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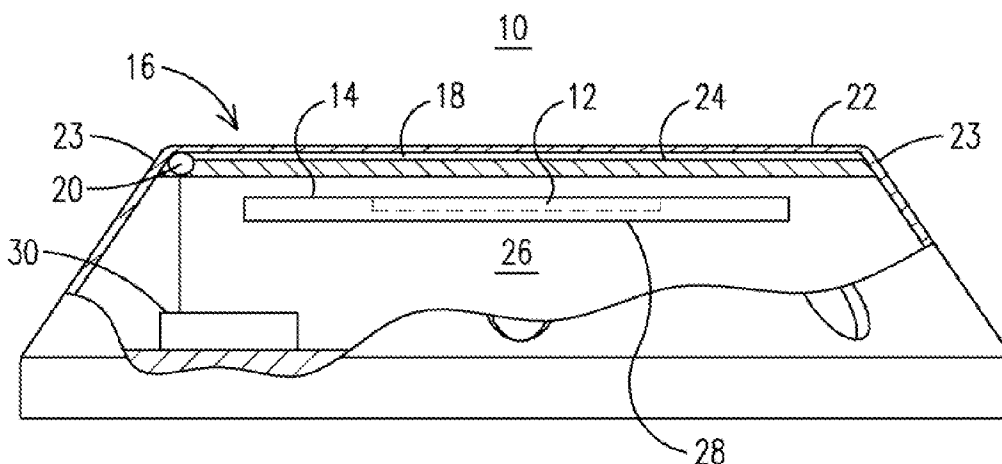


FIG. 1

(57) Abstract: A communication system (10), as may be used in a locomotive, is provided. The communication system includes a heating system, a communication antenna (12) and a communication electronics (14) disposed in a radome (16) made of a material permeable to electromagnetic radiation. An air gap (18) is defined by one or more walls of the radome and a thermally insulating plate (24) with respect to an inner compartment (26) of the radome. The inner compartment may accommodate an enclosure (28) where the antenna and the electronics are disposed. The heating system includes a heating device (20) for heating air in the air gap. A heated air gap makes it possible to defrost one or more outer surfaces of the radome, without affecting antenna and electronics performance, and without overheating the electronic components in the inner compartment of the radome.

COMMUNICATION SYSTEM WITH HEATING ARRANGEMENT IN A RADOME ON A RAILWAY LOCOMOTIVE

FIELD OF THE INVENTION

[001] The present invention is generally directed to communication systems for railway locomotives, and, more particularly, to a system with a heating arrangement as may be constructed in a radome mounted on a railway locomotive.

BACKGROUND OF THE INVENTION

[002] A railway locomotive may include communication electronics and at least one antenna packaged in a radome on the locomotive. These components may be part of a wayside/on-board communication system.

[003] The operating frequency of the system carrier may be in the ISM (Industrial, Scientific, Medical) band, such as in a range from 5.725 GHz to 5.825 GHz. It is known that this type of system is vulnerable to the formation and build-up of layers of snow and/or ice on one or more outer surfaces of the radome. For example, a build-up of ice and/or snow on the radome can deleteriously alter various electro-magnetic properties of the antenna and affect communications reliability.

[004] In order to improve the communication system reliability, it is desirable to provide a versatile heating arrangement that may provide the following example functionality:

[005] – function as a defrost system: melting, when activated, the ice and snow built-up on the radome;

[006] – function as an anti-icing system: keeping the receiver radome pre-heated to avoid the accumulation of ice and snow.

[007] It is also desirable that such a heating arrangement should keep undisturbed the electromagnetic properties of the antenna and the operational capabilities

of the system. A relatively low-cost, ease of installation and servicing are also desirable.

BRIEF DESCRIPTION OF THE INVENTION

[008] Generally, the present invention fulfils the foregoing needs and offers other advantages by providing in one aspect thereof a communication system for a locomotive. The communication system comprises a heating system, a communication antenna and a communication electronics disposed in a radome made of a material permeable to electromagnetic radiation. An air gap is defined by an upper wall of the radome, a section of a side wall of the radome and a thermally insulating plate with respect to an inner compartment of the radome. The inner compartment accommodates an enclosure where the antenna and the electronics are disposed. The heating system includes a heating device for heating air in the air gap.

[009] The present invention further fulfils the foregoing needs and offers other advantages by providing in another aspect thereof a heating system for a communications system mounted on a locomotive. The communications system comprises a communication antenna and a communication electronics disposed in a radome made of a material permeable to electromagnetic radiation. An air gap is defined by an upper wall of the radome, a section of a side wall of the radome and a thermally insulating plate with respect to an inner compartment of the radome. The inner compartment accommodates an enclosure where the antenna and the electronics are disposed. The heating system includes a heating device for heating air in the air gap. The inner compartment may also accommodate a controller configured to control the heating device

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Figure 1 illustrates a schematic representation of a radome that accommodates a communication system and a heating arrangement for preventing accumulation of ice and/snow on the radome.

[0011] Figure 2 illustrates a mounting arrangement of the radome of figure 1 on a locomotive.

[0012] Figure 3 is a diagram of an example radiation pattern of a communication antenna of the communication system.

[0013] Figures 4 and 5 respectively show generally top and bottom isometric views of a radome embodying aspects of the present invention.

[0014] Figure 6 show a top view of an air gap heated by a heating arrangement embodying aspects of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0015] FIG. 1 illustrates a schematic representation of a communications system 10, (e.g., a microwave receiver system) including a heating system and a communication antenna 12 (e.g., a receiving patch antenna disposed on a printed circuit) integrated with communication electronics 14 (e.g., receiver electronics) housed within a radome 16, such as may be made of a suitable dielectric, e.g., a plastic material.

[0016] The radome is permeable to electromagnetic radiation and in part defines an air gap 18 heated by a heating device 20 arranged to supply heat both to the surrounding structures and to the air contained in the air gap.

[0017] Air gap 18 is insulated from the outside environment by an upper wall 22 of the radome and a section of side wall 23 of the radome, and is insulated by an thermally insulating plate 24 (e.g., made from a suitable dielectric such as plastic) from an inner compartment 26, such as may accommodate an enclosure 28 that contains antenna 12 and electronics 14.

[0018] In one example embodiment, heating device 20 may comprise a metallic-wire resistor, such as may be configured with a rounded shape or any other suitable configuration. In an alternative embodiment, heating device 20 may comprise a

coil with one or more wires extending at respective right angles relative to a polarization direction of the electric field generated by the antenna.

[0019] Heating device 20 may be electronically controlled by a controller 30 (e.g., a microprocessor), as may be configured to measure the resistance of the heating device and the temperature of the inner surface of the upper wall of the radome and/or side wall section of the radome.

[0020] An example heating control strategy may be configured to prevent the heating device from reaching a temperature that may exceed the temperature ratings of the surrounding radome material, and may further prevent the temperature of the upper wall of the radome (and/or side wall section) from dropping below a predefined temperature threshold (e.g., to provide an anti-icing function).

[0021] In operation, a communication system with a heated air gap makes it possible to provide a substantially uniform heating with respect to the outer surfaces of the radome in spatial correspondence with the communication antenna, without affecting various antenna characteristics, such as lobes, gain, and matching characteristics and without overheating the electronic components in the inner compartment of the radome.

[0022] By way of example but not limited thereto, air gap 18 may be insulated from the outside by a predefined thickness (e.g., 1 mm) at the upper wall 22 and side section 23 of the radome, and may be insulated from the inner compartment 26, which accommodates the controller 30 and enclosure 28 that contains the antenna and circuitry by plate 24 (e.g., having a thickness of 3 mm) of plastic material. It will be appreciated that enclosure 28 could optionally accommodate controller 30.

[0023] In operation, heating device 20 supplies heat both to the surrounding structures, which in the case of a plastic structure has a relatively high thermal impedance, and to the air contained in air gap 18.

[0024] It will be appreciated that air heated proximate the heating device tends to flow in an upwardly direction, and since the radome is tilted with respect to a verti-

cal axis, this arrangement results in turbulence (e.g., micro-turbulent flow) which is conducive to heat transfer by convection.

[0025] Figure 2 illustrates a mounting arrangement of radome 16 on a locomotive 32. In this embodiment, the dome is installed on the locomotive at an inclined position with respect to a vertical axis 34, e.g., about 45° with respect to the vertical axis.

[0026] As will be appreciated by one skilled in the art, heat flow tends to follow the path having the lowest thermal resistance, and, in this case, this would include the air in air gap 18. The heat flow would encounter a high thermal resistance at plate 24 towards inner compartment 26 where the enclosure is housed, due to the plastic plate acting as an insulator. It is contemplated that the heating arrangement may optionally include a forced-convection device (e.g., a fan) for relatively quick and evenly distribution of the heated air throughout the air gap.

[0027] A heating system embodying aspects of the present invention provides substantial advantages over prior heating arrangements. For example, prior heating arrangements tend to introduce obstacles in the field area near the antenna and would therefore disturb the electromagnetic properties of the antenna. Moreover, although some systems, such as those based on a forced flow of hot air or water vapour, may not substantially affect the antenna, such systems tend to be difficult to install and service on the locomotive and this would considerably increase the time and cost associated with such systems.

[0028] Figure 3 is a diagram of an example radiation pattern of a receiving antenna of a receiver system. Table 1 lists further example characteristics of the receiving antenna that remain essentially undisturbed by a heating arrangement embodying aspects of the present invention. For example, lobe variation is expected not be higher than $\pm 5^\circ$ of the 3 dB beam for planes E, H of the radiation pattern.

Table 1

Example Characteristics of Antenna	
Vertical polarization Gain	6 dB
3db beam pattern of E plane	$100^{\circ} \pm 5^{\circ}$
3db beam pattern of H plane	$100^{\circ} \pm 5^{\circ}$

[0029] Figures 4 and 5 respectively show generally top and bottom isometric views of a radome embodying aspects of the present invention.

[0030] Figure 6 show a cut out in upper wall 22 of the radome that provides a top view of insulating plate 24 disposed to bound the bottom side of air gap 18, which is heated by a heating arrangement embodying aspects of the present invention.

[0031] Example physical features of the receiver, which are provided by way of illustration but not limited thereto, may be as follows:

- dimensions (mm): 206 (diameter) x 47 (height)
- weight (kg): about 0.6

[0032] While certain embodiments of the present invention have been shown and described herein, such embodiments are provided by way of example only. Numerous variations, changes and substitutions will occur to those of skill in the art without departing from the invention herein. Accordingly, it is intended that the invention be limited only by the spirit and scope of the appended claims.

CLAIMS

1. A communication system for a locomotive, said communication system comprising a heating system, a communication antenna and a communication electronics disposed in a radome made of a material permeable to electromagnetic radiation, wherein an air gap is defined by an upper wall of the radome, a section of a side wall of the radome and a thermally insulating plate with respect to an inner compartment of the radome, the inner compartment accommodating an enclosure where the antenna and the electronics are disposed, and wherein the heating system includes a heating device for heating air in the air gap.

2. The communication system according to claim 1, wherein the heating device comprises a wire resistor.

3. The communication system according to claim 1, wherein the heating device comprises a coil.

4. The communication system according to claim 3, wherein the coil includes at least one wire that extends at a right angle relative to a polarization direction of an electric field generated by the antenna.

5. The communication system according to claim 1, wherein the radome is mounted on the locomotive inclined at a predefined angle with respect to a vertical axis so that heated air proximate the heating device forms a turbulence conducive to a heat flow by convection

6. The communication system according to claim 5, wherein the predefined angle is an angle of about 45 degrees.

7. The communication system according to claim 1, further comprising a controller coupled to control the heating device by measuring at least one of the following parameters: a resistance of the heating device, a temperature of the heating device, and a temperature of an inner surface of the upper wall of the radome and/or a temperature of an inner surface of the side wall section of the radome.

8. The communication system according to claim 1, further comprising a controller coupled to control the heating device in accordance with a control strategy selected to bound an operational temperature of the heating device between an upper temperature threshold and a lower temperature threshold, the upper temperature threshold selected to avoid reaching a temperature that exceeds a temperature ratings of the radome material, and the lower temperature threshold selected to prevent a temperature of the upper wall of the radome from dropping below said lower threshold.

9. The communication system according to claim 1, further comprising a forced-convection device for distributing the heated air throughout the air gap.

10. A heating system for a communication system mounted on a locomotive, the communication system comprising a communication antenna and a communication electronics disposed in a radome made of a material permeable to electromagnetic radiation, wherein an air gap is defined by an upper wall of the radome, a section of a side wall of the radome and a thermally insulating plate with respect to an inner compartment of the radome, the inner compartment accommodating an enclosure where the antenna and the electronics are disposed, wherein the heating system includes a heating device for heating air in the air gap, and further wherein the inner compartment accommodates a controller configured to control the heating device.

11. The heating system according to claim 10, wherein the heating device comprises a wire resistor.

12. The heating system according to claim 10, wherein the heating device comprises a coil.

13. The heating system according to claim 12, wherein the coil includes at least one wire that extends at a right angle relative to a polarization direction of an electric field generated by the antenna.

14. The heating system according to claim 10, wherein the radome is mounted on the locomotive inclined at a predefined angle with respect to a vertical axis so that heated air proximate the heating device forms a turbulence conducive to a heat flow by convection

15. The heating system according to claim 14, wherein the predefined angle is an angle of about 45 degrees.

16. The heating system according to claim 10, wherein the controller controls the heating device in response to at least one of the following parameters: a resistance of the heating device, a temperature of the heating device, and a temperature of an inner surface of the upper wall of the radome and/or a temperature of an inner surface of the side wall section of the radome.

17. The heating system according to claim 10, wherein the controller controls the heating device in accordance with a control strategy selected to bound an operational temperature of the heating device between an upper temperature threshold and a lower temperature threshold, the upper temperature threshold selected to avoid reaching a temperature that exceeds a temperature ratings of the radome material, and the lower temperature threshold selected to prevent a temperature of the upper wall of the radome from dropping below said lower threshold.

18. The heating system according to claim 10, further comprising a forced-convection device for distributing the heated air throughout the air gap.

19. The heating system according to claim 10, wherein the communication system comprises a microwave receiver having a carrier frequency in a range from 5.725 GHz to 5.825 GHz.

20. The communication system according to claim 1, wherein the communication system comprises a microwave receiver having a carrier frequency in a range from 5.725 GHz to 5.825 GHz.

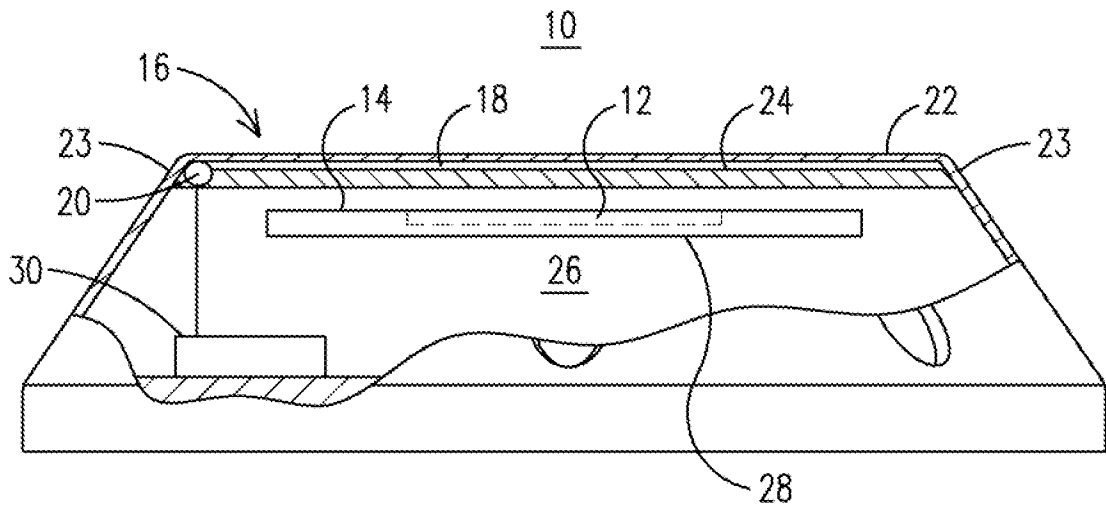


FIG. 1

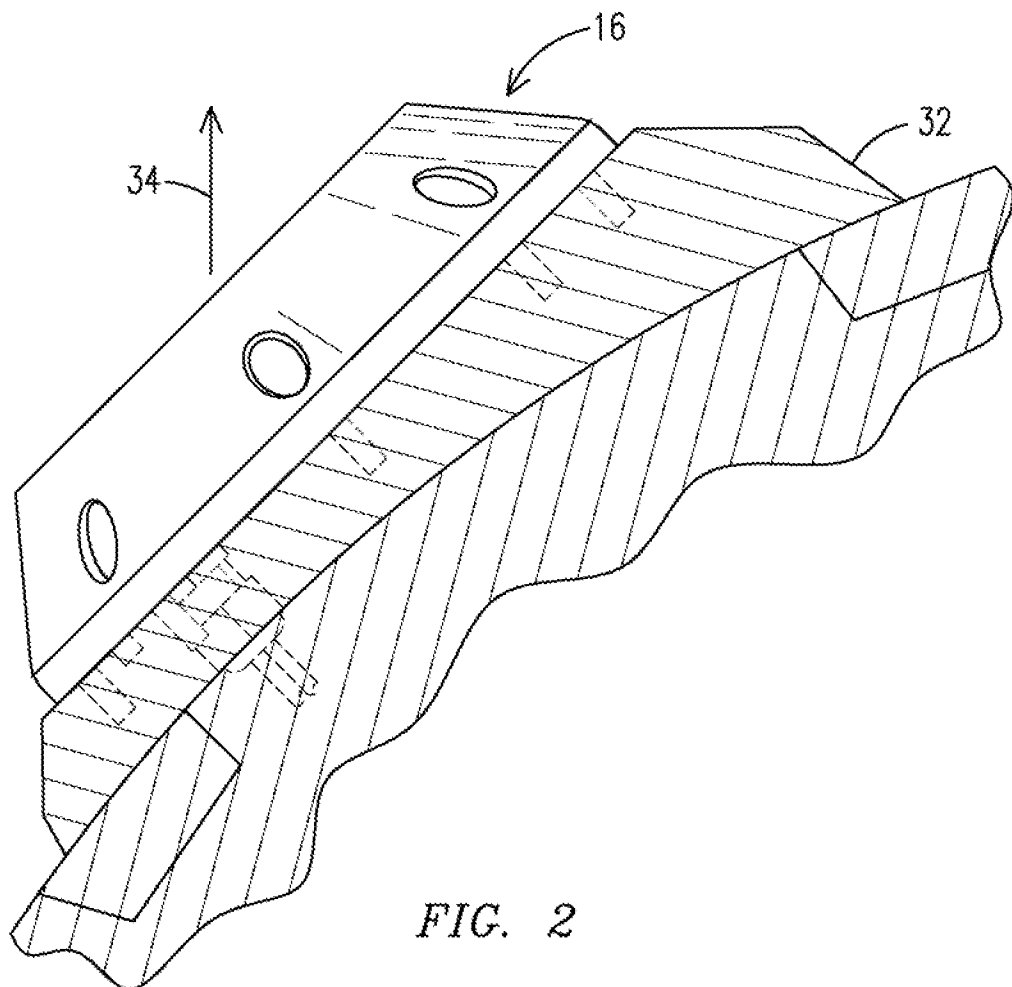


FIG. 2

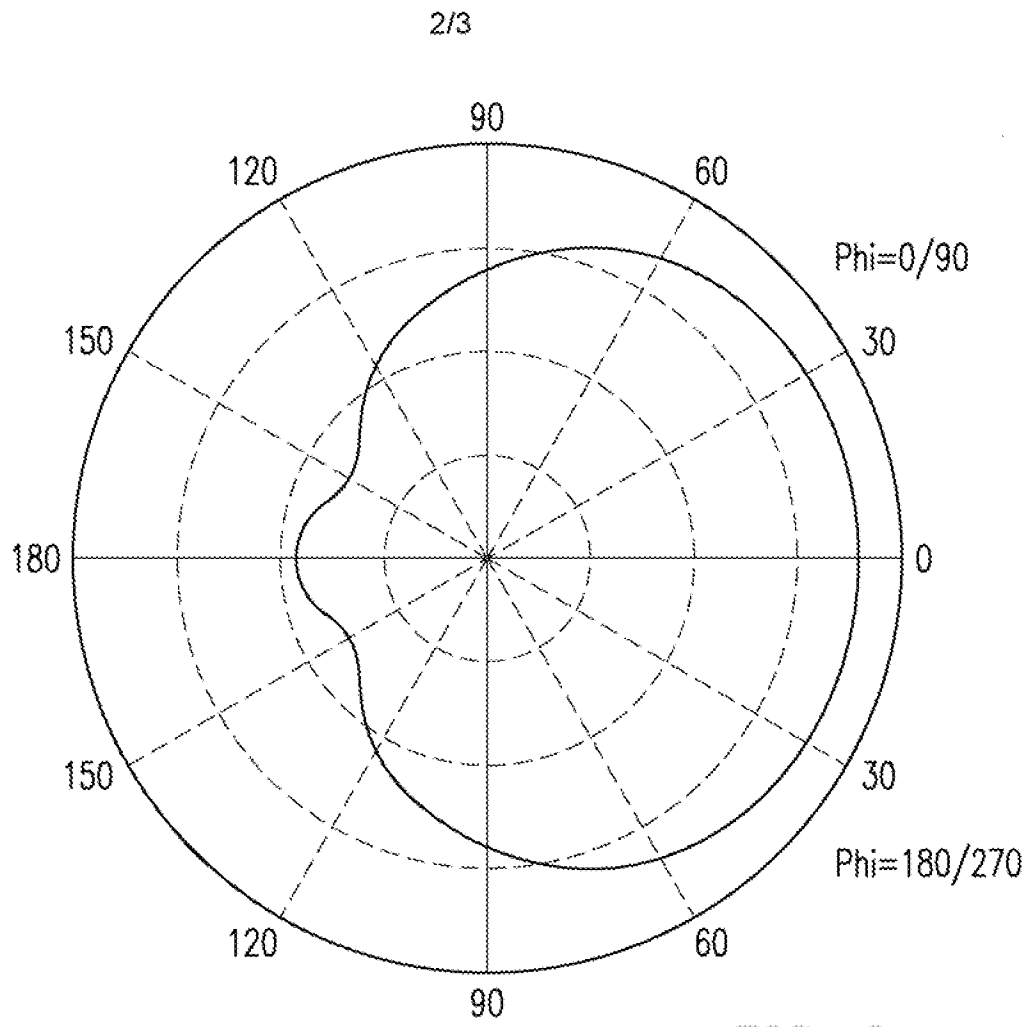


FIG. 3

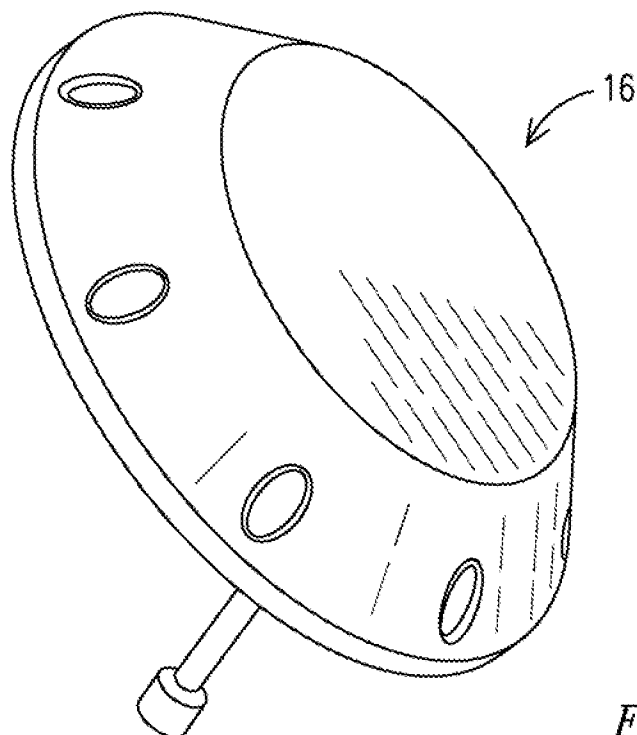


FIG. 4

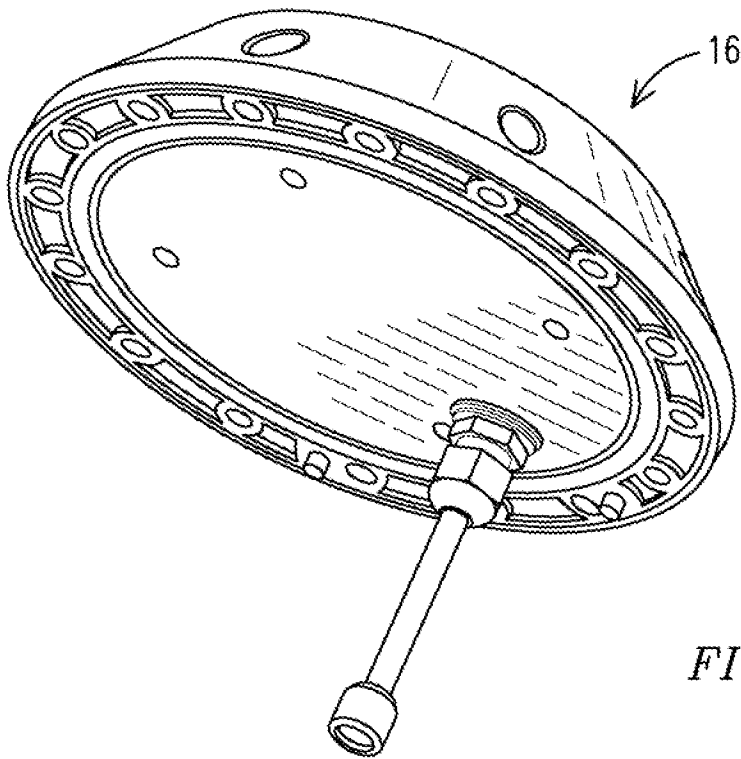


FIG. 5

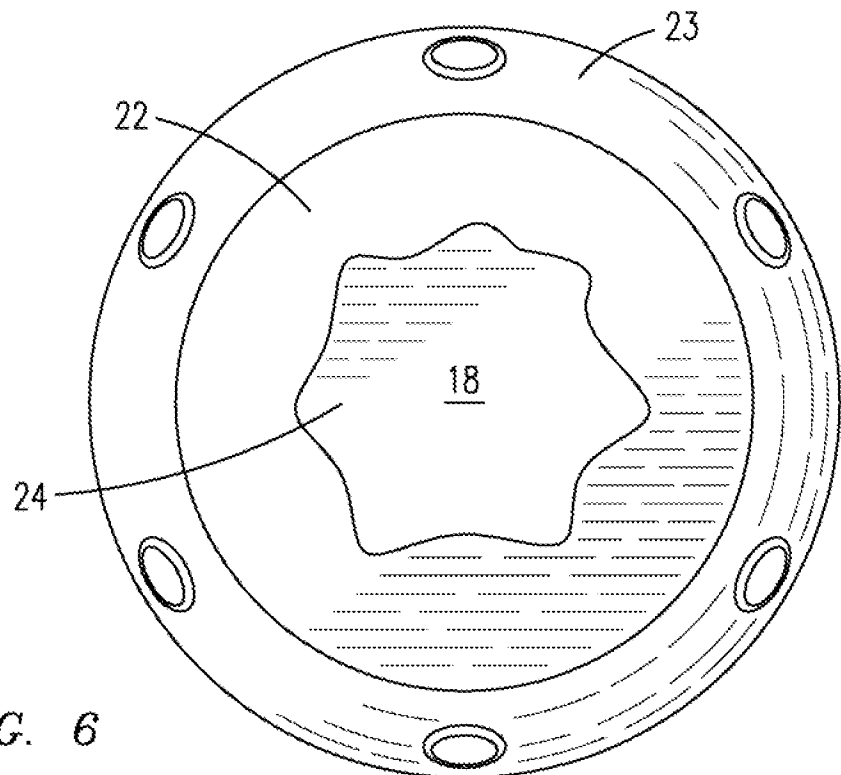


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/057308

A. CLASSIFICATION OF SUBJECT MATTER

INV. G01S13/93 H01Q1/02 H01Q1/42 H01Q1/32

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)
G01S H01Q

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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 199 63 004 A1 (BOSCH GMBH ROBERT [DE]) 28 June 2001 (2001-06-28) the whole document	1-20
X	JP 10 056309 A (HINO MOTORS LTD) 24 February 1998 (1998-02-24) the whole document	1-20
X	DE 101 49 337 A1 (BOSCH GMBH ROBERT [DE]) 17 April 2003 (2003-04-17) the whole document	1-20
X	JP 02 109403 A (FUJITSU LTD; KOKUSAI DENSHIN DENWA CO LTD) 23 April 1990 (1990-04-23) the whole document	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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