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(54) **RADAR ANTENNA ANTI-FREEZING APPARATUS AND ANTI-FREEZING RADAR ANTENNA APPARATUS**

(57) The disclosure provides an anti-freezing radar antenna (140), which includes a rotatable antenna with a rotating shaft (105), a cylindrical holder (120) rotatably supporting the rotating shaft (105), an electrical motor (160) that rotates the rotating shaft (105) and an anti-freezing apparatus. The anti-freezing apparatus is a heating device attached to the radar antenna housing by a detachable mechanism (185), and includes a plurality of sheathed heating wires (110) configured to be disposed in a plurality of stages around the cylindrical holder (120) in a plane perpendicular to the central axis, and a current supply cable that supplies current to the heating wires (110) as shown in the reference Fig. 7.

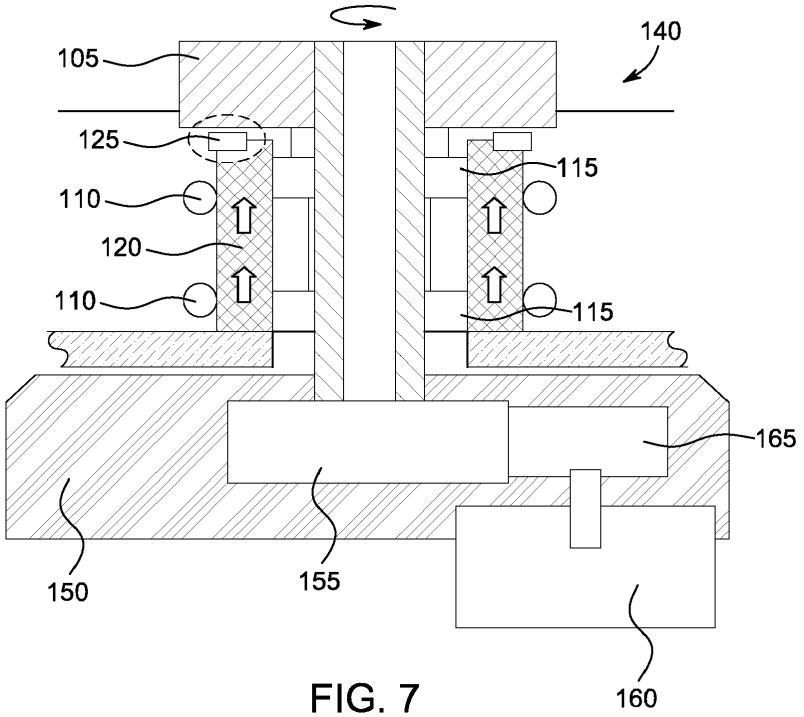

FIG. 7

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Description

TECHNICAL FIELD

[0001] The present invention relates to a radar antenna anti-freezing apparatus, and more particularly to a radar antenna anti-freezing apparatus that heats a boundary part between a rotating part and a supporting part of the radar antenna.

BACKGROUND OF THE INVENTION

[0002] Radar devices for mounting on vessels, such as ships are known in the art, which detect a surrounding target by rotating the antenna. In the Arctic and other regions where the sea surface is covered with ice, ice-class ships and icebreakers with high ice resistance are generally used. For efficient and safe navigation of these ships, it is important to choose a route with already broken ice. Ice radars, which can better see the cracks in ice are therefore used in such vessels and are required to operate properly even when the temperature is below zero.

[0003] Typically, in case of radars used in extreme cold, specifically ice radar, there is a risk of freezing at the boundary between the fixed side and the driving side of the antenna mount in the environment below the freezing point, thereby increasing the load torque for rotation. In case of higher degree of freezing, the driving torque generated by the motor cannot overcome the degree of freezing and the antenna cannot be rotated. To ensure efficient antenna performance in such environments, radars have sheath heaters arranged around the rotating parts of the antenna. When the ambient environmental temperature is detected to be near freezing temperature (0°C or lower) by a temperature sensor stored inside the body, a heater power source is turned on to prevent freezing of the antenna motor.

[0004] Japanese Patent Publication No. 5995365 discloses a radar antenna, and a radar antenna heating apparatus mounted on a radar antenna. The radar antenna comprises a radar antenna heating device, a rotating unit, and a support unit, wherein the rotating part rotates integrally with the antenna and the antenna and the support part supports the rotation part and is fixed. The radar antenna heating device comprises a plurality of heating parts and a movable mechanism. The heating device has a double arc shape in the horizontal direction and is laid out at the connecting portion between the antenna and the support portion of the radar antenna. The heating device disclosed in the prior art provides an easily replaceable device having high heat utilization efficiency.

[0005] However, in the conventional antenna device as disclosed in JP 5995365, the horizontal plane of the heater device causes the heat to spread in a lateral direction, which is efficient in heating the ice on the top surface of the support of the antenna, but not much efficient in concentrating the heat on the neck portion or the junction of rotating part and support part of the antenna where freezing generally occurs.

SUMMARY OF THE INVENTION

[0006] The present invention has been made in view of the above disclosed technical problem in the prior art, and an object of the present invention is a radar comprising an anti-freezing apparatus which enhances the utilization efficiency of heat by concentrating heat sources/ by arranging a sheathed heater between the rotating part and the fixed support of the radar.

[0007] One feature of the present invention is to provide a radar antenna anti-freezing apparatus (which is also referred to as heating device) attached to a radar antenna, which comprises a plurality of sheathed heating wires configured to be disposed in a plurality of stages around the cylindrical holder (which is also referred to as support shaft) of a radar antenna in a plane perpendicular to the central axis, connecting lines connecting the heating wires, a current supply cable that supplies current to the heating wires, and a detachable mechanism that fixes the heating device to the radar antenna.

[0008] Another feature of the present invention provides a radar antenna anti-freezing apparatus wherein the heating wires are arranged relative to each other, with respect to the plane containing the central axis of the support shaft.

[0009] Another feature of the present invention is to provide a radar antenna anti-freezing apparatus wherein the terminal position of the heating wires is lowered by bending the heater.

[0010] Yet another feature of the present invention is to provide a radar antenna anti-freezing apparatus wherein one half-arc heater is arranged on each side of the cylindrical holder. Such a heater configuration can be used to provide better and higher thermal efficiency.

[0011] Another feature of the present invention is to provide a radar antenna anti-freezing apparatus with one heater arrangement on each side of the cylindrical holder, wherein the tips of the heating wires are straight. Such a heater configuration has the advantage of easy attachment and detachment of the arrangements on both sides of the cylindrical holder.

[0012] Yet another feature of the present invention is to provide a radar antenna anti-freezing apparatus comprising one single heater arrangement with straight heating wire tips on both sides of the cylindrical holder. The arrangement will enable reduction of manufacturing cost, while allowing easy detachment of the anti-freezing apparatus.

[0013] Another feature of the present invention is to provide a radar antenna anti-freezing apparatus comprising one or more heating wires on each side of the cylindrical holder, arranged continuous wave assembly shape extending from lower region to upper. Such a heating wire arrangement with multiple waves has an added advantage of providing heat to maximum area of the cylindrical holder.

[0014] Another feature of the present invention is to provide the radar antenna anti-freezing apparatus wherein the plurality of heating wires has undulations or a wavy surface configuration. The arrangement will also enable heat dissipation to a higher region of the cylindrical holder. In another configuration, one or more of the plurality of the heating wire on each side can have undulations or wavy surface, while the remaining wires are straight without undulations. Further, in another configuration all the plurality of heating wire on each side can have undulations.

[0015] Another feature of the present invention is to provide a detachable mechanism for the radar antenna anti-freezing apparatus wherein the mechanism includes a clamp assembly with which the plurality of sheathed heating wires hold the cylindrical support.

[0016] Another feature of the present invention is to provide an anti-freezing radar antenna apparatus comprising a rotatable antenna with a rotating shaft, an electrical motor that rotates the rotating shaft, a housing configured to store the motor, a cylindrical holder integrated with the housing and configured to rotatably support the rotating shaft, a heating device including a plurality of sheathed heating wires configured to be disposed in a plurality of stages around the cylindrical holder in a plane perpendicular to the central axis, connecting lines connecting the heating wires, a current supply cable that supplies current to the heating wires, and a detachable mechanism that fixes the heating device to the housing.

[0017] Another feature of the present invention is to provide a method of heating a radar antenna apparatus wherein the radar antenna anti-freezing apparatus comprises plurality of heating wires arranged on the outer periphery of a cylindrical holder of the radar antenna, which supports the rotary shaft.

[0018] According to another aspect, of the present invention is to provide an attachment and detachment structure of the radar antenna anti-freezing apparatus wherein the power cable for supplying power to the heating apparatus is independently housed in a cover of the apparatus, that can be attached externally to the housing of the antenna. The arrangement will facilitate easy attachment and detachment of the anti-freezing apparatus without opening the antenna housing.

EFFECT(S) OF THE INVENTION

[0019] The radar antenna anti-freezing apparatus of the present invention is capable of easily adding and replacing a radar antenna heating device and having high heat utilization efficiency. The heating device of the present invention is more efficient to concentrate heat sources around the rotating part to prevent freezing of the rotating part of the radar. The device can be suitably installed on marine vessels, airplanes which travel in freezing temperatures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Referring now to the attached drawings which form a part of the invention disclosure:

FIG. 1 is a block diagram of a radar apparatus including the radar antenna and heating device as disclosed in prior art.

FIG. 2 shows the external perspective views of a radar antenna heating device as disclosed in prior art.

FIG. 3 and FIG. 4 are external perspective views showing the heater device arranged on the radar antenna in a separated (open) and closed position respectively as disclosed in the prior art.

FIG. 5 is an external perspective side view of the anti-freezing apparatus of the present invention attached to the radar antenna cylindrical support.

FIG. 6 is a front view of the heating wires attached around the cylindrical support where freezing generally occurs.

FIG. 7 is a conceptual diagram of the radar antenna showing placement of the sheathed heating wires of the present invention.

FIG. 8 is a perspective of the anti-freezing apparatus with heating wires in a half-arc shape in a vertical plane.

FIG. 9 shows a method of attachment of the heating wires of the anti-freezing apparatus to the cylindrical holder using clamp assembly.

FIG. 10 shows an open configuration of the anti-freezing apparatus with separated heating wires for detachable of the apparatus using the detachable mechanism from the cylindrical holder.

FIG. 11 shows a representation of a variation in the anti-freezing apparatus with bent heating wires.

FIG. 12 is a representation of variations in the anti-freezing apparatus with the heating wires shaped in a continuous wave assembly extending from lower region to upper.

FIG. 13 is a representation of a variation in the anti-freezing apparatus with one heater for each side of the holder having straight tips and single heater for both sides of a cylindrical heater with straight tips.

DETAILED DESCRIPTION

[0021] The present invention relates to a radar antenna anti-freezing apparatus. In particular, the present invention related to an anti-freezing apparatus comprising plurality of heating wires (110) attached to cylindrical support of the radar antenna (140) in a vertically stacked double-wire configuration, to prevent freezing at the junction of the fixed support and rotatable antenna.

[0022] Before the present invention is disclosed and described, it is to be understood that this invention is not limited to the particular embodiments illustrated in the present invention and various changes and modifications

can be made herein without departing from the scope of the invention as defined in the appended claims. Furthermore, the foregoing description of the invention and the embodiments of the present invention are provided for illustration only, and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

[0023] In understanding the scope of the present invention, the terms "comprising", "including", "having", "has", "comprises", "includes", "contains" and their derivatives, as used herein, are intended to be open ended terms and cover a non-exclusive inclusion that specify the presence of the stated features, elements, components, groups, integers, method, device and/or steps, but do not exclude the presence of other expressly listed features, elements, components, groups, integers, method, device and/or steps. Also, the terms "part," "section," "portion," "member" or "element" when used in the singular can have the dual meaning of disclosing a single element or more than one elements.

[0024] Moreover in the present disclosure, relational terms used such as first and second, upper and lower, and the like may be used solely to distinguish one element or action from another element or action and does not necessarily implies or requires any actual such relationship or order between such entities or actions.

[0025] In the present disclosure the term "anti-freezing" is also termed as "heating" and "freezing prevention".

[0026] Also, in the present disclosure, the terms 'outer' and 'external' may be used interchangeably throughout the document.

[0027] A radar antenna anti-freezing apparatus according to the disclosure of the present invention is described comprising a plurality of sheathed heating wires (110) arranged in a curved-end configuration around the cylindrical holder (120) of a radar antenna (140). The cylindrical holder is disposed around the rotating shaft (105) of the antenna, and rotatably supports the rotating shaft. The radar further comprises a housing configured to store an electrical motor which drives the rotation of the rotation shaft (105) via gears. Further, the anti-freezing apparatus is connected to the radar antenna using a detachable assembly which is attached to an external surface of the motor housing (150).

[0028] Hereinafter, the placement of the radar antenna anti-freezing apparatus is explained in detail. The sheathed heating wires of the anti-freezing apparatus are placed just under the rotating part of the antenna (140). More particularly, a space is formed between the lower end of the rotating part of the antenna (140) and the top surface of the antenna body, and the sheath heater is accommodated in the space. The junction of the cylindrical holder and the rotating part of antenna comprises a waterproof seal (125), which is most prone to freezing. The placement of sheathed heating wires (110) just under the waterproof seal (125) ensures intensive heating by the anti-freezing apparatus and therefore enhanced utilization of thermal energy by the apparatus.

[0029] The heating wires (110) of the anti-freezing apparatus are usually in a configuration wherein the wire is curved by 180° at the end and stacked on the first portion in a vertical direction. Thereby, as shown in FIG. 7, the heating wire (110) is configured to have three portions - a first sheathed wire portion, a second curved sheathed wire portion and a third sheathed wire portion, with the first portion and third portion wires lying in a vertical plane parallel to the surface of the cylindrical holder. Thus, the double-wire configuration of the heater allows current and heat to flow from the bottom to the top, and heat dissipation occurs in a vertical direction close to the junction of rotating part and fixed holder (120) (also referred to as the cylindrical holder).

[0030] The double-wire structure can be wound around the entire circumference or a portion of the circumference of the cylindrical holder (120). The plurality of heating wires of the anti-freezing apparatus is attached to the holder using clamps.

[0031] The power supply cables of the anti-freezing apparatus along with detachable mechanism is housed in a cover portion, independent of the radar antenna. The cover can be attached to the motor housing by means of any appropriate mechanism.

[0032] Further, an anti-freezing radar antenna apparatus is explained in detail, including a rotatable antenna with a rotating shaft (105), an electrical motor (160) that rotates the rotating shaft (105), a housing configured to store the motor (160), a cylindrical holder (120) integrated with the motor housing (150) and configured to rotatably support the rotating shaft (105), and a heating device (also referred to as an anti-freezing apparatus) attached to the motor housing (150) externally via a detachable mechanism (185) with a cover.

[0033] Hereinafter, referring to the appended drawings, preferred embodiments of the present invention will be explained.

[0034] FIG. 1 is a block diagram of a radar apparatus including a radar antenna and heating device as disclosed in the prior art. The radar apparatus includes a radar antenna, a transmission / reception unit and a display device. The radar antenna includes a rotating unit and a support unit. The rotating unit includes an antenna mounting plate and an antenna. A heating device is attached to the movable cover of the support unit, and heats the connecting portion present between the rotating unit and the support unit.

[0035] The antenna transmits and receives radio waves while rotating on the antenna mounting plate. The transmission and reception unit detects and amplifies the reflected wave received by the radar antenna, converts it to a digital signal by and outputs the detected signals to the display device. The display unit further includes a display control unit, a display device, and an operation unit. The display control unit includes the processing circuitry for generating image data based on the received signals. The generated radar images are displayed via the display device on the display screen.

[0036] FIG. 2 is an external perspective view of the radar antenna heating device as disclosed in the prior art. The radar antenna heating device includes a movable mechanism for separation of the two heating units. The movable mechanism includes a cover for housing the electrical circuits and a rotation member for rotating the heating units. The heating unit has a curved structure with a first portion, a second portion, and a third portion. The first portion and second portion are positioned lie in a horizontal plane with respect to each other, while the third portion connects the first and second portion. The two heating units are symmetrical to one another and lie in a single horizontal plane.

[0037] FIG. 3 is an external perspective views showing the heater device arranged on the radar antenna in a separated (open) configuration as disclosed in the prior art. The movable mechanism allows detachable of the heater device by rotating (or sliding) the heating unit(s), which allows the heating units to move away from each other. The movable mechanism and heating units are housed in a case.

[0038] FIG. 4 shows the heater device arranged on the radar antenna in a closed or attached configuration as disclosed in the prior art. The movable mechanism rotates back the heating units so as to arrange the heating units around the periphery of the connecting portion. The case housing the heating units and movable mechanism can be attached to the cover of the radar antenna using bolts. Each heating unit is in a half arc shape with curved ends and wherein the first and second portion of one heating unit (or heating wire) lies in the same horizontal plane as the first and second portion of the other heating unit (or heating wire).

[0039] FIG. 5 shows external perspective side view of radar antenna with the anti-freezing apparatus of the present invention attached to the cylindrical holder. The radar comprises a rotating radar antenna attached to a motor housing via rotating shaft. The motor housing encloses the motor that generates a driving force, when electric power is supplied thereto. The driving force by the motor is used to rotate the rotating shaft via one or more driving gears arranged in the motor housing. The rotating shaft further rotates the antenna device.

[0040] Further, the anti-freezing apparatus is attached to the radar, comprising heating wire(s) (110) wound around the outer circumference of the rotating shaft, and cover housing the connecting lines of the heater. The cover also houses the electric power supplying line to the heating wire(s) (110) and detachable mechanism. The cover can be attached to the external surface of the motor housing using any conventional mechanism such as bolts, screws, etc.

[0041] The independent assembly of the anti-freezing apparatus from the radar ensures easy facilitation of the attachment and detachment of the apparatus on any type of vessel, without any prior modifications in the radar for housing a heating device.

[0042] FIG. 6 is an enlarged view of the cylindrical shaft with heating wires (110) arranged on the outer circumference of a cylindrical holder which supports the rotary shaft (105) of the antenna. In the embodiment, two sheathed heating wires (110) are arranged in a vertical position with respect to each other around the outer circumference of the cylindrical holder, such that one heating wire (110) lies just above the motor housing, while the other is arranged just below the rotating antenna.

[0043] FIG. 7 is a side cross-sectional view of the radar antenna (140) with attached heating wires (110). During operation of the radar, the motor drives the rotation of the antenna via the rotating shaft (105). The rotating shaft (105) is enclosed inside the holder (120) with one or more bearings (115) present between the shaft and the holder (120). The rotating shaft and the holder are formed in a cylindrical shape. The driving force by the motor (160) is used to rotate the rotating shaft via one or more driving gears (155 and 165) arranged in the motor housing (150).

[0044] In the rotation shaft (105), a waveguide (shown by arrow) is formed to allow propagation of transmission signals therethrough and emission into the outer space. The transmission signals passed through the waveguide in the rotation shaft are emitted into the surrounding environment of the radar, and echo signals reflected back by the nearby objects are received.

[0045] A waterproof seal (125) is attached at the junction of the antenna (140) and the cylindrical holder. During rotation of the antenna in low-temperature environments, the waterproof seal gap can freeze (shown with dotted circle) which hinders the rotation of the radar antenna (140) and requires higher torque for movement. As shown in FIG. 7, the placement of plurality of sheathed heating wire(s) in a vertical plane around the circumference of the holder (120) and just below the waterproof seal allows intensive heating energy to be transmitted to the waterproof seal (125), and increases the efficiency of the anti-freezing apparatus.

[0046] Although, the embodiment discloses two heating wires (110) arranged in the same vertical plane, around the circumference of the cylindrical holder (120), plurality of heating wires can similarly be arranged around the cylindrical holder (120), in the same vertical plane and at the same distance from the outer surface of the cylindrical holder (120) in the perpendicular direction.

[0047] FIG. 8 shows an embodiment of the anti-freezing apparatus of the invention including half-arc shaped heating wires (110) in a double-wire configuration and attached via an attachment member (190). The anti-freezing apparatus comprises two heating wires (110) attached to the detachable mechanism. The heating wires (110) are configured to be formed in a semi-circular or semi-arc shape to allow conforming to the circumference of the cylindrical holder (120). The radius of the semi-arc formed by the wires is greater than the radius of the cylindrical holder (120). Each heating wire includes three portions - a first sheathed wire portion, a second curved sheathed wire portion and a third sheathed wire

portion, with the first and third wires lying in the same vertical plane parallel to the surface of the cylindrical holder (120). The second curved portion connects the first and second sheathed heating wire portions. Thus, the double-wire configuration of the heater allows current and heat to flow from the bottom to the top, and heat dissipation occurs in a vertical direction close to the junction of rotating part and fixed holder (120) (also referred to as the cylindrical holder).

[0048] The two heating wires (110) as shown in the FIG. 8 are symmetrical in shape and configuration to each other to allow winding around the entire circumference of the cylindrical holder. However, the two heating wires (110) can also have asymmetrical shape, size and configuration that may offer any benefit, advantage, or pronounce the efficiency of the anti-freezing apparatus.

[0049] FIG. 9 discloses an embodiment of the invention wherein the heating wires (110) are attached to the external cylindrical surface of the holder. Two half-arc heating wires (110) are disposed around the outer circumference of the holder. The arrangement (170) enables covering the entire circumference of the holder by the sheathed heating wires to ensure maximum thermal efficiency.

[0050] The close-up view of the two heating wires disposed around the holder is shown in FIG. 9. The end of each heating wire (110) not connected to the detachable mechanism and curved in a plane perpendicular to the central axis of the support, is coupled to the outer cylindrical surface of the support. The coupling can be achieved by any suitable connector assembly such as clamps. The coupling of the heating wires (110) to the surface of the support suppresses the movement of the anti-freezing apparatus during the rotational movement of the radar antenna, and allows continuous placement of the heating wires (110) around the support during the operation of the radar antenna.

[0051] Although, the configuration discloses the coupling of the heating wires to the support at the curved terminal portion of the heating wire (110), any suitable modifications are possible wherein the heating wires (110) can be coupled at any suitable location(s) such as but not limited to the middle protruding region of the half-arc heating wire. The clamp assembly (145) can also be placed on one or more suitable locations along the length of the heating wire(s).

[0052] With this configuration, the heating wires (110) can be easily coupled to any radar antenna or such vessels using attachment means such as clamps or any other attachment elements, thereby increasing the ease of replacement of the anti-freezing apparatus. Since no extra accommodations are required for the attachment and placement of the heating wires (110), the anti-freezing apparatus can be conveniently coupled to any vessel, which may or may not have been designed for adapting the anti-freezing apparatus.

[0053] Moreover, in the above-mentioned embodiments, the attachment of the heating wires is through a clamp assembly (145). However, any conventional mechanical coupling means such as bolts and/or screws, or any other may be implemented for connection.

[0054] Next, the opening mechanism of the anti-freezing apparatus will be explained in detail for coupling the heating wires around the radar antenna. FIG. 10 shows the anti-freezing apparatus of the invention in an open configuration for attachment or detachment of the apparatus from the radar antenna. As shown in FIG. 10, the anti-freezing apparatus includes two sheathed heating wires (110) and a detachable mechanism assembly (185) attached to the housing and a clamp assembly (145).

[0055] The detachable mechanism assembly (185) enables the plurality of heating wires to move away or separate from each other to allow detachment and attachment of the anti-freezing assembly around the cylindrical body of the holder. The detachable mechanism assembly (185) in FIG. 10 includes two attachment members, each connected to a heating wire at the terminal end which is not curved. The electric supply circuit for powering the detachable assembly (185) is housed in the cover, along with the current supply wires for the heater. The figure also shows the attachment of the detachable assembly to the housing (180).

[0056] During the process of attachment or detachment of the anti-freezing apparatus with respect to the radar antenna, the detachable assembly (185) is activated. The detachable assembly (185) controls the attachment members such that the members move in a plane parallel to the rotation axis of the antenna, as shown in FIG. 10. More specifically, the attachment members show a rotational movement with the side attached to the heating wires (110) moving rotatably in an arc and the opposite side is fixed to the cover 6. When one, or more preferably both the attachment member(s) show such a rotational movement, the heating wires are separated (or opened) with respect to each other to accommodate the diameter of the cylindrical support between the plurality of heating wires (110). More specifically, the rotational movement of attachment members and consequently the heating wires (110) allows the distance between the curved terminal portion between the two heating wires to be greater than the diameter of the support.

[0057] FIG. 10 shows an embodiment wherein the heating wires (110) are separated and the detachable mechanism assembly (185) is in an open configuration, while the anti-freezing apparatus is mounted on the radar antenna. The cover of the anti-freezing apparatus is mounted on the motor housing of the radar and attached via bolts at multiple positions. The cover has a substantially flattened configuration with a length that extends between the top of the motor housing where heating wires (110) are attached via the attachment member, to the bottom of the motor housing where a slot for supply of power cable is provided.

[0058] Moreover, in the above embodiments, the attachment member may also separate the heating wires (110) by a sliding movement as opposed to rotational

movement. One or both of the attachment members can slide in a direction opposite to each other in a plane parallel to the rotational axis of the antenna, such that the heating wires move to separate from each other.

[0059] However, the movement of the attachment members by rotationally separating the heating wires (110) is less as compared to the sliding movement, also requiring smaller area during the motion.

[0060] FIG. 11 shows an embodiment of the anti-freezing apparatus disclosed in the present invention wherein the terminal end(s) (210) of the one or more heating wires (110) is bent down to rest on the lower base of the holder or on top of the motor housing. Such an arrangement allows a more stable arrangement of the heating wires (110) and thereby the anti-freezing apparatus on the surface of the radar antenna during movement of the antenna via the rotation shaft (105).

[0061] FIG. 12 (V1) discloses an embodiment of the anti-freezing apparatus including two sheathed heating wires (110a) shaped in a continuous wave assembly extending from lower region to upper. More specifically, each heating wire has more than one curved portion such that the wire is arranged in multiple continuous waves in a vertical orientation, extending from the lower region of the support to the upper region. Such an arrangement of the heating wires provides higher heating capability with cost-efficiency in terms of reduced number of heating wires that have to be manufactured.

[0062] Alternatively, a plurality of half-arc heating wires can be arranged in a vertically stacked configuration on each side of the cylindrical support. The stacked configuration also facilitates high thermal efficiency proportional to the number of heating wires attached at the support.

[0063] Also, FIG. 12 (V2) shows another embodiment of the anti-freezing apparatus of the present invention wherein the plurality of heating wire (110b) has undulations or a wavy surface configuration and it is attached via an attachment member (190). To explain in more detail, each of the heating wire (110b) having a double-wire configuration has a plurality of undulations or a wave-like surface configuration, such that the undulations or the wave-like configuration extends in a vertical plane. Such a configuration provides increased surface area for heating of the support, which in turn increases the thermal efficiency of the radar antenna anti-heating apparatus.

[0064] Further, FIG. 12 (V3) exhibits a variation of the above embodiment wherein only a portion of the heating wire (110c) has undulations or a wavy surface configuration, as opposed to the whole heating wire (110c). More specifically, only the upper or lower portion of the heating wire on one or both sides of the double-wire configuration has undulations.

[0065] FIG. 13 shows another embodiment of the anti-freezing apparatus disclosed in the present invention wherein one or more of the plurality of heating wires (110) are configured to have a straight tip shape, instead of the half-arc structure and terminal ends (210). Such a configuration will enable the arrangement of the heating wires (110) partially along the circumference of the cylindrical support. However, the anti-freezing apparatus can be easily attached and detached by bringing the apparatus close to the support, without the requirement of a detachable mechanism assembly.

[0066] Each of the heating wire in such an embodiment has a half 'U-shape' with straight heating wire(s) (110) and a curved portion at the terminal end of the heating wire (110) close to the detachable assembly as shown in FIG. 13. However, other configurations such as completely straight heating wires (110) without curved portions at the terminal can also be framed.

[0067] Also, FIG. 13 shows a further modification in the aforementioned embodiment of the anti-freezing apparatus including only a single heater wire (110) that encloses around the circumference of the support. The heating wire (110) has a U-shaped configuration and is attached to the cover and detachable mechanism assembly at the curved position of the wire. Further, the heating wire (110) has a double stacked curved arrangement wherein the wire is curved at the end far from the cover and curved by 180° in a vertical direction to lie parallel to the bottom portion of the heating wire.

[0068] The U-shaped configuration of the heating wires (110) can be easily attached and removed near the cylindrical support without the requirement of a detachable assembly (185) or separation of the heating wires (110). Moreover, it will be possible with the arrangement to reduce manufacturing cost associated with the anti-freezing apparatus, as well as minimize the time and skills required during the attachment and detachment of the apparatus.

[0069] The radar device of the present invention is not limited for installation on marine vessels such as ships, but is also applicable to radar antenna devices installed on other moving bodies such as airplanes. The radar antenna device can also be installed on land. The present invention is applicable and can be used not only for semiconductor-type radar devices, but is also applicable for magnetron-type or any other type of radar apparatuses.

[0070] Although the present invention has been described in connection with the specific embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications can be made by those skilled in the art. Such changes and modifications of the present invention are to be intended as included within the scope of the present invention as defined by the appended claims. Also, a device or apparatus as disclosed in the present invention that is "configured" in a certain way is configured in at least that way, but may also be configured in other ways that are not disclosed.

[0071] Moreover in this document, relational terms such as first and second, top and bottom, and the like may be used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual relationship or order between such entities or actions. The terms "comprises," "comprising,"

"has," "having," "includes," "including," "contains," "containing" or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises, has, includes, contains a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. An element proceeded by "comprises ... a," "has . . . a," "includes ... a," "contains ... a" does not, without more constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises, has, includes, contains the element. The terms "a" and "an" are defined as one or more unless explicitly stated otherwise herein. The terms "substantially," "essentially," "approximately," "about" or any other version thereof, are defined as being close to as understood by one of ordinary skill in the art. The term "coupled" as used herein is defined as connected, although not necessarily directly and not necessarily mechanically. A device or structure that is "configured" in a certain way is configured in at least that way, but may also be configured in ways that are not listed.

Claims

1. A radar antenna anti-freezing apparatus attachable to a radar antenna (140) including, a rotatable antenna with a rotating shaft (105) and a cylindrical holder (120) rotatably supporting the rotating shaft (105), the radar antenna anti-freezing apparatus comprising:
   a heating device, including:

      a plurality of sheathed heating wires (110) configured to be disposed in a plurality of stages around the cylindrical holder in a plane perpendicular to the central axis,
      a plurality of connecting lines connecting the heating wires, and
      a current supply cable that supplies current to the heating wires; and
      a detachable mechanism (185) that fixes the heating device to the radar antenna.

2. The radar antenna anti-freezing apparatus according to claim 1, wherein the plurality of sheathed heating wires (110) are to be arranged relative to each other with respect to the plane containing the central axis of the shaft.

3. The radar antenna anti-freezing apparatus according to claim 1 or 2, wherein the plurality of sheathed heating wires (110) adopt a shape in which a terminal position of the heating wires is lowered by bending the heating device.

4. The radar antenna anti-freezing apparatus according to one of claims 1 to 3, wherein the heating device has a half-arc shape, a straight tip shape, or combinations thereof.

5. The radar antenna anti-freezing apparatus according to claim 4, wherein the straight tip shape comprises one or more heating devices.

6. The radar antenna anti-freezing apparatus according to one of claims 1 to 5, wherein the detachable mechanism (185) includes a clamp assembly (145) with which the plurality of sheathed heating wires (110) hold the cylindrical support (120).

7. The radar antenna anti-freezing apparatus according to one of claims 1 to 6, wherein the plurality of sheathed heating wires (110) comprise either a lower portion with undulating configuration or an upper portion with undulating configuration, or both the upper portion and the lower portion of the sheathed heating wires defines an undulating configuration.

8. An anti-freezing radar antenna apparatus, comprising:

   a rotatable antenna (140) with a rotating shaft (105);
   an electrical motor (160) that rotates the rotating shaft (105);
   a housing (150) configured to storage the motor (160);
   a cylindrical holder (120) configured to rotatably support the rotating shaft (105), and be integrated within the housing (150);
   a heating device including:

      a plurality of sheathed heating wires (110) configured to be disposed in a plurality of stages around the cylindrical holder in a plane perpendicular to the central axis,
      a plurality of connecting lines connecting the heating wires, and
      a current supply cable that supplies current to the heating wires; and
      a detachable mechanism (185) that fixes the heating device to the housing.

9. The radar antenna anti-freezing apparatus according to claim 8, wherein the plurality of sheathed heating wires (10) are to be arranged relative to each other with respect to the plane containing the central axis of the shaft.

10. The radar antenna anti-freezing apparatus according to claim 8 or 9, wherein the plurality of sheathed heating wires (110) adopt a shape in which a terminal position of the heating wires is lowered by bending the heating device.

11. The radar antenna anti-freezing apparatus according to one of claims 8 to 10, wherein the heating device has a half-arc shape, a straight tip shape or combinations thereof.

12. The radar antenna anti-freezing apparatus according to claim 11, wherein the straight tip shape comprises one or more heating device.

13. The radar antenna anti-freezing apparatus according to one of claims 8 to 12, wherein the detachable mechanism (185) includes a clamp assembly (145) with which the plurality of sheathed heating wires (110) hold the cylindrical support (120).

14. The radar antenna anti-freezing apparatus according to one of claims 8 to 13, wherein the plurality of sheathed heating wires (110) comprise either a lower portion with undulating configuration or an upper portion with undulating configuration, or both the upper portion and the lower portion of the sheathed heating wires defines an undulating configuration.

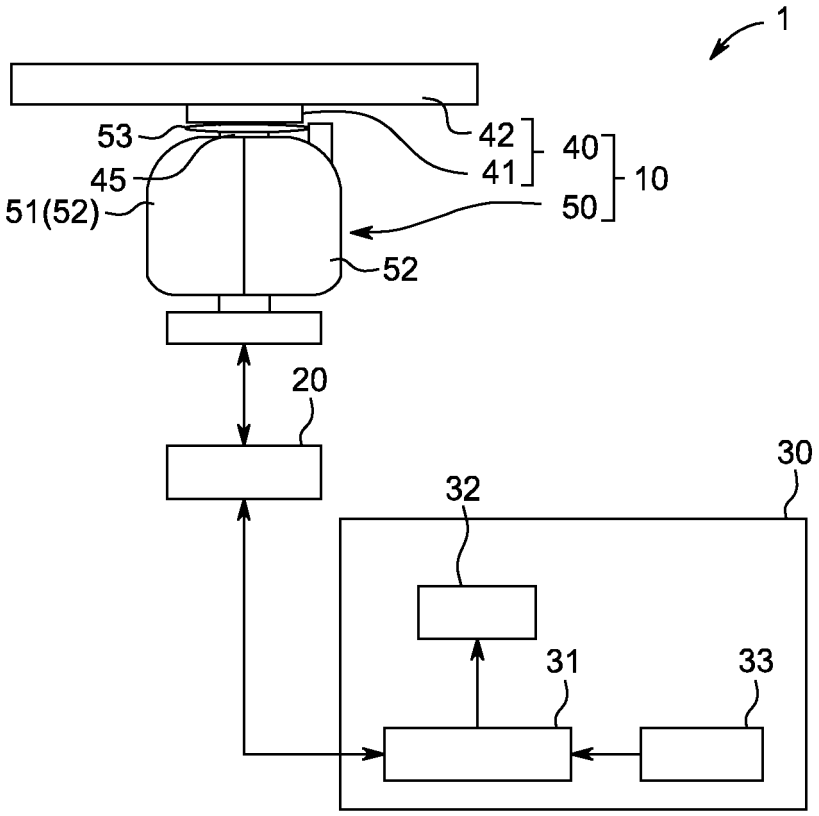

FIG. 1

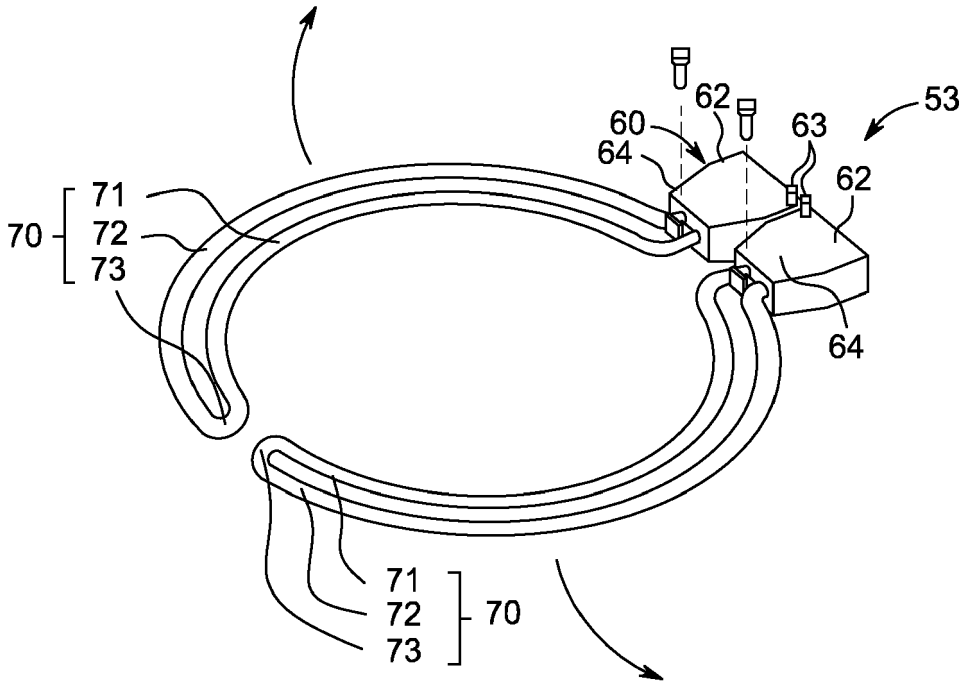

FIG. 2

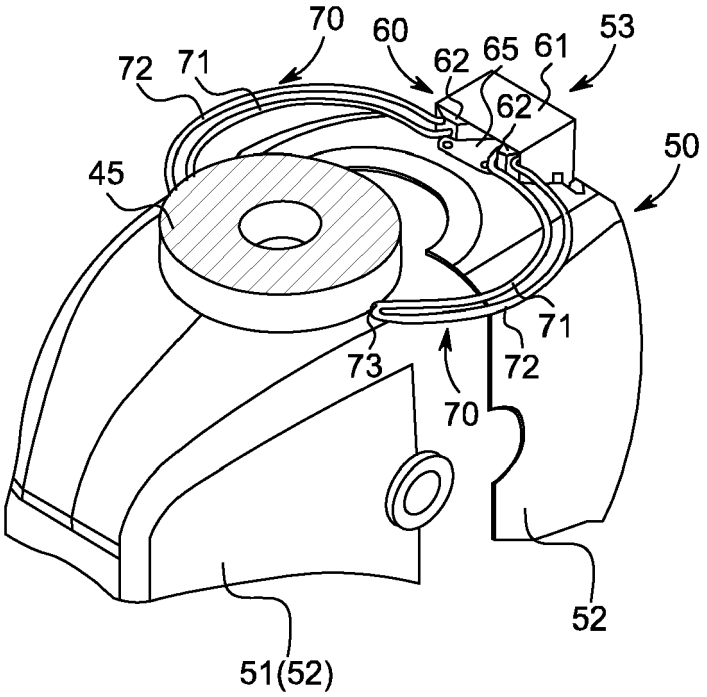

FIG. 3
PRIOR ART

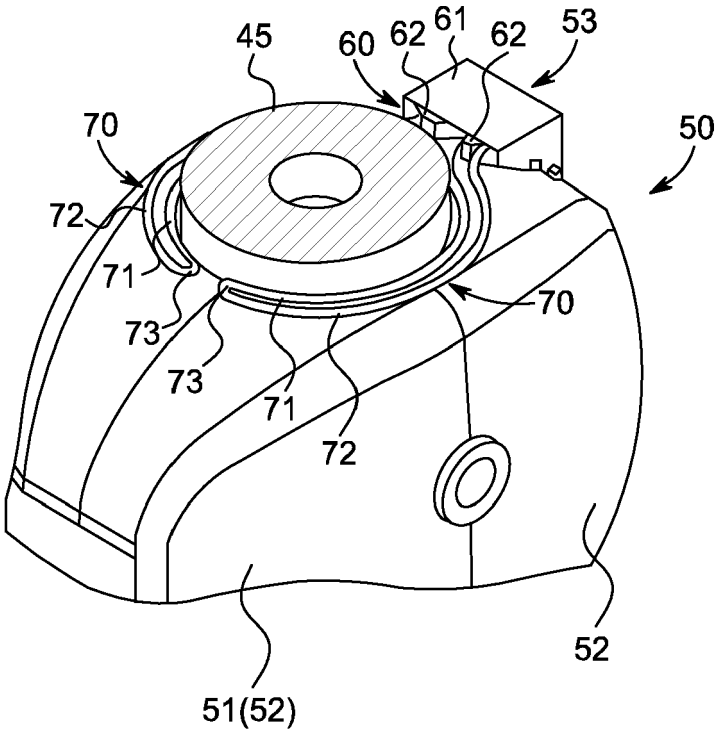

FIG. 4

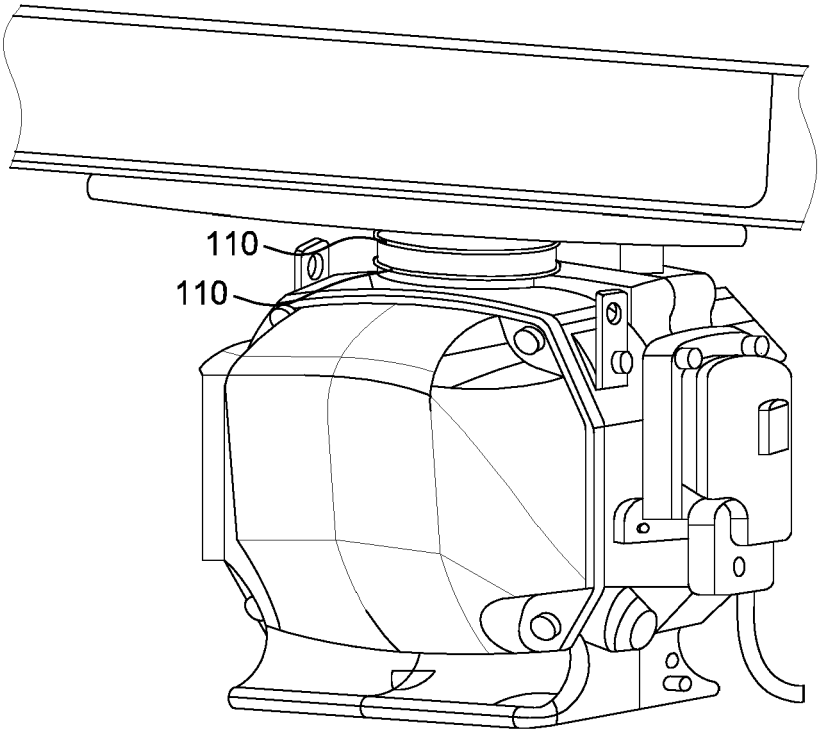

FIG. 5

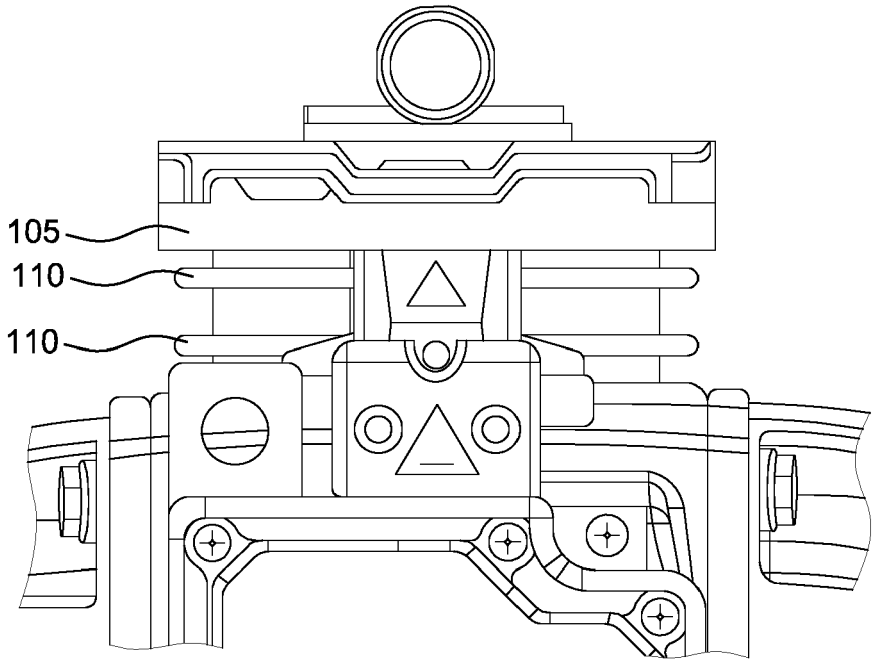

FIG. 6

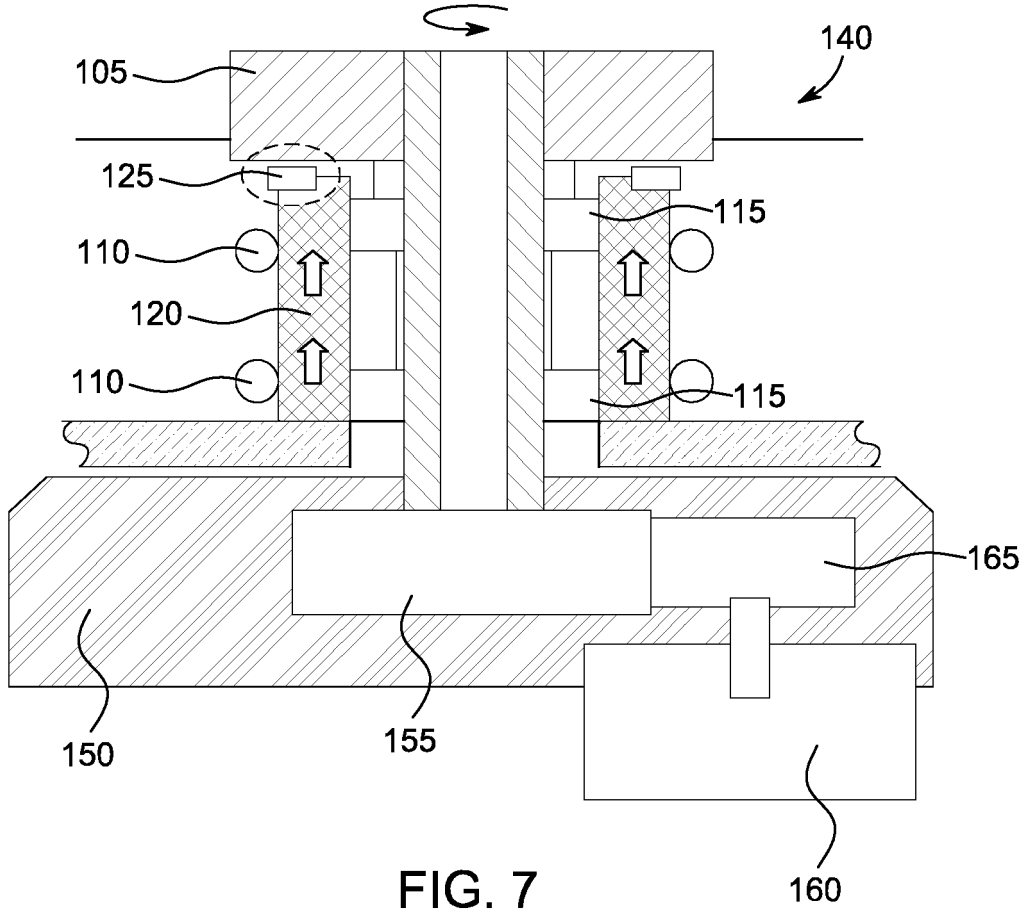

FIG. 7

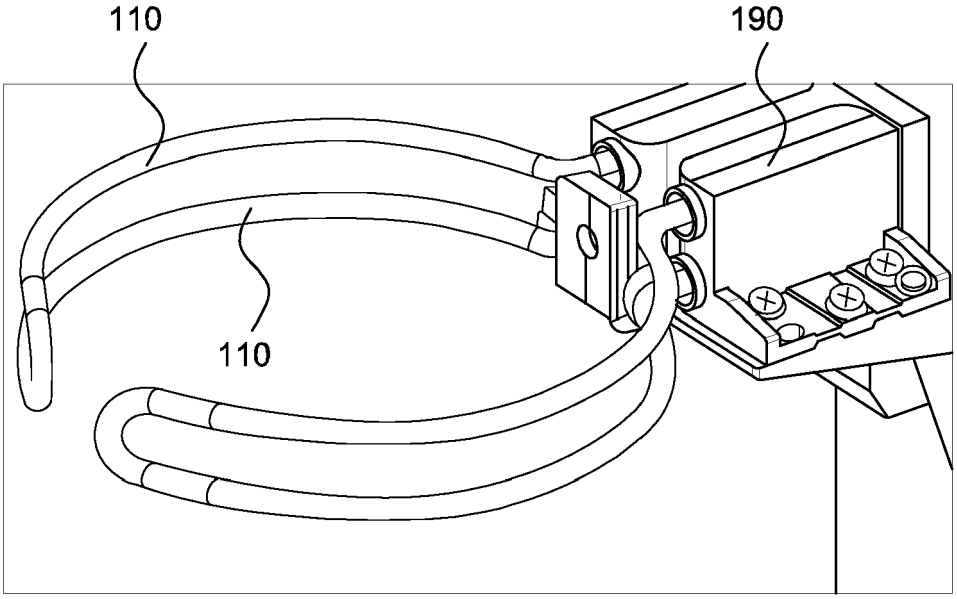

FIG. 8

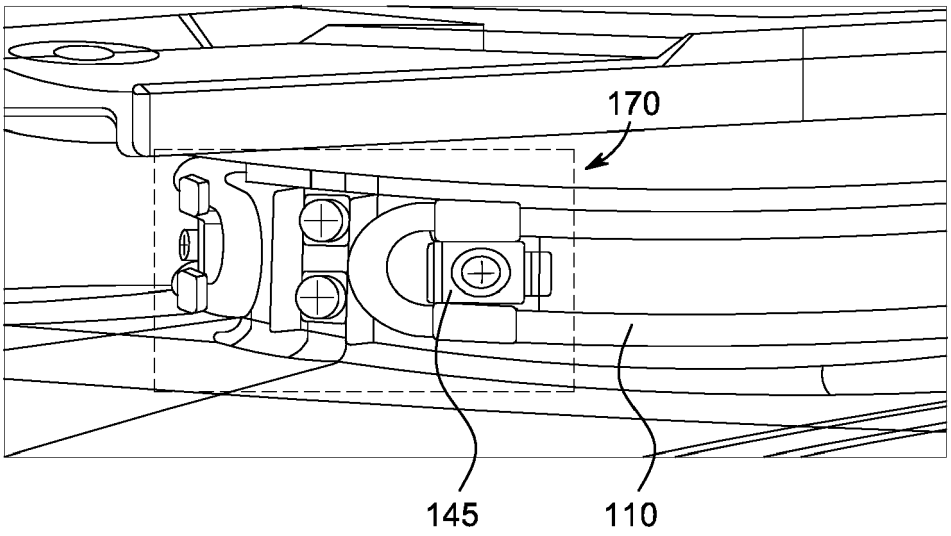

FIG. 9

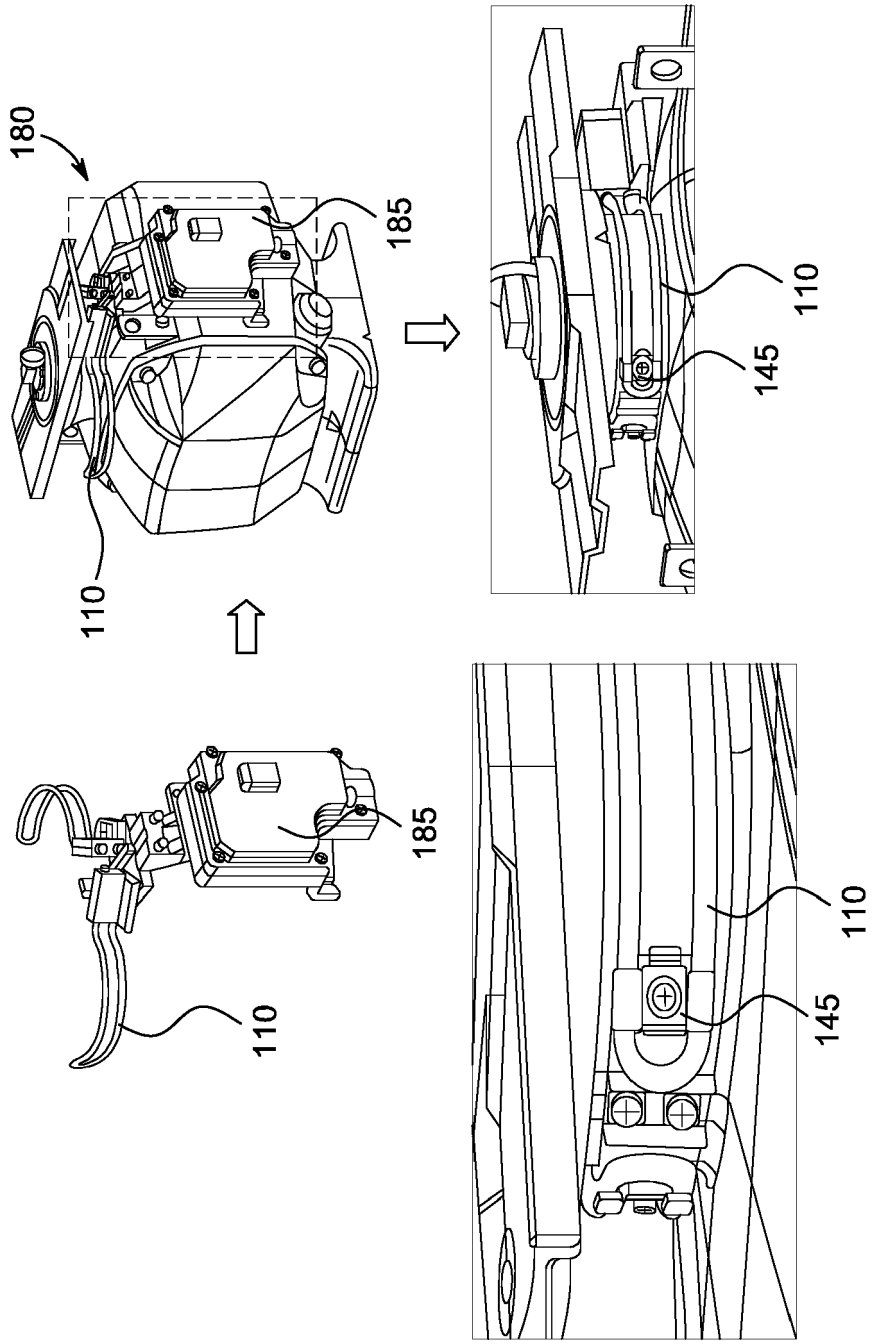

FIG. 10

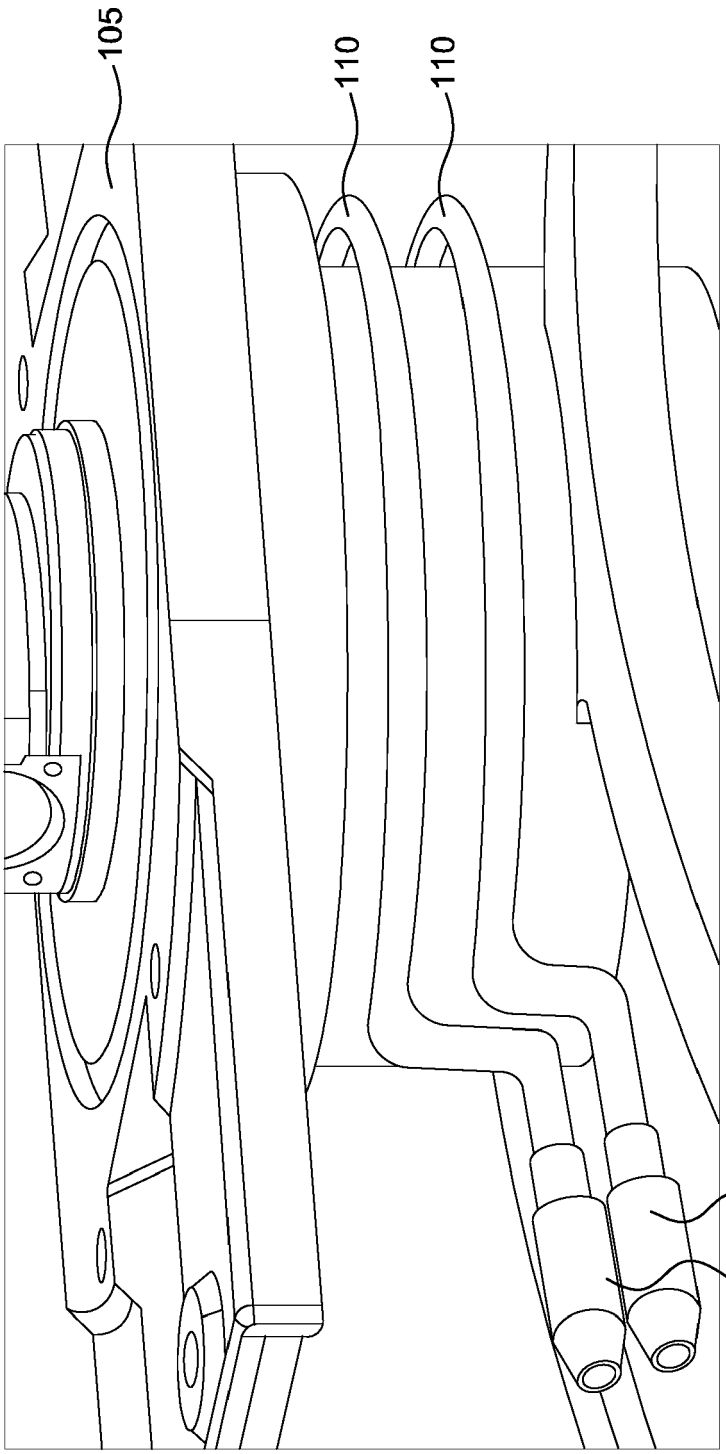

FIG. 11

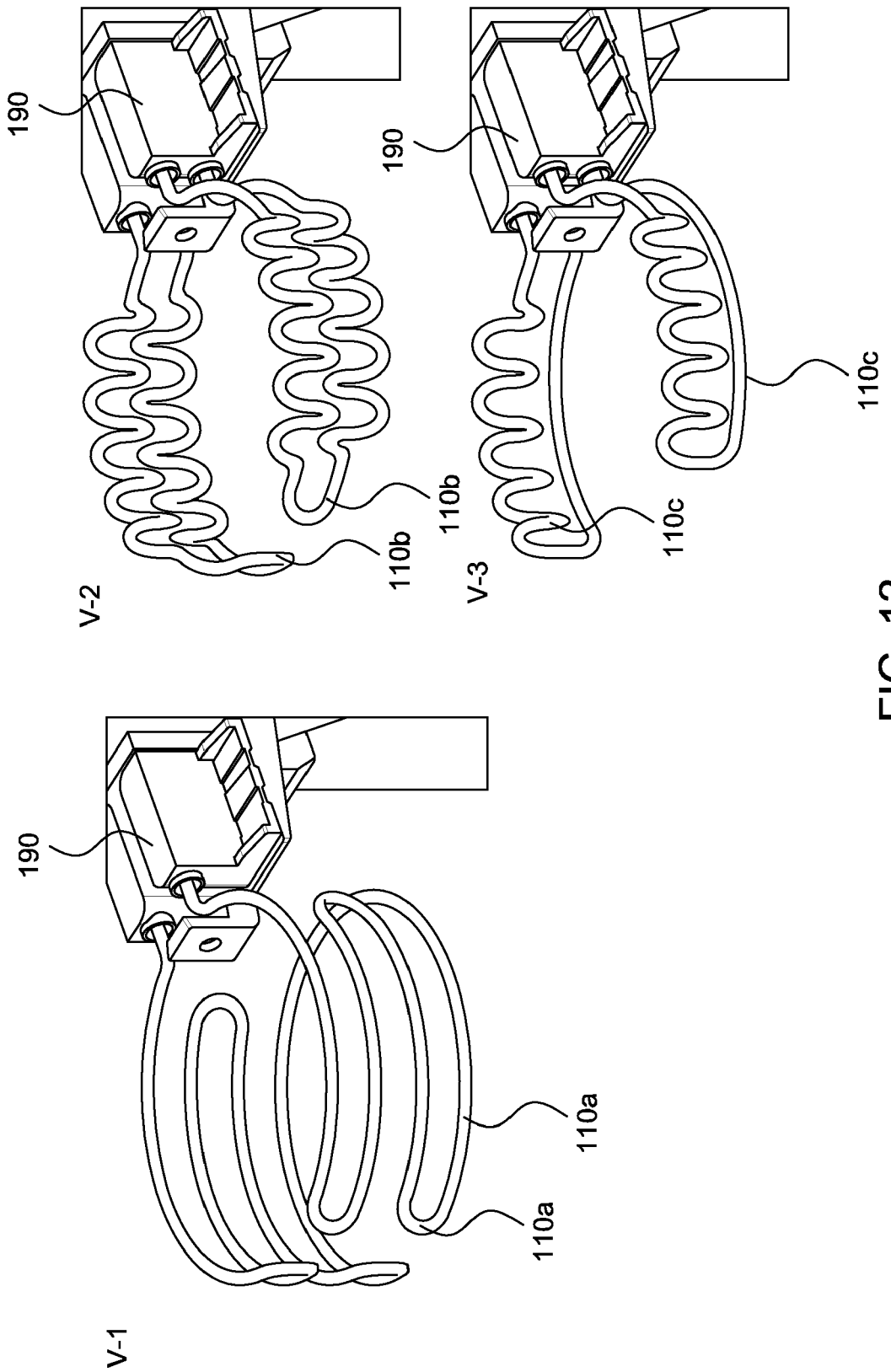

FIG. 12

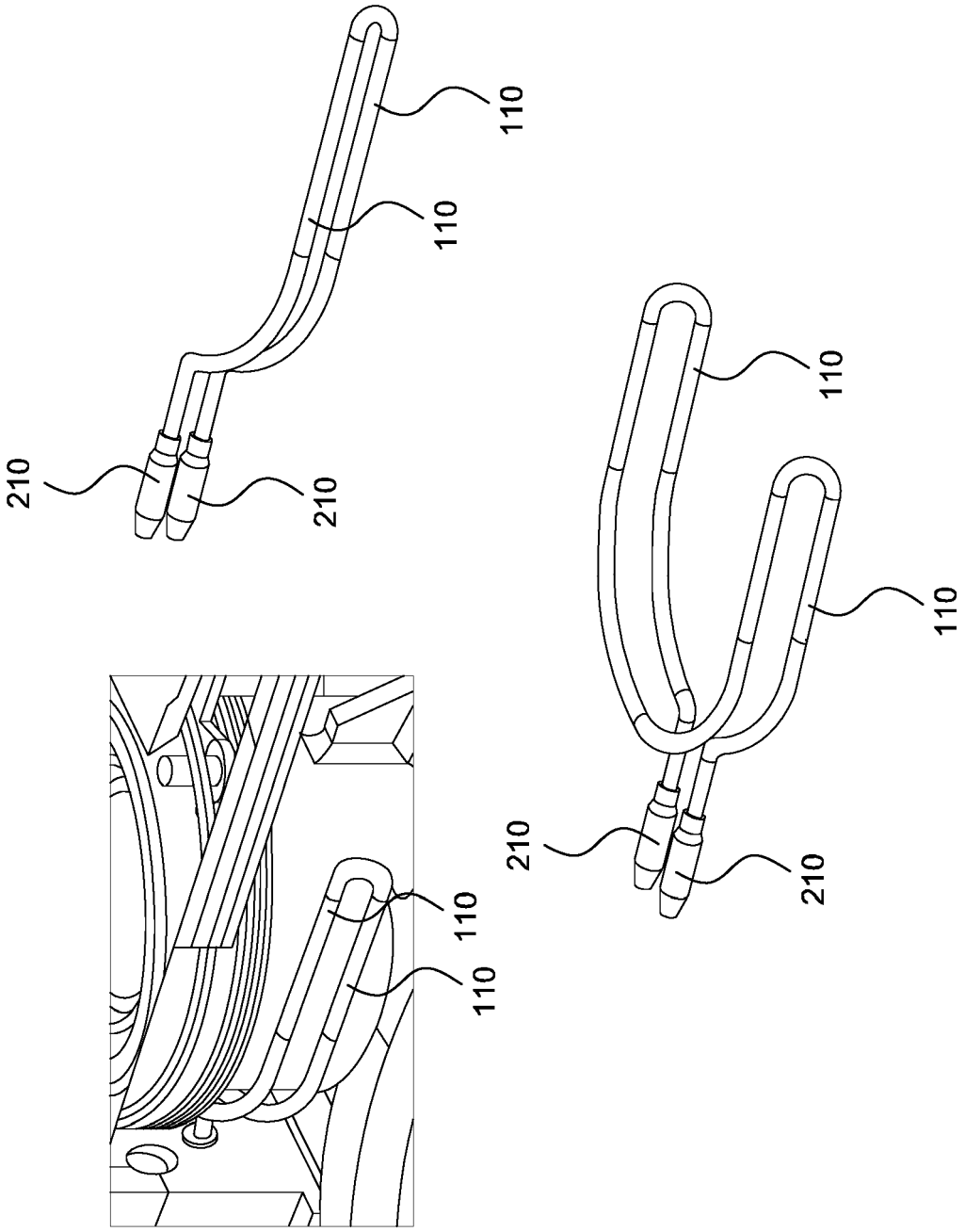

FIG. 13

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EUROPEAN SEARCH REPORT

Application Number
EP 22 15 4794

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D	JP 2014 116675 A (FURUNO ELECTRIC CO) 26 June 2014 (2014-06-26) * paragraphs [0001], [0002], [0008]; figures 1-4 * * paragraph [0012] - paragraph [0015] * * paragraph [0018] * * paragraph [0020] - paragraph [0024] * * paragraph [0028] * * paragraph [0030] - paragraph [0035] * * paragraph [0042] - paragraph [0045] * * paragraphs [0047], [0048], [0049], [0051] * * paragraphs [0054], [0057], [0058] *	1-6,8-13	INV. H01Q1/02 ADD. H01Q1/34 H01Q1/28
X	CN 208 284 610 U (FURUNO ELECTRIC CO) 25 December 2018 (2018-12-25) * figures 1-5 * * paragraphs [0002], [0004], [0006] * * paragraphs [0011], [0046] * * paragraph [0050] - paragraph [0055] * * paragraph [0060] - paragraph [0064] *	1,2,7-9, 14	
A	CN 214 849 015 U (NANJING CHIYUN TECH DEVELOPMENT CO LTD) 23 November 2021 (2021-11-23) * figures 1-4 * * paragraphs [0002], [0006], [0007] * * paragraphs [0011], [0018], [0019] * * paragraphs [0025], [0032] *	1-14	TECHNICAL FIELDS SEARCHED (IPC) H01Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	26 July 2022	Wattiaux, Véronique

CATEGORY OF CITED DOCUMENTS

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26-07-2022

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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- JP 5995365 B **[0004] [0005]**