(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 283 780 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
29.11.2023 Bulletin 2023/48

(21) Application number: **21922564.6**

(22) Date of filing: **13.12.2021**

(51) International Patent Classification (IPC):
H01Q 1/36 *(2006.01)* ***H01Q 1/38*** *(2006.01)*
H01Q 1/48 *(2006.01)* ***H01Q 1/50*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
H01Q 1/36; H01Q 1/38; H01Q 1/48; H01Q 1/50

(86) International application number:
PCT/CN2021/137447

(87) International publication number:
WO 2022/160974 (04.08.2022 Gazette 2022/31)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **01.02.2021 CN 202110139300**

(71) Applicant: **Huawei Technologies Co., Ltd.**
Shenzhen, Guangdong 518129 (CN)

(72) Inventors:
- **TAO, Jun**
  Shenzhen, Guangdong 518129 (CN)
- **PENG, Jie**
  Shenzhen, Guangdong 518129 (CN)
- **WANG, Zhiding**
  Xi'an, Shaanxi 710126 (CN)
- **LI, Long**
  Xi'an, Shaanxi 710126 (CN)

(74) Representative: **Huawei European IPR**
Huawei Technologies Duesseldorf GmbH
Riesstraße 25
80992 München (DE)

(54) ANTENNA, DETECTION APPARATUS, RADAR AND TERMINAL

(57) An antenna, a detection apparatus, a radar, and a terminal are provided. The antenna includes a first medium substrate, a feeder, a plurality of coupling patches, and a plurality of parasitic patches. The feeder and the coupling patches are located on a side of the first medium substrate, and the coupling patches are sequentially arranged along an extension direction of the feeder. There is a slot between at least one coupling patch and the feeder. The plurality of parasitic patches are located on a side, of the first medium substrate, away from the first medium substrate, and at least one of the plurality of parasitic patches corresponds to at least one coupling patch. An orthographic projection of a parasitic patch in the at least one parasitic patch on the first medium substrate at least partially overlaps an orthographic projection of a slot between the feeder and a coupling patch that corresponds to the parasitic patch on the first medium substrate. In this way, coupling feeding is implemented between the coupling patch and the feeder in a slot coupling form, and the parasitic patch is excited by a coupling slot. Finally, the coupling patch and the parasitic patch are excited at the same time to implement different resonance frequencies, thereby broadening an operating bandwidth and implementing a broadband feature.

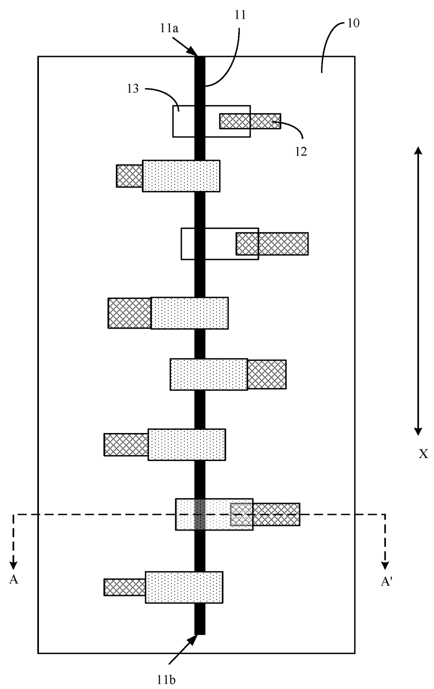


FIG. 1

Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Chinese Patent Application No. 202110139300.8, filed with the China National Intellectual Property Administration on February 1, 2021 and entitled "ANTENNA, DETECTION APPARATUS, RADAR, AND TERMINAL", which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] This application relates to the sensing field, and in particular, to an antenna, a detection apparatus, a radar, and a terminal, which may be applied to automated driving, intelligent driving, or self driving.

BACKGROUND

[0003] With social development, intelligent terminals such as intelligent transportation devices, smart home devices, and robots, are gradually becoming a part of people's daily lives. Sensors play a very important role in the intelligent terminals. Various sensors, such as a mmWave radar, a lidar, a camera, and an ultrasonic radar, that are installed on the intelligent terminals, sense a surrounding environment, collect data, recognize and track a moving object, recognize a static scene such as a lane line or a signboard, and plan a route in combination with a navigator and map data during the movement of the intelligent terminals. The sensors can detect a potential danger in advance, and assist in taking or even independently take, a necessary avoidance measure, thereby effectively improving security and comfort of the intelligent terminals.

[0004] The intelligent terminal being an intelligent transportation device is used as an example. A mmWave antenna first becomes a major sensor of a self-driving system and a driver assistance system thanks to relatively low costs and relatively mature technologies. Currently, more than 10 functions have been developed for an advanced driver assistance system (Advanced Driver Assistance System, ADAS), including adaptive cruise control (Adaptive Cruise Control, ACC), autonomous emergency braking (Autonomous Emergency Braking, AEB), lane change assist (Lane Change Assist, LCA), and blind spot detection (Blind Spot Detection, BSD), all of which would be impossible without the mmWave antenna.

[0005] To meet various changeable and complex application environments of the intelligent transportation device, an antenna needs to satisfy requirements such as a large bandwidth, a wide beam, and a low side lobe. A wider bandwidth indicates that the antenna can support more operating frequency bands, and can therefore support transmission with a higher channel capacity. Currently, a common antenna has a limited operating bandwidth due to a single resonance mode. Therefore, how to improve the bandwidth of an antenna is one of technical problems that need to be urgently resolved by a skilled person.

SUMMARY

[0006] This application provides an antenna, a detection apparatus, a radar, and a terminal, to broaden an operating bandwidth of the antenna.

[0007] According to a first aspect, this application provides an antenna. The antenna includes a first medium substrate, a feeder, a plurality of coupling patches, and a plurality of parasitic patches. The feeder and the plurality of coupling patches are located on a side of the first medium substrate, the plurality of coupling patches are sequentially arranged along an extension direction X of the feeder, and there is a slot between the feeder and at least one of the plurality of coupling patches, so that coupling feeding can be implemented between the coupling patch and the feeder in a slot coupling form. The plurality of parasitic patches are located on a side, of the first medium substrate, away from the first medium substrate, and at least one of the plurality of parasitic patches corresponds to at least one of the coupling patches. In the parasitic patch that corresponds to the coupling patch, an orthographic projection of the parasitic patch on the first medium substrate at least partially overlaps an orthographic projection of a slot between the feeder and the coupling patch that corresponds to the parasitic patch on the first medium substrate. In this way, the parasitic patch is excited by a coupling slot, and finally the coupling patch and the parasitic patch are excited at the same time to implement different resonance frequencies, thereby broadening an operating bandwidth and implementing a broadband feature. In addition, in this application, the coupling patch radiates jointly with the parasitic patch, to implement a far-field radiation pattern through superposition of electromagnetic waves. Because both the parasitic patch and the coupling patch can implement independent resonance, the antenna in this application is a dual-resonance antenna.

[0008] A start end of the feeder is configured to implement feeding of the antenna, and a termination end of the feeder may be in an open state or a short-circuited state. When in the open state, the termination end of the feeder is in a free extending state, and is not connected to any conductor. When in the short-circuited state, the termination end of the feeder is used for grounding.

[0009] The antenna further includes a ground layer. The ground layer is configured for grounding, and the ground layer is located on a side, of the first medium substrate, away from the parasitic patch. During specific implementation, both the feeder and the coupling patch need to be disposed in isolation from the ground layer.

[0010] For example, the antenna may further include a second medium substrate. The second medium substrate is located on a side, of the first medium substrate, away from the parasitic patch. The parasitic patch is located on the first medium substrate. The feeder and the coupling patch are located on the second medium substrate, and are located on a side, of the second medium substrate, facing the first medium substrate. In this way, the feeder and the coupling patch are disposed in isolation from the ground layer by using the second medium substrate.

[0011] In actual production, a parasitic patch may be formed on a first medium substrate by using a printed circuit board (printed circuit board, PCB) process, and a coupling patch may be formed on a second medium substrate by using a PCB process. This leads to an antenna with a simple structure, a low profile, easy integration, and a low cost, that is suitable for mass production.

[0012] It may be understood that, in this application, the feeder, the plurality of coupling patches, and the plurality of parasitic patches are one set of array elements. There may be one set of array elements on the ground layer, or certainly, there may be a plurality of sets of array elements, which is not limited herein.

[0013] The parasitic patch and the coupling patch are not limited to specific shapes and sizes in this application, and may be designed and debugged based on requirements of coupling degrees and impedance.

[0014] During specific implementation, the coupling patch may be in the shape of a regular pattern, such as a rectangle or an ellipse, or certainly may be in the shape of an irregular pattern. The parasitic patch may be in the shape of a regular pattern, for example, a rectangle or an ellipse, or certainly may be in the shape of an irregular pattern.

[0015] In this application, the feeder may be in the shape of a straight line, a broken line, or a curve, such as a sawtooth (zigzag), a wave, or a bow. This is not limited herein.

[0016] It may be understood that a quantity of coupling patches and a quantity of parasitic patches are not limited in this application. The quantity of coupling patches may be the same as or different from the quantity of parasitic patches. For example, the quantity of parasitic patches may be set to be the same as a quantity of coupling patches having a slot with the feeder, so that each parasitic patch corresponds to one slot.

[0017] In this application, to ensure coupling performance, a distance between a center of the orthographic projection of the parasitic patch in the at least one parasitic patch on the first medium substrate and a center of the orthographic projection of the slot between the feeder and the coupling patch that corresponds to the parasitic patch on the first medium substrate is less than a preset value.

[0018] In this application, to ensure consistency of radiation features, when a quantity of parasitic patches in the at least one parasitic patch is greater than 1, for each parasitic patch that corresponds to a coupling patch, position vectors of centers, of orthographic projections of all parasitic patches on the first medium substrate, relative to centers of orthographic projections of slots between the feeder and the coupling patches that correspond to the parasitic patches on the first medium substrate are equal. This ensures consistency of radiation features.

[0019] Further, to ensure consistency of radiation features, for each parasitic patch that corresponds to a coupling patch, a center of an orthographic projection of the parasitic patch in the at least one parasitic patch on the first medium substrate overlaps a center of an orthographic projection of a slot between the feeder and a coupling patch that corresponds to the parasitic patch on the first medium substrate. The "overlap" herein is not a strict geometrical overlap, but a deviation of a distance is allowed in an actual operation.

[0020] For example, there is a slot between each of the coupling patches and the feeder in the antenna provided in this embodiment of this application.

[0021] Further, each of the plurality of parasitic patches corresponds to one of the plurality of coupling patches, and the orthographic projection of each parasitic patch on the first medium substrate at least partially overlaps the orthographic projection of the slot between the feeder and the coupling patch that corresponds to the parasitic patch on the first medium substrate.

[0022] To ensure consistency of radiation features, for each parasitic patch that corresponds to a coupling patch, the center of the orthographic projection of the parasitic patch on the first medium substrate overlaps the center of the orthographic projection of the slot between the feeder and the coupling patch that corresponds to the parasitic patch on the first medium substrate.

[0023] In specific implementation, to ensure coupling strength between the coupling patch and the feeder, a width of the slot between the coupling patch and the feeder cannot be excessively wide or excessively small. Optionally, in this application, the width of the slot between the coupling patch and the feeder is controlled to be within [0.02 λg, 0.5 λg], where λg is a waveguide wavelength.

[0024] For coupling patches having a slot with the feeder, widths of slots between at least two coupling patches and the feeder are inconsistent. In this way, different coupling degrees are controlled by enabling inconsistent widths of slots between the coupling patches and the feeder, to implement a low side lobe weighting design.

[0025] For example, in this application, widths of slots between all the coupling patches and the feeder are inconsistent, to achieve a better low side lobe effect.

[0026] For example, the plurality of coupling patches are sequentially arranged on two sides of the feeder along the extension direction of the feeder, and any two adjacent coupling patches along the extension direction of the feeder are located on different sides of the feeder. A feeder length between orthographic projections of centers of two adjacent coupling patches on the feeder is equal to 0.5 λg, and a feeder length between orthographic projections of centers of two adjacent parasitic patches on the feeder is equal to 0.5 λg. In this way, two adjacent coupling patches have inverse phases, and the antenna as a whole is arrayed with a half-wavelength spacing. In addition, because the coupling patches are arranged on two sides of the feeder in a staggered manner, the parasitic patches that correspond to the coupling patches are also arranged on the two sides of the feeder in a staggered manner, so that a horizontal beam width is broadened.

[0027] Further, in this application, to improve a radiation effect, a side of the coupling patch facing the feeder is parallel to a side of the feeder facing the coupling patch. In this way, it can be ensured that all widths of slots between the coupling patches and the feeder are equal.

[0028] In this application, with a parasitic patch and a corresponding coupling patch as one set of patches, relative positions of two adjacent sets of patches that are perpendicular to the extension direction of the feeder are adjusted to broaden a horizontal beam and implement a wide beam feature.

[0029] For example, a quantity of the plurality of coupling patches is N, where N is a positive integer. Along the extension direction of the feeder, a distance between a center of an i^{th} coupling patch and the feeder is the same as a distance between a center of a j^{th} coupling patch and the feeder, where $i + j = N + 1$, and i and j are positive integers.

[0030] When N is an even number, a shape of the i^{th} coupling patch and a shape of the j^{th} coupling patch are centro-symmetric along the extension direction of the feeder. Widths of slots between a 1^{st} coupling patch to an $(N/2)^{th}$ coupling patch and the feeder are all inconsistent, with a width of a slot between the i^{th} coupling patch and the feeder being the same as a width of a slot between the j^{th} coupling patch and the feeder.

[0031] When N is an odd number, a shape of the i^{th} coupling patch and a shape of the j^{th} coupling patch are axisymmetric along the extension direction of the feeder, and a direction of a symmetry axis is perpendicular to the extension direction of the feeder. Widths of slots between a 1^{st} coupling patch to an $(N+1/2)^{th}$ coupling patch and the feeder are all inconsistent, with a width of a slot between the i^{th} coupling patch and the feeder being the same as a width of a slot between the j^{th} coupling patch and the feeder.

[0032] To optimize a pattern feature of the antenna, when N is an even number, along the extension direction of the feeder, widths of the coupling patches from the 1^{st} coupling patch to the $(N/2)^{th}$ coupling patch are in ascending order along the extension direction of the feeder, but adjacent coupling patches may have an equal width or have widths with close values, provided that it is ensured that the widths of the coupling patches from the 1^{st} coupling patch to the $(N/2)^{th}$ coupling patch are in ascending order along the extension direction X of the feeder. When N is an odd number, along the extension direction of the feeder, widths of the coupling patches from the 1^{st} coupling patch to the $[(N+1)/2]^{th}$ coupling patch are in ascending order along the extension direction of the feeder, but adjacent coupling patches may have an equal width or have widths with close values, provided that it is ensured that the widths of the coupling patches from the 1^{st} coupling patch to the $[(N+1)/2]^{th}$ coupling patch are in ascending order along the extension direction of the feeder.

[0033] Further, when N is an odd number, the $[(N+1)/2]^{th}$ coupling patch is in the shape of an axisymmetric pattern along the extension direction of the feeder, and a direction of a symmetry axis is perpendicular to the extension direction of the feeder.

[0034] To suppress cross polarization, at least one coupling patch in the plurality of coupling patches has a groove on a side away from the feeder, and the groove penetrates through a thickness of the coupling patch. A thickness direction of the coupling patch is a direction perpendicular to a plane on which the first medium substrate is located.

[0035] In a possible implementation, each of the plurality of coupling patches has a groove on a side away from the feeder.

[0036] During specific implementation, when a width of a coupling patch along a feeder is greater than a specific value, cross polarization is prone to occur. Therefore, disposing a groove in a coupling patch whose width is greater than the specific value can effectively suppress the cross polarization.

[0037] For example, from the 1^{st} coupling patch to the N^{th} coupling patch along the extension direction of the feeder:

when N is an even number, an $(N/2-x)^{th}$ to an $(N/2+y)^{th}$ coupling patches are coupling patches each having a groove, where x is an integer greater than or equal to 0 and less than N/2-1, and y is an integer greater than 0 and less than or equal to N/2-1; or

when N is an odd number, an $[(N+1)/2-x]^{th}$ to an $[(N+1)/2+y]^{th}$ coupling patches are coupling patches each having a groove, where x is an integer greater than or equal to 0 and less than (N+1)/2-1, and y is an integer greater than or equal to 0 and less than (N+1)/2-1.

[0038] During specific implementation, due to a limitation of an antenna pattern, a width of the coupling patch along the extension direction of the feeder is within [0.02 λg, 0.5 λg], for example, 0.02 λg, 0.05 λg, 0.1 λg, 0.2 λg, 0.3 λg, 0.4 λg, or 0.5 λg. This is not limited herein.

[0039] A length of the coupling patch in a direction perpendicular to the extension direction of the feeder falls in [0.02 λg, 0.6 λg], for example, 0.02 λg, 0.05 λg, 0.1 λg, 0.2 λg, 0.3 λg, 0.4 λg, 0.5 λg, or 0.6 λg, so as to implement small-diameter arrangement of the antenna.

[0040] Correspondingly, a length of the parasitic patch in the direction perpendicular to the extension direction of the feeder is 0.5 λg, and a width of the parasitic patch along the extension direction of the feeder is less than or equal to 0.5 λg. For example, the width of the parasitic patch along the extension direction of the feeder is equal to 0.25 λg. This is not limited herein.

[0041] During specific implementation, shapes and/or sizes of at least two parasitic patches in the plurality of parasitic patches are the same.

[0042] To ensure consistency of radiation features, all parasitic patches have the same shape and size. In addition, when all the parasitic patches have the same shape and size, difficulty of a manufacturing process can be reduced.

[0043] According to a second aspect, a radar is provided. The radar includes the antenna according to the first aspect or various implementations of the first aspect.

[0044] In a possible implementation, the radar further includes a control chip, where the control chip is connected to the antenna, and the control chip is configured to control the antenna to transmit or receive a signal.

[0045] According to a third aspect, a detection apparatus is provided. The detection apparatus includes the antenna according to the first aspect or various implementations of the first aspect.

[0046] According to a fourth aspect, a terminal is provided. The terminal includes the antenna according to the first aspect or various implementations of the first aspect, or the terminal includes the radar according to the second aspect or various implementations of the second aspect.

[0047] In a possible implementation, the terminal is a vehicle, an unmanned aerial vehicle, or a robot.

BRIEF DESCRIPTION OF DRAWINGS

[0048]

FIG. 1 is a schematic diagram of a top-view structure of an antenna according to an embodiment of this application;
FIG. 2 is a schematic diagram of a cross-sectional structure of the antenna in FIG. 1 along an AA' direction;
FIG. 3 is a schematic diagram of a cross-sectional structure of another antenna according to an embodiment of this application;
FIG. 4 is a schematic diagram of electric field distribution of an antenna according to an embodiment of this application;
FIG. 5 is a schematic diagram of a cross-sectional structure of still another antenna according to an embodiment of this application;
FIG. 6 is a schematic diagram of a partial top-view structure of an antenna according to an embodiment of this application;
FIG. 7 is a schematic diagram of a center of an irregular pattern according to this application;
FIG. 8 is a schematic diagram of a top-view structure of another antenna according to an embodiment of this application;
FIG. 9 is a schematic diagram of a top-view structure of another antenna according to an embodiment of this application;
FIG. 10 is a schematic diagram of a top-view structure of another antenna according to an embodiment of this application;
FIG. 11 is a schematic diagram of a top-view structure of another antenna according to an embodiment of this application;
FIG. 12 is a schematic diagram of a partial top-view structure of an antenna according to an embodiment of this application;
FIG. 13 is a schematic diagram of a partial top-view structure of an antenna according to an embodiment of this application;
FIG. 14 is a schematic diagram of operating bandwidth of an antenna according to an embodiment of this application; and
FIG. 15 is a schematic diagram of a pattern of an antenna according to an embodiment of this application.

DESCRIPTION OF EMBODIMENTS

[0049] To make the objectives, technical solutions, and advantages of this application clearer, the following further describes this application in detail with reference to the accompanying drawings.

[0050] It should be noted that, in this specification, similar reference numerals and letters in the following accompanying drawings represent similar items. Therefore, once an item is defined in an accompanying drawing, the item does not need to be further defined or interpreted in following accompanying drawings.

[0051] In descriptions of this application, it should be noted that orientation or location relationships indicated by terms "middle", "above", "below", "left", "right", "vertical", "horizontal", "inner", "outer", and the like are orientation or location relationships based on the accompanying drawings, and are merely intended for conveniently describing this application and simplifying descriptions, rather than indicating or implying that an apparatus or an element described needs to have a specific orientation or needs to be constructed and operated in a specific orientation, and therefore cannot be construed as a limitation on this application. In addition, terms "first" and "second" are merely used for a purpose of description, and shall not be understood as an indication or implication of relative importance.

[0052] In descriptions of this application, it should be noted that unless otherwise expressly specified and limited, terms "mount", "interconnect", and "connect" should be understood in a broad sense. For example, such terms may indicate a fixed connection, a detachable connection, or an integral connection; may indicate a mechanical connection or an electrical connection; and may indicate direct interconnection, indirect interconnection through an intermediate medium, or internal communication between two elements. A person of ordinary skill in the art may understand specific meanings of the foregoing terms in this application based on a specific situation.

[0053] In the following, some terms in embodiments of this application are explained and described to facilitate understanding by a person skilled in the art.

1. Patch: A patch is a module with wireless receiving and transmitting functions in an antenna.
2. Feeder: A feeder is also referred to as a cable and is used to transmit a signal.

[0054] For ease of understanding an antenna provided in embodiments of this application, the following first describes an application scenario of the antenna. The antenna provided in embodiments of this application may be applied to a terminal that implements a communication function and/or a detection function by using a radar or another detection apparatus with a detection function. The terminal may be a vehicle, an unmanned aerial vehicle, an unmanned transportation vehicle, a robot, or the like in automated driving or intelligent driving. To enable the terminal to be applied in a complex and changeable environment, the antenna needs to satisfy requirements such as a large bandwidth, a wide beam, and a low side lobe. Currently, however, a common antenna has a limited operating bandwidth due to a single resonance mode.

[0055] Based on this, embodiments of this application provide an antenna that can satisfy a design requirement of broadband coverage. The following describes in detail the antenna provided in embodiments of this application with reference to the accompanying drawings.

[0056] First, FIG. 1 is a top view of the antenna according to an embodiment of this application, and FIG. 2 is a cross-sectional view of the antenna in FIG. 1 along an AA' direction. The antenna includes a first medium substrate 10, a feeder 11, a plurality of coupling patches 12, and a plurality of parasitic patches 13. The feeder 11 and the plurality of coupling patches 12 are located on a side of the first medium substrate 10, the plurality of coupling patches 12 are sequentially arranged along an extension direction X of the feeder 11, and there is a slot between at least one of the plurality of coupling patches 12 and the feeder 11. The plurality of parasitic patches 13 are located on one side, of the first medium substrate 20, away from the first medium substrate 10, and at least one of the plurality of parasitic patches 13 corresponds to at least one of the coupling patches 12. In the parasitic patch that corresponds to the coupling patch 12, an orthographic projection of the parasitic patch 13 on the first medium substrate 10 at least partially overlaps an orthographic projection of a slot between the feeder 11 and the coupling patch 12 that corresponds to the parasitic patch 13 on the first medium substrate 10.

[0057] In the antenna provided in this application, because there is a slot between a coupling patch 12 and the feeder 11, coupling feeding may be implemented between the coupling patch 12 and the feeder 11 in a slot coupling form. Because the orthographic projection of the parasitic patch 13 on the first medium substrate 10 at least partially overlaps the orthographic projection of the slot between the feeder 11 and the coupling patch 12 that corresponds to the parasitic patch 13 on the first medium substrate 10, the parasitic patch 13 is excited by a coupling slot, and finally the coupling patch 12 and the parasitic patch 13 are excited at the same time to implement different resonance frequencies, thereby broadening an operating bandwidth and implementing a broadband feature. In addition, in this application, the coupling patch 12 radiates jointly with the parasitic patch 13, to implement a far-field radiation pattern through superposition of electromagnetic waves. Because both the parasitic patch 13 and the coupling patch 12 can implement independent resonance, the antenna in this application is a dual-resonance antenna.

[0058] With reference to FIG. 1, a start end 11a of the feeder 11 is configured to implement feeding of the antenna, and a termination end 11b of the feeder 11 may be in an open state or a short-circuited state. When the termination end 11b of the feeder 11 is in the open state, the termination end 11b of the feeder 11 is in a free extending state, and is not connected to any conductor. When the termination end 11b of the feeder 11 is in the short-circuited state, the termination end 11b of the feeder 11 is used for grounding.

[0059] For example, FIG. 3 is a schematic diagram of a cross-sectional structure of another antenna according to an embodiment of this application. The antenna further includes a ground layer 30. The ground layer 30 is configured for grounding, and the ground layer 30 is located on a side, of the first medium substrate 10, away from the parasitic patch 13. During specific implementation, both the feeder 11 and the coupling patch 12 need to be disposed in isolation from the ground layer 30.

[0060] In this application, the coupling feeding is implemented between the coupling patch 12 and the feeder 11 in the slot coupling form, and the parasitic patch 13 is excited by the coupling slot. Finally, the coupling patch 12 and the parasitic patch 13 are excited at the same time to implement different resonance frequencies, thereby broadening an operating bandwidth and implementing a broadband feature. Because both the parasitic patch 13 and the coupling patch 12 can implement independent resonance, the antenna in this application is a dual-resonance antenna. In addition, both the coupling patch 12 and the parasitic patch 13 operate in the TM01 mode, which is an operating mode.

[0061] FIG. 4 is a schematic diagram of electric field distribution of an antenna according to an embodiment of this application. Arrow directions in FIG. 4 are directions of electric field lines, and an area with dense electric field lines indicates a smaller electric field strength in the area. It can be seen from FIG. 4 that, an electric field at a slot between the feeder 11 and the coupling patch 12 and an electric field between the slot and the parasitic patch 13 are relatively strong. An electric field between the parasitic patch 13 and the ground layer 30 and an electric field between the coupling patch 12 and the ground layer 30 may be equivalent to magnetic currents, and a direction of the magnetic current is parallel to the extension direction X of the feeder 11, so as to implement horizontal polarization.

[0062] For example, FIG. 5 is a schematic diagram of a cross-sectional structure of still another antenna according to an embodiment of this application. The antenna may further include a second medium substrate 20. The second medium substrate 20 is located on a side, of the first medium substrate 10, away from the parasitic patch 13. The parasitic patch 13 is located on the first medium substrate 10. The feeder 11 and the coupling patch 12 are located on the second medium substrate 20, and are located on a side, of the second medium substrate 20, facing the first medium substrate 10. In this way, the feeder 11 and the coupling patch 12 are disposed in isolation from the ground layer 30 by using the second medium substrate 20.

[0063] In actual production, a parasitic patch may be formed on a first medium substrate by using a printed circuit board (printed circuit board, PCB) process, and a coupling patch may be formed on a second medium substrate by using a PCB process. This leads to an antenna with a simple structure, a low profile, easy integration, and a low cost, that is suitable for mass production.

[0064] It may be understood that, in this application, the feeder, the plurality of coupling patches, and the plurality of parasitic patches are one set of array elements. There may be one set of array elements on the ground layer, or certainly, there may be a plurality of sets of array elements, which is not limited herein. In FIG. 1, only one set of array elements is used as an example for description.

[0065] During specific implementation, the parasitic patch and the coupling patch may be made of metal, for example, copper. This is not limited herein. Both a first medium substrate and a second medium substrate may be fabricated using epoxy resin, polystyrene resin, or fluorine resin as a main material. That is, a medium substrate is a high-frequency substrate that features a small and stable dielectric constant, a small dielectric loss, a coefficient of thermal expansion close to that of copper, low water absorption, and high chemical resistance, making the medium substrate suitable for a development trend of high-frequency communication devices.

[0066] The parasitic patch and the coupling patch are not limited to specific shapes and sizes in this application, and may be designed and debugged based on requirements of coupling degrees and impedance.

[0067] During specific implementation, the coupling patch may be in the shape of a regular pattern, such as a rectangle or an ellipse, or certainly may be in the shape of an irregular pattern. The parasitic patch may be in the shape of a regular pattern, for example, a rectangle or an ellipse, or certainly may be in the shape of an irregular pattern.

[0068] In this application, the feeder 11 may be in the shape of a straight line as shown in FIG. 1, or may be in the shape of a broken line or a curve as shown in FIG. 9, such as a sawtooth (zigzag), a wave, or a bow as shown in FIG. 9. This is not limited herein.

[0069] It may be understood that a quantity of coupling patches and a quantity of parasitic patches are not limited in this application. The quantity of coupling patches may be the same as or different from the quantity of parasitic patches. For example, the quantity of parasitic patches may be set to be the same as a quantity of coupling patches having a slot with the feeder, so that each parasitic patch corresponds to one slot.

[0070] In this application, to ensure coupling performance, a distance between a center of the orthographic projection of the parasitic patch in the at least one parasitic patch on the first medium substrate and a center of the orthographic projection of the slot between the feeder and the coupling patch that corresponds to the parasitic patch on the first medium substrate is less than a preset value.

[0071] In this application, to ensure consistency of radiation features, when a quantity of parasitic patches in the at least one parasitic patch is greater than 1, for each parasitic patch that corresponds to a coupling patch, position vectors of centers, of orthographic projections of all parasitic patches on the first medium substrate, relative to centers of orthographic projections of slots between the feeder and the coupling patches that correspond to the parasitic patches on the first medium substrate are equal. This ensures consistency of radiation features.

[0072] Herein, a "position vector" of a point A relative to a point B may be understood as a vector with the point B as an origin and with the point A as an end point. As shown in FIG. 6, two parasitic patches 13 are used as an example. A position vector of a center A1 of an orthographic projection of a first parasitic patch 13(a) on the first medium substrate relative to a center B1 of an orthographic projection of a slot between the feeder 11 and a coupling patch 12(a) that corresponds to the first parasitic patch 13(a) on the first medium substrate is B1A1, and a position vector of a center A2 of an orthographic projection of a second parasitic patch 13(b) on the first medium substrate relative to a center B2 of an orthographic projection of a slot between the feeder 11 and a coupling patch 12(b) that corresponds to the second parasitic patch 13(b) on the first medium substrate is B2A2, where B1A1=B2A2.

[0073] Further, to ensure consistency of radiation features, for each parasitic patch that corresponds to a coupling patch, a center of an orthographic projection of the parasitic patch in the at least one parasitic patch on the first medium substrate overlaps a center of an orthographic projection of a slot between the feeder and a coupling patch that corresponds to the parasitic patch on the first medium substrate. The "overlap" herein is not a strict geometrical overlap, but a deviation of a distance is allowed in an actual operation.

[0074] It should be noted that a "center" of an orthographic projection in this application may be understood as follows: If the orthographic projection is a regular pattern, the "center" of the orthographic projection is a geometric center. If the orthographic projection is an irregular pattern, the "center" of the orthographic projection may be an intersection point of the orthographic projection in two directions perpendicular to each other. For example, as shown in FIG. 7, in the orthographic projection, a midpoint x1 is selected at a widest part along a first direction x, and a midpoint y1 is selected at a widest part along a second direction y. An intersection point O at which a line that extends along the second direction y and passes through the point x1 meets a line that extends along the first direction x and passes through the point y1 is the "center" of the orthographic projection. The first direction x is perpendicular to the second direction y, and the first direction may be an extension direction of the feeder.

[0075] The following describes the antenna provided in this application by using an example in which the coupling patch and the parasitic patch are in the shape of a rectangle, and the feeder is in the shape of a straight line or a broken line.

[0076] For example, with reference to FIG. 8 to FIG. 11, there is a slot between each of the coupling patches 12 and the feeder 11 in the antenna provided in this embodiment of this application.

[0077] Further, each of the plurality of parasitic patches 13 corresponds to one of the plurality of coupling patches 12, and the orthographic projection of each parasitic patch 13 on the first medium substrate 10 at least partially overlaps the orthographic projection of the slot between the feeder 11 and the coupling patch 12 that corresponds to the parasitic patch 13 on the first medium substrate 10.

[0078] To ensure consistency of radiation features, for each parasitic patch that corresponds to a coupling patch, the center of the orthographic projection of the parasitic patch on the first medium substrate overlaps the center of the orthographic projection of the slot between the feeder and the coupling patch that corresponds to the parasitic patch on the first medium substrate.

[0079] In specific implementation, to ensure coupling strength between the coupling patch and the feeder, a width of the slot between the coupling patch and the feeder cannot be excessively wide or excessively small. Optionally, in this application, the width of the slot between the coupling patch and the feeder is controlled to be within [0.02 λg, 0.5 λg], where λg is a waveguide wavelength.

[0080] For coupling patches having a slot with the feeder, widths of slots between at least two coupling patches and the feeder are inconsistent. In this way, different coupling degrees are controlled by enabling inconsistent widths of slots between the coupling patches and the feeder, to implement a low side lobe weighting design.

[0081] For example, in this application, widths of slots between all the coupling patches and the feeder are inconsistent, to achieve a better low side lobe effect.

[0082] For example, with reference to FIG. 8 to FIG. 11, the plurality of coupling patches 12 are sequentially arranged on two sides of the feeder 11 along the extension direction X of the feeder 11, and any two adjacent coupling patches 12 along the extension direction X of the feeder 11 are located on different sides of the feeder 11. A feeder length between orthographic projections of centers of two adjacent coupling patches 12 on the feeder 11 is equal to 0.5 λg, and a feeder length between orthographic projections of centers of two adjacent parasitic patches 12 on the feeder 11 is equal to 0.5 λg. In this way, two adjacent coupling patches 12 have inverse phases, and the antenna as a whole is arrayed with a half-wavelength spacing. In addition, because the coupling patches 12 are arranged on two sides of the feeder 11 in a staggered manner, the parasitic patches 13 that correspond to the coupling patches 12 are also arranged on the two sides of the feeder 11 in a staggered manner, so that a horizontal beam width is broadened.

[0083] Herein, a "center" of the coupling patch (or the parasitic patch) may be understood as follows: If the coupling patch (or the parasitic patch) is in the shape of a regular pattern, the "center" of the coupling patch (or the parasitic patch) is a geometric center. If the coupling patch (or the parasitic patch) is in the shape of an irregular pattern, the "center" of the coupling patch (or the parasitic patch) may be an intersection point of the coupling patch (or the parasitic patch) in two directions that are perpendicular to each other. For example, as shown in FIG. 7, in the coupling patch (or the parasitic patch), the midpoint x1 is selected at the widest part along the first direction x, and the midpoint y1 is selected at the widest part along the second direction y. The intersection point of the line that extends along the second direction y and passes through the point x1 and the line that extends along the first direction x and passes through the point y1 is the "center" of the coupling patch (or the parasitic patch). The first direction x is perpendicular to the second direction y, and the first direction may be the extension direction of the feeder.

[0084] Specifically, with reference to FIG. 12 and FIG. 13, a length of the feeder 11 between orthographic projections of centers O1 and O2 of two adjacent coupling patches 12 (or parasitic patches) on the feeder 11 is equal to 0.5 λg. It may be understood that "0.5 λg" herein refers to an ideal length of 0.5 λg, while a deviation due to a manufacturing process is allowed during actual production.

[0085] Further, in this application, to improve a radiation effect, with reference to FIG. 12 and FIG. 13, a side 120 of the coupling patch 12 facing the feeder 11 is parallel to a side 110 of the feeder 11 facing the coupling patch 12. In this way, it can be ensured that all widths of slots between the coupling patch 12 and the feeder 11 are equal.

[0086] In this application, with a parasitic patch 13 and a corresponding coupling patch 12 as one set of patches, relative positions of two adjacent sets of patches that are perpendicular to the extension direction X of the feeder 11 are adjusted to broaden a horizontal beam and implement a wide beam feature.

[0087] With reference to FIG. 8 to FIG. 11, a quantity of the plurality of coupling patches 12 is N, where N is a positive integer. Along the extension direction X of the feeder 11, a distance between a center of an i^{th} coupling patch 12 and the feeder 11 is the same as a distance between a center of a j^{th} coupling patch 12 and the feeder 11, where i + j = N + 1.

[0088] When N is an even number, a shape of the i^{th} coupling patch and a shape of the j^{th} coupling patch are centrosymmetric along the extension direction of the feeder. With reference to FIG. 8 and FIG. 9, N = 8 is used as an example. A 1st coupling patch 12 and an 8th coupling patch 12 are located on two sides of the feeder 11. A shape of the 1st coupling patch 12 and a shape of the 8th coupling patch 12 are two centrosymmetric patterns. A distance between a center of the 1st coupling patch 12 and the feeder 12 is the same as a distance between a center of the 8th coupling patch 12 and the feeder 11. A 2nd coupling patch 12 and a 7th coupling patch 12 are located on two sides of the feeder 11. A shape of the 2nd coupling patch 12 and a shape of the 7th coupling patch 12 are two centrosymmetric patterns. A distance between a middle line of the 2nd coupling patch 12 and the feeder 11 is the same as a distance between a middle line of the 7th coupling patch 12 and the feeder 11. A 3rd coupling patch 12 and a 6th coupling patch 12 are located on two sides of the feeder 11. A shape of the 3rd coupling patch 12 and a shape of the 6th coupling patch 12 are two centrosymmetric patterns. A distance between a center of the 3rd coupling patch 12 and the feeder 11 is the same as a distance between a center of the 6th coupling patch 12 and the feeder 11. A 4th coupling patch 12 and a 5th coupling patch 12 are located on two sides of the feeder 11. A shape of the 4th coupling patch 12 and a shape of the 5th coupling patch 12 are two centrosymmetric patterns. A distance between a center of the 4th coupling patch 12 and the feeder 11 is the same as a distance between a center of the 5th coupling patch 12 and the feeder 11. In this way, symmetry and consistency of a pattern of an antenna are ensured.

[0089] When N is an even number, widths of slots between a 1st coupling patch to an $(N/2)^{th}$ coupling patch and the feeder are inconsistent along the extension direction of the feeder, with a width of a slot between the i^{th} coupling patch and the feeder being the same as a width of a slot between the j^{th} coupling patch and the feeder, where i + j = N + 1.

[0090] When N is an odd number, a shape of the i^{th} coupling patch and a shape of the j^{th} coupling patch are axisymmetric along the extension direction of the feeder, and a direction of a symmetry axis is perpendicular to the extension direction of the feeder. With reference to FIG. 10 and FIG. 11, N = 9 is used as an example. Both a 1st coupling patch 12 and a 9th coupling patch 12 are located on a same side of the feeder 11. A shape of the 1st coupling patch 12 and a shape of the 9th coupling patch 12 are two axisymmetric patterns. A direction of a symmetry axis is perpendicular to the extension direction X of the feeder 11, and a distance between a center of the 1st coupling patch 12 and the feeder 12 is the same as a distance between a center of the 9th coupling patch 12 and the feeder 11. Both a 2nd coupling patch 12 and an 8th coupling patch 12 are located on a same side of the feeder 11. A shape of the 2nd coupling patch 12 and a shape of the 8th coupling patch 12 are two axisymmetric patterns. A direction of a symmetry axis is perpendicular to the extension direction X of the feeder 11, and a distance between a middle line of the 2nd coupling patch 12 and the feeder 11 is the same as a distance between a middle line of the 8th coupling patch 12 and the feeder 11. Both a 3rd coupling patch 12 and a 7th coupling patch 12 are located on a same side of the feeder 11, a shape of the 3rd coupling patch 12 and a shape of the 7th coupling patch 12 are two axisymmetric patterns. A direction of a symmetry axis is perpendicular to the extension direction X of the feeder 11, and a distance between a center of the 3rd coupling patch 12 and the feeder 11 is the same as a distance between a center of the 7th coupling patch 12 and the feeder 11. Both a 4th coupling patch 12 and a 6th coupling patch 12 are located on a same side of the feeder 11. A shape of the 4th coupling patch 12 and a shape of the 6th coupling patch 12 are two axisymmetric patterns. A direction of a symmetry axis is perpendicular to the extension direction X of the feeder 11, and a distance between a center of the 4th coupling patch 12 and the feeder 11 is the same as a distance between a center of the 6th coupling patch 12 and the feeder 11. In this way, symmetry and consistency of a pattern of an antenna are ensured.

[0091] When N is an odd number, widths of slots between a 1st coupling patch to an (N+1/2)th coupling patch and the feeder are inconsistent along the extension direction of the feeder, with a width of a slot between an ith coupling patch and the feeder being the same as a width of a slot between a jth coupling patch and the feeder, where i + j = N + 1.

[0092] With reference to FIG. 8 to FIG. 11, to optimize a pattern feature of an antenna, as shown in FIG. 8 and FIG. 9, when N is an even number, along the extension direction X of the feeder 11, widths of the coupling patches 12 from the 1st coupling patch 12 to the (N/2)th coupling patch 12 are in ascending order along the extension direction X of the feeder 11, but adjacent coupling patches 12 may have an equal width or have widths with close values, provided that it is ensured that the widths of the coupling patches 12 from the 1st coupling patch 12 to the (N/2)th coupling patch 12 are in ascending order along the extension direction X of the feeder 11. As shown in FIG. 10 and FIG. 11, when N is an odd number, along the extension direction X of the feeder 11, widths of the coupling patches 12 from the 1st coupling patch 12 to the [(N+1)/2]th coupling patch 12 are in ascending order along the extension direction X of the feeder 11, but adjacent coupling patches 12 may have an equal width or have widths with close values, provided that it is ensured that the widths of the coupling patches 12 from the 1st coupling patch 12 to the [(N+1)/2]th coupling patch 12 are in ascending order along the extension direction X of the feeder 11.

[0093] Further, when N is an odd number, a width of the [(N+1)/2]th coupling patch is the largest along the extension direction of the feeder. With reference to FIG. 10 and FIG. 11, a width of a 5th coupling patch 12 is the largest along the extension direction X of the feeder 11. Certainly, during specific implementation, a width of the [(N+1)/2]th coupling patch along the extension direction of the feeder may be the same as a width of an [(N-1)/2]th coupling patch and a width of an [(N-3)/2]th coupling patch.

[0094] To ensure symmetry and consistency of a pattern of an antenna, when a quantity of coupling patches is an odd number, the [(N+1)/2]th coupling patch 12 is in the shape of an axisymmetric pattern along the extension direction X of the feeder 11, and a direction of a symmetry axis is perpendicular to the extension direction X of the feeder 11. Still with reference to FIG. 10 and FIG. 11, the 5th coupling patch 12 is in the shape of an axisymmetric pattern, and a direction of a symmetry axis is perpendicular to the extension direction X of the feeder 11.

[0095] With reference to FIG. 8 to FIG. 11, to suppress cross polarization, at least one coupling patch 12 in the plurality of coupling patches 12 has a groove V on a side away from the feeder 11, and the groove V penetrates through a thickness of the coupling patch 12. A thickness direction of the coupling patch 12 is a direction perpendicular to a plane on which the first medium substrate 10 is located. In FIG. 8 to FIG. 11, the thickness direction of the coupling patch 12 is perpendicular to a plane formed by the direction X and the direction Y, and the direction Y is a direction perpendicular to the extension direction X of the feeder.

[0096] In a possible implementation, each of the plurality of coupling patches has a groove on a side away from the feeder.

[0097] During specific implementation, when a width of a coupling patch along a feeder is greater than a specific value, cross polarization is prone to occur. Therefore, disposing of a groove in a coupling patch whose width is greater than the specific value can effectively suppress the cross polarization.

[0098] Still with reference to FIG. 8 to FIG. 11, a coupling patch 12 arranged closer to a middle position has a larger width along the extension direction X of the feeder 11. Therefore, in the plurality of coupling patches 12 arranged along the extension direction X of the feeder 11, the coupling patch 12 arranged close to the middle position is the coupling patch 12 having a groove V

[0099] For example, a quantity of coupling patches is N. When N is an even number, coupling patches arranged close to the middle position each having a groove may be an (N/2-x)th to an (N/2+y)th coupling patches 12, where x is an integer greater than or equal to 0 and less than N/2-1, and y is an integer greater than 0 and less than or equal to N/2-1. For example, coupling patches 12 each having a groove may be an (N/2)th and an (N/2+1)th coupling patches, or may be an (N/2-i)th to an (N/2+1+j)th coupling patches, where i is an integer greater than or equal to 1 and less than N/2-1, j is an integer greater than or equal to 1 and less than N/2-1, and i and j may be the same or different. To ensure symmetry of the pattern of the antenna, i and j are the same. N = 8 is used as an example. Coupling patches arranged close to a middle position may be a 4th and a 5th coupling patches, or may be a (4-i)th to a (5+j)th coupling patches, where i is an integer greater than or equal to 1 and less than 3, and j is an integer greater than or equal to 1 and less than 3.

[0100] When N is an odd number, the coupling patches arranged close to the middle position may be an [(N+1)/2-x]th to an [(N+1)/2+y]th coupling patches 12, where x is an integer greater than or equal to 0 and less than (N+1)/2-1, and y is an integer greater than or equal to 0 and less than (N+1)/2-1. For example, coupling patches 12 each having a groove may be an [(N+1)/2]th coupling patch, or may be an [(N+1)/2-i]th to an [(N+1)/2+j]th coupling patches, where i is an integer greater than or equal to 1 and less than (N+1)/2-1, j is an integer greater than or equal to 1 and less than (N+1)/2-1, and i and j may be the same or may be different. To ensure the symmetry of the pattern of the antenna, i and j are the same. N = 9 is used as an example. The coupling patches arranged close to the middle position each having a groove may be a 5th coupling patch, or may be a (5-i)th to a (5+j)th coupling patches, where i is an integer greater than or equal to 1 and less than 4, and j is an integer greater than or equal to 1 and less than 4. Specifically, the quantity of the coupling patches each having a groove may be set based on a width of the coupling patches along the extension direction of the feeder.

[0101] During specific implementation, with reference to FIG. 12 and FIG. 13, due to a limitation of an antenna pattern, a width w of the coupling patch along the extension direction X of the feeder 11 is controlled to be within [0.02 λg, 0.5 λg], for example, 0.02 λg, 0.05 λg, 0.1 λg, 0.2 λg, 0.3 λg, 0.4 λg, or 0.5 λg, which is not limited herein.

[0102] Still with reference to FIG. 12 and FIG. 13, a length L of the coupling patch in a direction perpendicular to the extension direction X of the feeder is controlled to be within [0.02 λg, 0.6 λg], for example, 0.02 λg, 0.05 λg, 0.1 λg, 0.2 λg, 0.3 λg, 0.4 λg, 0.5 λg, or, 0.6 λg, so as to implement small-diameter arrangement of the antenna.

[0103] Correspondingly, a length of the parasitic patch in the direction perpendicular to the extension direction of the feeder is 0.5 λg, and a width of the parasitic patch along the extension direction of the feeder is less than or equal to 0.5 λg. For example, the width of the parasitic patch along the extension direction of the feeder is equal to 0.25 λg. This is not limited herein.

[0104] Further, it may be understood that "0.5 λg" in the expression that a length of the parasitic patch in the direction perpendicular to the extension direction of the feeder is 0.5 λg refers to an ideal length of 0.5 λg, while a deviation due to a manufacturing process is allowed during actual production.

[0105] In this application, when a termination end of the feeder is in an open state, a feeder length between the termination end of the feeder and an orthographic projection of a center of a coupling patch closest to the termination end of the feeder is 0.5 λg. When the termination end of the feeder is in a short-circuited state, the feeder length between the termination end of the feeder and the orthographic projection of the center of the coupling patch closest to the termination end of the feeder is 0.25 λg. The 0.5 λg and 0.25 λg herein refer to ideal lengths, while a deviation due to a manufacturing process is allowed during actual production.

[0106] During specific implementation, shapes and/or sizes of at least two parasitic patches in the plurality of parasitic patches are the same.

[0107] To ensure consistency of radiation features, with reference to FIG. 8 to FIG. 11, all parasitic patches 13 have the same shape and size. In addition, when all the parasitic patches 13 have the same shape and size, difficulty of a manufacturing process can be reduced.

[0108] FIG. 14 is a schematic diagram of an operating bandwidth of an antenna obtained by designing a quantity and size of coupling patches, and a width of a slot in the antenna shown in FIG. 8, when a termination end of a feeder is in a short-circuited state. It can be learned from FIG. 14 that a start frequency is 74.68 GHz, a cut-off frequency is 81.77 GHz, and a bandwidth can reach 7.09 GHz, so as to implement a broadband feature.

[0109] FIG. 15 is a schematic diagram of a pattern that corresponds to the antenna in FIG. 14. It can be learned from FIG. 15 that the pattern of the antenna has good consistency on all operating bandwidths. The pattern does not exhibit distortion with a frequency variation, and a pattern bandwidth is approximately 5 GHz.

[0110] For example, in comparison with an existing comb-shaped antenna, the antenna provided in one embodiment of this application has various parameters as shown in the table below:

Antenna type	-10 dB impedance bandwidth	Level of a first left side lobe (dBc)	Level of a first right side lobe (dBc)	Horizontal 3 dB beam width	Vertical 3 dB beam width	Diameter (mm)	Gain (dB)	Radiation efficiency
Existing comb-shaped antenna	2.5 GHz (1.3%)	-28	-24.7	68	17	12.8*2.7	13	70%
Antenna in this application (termination end in an open state)	7.36 GHz (9.37%)	< -14	< -14	117	18	12.65*2.67	> 8.85	> 80.5%
Antenna in this application (termination end in a short-circuited	7.09 GHz (9%)	< 20	< 17	117	18	12.65*2.67	> 8.85	> 80.5%

Antenna type	-10 dB impedance bandwidth	Level of a first left side lobe (dBc)	Level of a first right side lobe (dBc)	Horizontal 3 dB beam width	Vertical 3 dB beam width	Diameter (mm)	Gain (dB)	Radiation efficiency
state)								

[0111] It can be learned from the foregoing table that the antenna provided in this embodiment of this application significantly improves the impedance bandwidth compared with the existing comb-shaped antenna.
[0112] Based on a same technical concept, this application further provides a radar. The radar includes an antenna, and the antenna may be the antenna in any one of the foregoing embodiments. Further, the radar is a mmWave radar.
[0113] Optionally, the radar further includes a control chip, where the control chip is connected to the antenna, and the control chip is configured to control the antenna to transmit or receive a signal.
[0114] The radar may alternatively be another detection apparatus having a detection function.
[0115] Based on a same technical concept, this application further provides a terminal, where the terminal includes the foregoing radar or the foregoing antenna.
[0116] Optionally, the terminal in this embodiment of this application may be capable of implementing a communication function and/or a detection function through a radar. This is not limited in this embodiment of this application.
[0117] In a possible implementation, the terminal may be a vehicle, an unmanned aerial vehicle, an unmanned transportation vehicle, a robot, or the like in automated driving or intelligent driving.
[0118] In another possible implementation, the terminal may be a mobile phone (mobile phone), a tablet computer (pad), a computer with a wireless transceiver function, a virtual reality (Virtual Reality, VR) terminal, an augmented reality (Augmented Reality, AR) terminal, a terminal in industrial control (industrial control), a terminal in self driving (self driving), a terminal in remote medical care (remote medical care), a terminal in smart grid (smart grid), a terminal in transportation safety (transportation safety), a terminal in smart city (smart city), a terminal in smart home (smart home), or the like.
[0119] It is clear that a person skilled in the art can make various modifications and variations to this application without departing from the spirit and scope of this application. This application is intended to cover these modifications and variations of this application provided that they fall within the scope of protection defined by the claims of this application and their equivalent technologies.

Claims

1. An antenna, comprising a first medium substrate, a feeder, a plurality of coupling patches, and a plurality of parasitic patches, wherein

   the feeder and the plurality of coupling patches are located on a side of the first medium substrate, the plurality of coupling patches are sequentially arranged along an extension direction of the feeder, and there is a slot between the feeder and at least one of the plurality of coupling patches; and
   the plurality of parasitic patches are located on a side, of the first medium substrate, away from the feeder, and at least one of the plurality of parasitic patches corresponds to at least one of the coupling patches; wherein
   an orthographic projection of a parasitic patch in the at least one parasitic patch on the first medium substrate at least partially overlaps an orthographic projection of a slot between the feeder and a coupling patch that corresponds to the parasitic patch on the first medium substrate; and
   a quantity of the plurality of coupling patches is N, and N is a positive integer.

2. The antenna according to claim 1, wherein a distance between a center of the orthographic projection of the parasitic patch in the at least one parasitic patch on the first medium substrate and a center of the orthographic projection of the slot between the feeder and the coupling patch that corresponds to the parasitic patch on the first medium substrate is less than a preset value.

3. The antenna according to claim 1 or 2, wherein a quantity of parasitic patches in the at least one parasitic patch is greater than 1, and position vectors of centers, of orthographic projections of all of the at least one parasitic patch on the first medium substrate, relative to centers of orthographic projections of slots between the feeder and the coupling patches that correspond to the parasitic patches on the first medium substrate are equal.

4. The antenna according to any one of claims 1 to 3, wherein there is a slot between the feeder and each of the plurality of coupling patches.

5. The antenna according to claim 4, wherein each of the plurality of parasitic patches corresponds to one of the plurality of coupling patches, and the orthographic projection of each parasitic patch on the first medium substrate at least partially overlaps the orthographic projection of the slot between the feeder and the coupling patch that corresponds to the parasitic patch on the first medium substrate.

6. The antenna according to any one of claims 1 to 5, wherein the plurality of coupling patches are sequentially arranged on two sides of the feeder along the extension direction of the feeder, and any two adjacent coupling patches along the extension direction of the feeder are located on different sides of the feeder; and
a feeder length between orthographic projections of centers of two adjacent coupling patches on the feeder is equal to 0.5 λg, and a feeder length between orthographic projections of centers of two adjacent parasitic patches on the feeder is equal to 0.5 λg, wherein λg is a waveguide wavelength.

7. The antenna according to any one of claims 1 to 6, wherein

along the extension direction of the feeder, a distance between a center of an i^{th} coupling patch and the feeder is the same as a distance between a center of a j^{th} coupling patch and the feeder, $i + j = N + 1$, and i and j are positive integers;
wherein
when N is an even number, a shape of the i^{th} coupling patch and a shape of the j^{th} coupling patch are centro-symmetric along the extension direction of the feeder; or
when N is an odd number, a shape of the i^{th} coupling patch and a shape of the j^{th} coupling patch are axisymmetric along the extension direction of the feeder, and a direction of a symmetry axis is perpendicular to the extension direction of the feeder.

8. The antenna according to any one of claims 1 to 7, wherein N is an even number, and along the extension direction of the feeder, widths of coupling patches from a 1^{st} coupling patch to an $(N/2)^{th}$ coupling patch are in ascending order along the extension direction of the feeder.

9. The antenna according to any one of claims 1 to 7, wherein N is an odd number, and along the extension direction of the feeder, widths of coupling patches from a 1^{st} coupling patch to an $[(N+1)/2]^{th}$ coupling patch are in ascending order along the extension direction of the feeder.

10. The antenna according to any one of claims 1 to 7, or 9, wherein N is an odd number, the $[(N+1)/2]^{th}$ coupling patch is in the shape of an axisymmetric pattern along the extension direction of the feeder, and a direction of a symmetry axis is perpendicular to the extension direction of the feeder.

11. The antenna according to any one of claims 1 to 10, wherein at least one coupling patch in the plurality of coupling patches has a groove on a side away from the feeder, and the groove penetrates through a thickness of the coupling patch.

12. The antenna according to claim 11, wherein from the 1^{st} coupling patch to the N^{th} coupling patch along the extension direction of the feeder:

when N is an even number, an $(N/2-x)^{th}$ to an $(N/2+y)^{th}$ coupling patches are coupling patches each having a groove, wherein x is an integer greater than or equal to 0 and less than N/2-1, and y is an integer greater than 0 and less than or equal to N/2-1; or
when N is an odd number, an $[(N+1)/2-x]^{th}$ to an $[(N+1)/2+y]^{th}$ coupling patches are coupling patches each having a groove, wherein x is an integer greater than or equal to 0 and less than (N+1)/2-1, and y is an integer greater than or equal to 0 and less than (N+1)/2-1.

13. The antenna according to any one of claims 1 to 12, wherein a width of the coupling patch along the extension direction of the feeder belongs to [0.02 λg, 0.5 λg], and a length of the coupling patch in a direction perpendicular to the extension direction of the feeder belongs to [0.02 λg, 0.6 λg], wherein λg is the waveguide wavelength.

14. The antenna according to any one of claims 1 to 13, wherein widths of slots between at least two coupling patches

and the feeder are inconsistent.

15. The antenna according to any one of claims 1 to 14, wherein a width of a slot between the coupling patch and the feeder belongs to [0.02 λg, 0.5 λg], wherein λg is the waveguide wavelength.

16. The antenna according to any one of claims 1 to 15, wherein shapes and/or sizes of at least two parasitic patches in the plurality of parasitic patches are the same.

17. The antenna according to any one of claims 1 to 16, wherein a length of the parasitic patch in the direction perpendicular to the extension direction of the feeder is 0.5 λg, and a width of the parasitic patch along the extension direction of the feeder is less than or equal to 0.5 λg, wherein λg is the waveguide wavelength.

18. The antenna according to any one of claims 1 to 17, wherein the feeder is in the shape of a straight line, a broken line, or a curve.

19. The antenna according to any one of claims 1 to 18, further comprising a second medium substrate, wherein

the second medium substrate is located on a side, of the first medium substrate, away from the parasitic patch;
the parasitic patch is located on the first medium substrate; and
the feeder and the coupling patch are located on the second medium substrate, and are located on a side, of the second medium substrate, facing the first medium substrate.

20. A radar, wherein the radar comprises the antenna according to any one of claims 1 to 19.

21. The radar according to claim 20, wherein the radar further comprises a control chip, the control chip is connected to the antenna, and the control chip is configured to control the antenna to transmit or receive a signal.

22. A detection apparatus, wherein the detection apparatus comprises the antenna according to any one of claims 1 to 19.

23. A terminal, wherein the terminal comprises the antenna according to any one of claims 1 to 19 or the radar according to claim 20 or 21.

24. The terminal according to claim 23, wherein the terminal is a vehicle, an unmanned aerial vehicle, or a robot.

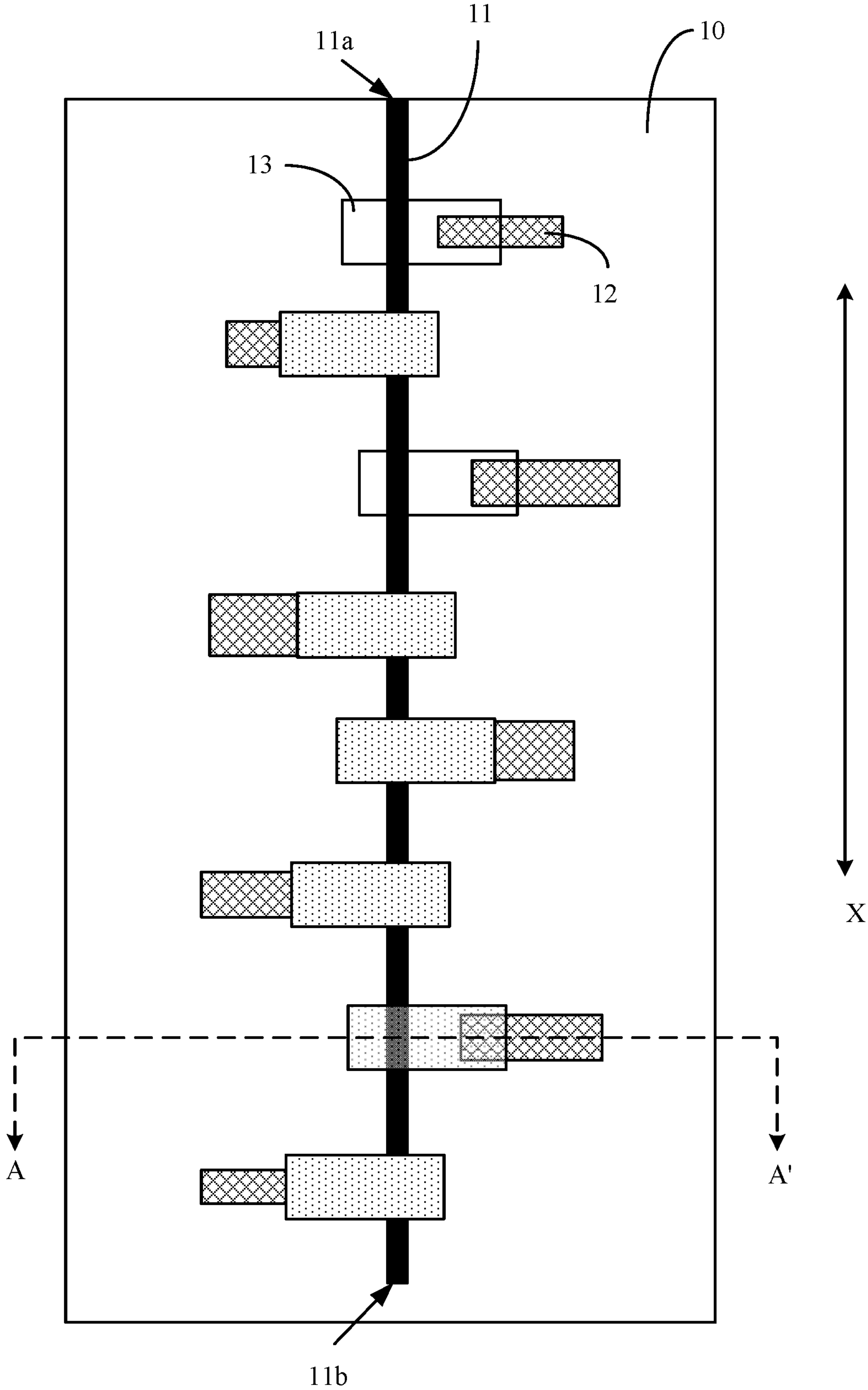


FIG. 1

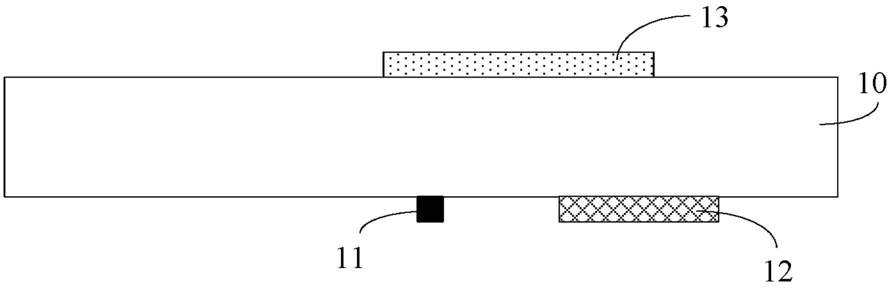


FIG. 2

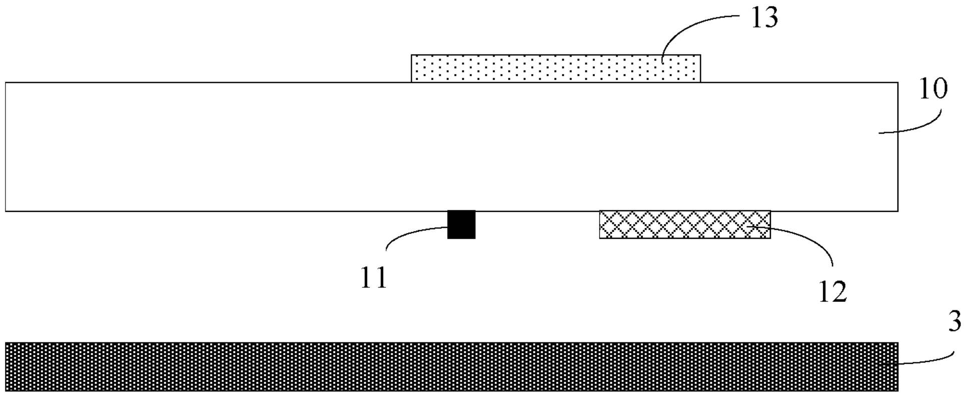


FIG. 3

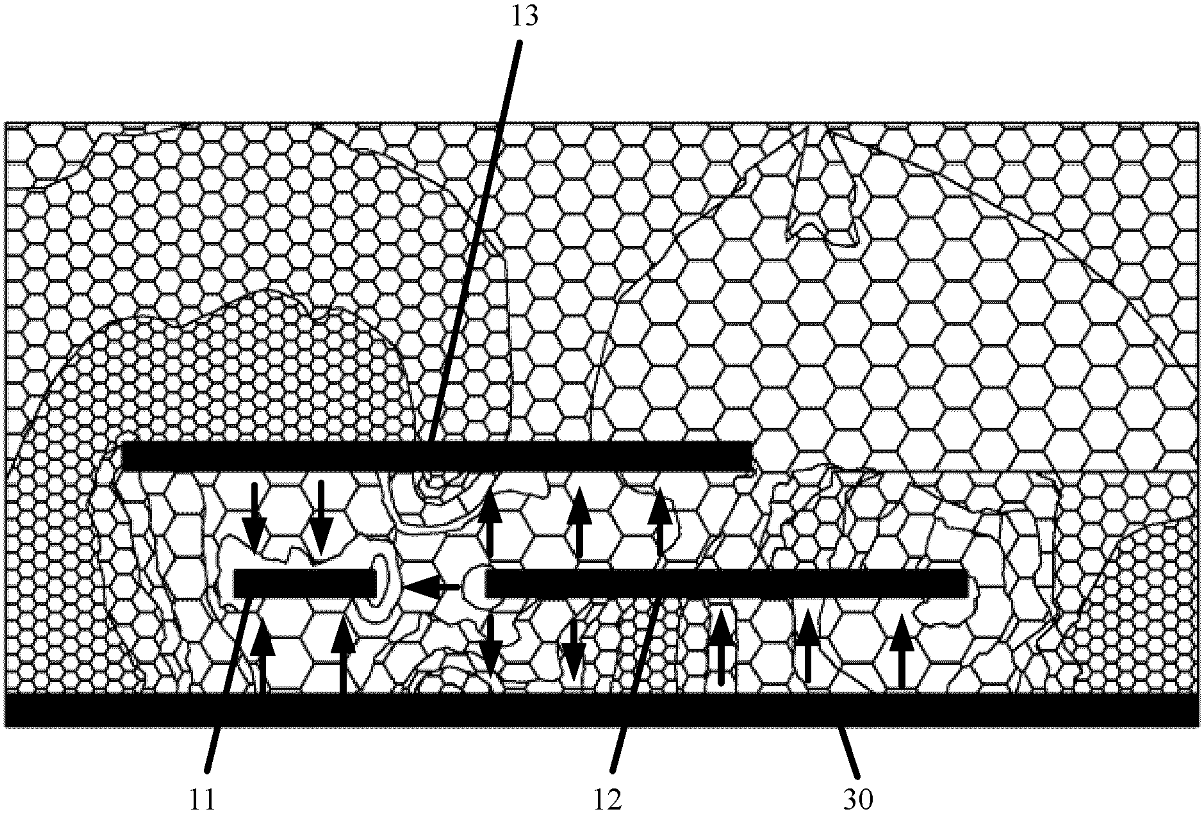


FIG. 4

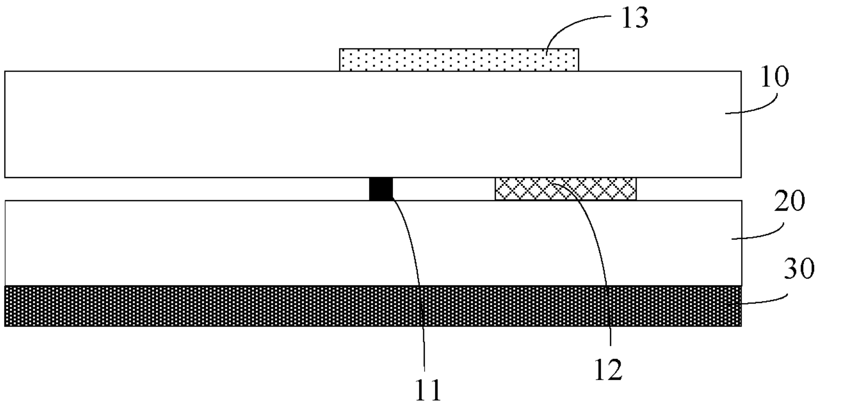


FIG. 5

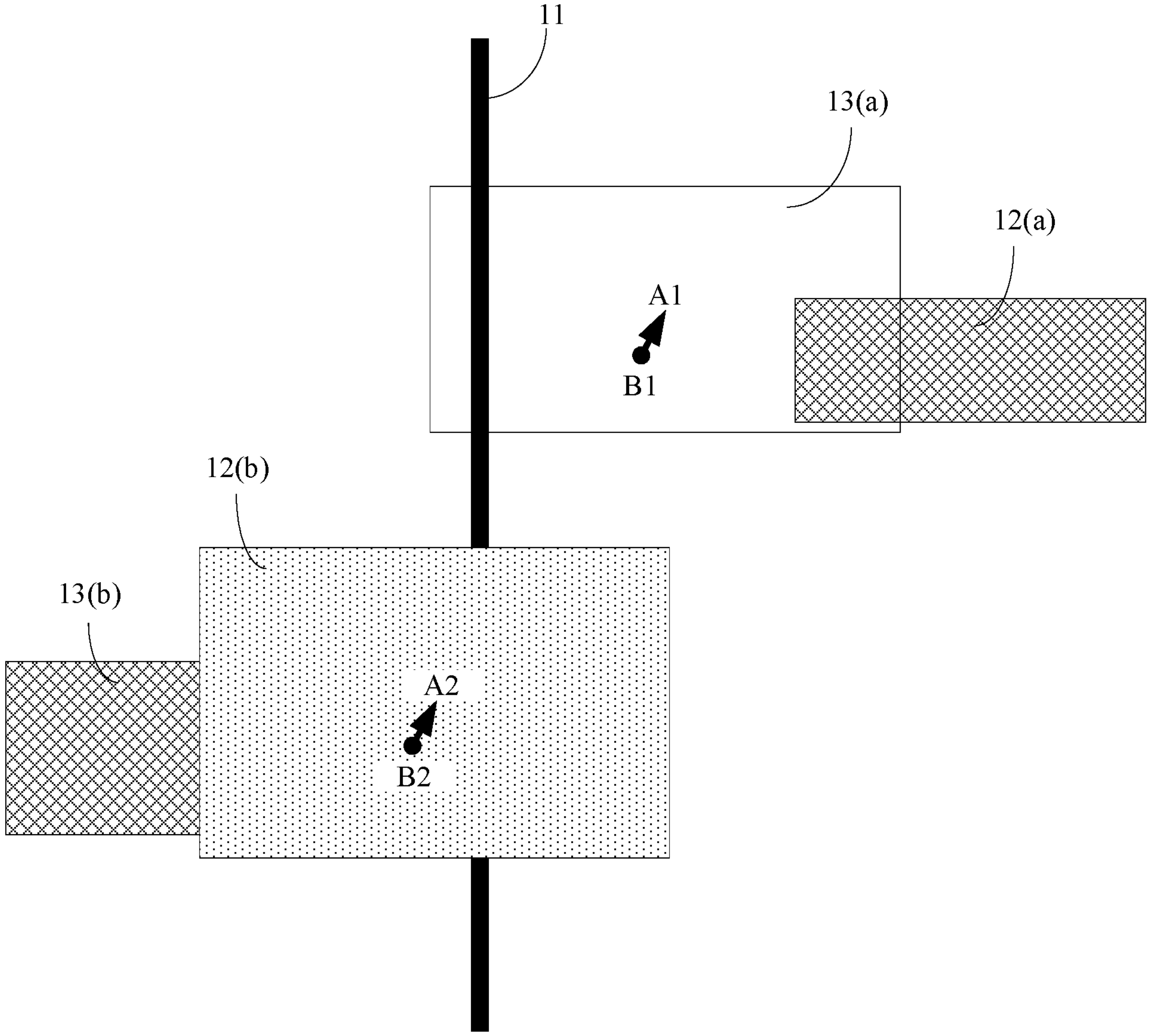


FIG. 6

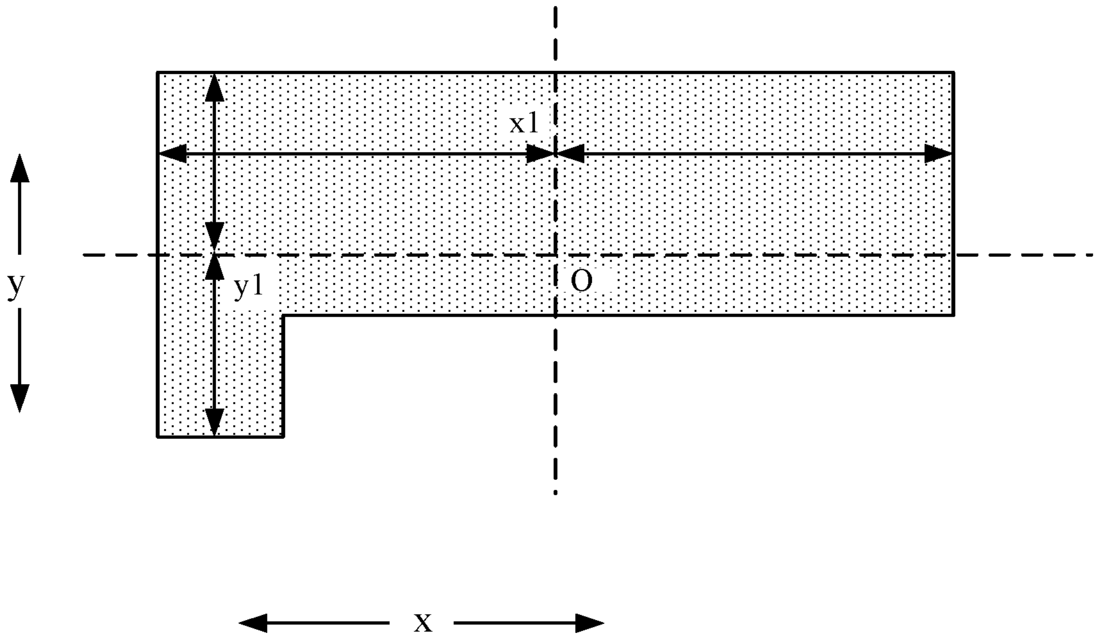


FIG. 7

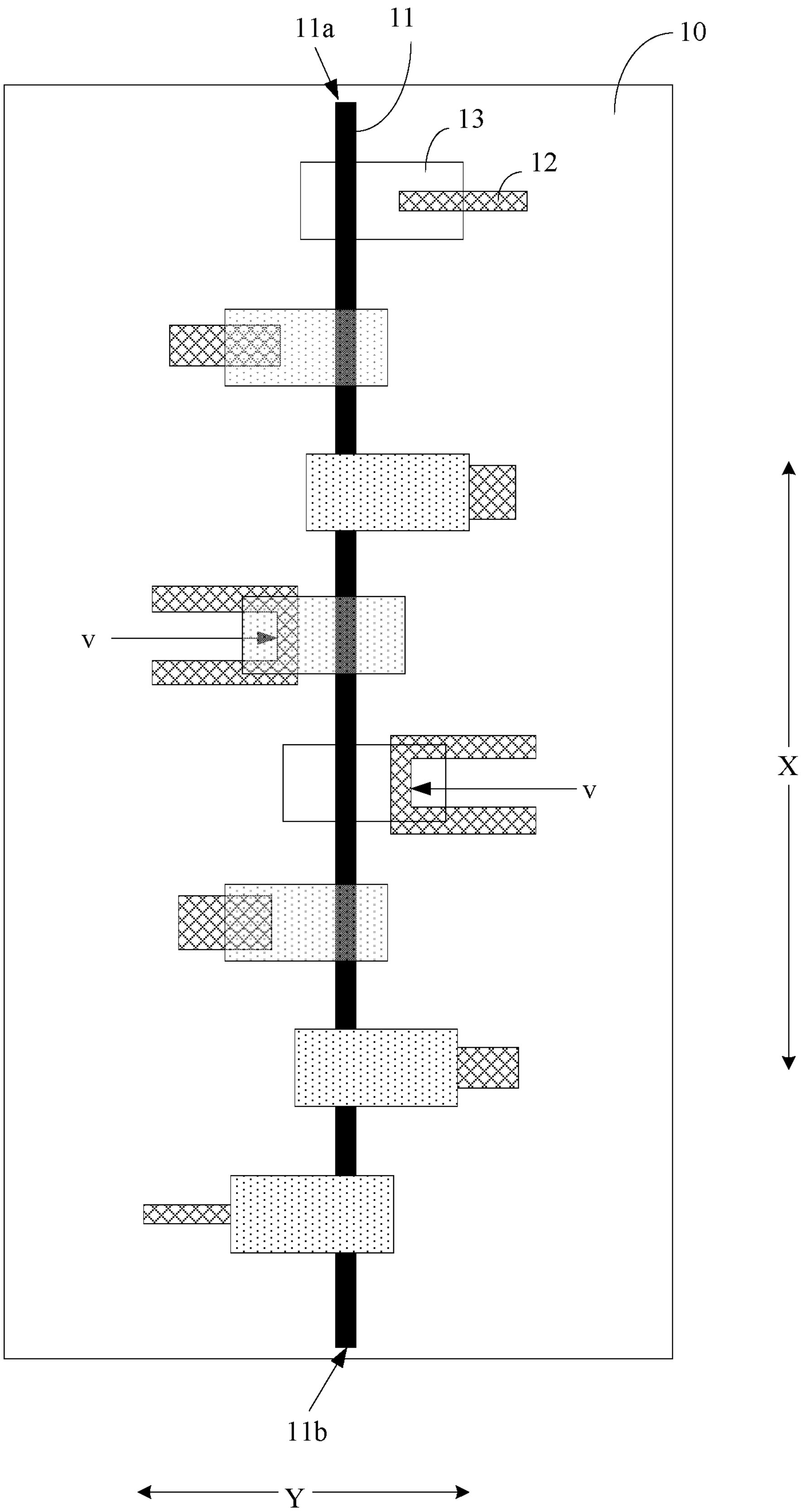


FIG. 8

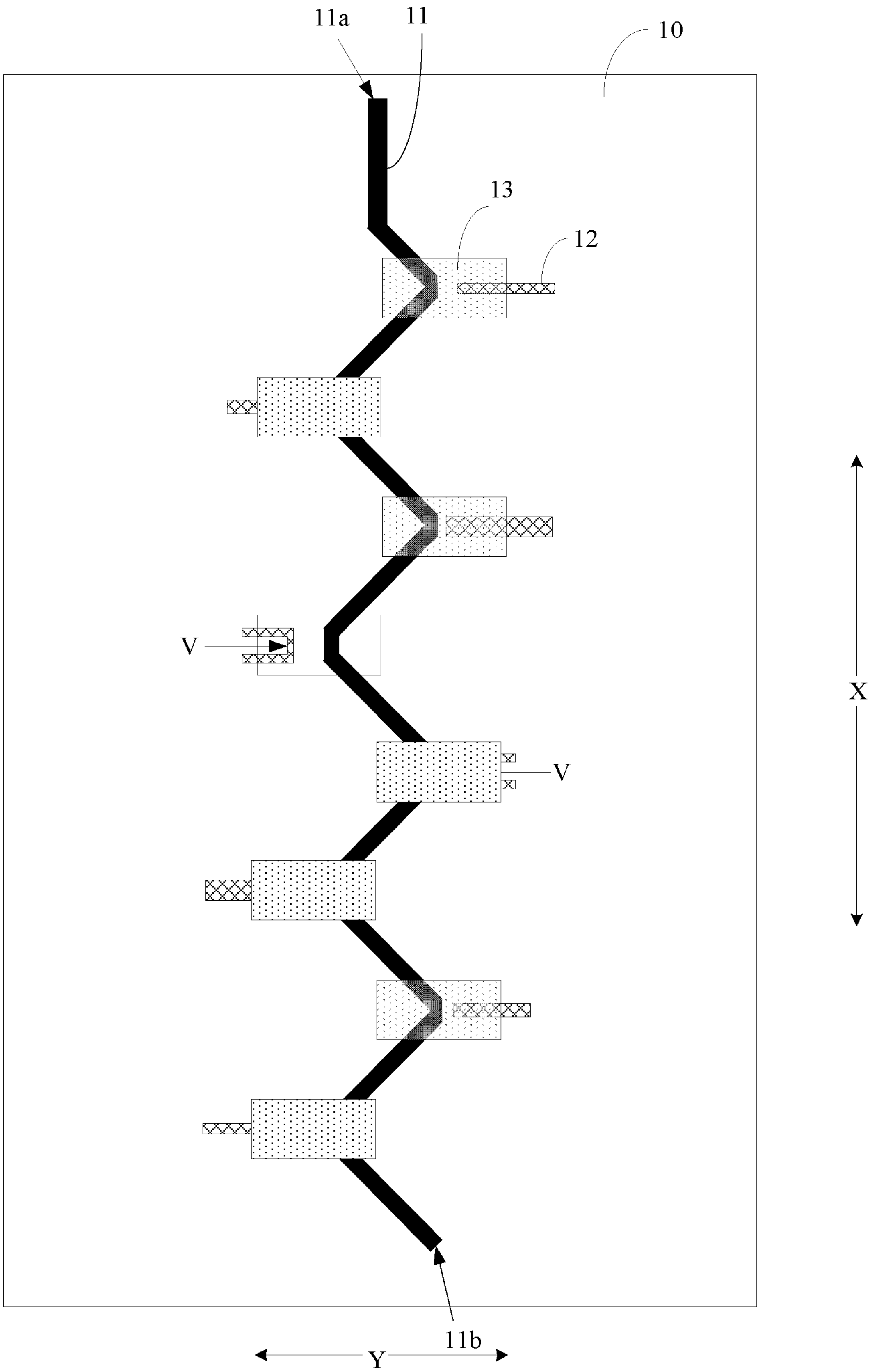


FIG. 9

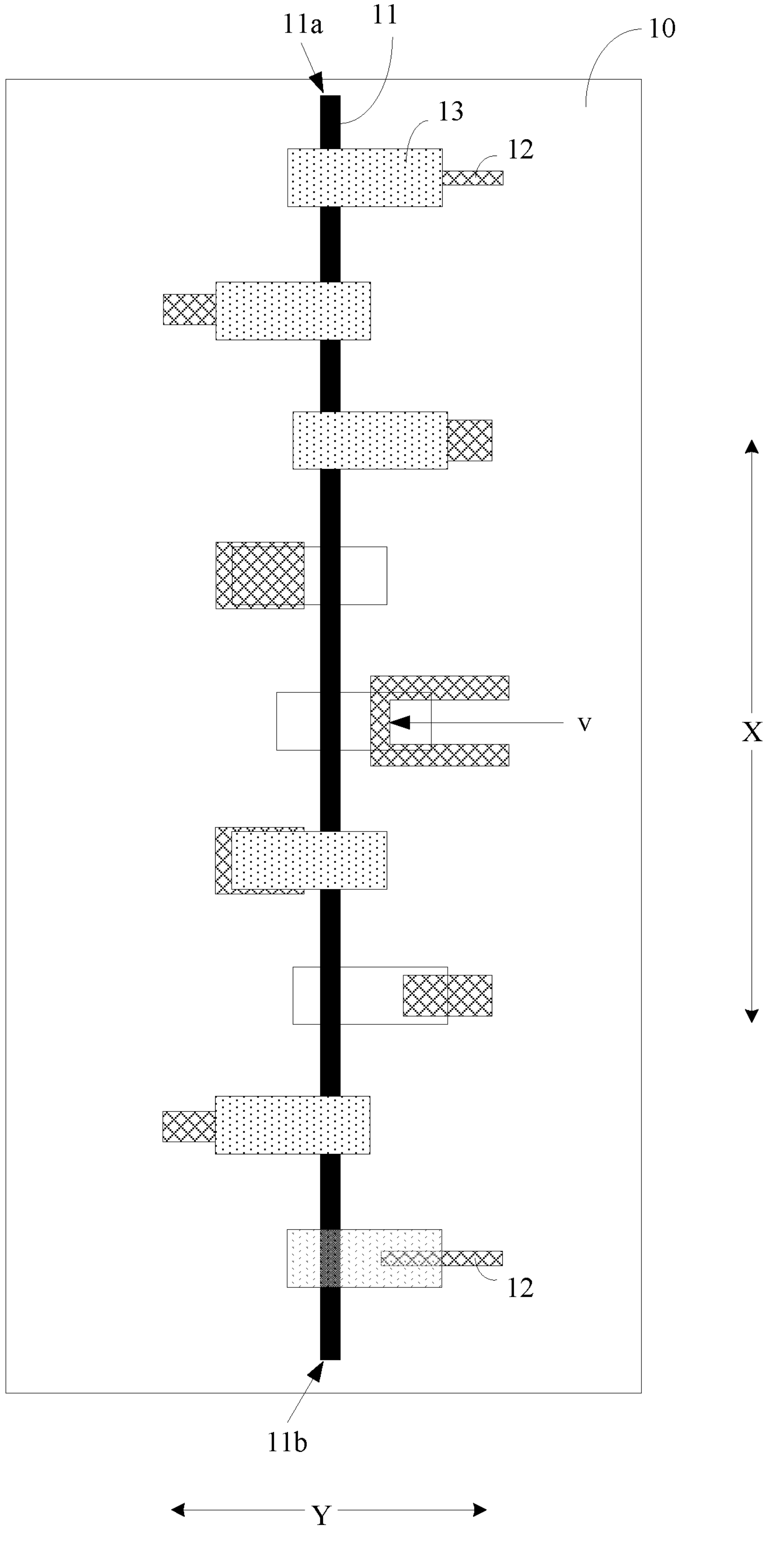


FIG. 10

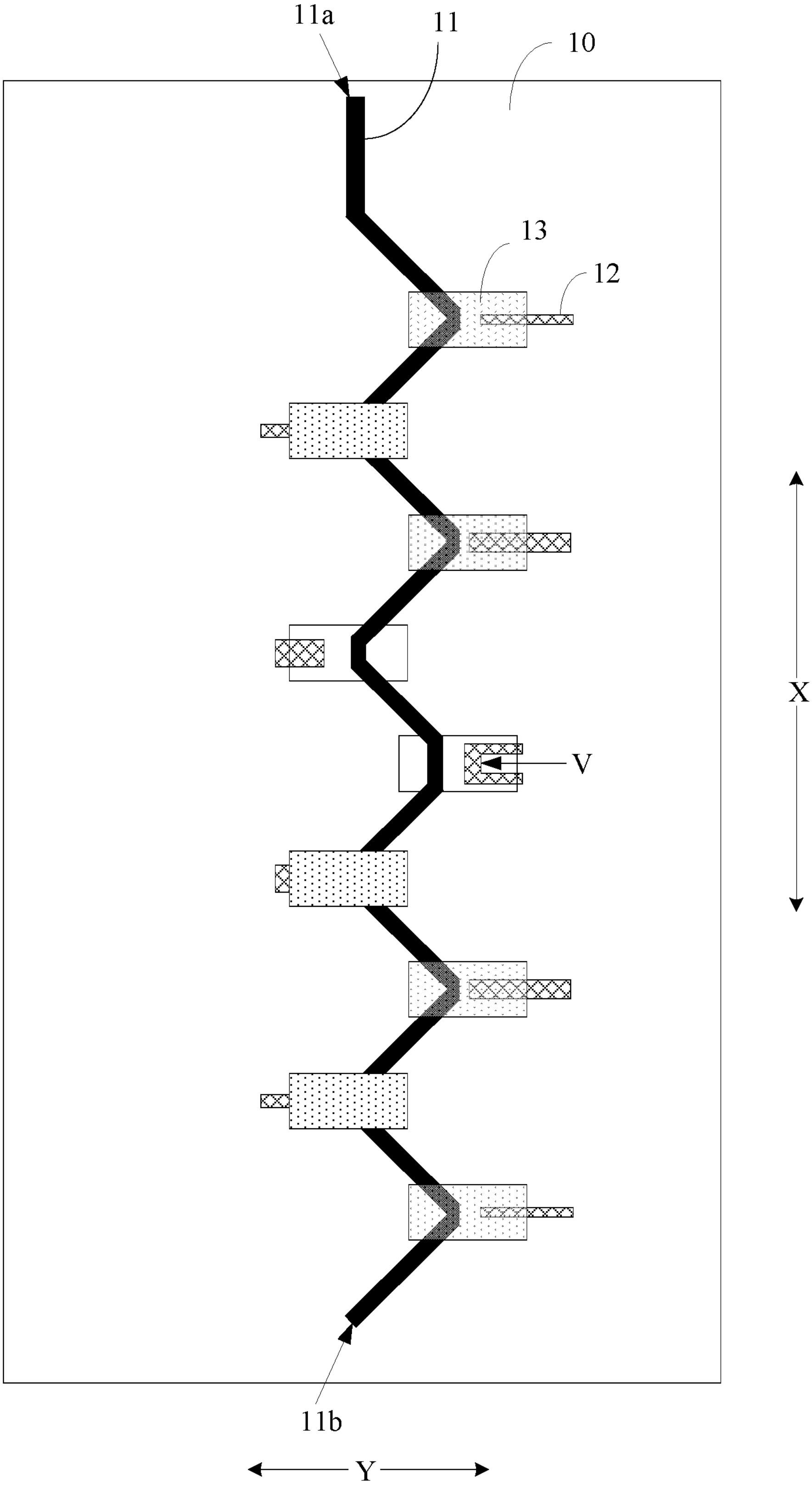


FIG. 11

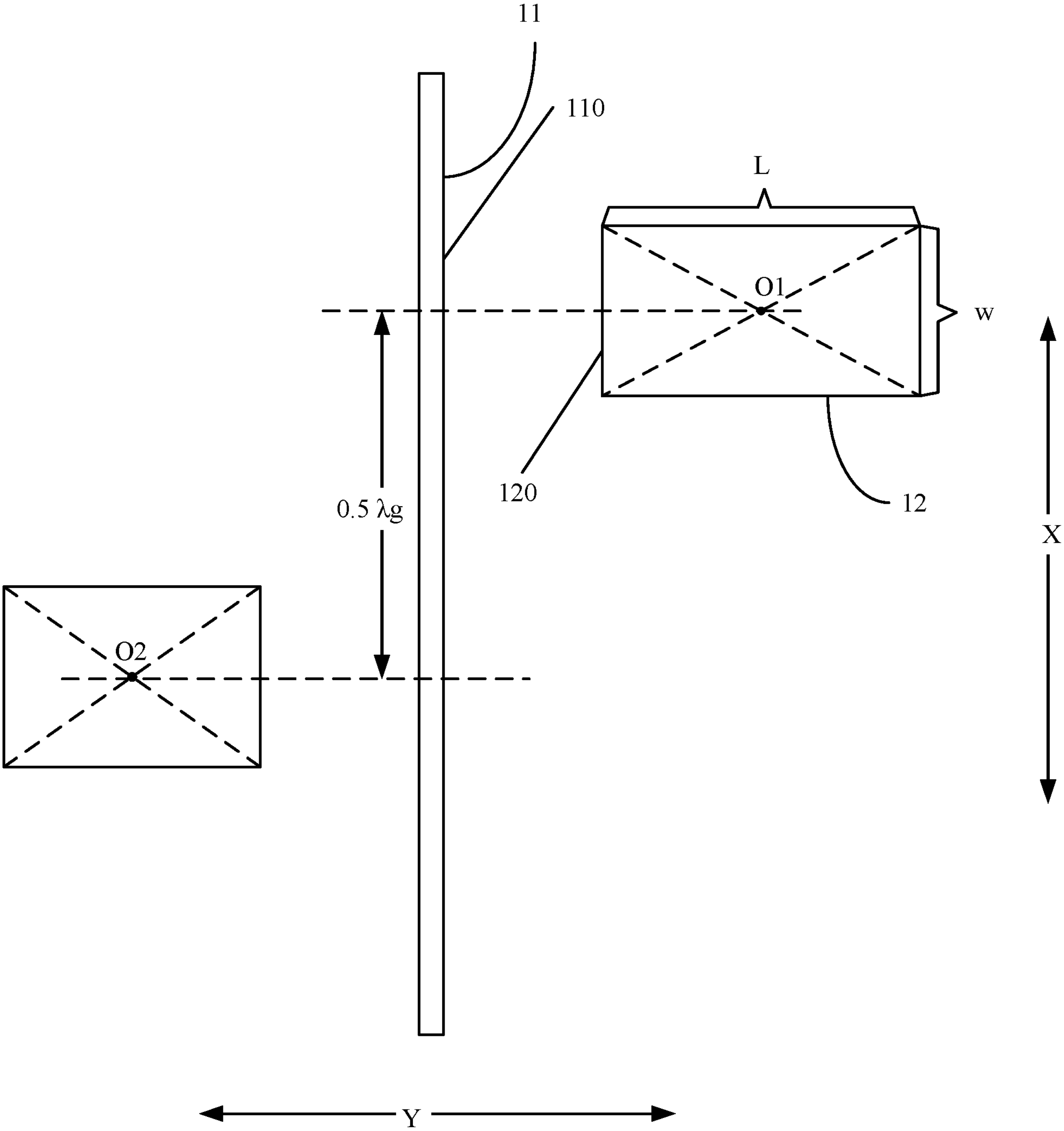


FIG. 12

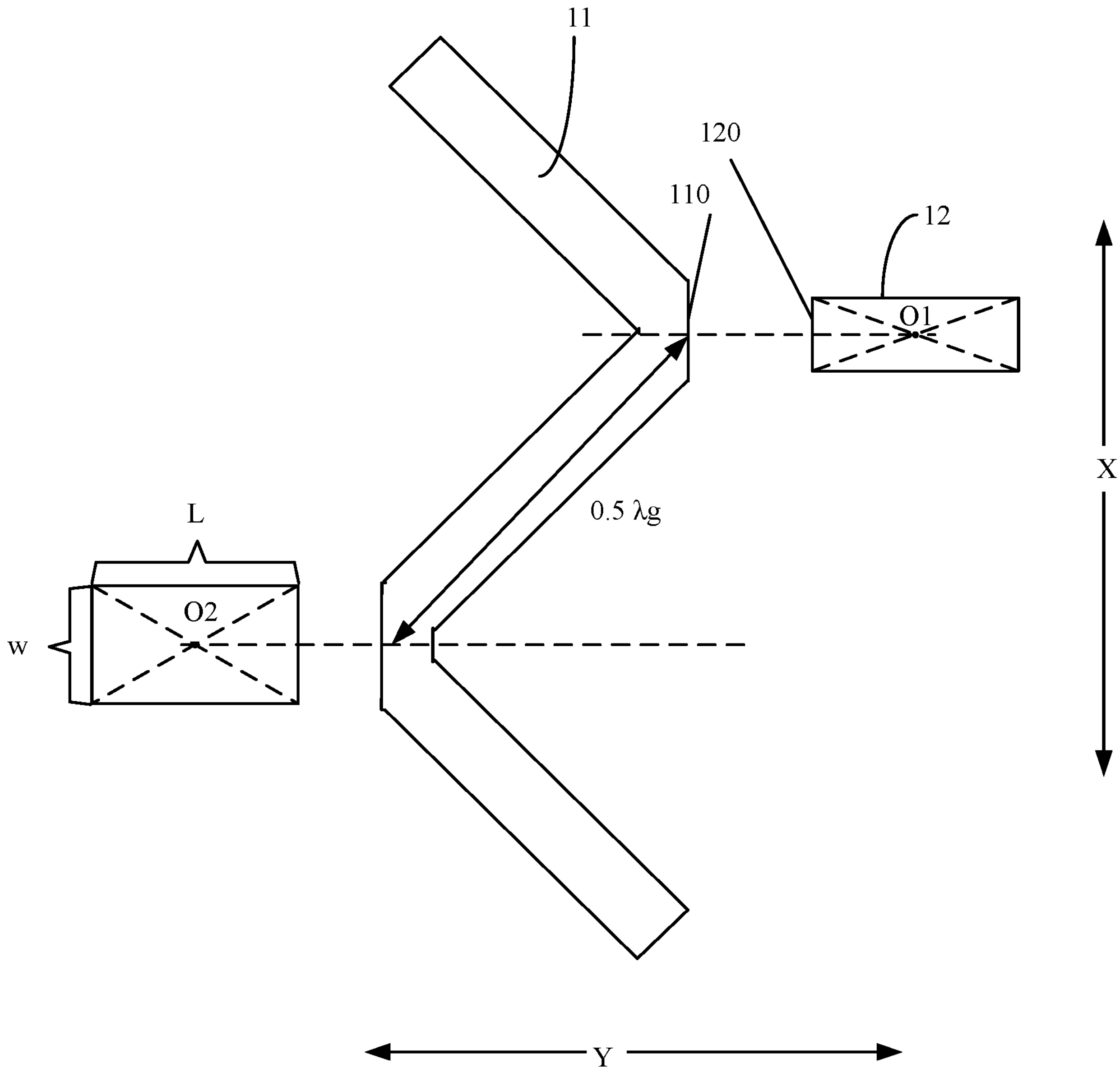
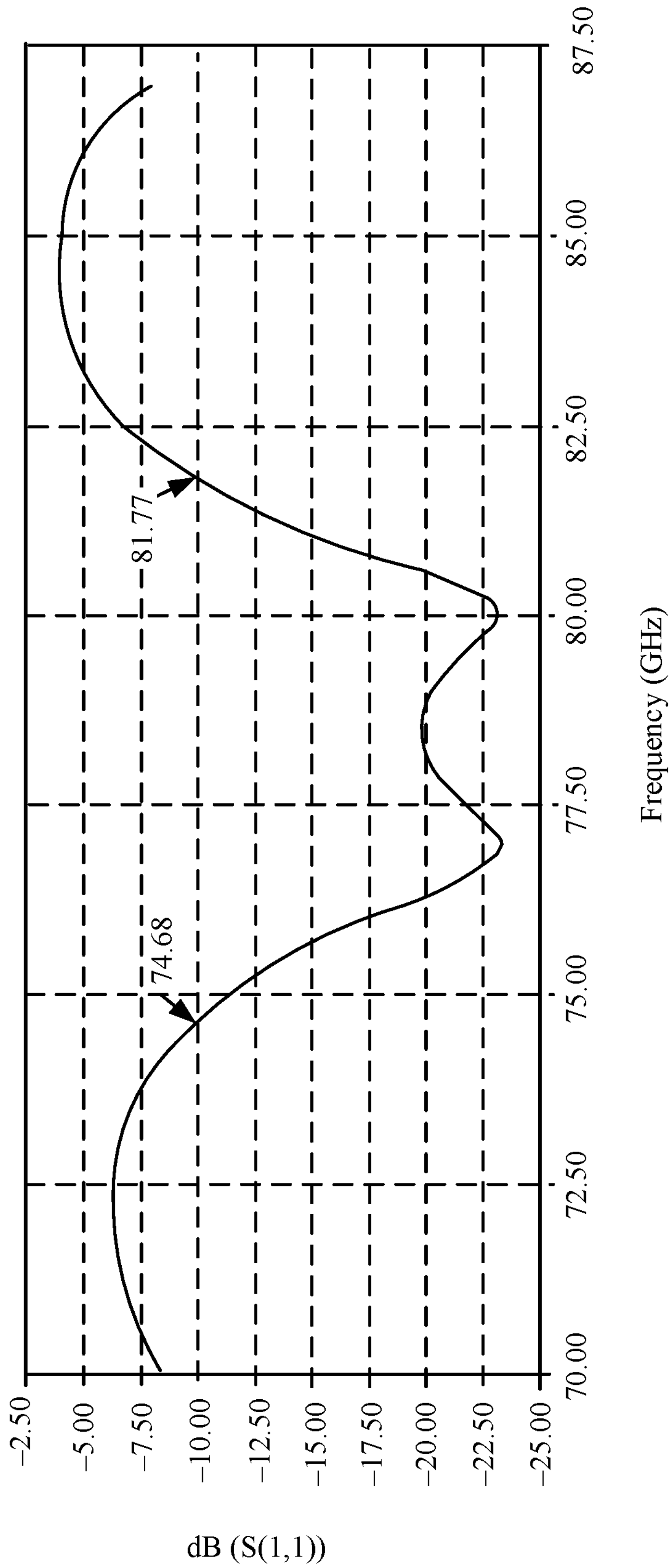


FIG. 13



dB (S(1,1))
−2.50
−5.00
−7.50
−10.00
−12.50
−15.00
−17.50
−20.00
−22.50
−25.00
Frequency (GHz)
70.00
72.50
75.00
77.50
80.00
82.50
85.00
87.50
74.68
81.77

FIG. 14

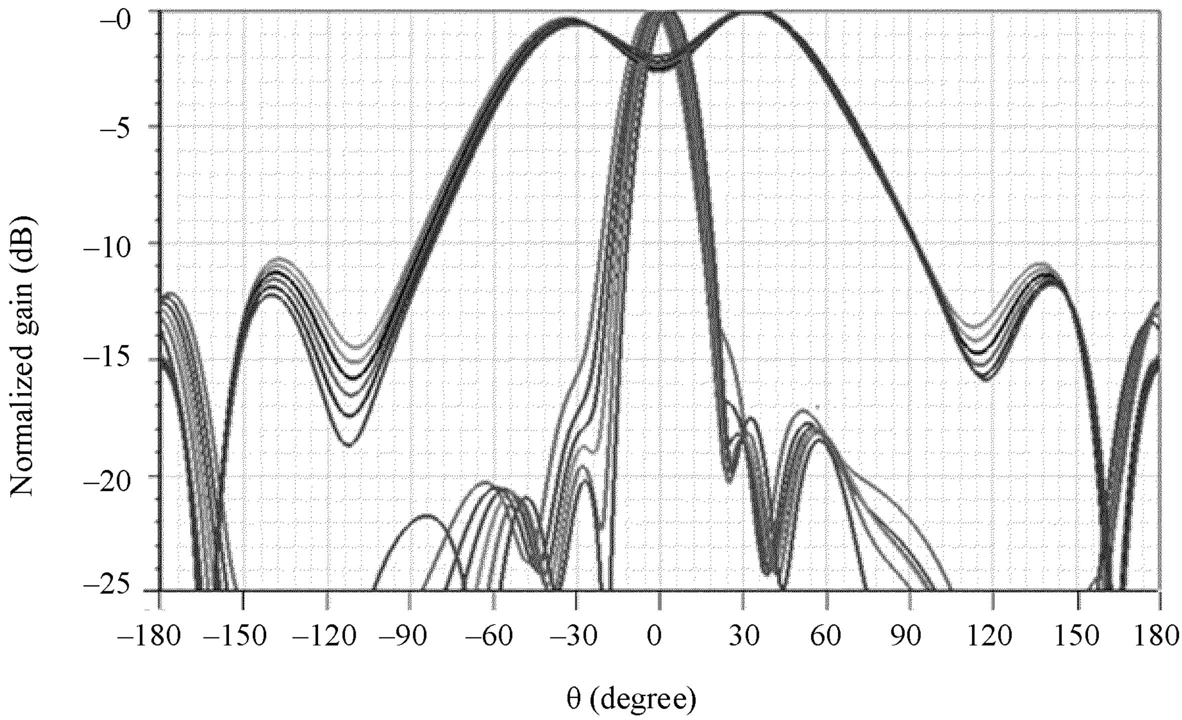

–0
–5
–10
–15
–20
–25
Normalized gain (dB)
–180 –150 –120 –90 –60 –30 0 30 60 90 120 150 180
θ (degree)

FIG. 15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2021/137447

A. CLASSIFICATION OF SUBJECT MATTER

H01Q 1/36(2006.01)i; H01Q 1/38(2006.01)i; H01Q 1/48(2006.01)i; H01Q 1/50(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01Q

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

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

CNABS; CNTXT; CNKI; VEN; USTXT; WOTXT; EPTXT; IEEE: 天线, 基板, 介质板, PCB, 馈, 串馈, 耦合, 缝, 寄生, 正面, 背面, 背离, 第二面, 侧, antenna, substrate, feed+, coupl+, slot, parasitic, back, side

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 110994194 A (CALTERAH SEMICONDUCTOR TECHNOLOGY (SHANGHAI) CO., LTD.) 10 April 2020 (2020-04-10) description, paragraphs [0084]-[0129], and figures 1-13	1-24
Y	CN 110380232 A (HUIZHOU DESAY SV AUTOMOTIVE CO., LTD.) 25 October 2019 (2019-10-25) description, paragraphs [0004]-[0037], and figures 1-4	1-24
A	CN 110611160 A (HUAWEI TECHNOLOGIES CO., LTD.) 24 December 2019 (2019-12-24) entire document	1-24
A	CN 102738572 A (SOUTHEAST UNIVERSITY) 17 October 2012 (2012-10-17) entire document	1-24

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

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

Date of the actual completion of the international search	Date of mailing of the international search report
04 February 2022	**18 February 2022**

Name and mailing address of the ISA/CN	Authorized officer
China National Intellectual Property Administration (ISA/CN) **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088, China**	
Facsimile No. **(86-10)62019451**	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2021/137447

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 110994194 A	10 April 2020	CN 211182538 U	04 August 2020
CN 110380232 A	25 October 2019	None	
CN 110611160 A	24 December 2019	CN 110611160 B	03 August 2021
CN 102738572 A	17 October 2012	None	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- CN 202110139300 **[0001]**