

Structure for antennae

FIELD OF THE INVENTION

The present invention relates to the field of antennae, and structures for incorporating antennae.

BACKGROUND PRIOR ART

Radar systems are expensive and complex, and comprise many sensitive electronic components. Furthermore, with a view to limiting interference from intervening structures, Radar Systems are generally fairly exposed, with minimal protection from the elements. A common structure providing some protection for radar transducer elements and associated mechanical and electrical systems known in the art is a Radome. A radome (a portmanteau of radar and dome) is a structural, weatherproof enclosure that protects a radar antenna. The radome is typically constructed of material transparent to radio waves. Radomes protect the antenna from weather and may conceal antenna electronic equipment from view. They may also protect nearby personnel from being accidentally struck by quickly rotating antennas.

Radomes can be constructed in several shapes – spherical, geodesic, planar, etc. – depending on the particular application, using various construction materials such as fiberglass, polytetrafluoroethylene (PTFE)-coated fabric, and others.

The need for the structure to be transparent to radio waves is to some extent in contradiction with some possible objectives of a Radome. In particular, Radar systems can be seriously damaged by a lightning strike, and it is known in the art to provide such systems with lightning rods substantially as known in other domains, however it is not straight forward to provide protection from such lightning strikes by means of the Radome structure without undermining the primary requirement that the structure be transparent to radio waves, bearing in mind that a perfect Radome is a dielectric with a high voltage breakdown, such that the Rolling Sphere Model has to

be changed considerably, i.e. dynamic diameter, meaning that, no lightning stroke will penetrate the radome. As a result, any lightning plasma will flow over the radome until it finds an attachment point at the bottom of the radome. The unpredictable path over the radome surface may lead to correspondingly unpredictable and therefore uncontrollable damage to the radar system. This may occur if there is a weak spot in the radome (e.g. due to ageing, due to moisture or due to production differences), in which case the lightning could penetrate the radome at that weak spot, which will damage the radome

One possible solution to this problem is the provision of a conductive element on an outer surface of the Radome, providing a current path to ground. Such structures can nevertheless interfere with the radar image, and furthermore can cause damage to the Radome structure when superheated by a lightning strike. A further problem with this approach is that it is common to provide a rope fixed at the zenith of a Radome hanging down the side thereof that can be used from the ground to manually dislodge snow or other debris that may settle on the upper surfaces of the dome. Such provisions are incompatible with the presence of external current paths, since external metal structures provided to enable a current path may hinder the movement of the rope to dislodge the snow. Any penetration to the inside of the radome brings the full lightning stroke inside, with the loss of any protection from the dielectric.

It is accordingly desired to develop new radar structures better addressing the foregoing considerations.

SUMMARY OF THE INVENTION

In accordance with the invention in a first aspect there is provided a housing for a radar antenna comprising a weatherproof enclosure formed substantially of materials that are transparent to radio frequency electromagnetic radiation, such that the enclosure as whole presents minimal interference to a radar antenna situated therein, a platform situated within the weatherproof enclosure and mounted for rotational motion therein, a conductive projection situated on the upper half of the

enclosure having a distal extremity outside and oriented away from the enclosure, and a proximal part passing through to the interior of the enclosure, and

a conductive member situated within the enclosure and in fixed relation to the platform, the conductive member being electrically coupled to ground, wherein the proximal part of the conductive projection and the conductive member are disposed such that regardless of the orientation of the platform, the proximal part of the conductive projection and the conductive member belong to a viable current path for a high voltage discharge.

In a development of the first aspect, the spark gap is maintained between the proximal part of the conductive projection and the conductive member.

In a development of the first aspect, the proximal part of the conductive projection and the conductive member are mechanically connected by a rotary joint.

In a development of the first aspect, the housing further comprises a radar antenna mounted on the platform, wherein the conductive member is mounted on the radar antenna.

In a development of the first aspect, a spark gap is maintained between the proximal part of the conductive projection and the conductive member, the distance of the spark gap between the proximal part of the conductive projection and the conductive member is less than the shortest distance between the radar antenna and the enclosure.

In a development of the first aspect, the radar antenna comprises a support structure which is at least partially conductive, the structure being coupled to ground whereby the viable current path passes through the structure.

In a development of the first aspect the viable current path passes through one or more cables, wires or conductive bars.

In a development of the first aspect, the conductive member comprises a structure that is arranged such that a part of the structure is in proximity to the proximal part of the conductive projection regardless of the orientation of the platform with respect to the enclosure about the axis.

In a development of the first aspect, the proximal part of the conductive projection is positioned coaxially with respect to the axis of rotation of the platform.

In a development of the first aspect, the proximal part comprises a structure that is arranged such that a part of the structure is in proximity to the conductive member regardless of the orientation of the platform with respect to the enclosure about the axis.

In a development of the first aspect, the proximal part of the conductive projection and the conductive member are substantially rod shaped, with the respective major axes disposed coaxially with an axis of rotation of the platform.

In a development of the first aspect, the conductive member is electrically coupled to ground via the platform.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood and its various features and advantages will emerge from the following description of a number of exemplary embodiments provided for illustration purposes only and its appended figures in which:

Figure 1 shows a housing for a radar antenna in accordance with a first embodiment;

Figure 2 shows a housing for a radar antenna in accordance with a second embodiment;

Figure 3 shows a housing for a radar antenna in accordance with a third embodiment;

Figure 4 shows a housing for a radar antenna in accordance with a fourth embodiment;

Figure 5 shows a housing for a radar antenna in accordance with a fifth embodiment; and

Figure 6 shows a housing for a radar antenna in accordance with a sixth embodiment.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 shows a housing for a radar antenna in accordance with a first embodiment.

As shown, there is provided a housing 100 for a radar antenna 101. The housing comprises a weatherproof enclosure 130 that is formed substantially of materials that are transparent to radio frequency electromagnetic radiation, such as fiberglass, polytetrafluoroethylene (PTFE)-coated fabric, ABS, Thermoplastics, polycarbonate, polyaryletherketones, fluoropolymers, polyimide and the like, such that the enclosure as whole presents minimal interference to the radar antenna situated therein.

There is further provided a platform 120 situated within the weatherproof enclosure and mounted for rotational motion therein. It may be noted that the platform is preferably mounted for continuous movement, typically under the impulsion of an automatically controlled electric motor or the like, with respect to the enclosure during the operation of the system, and not merely an initial manual orientation at installation. Such mounting may typically require the provision of low friction bearings or the like, with a view to providing a smooth, vibration free, silent operation which may be relied on not to produce heat, dust, debris, static electricity etc. which may otherwise interfere with the operation of the sensitive equipment mounted on the platform. On this basis, the system may optionally additionally comprise an electric, hydraulic or pneumatic motor or another drive type as may occur to the skilled person to assure controlled rotation in the horizontal plane.

There is further provided a conductive projection 110 situated on the upper half of the enclosure 130 having a distal extremity 111 outside and oriented away from the enclosure, and a proximal part 112 passing through to the interior of the enclosure 130. The conductive projection 110 is preferably configured as a lightning rod, and preferably formed of a rigid conductive material, for example a metal, and of sufficient dimensions as to support the very high currents implied by a lightning strike, having ideally a low resistance and low self-induction. Aluminium or Copper and their alloys are commonly used in such applications, for example in a rod or bar configuration.

The conductive projection may protrude from the outer surface of the radome at any desired angle, and from any part of the upper half of the enclosure, that is to say, the part of the outer surface of the enclosure situated above the halfway point in the enclosure's overall height. The distal extremity 111 may be rounded, spherical, pointed, provided with multiple sharp projections or take any form as may be found to be effective in attracting lightning in preference to other parts of the system. The conductive projection is preferably in fixed, or non rotatable relation to the weatherproof enclosure, and thus in a rotatable relationship with respect to the platform.

There is further provided a conductive member 140 situated within the enclosure 130 and in fixed relation to the platform 120, and electrically coupled to ground. The conductive member 140 is preferably formed of a rigid conductive material, for example a metal, and of sufficient dimensions as to support the very high currents implied by a lightning strike, having ideally a low resistance and low self-induction. Aluminium or Copper and their alloys are commonly used in such applications for example, in a rod or bar configuration.

The proximal part 112 of the conductive projection and the conductive member 140 are disposed such that regardless of the orientation of the platform, the proximal part of the conductive projection and the conductive member belong to a viable current path for a high voltage discharge.

In certain embodiments, and as shown, this viable current path may be achieved by maintaining a spark gap between the proximal part 112 of the conductive projection 110 and the conductive member 140. By providing a spark gap, which may constitute an open circuit as regards the signals processed by the radar system, any risk of interference in the radar signals from the conductive projection is averted, however in the case of a lightning strike, the very high voltages involved will enable the lightning to easily jump this gap and reach ground, through a path whose overall resistance is still much lower than the available alternatives. This approach has the additional advantage that the two elements may move relative to each other, for example due to rotation of the radar system within the radome, without any risk of friction or transfer of forces between the two elements, even in case of an imperfect alignment.

Alternatively, the proximal part of the conductive projection and the conductive member may be mechanically connected by a rotary joint, such that a permanent electrical connection is maintained between the two elements, regardless of any relative movement of the elements. This may be achieved using conventional mechanical bearings and the like, which may be formed of conventional engineering materials such as steel, titanium, brass etc., which may all be sufficiently conductive to maintain the desired electrical coupling with minimal resistance, or from materials which may have inferior mechanical properties, but superior electrical properties such as copper, aluminium or their alloys, etc. the electrical and mechanical properties of such bearings may be further improved by using a conductive lubricant such as a carbon, silver or copper loaded grease, and the like.

As shown, the radar antenna 101 may also be mounted on the platform 120, and the conductive member 140 mounted on the radar antenna. In such a configuration, where a spark gap is maintained between the proximal part of the conductive projection and the conductive member, the overall dimension of the system may preferably be determined such that the distance of the spark gap between the proximal part of the conductive projection 110 and the conductive member 140 is less than the shortest distance between the radar antenna and the enclosure. Still more preferably, the distance of the spark gap may be less than half the shortest distance between radar and enclosure. Bearing in mind that a substantial part of the structure of the radar antenna may be of metallic or other conductive materials, there is a risk that an alternative conductive path may arise through the antenna structure if it approaches the enclosure too closely. Similarly, the conductive member may be electrically coupled to ground via the platform.

Indeed, the radar antenna may comprise a support structure which is at least partially conductive. Where this is the case, the structure may be coupled to ground and to the conductive member 140, such that the viable current path passes through the structure. In such cases, the system may take advantage of existing massive metal structures which themselves may be suitable for providing a conductive path to ground. Such structures may be optimised with a view to both their conventional load bearing purpose, and also their conductive role in view of the present invention, for example in terms of the choice of materials and their physical configuration, for example providing a strut or other substantially vertical support member which is also

adapted to provide a low resistance path to ground, and to which the conductive member 140 may conveniently be coupled.

It will be appreciated that any viable current path as discussed herein may be achieved in part by passing through one or more cables, wires or conductive bars in addition to any of the elements mentioned herein.

The proximal part of the conductive projection may be, as shown, disposed coaxially with the axis of rotation of the platform. The proximal part of the conductive projection and the conductive member may be substantially rod shaped, with the respective major axes disposed coaxially with an axis of rotation of the platform.

In certain embodiments, and as shown, the conductive member 140 may be disposed coaxially with an axis of rotation of the platform. This means that the distal end 141 of the conductive member may remain stationary in space. In embodiments where a spark gap is maintained between the proximal part 112 of the conductive projection and the distal end 141 of the conductive member, maintaining the extremity of the conductive member at a fixed position in space regardless of movement of the platform will facilitate coupling with the conductive projection. In embodiments where a mechanical coupling is maintained between the proximal part of the conductive projection and the distal end 141 of the conductive member, maintaining the extremity 141 of the conductive member at a fixed position in space regardless of movement of the platform will simplify the bearing, as the number of mechanical degrees of freedom are constrained.

Figure 2 shows a housing for a radar antenna in accordance with a second embodiment.

Certain elements of the second embodiment are substantially unchanged with respect to the first embodiment, and will not be described again. Like elements retain like numbering.

In particular, in accordance with the second embodiment, the conductive member 240 of housing 200 comprises an annular structure 244 disposed coaxially with an axis of rotation of the platform such that a part of the annular structure is in proximity to the proximal part 212 of the conductive projection 210 regardless of the orientation of the platform with respect to the enclosure about the axis, e.g. so as to define a spark gap. This being the case, the proximal part of the conductive projection 210

may be offset with respect to the axis of rotation of the platform 120, which may be convenient in certain scenarios, for example where the radar antenna does not rotate through a full 360 degrees, in which case it may be preferred to situate the proximal part 212 of conductive projection 210 in a region set back from the primary orientation of the antenna. As such, the proximal part of the conductive projection may be positioned eccentrically with respect to the axis of rotation of the platform.

Advantageously, a plurality of conductive members may be provided, which may engage or approach the annular structure 244 at different points of its circumference, as represented by way of example by optional elements 240a and 240b of figure 2, as well as or instead of element 240, so as for example to provide multiple viable paths to ground, and to ensure a good coupling between the conductive projection and conductive members for every orientation of the platform.

In other embodiments, the annular structure may be replaced with a disc structure.

Figure 3 shows a housing for a radar antenna in accordance with a third embodiment.

Certain elements of the third embodiment are substantially unchanged with respect to the first embodiment, and will not be described again. Like elements retain like numbering.

In particular, in accordance with the third embodiment the proximal part of the conductive projection 310 of housing 300 comprises an annular structure 331 disposed coaxially with an axis of rotation of the platform 120 such that a point of the annular structure is in proximity to the conductive member 340, e.g. so as to define a spark gap, regardless of the orientation of the platform with respect to the enclosure about the axis.

Accordingly, the conductive member 340 may be positioned eccentrically with respect to the axis of rotation of the platform. In particular, as shown the conductive member 340 is shown as being aligned with the rear of the antenna structure 101.

In other embodiments, the annular structure may be replaced with a disc structure.

Figure 4 shows a housing 400 for a radar antenna in accordance with a fourth embodiment.

Certain elements of the fourth embodiment are substantially unchanged with respect to the first embodiment, and will not be described again. Like elements retain like numbering.

In particular, in accordance with the fourth embodiment the distal extremity 441a, 441b of the conductive member 440a, 440b of housing 400 comprises an annular structure 444 disposed coaxially with an axis of rotation of the platform 120, and with the conductive projection 410, such that the proximal part 412 of the conductive projection 410 passes through the annular structure 444, and a point of the annular structure is in proximity to the conductive projection 410, e.g. so as to define a spark gap regardless of the orientation of the platform with respect to the enclosure about the axis. As such, the spark gap may be considered to be defined radially, rather than vertically as presented in preceding embodiments.

Although as shown the conductive member comprises two elements 440a, 440b, it will be appreciated that a single element may be provided in line with the drawings of figures 1 or 2, or more than two, as may be deemed appropriate.

Because the conductive projection extends to within the annular structure, there may always a short distance between the annular structure 444 and conductive projection. A problem with the two bar like conductive projections /member configuration as described with reference to figure 1 for example is that there could be a slight misalignment between the elements which may make the spark gap larger. If there is a slight misalignment between conductive projection or member and an annular structure as shown, the conductive projection or member will just be closer to one part of the annular structure.

It will be appreciated that the features described above are susceptible of many alternative combinations. For example, a system may comprise the annular structures of both figures 2 and/or 4 and 3 in combination. A system may combine the annular structures of figures 2 and/or 4 and/or 3 with mechanical and direct electrical connection in place of the spark gap as shown.

Figure 5 shows a housing for a radar antenna in accordance with a fifth embodiment.

Certain elements of the fourth embodiment are substantially unchanged with respect to the first embodiment, and will not be described again. Like elements retain like numbering.

In particular, in accordance with the fifth embodiment the distal extremity of the conductive member 540 of housing 500 comprises a disc structure 544 disposed coaxially with an axis of rotation of the platform 120, and with the proximal part 512 of the conductive projection 510, such that the proximal part 512 of the conductive projection 510 approaches the upper surface or edge of the disc structure 544, and a point of the disc structure is in proximity to the conductive projection 510, e.g. so as to define a spark gap, regardless of the orientation of the platform with respect to the enclosure about the axis.

It may be noted that in use the radome may move to some extent in a horizontal direction due to wind for example. Certain variants presented above, for example based on the disk-shaped structure of figure 5 take this into account because the conductive projection extends above the disk shaped structure and even if the radome moves in a horizontal direction by the wind and thereby also the conductive projection moves in the horizontal direction, the conductive projection will remain in close proximity, e.g. so as to define a spark gap, to the disk shaped structure. This also allows the conductive projection to not being coaxially arranged with respect to rotation axis.

Figure 6 shows a housing for a radar antenna in accordance with a sixth embodiment.

Certain elements of the fourth embodiment are substantially unchanged with respect to the first embodiment, and will not be described again. Like elements retain like numbering.

In particular, in accordance with the sixth embodiment the distal extremity of the conductive member 640 of housing 600 comprises a bar or rod 641, which is at least not vertical, and which is preferably within 45 degrees of horizontal, and more preferably within 30 degrees of horizontal, and still more preferably substantially horizontal disposed so as to approach an axis of rotation of the platform 120, and the conductive projection 610, such that the proximal part 612 of the conductive projection 610 approaches the structure 641, and a point of the structure is in proximity to the conductive projection 610, e.g. so as to define a spark gap, regardless of the orientation of the platform with respect to the enclosure about the axis. As shown, the conductive projection 610 extends below the horizontal plane in which the rod structure 641 is situated, which is slightly offset with respect to the

axis of rotation of the platform 120, so that as the platform rotates, the rod structure rotates about the conductive projection 610. Alternatively, the conductive projection 610 may terminate just above the horizontal plane in which the rod structure 641 is situated, in which case this need not be offset with respect to the axis of rotation of the platform 120.

It may be noted that in use the radome may collapse to some extent for example when it is covered with snow or ice, such that it moves in a vertical direction. Variants based for example on the horizontal rod of figure 6 (or the configuration of figure 4) makes sure that it does not matter if the vertical position of the conductive projection changes. This embodiment thus provides sufficient freedom in a vertical direction.

On this basis, it will be appreciated that the embodiments of figures 2, 4, 5 and 6 at least constitute examples of a structure 244, 441a, 441b, 444, 544, 641, for example an annular structure, a disk, bar or rod, which is at least not vertical, and which is preferably within 45 degrees of horizontal, and more preferably within 30 degrees of horizontal, and still more preferably substantially horizontal, such that a part of the structure is in proximity to the proximal part of the conductive projection, e.g. so as to define a spark gap, regardless of the orientation of the platform with respect to the enclosure about the axis.

Accordingly various forms have been presented which may constitute suitable structures for the distal extremity of the conductive member.

As such, embodiments cover any configuration wherein a part of the conductive member is in sufficient proximity of the proximal part of the conductive projection to provide a spark gap for lightning voltages regardless of the orientation of the platform with respect to the enclosure about the axis. In principle the breakdown is usually related to the local field strength being sufficiently high for a breakdown through the air/atmosphere, which will vary according to the presence of water and/or ice and may be anything from 500 kV/m to 2 or 3 Megavolts per meter (MV/m). However, in dry air it is likely a value around 2 MV/m. In the entire path of lightning from cloud to earth we bring a piece of metal (the rod) and another piece of metal separated by a small air gap. The air gap may for example be in the order of 100mm or less, and preferably in the order of 50 mm or less, and still more preferably in the order of 25mm or less, such that the air gap is not too large, to guarantee that the lightning

strikes via the defined path (the rod) and not via other unwanted paths. The figures presented above provide examples of such configurations. Further configurations may include as the conductive member structure any form that has a shape such that this proximity, e.g. so as to define a spark gap, is achieved, for example, annular, disk shaped, polygonal, rod. The structure may be any form that has a dimension in a direction extending under a non-zero angle with respect to the axis of rotation that is larger than the dimension of the proximal part of the conductive projection in this direction. The structure may be any form that extends at least partly around the proximal part. The structure may be any form that is rotationally symmetrical with respect to the axis of rotation of the platform. The form may exhibit any combination of these characteristics, certain such combinations are presented in the above embodiments.

Likewise, embodiments cover any configuration wherein a part of said proximal part of said conductive projection is in sufficient proximity of a part of said conductive member to provide a spark gap for lightning voltages regardless of the orientation of said platform with respect to said enclosure about said axis in line with the foregoing discussion. The figures presented above provide examples of such configurations. Further configurations may include as the proximal part structure any form that has a shape such that this proximity is achieved, for example, annular, disk shaped, polygonal, rod. The structure may be any form that has a dimension in a direction extending under a non-zero angle with respect to the axis of rotation that is larger than the dimension of the conductive member in this direction. The structure may be any form that extends at least partly around the conductive member. The structure may be any form that is rotationally symmetrical with respect to the axis of rotation of the platform. The form may exhibit any combination of these characteristics, certain such combinations are presented in the above embodiments.

Accordingly, as described, a radar system with a radome may be protected from lightning strikes by a first conductor projecting into space outside the radome in the manner of a lightning rod, and passing through the wall of the radome to the inside, where its proximal part is in electrical contact with, or in so close proximity as to constitute a spark gap with an internal conductive member which passes within the

radome to provide a conductive path for example via a platform on which an antenna may be mounted, to ground, so as to provide a viable path from the first conductor to ground.

The examples described above are given as non-limitative illustrations of embodiments of the invention. They do not in any way limit the scope of the invention which is defined by the following claims.

CLAIMS

1. A housing (100) for a radar antenna (101), said housing comprising
a weatherproof enclosure (130) formed substantially of materials that are transparent to radio frequency electromagnetic radiation, such that the enclosure as whole presents minimal interference to a said radar antenna situated therein,
a platform (120) situated within said weatherproof enclosure and mounted for rotational motion therein,
a conductive projection (110) configured as a lightning rod situated on the upper half of said enclosure (130) having a distal extremity (111) outside and oriented away from said enclosure, and a proximal part (112) passing through to the interior of said enclosure (130), and
a conductive member (140) situated within said enclosure (130) and in fixed relation to said platform (120), said conductive member being electrically coupled to ground, wherein the proximal part (112) of said conductive projection and said conductive member (140) are disposed such that regardless of the orientation of said platform, the proximal part of said conductive projection and said conductive member belong to a viable current path for a high voltage discharge.
2. The housing of claim 1 wherein a spark gap is maintained between the proximal part of said conductive projection and said conductive member.
3. The housing of claim 1 wherein the proximal part of said conductive projection and said conductive member are mechanically connected by a rotary joint.
4. The housing of any preceding claim further comprising a radar antenna mounted on said platform, wherein said conductive member is mounted on said radar antenna.

5. The housing of claim 4 wherein a spark gap is maintained between the proximal part of said conductive projection and said conductive member, the distance of said spark gap between the proximal part of said conductive projection and said conductive member is less than the shortest distance between said radar antenna and said enclosure.
6. The housing of claim 4 or 5 wherein said radar antenna comprises a support structure which is at least partially conductive, said structure being coupled to ground whereby said viable current path passes through said structure.
7. The housing of any preceding claim whereby said viable current path passes through one or more cables, wires or conductive bars.
8. The housing of any of claims 1 to 7 wherein said conductive member comprises a structure that is arranged such that a spark gap is defined between part of said structure and said proximal part of said conductive projection regardless of the orientation of said platform with respect to said enclosure about said axis.
9. The housing of any of claims 1- 8 wherein said proximal part of said conductive projection is positioned coaxially with respect to said axis of rotation of said platform.
10. The housing of any of claims 1 to 9 wherein said proximal part comprises a structure that is arranged such that a spark gap is defined between part of said structure and said conductive member regardless of the orientation of said platform with respect to said enclosure about said axis.
11. The housing of any of claims 1 to 9 wherein the proximal part of said conductive projection and said conductive member are substantially rod shaped, with the respective major axes disposed coaxially with an axis of rotation of said platform.

12. The housing of any preceding claim in which said conductive member is electrically coupled to ground via said platform.