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Kim

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(45) **Date of Patent: Jul. 10, 2018**

(54) **ANTENNA AND VEHICLE HAVING THE ANTENNA**

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(73) Assignee: **HYUNDAI MOTOR COMPANY**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 13 days.

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(22) Filed: **Dec. 20, 2016**

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(30) **Foreign Application Priority Data**

Sep. 1, 2016 (KR) 10-2016-0112487

(51) **Int. Cl.**

H01Q 13/10	(2006.01)
H01Q 1/32	(2006.01)
H01Q 3/24	(2006.01)
H01Q 1/42	(2006.01)
H01Q 5/307	(2015.01)
H01Q 5/30	(2015.01)

(Continued)

(52) **U.S. Cl.**

CPC ***H01Q 1/3291*** (2013.01); ***H01Q 1/42*** (2013.01); ***H01Q 3/24*** (2013.01); ***H01Q 5/30*** (2015.01); ***H01Q 5/307*** (2015.01); ***H01Q 13/10*** (2013.01); ***H01Q 13/12*** (2013.01); ***H01Q 13/18*** (2013.01); *G01S 13/931* (2013.01); *G08G 1/16* (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/30; H01Q 5/307; H01Q 13/10; H01Q 13/12; H01Q 13/18; H01Q 1/3291; H01Q 3/24

See application file for complete search history.

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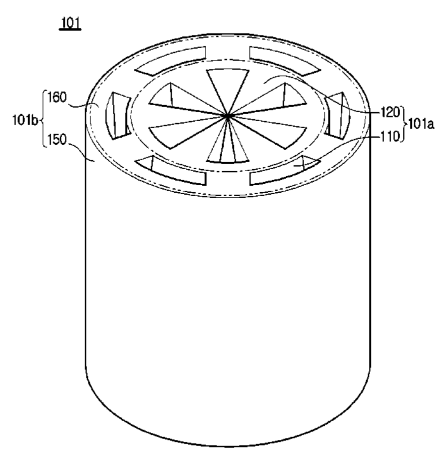
Primary Examiner — Hoang Nguyen

(74) *Attorney, Agent, or Firm* — McDermott Will & Emery LLP

(57) **ABSTRACT**

An antenna includes a first antenna body formed as a hollow cylindrical shape having a first outer surface, a first inner surface and a first radiation surface formed in a circular shape, a second antenna body accommodating the first antenna body inside the second antenna body, the second antenna body formed as a hollow cylindrical shape with a second outer surface, a second inner surface and a second radiation surface formed in a ring shape, a plurality of first partitions, and a plurality of second partitions, wherein a plurality of first radiation apertures, formed by the plurality of first partitions for radiating a first radio wave, is formed on the first radiation surface, and a plurality of second radiation apertures, formed by the plurality of second partitions for radiating a second radio wave, is formed on the second radiation surface.

20 Claims, 26 Drawing Sheets



(51) **Int. Cl.**

H01Q 13/12	(2006.01)
H01Q 13/18	(2006.01)
G08G 1/16	(2006.01)
G01S 13/93	(2006.01)

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Notice of Allowance issued in Korean Patent Application No. 10-2016-0112487, dated Mar. 16, 2018 (English translation).

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FIG. 1

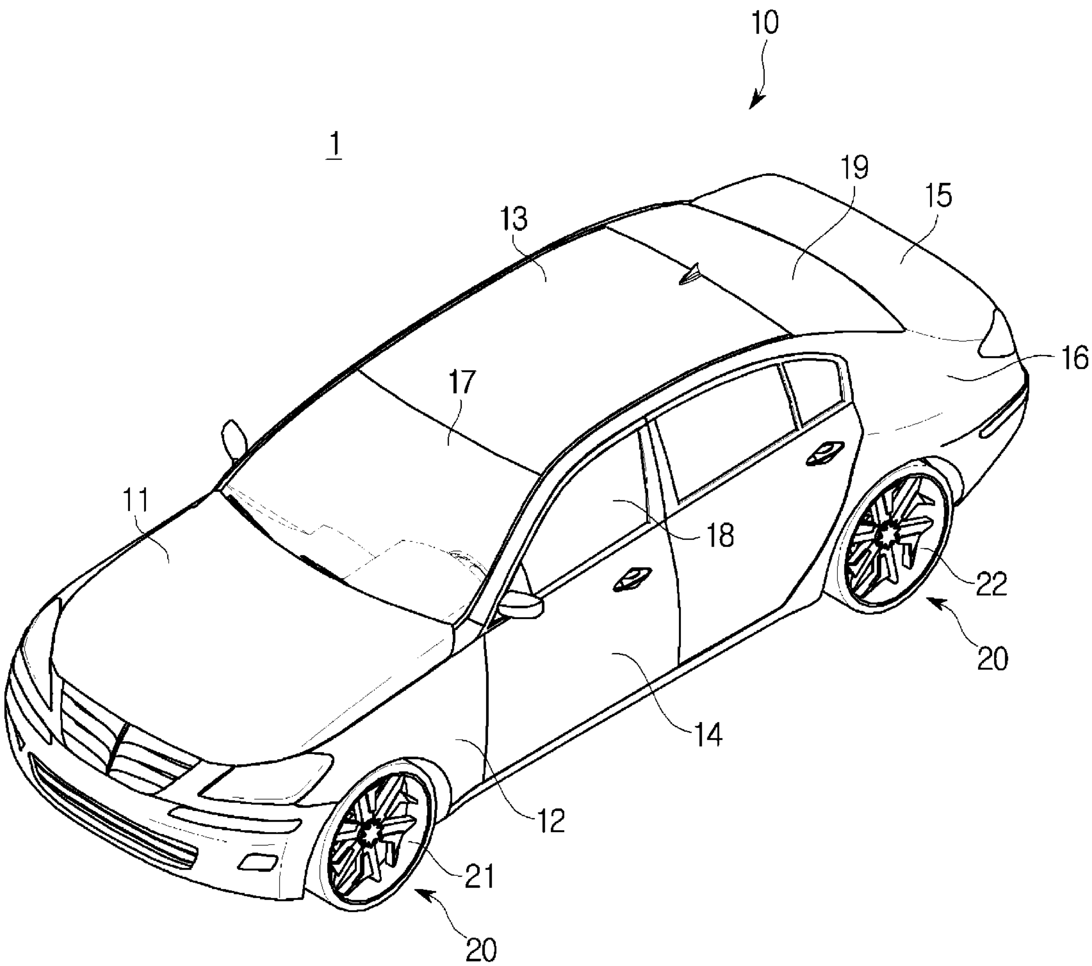
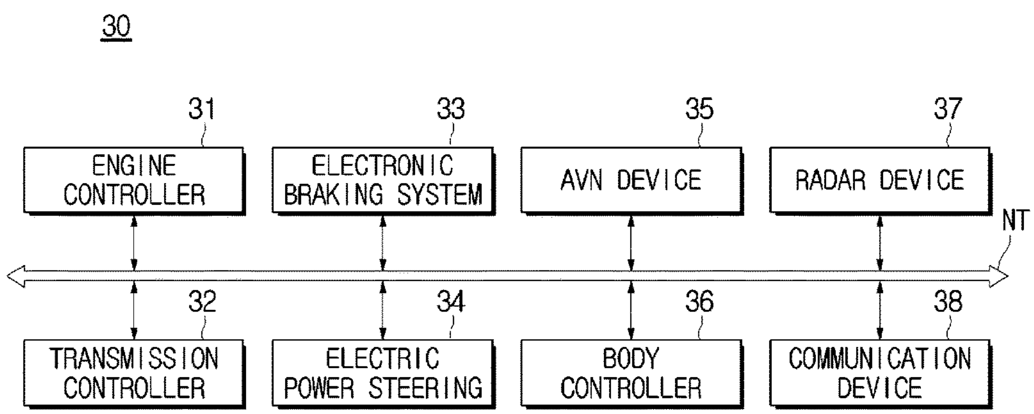


FIG.2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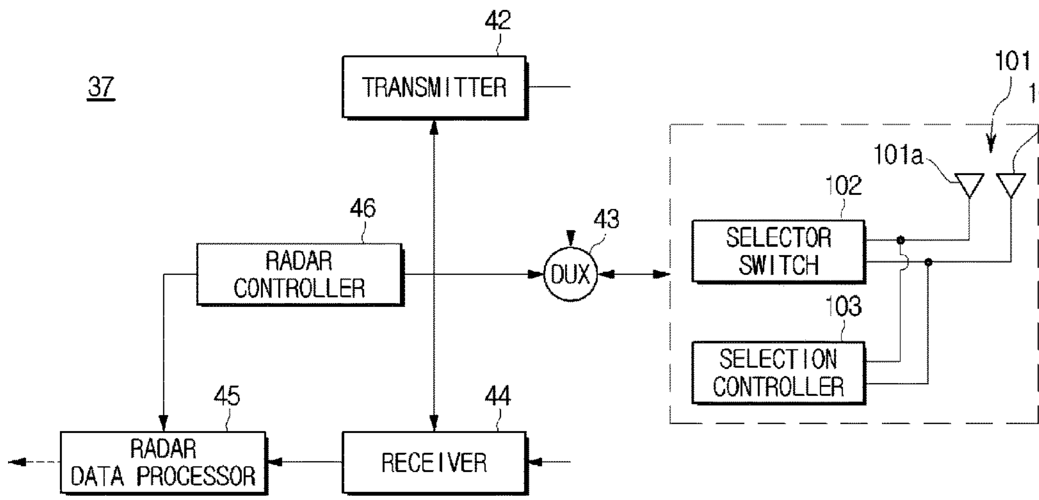
31
ENGINE CONTROLLER
33
ELECTRONIC BRAKING SYSTEM
35
AVN DEVICE
37
RADAR DEVICE
NT
32
TRANSMISSION CONTROLLER
34
ELECTRIC POWER STEERING
36
BODY CONTROLLER
38
COMMUNICATION DEVICE

FIG.3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RADAR CONTROLLER
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DUX
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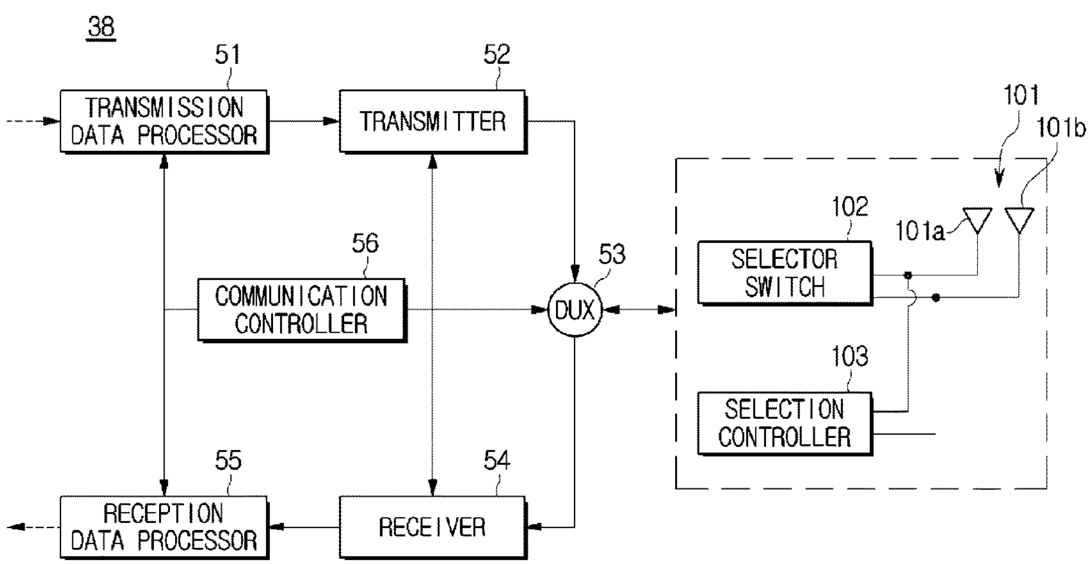
102
SELECTOR SWITCH
103
SELECTION CONTROLLER

FIG.4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SELECTOR SWITCH
103
SELECTION CONTROLLER

FIG.5

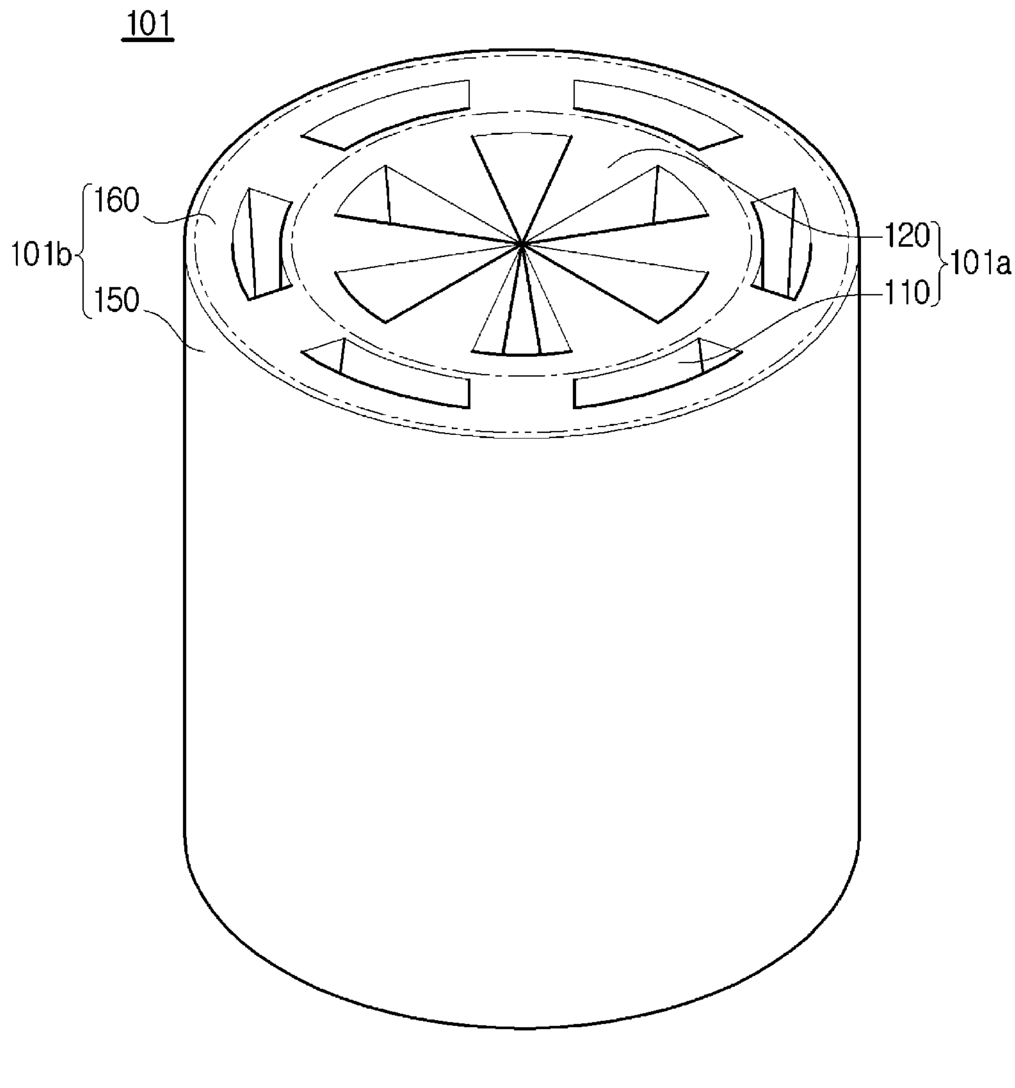

FIG.6

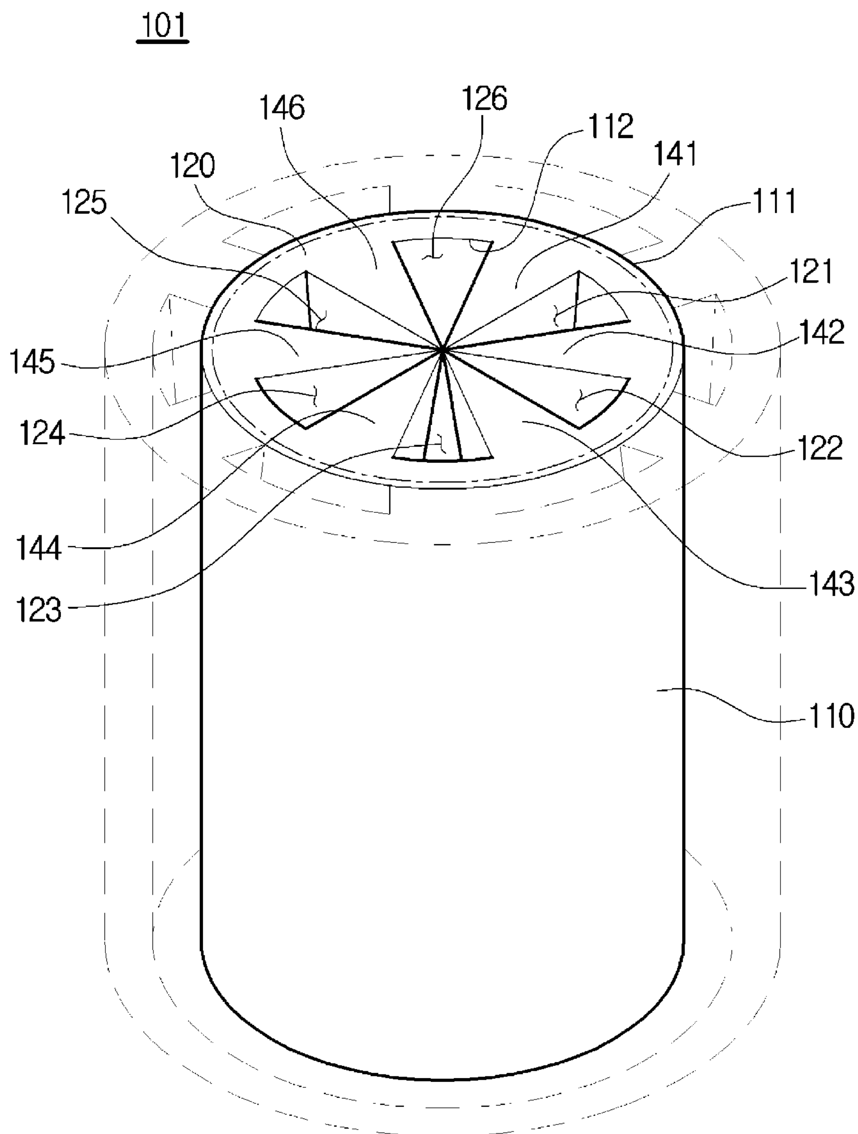
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FIG.7

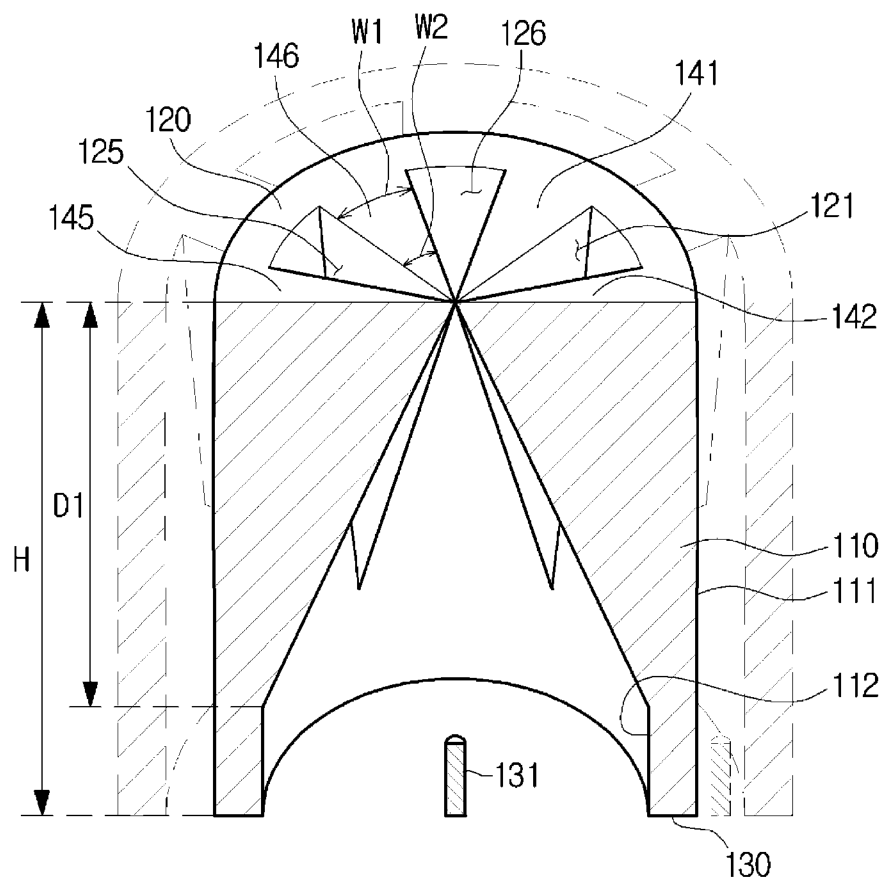

FIG.8A

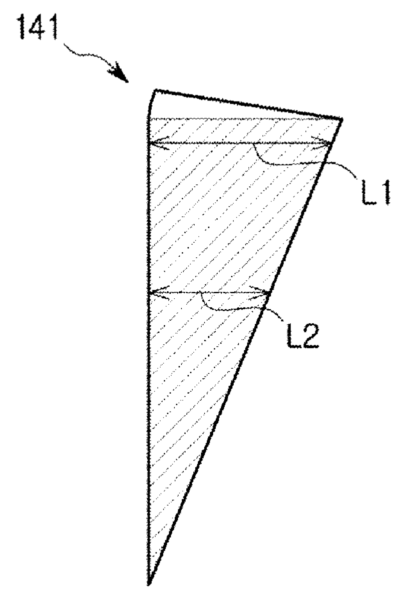

FIG.8B

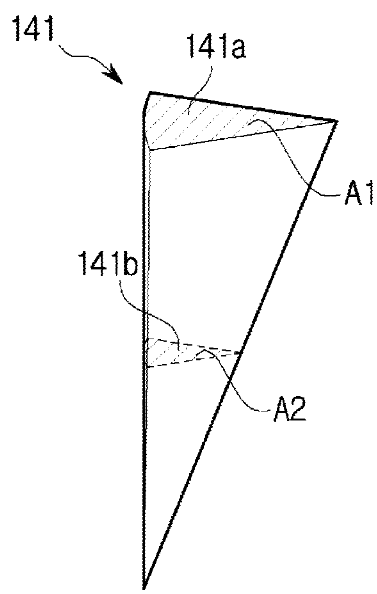

FIG.9

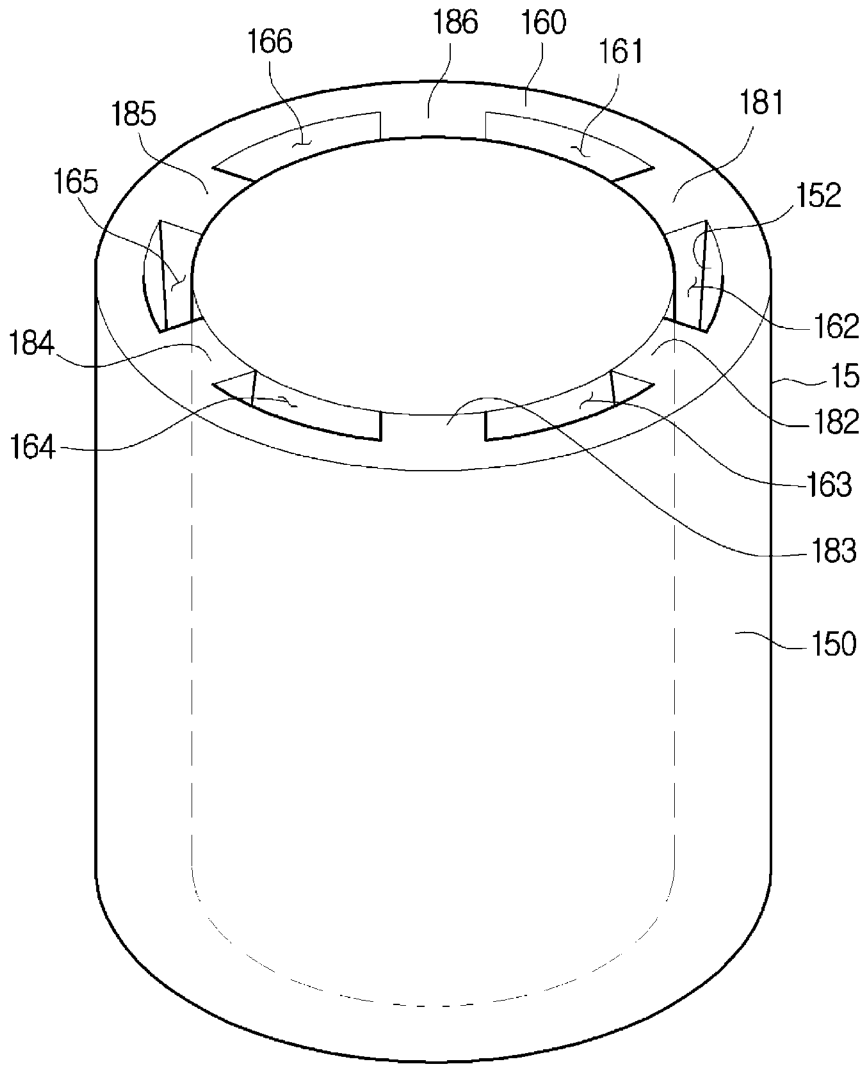

FIG.10

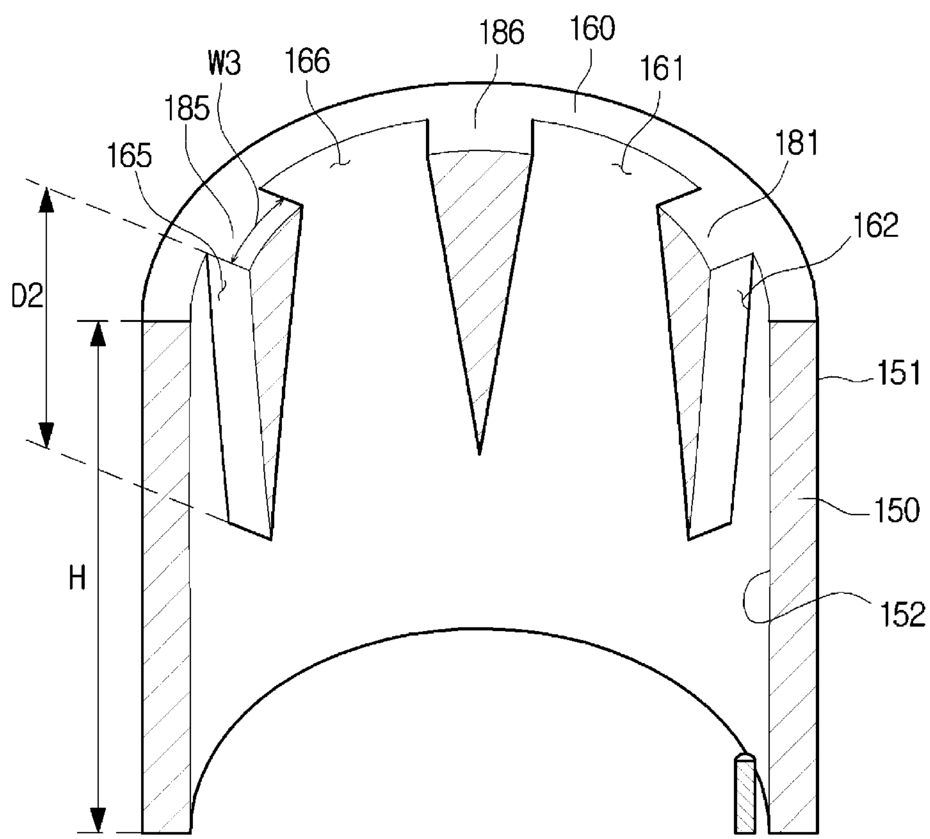

FIG.11A

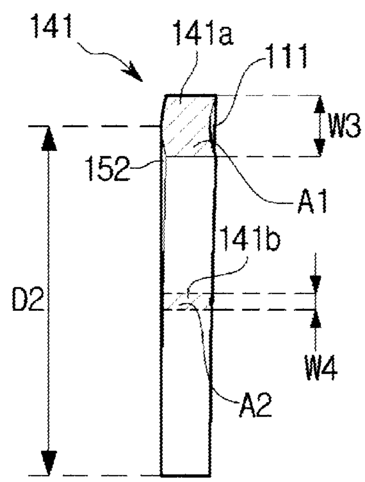

FIG.11B

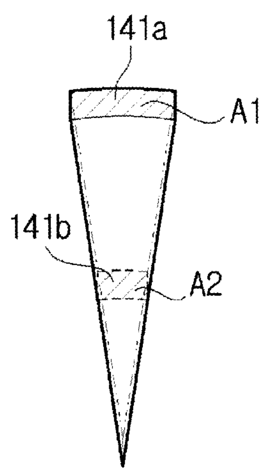

FIG.12

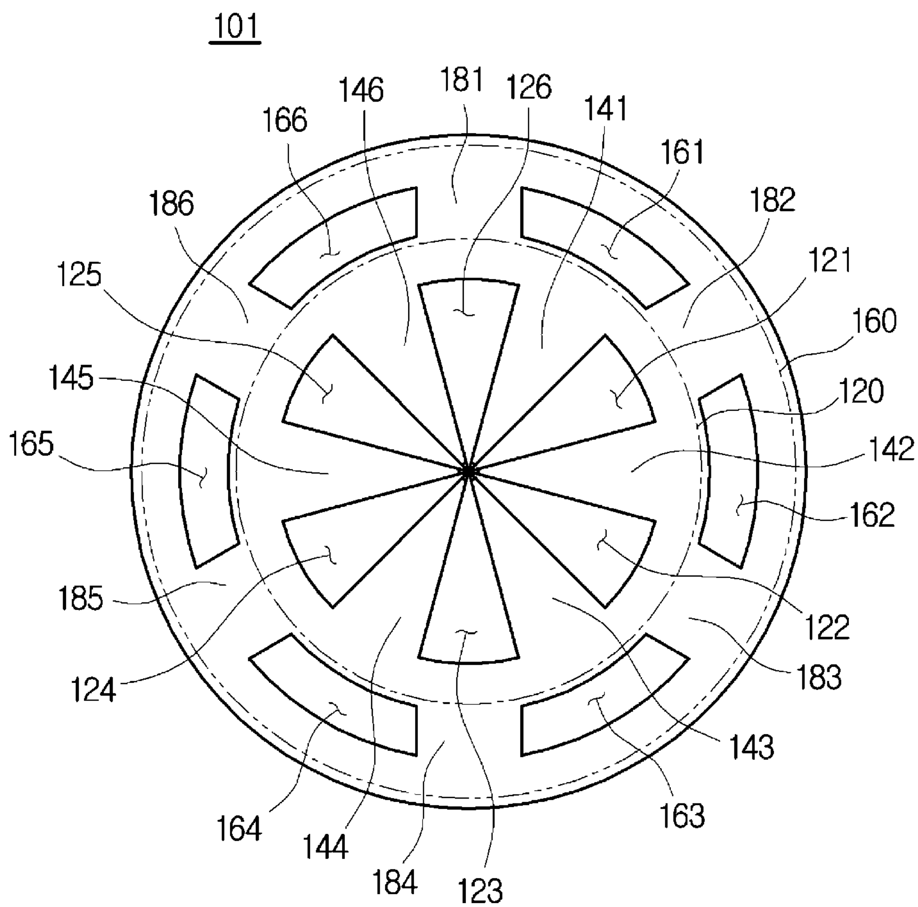
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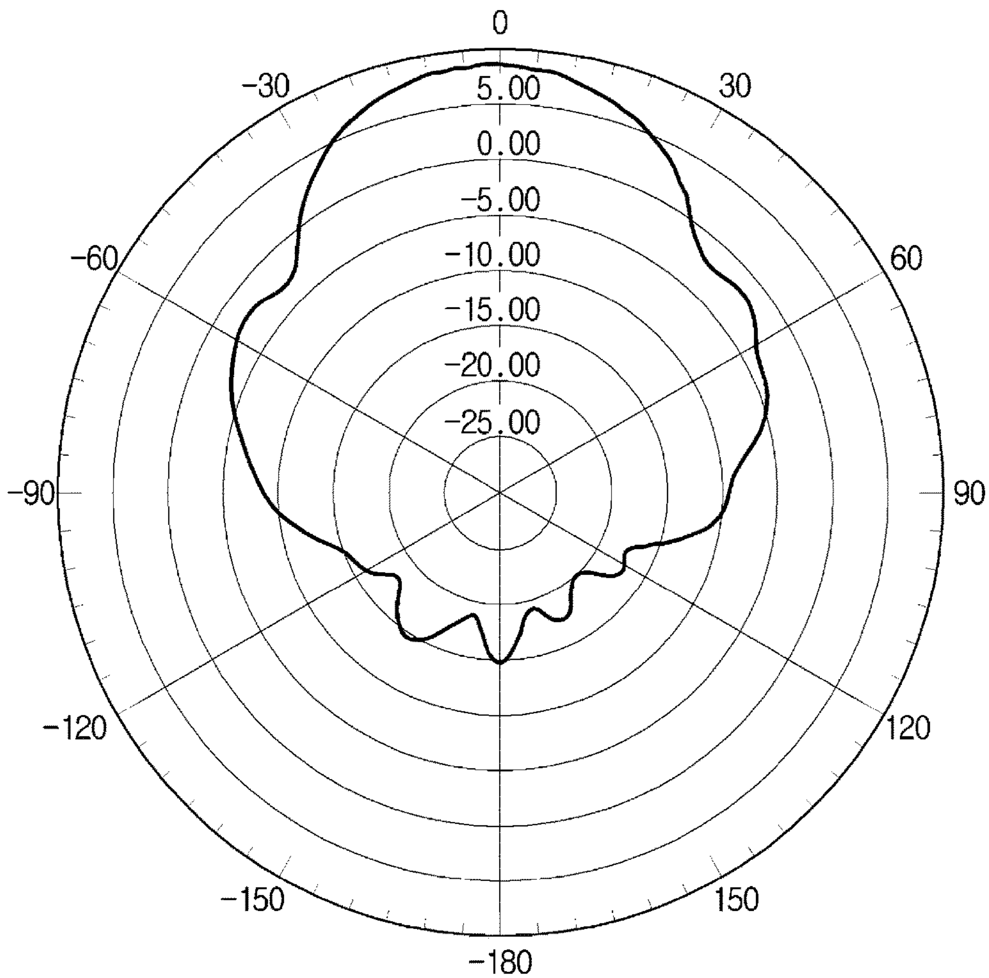
FIG.13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-20.00
-25.00

FIG.14

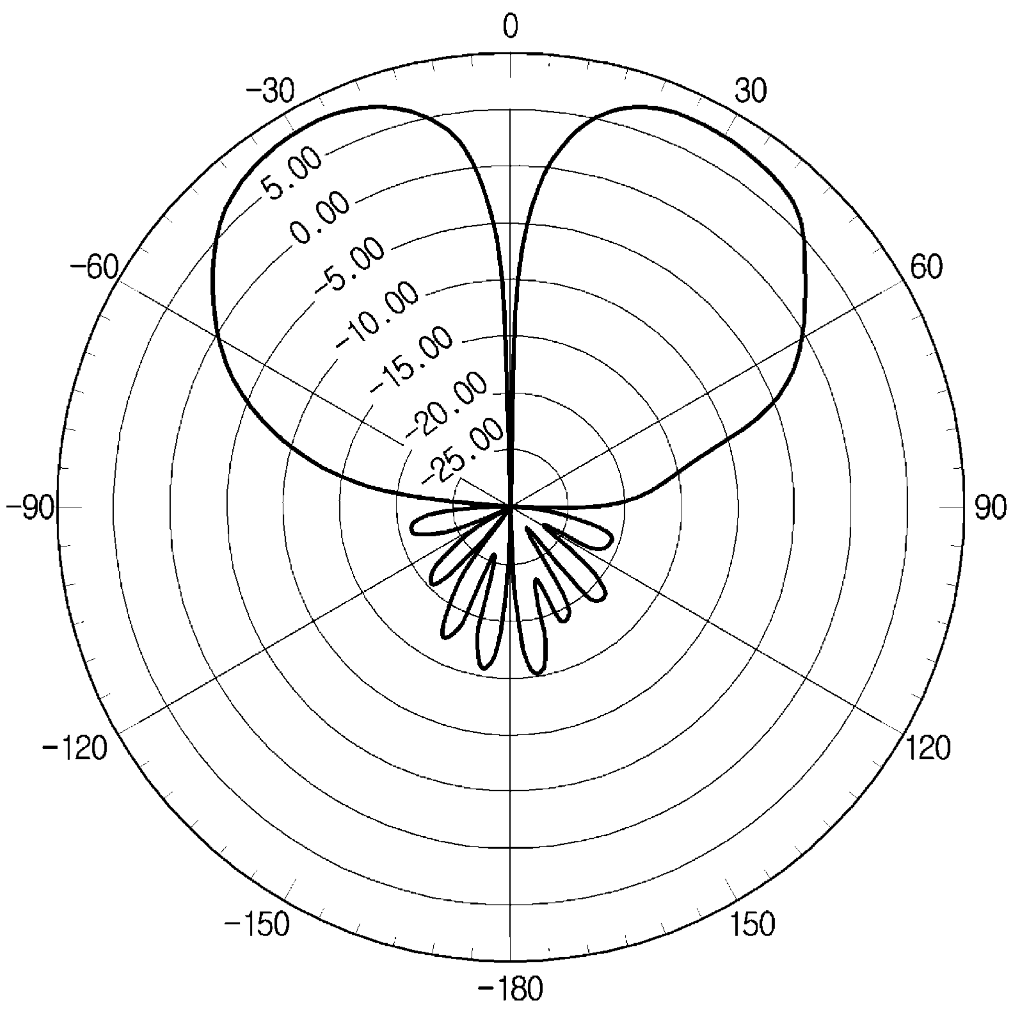
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FIG.15

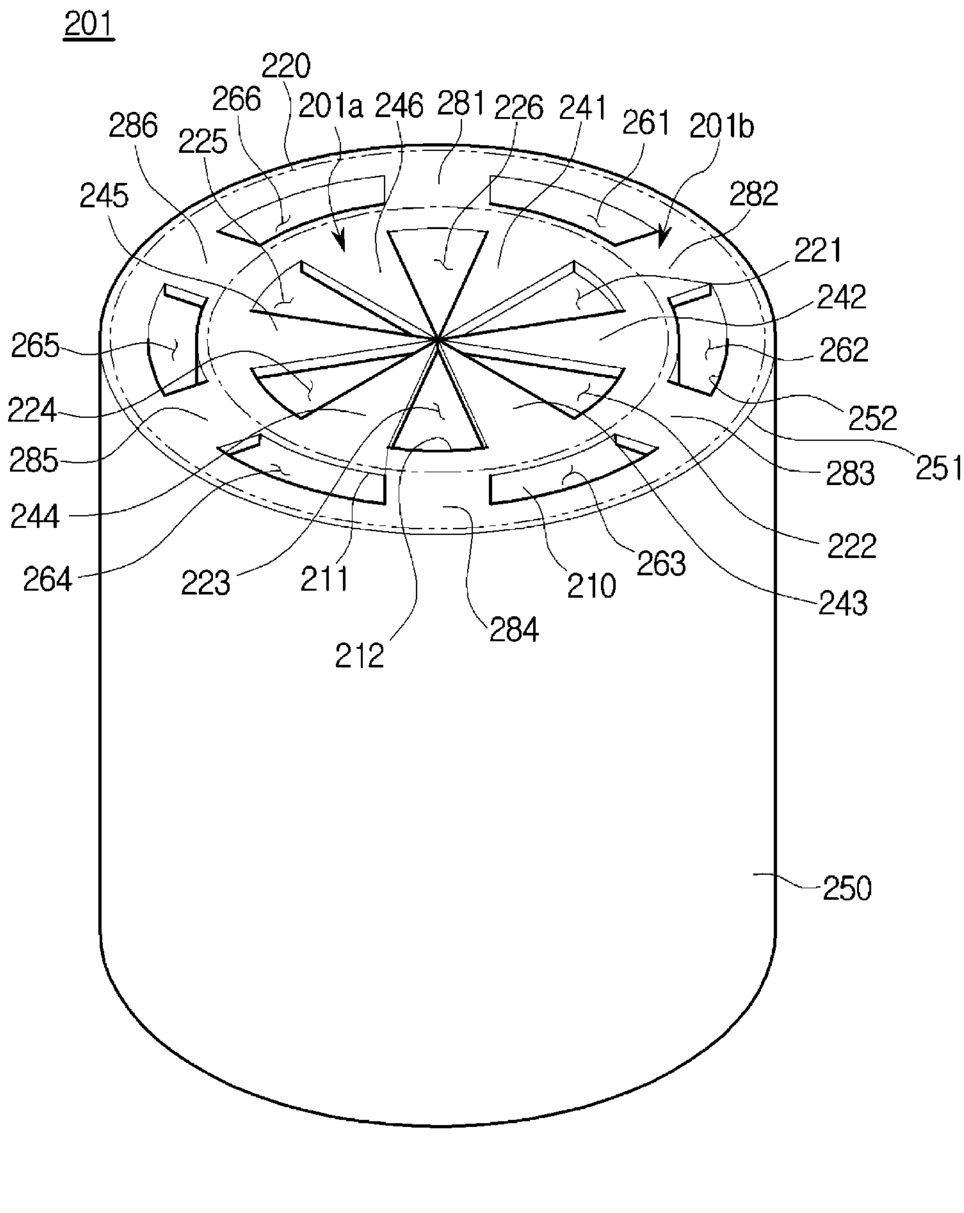
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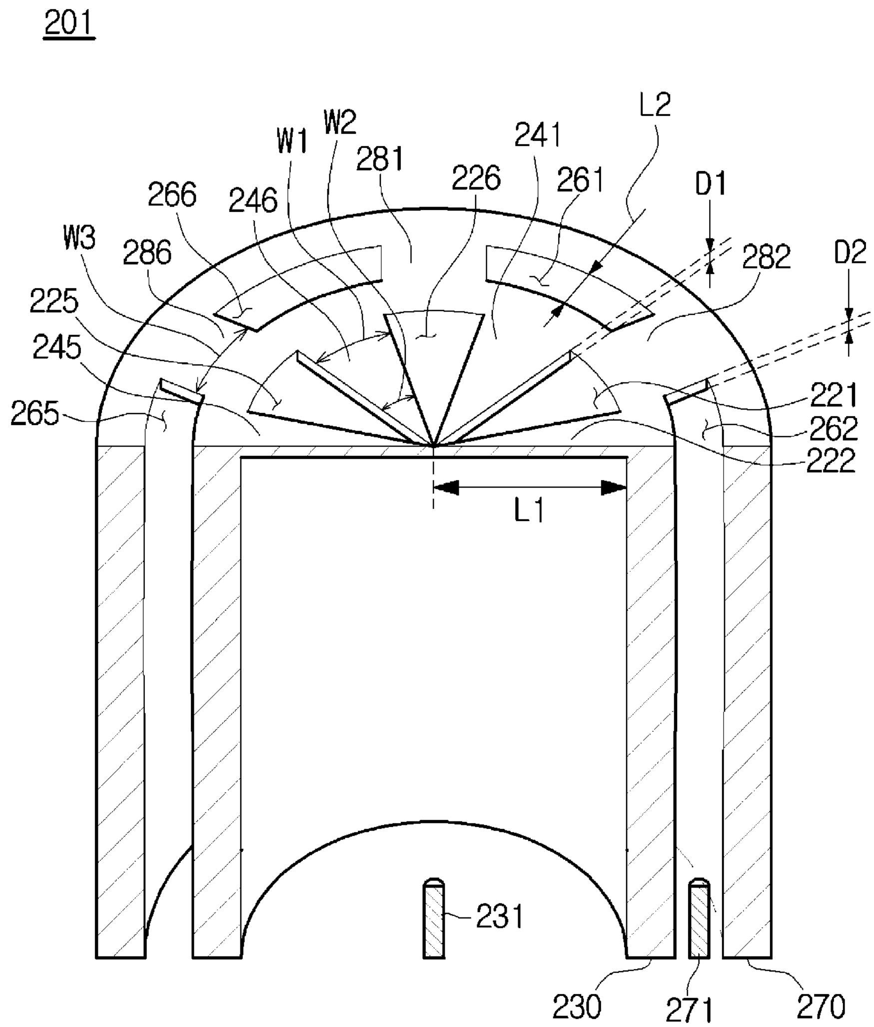
FIG.16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L1
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230
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270

FIG.17

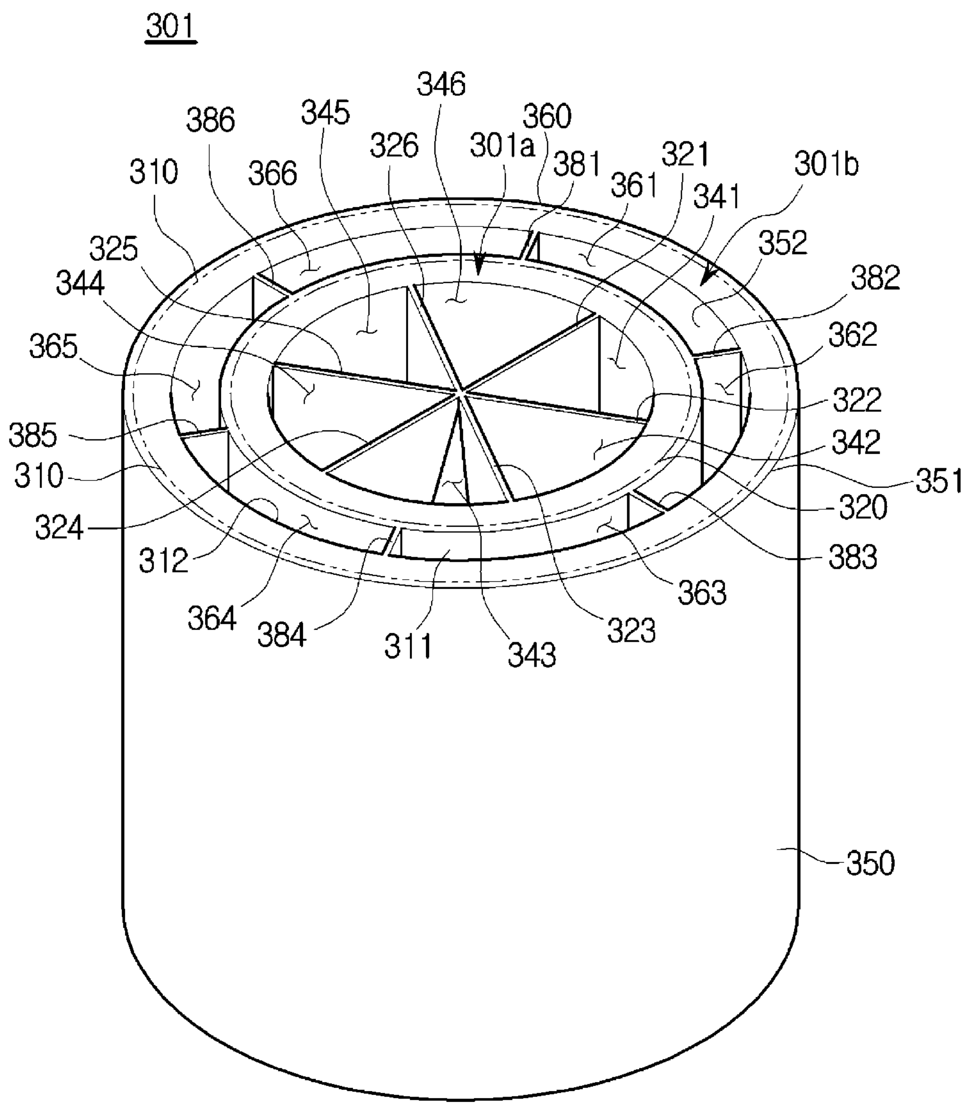
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FIG.18

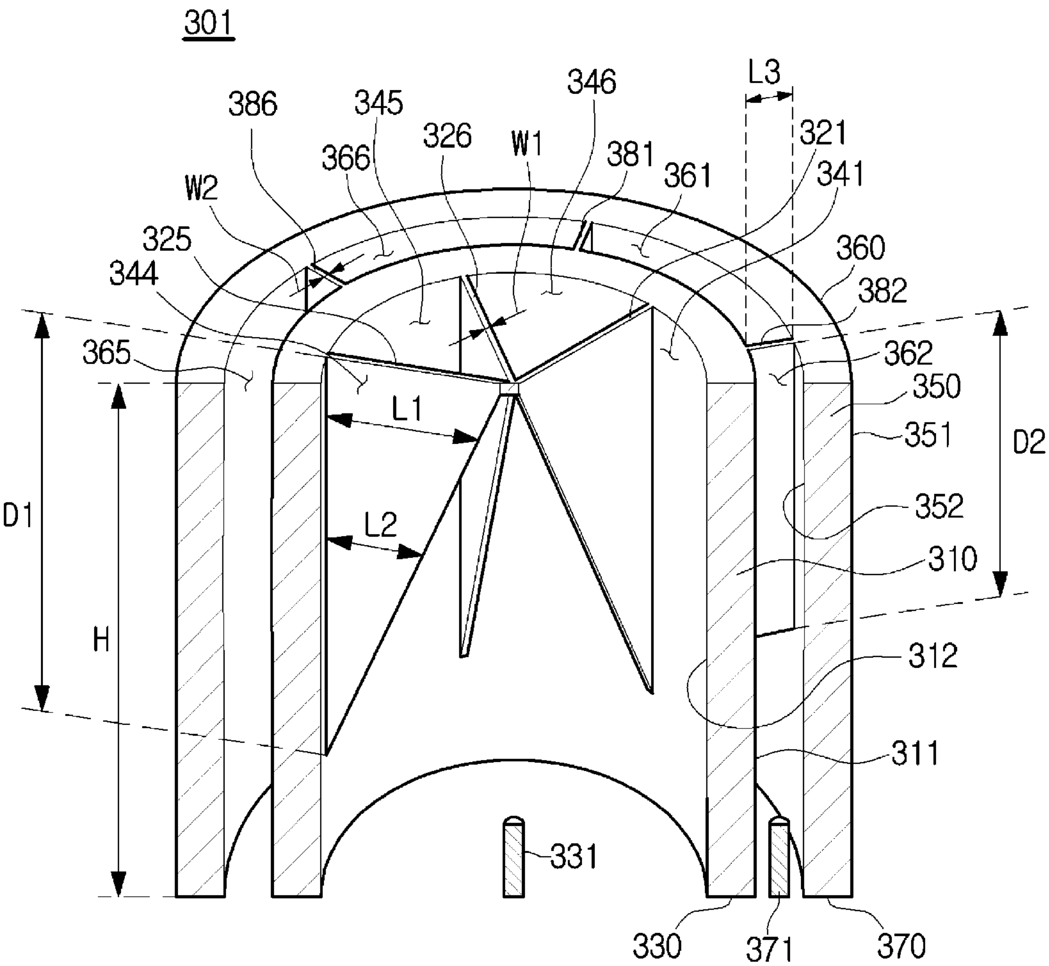
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FIG.19

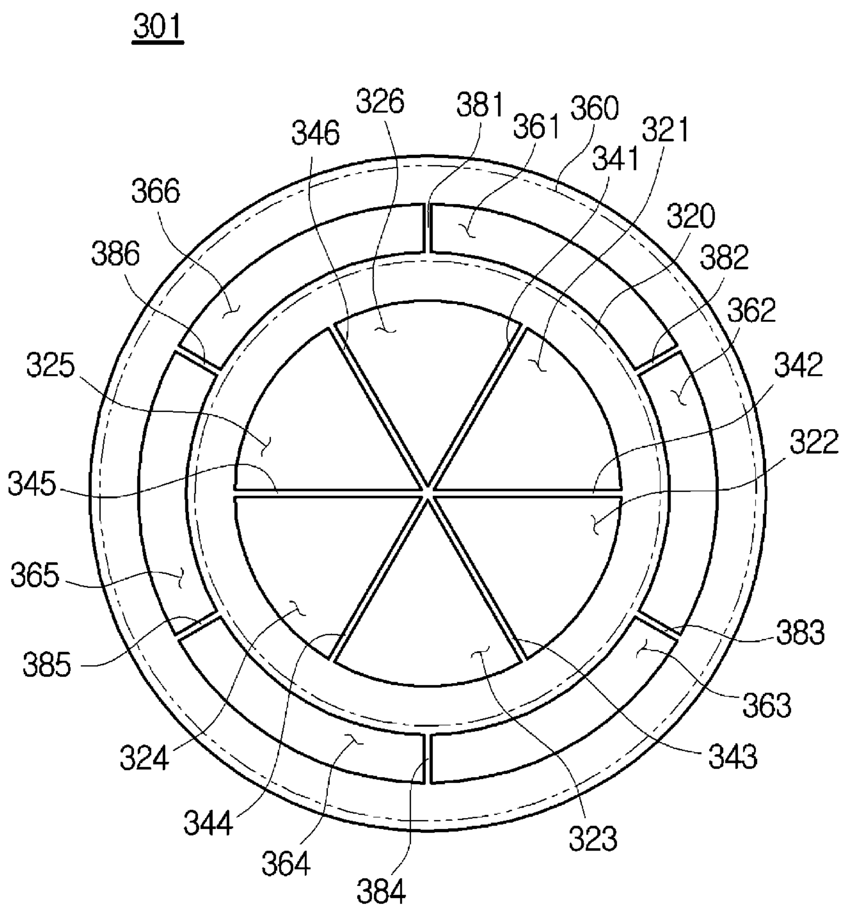
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FIG.20

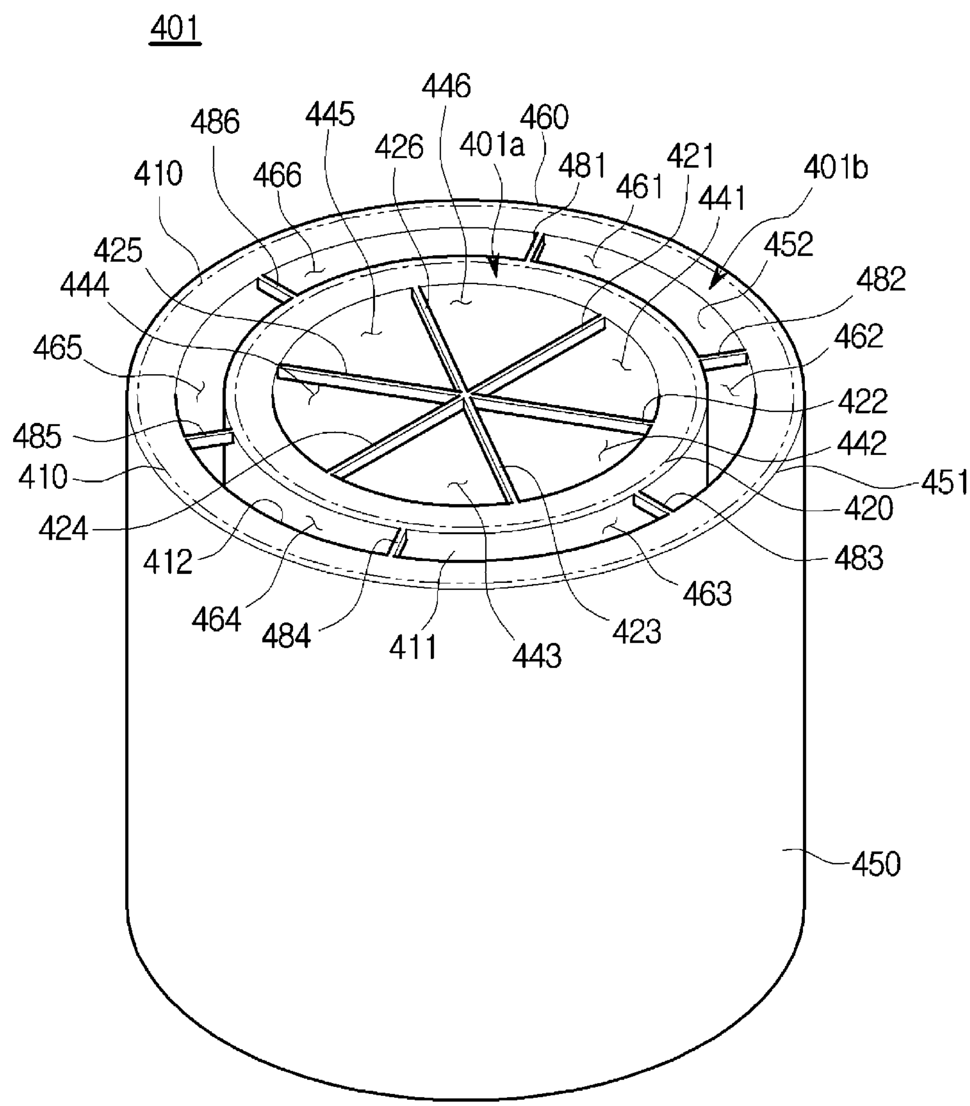

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FIG.21

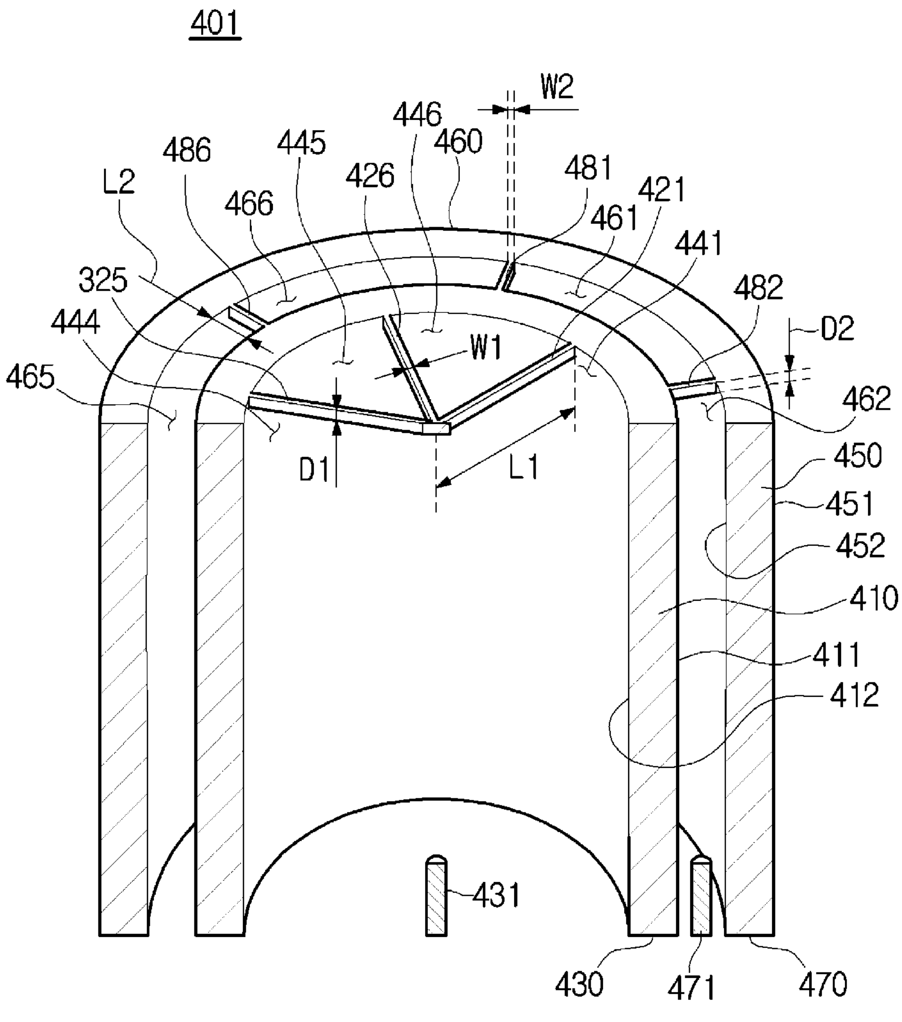
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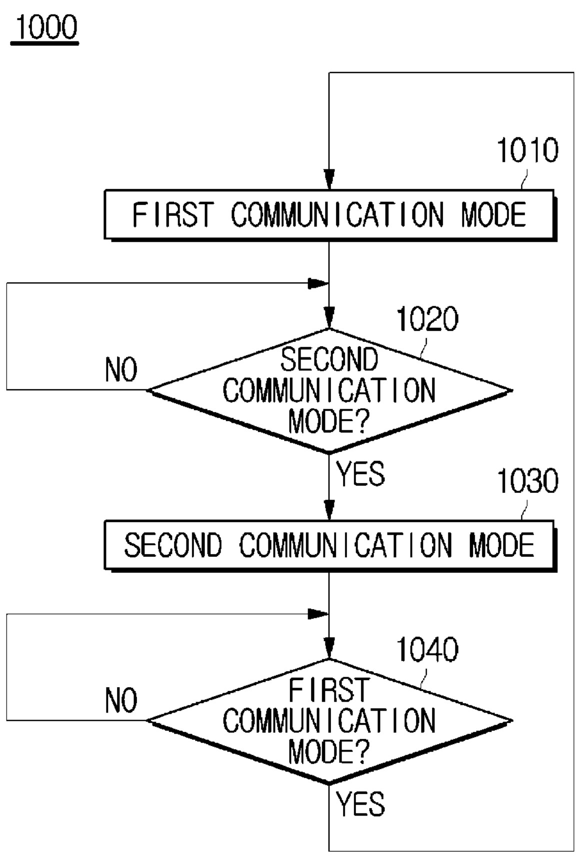
FIG.22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SECOND COMMUNICATION MODE?
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NO
YES

FIG.23

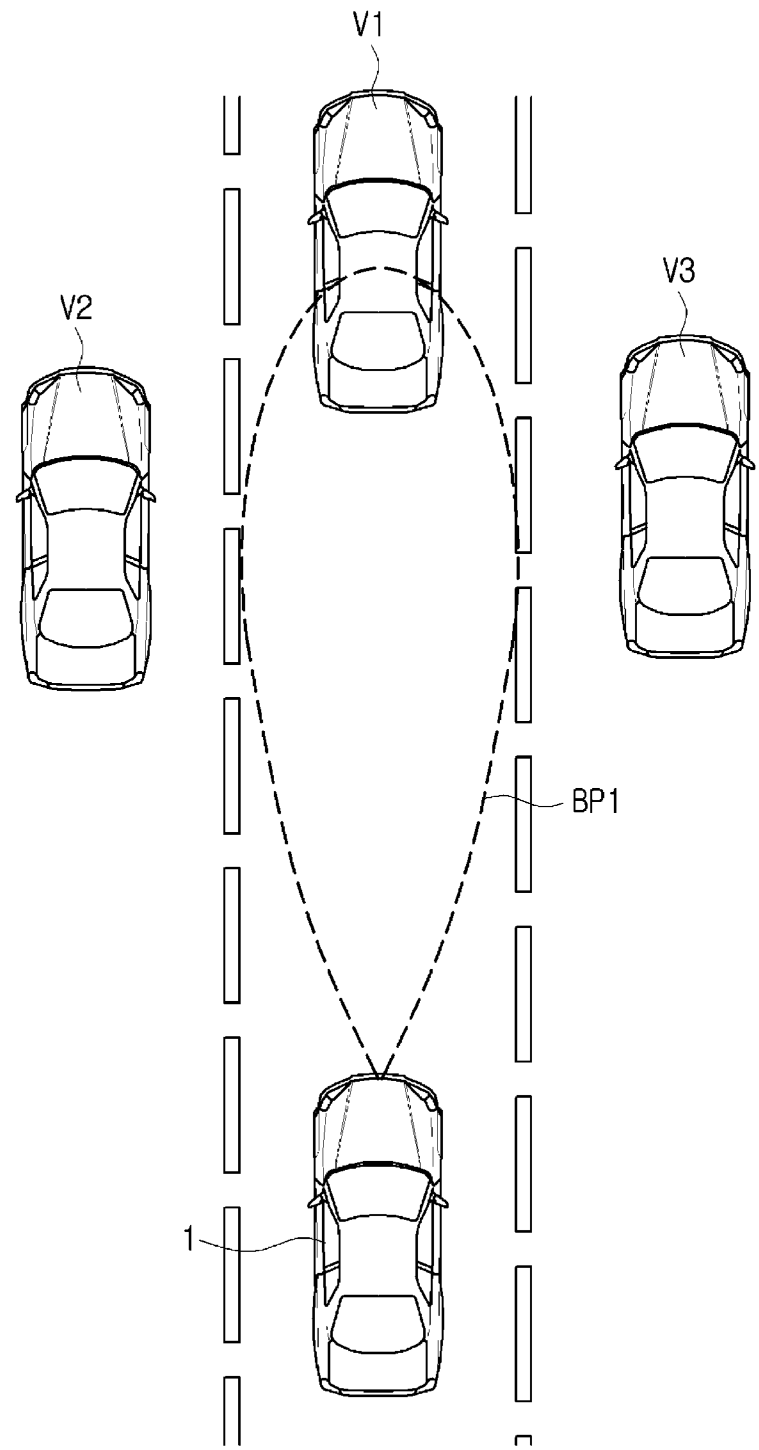
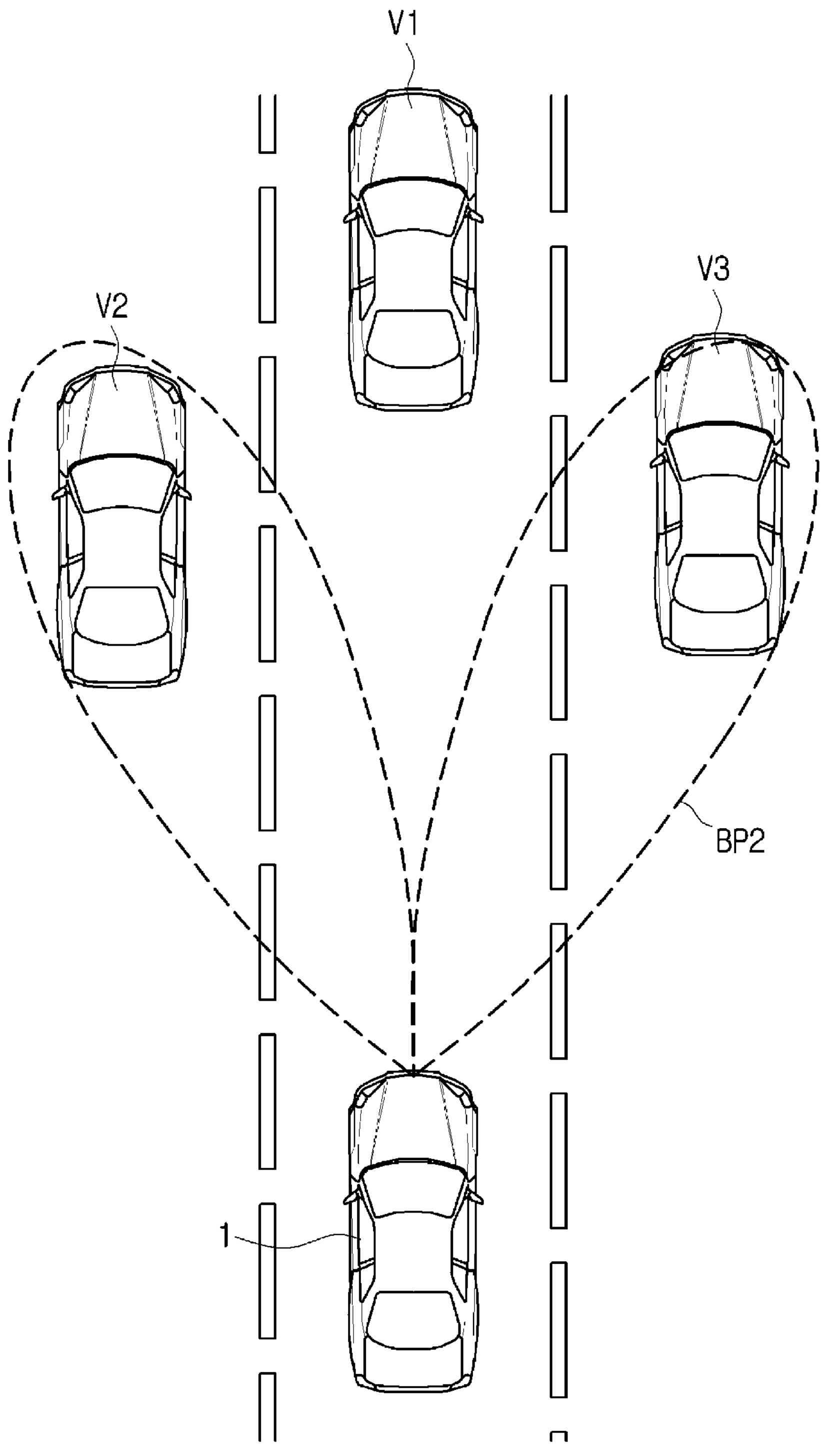


FIG.24



ANTENNA AND VEHICLE HAVING THE ANTENNA

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of priority to Korean Patent Application No. 10-2016-0112487, filed on Sep. 1, 2016 with the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

TECHNICAL FIELD

Embodiments of the present disclosure relate to an antenna and a vehicle having the antenna, and more particularly to an antenna able to generate a variety of radial patterns and a vehicle having the antenna.

BACKGROUND

A vehicle enables transportation on the road using fossil fuel and electricity as a power source.

Recently, it has been common for the vehicle to include an audio device and a video device to allow a driver to listen to music and to watch videos, as well as to simply transport cargo and people. Further, a navigation system has been widely installed in vehicles to display a route to a destination that is desired by the driver.

Recently, there is a growing need for the vehicle to communicate with an external device. For example, in the case of a navigation function, to guide the route to the destination, information about the traffic conditions of the road is required to find the optimal route. Since the traffic conditions frequently change, it may be required for the vehicle to acquire the information about the traffic conditions in real time.

In addition the system for driver's safety has been actively developed, e.g. Forward Collision Warning System (FCWS) and Autonomous Emergency Braking (AEB) for ensuring the safety of the driver and for providing convenience to the driver. The Forward Collision Warning System (FCWS) and Autonomous Emergency Braking (AEB) may estimate whether a collision with a proceeding vehicle is likely and a collision estimated time based on location information of the proceeding vehicle detected by a radar device.

A communication device for communication with the external device and a radar device for the forward collision warning includes an antenna configured to send and receive radio waves.

A car antenna technology currently on the market is limited to a patch antenna array. This is because it is possible to implement a light weight and a thin antenna in such an array. However, for the patch array antenna, there may be a dielectric loss caused by the use of a dielectric substrate and thus the performance of the antenna is significantly reduced due to the dielectric loss. In particular, in 5G communication technology or the radar using several tens of GHz or more as a high frequency, the efficiency of the patch antenna is less than 30%. In addition, the patch array antenna uses a feeding structure in series and thus the patch array antenna has an extremely narrow frequency band characteristic.

SUMMARY

Therefore, it is an aspect of the present disclosure to provide an antenna capable of minimizing a space occupied by the antenna and a vehicle having the same.

It is another aspect of the present disclosure to provide an antenna having a shape similar with a cable transmitting a high frequency electrical signal and a vehicle having the same.

It is another aspect of the present disclosure to provide an antenna capable of outputting radio waves having a directional radial pattern and a vehicle having the same.

It is another aspect of the present disclosure to provide an antenna structure having a plurality of antennas capable of outputting radio waves having a directional radial pattern and a vehicle having the same.

Additional aspects of the present disclosure will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the present disclosure.

In accordance with one aspect of an exemplary embodiment, an antenna may include a first antenna body formed in a hollow cylindrical shape with a first outer surface, a first inner surface and a first radiation surface in a circular shape, a second antenna body accommodating the first antenna body inside the second antenna body and formed in a hollow cylindrical shape with a second outer surface, a second inner surface and a second radiation surface in a ring shape, a plurality of first partitions protruded from the first inner surface to a central axis of the first antenna body and a plurality of second partitions protruded from the second inner surface to the first outer surface of the first antenna body. A plurality of first radiation apertures formed by the plurality of first partitions and configured to radiate a first radio wave may be formed in the first radiation surface, and a plurality of second radiation apertures formed by the plurality of second partitions and configured to radiate a second radio wave may be formed in the second radiation surface.

The plurality of the first radiation apertures may be apart from each other by the same distance along the first inner surface of the first antenna body.

Each of the first radiation apertures may have a sector shape in which the central axis of the first antenna body corresponds to a vertex.

The plurality of the first partitions may make contact with each other in the central axis of the first antenna body.

A cross section of each of the first partitions in the first radiation surface may have a sector shape, and each of the first partitions may have a sector-shaped cone shape, which is extended from the first radiation surface along the first inner surface.

A cross section of each of the first partitions in the first radiation surface may have a sector shape, and each of the first partitions may have a sector-shaped cylindrical shape, which is extended from the first radiation surface along the first inner surface.

Each of the first partitions may be extended from the first inner surface to the central axis of the first antenna body along the first radiation surface and a length protruded toward the central axis may vary inversely with a distance from the first radiation surface.

Each of the first partitions may be extended from the first inner surface to the central axis of the first antenna body along the first radiation surface and a length protruded toward the central axis may be constant.

The plurality of the second radiation apertures may be apart from each other by the same distance along the second inner surface of the second antenna body.

The plurality of the second radiation apertures may be formed between the first outer surface of the first antenna body and the second inner surface of the second antenna body.

The plurality of the second radiation apertures may have a ring shape that is cut by the second partition.

Each of the second partitions may be extended from the second inner surface to the central axis of the second antenna body along the second radiation surface and a width of the second partition may vary inversely with a distance from the second radiation surface.

Each of the second partitions may be extended from the second inner surface to the central axis of the second antenna body along the second radiation surface and a width of the second partition may be constant.

In accordance with one aspect of an exemplary embodiment, a vehicle may include a first antenna and a second antenna, and a selection controller configure to activate any one of the first antenna and the second antenna. The first antenna may included a first antenna body formed in a hollow cylindrical shape with a first outer surface, a first inner surface and a first radiation surface in a circular shape, and a plurality of first partitions protruded from the first inner surface to a central axis of the first antenna body. The second antenna may include a second antenna body configured to accommodate the first antenna body inside the second antenna body, and formed in a hollow cylindrical shape with a second outer surface, a second inner surface and a second radiation surface in a ring shape, and a plurality of second partitions protruded from the second inner surface to the first outer surface of the first antenna body. A plurality of first radiation apertures formed by the plurality of first partitions and configured to radiate a first radio wave may be formed in the first radiation surface, and a plurality of second radiation apertures formed by the plurality of second partitions and configured to radiate a second radio wave may be formed in the second radiation surface.

The plurality of the first and second radiation apertures may be apart from each other by the same distance along the first and second inner surface.

Each of the plurality of the first radiation apertures may have a sector shape in which the central axis of the first antenna body corresponds to vertex.

The plurality of the first partitions may make contact with each other in the central axis of the first antenna body.

The plurality of the second radiation apertures may be formed between the first outer surface of the first antenna body and the second inner surface of the second antenna body.

The first antenna may further include a first feeding pin provided inside of the first antenna body and configured to radiate the first radio wave to the inside of the first antenna body. The second antenna may further include a second feeding pin provided between the first antenna body and the second antenna body and configured to radiate the second radio wave to between the first antenna body and the second antenna body.

A first radio wave radiated from the first feeding pin may be divided by the plurality of the first partitions and radiated via the plurality of the first radiation apertures. A second radio wave radiated from the second feeding pin may be divided by the plurality of the second partitions and radiated via the plurality of the second radiation apertures.

BRIEF DESCRIPTION OF THE DRAWINGS

These and/or other aspects of the disclosure will become apparent and more readily appreciated from the following description of embodiments, taken in conjunction with the accompanying drawings of which:

FIG. **1** is a view illustrating an exterior of a vehicle in accordance with exemplary embodiments of the present disclosure;

FIG. **2** is a view illustrating an electronic device of a vehicle in accordance with exemplary embodiments of the present disclosure;

FIG. **3** is a view illustrating an example of a radar device included in a vehicle in accordance with exemplary embodiments of the present disclosure;

FIG. **4** is a view illustrating an example of a wireless communication device included in a vehicle in accordance with exemplary embodiments of the present disclosure;

FIG. **5** is a view illustrating an antenna structure in accordance with exemplary embodiments of the present disclosure;

FIG. **6** is a view illustrating a first antenna of the antenna structure shown in FIG. **5**;

FIG. **7** is a vertical cross-sectional view illustrating the antenna structure shown in FIG. **5**;

FIGS. **8*a*** and **8*b*** are views illustrating a first partition included in the antenna structure shown in FIG. **5**;

FIG. **9** is a view illustrating a second antenna of the antenna structure shown in FIG. **5**;

FIG. **10** is a vertical cross-sectional view illustrating the antenna structure shown in FIG. **5** in which the first antenna is omitted;

FIGS. **11*a*** and **11*b*** are views illustrating a second partition included in the antenna structure shown in FIG. **5**;

FIG. **12** is a view illustrating a radiation aperture of the antenna structure shown in FIG. **5**;

FIG. **13** is a view illustrating a radial pattern of a radio wave radiated from the first antenna of the antenna structure shown in FIG. **5**;

FIG. **14** is a view illustrating a radial pattern of a radio wave radiated from the second antenna of the antenna structure shown in FIG. **5**;

FIG. **15** is a view illustrating an antenna structure in accordance with exemplary embodiments of the present disclosure;

FIG. **16** is a vertical cross-sectional view illustrating the antenna structure shown in FIG. **15**;

FIG. **17** is a view illustrating an antenna structure in accordance with exemplary embodiments of the present disclosure;

FIG. **18** is a vertical cross-sectional view illustrating the antenna structure shown in FIG. **17**;

FIG. **19** is a view illustrating a radiation aperture of the antenna structure shown in FIG. **17**;

FIG. **20** is a view illustrating an antenna structure in accordance with exemplary embodiments of the present disclosure;

FIG. **21** is a vertical cross-sectional view illustrating the antenna structure shown in FIG. **20**;

FIG. **22** is a flowchart illustrating operations of an antenna included in a vehicle in accordance with exemplary embodiments of the present disclosure;

FIGS. **23** and **24** are views illustrating a radiation pattern of an antenna included in a vehicle in accordance with exemplary embodiments of the present disclosure;

DETAILED DESCRIPTION

The present disclosure will be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the present disclosure are shown. As those skilled in the art would realize, the described embodiments may be modified in various different ways, all without departing from the spirit or scope of the present disclosure.

Parts which are not associated with the description are omitted in order to specifically and clearly describe the present disclosure, and like reference numerals refer to like elements throughout the specification.

FIG. **1** is a view illustrating an exterior of a vehicle in accordance with exemplary embodiments of the present disclosure and FIG. **2** is a view illustrating an electronic device of the vehicle in accordance with exemplary embodiments of the present disclosure.

As illustrated in FIG. **1**, a vehicle **1** may include a body **10** forming an exterior of the vehicle **1** and accommodating a variety of components, and a vehicle wheel **20** moving the vehicle **1**.

The body **10** may include a hood **11**, a front fender **12**, a roof panel **13**, a door **14**, a trunk lid **15** and a quarter panel **16** to form an inner space in which a driver is located. To provide a view to a driver, a front window **17** may be installed in the front side of the body **10** and a side window **18** may be installed in a lateral side of the body **10**. Further, a rear window **19** may be installed in a rear side of the body **10**.

The vehicle wheel **20** may include a front wheel **21** provided in the front side of the vehicle, and a rear wheel **22** provided in the rear side of the vehicle, wherein the vehicle **1** may move back and forth by a rotation of the vehicle wheel **20**.

For the drive of the vehicle **1**, a power system, a powertrain, a steering system, and a brake system may be provided in the inside of the body **10**. The power system may be configured to generate a torque of the vehicle wheel **20** and include an engine, a fuel device, a cooling device, an exhaust system and an ignition system, and the power train may be configured to transmit the torque generated by the power system to the vehicle wheel **20** and include a clutch, a gear lever, a transmission a differential device and a drive shaft. The steering system may be configured to change a driving direction of the vehicle **1** and include a steering wheel, a steering gear and a steering link. In addition, the brake system may be configured to stop a driving of the vehicle **1** by stopping the rotation of the vehicle wheel **20** and include a brake pedal, a master cylinder, a brake disk, and a brake pad.

For the control of the vehicle **1** and the safety and convenience of the passenger and the driver, the vehicle **1** may include a variety of electronic control devices **30** of the vehicle **1**, as well as the above mentioned mechanical devices.

For example, as illustrated in FIG. **2**, the vehicle **1** may include an engine controller **31**, a transmission controller **32**, an electronic braking system **33**, an electric power steering **34**, an Audio/Video/Navigation (AVN) device **35**, a body controller **36**, a radar device **37** and a wireless communication device **38**.

The engine controller **31** may perform a fuel injection control, an air-fuel ratio feedback control, a lean combustion control, an ignition timing control and an idling speed control.

The transmission controller **32** may perform a transmission control, a damper clutch control, a pressure control when a friction clutch is turned on/off and an engine torque control during shifting.

The electronic braking system **33** may control a braking system of the vehicle **1**, and include an Anti-lock Brake System (ABS).

The electric power steering **34** may assist a driver's steering operation by reducing a steering force during driving at a low-speed or during parking, and by increasing the steering force during driving at high-speed.

In response to a user's input, the AVN device **35** may output music or an image or display a route to a destination that is input by the driver.

The body controller **36** may control an operation of the electronic control device configured to provide the convenience to the driver and to secure the safety of the driver. For example, the body controller **36** may control a power window, a door lock device, a wiper, a head lamp, an interior light, a sun roof, a power seat and a seat heating wire.

The radar device **37** may detect an obstacle or another vehicle in a front, rear and/or lateral side of the vehicle **1**. The radar device **37** may be used for a forward collision avoidance function, a lane departure warning function, a blind spot detection function, and a rear detection function. For example, the radar device **37** may include a Forward Collision Warning System (FCW), an Advanced Emergency Braking System (AEBS), an Adaptive Cruise Control (ACC), a Lane Departure Warning System (LDWS), a Lane Keeping Assist System (LKAS), a Blind Spot Detection (BSD) and a Rear-end Collision Warning System (RCW).

The wireless communication device **38** may communicate with another vehicle, a user's terminal or a communication relay device through a wireless communication technology. The wireless communication device **38** may be used for a vehicle to vehicle communication (V2V communication), a vehicle to infrastructure communication (V2I communication), a vehicle to nomadic devices communication (V2N communication) and a vehicle to grid communication (V2G communication).

The wireless communication device **38** may transmit and receive a signal by using a variety of communication protocols. For example, the wireless communication device **38** may employ a 2G communication method, e. g. Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA), a 3G communication method, e. g. Wide Code Division Multiple Access (WCDMA), a Code Division Multiple Access (CDMA) 2000, a Wireless Broadband (Wibro), a World Interoperability for Microwave Access (WiMAX) and a 4G communication method, e. g. Long Term Evolution (LTE) and Wireless Broadband Evolution. In addition, the wireless communication device **38** may employ a 5G communication method.

A variety of the electric control devices **30** included in the vehicle **1** may communicate with each other via a vehicle communication network (NT).

For example, the engine controller **31**, the transmission controller **32**, the electronic braking system **33**, the electric power steering **34**, the Audio/Video/Navigation (AVN) device **35**, the body controller **36**, the radar device **37** and the wireless communication device **38** may send and receive data via the vehicle communication network (NT). The vehicle communication network (NT) may employ a communication standard, e.g. Media Oriented Systems Transport (MOST) having a maximum communication speed of 24.5 (Mega-bits per second) Mbps, FlexRay having a maximum communication speed of 10 Mbps, Controller Area Network (CAN) having a communication speed of 125 (kilo-bits per second) kbps to 1 Mbps, and Local Interconnect Network (LIN) having a communication speed of 20 kbps. The vehicle communication network (NT) may employ a single communication standard, e.g. MOST, FlexRay, CAN and LIN, but also may employ a plurality of communication standards.

The above mentioned electric control device **30** may be an example of electronics installed in the vehicle **1**. In the vehicle **1**, an electronic device that is different from the above mentioned electric control device **30** may be installed, an additional electronic device may be installed other than the above mentioned electric control device **30** and a part of the above mentioned electric control device **30** may be omitted.

Hereinafter, the above mentioned radar device **37** and the wireless communication device **38** will be described in detail.

FIG. **3** is a view illustrating an example of a radar device included in a vehicle in accordance with exemplary embodiments of the present disclosure.

As illustrated in FIG. **3**, the radar device **37** may include a transmitter **42**, a duplexer **43**, a receiver **44**, a radar data processor **45**, a radar controller **46** and an antenna **100**.

The transmitter **42** may generate a radio frequency transmission signal using a radio frequency (RF) signal of a local oscillator.

The duplexer **43** may provide the radio frequency transmission signal received from the transmitter **42** to the antenna **100**, or a reflection signal of the radio frequency received from the antenna **100** to the receiver **44**.

The receiver **44** may extract radar data from the reflection signal received from the duplexer **43** using the radio frequency (RF) signal of the local oscillator.

The radar data processor **45** may extract location information of an object by processing the radar data received from the receiver **44**.

The radar controller **46** may control an operation of the transmitter **42**, the duplexer **43**, the receiver **44**, the radar data processor **45** and the antenna **100**.

The antenna **100** may radiate the radar signal received from the duplexer **43** to a free space and then provide a reflection signal received from the free space to the duplexer **43**.

The antenna **100** may include an antenna structure **101**, a selector switch **102**, and a selection controller **103**.

The antenna structure **101** may include a first antenna **101***a* and a second antenna **101***b*, wherein the first antenna **101***a* and the second antenna **101***b* may have a different radial pattern. For example, the first antenna **101***a* may have a first radial pattern radiating a radio signal in a narrow radiation angle, and the second antenna **101***b* may have a second radial pattern radiating a radio signal in a wide radiation angle.

The selector switch **102** may provide a frequency transmission signal to any one of the first antenna **101***a* and the second antenna **101***b* according to an antenna selection signal of the selection controller **103**, or receive a radio frequency reception signal from any one of the first antenna **101***a* and the second antenna **101***b*. The selector switch **102** may include at least one high frequency transistor.

The selection controller **103** may select any one of the first antenna **101***a* and the second antenna **101***b* according to a control signal of the radar controller **46**, and then provide an antenna selection signal to activate the selected antenna, i.e. the first antenna **101***a* or the second antenna **101***b*, to the selector switch **102**. Further, the selection controller **103** may select any one of the first antenna **101***a* and the second antenna **101***b* according to a signal strength received via the first antenna **101***a* and the second antenna **101***b*.

The selector switch **102** and the selection controller **103** may be implemented by an additional processor or a single processor integrated with the transmitter **42**, the duplexer **43**, the receiver **44**, the radar data processor **45** and/or the radar controller **46**.

As mentioned above, the radar device **37** may radiate the radio frequency transmission signal to the free space via the antenna **100**, and estimate location information of the object by acquiring a reflection signal reflected from the object via the antenna **100**.

FIG. **4** is a view illustrating an example of a wireless communication device included in a vehicle in accordance with exemplary embodiments of the present disclosure.

As illustrated in FIG. **4**, the wireless communication device **38** may include a transmission data processor **51**, a transmitter **52**, a duplexer **53**, a receiver **54**, a reception data processor **55**, a communication controller **56** and an antenna **100**.

The transmission data processor **51** may convert digital transmission data received from another electronic device into a low frequency transmission signal, and provide the low frequency transmission signal to the transmitter **52**.

The transmitter **52** may modulate the low frequency transmission signal into a radio frequency transmission signal using a radio frequency (RF) signal of a local oscillator.

The duplexer **53** may provide the radio frequency transmission signal received from the transmitter **52** to the antenna **100**, or a radio frequency reception signal received from the antenna **100** to the receiver **54**.

The receiver **54** may demodulate the radio frequency reception signal received from the duplexer **53** using the radio frequency (RF) signal of the local oscillator.

The reception data processor **55** may convert a low frequency reception signal received from the receiver **54** into digital reception data.

The communication controller **56** may control an operation of the transmission data processor **51**, the transmitter **52**, the duplexer **53**, the receiver **54**, the reception data processor **55** and the antenna **100**.

The antenna **100** may radiate the radar signal received from the duplexer **53** to a free space and then provide a reflection signal received from the free space to the duplexer **53**.

The antenna **100** may include an antenna structure **101**, a selector switch **102** and a selection controller **103**.

The configuration and the function of the antenna **100** is similar to those of the antenna **100** described in FIG. **3**, and thus a detailed description thereof is replaced by the description of the antenna **100** of FIG. **3**.

As mentioned above, the wireless communication device **38** may transmit the radio frequency transmission signal to an external device via the antenna **100**, and receive the radio frequency reception signal from the external device via the antenna **100**.

The radar device **37** and the wireless communication device **38** may include the antenna **100** in common and the configuration and function of the antenna **100** of the radar device **37** and the antenna **100** of the wireless communication device **38** may be substantially identical to each other.

The performance of the radar device **37** and the wireless communication device **38** may be determined by the property of the antenna **100**. For example, when using millimeter waves in which a frequency is 30-300 GHz (Giga Hertz) and a wavelength is 10-1 mm, the performance of the radar device **37** and the wireless communication device **38** may substantially depend on the properties of the antenna **100**.

Further, an array antenna may be used for improving the performance of the antenna **100**.

Hereinafter an antenna included in a vehicle according to exemplary embodiments of the present disclosure will be described.

FIG. **5** is a view illustrating an antenna structure in accordance with exemplary embodiments of the present disclosure.

As illustrated in FIG. **5**, the antenna structure **101** may include the first antenna **101***a* and the second antenna **101***b*.

The first antenna **101***a* may include a first antenna body **110** having a cylindrical shape with a hollow, i.e., a hollow cylindrical shape, and a second antenna body **150** having a hollow cylindrical shape.

The first antenna body **110** may be disposed inside of the second antenna body **150**. As a result, the first antenna body **110** may have a cylindrical space inside thereof, and a hollow cylindrical space may be formed between the first antenna body **110** and the second antenna body **150**.

A radio wave may be transmitted via the cylindrical space inside of the first antenna body **110**. Further, the radio wave may be transmitted via the hollow cylindrical space between the first antenna body **110** and the second antenna body **150**.

A first radiation surface **120** in a circular shape may be formed in an upper side of the first antenna body **110** to radiate a radio wave to a free space, and a second radiation surface **160** in a ring shape may be formed in an upper side of the second antenna body **150** to radiate a radio wave to the free space.

A plurality of apertures may be formed on the first radiation surface **120** and the second radiation surface **160** respectively, and a detailed description will be described later. A radio wave output from the first antenna **101***a* may be radiated via the aperture of the first radiation surface **120** and a radio wave output from the second antenna **101***b* may be radiated via the aperture of the second radiation surface **160**.

Hereinafter a detailed description of the first antenna **101***a* and the second antenna **101***b* will be described below.

FIG. **6** is a view illustrating a first antenna of the antenna structure shown in FIG. **5**. FIG. **7** is a vertical cross-sectional view illustrating the antenna structure shown in FIG. **5**. Further, FIG. **8** is a view illustrating a first partition included in the antenna structure shown in FIG. **5**.

Referring to FIGS. **6** to **8**, the first antenna **101***a* may include the first antenna body **110** formed in a hollow cylindrical shape.

The first radiation surface **120** and a first feeding surface **130** may be formed in an upper side and a lower side of the first antenna body **110**, respectively. The first radiation surface **120** and the first feeding surface **130** may be formed in a circular shape, and the first radiation surface **120** and the first feeding surface **130** may have the same shape.

On the outside of the first antenna body **110**, a first outer surface **111** may be formed along a circumference of the first radiation surface **120** and the first feeding surface **130**. The first outer surface **111** may be provided between the first radiation surface **120** and the first feeding surface **130** wherein a direction to which the first outer surface **111** is directed is perpendicular to a direction to which the first radiation surface **120** and the first feeding surface **130** are directed.

In the inside of the first antenna body **110**, a hollow, or hollow area, passing through the first antenna body **110** may be formed in a direction perpendicular to the first radiation surface **120** and the first feeding surface **130**. The hollow may have a cylindrical shape and a central axis of the hollow may be identical to a central axis (C) of the first antenna body **110**.

Further, a first inner surface **112** facing the hollow may be formed in the inside of the first antenna body **110**. The first inner surface **112** may be provided between the first radiation surface **120** and the first feeding surface **130** wherein a direction to which the first inner surface **112** is directed is perpendicular to a direction to which the first radiation surface **120** and the first feeding surface **130** are directed.

As a result, the first antenna body **110** may have a hollow cylindrical shape having the first outer surface **111** and the first inner surface **112** together with opposite bottom surfaces, i.e., the radiation surface and the feeding surface.

The first antenna body **110** may be formed of electrically conductive material.

In the inside of the first antenna body **110**, a plurality of first partitions **141**, **142**, **143**, **144**, **145** and **146** may be provided.

As illustrated in FIG. **7**, the plurality of the first partitions **141-146** may be protruded from the first inner surface **112** of the first antenna body **110** to the central axis (C) of the first antenna body **110**. Due to the plurality of the first partitions **141-146**, a part of the first radiation surface **120** of the first antenna body **110** may be closed, and a plurality of first radiation apertures **121**, **122**, **123**, **124**, **125** and **126** may be formed between the plurality of the first partitions **141-146**. A detailed description of the plurality of the first radiation apertures **121-126** will be described below.

According to the drawings, the plurality of the first partitions **141-146** may be provided to be apart from each other by the same distance along the first inner surface **112** of the first antenna body **110**, but the arrangement of the plurality of the first partitions **141-146** is not limited thereto. For example, the plurality of the first partitions **141-146** may be irregularly arranged along the first inner surface **112** of the first antenna body **110**. Further, FIG. **6** illustrates that six first partitions **141-146** are described, but the number of the first partitions is not limited thereto. Thus, the number of the first partitions may be less than or more than six.

The plurality of the first partitions **141-146** may make contact with each other around the central axis (C) of the first antenna body **110**. As a result, an inner space of the first antenna body **110** may be divided by the plurality of the first partitions **141-146**. Particularly, the plurality of the first radiation apertures **121-126** formed by the plurality of the first partitions **141-146** may be not communicated with each other.

A width (W**1** and W**2**) of the plurality of the first partitions **141-146** may vary inversely with a distance from the first inner surface **112** of the first antenna body **110** and closer to the central axis (C) of the first antenna body **110**. Particularly, the width (W**1**) of the plurality of the first partitions **141-146** adjacent to the first inner surface **112** of the first antenna body **110** may be larger than the width (W**2**) of the plurality of the first partitions **141-146** adjacent to the central axis (C) of the first antenna body **110**.

As a result, a horizontal cross section of the plurality of the first partitions **141-146**, i.e. a cross section perpendicular to the central axis (C) of the first antenna body **110**, may have a sector shape. Particularly, the horizontal cross section of the plurality of the first partitions **141-146** in the first radiation surface **120** of the first antenna body **110** may have a sector shape in which the central axis (C) of the first antenna body **110** corresponds to a vertex.

In addition, the plurality of the first partitions **141-146** may be downwardly extended from the first radiation surface **120** of the first antenna body **110** to the first feeding surface **130**.

A distance (D**1**) in which the plurality of the first partitions **141-146** is extended from the first radiation surface **120** to the first feeding surface **130** may be less than a height (H) of the first antenna body **110**. In other words, the plurality of the first partitions **141-146** may be extended from the first radiation surface **120** of the first antenna body **110** to an appropriate height or to the first feeding surface **130**.

In addition, a length (L**1** and L**2**) in which the plurality of the first partitions **141-146** is protruded from the first inner surface **112** of the first antenna body **110** to the central axis (C) may vary inversely with a distance from the first radiation surface **120**. Particularly, as illustrated in FIG. **8**A, the length (L**1**) in which the plurality of the first partitions **141-146** adjacent to the first radiation surface **120** of the first antenna body **110** is extended to the central axis (C) may be larger than the length (L**2**) in which the plurality of the first partitions **141-146** adjacent to the first feeding surface **130** of the first antenna body **110** is extended to the central axis (C).

As a result, a vertical cross section of the plurality of the first partitions **141-146**, i.e., a cross section parallel with the central axis (C) of the first antenna body **110** may have a right triangle shape.

In addition, a horizontal cross section of the plurality of the first partitions **141-146**, that is an area of cross section perpendicular to the central axis (C) of the first antenna body **110**, may vary inversely with a distance from the first radiation surface **120**. Particularly, as illustrated in FIG. **8**B, an area (A**1**) of a horizontal cross section **141***a* of the plurality of the first partitions **141-146** in the first radiation surface **120** of the first antenna body **110** may be larger than an area (A**2**) of a horizontal cross section **141***b* of the plurality of the first partitions **141-146** in the center of the first antenna body **110**.

As a result, the plurality of the first partitions **141-146** may have a polygonal pyramid shape in which a bottom has a sector shape. In addition, a vertical cross section of the sector-shaped cone forming the plurality of the first partitions **141-146** may be a right triangle.

Since the plurality of the first partitions **141-146** has the polygonal pyramid shape in which a bottom has a sector shape, a radio wave inside of the first antenna **101***a* may be smoothly divided along a side wall of the plurality of the first partitions **141-146**, and then radiated to the free space via the plurality of the first radiation apertures **121-126** formed between the plurality of the first partitions **141-146**.

The plurality of the first partitions **141-146** may be formed of electrically conductive material.

FIG. **9** is a view illustrating a second antenna of the antenna structure shown in FIG. **5**. FIG. **10** is a vertical cross-sectional view illustrating the antenna structure shown in FIG. **5** in which the first antenna is omitted. In addition, FIG. **11** is a view illustrating a second partition included in the antenna structure shown in FIG. **5**.

Referring to FIGS. **9** to **11**, the second antenna **101***b* may include the second antenna body **150** formed in a hollow cylindrical shape, wherein the above mentioned the first antenna body **110** of the first antenna **101***a* may be disposed in the hollow of the second antenna **101***b*.

The second radiation surface **160** and a second feeding surface **170** may be formed in an upper side and a lower side of the second antenna body **150**, respectively. The second radiation surface **160** and the second feeding surface **170** may be formed in a ring shape, and the second radiation surface **160** and the second feeding surface **170** may have the same shape.

On the outside of the second antenna body **150**, a second outer surface **151** may be formed along a circumference of the second radiation surface **160** and the second feeding surface **170**. The second outer surface **151** may be provided between the second radiation surface **160** and the second feeding surface **170** wherein a direction to which the second outer surface **151** is directed is perpendicular to a direction to which the second radiation surface **160** and the second feeding surface **170** are directed.

In the inside of the second antenna body **150**, a hollow, or a hollow area, passing through the second antenna body **150** may be formed in a direction perpendicular to the second radiation surface **160** and the second feeding surface **170**. The hollow may have a cylindrical shape and a central axis of the hollow may be identical to a central axis (C) of the second antenna body **150**.

Further, a second inner surface **152** facing the hollow may be formed in the inside of the second antenna body **150**. The second inner surface **152** may be provided between the second radiation surface **160** and the second feeding surface **170** wherein a direction to which the second inner surface **152** is directed is perpendicular to a direction to which the second radiation surface **160** and the second feeding surface **170** are directed.

Therefore, the second antenna body **150** may have a hollow cylindrical shape having the second outer surface **151** and the second inner surface **152** together with opposite bottom surfaces, i.e., the radiation surface and the feeding surface.

The second antenna body **150** may be formed of electrically conductive material.

In the inside of the second antenna body **150**, a plurality of second partitions **181**, **182**, **183**, **184**, **185** and **186** may be provided.

As illustrated in FIG. **10**, the plurality of the second partitions **181-186** may be protruded from the second inner surface **152** of the second antenna body **150** to the first antenna body **110**. Due to the plurality of the second partitions **181-186**, a part of the second radiation surface **160** of the second antenna body **150** may be closed, and a plurality of second radiation apertures **161**, **162**, **163**, **164**, **165** and **166** may be formed between the plurality of the second partitions **181-186**. A detailed description of the plurality of the second radiation apertures **161-166** will be described below.

According to the drawings, the plurality of the second partitions **181-186** may be provided to be apart from each other by the same distance along the second inner surface **152** of the second antenna body **150**, but the arrangement of the plurality of the second partitions **181-186** is not limited thereto. For example, the plurality of the second partitions **181-186** may be irregularly arranged along the second inner surface **152** of the second antenna body **150**. Further, in the drawings, six second partitions **181-186** are described, but the number of the second partitions is not limited thereto. Thus, the number of the second partitions may be less than or more than six.

The plurality of the second partitions **181-186** may make contact with the first antenna body **110**. In other words, the plurality of the second partitions **181-186** may be extended from the second inner surface **152** of the second antenna body **150** to the first outer surface **111** of the first antenna body **110**. As a result, a space between the first antenna body

110 and the second antenna body 150 may be divided by the plurality of the second partitions 181-186. Particularly, the plurality of the second radiation apertures 161-166 formed by the plurality of the second partitions 181-186 may be not communicated with each other.

A width (W3) of the plurality of the second partitions 181-186 may be constant regardless of a distance from the second inner surface 152 of the second antenna body 150. In other words, the width (W3) of the plurality of the second partitions 181-186 adjacent to the second inner surface 152 of the second antenna body 150 may be the same as the width (W3) of the plurality of the second partitions 181-186 adjacent to the first outer surface 111 of the first antenna body 110. As a result, a horizontal cross section of the plurality of the second partitions 181-186, i.e. a cross section perpendicular to the central axis (C) of the second antenna body 150, may have a polygon shape formed by two straight lines facing and being parallel to each other, and two arcs parallel to each other.

However, the width (W3) of the plurality of the second partitions 181-186 is not limited thereto, and thus the width (W3) of the plurality of the second partitions 181-186 may vary according to a distance from the second inner surface 152 of the second antenna body 150. For example, the width (W3) of the plurality of the second partitions 181-186 may vary inversely or directly with a distance from the second inner surface 152 of the second antenna body 150.

The plurality of the second partitions 181-186 may be extended from the second radiation surface 160 of the second antenna body 150 to the second feeding surface 170. In this time, a distance (D2) in which the plurality of the second partitions 181-186 is extended from the second radiation surface 160 to the second feeding surface 170 may be less than a height (H) of the second antenna body 150. In other words, the plurality of the second partitions 181-186 may be extended from the second radiation surface 160 of the second antenna body 150 to a certain height or to the second feeding surface 170.

A width (W3 and W4) of the plurality of the second partitions 181-186 may vary inversely with a distance from the second radiation surface 160 of the second antenna body 150. Particularly, as illustrated in FIGS. 11A and 11B, the width (W3) of the plurality of the second partitions 181-186 adjacent to the second radiation surface 160 of the second antenna body 150 may be larger than the width (W4) of the plurality of the second partitions 181-186 adjacent to a middle height of the second antenna body 150. As a result, the plurality of the second partitions 181-186 may have a triangle shape when viewed from the central axis (C) of the second antenna body 150.

In addition, a horizontal cross section of the plurality of the second partitions 181-186, that is an area of cross section perpendicular to the central axis (C) of the second antenna body 150 may vary inversely with a distance from the second radiation surface 160. Particularly, as illustrated in FIGS. 11A and 11B, an area (A1) of a horizontal cross section 181*a* of the plurality of the second partitions 181-186 in the second radiation surface 160 of the second antenna body 150 may be larger than an area (A2) of a horizontal cross section 181*b* of the plurality of the second partitions 181-186 in the middle of the second antenna body 150.

As mentioned above, since the width (W3 and W4) of the plurality of the second partitions 181-186 vary inversely with a distance from the second radiation surface 160, a radio wave inside of the second antenna body 150 may be smoothly divided along a side wall of the plurality of the second partitions 181-186, and then radiated to the free space via the plurality of the second radiation apertures 161-166 formed between the plurality of the second partitions 181-186.

However, the width (W3 and W4) of the plurality of the second partitions 181-186 is not limited thereto, and thus the width (W3 and W4) of the plurality of the second partitions 181-186 may be constant regardless of a distance from the second radiation surface 160 of the second antenna body 150 or may be increased as being farther from the second radiation surface 160 of the second antenna body 150.

The plurality of the second partitions 181-186 may be formed of electrically conductive material, in the same manner as the second antenna body 150.

The above mentioned first antenna body 110, plurality of first partitions 141-146, second antenna body 150, and plurality of second partitions 181-186 may be integrally formed with each other. For example, the first antenna body 110, the plurality of the first partitions 141-146, the second antenna body 150, and the plurality of the second partitions 181-186 may be integrally manufactured with each other by using a 3D printer or by depositing a plurality of metal plates.

Alternatively, the first antenna body 110, the plurality of the first partitions 141-146, the second antenna body 150, and the plurality of the second partitions 181-186 may be individually manufactured and then assembled with each other.

FIG. 12 is a view illustrating the radiation aperture of the antenna structure shown in FIG. 5.

As illustrated in FIG. 12, the first radiation surface 120 may be divided into the plurality of the first radiation apertures 121-126 by the plurality of the first partitions 141-146, and the second radiation surface 160 may be divided into the plurality of the second radiation apertures 161-166 by the plurality of the second partitions 181-186.

The number of the first and second radiation apertures 121-126 and 161-166 may be determined by the number of first and second partitions 141-146 and 181-186. For example, when the antenna structure 101 includes six first partitions 141-146 and six second partitions 181-186, six first radiation apertures 121-126 and six second radiation apertures 161-166 may be formed. However, the numbers of the first partition and second partition and the numbers of the first radiation aperture and second radiation aperture is not limited to six. Thus, the antenna structure 101 may include less than or more than six first and second partitions, and less than or more than six first and second radiation apertures may be formed.

An area of the first and second radiation apertures 121-126 and 161-166 may be determined by an area occupied by the first and second partitions 141-146 and 181-186. Particularly, the area of the first and second radiation apertures 121-126 and 161-166 may be reduced as the area occupied by the first and second partitions 141-146 and 181-186 is further increased, and the area of the first and second radiation apertures 121-126 and 161-166 may be increased as the area occupied by the first and second partitions 141-146 and 181-186 is further reduced.

Each of first radiation apertures 121-126 may have a sector shape in which a central axis (C1) of the first radiation surface 120 corresponds to a vertex, and each of second radiation apertures 161-166 may have a polygon shape formed by two straight lines facing and being parallel to each other, and two arcs parallel to each other.

When the plurality of the first and second partitions 141-146 and 181-186 are apart from each other by the same distance, each of the area of the first radiation apertures **121-126** may be the same as each other and each of the area of the second radiation apertures **161-166** may be the same as each other. Alternatively, when the plurality of the first and second partitions **141-146** and **181-186** is irregularly disposed, each of the areas of the first radiation apertures **121-126** may be different from each other and each of the areas of the second radiation apertures **161-166** may be different from each other.

Further, a diameter of the first and second radiation surface **120** and **160**, a height of the first and second antenna body **110** and **150**, and an area of the first and second radiation apertures **121-126** and **161-166** may vary according to a frequency of a radio wave intended to be radiated through the antenna structure **101**.

A first feeding pin **131** configured to supply power to the first antenna **101***a* may be provided on the first feeding surface **130** of the first antenna body **110**, and a second feeding pin **171** configured to supply power to the second antenna **101***b* may be provided on the second feeding surface **170** of the second antenna body **150**. At this time, the first and second feeding pin **131** and **171** may be a signal line of a cable (not shown) configured to output a signal to the first and second antenna **101***a* and **101***b*.

The first feeding pin **131** may be provided on a center (C**2**) of the first feeding surface **130**, but a position of the first feeding pin **131** is not limited to the center (C**2**) of the first feeding surface **130**. Thus, the first feeding pin **131** may be disposed on any position of the first feeding surface **130**. In addition, the second feeding pin **171** may be provided on one side of the second feeding surface **170**.

The first and second feeding pins **131** and **171** may receive a high frequency signal, which is intended to be radiated through the first antenna **101***a* and the second antenna **101***b*, from the cable, and radiate the received high frequency signal to the inside of the first antenna **101***a* and the second antenna **101***b*, in the form of radio waves. In other words, a high frequency radio wave may be generated in the inside of the first antenna **101***a* and the second antenna **101***b* by the high frequency signal transmitted to the first and second feeding pins **131** and **171**.

In addition, the high frequency radio wave generated in the inside of the first antenna **101***a* and the second antenna **101***b* may be divided by the plurality of the first and second partitions **141-146** and **181-186**, and then radiated via of the first and second radiation apertures **121-126** and **161-166**. In this time, a distance, in which each of the radio waves radiated via the first and second radiation apertures **121-126** and **161-166** is radiated in the inside of the first antenna **101***a* and the second antenna **101***b*, may be the same as each other. Therefore, a phase and amplitude of the radio wave radiated through the first and second radiation apertures **121-126** and **161-166** may be the same as each other.

As a result, the radio wave radiated from the first antenna **101***a* and the second antenna **101***b* may have the directivity.

FIG. **13** is a view illustrating a radial pattern of a radio wave radiated from the first antenna of the antenna structure shown in FIG. **5**. Particularly, FIG. **13** illustrates the intensity of the radio wave radiated by the first antenna **101***a* about a direction in which the radio wave is radiated, with respect to a direction to which the central axis (C) of the antenna structure **101** is directed.

As illustrated in FIG. **13**, the radio wave radiated from the first antenna **101***a* may be focused in a direction perpendicular to the first radiation surface **120** of the first antenna **101***a*. In other words, the radio wave radiated along the central axis (C) of the first antenna **101***a* may have the strongest electricity and the radio wave radiated from the first antenna **101***a* may have the directivity toward the central axis (C) of the antenna structure **101**.

FIG. **14** is a view illustrating a radial pattern of a radio wave radiated from the second antenna of the antenna structure shown in FIG. **5**. Particularly, FIG. **14** illustrates the intensity of the radio wave radiated by the second antenna **101***b* about a direction in which the radio wave is radiated, with respect to a direction to which the central axis (C) of the antenna structure **101** is directed.

As illustrated in FIG. **14**, the radio wave radiated from the second antenna **101***b* may be focused in a lateral direction of a direction perpendicular to the second radiation surface **160** of the second antenna **101***b*. In other words, the radio wave radiated in a direction that is deviated from the central axis (C) of the second antenna **101***b* with a predetermined angle may have the strongest electricity and the radio wave radiated from the second antenna **101***b* may have the directivity toward a direction with a predetermined angle from the central axis (C) of the second antenna **101***b*. "Predetermined angle" may be determined by the diameter of the second radiation surface **160** of the second antenna **101***b*, the diameter of the first radiation surface **120** of the first antenna **101***a*, the height of the second antenna body **150** and the area of the plurality of the second radiation apertures **161-166**.

As mentioned above, the antenna structure **101** may include the first antenna **101***a* and the second antenna **101***b* having the hollow cylindrical shape, and the first antenna **101***a* and the second antenna **101***b* may have a different radial pattern.

The first antenna **101***a* may radiate a radio wave that is focused in a direction perpendicular to the first radiation surface **120**, and the second antenna **101***b* may radiate a radio wave that is focused in a direction deviated from the direction perpendicular to the second radiation surface **160**, with a predetermined angle therefrom.

Further, since the first and second feeding surface **130** and **170** have circular shapes, it may be easy for them to be connected to a coaxial cable supplying a signal. In addition, the antenna structure **101** may easily adjust an antenna gain by changing the diameter of the first and second antenna body **110** and **150** or changing the area of the first and second radiation apertures **121-126** and **161-166**.

Hereinafter an antenna radiating a radio wave having directivity will be described according to exemplary embodiments of the present disclosure.

FIG. **15** is a view illustrating an antenna structure in accordance with exemplary embodiments of the present disclosure. FIG. **16** is a vertical cross-sectional view illustrating the antenna structure shown in FIG. **15**.

Referring to FIGS. **15** and **16**, an antenna structure **201** may include a first antenna **201***a* and a second antenna **201***b*.

The first antenna **201***a* may include a first antenna body **210** wherein the first antenna body **210** may include a first radiation surface **220**, a first feeding surface **230**, a first outer surface **211** and a first inner surface **212**. Further, the second antenna **201***b* may include a second antenna body **250** wherein the second antenna body **250** may include a second radiation surface **260**, a second feeding surface **270**, a second outer surface **251** and a second inner surface **252**.

The structure of the first and second antenna body **210** and **250** is the same as the structure of the first and second antenna body **110** and **150** shown in FIG. **5**, and thus a detailed description thereof will be replaced by the description of a structure of the first and second antenna body **110** and **150** shown in FIG. **5**.

In the inside of the first antenna body **210**, a plurality of first partitions **241**, **242**, **243**, **244**, **245** and **246** may be provided.

The plurality of the first partitions **241**-**246** may be protruded from the first inner surface **212** of the first antenna body **210** to a central axis (C) of the first antenna body **210**. Due to the plurality of the first partitions **241**-**246**, a part of the first radiation surface **220** of the first antenna body **210** may be closed, and a plurality of first radiation apertures **221**-**226** may be formed between the plurality of the first partitions **241**-**246**.

However, the arrangement and the number of the plurality of the first partitions **241**-**246** may be not limited to those shown in FIGS. **15** and **16**.

The plurality of the first partitions **241**-**246** may make contact with each other around the central axis (C) of the first antenna body **210**. Since the plurality of the first partitions **241**-**246** makes contact with each other around the central axis (C) of the first antenna body **210**, the area around the center (C**1**) of the first radiation surface **220** may be closed.

A width (W**1** and W**2**) of the plurality of the first partitions **241**-**246** may vary inversely with a distance from the first inner surface **212** of the first antenna body **210**. Particularly, the width (W**1**) of the plurality of the first partitions **241**-**246** adjacent to the first inner surface **212** of the first antenna body **210** may be larger than the width (W**2**) of the plurality of the first partitions **241**-**246** adjacent to the central axis (C) of the first antenna body **210**. As a result, a horizontal cross section of the plurality of the first partitions **241**-**246**, i.e. a cross section perpendicular to the central axis (C) of the first antenna body **210**, may have a sector shape in which the central axis (C) of the first antenna body **210** corresponds to a vertex.

The plurality of the first partitions **241**-**246** may be downwardly extended from the first radiation surface **220** of the first antenna body **210** to the first feeding surface **230**. At this time, a distance in which the plurality of the first partitions **241**-**246** is extended from the first radiation surface **220** to the first feeding surface **230**, i.e., a thickness (D**1**) of the plurality of the first partitions **241**-**246** may be less than a height (H) of the first antenna body **210**. Particularly, the thickness (D**1**) of the plurality of the first partitions **241**-**246** may be sufficiently thin and in this case, the plurality of the first partitions **241**-**246** may have a plate shape.

A length (L**1**) in which the plurality of the first partitions **241**-**246** is protruded from the first inner surface **212** of the first antenna body **210** to the central axis (C) may be constant. As a result, a vertical cross section of the plurality of the first partitions **241**-**246**, i.e., a cross section parallel with the central axis (C) of the first antenna body **210** may have a rectangular shape.

As mentioned above, the plurality of the first partitions **241**-**246** may have a polygon column shape in which a bottom thereof is a sector shape, according to the thickness (D**1**) of the plurality of the first partitions **241**-**246**. When the thickness (D**1**) of the plurality of the first partitions **241**-**246** is sufficiently thin, the plurality of the first partitions **241**-**246** may be a sector-shaped plate.

Between the first antenna body **210** and the second antenna body **250**, a plurality of second partitions **281**, **282**, **283**, **284**, **285** and **286** may be provided.

The plurality of the second partitions **281**-**286** may be protruded from the second inner surface **252** of the second antenna body **250** to the first outer surface **211** of the first antenna body **210**. Due to the plurality of the second partitions **281**-**286**, a part of the second radiation surface **260** of the second antenna body **250** may be closed, and a plurality of second radiation apertures **261**-**266** may be formed between the plurality of the second partitions **281**-**286**.

However, the arrangement and the number of the plurality of the second partitions **281**-**286** may be not limited to FIGS. **15** and **16**.

The plurality of the second partitions **281**-**286** may make contact with the first antenna body **210**. As a result, the plurality of the second radiation apertures **261**-**266** formed by the plurality of the second partitions **281**-**286** may not communicate with each other.

A width (W**3**) of the plurality of the second partitions **281**-**286** may be constant regardless of a distance from the second inner surface **252** of the second antenna body **250**. As a result, a horizontal cross section of the plurality of the second partitions **281**-**286**, i.e. a cross section perpendicular to the central axis (C) of the second antenna body **250**, may have a polygon shape formed by two straight lines facing and being parallel to each other, and two arcs parallel to each other.

However, the width (W**3**) of the plurality of the second partitions **281**-**286** is not limited thereto, and thus the width (W**3**) of the plurality of the second partitions **281**-**286** may vary inversely or directly with a distance from the second inner surface **252** of the second antenna body **250**.

The plurality of the second partitions **281**-**286** may be downwardly extended from the second radiation surface **260** of the second antenna body **250** to the second feeding surface **270**. In this time, a distance in which the plurality of the second partitions **281**-**286** is extended from the second radiation surface **260** to the second feeding surface **270**, i.e., a thickness (D**2**) of the plurality of the second partitions **281**-**286** may be less than a height (H) of the second antenna body **250**. Particularly, the thickness (D**2**) of the plurality of the second partitions **281**-**286** may be sufficiently thin and in this case, the plurality of the second partitions **281**-**286** may have a plate shape.

A length (L**2**) in which the plurality of the second partitions **281**-**286** is protruded from the second inner surface **252** of the second antenna body **250** to the first outer surface **211** of the first antenna body **210** may be constant. As a result, a vertical cross section of the plurality of the second partitions **281**-**286**, i.e., a cross section parallel with the central axis (C) may have a rectangular shape.

A width (W**3**) of the plurality of the second partitions **281**-**286** may be constant regardless of a distance from the second radiation surface **260** of the second antenna body **250**. As a result, the plurality of the second partitions **281**-**286** may have a rectangular shape when viewed from the central axis (C) of the second antenna body **250**.

As mentioned above, the plurality of the second partitions **281**-**286** may have a polygon column shape in which a bottom has a polygon shape formed by two straight lines facing and being parallel to each other, and two arcs parallel to each other, according to the thickness (D**2**) of the second partitions **281**-**286**. In addition, when the thickness (D**2**) of the plurality of the second partitions **281**-**286** is sufficiently thin, the plurality of the first partitions **241**-**246** may be a polygon-shaped plate having two straight lines facing and being parallel to each other, and two arcs parallel to each other.

The plurality of the first and second partitions **241**-**246** and **281**-**286**, and the first and second antenna body **210** and **250** may be formed of electrically conductive material, and the plurality of the first and second partitions **241**-**246** and

281-286, and the first and second antenna body **210** and **250** may be integrally manufactured or individually manufactured and then assembled together.

The first radiation surface **220** may be divided into the plurality of the first radiation apertures **221-226** by the plurality of the first partitions **241-246**, and the second radiation surface **260** may be divided into the plurality of the second radiation apertures **261-266** by the plurality of the second partitions **281-286**.

The structures of the first and second radiation apertures **221-226** and **261-266** are the same as the structures of the first and second radiation apertures **121-126** and **161-166** shown in FIG. **12**, and thus a detailed description thereof will be replaced by the description of structures of the first and second radiation apertures **121-126** and **161-166** shown in FIG. **12**.

A first feeding pin **231** configured to supply power to the first antenna **201***a* may be provided on the first feeding surface **230** of the first antenna body **210**, and a second feeding pin **271** configured to supply power to the second antenna **201***b* may be provided on the second feeding surface **270** of the second antenna body **250**.

The structure and function of the first and second feeding pin s**231** and **271** is the same as the structure and function of the first and second feeding pins **131** and **171** shown in FIGS. **7** to **10**, and thus a detailed description thereof will be replaced by the description of structures and functions of the first and second feeding pins **131** and **171** shown in FIGS. **7** to **10**.

A high frequency radio wave generated in the inside of the first antenna **201***a* by the first feeding pin **231** may be divided by the plurality of the first partitions **241-246** and then radiated via of the first radiation apertures **221-226** formed in the first radiation surface **220**. A high frequency radio wave generated in the inside of the second antenna **201***b* by the second feeding pin **271** may be divided by the plurality of the second partitions **281-286** and then radiated via of the second radiation apertures **261-266** formed in the second radiation surface **260**

At this time, since a distance, in which each of the radio waves radiated via the first radiation apertures **221-226** is radiated in the inside of the first antenna **201***a*, may be the same as each other, a phase and amplitude of the radio wave radiated through the first radiation apertures **221-226** may be the same as each other. In addition, since a distance, in which each of the radio waves radiated via the second radiation apertures **261-266** is radiated in the inside of the second antenna **201***b*, may be the same as each other, a phase and amplitude of the radio wave radiated through the second radiation apertures **261-266** may be the same as each other.

Therefore, the radio wave radiated from the first antenna **201***a* and the second antenna **201***b* may have the directivity, respectively.

Hereinafter an antenna radiating a radio wave having directivity will be described according to exemplary embodiments of the present disclosure.

FIG. **17** is a view illustrating an antenna structure in accordance with exemplary embodiments of the present disclosure. FIG. **18** is a vertical cross-sectional view illustrating the antenna structure shown in FIG. **17**. FIG. **19** is a view illustrating a radiation aperture of the antenna structure shown in FIG. **17**.

Referring to FIGS. **17** to **19**, an antenna structure **301** may include a first antenna **301***a* and a second antenna **301***b*.

The first antenna **301***a* may include a first antenna body **310** wherein the first antenna body **310** may include a first radiation surface **320**, a first feeding surface **330**, a first outer surface **311** and a first inner surface **312**. Further, the second antenna **301***b* may include a second antenna body **350** wherein the second antenna body **350** may include a second radiation surface **360**, a second feeding surface **370**, a second outer surface **351** and a second inner surface **352**.

The structure of the first and second antenna body **310** and **350** is the same as the structure of the first and second antenna body **110** and **150** shown in FIG. **5**, and thus a detailed description thereof will be replaced by the description of structure of the first and second antenna body **110** and **150** shown in FIG. **5**.

In the inside of the first antenna body **310**, a plurality of first partitions **341**, **342**, **343**, **344**, **345** and **346** may be provided.

The plurality of the first partitions **341-346** may be protruded from the first inner surface **312** of the first antenna body **310** to a central axis (C) of the first antenna body **310**. Due to the plurality of the first partitions **341-346**, a part of the first radiation surface **320** of the first antenna body **310** may be closed, and a plurality of first radiation apertures **321-326** may be formed between the plurality of the first partitions **341-346**.

However, the arrangement and the number of the plurality of the first partitions **341-346** may be not limited to those shown in FIGS. **17** and **18**.

The plurality of the first partitions **341-346** may make contact with each other around the central axis (C) of the first antenna body **310**. Since the plurality of the first partitions **341-346** makes contact with each other around the central axis (C) of the first antenna body **310**, the area around of the center (C**1**) of the first radiation surface **320** may be closed.

The plurality of the first partitions **341-346** may be formed in a thin plate shape and a width (W) thereof may be constant.

The plurality of the first partitions **341-346** may be downwardly extended from the first radiation surface **320** of the first antenna body **310** to the first feeding surface **330**. In this time, a distance (D**1**) in which the plurality of the first partitions **341-346** is extended from the first radiation surface **320** to the first feeding surface **330** may be less than a height (H) of the first antenna body **310**.

In addition, a length (L**1** and L**2**) in which the plurality of the first partitions **341-346** is protruded from the first inner surface **312** of the first antenna body **310** to the central axis (C) may vary inversely with a distance from the first radiation surface **320**. Particularly, the length (L**1**) in which the plurality of the first partitions **341-346** adjacent to the first radiation surface **320** of the first antenna body **310** is extended to the central axis (C) may be larger than the length (L**2**) in which the plurality of the first partitions **341-346** adjacent to the first feeding surface **330** is extended from to the central axis (C).

As a result, the plurality of the first partitions **341-346** may have a right triangle shape.

Between the first antenna body **310** and the second antenna body **350**, a plurality of second partitions **381**, **382**, **383**, **384**, **385** and **386** may be provided.

The plurality of the second partitions **381-386** may be protruded from the second inner surface **352** of the second antenna body **350** to the first outer surface **311** of the first antenna body **310**. Due to the plurality of the second partitions **381-386**, a part of the second radiation surface **360** of the second antenna body **350** may be closed, and a plurality of second radiation apertures **361-366** may be formed between the plurality of the second partitions **381-386**.

However, the arrangement and the number of the plurality of the second partitions **381**-**386** may be not limited to those shown in FIGS. **17** and **18**.

The plurality of the second partitions **381**-**386** may make contact with the first antenna body **310**. As a result, the plurality of the second radiation apertures **361**-**366** formed by the plurality of the second partitions **381**-**386** may not communicate with each other.

The plurality of the second partitions **381**-**386** may be formed in a thin plate shape and a width (W**2**) thereof may be constant.

The plurality of the second partitions **381**-**386** may be downwardly extended from the second radiation surface **360** of the second antenna body **350** to the second feeding surface **370**. At this time, a distance (D**2**) in which the plurality of the second partitions **381**-**386** is extended from the second radiation surface **360** to the second feeding surface **370** may be less than a height (H) of the second antenna body **350**.

A length (L**3**) in which the plurality of the second partitions **381**-**386** is protruded from the second inner surface **352** of the second antenna body **350** to the first outer surface **311** of the first antenna body **310** may be constant. As a result, a vertical cross section of the plurality of the second partitions **381**-**386**, i.e., a cross section parallel with the central axis (C) may have a rectangular shape.

A width (W**2**) of the plurality of the second partitions **381**-**386** may be constant regardless of a distance from the second radiation surface **360** of the second antenna body **350**. As a result, the plurality of the second partitions **381**-**386** may have a rectangular shape when viewed from the central axis (C) of the second antenna body **350**.

As mentioned above, the plurality of the second partitions **381**-**386** may have a polygon column shape in which a bottom thereof has a polygon shape formed by two straight lines facing and being parallel to each other and two arcs parallel to each other, according to the width (W**2**) of the plurality of the second partitions **381**-**386**. In addition, when the width (W**2**) of the plurality of the second partitions **381**-**386** is sufficiently thin, the plurality of the second partitions **381**-**386** may be a rectangular-shaped plate.

The plurality of the first and second partitions **341**-**346** and **381**-**386**, and the first and second antenna bodies **310** and **350** may be formed of electrically conductive material, and the plurality of the first and second partitions **341**-**346** and **381**-**386**, and the first and second antenna body **310** and **350** may be integrally manufactured or individually manufactured and then assembled together.

As illustrated in FIG. **19**, the first radiation surface **320** may be divided into the plurality of the first radiation apertures **321**-**326** by the plurality of the first partitions **341**-**346**, and the second radiation surface **360** may be divided into the plurality of the second radiation apertures **361**-**366** by the plurality of the second partitions **381**-**386**.

The number of the first and second radiation apertures **321**-**326** and **361**-**366** may be determined by the number of the first and second partitions **341**-**346** and **381**-**386**. In addition, an area of the first and second radiation apertures **321**-**326** and **361**-**366** may be determined by an area occupied by the first and second partitions **341**-**346** and **381**-**386**.

The plurality of the first radiation apertures **321**-**326** may have a sector shape in which the central axis (C) of the first radiation surface **320** corresponds to a vertex, and the plurality of the second radiation apertures **361**-**366** may have a polygon shape formed by two straight lines facing and being parallel to each other, and two arcs parallel to each other.

When the plurality of the first and second partitions **341**-**346** and **381**-**386** is apart from each other by the same distance, each of the area of the first radiation apertures **321**-**326** may be the same as each other and the area of the second radiation apertures **361**-**366** may be the same as each other. Alternatively, when the plurality of the first and second partitions **341**-**346** and **381**-**386** is irregularly disposed, each of the area of the first radiation apertures **321**-**326** may be different from each other and each of the area of the second radiation apertures **361**-**366** may be different from each other

Further, a diameter of the first and second radiation surface **320** and **360**, a height of the first and second antenna body **310** and **350**, and an area of the first and second radiation apertures **321**-**326** and **361**-**366** may vary according to a frequency of a radio wave intended to be radiated through the antenna structure **301**.

A first feeding pin **331** configured to supply power to the first antenna **301***a* may be provided on the first feeding surface **330** of the first antenna body **310**, and a second feeding pin **371** configured to supply power to the second antenna **301***b* may be provided on the second feeding surface **370** of the second antenna body **350**.

The structure and function of the first and second feeding pin **331** and **371** is the same as the structure and function of the first and second feeding pin **131** and **171** shown in FIGS. **7** to **10**, and thus a detailed description thereof will be replaced by the description of a structure and a function of the first and second feeding pin **131** and **171** shown in FIGS. **7** to **10**.

A high frequency radio wave generated in the inside of the first antenna **301***a* by the first feeding pin **331** may be divided by the plurality of the first partitions **341**-**346** and then radiated via of the first radiation apertures **321**-**326** formed in the first radiation surface **320**. A high frequency radio wave generated in the inside of the second antenna **301***b* by the radar device **371** may be divided by the plurality of the second partitions **381**-**386** and then radiated via one of the second radiation apertures **361**-**366** formed in the second radiation surface **360**

At this time, since a distance, in which each of the radio waves radiated via the first radiation apertures **321**-**326** is radiated in the inside of the first antenna **301***a*, may be the same with each other, a phase and amplitude of the radio wave radiated through the first radiation apertures **321**-**326** may be the same as each other. In addition, since a distance, in which each of the radio wave radiated via the second radiation apertures **361**-**366** is radiated in the inside of the second antenna **301***b*, may be the same as each other, a phase and amplitude of the radio wave radiated through the second radiation apertures **361**-**366** may be the same as each other.

As a result, the radio wave radiated from the first antenna **301***a* and the second antenna **301***b* may have the directivity, respectively.

Hereinafter an antenna radiating a radio wave having directivity will be described according to exemplary embodiments of the present disclosure.

FIG. **20** is a view illustrating an antenna structure in accordance with exemplary embodiments of the present disclosure. FIG. **21** is a vertical cross-sectional view illustrating the antenna structure shown in FIG. **20**.

Referring to FIGS. **20** and **21**, an antenna structure **401** may include a first antenna **401***a* and a second antenna **401***b*.

The first antenna **401***a* may include a first antenna body **410** wherein the first antenna body **410** may include a first radiation surface **420**, a first feeding surface **430**, a first outer surface **411** and a first inner surface **412**. Further, the second antenna **401***b* may include a second antenna body **450** wherein the second antenna body **450** may include a second radiation surface **460**, a second feeding surface **470**, a second outer surface **451** and a second inner surface **452**.

The structure of the first and second antenna body **410** and **450** is the same as the structure of the first and second antenna body **110** and **150** shown in FIG. **5**, and thus a detailed description thereof will be replaced by the description of a structure of the first and second antenna body **110** and **150** shown in FIG. **5**.

In the inside of the first antenna body **410**, a plurality of first partitions **441**, **442**, **443**, **444**, **445** and **446** may be provided.

The plurality of the first partitions **441-446** may be protruded from the first inner surface **412** of the first antenna body **410** to a central axis (C) of the first antenna body **410**. A plurality of first radiation apertures **421-426** may be formed between the plurality of the first partitions **441-446**.

However, the arrangement and the number of the plurality of the first partitions **441-446** may be not limited to those shown in FIGS. **20** and **21**.

The plurality of the first partitions **441-446** may make contact with each other around the central axis (C) of the first antenna body **410**. Since the plurality of the first partitions **441-446** makes contact with each other around the central axis (C) of the first antenna body **410**, the area around of the center (C**1**) of the first radiation surface **420** may be closed.

A length (L**1**) in which the plurality of the first partitions **441-446** is protruded from the first inner surface **412** to the central axis (C) may be constant. In addition, a width (W**1**) of the plurality of the first partitions **441-446** may be also constant and the width (W**1**) of the plurality of the first partitions **441-446** may be sufficiently thin.

The plurality of the first partitions **441-446** may be downwardly extended from the first radiation surface **420** of the first antenna body **410** to the first feeding surface **430**. At this time, a distance in which the plurality of the first partitions **441-446** is extended from the first radiation surface **420** to the first feeding surface **430**, i.e., a thickness (D**1**) may be constant and the thickness (D**1**) of the plurality of the first partitions **441-446** may be sufficiently thin.

When the width (W**1**) and the thickness (D**1**) of the plurality of the first partitions **441-446** are sufficiently thin, the plurality of the first partitions **441-446** may have a wire shape.

Between the first antenna body **410** and the second antenna body **450**, a plurality of second partitions **481**, **482**, **483**, **484**, **485** and **486** may be provided.

The plurality of the second partitions **481-486** may be protruded from the second inner surface **452** of the second antenna body **450** to the first outer surface **411** of the first antenna body **410**. Due to the plurality of the second partitions **481-486**, a part of the second radiation surface **460** of the second antenna body **450** may be closed, and a plurality of second radiation apertures **461-466** may be formed between the plurality of the second partitions **481-486**.

However, the arrangement and the number of the plurality of the second partitions **481-486** may be not limited to those shown in FIGS. **20** and **21**.

The plurality of the second partitions **481-486** may make contact with the first antenna body **410**. As a result, the plurality of the second radiation apertures **461-466** formed by the plurality of the second partitions **481-486** may not communicate with each other.

A length (L**2**) in which the plurality of the second partitions **481-486** is protruded from the second inner surface **452** of the second antenna body **450** to the first outer surface **411** of the first antenna body **410** may be constant. In addition, a width (W**2**) of the plurality of the second partitions **481-486** may be also constant and the width (W**2**) of the plurality of the second partitions **481-486** may be sufficiently thin.

The plurality of the second partitions **481-486** may be downwardly extended from the second radiation surface **460** of the second antenna body **450** to the second feeding surface **470**. At this time, a distance in which the plurality of the second partitions **481-486** is extended from the second radiation surface **460** to the second feeding surface **470**, i.e., a thickness (D**2**) may be constant and the thickness (D**2**) of the plurality of the second partitions **481-486** may be sufficiently thin.

When the width (W**2**) and the thickness (D**2**) of the plurality of the second partitions **481-486** are sufficiently thin, the plurality of the second partitions **481-486** may have a wire shape.

The plurality of the first and second partitions **441-446** and **481-486**, and the first and second antenna body **410** and **450** may be formed of electrically conductive material, and the plurality of the first and second partitions **441-446** and **481-486**, and the first and second antenna body **410** and **450** may be integrally manufactured or individually manufactured and then assembled together.

The first radiation surface **420** may be divided into the plurality of the first radiation apertures **421-426** by the plurality of the first partitions **441-446**, and the second radiation surface **460** may be divided into the plurality of the second radiation apertures **461-466** by the plurality of the second partitions **481-486**.

The structure of the first and second radiation apertures **421-426** and **461-466** is the same as the structure of the first and second radiation apertures **321-326** and **361-366** shown in FIG. **19**, and thus a detailed description thereof will be replaced by the description of structure of the first and second radiation apertures **321-326** and **361-366** shown in FIG. **19**.

A first feeding pin **431** configured to supply power to the first antenna **401***a* may be provided on the first feeding surface **430** of the first antenna body **410**, and a second feeding pin **471** configured to supply power to the second antenna **401***b* may be provided on the second feeding surface **470** of the second antenna body **450**.

The structure and function of the first and second feeding pins **431** and **471** is the same as the structure and function of the first and second feeding pins **131** and **171** shown in FIGS. **7** to **10**, and thus a detailed description thereof will be replaced by the description of structure and function of the first and second feeding pins **131** and **171** shown in FIGS. **7** to **10**.

A high frequency radio wave generated in the inside of the first antenna **401***a* by the first feeding pin **431** may be divided by the plurality of the first partitions **441-446** and then radiated via one of the first radiation apertures **421-426** formed in the first radiation surface **420**. A high frequency radio wave generated in the inside of the second antenna **401***b* by the second feeding pin **471** may be divided by the plurality of the second partitions **481-486** and then radiated via one of the second radiation apertures **461-466** formed in the second radiation surface **460**.

At this time, since a distance, in which each of the radio wave radiated via the first radiation apertures **421-426** is radiated in the inside of the first antenna **401***a*, may be the same as each other, a phase and amplitude of the radio wave radiated through the first radiation apertures **421**-**426** may be the same as each other. In addition, since a distance, in which each of the radio waves radiated via the first radiation apertures **461**-**466** is radiated in the inside of the second antenna **401***b*, may be the same as each other, a phase and amplitude of the radio wave radiated through the second radiation apertures **461**-**466** may be the same as each other.

As a result, the radio wave radiated from the first antenna **401***a* and the second antenna **401***b* may have the directivity, respectively.

Hereinbefore the antenna structure **101**, **201**, **301** and **401** having a hollow cylindrical shape or a cylindrical shape has been described, but the shape of the antenna structure is not limited to the hollow cylindrical shape or the cylindrical shape. For example, the antenna structure may have a truncated cone shape in which a diameter of the radiation surface is different from a diameter of the feeding surface.

Hereinafter an operation of an antenna **100** including the antenna structure will be described.

FIG. **22** is a view illustrating an operation of an antenna included in a vehicle in accordance with exemplary embodiments of the present disclosure. FIGS. **23** and **24** are views illustrating a radiation pattern of the antenna included in the vehicle in accordance with n exemplary embodiments of the present disclosure.

An operation **1000** of the antenna **100** will be described with reference to FIGS. **22** to **24**.

The antenna **100** may be operated in a first communication mode (**1010**).

During the first communication mode, the antenna **100** may activate the first antenna **101***a*.

Particularly, the selection controller **103** of the antenna **100** may provide a first antenna selection signal to select the first antenna **101***a* to the selector switch **102**. In addition, the selector switch **102** receiving the first antenna selection signal may activate the first antenna **101***a* and inactivate the second antenna **101***b*.

As a result, as illustrated in FIG. **23**, a first radiation pattern (BP**1**) may be generated by the first antenna **101***a*. In other words, the first antenna **101***a* may radiate a radio wave having directivity, and the radio wave radiated from the first antenna **101***a* may have directivity toward the front of the vehicle **1**. Therefore, the vehicle **1** may communicate with a first vehicle (V**1**) in a front direction.

During the first communication mode, the antenna **100** may determine whether to switch to a second communication mode (**1020**).

The antenna **100** may be switched to the second communication mode according to various conditions.

For example, when a signal strength, which is received by the first antenna **101***a* activated during the first communication mode, is less than a first reference strength, the selector switch **102** may switch the operation mode of the antenna **100** to the second communication mode.

In another example, when a second communication mode switch signal is received from the radar controller **46** or the communication controller **57** during the first communication mode, the selector switch **102** may switch the operation mode of the antenna **100** to the second communication mode.

When a condition for switching to the second communication mode is achieved (YES of **1020**), the antenna **100** may be operated in the second communication mode (**1030**).

During the second communication mode, the antenna **100** may activate the second antenna **101***b*. Particularly, the selection controller **103** of the antenna **100** may provide a second antenna selection signal to select the second antenna **101***b* to the selector switch **102**. In addition, the selector switch **102** receiving the second antenna selection signal may activate the second antenna **101***b* and inactivate the first antenna **101***a*.

As a result, as illustrated in FIG. **24**, a second radiation pattern (BP**2**) may be generated by the second antenna **101***b*. In other words, the second antenna **101***b* may radiate a radio wave having directivity, and the radio wave radiated from the second antenna **101***b* may have directivity toward a direction that is deviated from the front of the vehicle **1** with a predetermined angle. Therefore, the vehicle **1** may communicate with a second vehicle (V**2**) or a third vehicle (V**3**) in front of the vehicle **1**.

During the second communication mode, the antenna **100** may determine whether to switch to the first communication mode (**1040**).

The antenna **100** may be switched to the first communication mode according to various conditions.

For example, when a signal strength, which is received by the second antenna **101***b* activated during the second communication mode, is less than a second reference strength, the selector switch **102** may switch the operation mode of the antenna **100** to the first communication mode.

In another example, when a first communication mode switch signal is received from the radar controller **46** or the communication controller **57** during the second communication mode, the selector switch **102** may switch the operation mode of the antenna **100** to the first communication mode.

When a condition for switching to the first communication mode is achieved (YES of **1040**), the antenna **100** may be operated in the first communication mode (**1010**).

As mentioned above, the antenna **100** may be set as the first communication mode or the second communication mode. Further, the radiation pattern of the radio wave radiated by the antenna **100** in the first communication mode and the radiation pattern of the radio wave radiated by the antenna **100** in the second communication mode may be different from each other.

As is apparent from the above description, according to the proposed antenna and vehicle having the same, it may be possible to minimize a space occupied by the antenna.

In addition, it may be possible to provide the antenna having a shape similar to a cable capable of transmitting a high frequency electrical signal and a vehicle having the same.

It may be possible to provide the antenna capable of outputting radio waves having a directional radial pattern and a vehicle having the same.

It may also be possible to provide the antenna structure having a plurality of antenna capable of outputting radio waves having a directional radial pattern and a vehicle having the same.

Although exemplary embodiments of the present disclosure have been shown and described, it would be appreciated by those skilled in the art that changes may be made to these embodiments without departing from the principles and spirit of the disclosure, the scope of which is defined in the claims and their equivalents.

What is claimed is:

1. An antenna comprising:

a first antenna body formed as a hollow cylindrical shape having a first outer surface, a first inner surface and a first radiation surface formed in a circular shape;

a second antenna body accommodating the first antenna body inside the second antenna body, the second antenna body formed as a hollow cylindrical shape with a second outer surface, a second inner surface and a second radiation surface formed in a ring shape;

a plurality of first partitions protruding from the first inner surface to a central axis of the first antenna body; and

a plurality of second partitions protruding from the second inner surface to the first outer surface of the first antenna body,

wherein a plurality of first radiation apertures, formed by the plurality of first partitions for radiating a first radio wave, is formed on the first radiation surface, and

a plurality of second radiation apertures, formed by the plurality of second partitions for radiating a second radio wave, is formed on the second radiation surface.

2. The antenna of claim **1**, wherein each of the plurality of the first radiation apertures are apart from each other by the same distance along the first inner surface of the first antenna body.

3. The antenna of claim **1**, wherein each of the first radiation apertures has a sector shape in which the central axis of the first antenna body corresponds to a vertex.

4. The antenna of claim **1**, wherein each of the plurality of the first partitions make contact with each other in the central axis of the first antenna body.

5. The antenna of claim **1**, wherein a cross section of each of the first partitions in the first radiation surface has a sector shape, and each of the first partitions has a sector-shaped cone shape, which is extended from the first radiation surface along the first inner surface.

6. The antenna of claim **1**, wherein a cross section of each of the first partitions in the first radiation surface has a sector shape, and each of the first partitions has a sector-shaped cylindrical shape, which is extended from the first radiation surface along the first inner surface.

7. The antenna of claim **1**, wherein each of the first partitions is extended from the first inner surface to the central axis of the first antenna body along the first radiation surface and a length protruded toward the central axis varies inversely with a distance from the first radiation surface.

8. The antenna of claim **1**, wherein each of the first partitions is extended from the first inner surface to the central axis of the first antenna body along the first radiation surface and a length protruded toward the central axis is constant.

9. The antenna of claim **1**, wherein each of the plurality of the second radiation apertures are apart from each other by the same distance along the second inner surface of the second antenna body.

10. The antenna of claim **1**, wherein the plurality of the second radiation apertures is formed between the first outer surface of the first antenna body and the second inner surface of the second antenna body.

11. The antenna of claim **1**, wherein the plurality of the second radiation apertures has a ring shape that is cut by the second partition.

12. The antenna of claim **1**, wherein each of the second partitions is extended from the second inner surface to the central axis of the second antenna body along the second radiation surface and a width of the second partition varies inversely with a distance from the second radiation surface.

13. The antenna of claim **1**, wherein each of the second partitions is extended from the second inner surface to the central axis of the second antenna body along the second radiation surface and a width of the second partition is constant.

14. A vehicle comprising:

a first antenna and a second antenna; and

a selection controller for activating any one of the first antenna and the second antenna,

wherein the first antenna comprises:

a first antenna body formed as a hollow cylindrical shape having a first outer surface, a first inner surface and a first radiation surface formed in a circular shape; and

a plurality of first partitions protruded from the first inner surface to a central axis of the first antenna body; and

the second antenna comprises:

a second antenna body accommodating the first antenna body inside the second antenna body and formed as a hollow cylindrical shape having a second outer surface, a second inner surface and a second radiation surface in a ring shape; and

a plurality of second partitions protruded from the second inner surface to the first outer surface of the first antenna body,

wherein a plurality of first radiation apertures formed by the plurality of first partitions for radiating a first radio wave is formed in the first radiation surface and,

a plurality of second radiation apertures formed by the plurality of second partitions for radiating a second radio wave is formed in the second radiation surface.

15. The vehicle of claim **14**, wherein the plurality of the first and second radiation apertures are apart from each other by the same distance along the first and second inner surface.

16. The vehicle of claim **14**, wherein each of the plurality of the first radiation apertures has a sector shape in which the central axis of the first antenna body corresponds to vertex.

17. The vehicle of claim **14**, wherein each of the plurality of the first partitions makes contact with each other in the central axis of the first antenna body.

18. The vehicle of claim **14**, wherein the plurality of the second radiation apertures is formed between the first outer surface of the first antenna body and the second inner surface of the second antenna body.

19. The vehicle of claim **14**, wherein the first antenna further comprises a first feeding pin provided inside of the first antenna body for radiating the first radio wave to the inside of the first antenna body, and

the second antenna further comprises a second feeding pin provided between the first antenna body and the second antenna body radiates the second radio wave to between the first antenna body and the second antenna body.

20. The vehicle of claim **14**, wherein the first radio wave radiated from the first feeding pin is divided by the plurality of the first partitions and radiated via the plurality of the first radiation apertures, and

the second radio wave radiated from the second feeding pin is divided by the plurality of the second partitions and radiated via the plurality of the second radiation apertures.

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