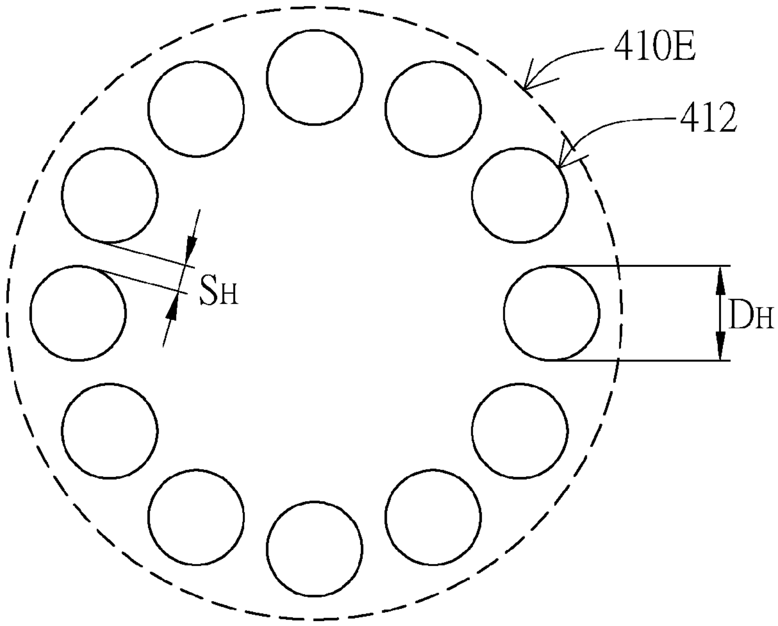
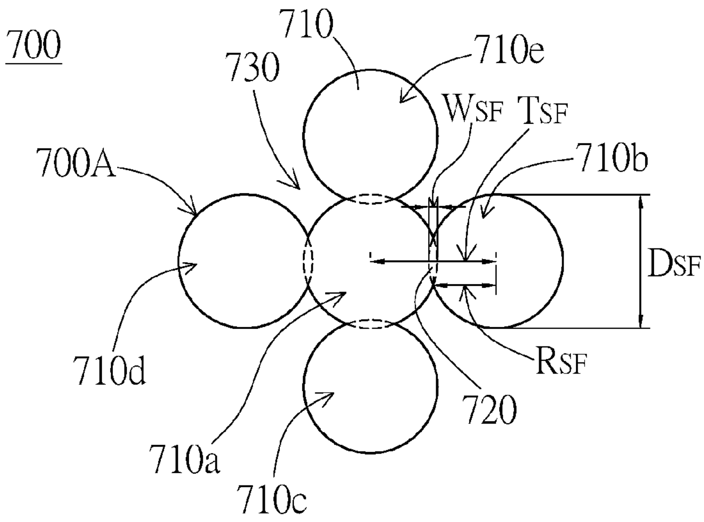


FIG. 5D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710
710e
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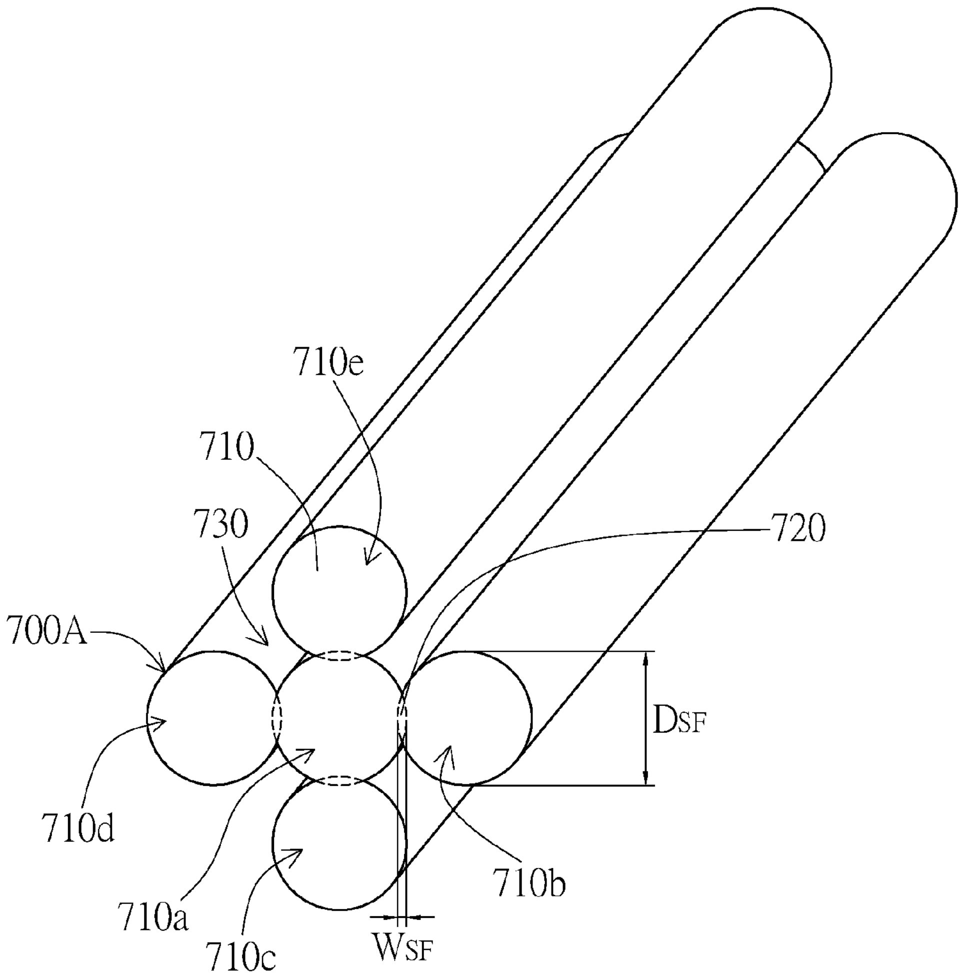
TSF
710b
700A
DSF
RSF
710d
720
710a
710c

FIG. 6A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DSF
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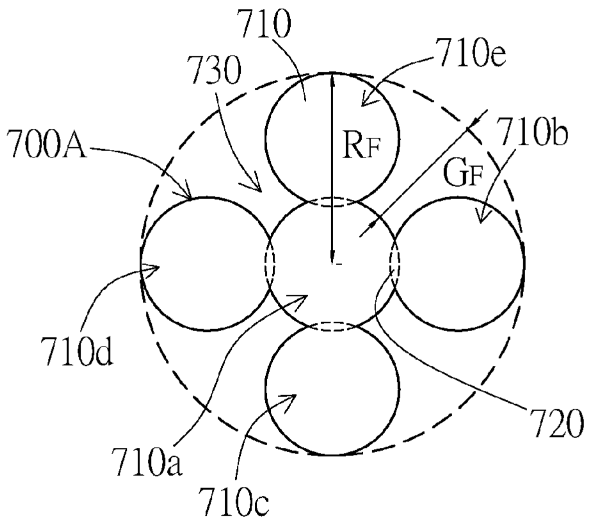
710b
710a
710c
WSF

FIG. 6B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RF
710b
GF
710d
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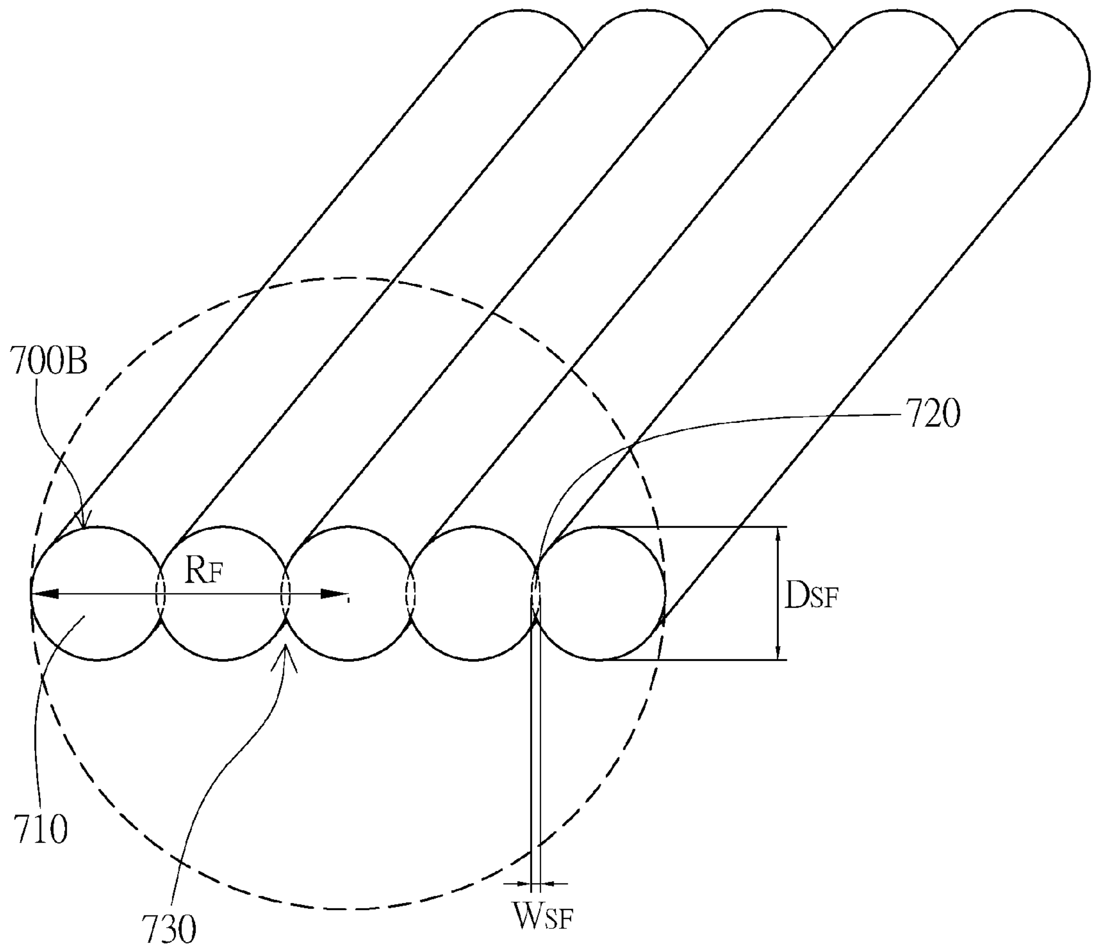
710a
710c

FIG. 6C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RF
DSF
710
730
WSF

FIG. 7A

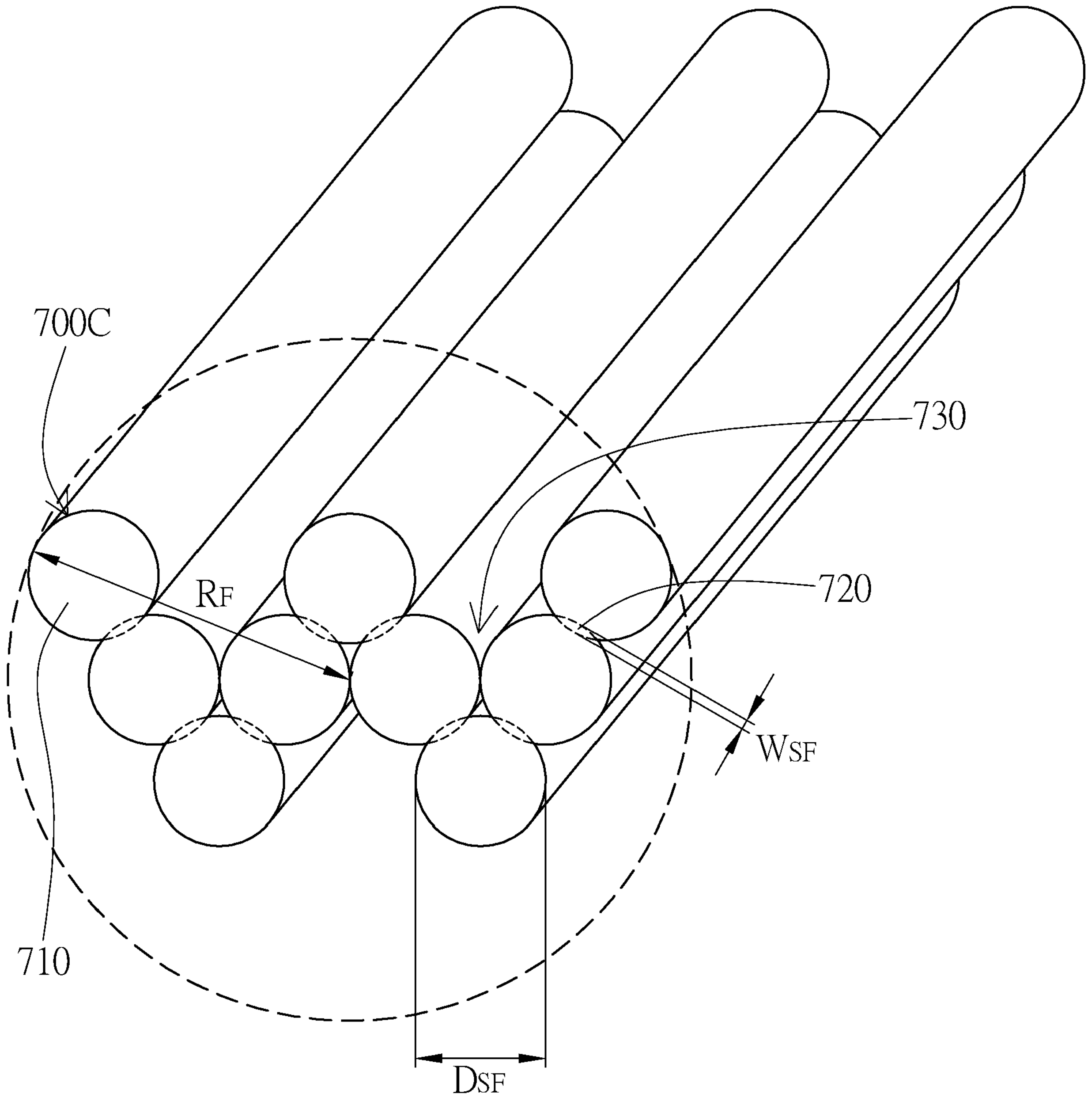

FIG. 7B

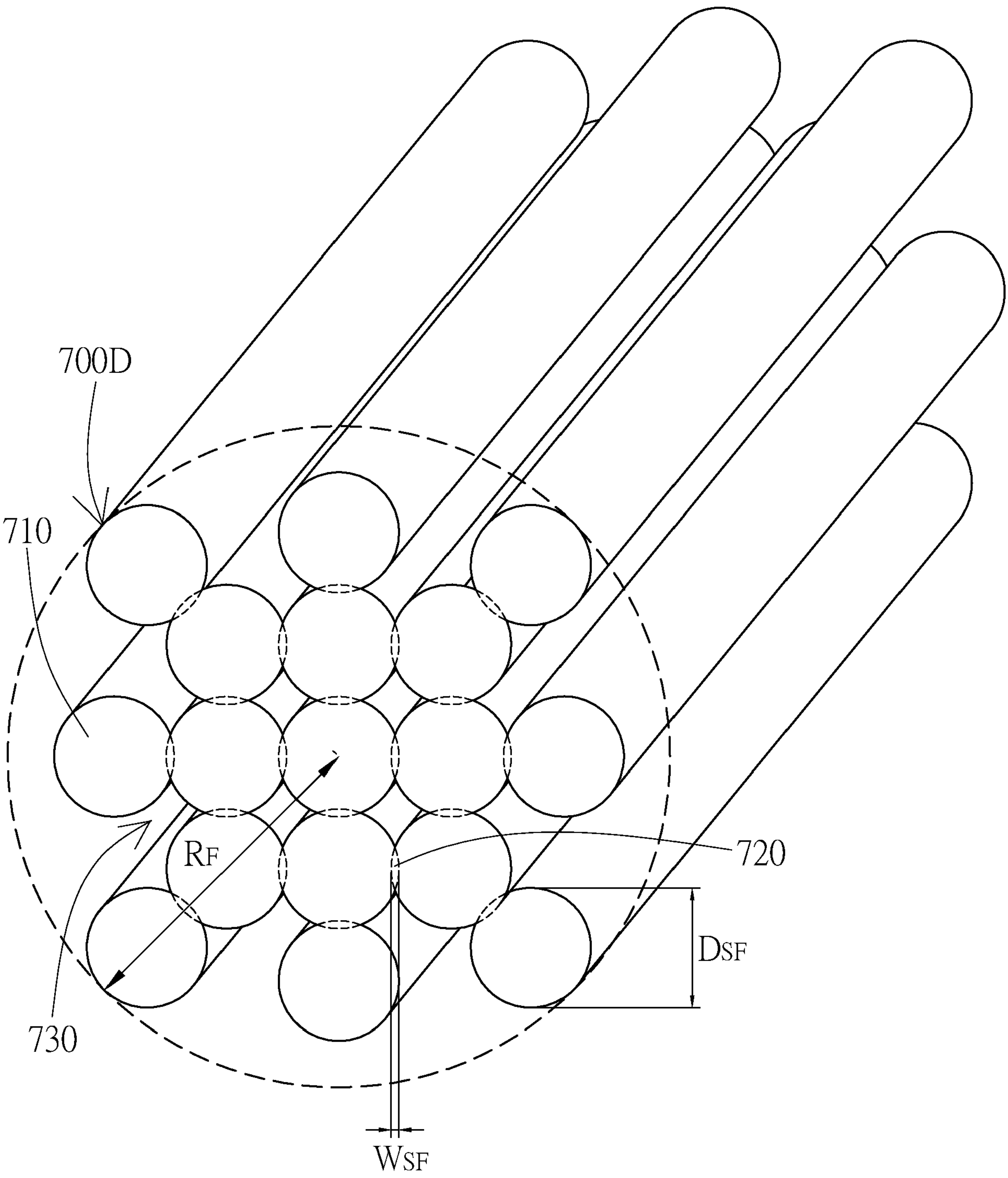

FIG. 7C

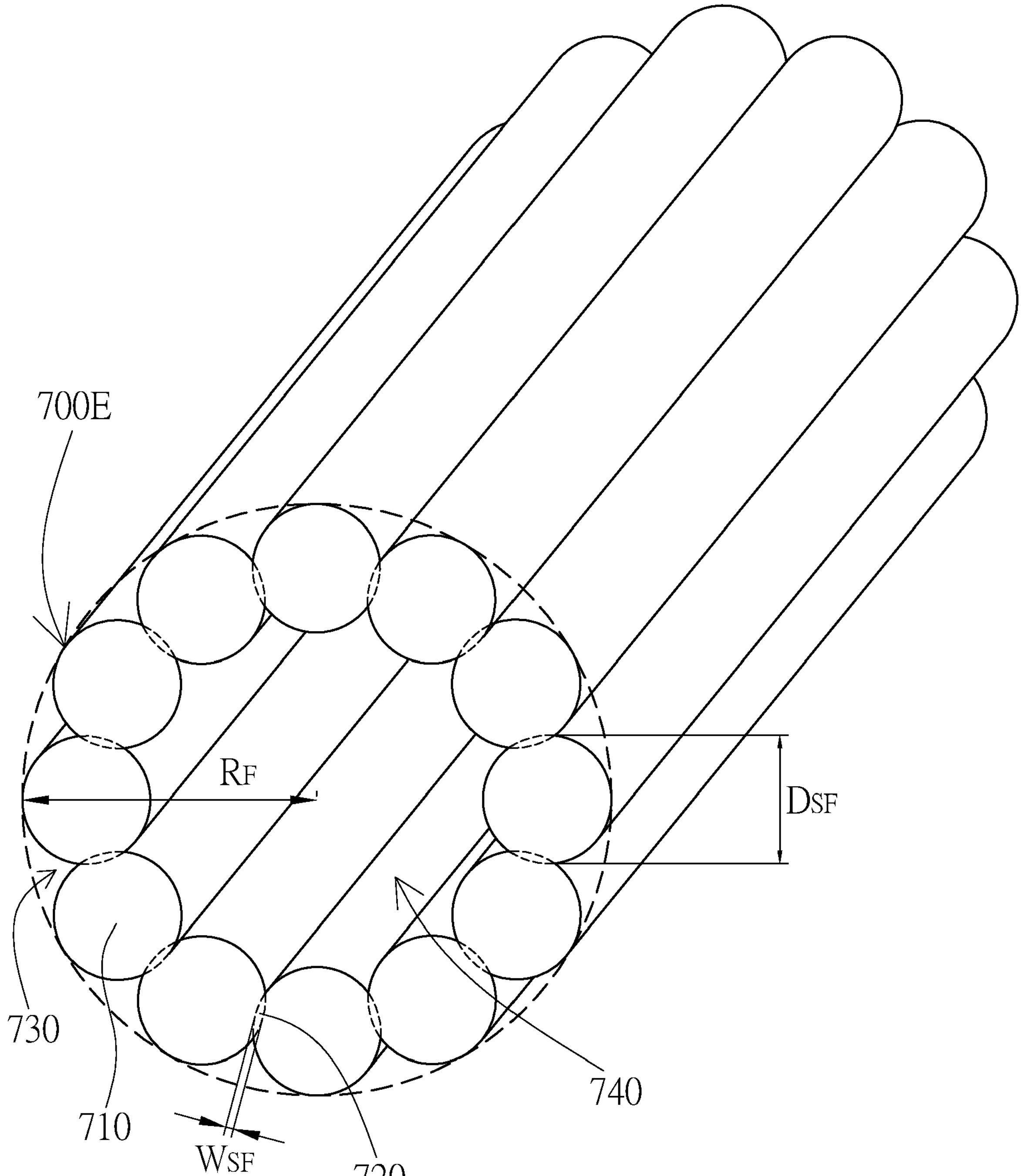

FIG. 7D

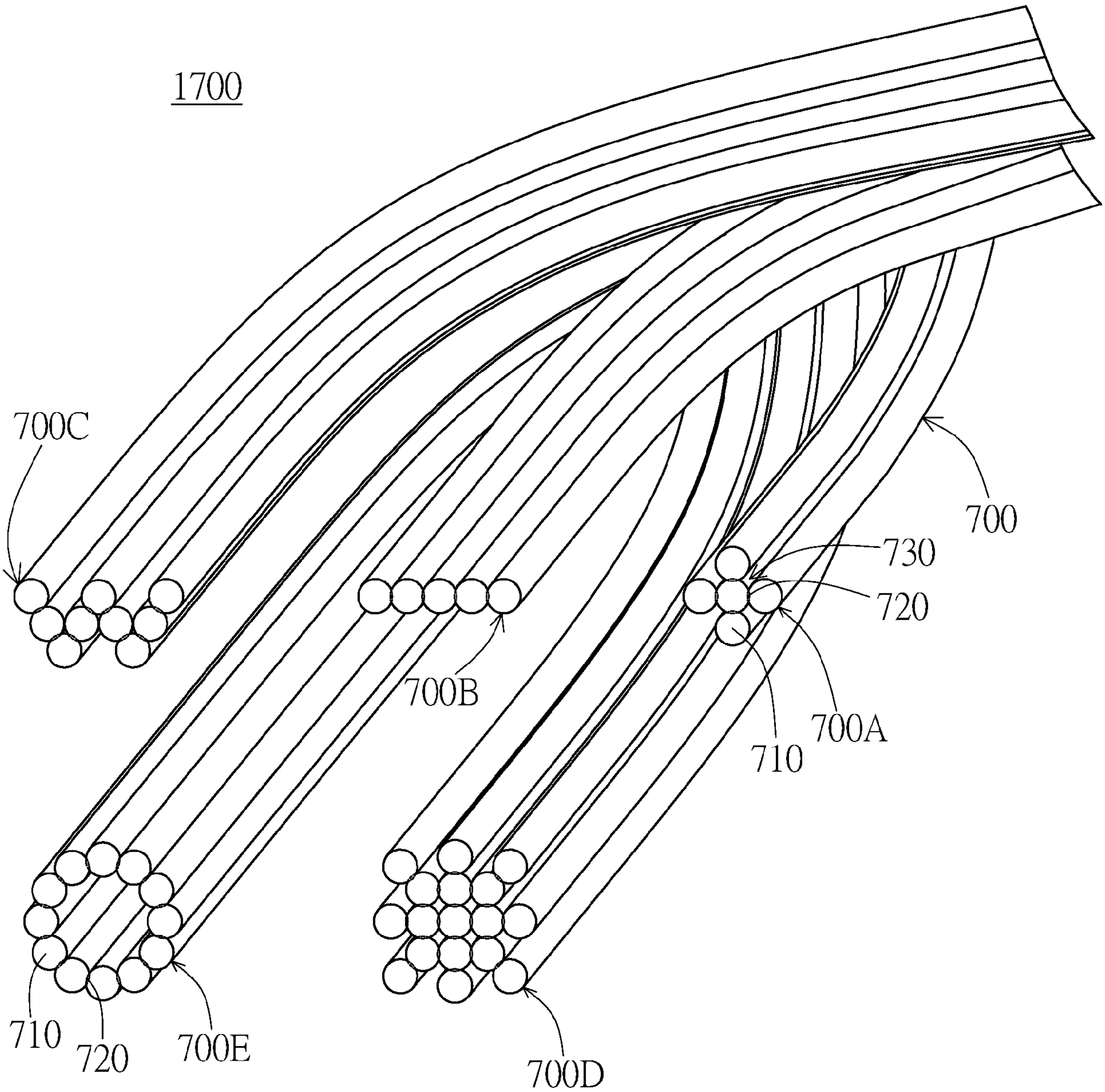

FIG. 8

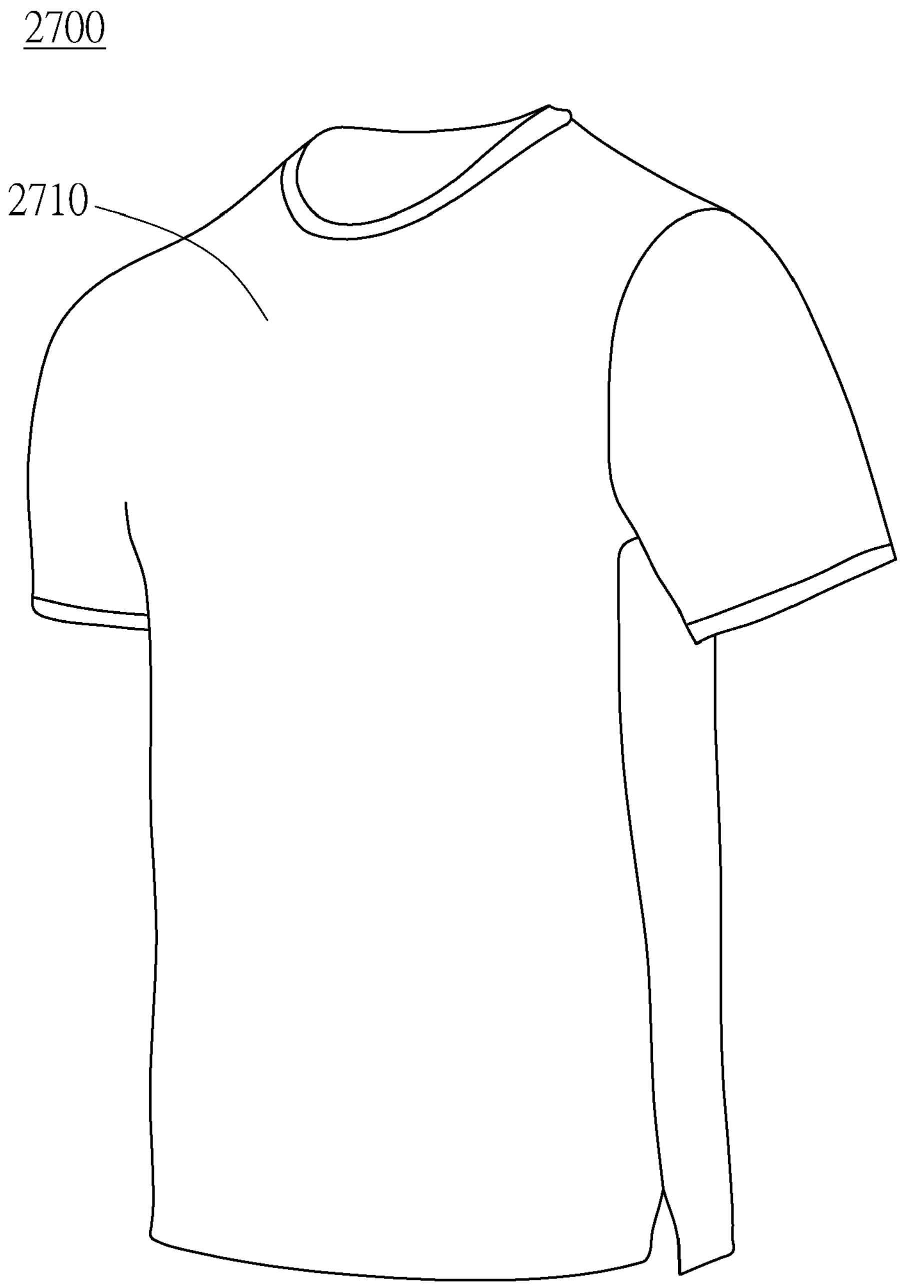

FIG. 9

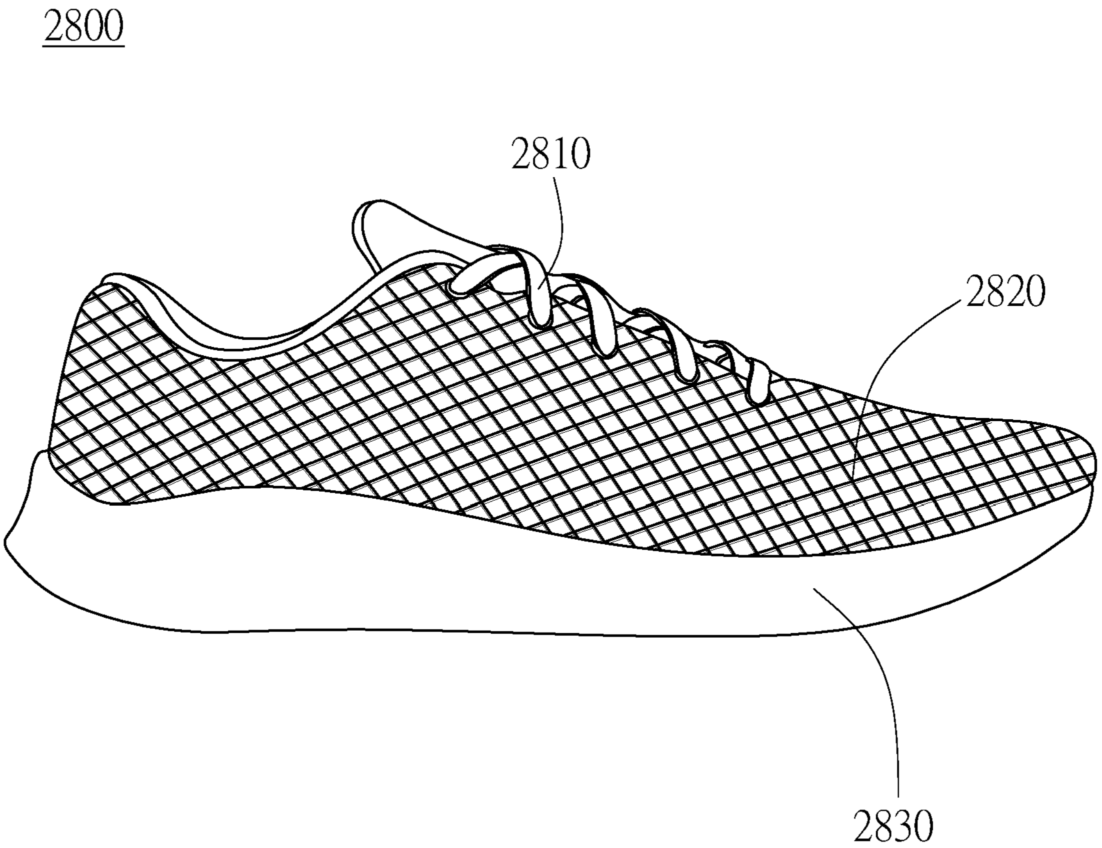

FIG. 10

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EUROPEAN SEARCH REPORT

Application Number
EP 23 18 3195

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X	EP 0 182 615 A2 (DU PONT [US]) 28 May 1986 (1986-05-28) * page 3, line 21 - page 4, line 18; examples 1,2 *	1-16	D01D D01F
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	13 December 2023	Van Beurden-Hopkins

CATEGORY OF CITED DOCUMENTS

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