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(54) **HIGH-VOLTAGE WINDING AND DRY-TYPE TRANSFORMER**

(57) Disclosed is a high-voltage winding (130), comprising a winding body (1310), a high-voltage coil (1320), a high-voltage insulating layer (1330), and an external insulating layer (1340). The winding body (1310) comprises a plurality of winding plates (1313, 2311, 1316); the plurality of winding plates (1313, 2311, 1316) are uniformly distributed in the circumferential direction of the winding body (1310); a wire is wound on the winding plates (1313, 2311, 1316) to form the high-voltage coil (1320); two ends of the wire form two external connections (D, X); the high-voltage insulating layer (1330) wraps the high-voltage coil (1320) and the winding body (1310); and the external insulating layer (1340) wraps the side walls of the external connections (D, X). Further disclosed is a dry-type transformer (10). The high-voltage winding (130) uses the external insulating layer (1340) to wrap the side walls of the external connections (D, X), thereby preventing the permeation of water vapor, ensuring the sealing effect, and effectively avoiding the problem of discharge of a wire outlet end.

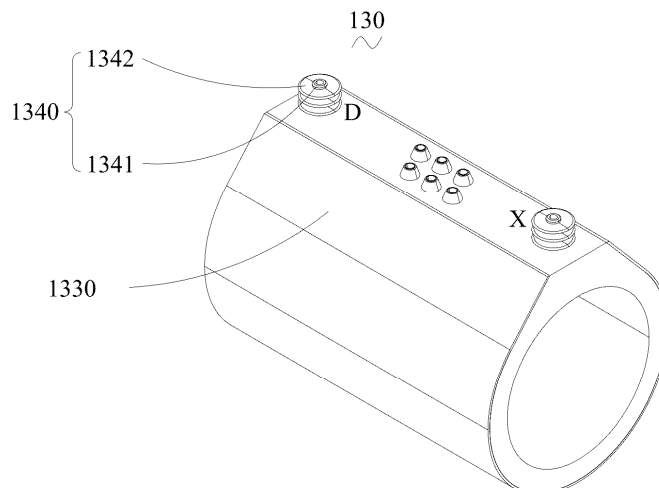


FIG. 14

Description

TECHNICAL FIELD

[0001] The present application relates to the field of dry-type transformer manufacturing, and in particular, to a high-voltage winding and a dry-type transformer.

BACKGROUND

[0002] In a conventional silicone rubber dry-type transformer, lead-out terminals of a high-voltage winding require connection to structures such as a lead-out bushing and a heat-shrink tube to prevent the problem of discharge at the lead-out terminals. The lead-out bushing generally has a structure formed by casting an epoxy resin insulating layer around a conductive copper rod or by reinforcing the conductive copper rod with a fiber-glass-reinforced plastic barrel and then casting liquid silicone rubber sheds thereon. However, this structure cannot be integrally formed with an insulating layer of the high-voltage winding, requiring the design of a sealed structure, which has a problem of sealing failure. The heat-shrink tube typically encapsulates the lead-out terminals by using materials such as PVC or PEC, which cannot achieve a complete seal. Rainwater seeping into the heat-shrink tube may corrode a conductor and affect insulation properties of the product. In addition, the above structures require additional processing and overall assembling, resulting in a long processing cycle.

SUMMARY

[0003] With respect to the shortcomings in the prior art, an object of the present application is to provide a high-voltage winding to solve the problem of sealing failure at lead-out terminals of an existing high-voltage winding.

[0004] To achieve the above object, the present application employs the following technical means: a high-voltage winding, including a winding body, a high-voltage coil, a high-voltage insulating layer, and an external insulating layer. The winding body includes a plurality of winding plates. The plurality of winding plates are evenly distributed along a circumferential direction of the winding body. A conductor is wound around the winding plates to form the high-voltage coil. Two ends of the conductor respectively form two external connectors. The high-voltage insulating layer is wrapped around the high-voltage coil and the winding body. The external insulating layer is wrapped around sidewalls of the external connectors.

[0005] Preferably, each external connector is further connected to a center conductor. The center conductor is configured to support the each external connector. The external insulating layer is wrapped around the each external connector and the center conductor.

[0006] Preferably, the each external connector is connected to the center conductor by welding.

[0007] Preferably, the external insulating layer includes a sheath and a plurality of sheds. The sheath is arranged on outer peripheries of the external connectors. The plurality of sheds are spaced apart on an outer periphery of the sheath.

[0008] Preferably, each winding plate is provided with a plurality of comb teeth, and the high-voltage coil includes a plurality of coil sections. At least one of the coil sections is arranged between two adjacent comb teeth on the each winding plate.

[0009] Preferably, the winding body further includes a plurality of auxiliary members. The plurality of auxiliary members are ring-shaped and spaced apart along an axial direction of the high-voltage winding. The auxiliary members are respectively engaged with and connected to the winding plates.

[0010] Preferably, each winding plate is provided with a plurality of winding members that are movable along the each winding plate. A winding groove is formed between two adjacent winding members on the each winding plate and is configured to wind the conductor.

[0011] Preferably, each winding member is provided with a moving groove, and the each winding member is slidably connected to the each winding plate through the moving groove.

[0012] Preferably, the each winding plate is an I-shaped long strip, the moving groove in the each winding member is a T-shaped groove. At least part of the each winding plate passes through the moving groove, to enable the each winding member to move along the each winding plate.

[0013] Preferably, the external insulating layer and the high-voltage insulating layer are made of high-temperature vulcanized silicone rubber.

[0014] Preferably, the external insulating layer and the high-voltage insulating layer are integrally injection-molded.

[0015] Preferably, the high-voltage winding further includes a semi-conductive shielding layer. The semi-conductive shielding layer is wrapped around an outer peripheral surface of the high-voltage insulating layer.

[0016] Preferably, the semi-conductive shielding layer is a semi-conductive silicone rubber layer formed by an injection process, or the semi-conductive shielding layer is a semi-conductive paint layer formed by a spraying process.

[0017] Preferably, a curved-surface structure is arranged on an outer surface of the high-voltage insulating layer.

[0018] Preferably, a plurality of sheds or a plurality of arc-shaped protrusions are arranged on an outer periphery of the high-voltage insulating layer. The plurality of sheds or the plurality of arc-shaped protrusions are evenly spaced apart along an axial direction of the high-voltage winding to form the curved-surface structure.

[0019] Preferably, an intermediate insulating layer is provided between each winding plate and the high-vol-

tage coil. The intermediate insulating layer is an elastic insulator, the elastic insulator being a silicone rubber gasket, a high-temperature vulcanized silicone rubber layer, a liquid silicone rubber layer, or a room-temperature vulcanized silicone rubber layer.

[0020] Preferably, the intermediate insulating layer includes a first insulating layer and a second insulating layer. The first insulating layer is wrapped around an outer periphery of the each winding plate, the second insulating layer is wrapped around an outer periphery of the conductor, so that the intermediate insulating layer is located between the winding body and the high-voltage coil. The first insulating layer and the second insulating layer are liquid silicone rubber layers.

[0021] In order to achieve the above object, another technical solution employed in the present application is as follows: a dry-type transformer, including an iron core, a low-voltage winding, and the foregoing high-voltage winding. The low-voltage winding is sleeved on the iron core, and the high-voltage winding is sleeved on the low-voltage winding.

[0022] The present application achieves the following beneficial effects: in the high-voltage winding of the present application, the external insulating layer is wrapped around the sidewalls of the external connectors, which can prevent vapor permeation, thereby ensuring a sealing effect and effectively preventing the problem of discharge at lead-out terminals.

[0023] Meanwhile, the external insulating layer and the high-voltage insulating layer are integrally injection-molded, so that an interface caused by material differences does not exist between the high-voltage insulating layer and the external insulating layer, resulting in better sealing performance. Furthermore, the integral molding process eliminates the time required for separate fabrication of the external insulating layer, leading to a shorter processing cycle, reduced labor costs and manufacturing energy consumption, and a lower overall cost.

[0024] In addition, with the arrangement of the sheds, a creepage distance is increased, which can prevent the problem of insulation degradation caused by partial discharge on the outer surface of the high-voltage winding during long-term operation, thereby effectively enhancing pollution flashover resistance of the dry-type transformer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025]

FIG. 1 is a front view of a dry-type transformer 10 according to an implementation of the present application;

FIG. 2 is a top view of the dry-type transformer 10 according to an implementation of the present application;

FIG. 3 is a front view of an assembled iron core 110 according to an implementation of the present ap-

plication;

FIG. 4 is an enlarged view of portion G in FIG. 2; FIG. 5 is a schematic three-dimensional view of a winding body 1310 according to an implementation of the present application;

FIG. 6 is a sectional view of a support barrel 1311 according to an implementation of the present application;

FIG. 7 is a schematic three-dimensional view of a high-voltage coil 1320 wound around a winding body 1310 according to an implementation of the present application;

FIG. 8 is a schematic three-dimensional view of a winding plate 1316 according to another implementation of the present application;

FIG. 9 is an enlarged view of portion L in FIG. 8;

FIG. 10 is a schematic three-dimensional view of a high-voltage winding 130 according to an implementation of the present application;

FIG. 11 is a simplified circuit diagram of the high-voltage coil 1320 according to an implementation of the present application;

FIG. 12 is a schematic three-dimensional view of a winding portion 2310 according to an implementation of the present application;

FIG. 13 is a schematic three-dimensional view of an auxiliary member 2312 according to an implementation of the present application;

FIG. 14 is a schematic three-dimensional view of a high-voltage winding 130 according to another implementation of the present application;

FIG. 15 is another view of the high-voltage winding 130 shown in FIG. 12;

FIG. 16 is a schematic three-dimensional view of a tooling connector 101 according to an implementation of the present application;

FIG. 17 is a schematic diagram of a curved-surface structure arranged on an outer surface of a high-voltage insulating layer 1330 according to an implementation of the present application;

FIG. 18 is a sectional view of the high-voltage winding 130 shown in FIG. 17;

FIG. 19 is a schematic diagram of a curved-surface structure arranged on an outer surface of the high-voltage insulating layer 1330 according to another implementation of the present application; and

FIG. 20 is a sectional view of the high-voltage winding 130 shown in FIG. 19.

DETAILED DESCRIPTION

[0026] In accordance with the requirements, specific implementations of the present application will be disclosed herein. However, it should be understood that the implementations disclosed herein are merely typical examples of the present application and may be embodied in various forms. Therefore, specific details disclosed herein are not intended to be limiting, but merely serve

as a basis for the claims and as a representative basis for teaching those skilled in the art to apply the present application differently in any appropriate manner in practice, including employing various features disclosed herein in combination with features that may not be explicitly disclosed herein.

[0027] As shown in FIG. 1 to FIG. 3, a dry-type transformer 10 is a three-phase transformer, including a phase A, a phase B, and a phase C. That is, the dry-type transformer 10 includes three single-phase transformers 100. According to different configurations of iron cores 110, the three transformers 100 may be arranged to form a linear or triangular structure, and the three transformers 100 are arranged to form a symmetrical structure. In addition, the dry-type transformer 10 may also be an isolation transformer, a variable frequency transformer, a testing transformer, or the like.

[0028] In some embodiments, still referring to FIG. 1 to FIG. 3, the three transformers 100 are arranged to form a linear structure, and the dry-type transformer 10 includes an iron core 110, three low-voltage windings 120, and three high-voltage windings 130. The iron core 110 includes three columnar core bodies 111, an upper yoke 112 located at upper ends of the three columnar core bodies 111, and a lower yoke 113 located at lower ends of the three columnar core bodies 111. The three low-voltage windings 120 are respectively sleeved on peripheries of the three columnar core bodies 111, and the three high-voltage windings 130 are respectively sleeved on peripheries of the three low-voltage windings 120. The columnar core body 111 is formed by multiple layers of silicon steel sheets that are stacked together and bound and secured with cable ties. A radial cross-section of the columnar core body 111 is roughly elliptical, circular, or in other shapes, provided that the columnar core body 111 can be accommodated in hollow cavities of the low-voltage windings 120, which is not limited herein. The upper yoke 112 and the lower yoke 113 are also formed by stacking multiple layers of silicon steel sheets, so that the three columnar core bodies 111 are securely connected.

[0029] An outer side of the iron core 110 is provided with a core clamp 140 configured to clamp the iron core 110. The core clamp 140 may be a channel steel member or a hollow pipe. Four core clamps 140 are provided. Two of the core clamps 140 are symmetrically located on two sides of an upper end of the iron core 110 and above the high-voltage windings 130. The other two of the core clamps 140 are symmetrically located on two sides of a lower end of the iron core 110 and below the high-voltage windings 130.

[0030] Referring to FIG. 2 and FIG. 4, the low-voltage winding 120 includes a copper foil 121, a low-voltage insulating layer 122, and a support bar 123. The copper foil 121 and the low-voltage insulating layer 122 are alternately arranged. The copper foil 121 is formed by winding an entire sheet of copper foil paper, and the low-voltage insulating layer 122 and the copper foil 121 are

overlapped, and then wound together.

[0031] At least one heat dissipation air duct is arranged in the low-voltage winding 120. The heat dissipation air duct is located between the copper foil 121 and the low-voltage insulating layer 122 that are adjacent to each other. Furthermore, the support bar 123 is located in the heat dissipation air duct to support and isolate the copper foil 121 and the low-voltage insulating layer 122 that are adjacent to each other.

[0032] The low-voltage insulating layer 122 is formed by polyimide impregnated paper, that is, by impregnating a polyimide film and a polysulfone fiber nonwoven soft composite material with diphenyl ether resin, and followed by baking, or may be made of other insulating material such as DMD insulating paper or a silicon rubber film, which may be selected according to different heat resistance levels of the dry-type transformer.

[0033] The insulating support bar 123 may be made of glass fibers or aramid fibers impregnated with epoxy resin, and the insulating support bar 123 may be a long strip with an I-shaped or square cross-section, which is not limited herein.

[0034] As shown in FIG. 5 to FIG. 7, FIG. 10, and FIG. 11, the high-voltage winding 130 includes a winding body 1310, a high-voltage coil 1320, and a high-voltage insulating layer 1330; and a conductor is wound around the winding body 1310 to form the high-voltage coil 1320. The winding body 1310 includes a support barrel 1311 and a winding portion 1312. The support barrel 1311 is a hollow column, which may be a hollow cylinder, a hollow elliptical column, or other hollow columns. The winding portion 1312 is located on an outer peripheral surface of the support barrel 1311. The conductor is wound in the winding portion 1312 to form the high-voltage coil 1320. The high-voltage coil 1320 includes a plurality of coil sections. The plurality of coil sections are spaced apart along an axial direction of the support barrel 1311.

[0035] The winding portion 1312 includes a plurality of winding plates 1313. The plurality of winding plates 1313 are evenly distributed circumferentially on the outer peripheral surface of the support barrel 1311. Each winding plate 1313 is arranged along the axial direction of the support barrel 1311, and a length of the winding plate 1313 along the axial direction of the support barrel 1311 is less than that of the support barrel 1311 along the axial direction thereof. At least two, for example, two, three, four, or more, winding plates 1313 may be provided, which is not limited herein. A 10 kV/1000 kVA dry-type transformer may be provided with twelve winding plates 1313, so as to ensure reliable winding of the conductor and save materials as much as possible. In other implementations, the length of the winding plate along the axial direction of the support barrel may alternatively be equal to that of the support barrel along the axial direction thereof.

[0036] The winding plate 1313 is a rectangular plate, and a longer side of the winding plate 1313 is arranged along the axial direction of the support barrel 1311. The

winding plate 1313 is further provided with a plurality of winding grooves 1314. The plurality of winding grooves 1314 are arranged along a radial direction of the support barrel 1311 and are distributed and spaced apart along the axial direction of the support barrel 1311, so that the winding plate 1313 is comb-shaped. Heights of the comb teeth on the winding plate 1313 along the axial direction of the support barrel 1311 are defined as tooth heights. Tooth heights of the comb teeth at two ends of the winding plate 1313 and tooth heights of the comb teeth in the middle of the winding plate 1313 are both greater than tooth heights of the comb teeth in other parts. This is due to uneven field strength at the ends of the high-voltage coil 1320, and a uniform electric field can be achieved by setting greater tooth heights at the two ends of the winding plate 1313. Moreover, taps of a tap conductor are required to be led out from the middle of the winding plate 1313. If the tooth heights in the middle of the winding plate 1313 are set to greater values, a distance between corresponding two adjacent winding grooves 1314 is also greater, which may leave placement space for the taps to be led out from the middle of the winding plate 1313.

[0037] At least one coil section is arranged between two adjacent comb teeth on the winding plate 1313, so that a conductor is wound in each winding groove 1314, the high-voltage coil 1320 is reasonably distributed and arranged, and the coil sections are spaced apart.

[0038] When the plurality of winding plates 1313 are evenly distributed circumferentially on the outer peripheral surface of the support barrel 1311, two ends of all the winding plates 1313 are flush with each other, and the winding grooves 1314 in all the winding plates 1313 are aligned with each other correspondingly in a circumferential direction of the support barrel 1311. For each coil section, the conductor is wound in a corresponding circle of winding grooves 1314 in all the winding plates 1313 along the circumferential direction of the support barrel 1311, with balanced force and good mechanical strength.

[0039] In other implementations, the winding plates may alternatively be annular disc members arranged circumferentially around the support barrel. The plurality of winding plates are spaced apart along the axial direction of the support barrel, and the conductor is wound in a recess formed by two adjacent winding plates.

[0040] The support barrel 1311 is a hollow tube formed from a composite material. A specific material and a forming process may be adjusted according to a design requirement of the high-voltage winding, which is not limited herein.

[0041] The winding body 1310 may be formed by separately molding the support barrel 1311 and the winding plates 1313 and then fixing them by bonding, or by integrally casting a hollow pipe in a single process and then forming the support barrel and the winding plates through turning.

[0042] In an application scenario, referring to FIG. 5, FIG. 6, and FIG. 10, the winding body 1310 further includes two flanges 1315. The flanges 1315 are located

on two end portions of the support barrel 1311 and extend outwards along the radial direction of the support barrel 1311 to form annular disc faces. The flanges 1315 at the two ends are arranged opposite to each other. When the winding plate 1313 is placed on the outer peripheral surface of the winding body 1310, outer end faces of two end portions of the winding plate 1313 respectively abut against the disc faces of the two flanges 1315 facing each other, so as to prevent damage to the winding plates 1313 due to large injection pressure during the injection of the high-voltage insulating layer 1330.

[0043] In other implementations, the support barrel and the winding portion of the winding body may be engaged with each other by using an auxiliary member, which is not limited herein.

[0044] In another implementation, referring to FIG. 12 and FIG. 13, the winding body may include only the winding portion 2310, that is, a structure of a rigid insulating liner barrel is omitted in the winding body, which enables a better heat conduction effect of the high-voltage winding, and eliminates an interface between the high-voltage insulating layer and the rigid insulating liner barrel, thereby inhibiting surface discharge of the rigid insulating liner barrel, saving materials, and reducing costs.

[0045] The winding portion 2310 includes a plurality of comb-shaped winding plates 2311 and a plurality of auxiliary members 2312. The plurality of auxiliary members 2312 are ring-shaped and spaced apart along axial directions of the auxiliary members 2312. The winding plates 2311 are secured to outer peripheries of the plurality of auxiliary members 2312 along the axial directions of the auxiliary members 2312, so that the winding plates 2311 are simultaneously connected to all the auxiliary members 2312. Furthermore, the plurality of winding plates 2311 are evenly distributed along circumferential directions of the auxiliary members 2312. The axial direction of the auxiliary member 2312 is an axial direction of the winding portion 2310, that is, an axial direction of the high-voltage winding. The auxiliary member 2312 may be in a shape of a circular ring or an elliptical ring, which may be designed according to an overall shape of the high-voltage winding. The plurality of winding plates 2311 are arranged circumferentially, the conductor is wound around the winding portion 2310 to form the high-voltage coil. The high-voltage coil includes a plurality of coil sections. The plurality of coil sections are spaced apart along the axial direction of the high-voltage winding. The high-voltage insulating layer is wrapped around the high-voltage coil, the plurality of auxiliary members 2312, and the winding plates 2311. The auxiliary members 2312 can maintain stable arrangement of the winding plates 2311, preventing displacement and dislocation of the winding plates 2311 during the winding of the conductor and the injection of the high-voltage insulating layer.

[0046] In an implementation, an outer surface of the auxiliary member 2312 is provided with a plurality of first slots 23121. The plurality of first slots 23121 are evenly

distributed along the circumferential direction of the auxiliary member 2312. Side surfaces of the plurality of winding plates 2311 are respectively engaged into the plurality of first slots 23121, so that the plurality of winding plates 2311 are evenly arranged circumferentially on outer peripheries of the plurality of auxiliary members 2312. Two ends of each of all the winding plates 2311 are flush with each other, and the first slots 23121 in all the auxiliary members 2312 are aligned with each other correspondingly in the axial directions of the auxiliary members 2312, so that each winding plate 2311 can be arranged along the axial direction of the auxiliary member 2312, allowing the conductor to be wound in the comb teeth of the winding plate 2311 to form the high-voltage coil. That is, the plurality of coil sections of the high-voltage coil are distributed and spaced apart along the axial direction of the winding portion 2310, with balanced force and good mechanical strength.

[0047] A width of the first slot 23121 along the circumferential direction of the auxiliary member 2312 is defined as a slot width of the first slot 23121. The slot width of the first slot 23121 matches a thickness of the winding plate 2311, so that the winding plate 2311 is firmly assembled with the auxiliary member 2312, preventing that the winding plate 2311 is difficult to be aligned and secured to the auxiliary member 2312 when the slot width of the first slot 23121 is less than the thickness of the winding plate 2311, or preventing falling of the winding plate 2311 from the auxiliary member 2312 when the slot width of the first slot 23121 is greater than the thickness of the winding plate 2311. The winding plate 2311 is fixedly connected in the first slot 23121 by an adhesive. The adhesive is a two-component high-temperature resistant epoxy adhesive, which may alternatively be other adhesives, provided that the adhesive can ensure a firm bonding between the winding plate 2311 and the auxiliary member 2312. Besides, the adhesive is required to be high-temperature resistant, so as to adapt to the wrapping of the high-voltage insulating layer around the winding plate 2311 and the auxiliary member 2312 by high-temperature injection.

[0048] In other implementations, the slot may alternatively be arranged on a side surface of the winding plate adjacent to the auxiliary member, and the auxiliary member is engaged in the slot of the winding plate, so that the winding plate is securely connected to the auxiliary member. Certainly, preferably, the auxiliary member 2312 is provided with the first slot 23121 in the foregoing implementations, which prevents weakening of mechanical strength of the winding plate due to the arrangement of the slot in the winding plate.

[0049] The winding plate 2311 is similar to the winding plate 1313 as described above in configuration, except that two ends of the winding plate 2311 are each provided with a flow groove 23111, which enables injected silicone rubber raw materials to flow from an end portion of the winding portion 2310 into an inner side of the winding portion 2310 during injection molding of the high-voltage

insulating layer, and then allows the high-voltage insulating layer to fully fill a gap between the winding portion 2310 and the high-voltage coil, as well as two ends of the winding portion 2310.

[0050] The winding plate 2311 and the auxiliary member 2312 are both made of glass fibers impregnated with epoxy resin. Multiple layers of glass fiber cloth impregnated with epoxy resin are stacked to a certain thickness, and molded and cured to form a fiberglass-reinforced plastic member. The winding plate 2311 and the auxiliary member 2312 may be separately formed and then bonded and fixed to each other, or may be integrally formed.

[0051] Referring to FIG. 5, FIG. 7, and FIG. 10, taking an A-phase transformer 100 as an example, the conductor is wound circumferentially around the outer peripheral surface of the winding body 1310 to form the high-voltage coil 1320. The conductor is wound in the winding grooves 1314 of the winding portion 1312, so that the high-voltage coil 1320 is distributed and spaced apart in the axial direction of the support barrel 1311, and after the winding is completed, head and tail ends of the conductor form two external connectors, which are respectively a first external connector D and a second external connector X. The first external connector D is configured to be connected to a cable, and the second external connector X is configured to be connected to other external conductors, for example, to interconnect transformers in various phases in the three-phase transformer. Six taps are led out from the conductor on the middle of the winding body 1310 along the axial direction thereof, which are a tap 2, a tap 3, a tap 4, a tap 5, a tap 6, and a tap 7 respectively. The six taps form a tap changer. For ease of description, the tap 2, the tap 4, and the tap 6 are defined as a first tap changer, and the tap 3, the tap 5, and the tap 7 are defined as a second tap changer.

[0052] In an application scenario, referring to FIG. 5, FIG. 7, FIG. 10, and FIG. 11, the conductor includes a first conductor and a second conductor. Both the first conductor and the second conductor are continuous conductors, and each of the first conductor and the second conductor is coated with an insulating layer. The insulating layer may be a polyimide film or a glass fiber film, or may be made of other insulating materials such as polyester paint, or made of a combination of a plurality of insulating materials, which is not limited herein. The first conductor is wound from an end of the winding portion 1312 along the axial direction of the winding body 1310 to the middle of the winding portion 1312, and three taps are led out from the first conductor. For ease of expression, an upper end of the winding portion 1312 is defined as a first end, and a lower end of the winding portion 1312 is defined as a second end. The first conductor is wound from the first end of the winding portion 1312 towards the second end of the winding portion 1312. The first conductor is wound in a corresponding circle of first winding grooves 1314 in all the winding plates 1313 with a designed number of turns to form a first coil section 1321.

The first coil section 1321 is wound in a disc-type manner, with only one disc coil arranged in each winding groove 1314. In this case, each coil section includes only one disc coil. An inner-turn conductor end of the first conductor located at the first end of the winding portion 1312 forms a first external connector D exposed to the outside of the high-voltage insulating layer 1330. That is, the first external connector D is led out from the inner-turn conductor end of the first coil section 1321 (i.e., a head end of the first conductor). An outer-turn conductor end of the first coil section 1321 extends into a corresponding circle of second winding grooves 1314 in all the winding plates 1313 and continues to wind to form a second coil section 1322, and so on, until the first conductor is wound to the middle of the winding body 1310, and three taps, i.e., the tap 6, the tap 4, and the tap 2 shown in FIG. 11, are respectively led out from outer-turn conductor ends of the three coil sections. So far, the winding of the first conductor has been completed.

[0053] The second conductor is wound from the middle of the winding portion 1312 along the axial direction of the winding body 1310 to the second end of the winding portion 1312, and three other taps are led out from the second conductor. The second conductor starts to be wound in next circle of winding grooves 1314 adjacent to the tap 2 to form a third coil section 1323. The second conductor is continuously wound towards the second end of the winding portion 1312 in a same manner as the first conductor. Three other taps, i.e., the tap 3, the tap 5, and the tap 7, are respectively led out from three coil sections starting from the third coil section 1323, until the second conductor is wound to the last winding groove 1314 in each winding plate 1313 in a corresponding circle at the second end of the winding portion 1312, forming the terminal coil section 1324. An outer-turn conductor end of the second conductor located at the second end of the winding portion 1312 forms a second external connector X exposed to the outside of the high-voltage insulating layer 1330. That is, the second external connector X is led out from the outer-turn conductor end of the terminal coil section 1324 (i.e., a tail end of the second conductor). So far, the winding of the second conductor has been completed.

[0054] During the winding, the conductor is wound in a corresponding circle of winding grooves 1314 in all the winding plates 1313, so that each coil section formed by the winding of the conductor is perpendicular to the axial direction of the winding body 1310, which is convenient for the winding, and the conductor is arranged orderly. The winding plates 1313 are evenly stressed and have good mechanical strength. In other implementations, other existing conductor winding methods may alternatively be selected according to design requirements of the high-voltage winding, which are not limited herein.

[0055] In another application scenario, referring to FIG. 8 and FIG. 9, to enhance flexibility of winding of the conductor on the winding body and expand an application scope of the winding body, the winding body may

alternatively adopt a structure with movable comb teeth. That is, the winding portion of the winding body includes a plurality of winding plates 1316 (only one winding plate 1316 is shown in the figures for illustration), and the plurality of winding plates 1316 are evenly distributed along the circumferential direction of the winding body. The winding plate 1316 is provided with a plurality of winding members 1317 movable along the winding plate 1316. A winding groove is formed between two adjacent winding members 1317 on the winding plate 1316, and is configured to be wound by the conductor. A plurality of winding grooves are arranged along a radial direction of the winding body and distributed and spaced apart along the axial direction of the winding body, so that the winding plates 1316 and the winding members 1317 are comb-shaped as a whole after being assembled.

[0056] The bottom of the winding member 1317 connected to the winding plate 1316 is provided with a moving groove 1318. The winding member 1317 is slidably connected to the winding plate 1316 through the moving groove 1318, to enable the winding member 1317 to move along the winding plate 1316, which facilitates flexible adjustment of the position of the winding member 1317 according to the shape and the structure of the high-voltage coil, broadens the application scope, and further reduces the costs.

[0057] In this implementation, the winding plate 1316 is a long strip with an I-shaped cross-section, the winding member 1317 is a rectangular plate, and the moving groove 1318 of the winding member 1317 is correspondingly configured as a T-shaped groove. That is, at least part of the winding plate 1316 passes through the moving groove, to enable the winding member 1317 to move along the winding plate 1316. In other implementations, the winding plate may alternatively have a trapezoidal cross-section or other irregular polygonal cross-sections, provided that the shape of the moving groove of the winding member is correspondingly adjusted to match the winding plate so that the winding member can move smoothly along the winding plate and is not prone to falling off.

[0058] The winding member 1317 is made of a fiber-reinforced composite material, such as glass fiber reinforced epoxy resin or aramid fiber reinforced epoxy resin composite material. The winding member 1317 may alternatively be made of a resin material, for example, an epoxy resin material, which is not limited in the present application, as long as strength of the winding member 1317 can be ensured.

[0059] Referring to FIG. 10, the high-voltage insulating layer 1330 wraps around the high-voltage coil 1320 and the winding body 1310 to form the high-voltage winding 130. The high-voltage insulating layer 1330 is made of high-temperature vulcanized silicone rubber. Firstly, the conductor is wound on the winding body 1310 to form the high-voltage coil 1320, and then, the winding body 1310 and the high-voltage coil 1320 are used as a to-be-injected body, and the to-be-injected body is put into a

mold of an injection molding machine. By adding silicone rubber raw materials, the high-temperature vulcanized silicone rubber is integrally injected around an outer periphery of the to-be-injected body and molded to obtain the high-voltage winding 130. The high-voltage insulating layer 1330 is made of the high-temperature vulcanized silicone rubber, which improves overall insulation and mechanical properties of the high-voltage winding 130.

[0060] The high-temperature vulcanized silicone rubber in the present application adopts a high-temperature vulcanized silicone rubber material system, including raw rubber, a reinforcing agent, a flame retardant, a heat-resistant agent, and other auxiliary materials.

[0061] After the high-temperature vulcanized silicone rubber is wrapped around the high-voltage coil 1320 and the winding body 1310 by integral vacuum injection, the high-temperature vulcanized silicone rubber fills a gap between the high-voltage coil 1320 and the winding body 1310 and wraps around the two ends of the winding body 1310, and an inner wall of the support barrel 1311 is not coated with the high-temperature vulcanized silicone rubber, so that the high-voltage winding 130 is in the shape of a hollow column as a whole, which may be a hollow cylinder, a hollow elliptical column, or other hollow columns.

[0062] Compared with the epoxy resin high-voltage insulating layer in the prior art, the silicone rubber has the following advantages. 1) It has good fire resistance, low temperature resistance, aging resistance, and short circuit resistance, which can prolong the service life of the dry-type transformer 10. 2) The copper coil is easy to peel off from the silicone rubber, and thus, a material recovery rate is greater than 99%, which is more environmentally friendly. 3) The silicone rubber elastomer can reduce inducing factors of partial discharge caused by mechanical vibration, and have an inhibitory effect on device discharge, and a product of the silicone rubber under discharge is non-conductive silicon dioxide, which can effectively inhibit further deterioration of insulation. 4) It can reduce operation losses of the dry-type transformer 10, and is more energy-efficient. 5) It has good resistance to harsh environments and enables indoor and outdoor mounting. Meanwhile, the high-voltage insulating layer 1330 is integrally formed by high-temperature vulcanization injection molding. Compared with existing room temperature vulcanization, this process enables the high-voltage insulating layer 1330 to be more stable, to have higher mechanical properties and better adhesion to the high-voltage coil 1320 and the winding body 1310, which can effectively prolong the service life of the high-voltage insulating layer 1330. Moreover, compared to liquid silicone rubber, high-temperature vulcanized silicone rubber offers homogeneous filler dispersion, which may not cause partial discharge in the dry-type transformer 10 due to agglomeration of the fillers, so that the overall performance of the dry-type transformer 10 is better.

[0063] Further, referring to FIG. 5 and FIG. 7, to address the problem of a solid interface between the high-voltage coil 1320 and the winding plate 1313, an intermediate insulating layer (not shown in figures) is provided between the winding plate 1313 and the high-voltage coil 1320.

[0064] In an implementation, an intermediate insulating layer is arranged on a contact surface between the comb teeth of the winding plate 1313 and the high-voltage coil 1320. That is, the intermediate insulating layer is first arranged in the winding groove 1314 of the winding plate 1313, and then the conductor is wound, so that the intermediate insulating layer is located between the comb teeth of the winding plate 1313 and the high-voltage coil 1320, preventing the problem of partial discharge caused by generation of a solid interface due to direct contact between the comb teeth of the winding plate 1313 and the high-voltage coil 1320, thereby enhancing insulating properties of the high-voltage winding 130.

[0065] In this implementation, the intermediate insulating layer is an elastic insulator. The elastic insulator can effectively fill gaps between the conductor and the comb teeth of the winding plate 1313, ensuring an insulation effect.

[0066] Preferably, the elastic insulator is made of a same insulating material as the high-voltage insulating layer 1330, that is, the elastic insulator is made of silicone rubber. The silicone rubber can reduce mechanical vibration, lower noise, and prevent interface separation between the winding body and the conductor, which can prevent the problem of partial discharge caused by interface separation between different materials. For example, the elastic insulator may be a silicone rubber gasket, whose dimensions match those of the winding groove 1314 to conform to sidewalls and the bottom of the winding groove 1314; or may alternatively be an integrated or split silicone rubber washer, which is arranged in each corresponding circle of winding grooves 1314 in all the winding plates 1313. In another example, the elastic insulator may alternatively be a high-temperature vulcanized silicone rubber layer, a liquid silicone rubber layer, or a room-temperature vulcanized silicone rubber layer. That is, a silicone rubber layer is first formed on the surface of the winding plate 1313, and then the conductor is wound. In other implementations, the configuration and the material of the intermediate insulating layer may be adjusted according to a design requirement of the high-voltage winding, which is not limited herein.

[0067] In another implementation, the intermediate insulating layer is wrapped around the outer periphery of the conductor, that is, the intermediate insulating layer is first wrapped around the outer periphery of the conductor, and then the conductor is wound between the comb teeth of the winding plate 1313, so that the intermediate insulating layer is located between the comb teeth of the winding plate 1313 and the high-voltage coil 1320. The intermediate insulating layer may be a liquid silicone

rubber layer. That is, the liquid silicone rubber layer is first formed on the surface of the conductor through a spraying or impregnation process, and then the conductor is wound.

[0068] In yet another implementation, the intermediate insulating layer is arranged on both the surface of the winding plate 1313 and the surface of the conductor. The intermediate insulating layer includes a first insulating layer and a second insulating layer. The first insulating layer is wrapped around the outer periphery of the winding plate 1313, and the second insulating layer is wrapped around the outer periphery of the conductor, so that the intermediate insulating layer is located between the winding body 1310 and the high-voltage coil 1320, which can further prevent the problem of partial discharge caused by formation of the solid interface due to direct contact between the coil and the winding plate 1313.

[0069] In this implementation, both the first insulating layer and the second insulating layer are liquid silicone rubber layers, and formed in the same manner as described above. Liquid silicone rubber is characterized by excellent flowability, which is in a liquid state during the spraying or impregnation and is then cured naturally over time. Compared to solid silicone rubber, the liquid silicone rubber can better coat the surfaces of the conductor and the winding plate 1313, thereby enhancing the insulation effect. In other implementations, the first insulating layer and the second insulating layer may be made of different materials, which is not limited.

[0070] Further, referring to FIG. 14 and FIG. 15, the high-voltage winding 130 includes an external insulating layer 1340. The external insulating layer 1340 is wrapped around sidewalls of the two external connectors respectively. That is, the external insulating layer 1340 is wrapped around a sidewall of the first external connector D and a sidewall of the second external connector X respectively, which can prevent vapor permeation, ensure a sealing effect, and effectively prevents the problem of discharge at the lead-out terminals.

[0071] The external insulating layer 1340 includes a sheath 1341 and a plurality of sheds 1342. The sheath 1341 is arranged on outer peripheries of the external connectors, that is, the sheath 1341 is arranged on the outer periphery of the first external connector D and the outer periphery of the second external connector X respectively, and the plurality of sheds 1342 are spaced apart on an outer periphery of the sheath 1341.

[0072] In this implementation, the plurality of sheds 1342 are of an equal size, that is, each of the sheds 1342 extends outwards from an outer surface of the respective external connector by a same length. Through the arrangement of the plurality of sheds 1342, a creepage distance on the outer surface of the high-voltage winding 130 is increased, which can prevent the problem of insulation degradation caused by partial discharge on the outer surface of the high-voltage winding 130 during long-term operation, thereby effectively enhancing pollu-

tion flashover resistance of the dry-type transformer 10 and guaranteeing stable and safe operation of the dry-type transformer 10.

[0073] In other implementations, the sizes and shapes of the sheds may be adjusted according to a design requirement of the high-voltage winding. For example, the sheds may be designed in a manner in which large and small sheds are arranged alternately. That is, the sheds include a plurality of small sheds and a plurality of large sheds. An extending length of the small shed extending from the outer surface of the external connector is less than that of the large shed extending from the outer surface of the external connector. The plurality of small sheds and the plurality of large sheds may be arranged alternately and spaced apart along an axial direction of the external connector. A specific arrangement sequence of the large sheds and the small sheds and a spacing distance between the large shed and the small shed may be adjusted according to a design requirement of the high-voltage winding. The configuration with the large and small sheds alternately arranged exhibits excellent self-cleaning properties, making it suitable for heavily polluted areas.

[0074] The first external connector D and the second external connector X are further respectively connected to center conductors (not shown in figures). The center conductor is configured to support the external connector. The external insulating layer 1340 is wrapped around the center conductors. The center conductors respectively support the first external connector D and the second external connector X, which can prevent that case that the first external connector D and the second external connector X are deformed by stress during the formation of the external insulating layer 1340 so that the external insulating layer 1340 cannot be fully wrapped around the first external connector D and the second external connector X.

[0075] In this implementation, the center conductors are made of metal materials, and the external connectors and the center conductors are connected to each other by welding, which can ensure strength of the connection therebetween. The center conductors may be solid rod members or hollow pipes, as long as they can support and fix the external connectors, which is not limited herein. Moreover, the center conductor projects outwards by a certain distance from the outer surface of the high-voltage insulating layer 1330. With the arrangement of the external insulating layer 1340, a longer dry arcing distance can be provided, effectively enhancing a lightning protection capability of the dry-type transformer 10.

[0076] The external insulating layer 1340 is made of high-temperature vulcanized silicone rubber, and the advantages of the high-temperature vulcanized silicone rubber are as described above. Details thereof are not repeatedly described again.

[0077] The external insulating layer 1340 and the high-voltage insulating layer 1330 are integrally injection-molded, so that an interface caused by material differ-

ences does not exist between the high-voltage insulating layer 1330 and the external insulating layer 1340, which eliminates the problems such as vapor permeation and results in better sealing performance. Furthermore, the integral molding process eliminates the time required for separate fabrication of the external insulating layer 1340, leading to a shorter processing cycle, reduced labor costs and manufacturing energy consumption, and a lower overall cost. In other implementations, the high-voltage insulating layer may be first injection-molded, and then the external insulating layer is injection-molded on the outer periphery of the external connector, or the external insulating layer and the high-voltage insulating layer may be injection-molded separately, and then the external insulating layer is sleeved and is fixed to the outer periphery of the external connector, which is not limited herein.

[0078] Referring to FIG. 14, prior to the integral injection of the high-temperature vulcanized silicone rubber, a tooling connector 101 is provided on each high-voltage coil 1320, with six stepped holes 1011 provided on a plate surface thereof. The six stepped holes 1011 are used respectively to be connected to six taps, to prevent that the six taps are also wrapped with the silicone rubber during the injection and cannot be used for conductor connections.

[0079] In another application scenario, referring to FIG. 10, to reduce electromagnetic interference of the dry-type transformer 10 with an external environment and mitigate an electrostatic effect of the high-voltage winding 130, the high-voltage winding 130 of the present application further includes a semi-conductive shielding layer (not shown in figures). The semi-conductive shielding layer is wrapped around the outer peripheral surface of the high-voltage insulating layer 1330, which can reduce electromagnetic interference of the dry-type transformer 10 with the external environment and mitigate the electrostatic effect of the high-voltage winding. Furthermore, a heat effect produced by an induced current inside the semi-conductive shielding layer can keep the surface of the high-voltage winding 130 dry in salt-fog or contaminated, humid environments, thereby reducing safety risks. Meanwhile, due to relatively low conductivity of the semi-conductive shielding layer, the above induced current is low, leading to correspondingly low energy losses. Furthermore, when the semi-conductive shielding layer is grounded for shielding, due to the low conductivity thereof, a potential may not directly drop to 0, so that potentials of the high-voltage coil 1320, semi-conductive shielding layer, and ground exhibit a gradual decreasing gradient, thereby preventing electrical safety hazards caused by an abrupt potential drop.

[0080] In this implementation, the semi-conductive shielding layer is a semi-conductive silicone rubber layer, which is manufactured from a semi-conductive silicone rubber material by an injection process. That is, the semi-conductive shielding layer is formed by integrally injecting the semi-conductive silicone rubber material on the

outer periphery of the high-voltage insulating layer 1330. The semi-conductive silicone rubber material includes a silicone rubber material, a conductive filler, a semi-conductive filler, a reinforcing filler, a heat conductive filler, and a flame-retardant filler. That is, prior to injection, the conductive filler, the semi-conductive filler, the reinforcing filler, the heat conductive filler, and the flame-retardant filler are respectively added to the silicone rubber material and mixed to form the semi-conductive silicone rubber material, which is then used for subsequent injecting of the semi-conductive shielding layer. The conductive filler is aluminum, silver oxide, or a mixture thereof. The semi-conductive filler is one or more the group consisting of carbon black, acetylene black, graphene, silicon carbide, and beryllium nitride. The reinforcing filler is silica white carbon black. The heat conductive filler is aluminum oxide. The flame-retardant filler is aluminum hydroxide. In other implementations, types and proportions of the components in the semi-conductive silicone rubber material may alternatively be adjusted according to a shielding requirement of the high-voltage winding, which is not limited herein.

[0081] The semi-conductive shielding layer has a thickness ranging from 2 mm to 5 mm, which can ensure a shielding effect without affecting heat dissipation performance of the high-voltage winding 130.

[0082] Compared with the conventional conductive coating, the semi-conductive shielding layer of the present application has the following advantages. 1) The semi-conductive silicone rubber material of the semi-conductive shielding layer and the high-temperature vulcanized silicone rubber material of the high-voltage insulating layer 1330 both employ a silicone rubber material as a primary matrix and are both molded by a high-temperature vulcanization injection process, so that the semi-conductive shielding layer and the high-voltage insulating layer 1330 are physically bonded and are also chemically bonded through molecular chain cross-linking. This results in better interfacial compatibility and a smaller difference in electrical conductivity between the semi-conductive shielding layer and the high-voltage insulating layer 1330, and can reduce heat generation caused by interfacial currents. 2) The semi-conductive shielding layer made of the semi-conductive silicone rubber material has high mechanical strength and is an elastomer, which is less prone to damage from impacts during operation and maintenance. 3) The semi-conductive shielding layer is molded in a single step by an injection process, which is simple to operate and has high production efficiency, and the manufacturing process requires no volatile substances, has no chemical liquid discharge, and is pollution-free. 4) Electrical conductivity of the semi-conductive silicone rubber material is between that of the conductive material and that of the silicone rubber material, so that the induced current within the semi-conductive shielding layer during operation is relatively low, thereby resulting in relatively low energy losses. 5) The semi-conductive shielding layer made of

the semi-conductive silicone rubber material has a characteristic of self-regulating conductivity, the conductivity increases under high electric field environments, and the conductivity decreases under low electric field environments, which can effectively optimize electric field distribution of the high-voltage winding. 6) The semi-conductive silicone rubber material also has hydrophobicity and migration of hydrophobicity of the silicone rubber material, which enables a lotus effect to be generated on the surface of the high-voltage winding 130, making it less prone to formation of water film and discharge. Even if contamination occurs on the surface of the high-voltage winding 130, small-molecule substances within the semi-conductive shielding layer can migrate to a contamination layer, imparting hydrophobicity to the contamination layer as well, thereby enhancing electrical safety of the high-voltage winding 130.

[0083] In other implementations, the semi-conductive shielding layer may alternatively be a semi-conductive paint layer, which is manufactured by applying semi-conductive paint by a spraying process. The semi-conductive paint may be selected from existing materials, or a formula may be adjusted according to a shielding requirement of the high-voltage winding, which is not limited herein.

[0084] In another application scenario, referring to FIG. 17 to FIG. 20, to further alleviate the problem of partial discharge easily occurring during long-term use of the high-voltage winding 130, the outer surface of the high-voltage insulating layer 1330 of the high-voltage winding 130 in the present application is provided with a curved-surface structure (for ease of expression, the external connectors and related structures are not shown in figures), which can increase the creepage distance on the outer surface of the high-voltage winding 130 and also make the product more aesthetically pleasing.

[0085] In an implementation, referring to FIG. 17 and FIG. 18, a plurality of sheds 1331 are arranged on the outer periphery of the high-voltage insulating layer 1330. The plurality of sheds 1331 are evenly spaced apart along the axial direction of the high-voltage winding 130 to form the curved-surface structure. Each shed 1331 extends outwards along a circumferential direction of the high-voltage insulating layer 1330 from the outer surface of the high-voltage insulating layer 1330 to form an elliptical disk shape, and a thickness of an edge of the shed 1331 away from the high-voltage insulating layer 1330 is less than a thickness of a root of the shed 1331 adjacent to the high-voltage insulating layer 1330. No sheds 1331 are provided at the top or the bottom of the high-voltage insulating layer 1330, to prevent an influence on subsequent assembly of the dry-type transformer 10.

[0086] In this implementation, the specific arrangement manner and the purpose of the plurality of sheds 1331 are similar to those of the foregoing sheds 1342. Details thereof are not repeatedly described herein again.

[0087] In another implementation, referring to FIG. 19 and FIG. 20, a plurality of arc-shaped protrusions 1332 are arranged on the outer peripheral surface of the high-voltage insulating layer 1330. The plurality of arc-shaped protrusions 1332 are evenly spaced apart along the axial direction of the high-voltage winding 130 to form the curved-surface structure. Each arc-shaped protrusion 1332 is arranged along the circumferential direction of the high-voltage insulating layer 1330, and extends outwards from the outer peripheral surface of the high-voltage insulating layer 1330 to form an annular structure. A maximum distance by which the arc-shaped protrusion 1332 extends outwards from the outer peripheral surface of the high-voltage insulating layer 1330 is defined as a protrusion height, and the protrusion heights of all the arc-shaped protrusions 1332 are equal. The plurality of arc-shaped protrusions 1332 are continuously arranged to be in a wavy pattern, and are evenly distributed with a smooth transition. No arc-shaped protrusions 1332 are arranged at the top or the bottom of the high-voltage insulating layer 1330 to prevent an influence on subsequent assembly of the dry-type transformer 10.

[0088] The plurality of arc-shaped protrusions 1332 are arranged on the outer peripheral surface of the high-voltage insulating layer 1330, so that: on the one hand, the creepage distance on the outer surface of the high-voltage insulating layer 1330 can be increased, effectively preventing the problem of insulation degradation caused by partial discharge occurring on the outer surface of the high-voltage insulating layer 1330 during long-term operation of the high-voltage winding 130; and on the other hand, a surface area of the high-voltage insulating layer 1330 can also be enlarged, which facilitates heat dissipation from the high-voltage winding 130. In addition, since various components in the dry-type transformer 10 are made of different materials and have different shrinkage rates, the outer surface of the high-voltage insulating layer 1330 is prone to being uneven after molding. With the arrangement of evenly distributed and smoothly transitioning arc-shaped protrusions 1332, an appearance of the high-voltage insulating layer 1330 can be improved, making the dry-type transformer 10 more aesthetically pleasing.

[0089] In this implementation, both the high-voltage insulating layer 1330 and the curved-surface structure are integrally formed in a single molding process by using high-temperature vulcanized silicone rubber through overall injection, which can prevent interface problems caused by material differences between the high-voltage insulating layer 1330 and the curved-surface structure, thereby enhancing overall insulation and mechanical properties of the high-voltage winding 130. The specific molding manner is as described above, provided that the shape and dimensions of the mold can be adjusted according to the curved-surface structure. Details thereof are not repeatedly described again.

[0090] In other implementations, the high-voltage insulating layer and the curved-surface structure may al-

ternatively be integrally molded by using liquid silicone rubber by a casting process, which is easy to operate and highly efficient, and can also prevent interface problems caused by material differences between the high-voltage insulating layer and the curved-surface structure, thereby enhancing overall insulation and mechanical properties of the high-voltage winding; or, may be made of other types of silicone rubber materials. A specific molding manner may be adjusted according to material properties and design requirements of the high-voltage winding, which is not limited herein.

[0091] The technical contents and features of the present application have been already disclosed as above. However, it should be appreciated that as guided by the creation idea of the present application, those skilled in the art can make various modifications and improvements to the above structures and materials, including combinations of technical features individually disclosed herein or sought for protection, obviously including other combinations of these features. These variants and/or combinations all fall within the technical field to which the present application relate to and fall within the protection scope of claims of the present application.

Claims

1. A high-voltage winding, comprising: a winding body, a high-voltage coil, a high-voltage insulating layer, and an external insulating layer, wherein the winding body comprises a plurality of winding plates, the plurality of winding plates being evenly distributed along a circumferential direction of the winding body, wherein a conductor is wound around the winding plates to form the high-voltage coil, two ends of the conductor respectively form two external connectors, wherein the high-voltage insulating layer is wrapped around the high-voltage coil and the winding body, and the external insulating layer is wrapped around sidewalls of the external connectors.
2. The high-voltage winding according to claim 1, wherein each external connector is further connected to a center conductor, the center conductor being configured to support the each external connector, and the external insulating layer is wrapped around the each external connector and the center conductor.
3. The high-voltage winding according to claim 2, wherein the each external connector is connected to the center conductor by welding.
4. The high-voltage winding according to claim 1, wherein the external insulating layer comprises a sheath and a plurality of sheds, wherein the sheath is arranged on outer peripheries of the external connectors, and the plurality of sheds are spaced

apart on an outer periphery of the sheath.

5. The high-voltage winding according to claim 4, wherein each winding plate is provided with a plurality of comb teeth, and the high-voltage coil comprises a plurality of coil sections, wherein at least one of the coil sections is arranged between two adjacent comb teeth on the each winding plate.
6. The high-voltage winding according to claim 1, wherein the winding body further comprises a plurality of auxiliary members, the plurality of auxiliary members being ring-shaped and spaced apart along an axial direction of the high-voltage winding, wherein the auxiliary members are respectively engaged with and connected to the winding plates.
7. The high-voltage winding according to claim 1, wherein each winding plate is provided with a plurality of winding members that are movable along the each winding plate, and a winding groove is formed between two adjacent winding members on the each winding plate and is configured to wind the conductor.
8. The high-voltage winding according to claim 7, wherein each winding member is provided with a moving groove, and the each winding member is slidably connected to the each winding plate through the moving groove.
9. The high-voltage winding according to claim 8, wherein the each winding plate is an I-shaped long strip, the moving groove in the each winding member is a T-shaped groove, at least part of the each winding plate passes through the moving groove, to enable the each winding member to move along the each winding plate.
10. The high-voltage winding according to claim 1, wherein the external insulating layer and the high-voltage insulating layer are made of high-temperature vulcanized silicone rubber.
11. The high-voltage winding according to claim 1, wherein the external insulating layer and the high-voltage insulating layer are integrally injection-molded.
12. The high-voltage winding according to claim 1, further comprising a semi-conductive shielding layer, the semi-conductive shielding layer being wrapped around an outer peripheral surface of the high-voltage insulating layer.
13. The high-voltage winding according to claim 12, wherein the semi-conductive shielding layer is a semi-conductive silicone rubber layer formed by

an injection process, or the semi-conductive shielding layer is a semi-conductive paint layer formed by a spraying process.

14. The high-voltage winding according to claim 1,
wherein a curved-surface structure is arranged on
an outer surface of the high-voltage insulating layer. 5
15. The high-voltage winding according to claim 14,
wherein a plurality of sheds or a plurality of arc-
shaped protrusions are arranged on an outer per-
iphery of the high-voltage insulating layer, the plur-
ality of sheds or the plurality of arc-shaped protru-
sions being evenly spaced apart along an axial di-
rection of the high-voltage winding to form the
curved-surface structure. 10 15
16. The high-voltage winding according to claim 1,
wherein an intermediate insulating layer is provided
between each winding plate and the high-voltage
coil, wherein the intermediate insulating layer is an
elastic insulator, the elastic insulator being a silicone
rubber gasket, a high-temperature vulcanized sili-
cone rubber layer, a liquid silicone rubber layer, or a
room-temperature vulcanized silicone rubber layer. 20 25
17. The high-voltage winding according to claim 16,
wherein the intermediate insulating layer comprises
a first insulating layer and a second insulating layer,
wherein the first insulating layer is wrapped around
an outer periphery of the each winding plate, the
second insulating layer is wrapped around an outer
periphery of the conductor, so that the intermediate
insulating layer is located between the winding body
and the high-voltage coil, wherein the first insulating
layer and the second insulating layer are liquid sili-
cone rubber layers. 30 35
18. A dry-type transformer, comprising an iron core, a
low-voltage winding, and the high-voltage winding
according to any one of claims 1 to 17, wherein the
low-voltage winding is sleeved on the iron core, and
the high-voltage winding is sleeved on the low-vol-
tage winding. 40 45

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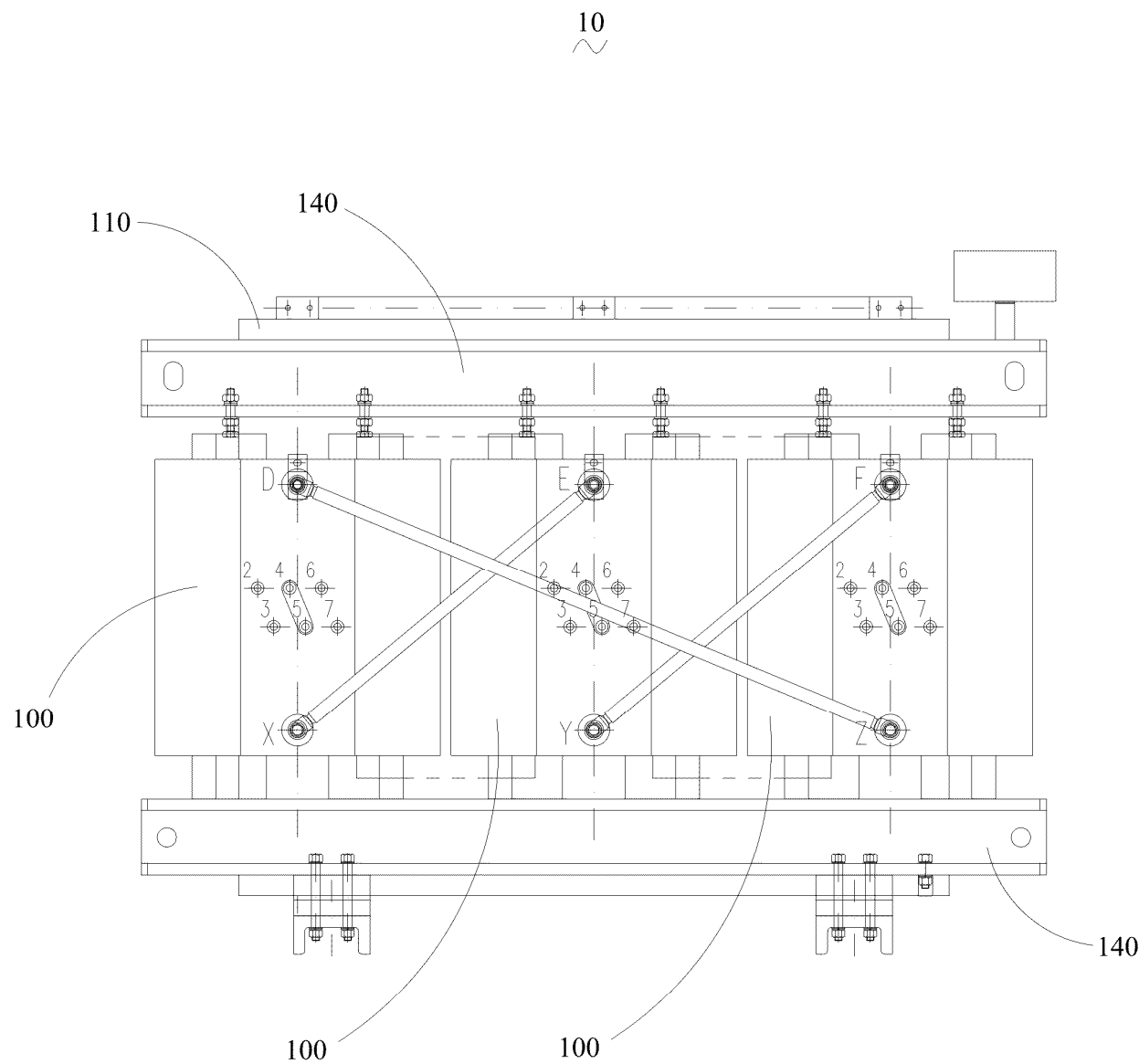


FIG. 1

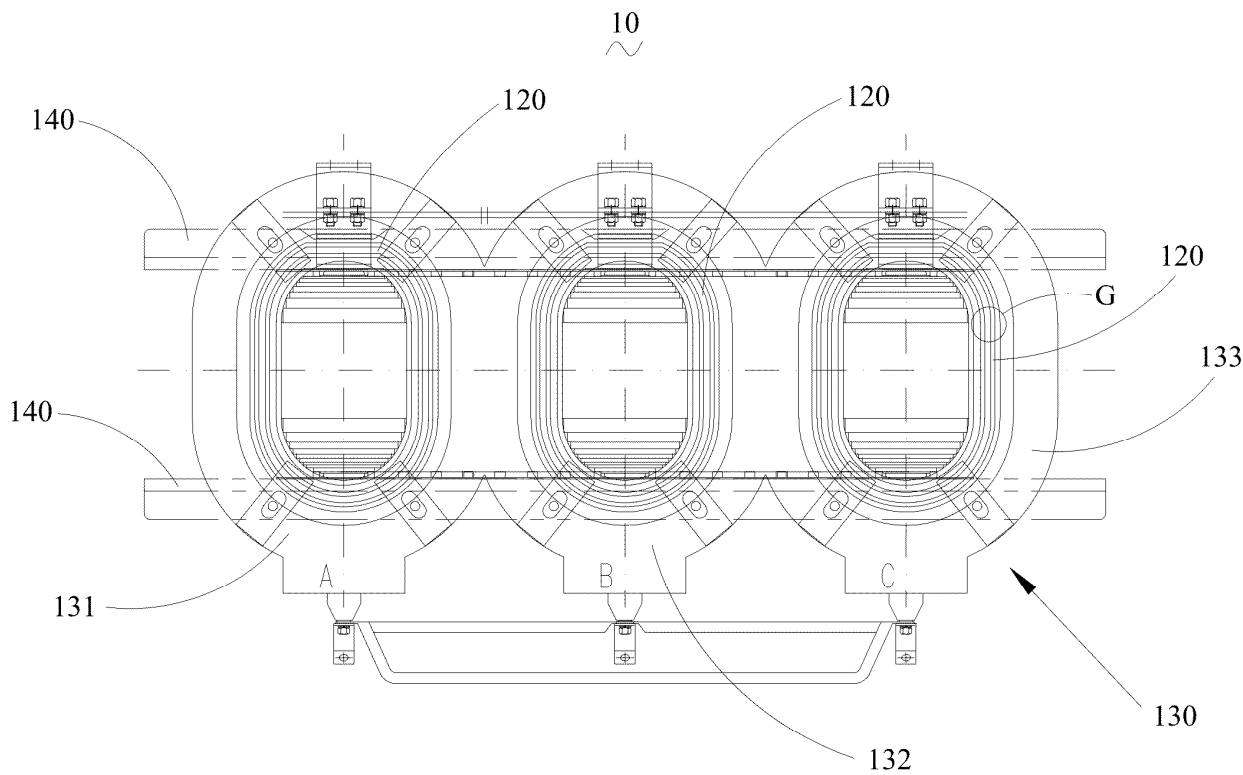


FIG. 2

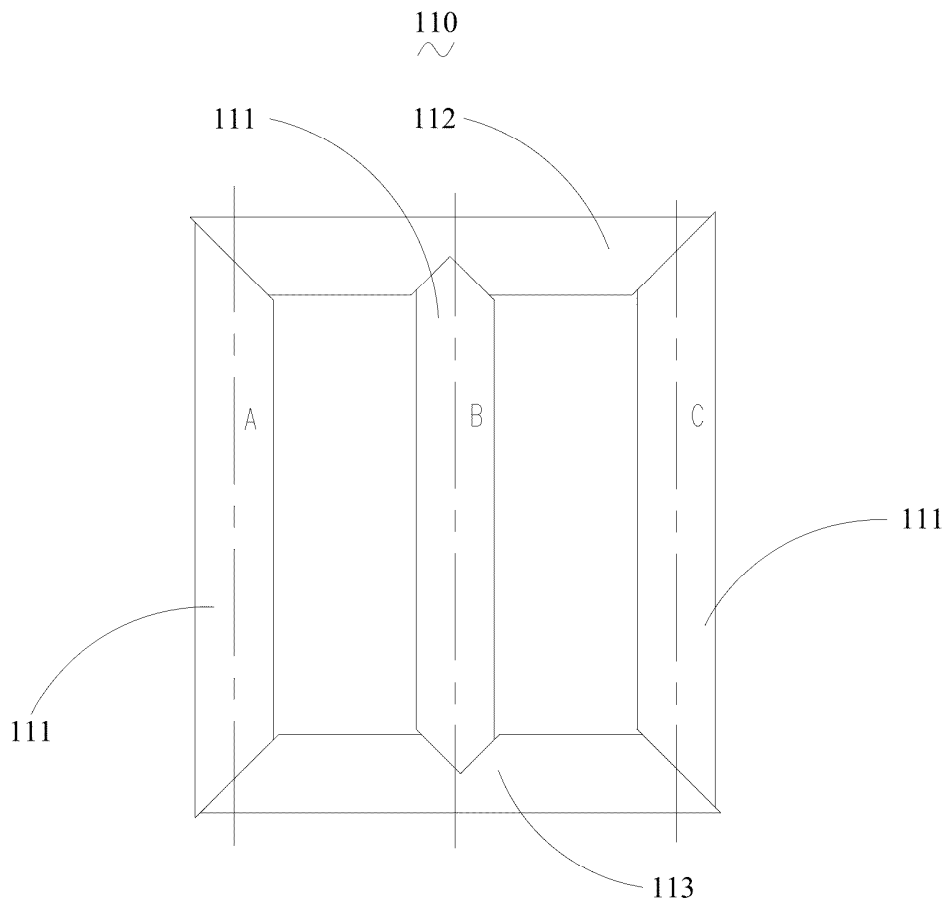


FIG. 3

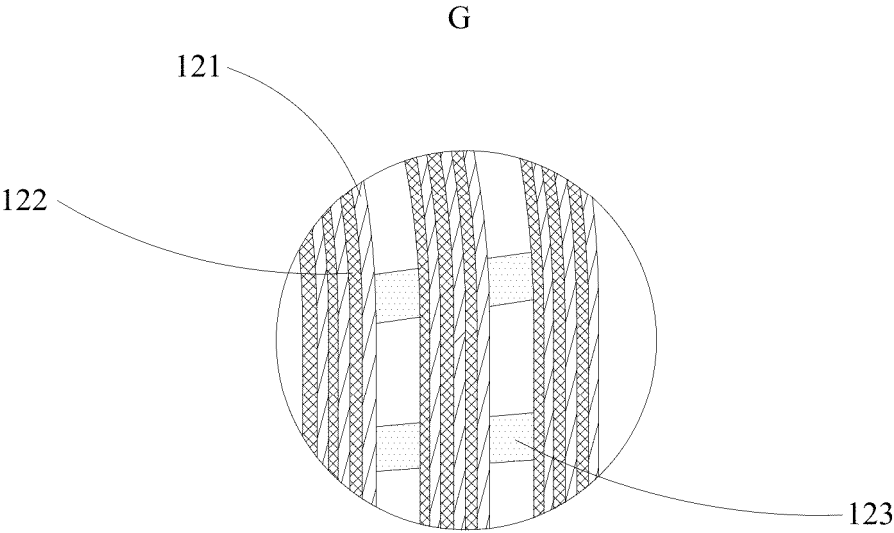


FIG. 4

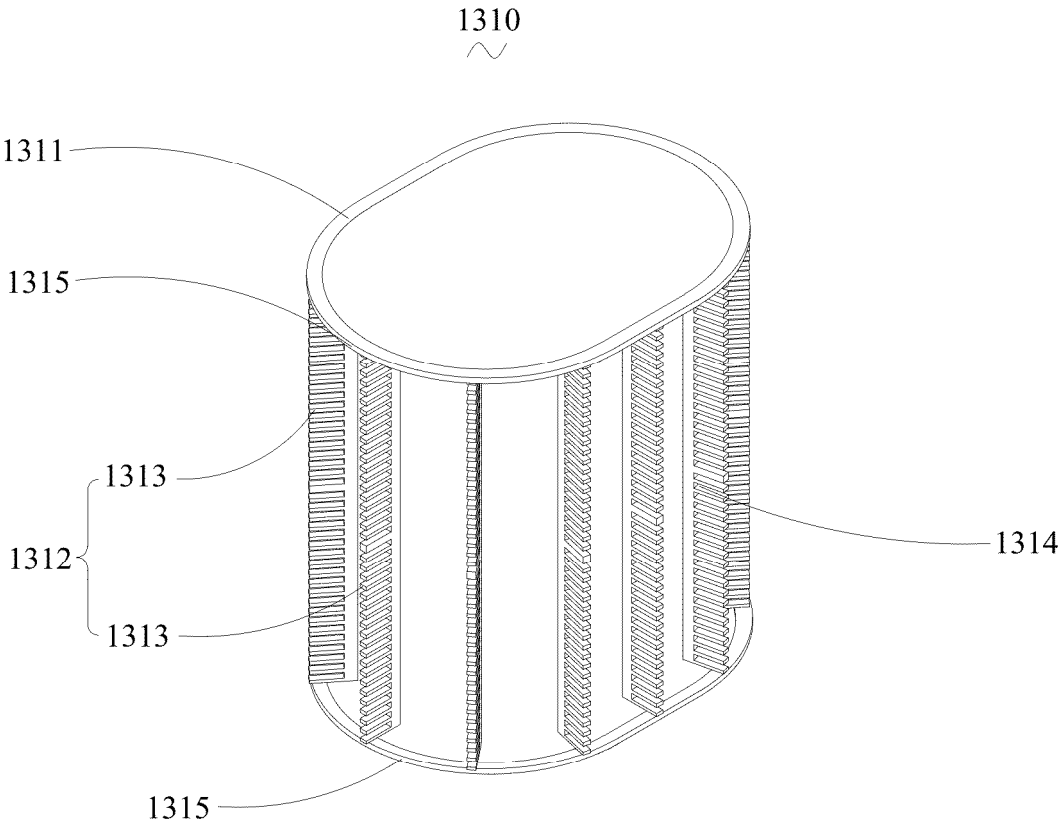


FIG. 5

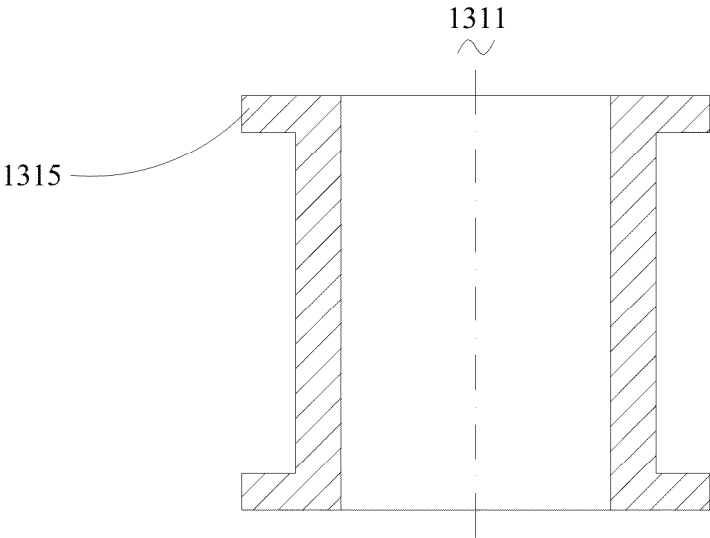


FIG. 6

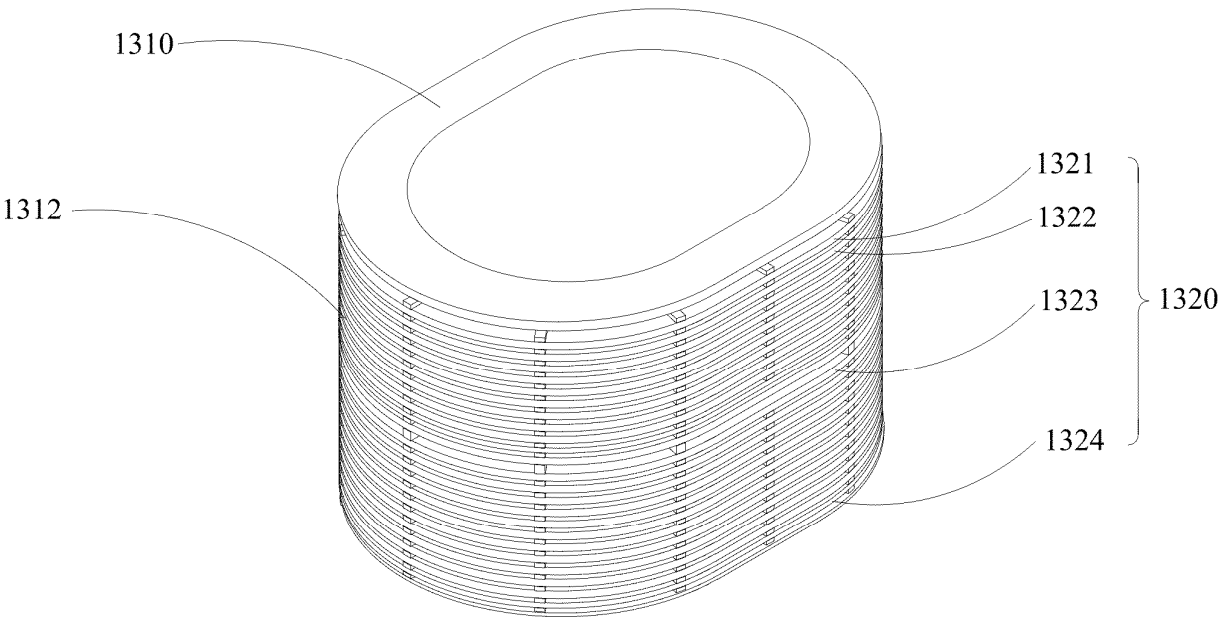


FIG. 7

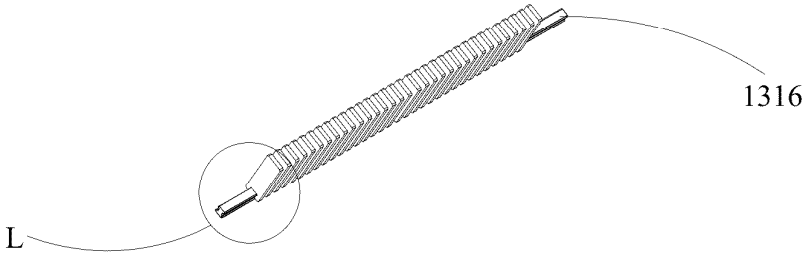


FIG. 8

L

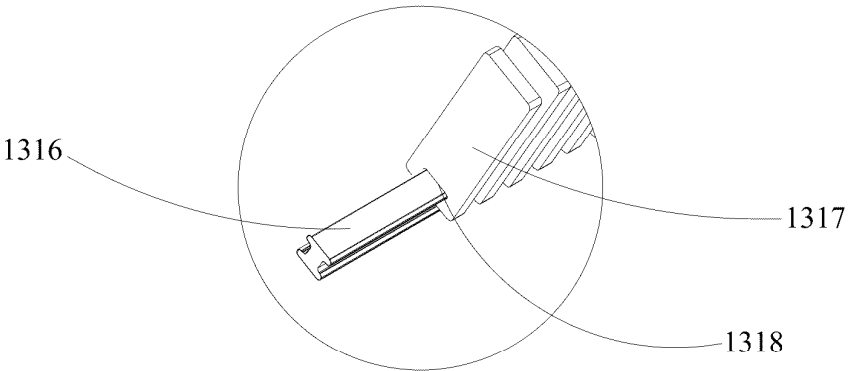


FIG. 9

130

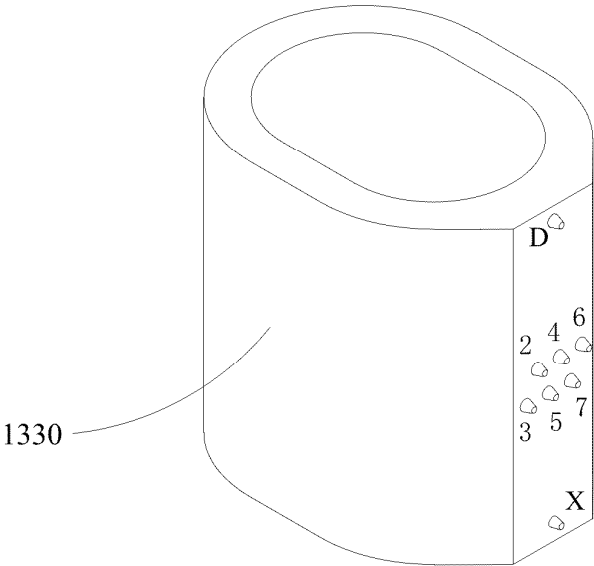


FIG. 10

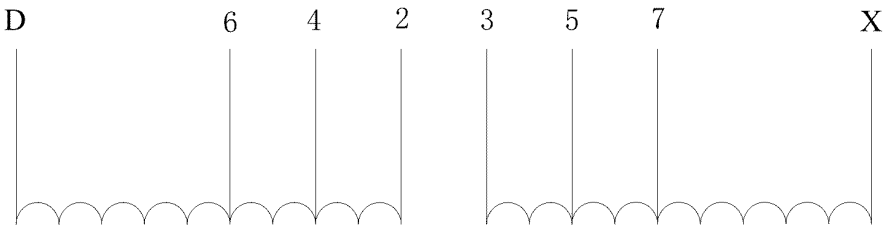


FIG. 11

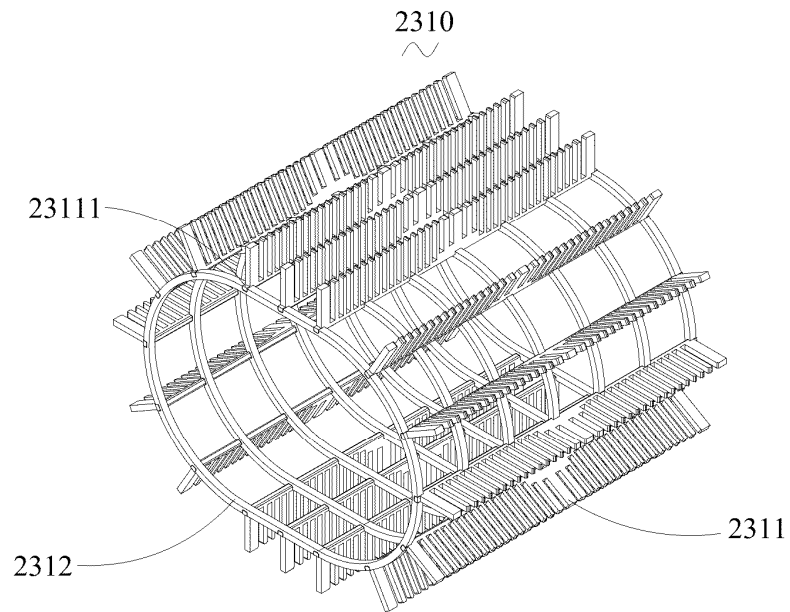


FIG. 12

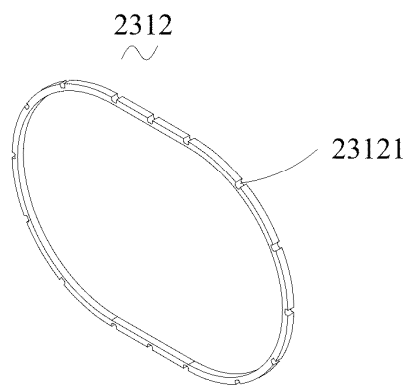


FIG. 13

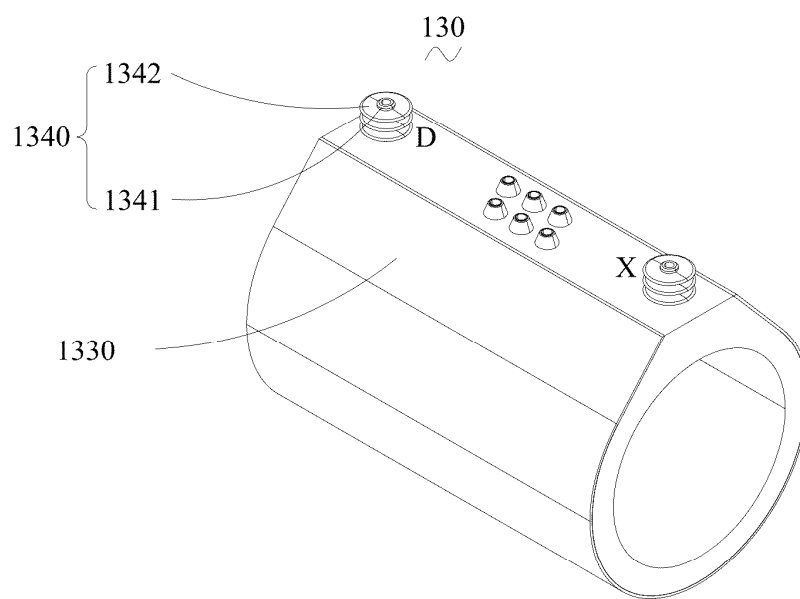


FIG. 14

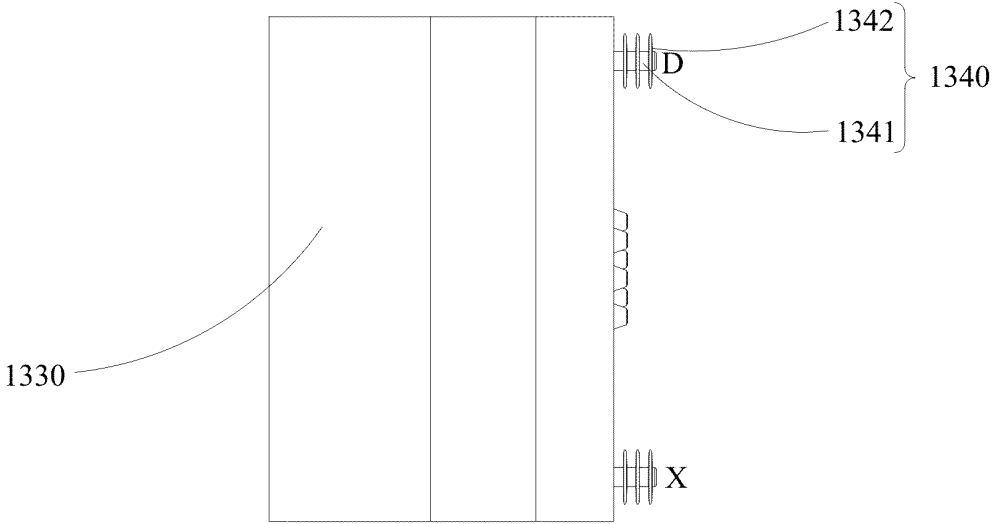


FIG. 15

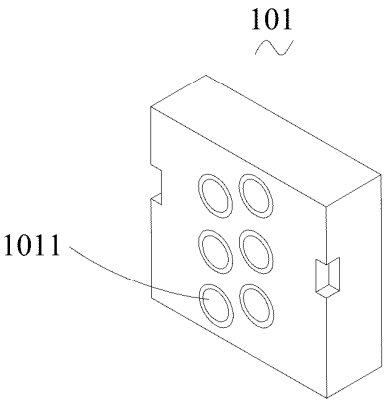


FIG. 16

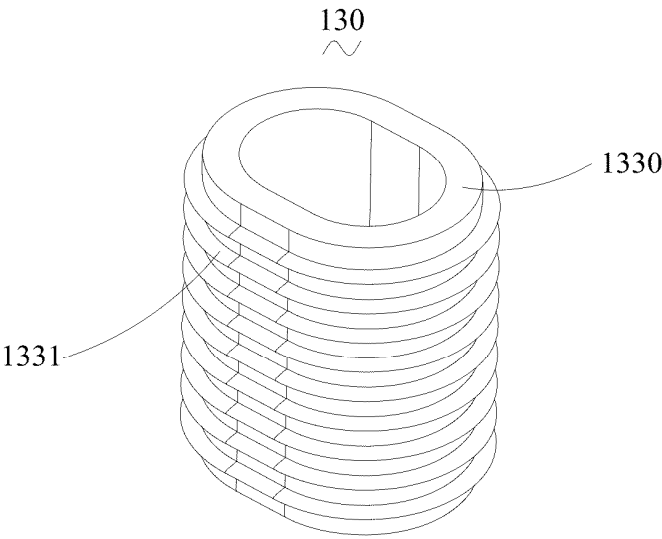


FIG. 17

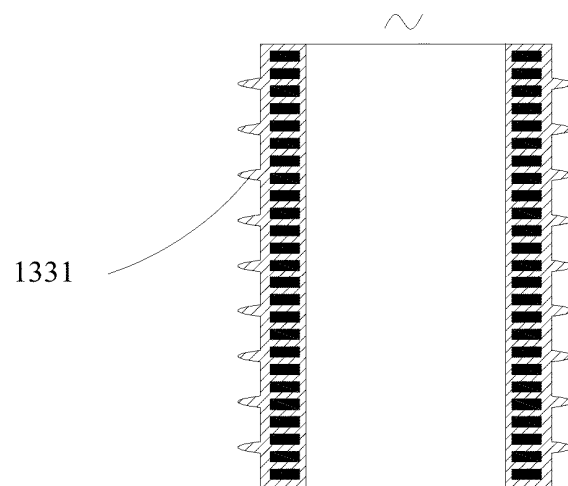


FIG. 18

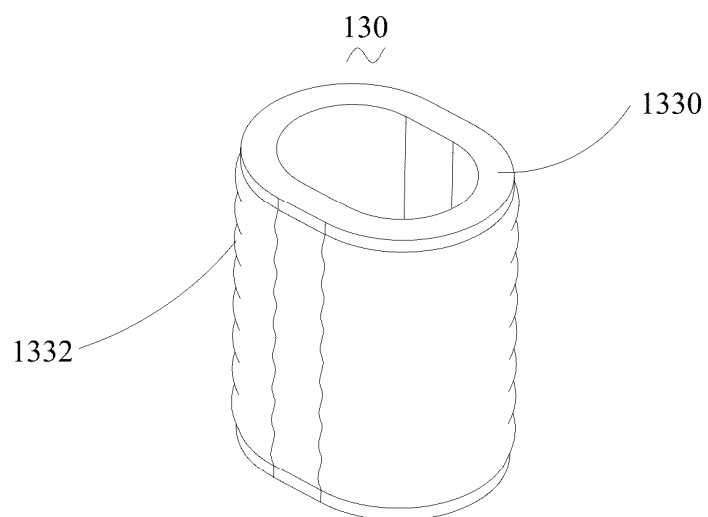


FIG. 19

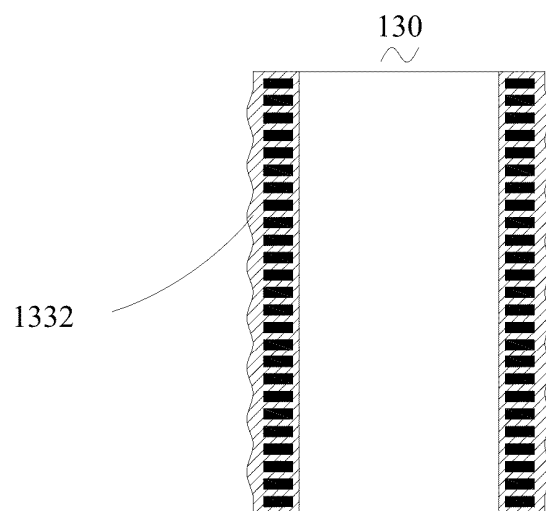


FIG. 20

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2024/104995

A. CLASSIFICATION OF SUBJECT MATTER

H01F27/32(2006.01)i; H01F27/30(2006.01)i; H01F27/29(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC:H01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CNTXT, ENTXTC, VEN, CNKI: 半导体屏蔽, 侧壁, 侧面, 端子, 分接头, 辅助件, 接线柱, 绝缘, 绕线板, 绕线槽, 绕线件, 伞裙, 外接绝缘层, 移动, 移动槽, 中心导体, side, terminal, lead, insulation, shift, move, winding, coil, groove

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 116936243 A (JIANGSU SHEMA ELECTRIC CO., LTD.) 24 October 2023 (2023-10-24) entire document	1-18
PX	CN 220672369 U (JIANGSU SHEMA ELECTRIC CO., LTD.) 26 March 2024 (2024-03-26) entire document	1-18
Y	WO 2023125633 A1 (JIANGSU SHEMAR ELECTRIC CO., LTD.) 06 July 2023 (2023-07-06) description, specific embodiments, and figures 1-32	1-18
Y	CN 208521771 U (HENAN SENYUAN ELECTRIC CO., LTD.) 19 February 2019 (2019-02-19) description, specific embodiments, and figures 1-4	1-18
Y	CN 206619476 U (ZHONGSHAN YUELONG PLASTIC PRODUCTS CO., LTD.) 07 November 2017 (2017-11-07) description, specific embodiments, and figures 1-3	7-9

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"D" document cited by the applicant in the international application	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"E" earlier application or patent but published on or after the international filing date	"&" document member of the same patent family
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

05 September 2024

Date of mailing of the international search report

24 September 2024

Name and mailing address of the ISA/CN

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Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2024/104995

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C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 204946672 U (KUNSHAN SPECIAL TRANSFORMER MANUFACTURE CO., LTD.) 06 January 2016 (2016-01-06) entire document	1-18
A	CN 208433296 U (WUXI XINCHANG ELECTRON FACTORY) 25 January 2019 (2019-01-25) entire document	1-18

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CN2024/104995

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)		Publication date (day/month/year)	
CN	116936243	A	24 October 2023	CN	220672371	U	26 March 2024
CN	220672369	U	26 March 2024	None			
WO	2023125633	A1	06 July 2023	EP	4394818	A1	03 July 2024
				KR	20240091014	A	21 June 2024
				AU	2022427639	A1	20 June 2024
				CA	3241493	A1	06 July 2023
				JP	2024506148	A	09 February 2024
				CN	114300235	A	08 April 2022
				CN	218525423	U	24 February 2023
CN	208521771	U	19 February 2019	None			
CN	206619476	U	07 November 2017	None			
CN	204946672	U	06 January 2016	None			
CN	208433296	U	25 January 2019	None			