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

(11) EP 2 849 285 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
21.10.2020 Bulletin 2020/43

(51) Int Cl.:
H01Q 21/20 *(2006.01)* *H01Q 13/08* *(2006.01)*

(21) Application number: **14183701.3**

(22) Date of filing: **05.09.2014**

(54) **Ultra-broadband antenna array with constant beamwidth throughout operating frequency band**

Ultra-Breitbandantennengruppe mit konstanter Strahlbreite über das gesamte Betriebsfrequenzband

Réseau d’antennes à ultra-large bande constante sur toute la largeur de bande de fréquence de fonctionnement

(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

(30) Priority: **05.09.2013 US 201361874035 P**
02.09.2014 US 201414474414

(43) Date of publication of application:
18.03.2015 Bulletin 2015/12

(73) Proprietor: **Howard, John**
Upper Mount Bethel, PA 18343 (US)

(72) Inventors:
- **Howard, John**
Upper Mount Bethel, PA 18343 (US)
- **Wah Fung, Chuck**
Mountain Lakes, NJ 07046 (US)

(74) Representative: **Kolster Oy Ab**
(Salmisaarenaukio 1)
P.O. Box 204
00181 Helsinki (FI)

(56) References cited:
WO-A1-2011/109238
WO-A2-2008/065311
DE-A1-102005 003 685
GB-A- 2 431 050
US-A- 2 562 332
US-A1- 2003 052 828
US-B1- 7 271 775
US-B1- 7 518 565

EP 2 849 285 B1

Description

BACKGROUND

Field

[0001] Embodiments disclosed herein generally relate to antennas and, more particularly, relate to circular, spherical, conformal ultra-broadband antenna arrays having a substantially constant beamwidth throughout a band of operation.

SUMMARY

[0002] In accordance with the appended device claims, an antenna array is provided, which includes a plurality of antenna elements configured in a flare such that each of the plurality of antenna elements is uniformly spaced apart from at least one adjacent antenna element. Each of the plurality of antenna elements is coupled in a common area, and each of the plurality of antenna elements extends radially outward from the common area.

[0003] The plurality of antenna elements may be configured in at least one of a circle, half circle, sphere, and plane. At least one of the plurality of antenna elements may include at least one of a bow tie antenna, log-periodic antenna, and Vivaldi antenna. The antenna array includes an axis of symmetry extending through the common area, and at least one of the plurality of antenna elements may include a planar area, which includes an edge that is disposed non-parallel to the axis of symmetry when viewed normal to the axis of symmetry. At east one of the plurality of antenna elements is disposed at a tilt with respect to the axis of symmetry. The feed may be disposed in the common area and operatively coupled to at least one of the plurality of antenna elements. Patent document US 7518565 presents a tapered slot antenna cylindrical array. Patent document 20100066622 presents a multi-sector antenna. Patent document DE 102005003685 presents an antenna with a reflector. Patent documents WO 2008/065311 and GB 2431050 present antenna arrays comprising plural elements arranged in a flare about a common area.

[0004] In accordance with the appended method claims, a method of arranging antenna elements in an antenna array includes configuring a plurality of antenna elements in a flare such that each antenna element is uniformly spaced apart from at least one adjacent antenna element, and each of the plurality of antenna elements extends radially outward from a common area; and coupling each of the plurality of antenna elements in the common area.

[0005] The method may include configuring the plurality of antenna elements in at least one of a circle, half circle, sphere, and plane. At least one of the plurality of antenna elements may include at least one of a bow tie antenna, log-periodic antenna, and Vivaldi antenna. The antenna array includes an axis of symmetry extending through the common area, and at least one of the plurality of antenna elements may include a planar area. The planar area may include an edge, and the method may include disposing the edge non-parallel to the axis of symmetry when viewed normal to the axis of symmetry. The method includes disposing at least one of the plurality of antenna elements at a tilt with respect to the axis of symmetry. The antenna array may include a feed, and the method may include disposing the feed in the common area, and operatively coupling the feed to at least one of the plurality of antenna elements.

[0006] Other embodiments will become apparent from the following detailed description considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are designed as an illustration only and not as a definition of the limits of any disclosed embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The following drawings are provided by way of example only and without limitation, wherein like reference numerals (when used) indicate corresponding elements throughout the several views, and wherein:

Figure 1 shows a circular array of antenna elements not part of the invention;

Figures 2A and 2B show isometric views of a flare of a circular and conformal array of antenna elements not part of the invention;

Figures 2C and 2D show isometric and top views, respectively, of a flare of a half circular and conformal array of antenna elements not part of the invention;

Figures 3A and 3B show side views of cross-polarized antenna elements at a 45 degree tilt in a planar antenna array and a circular antenna array, respectively;

Figures 4A-C show isometric, side, and top views, respectively, of cross-polarized antenna elements at a 45 degree tilt in a circular antenna array;

Figure 5 shows a top view of a circular antenna array, in which opposing elements have been identified; and

Figure 6 shows a flare of antenna elements.

Figures 7A to 8B show isometric views of antenna elements disposed about a semi-sphere and sphere.

[0008] It is to be appreciated that elements in the figures are illustrated for simplicity and clarity. Common but well-understood elements that are useful or necessary in a commercially feasible embodiment are not shown in order to facilitate a less hindered view of the illustrated embodiments.

DETAILED DESCRIPTION

[0009] A circular antenna array is an antenna, which includes antenna elements arranged in a circle. A conformal antenna array is an antenna that is designed to conform or follow a predetermined shape. In accordance with embodiments disclosed herein, elements on the circular and/or conformal array are spaced at a certain distance in relation to an operating wavelength λ or operating band of wavelengths. This spacing remains constant from element to element at all frequencies of operation.

[0010] Figure 1 shows a circular antenna array 10 with bow tie antenna elements 12 arranged in a vertical polarization. Although bow tie antenna elements 12 are shown in the circular antenna array 10, any type of antenna element may be used in the illustrated configuration. Embodiments disclosed herein include ultra-broadband antenna arrays, in connection with which large frequency bands are used that can result in large fluctuations in beamwidth.

[0011] A wavelength λ of the operating signal is given by the following equation:

$$\lambda = \frac{V}{f} \qquad (1),$$

where V represents the phase speed or magnitude of the phase velocity of light ($3x10^8$ meters/second), and f represents the wave frequency. Equation (1) provides a basis for explaining a flare in the embodiments disclosed herein. For every frequency f, there is a different wavelength λ since the phase velocity V is a constant. Thus, as the wavelength λ changes, so too must the frequency f change. The spacing of antenna elements in the flare in relation to the wavelength λ is maintained to provide a constant beamwidth. Thus, the flare is used to maintain the correct proportion of frequency f with respect to the wavelength λ.

[0012] Since ultra-broadband operation includes a wide band of frequencies, the corresponding frequency f changes substantially, which causes the wavelength λ to change significantly as the frequency f changes. Because broadband antenna arrays in accordance with embodiments disclosed herein operate over such a wide range of frequencies, the antenna elements in the broadband antenna array are flared to maintain adequate spacing in relation to the wavelength λ throughout the frequency range of operation. Since the minimum and maximum operating frequencies of the broadband antenna array are known, the distance between each element at the minimum and maximum operating frequency can be calculated using equation (1). For example, assuming an antenna that operates from 300 MHz to 3GHz, the wavelengths are as follows:

$$\text{wavelength } \lambda \text{ at 300 MHZ} = 3x10^8/300x10^6 \sim 1 \text{ meter;}$$

and

$$\text{wavelength } \lambda \text{ at 3 GHZ} = 3x10^8/3x10^9 \sim 0.1 \text{ meter.}$$

Thus, the flare between antenna elements for this example is as shown in Figure 6, in which antenna elements 11 are separated at one end by dimension 13, which is approximately 1 meter, and separated at another end by dimension 15, which is approximately 0.1 meter. The view of the antenna elements 11 shown in Figure 6 is essentially a top view, which is similar to the view of the antenna elements 16 shown in Figure 2D and the view of the antenna elements 26, 28 shown in Figure 4C.

[0013] To provide adequate distance between antenna elements, flares 14, 15 of antenna elements 16 are used as shown in Figures 2A-D. These flares 14, 15 maintain inter-element distance between the antenna elements 16 with respect to the wavelength λ of the operating signal, which results in a constant beamwidth over the operating frequency range. Figures 2A and 2B show a flare 14 of antenna elements configured as a circular and conformal antenna array. Figures 2C and 2D show a flare 15 of antenna elements configured as a half circular and conformal antenna array. The antenna elements 16 are configured in the flare 14, 15 such that each of the plurality of antenna elements 16 is uniformly spaced apart from at least one adjacent antenna element 16, each of the plurality of antenna elements 16 is coupled in a common area 46, and each of the plurality of antenna elements extends radially outward from a common area 46. As discussed above, the antenna elements in the flare are spaced apart from each other based on the high and low frequencies in the operational frequency bandwidth. The quantity of antenna elements can be increased or decreased to form a circle, which can be result in a semi-sphere 52 shown in Figure 7A and 7B, a sphere 54, as shown in Figures 8A and 8B, and/or a conformal shape to provide azimuth and/or elevation coverage up to 360 degrees.

[0014] The disclosed embodiments utilize one or more broadband antenna elements. The flare, as used herein, refers to an antenna array in which the antenna elements are configured such that each antenna element is uniformly spaced apart from at least one adjacent antenna element, and each antenna element extends radially outward from a common central area. The antenna elements can be separately fed, which results in lower gain than when using a beam forming network. The beam forming network can be used to provide 360 degree coverage. Multiple beams can be generated using the beam forming network at, for example 0, 45, 90, 135, 180 degrees, each of which has substantially the same beamwidth due to the flare.

[0015] The antenna elements are fed from the common central area, from which the antenna elements radiate outward. However, log periodic antennas are fed in the opposite direction since the antenna elements radiate in the opposite direction, that is, towards the common central area. However, if the antenna elements are flared at 45 degrees, an opposing antenna element will be at -45 degrees, and since the antenna elements are spaced 90 degrees apart, the antenna elements will be orthogonal, and thus will not be blocked by radiation from opposing elements in such a configuration.

[0016] Embodiments according to the appended claims provide for a planar antenna array 18 shown in Figure 3A, or a circular antenna array 19 shown in Figure 3B using antenna elements 20 that are cross-polarized. Cross-polarization refers to the antenna elements 18 not being disposed in a straight-up configuration, as shown in Figure 1, but instead being disposed at a 45° or -45° tilt from a vertical straight line or axis of symmetry 22, 23. Figures 3A and 3B illustrate this 45° tilt concept. Although a 45° tilt is shown, alternative angles may be used to define the degree of tilt including, but not limited to, 15°, 30°,60°, and 75° while remaining within the intended scope of the embodiments disclosed herein.

[0017] Figures 4A-C show isometric, side, and top views, respectively, of a flare 24 of antenna elements configured as a circular antenna array. In this flare 24, opposing front and rear antenna elements 26, 28 are disposed at a 90° difference in orientation, thereby making the antenna elements 26, 28 orthogonal with respect to each other, as shown in Figures 4A-C. An axis of symmetry 42 is shown in Figures 4A-C, which extends through a common area 47. The tilt concept is also illustrated by at least one of the antenna elements including a planar area, which has an edge 50 that is disposed non-parallel to the axis of symmetry 42 when viewed normal to the axis of symmetry 42.

[0018] When either the front antenna element 26 or the rear antenna element 28 is propagating, neither of the elements 26, 28 sees the opposing element since the elements 26, 28 are perpendicular to each other. That is, there is no coupling or reflection between the front and rear opposing elements 26, 28. Stated differently, an antenna element cannot see the antenna element on the other side of the circular antenna array, and thus there is no interaction between opposing antenna elements.

[0019] Figure 5 identifies pairs of opposing antenna elements (26, 28), (30, 32), (34, 36), and (38, 40). By configuring these antenna elements at a 45 degree tilt in a circle, an inward antenna element propagates through the corresponding opposing antenna element disposed on the opposing side of the circle. As indicated above, log periodic antennas are fed in the opposite direction because the antenna elements radiate in the opposite direction. That is, the antenna elements will radiate inward towards the center of the circle. However, if the antenna elements are flared at a 45 degree angle, the opposing antenna element disposed on the opposite side of the circle, will be flared at a -45 degree angle, and since the antenna elements are 90 degrees apart, the opposing antenna elements will be orthogonal to each other, and thus opposing antenna elements will not block their respective radiations.

[0020] Broadband antenna elements, such as, but not limited to, log-periodic and Vivaldi antenna elements can be used in the embodiments disclosed herein.

Claims

1. An antenna array, which comprises:

a plurality of antenna elements (26, 28, 30, 32, 34, 36, 38, 40), the plurality of antenna elements (26, 28, 30,

32, 34, 36, 38, 40) being configured in a flare such that each of the antenna elements (26, 28, 30, 32, 34, 36, 38, 40) is uniformly spaced apart from at least one adjacent antenna element, each of the antenna elements (26, 28, 30, 32, 34, 36, 38, 40) being coupled in a common area (47), each of the antenna elements (26, 28, 30, 32, 34, 36, 38, 40) extending radially outward from the common area (47), wherein the antenna array includes an axis of symmetry extending through the common area (47) and **characterized in that**
at least one of the antenna elements (26, 28, 30, 32, 34, 36, 38, 40), which comprises a planar area, is disposed at a tilt to the axis (42) of symmetry that extends through the common area (47), the antenna elements (26, 28, 30, 32, 34, 36, 38, 40) having a uniform spacing therebetween based on wavelengths associated with an operating frequency band and being coupled in the common area (47), thereby providing a constant beam width over the operating frequency band.

2. The antenna array, as defined by Claim 1, **characterized in that** the plurality of antenna elements (26, 28, 30, 32, 34, 36, 38, 40) is configured in at least one of a half circle and sphere.

3. The antenna array, as defined by Claim 1, **characterized in that** the antenna elements (26, 28, 30, 32, 34, 36, 38, 40) are configured to provide azimuth and elevation coverage of a semi-sphere or a sphere.

4. The antenna array, as defined by Claim 1, **characterized in that** the antenna elements (26, 28, 30, 32, 34, 36, 38, 40) comprise at least one of a bow tie antenna, log-periodic antenna and Vivaldi antenna.

5. The antenna array, as defined by Claim 1, **characterized in that** the antenna elements (26, 28, 30, 32, 34, 36, 38, 40) are fed from the common area (47).

6. A method of arranging a plurality of antenna elements (26, 28, 30, 32, 34, 36, 38, 40) in an antenna array; which comprises:

configuring the plurality of antenna elements (26, 28, 30, 32, 34, 36, 38, 40) in a flare such that each antenna element is uniformly spaced apart from at least one adjacent antenna element and each of the antenna elements (26, 28, 30, 32, 34, 36, 38, 40) extends radially outward from a common area (47), wherein the plurality of antenna elements are arranged so as to define an axis of symmetry extending through the common area (47) and **characterized by**
disposing the antenna elements (26, 28, 30, 32, 34, 36, 38, 40) uniformly based on wavelengths associated with an operating frequency band, and at least one of the antenna elements (26, 28, 30, 32, 34, 36, 38, 40), which comprises a planar area, at a tilt to the axis (42) of symmetry extending through the common area (47); and coupling each of the antenna elements (26, 28, 30, 32, 34, 36, 38, 40) in the common area (47), thereby providing a constant beam width over the operating frequency band.

7. The method, as defined by Claim 6, **characterized by** configuring the plurality of antenna elements (26, 28, 30, 32, 34, 36, 38, 40) in at least one of a half circle and sphere.

8. The method, as defined by Claim 6, **characterized by** providing the antenna elements (26, 28, 30, 32, 34, 36, 38, 40) with azimuth and elevation coverage of a semi-sphere or a sphere.

9. The method, as defined by Claim 6, **characterized in that** the antenna elements (26, 28, 30, 32, 34, 36, 38, 40) comprise at least one of a bow tie antenna, log-periodic antenna and Vivaldi antenna.

Patentansprüche

1. Antennenarray, das Folgendes umfasst:

eine Vielzahl von Antennenelementen (26, 28, 30, 32, 34, 36, 38, 40), wobei die Vielzahl von Antennenelementen (26, 28, 30, 32, 34, 36, 38, 40) in einer Aufweitung ausgelegt sind, derart, dass jedes der Antennenelemente (26, 28, 30, 32, 34, 36, 38, 40) von mindestens einem benachbarten Antennenelement einheitlich beabstandet ist, wobei jedes der Antennenelemente (26, 28, 30, 32, 34, 36, 38, 40) in einem gemeinsamen Bereich (47) gekoppelt ist, wobei sich jedes der Antennenelemente (26, 28, 30, 32, 34, 36, 38, 40) vom gemeinsamen Bereich (47) radial nach außen erstreckt, wobei das Antennenarray eine Symmetrieachse beinhaltet, die sich durch den gemeinsamen Bereich (47) erstreckt, und **dadurch gekennzeichnet, dass** mindestens eines der Antennenelemente (26, 28, 30, 32, 34, 36, 38, 40), das einen planaren Bereich umfasst, in einer Neigung zur Symmetrieachse (42), die sich durch den gemeinsamen Bereich (47) erstreckt, angeordnet ist, wobei die Antennenelemente (26, 28, 30, 32, 34, 36, 38, 40) auf Basis von Wellenlängen, die mit einem Betriebsfrequenzband verknüpft sind, eine einheitliche Beabstandung dazwischen aufweisen und im gemeinsamen Bereich (47) gekoppelt sind, wodurch eine konstante Strahlbreite über das Betriebsfrequenzband bereitgestellt wird.

2. Antennenarray nach Anspruch 1, **dadurch gekennzeichnet, dass** die Vielzahl von Antennenelementen (26, 28, 30, 32, 34, 36, 38, 40) in mindestens einem von einem Halbkreis und einer Kugel ausgelegt ist.

3. Antennenarray nach Anspruch 1, **dadurch gekennzeichnet, dass** die Antennenelemente (26, 28, 30, 32, 34, 36, 38, 40) dazu ausgelegt sind, eine Azimut- und eine Elevationsabdeckung einer Halbkugel oder einer Kugel bereitzustellen.

4. Antennenarray nach Anspruch 1, **dadurch gekennzeichnet, dass** die Antennenelemente (26, 28, 30, 32, 34, 36, 38, 40) mindestens eine von einer Bowtie-Antenne, einer logarithmischperiodischen Antenne und einer Vivaldi-Antenne umfassen.

5. Antennenarray nach Anspruch 1, **dadurch gekennzeichnet, dass** die Antennenelemente (26, 28, 30, 32, 34, 36, 38, 40) vom gemeinsamen Bereich (47) gespeist werden.

6. Verfahren zum Positionieren einer Vielzahl von Antennenelementen (26, 28, 30, 32, 34, 36, 38, 40) in einem Antennenarray, das Folgendes umfassend:

   Auslegen der Vielzahl von Antennenelementen (26, 28, 30, 32, 34, 36, 38, 40) in einer Aufweitung, derart, dass jedes Antennenelement von mindestens einem benachbarten Antennenelement einheitlich beabstandet ist und jedes der Antennenelemente (26, 28, 30, 32, 34, 36, 38, 40) sich von einem gemeinsamen Bereich (47) radial nach außen erstreckt, wobei die Vielzahl von Antennenelementen positioniert sind, um eine Symmetrieachse zu definieren, die sich durch den gemeinsamen Bereich (47) erstreckt, und **gekennzeichnet durch**
   einheitliches Anordnen der Antennenelemente (26, 28, 30, 32, 34, 36, 38, 40) auf Basis von Wellenlängen, die mit einem Betriebsfrequenzband verknüpft sind, und von mindestens einem der Antennenelemente (26, 28, 30, 32, 34, 36, 38, 40), das einen planaren Bereich umfasst, in einer Neigung zur Symmetrieachse (42), die sich durch den gemeinsamen Bereich (47) erstreckt; und
   Koppeln von jedem der Antennenelemente (26, 28, 30, 32, 34, 36, 38, 40) im gemeinsamen Bereich (47), dadurch Bereitstellen einer konstanten Strahlbreite über das Betriebsfrequenzband.

7. Verfahren nach Anspruch 6, **gekennzeichnet durch** Auslegen der Vielzahl von Antennenelementen (26, 28, 30, 32, 34, 36, 38, 40) in mindestens einem von einem Halbkreis und einer Kugel.

8. Verfahren nach Anspruch 6, **gekennzeichnet durch** Bereitstellen der Antennenelemente (26, 28, 30, 32, 34, 36, 38, 40) mit einer Azimut- und einer Elevationsabdeckung einer Halbkugel oder einer Kugel.

9. Verfahren nach Anspruch 6, **dadurch gekennzeichnet, dass** die Antennenelemente (26, 28, 30, 32, 34, 36, 38, 40) mindestens eine von einer Bowtie-Antenne, einer logarithmischperiodischen Antenne und einer Vivaldi-Antenne umfassen.

Revendications

1. Réseau d’antennes qui comprend :
   une pluralité d’éléments d’antenne (26, 28, 30, 32, 34, 36, 38, 40), la pluralité d’éléments d’antenne (26, 28, 30, 32, 34, 36, 38, 40) étant configurée en arrondi de sorte que chacun des éléments d’antenne (26, 28, 30, 32, 34, 36, 38, 40) est uniformément espacé d’au moins un élément d’antenne adjacent, chacun des éléments d’antenne (26, 28, 30, 32, 34, 36, 38, 40) étant couplé dans une zone commune (47), chacun des éléments d’antenne (26, 28, 30, 32, 34, 36, 38, 40) s’étendant radialement vers l’extérieur à partir de la zone commune (47), dans lequel le réseau d’antennes comprend un axe de symétrie s’étendant à travers la zone commune (47) et **caractérisé en ce que** :
   au moins l’un des éléments d’antenne (26, 28, 30, 32, 34, 36, 38, 40), qui comprend une zone planaire, est disposé selon une inclinaison par rapport à l’axe (42) de symétrie qui s’étend à travers la zone commune (47), les éléments

d'antenne (26, 28, 30, 32, 34, 36, 38, 40) ayant un espacement uniforme entre eux sur la base des longueurs d'onde associées avec une bande de fréquence de fonctionnement et étant couplés dans la zone commune (47), fournissant ainsi une largeur de faisceau constante sur la bande de fréquence de fonctionnement.

2. Réseau d'antennes selon la revendication 1, **caractérisé en ce que** la pluralité d'éléments d'antenne (26, 28, 30, 32, 34, 36, 38, 40) est configurée dans au moins l'un parmi un demi-cercle et une sphère.

3. Réseau d'antennes selon la revendication 1, **caractérisé en ce que** les éléments d'antenne (26, 28, 30, 32, 34, 36, 38, 40) sont configurés pour fournir une couverture d'azimut et d'élévation d'une demi-sphère ou d'une sphère.

4. Réseau d'antennes selon la revendication 1, **caractérisé en ce que** les éléments d'antenne (26, 28, 30, 32, 34, 36, 38, 40) comprennent au moins l'une parmi une antenne papillon, une antenne log-périodique et une antenne Vivaldi.

5. Réseau d'antennes selon la revendication 1, **caractérisé en ce que** les éléments d'antenne (26, 28, 30, 32, 34, 36, 38, 40) sont alimentés à partir de la zone commune (47) .

6. Procédé pour agencer une pluralité d'éléments d'antenne (26, 28, 30, 32, 34, 36, 38, 40) dans un réseau d'antennes, qui comprend l'étape suivante :
configurer la pluralité d'éléments d'antenne (26, 28, 30, 32, 34, 36, 38, 40) en arrondi de sorte que chaque élément d'antenne est uniformément espacé d'au moins un élément d'antenne adjacent et chacun des éléments d'antenne (26, 28, 30, 32, 34, 36, 38, 40) s'étend radialement vers l'extérieur à partir d'une zone commune (42), dans lequel la pluralité d'éléments d'antenne sont agencés afin de définir un axe de symétrie s'étendant à travers la zone commune (47) et **caractérisé par** les étapes suivantes :

    disposer les éléments d'antenne (26, 28, 30, 32, 34, 36, 38, 40) uniformément, sur la base des longueurs d'onde associées avec une bande de fréquence de fonctionnement, et au moins l'un des éléments d'antenne (26, 28, 30, 32, 34, 36, 38, 40) qui comprend une zone planaire, selon une inclinaison par rapport à l'axe (42) de symétrie s'étendant à travers la zone commune (47) ; et
    coupler chacun des éléments d'antenne (26, 28, 30, 32, 34, 36, 38, 40) dans la zone commune (47), fournissant ainsi une largeur de faisceau constante sur la bande de fréquence de fonctionnement.

7. Procédé selon la revendication 6, **caractérisé par** l'étape pour configurer la pluralité d'élément d'antenne (26, 28, 30, 32, 34, 36, 38, 40) dans au moins l'un parmi un demi-cercle et une sphère.

8. Procédé selon la revendication 6, **caractérisé par** l'étape pour doter les éléments d'antenne (26, 28, 30, 32, 34, 36, 38, 40) d'une couverture d'azimut et d'élévation d'une demi-sphère ou d'une sphère.

9. Procédé selon la revendication 6, **caractérisé en ce que** les éléments d'antenne (26, 28, 30, 32, 34, 36, 38, 40) comprennent au moins l'une parmi une antenne papillon, une antenne log-périodique et une antenne Vivaldi.

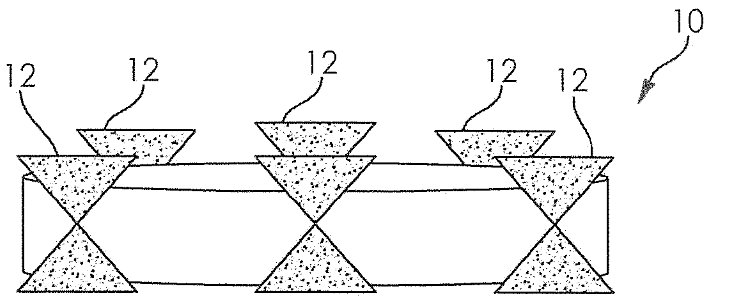

FIG. 1

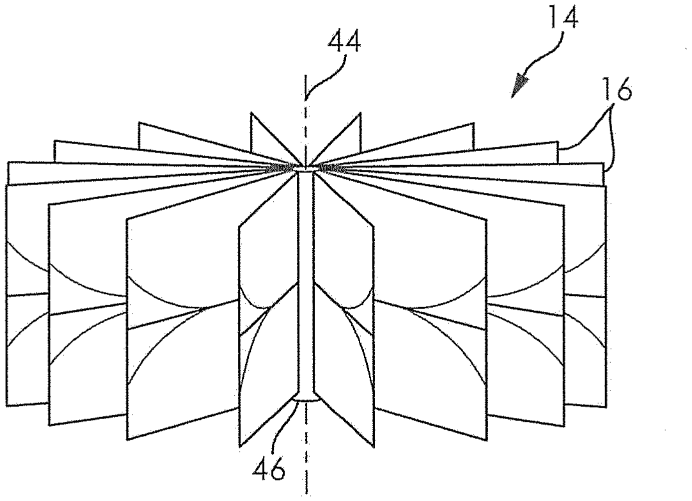

FIG. 2A

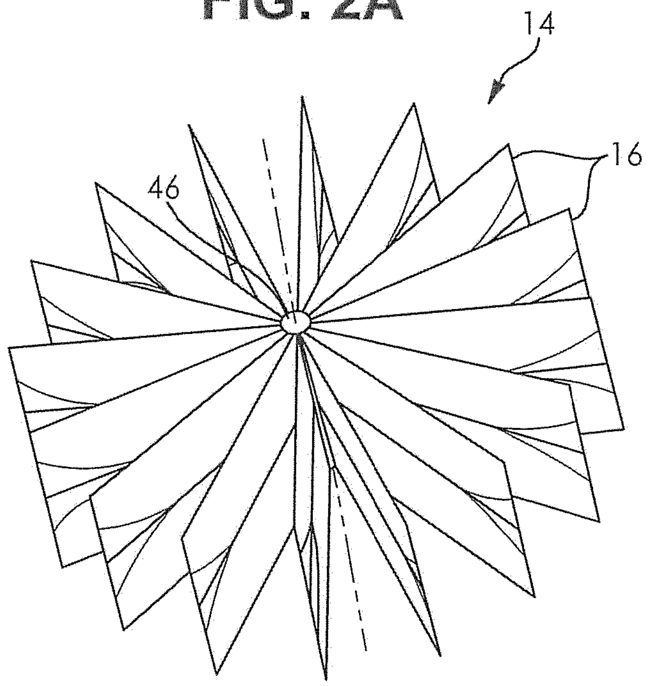

FIG. 2B

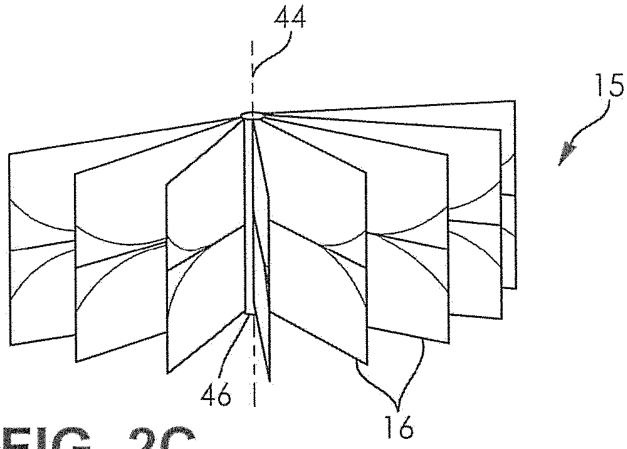

FIG. 2C

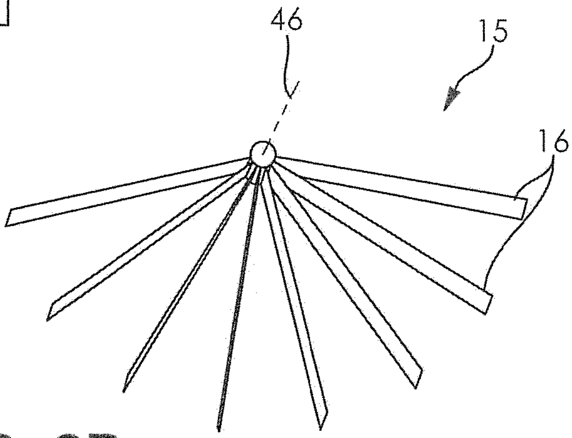

FIG. 2D

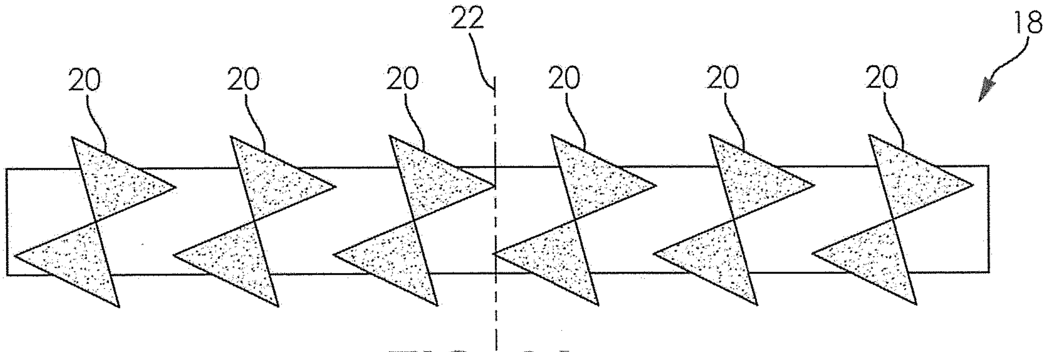

FIG. 3A

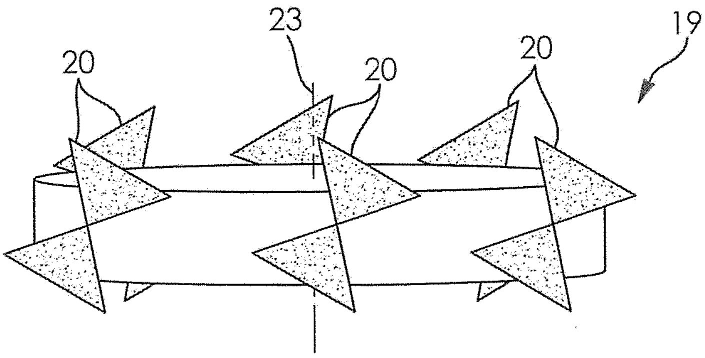

FIG. 3B

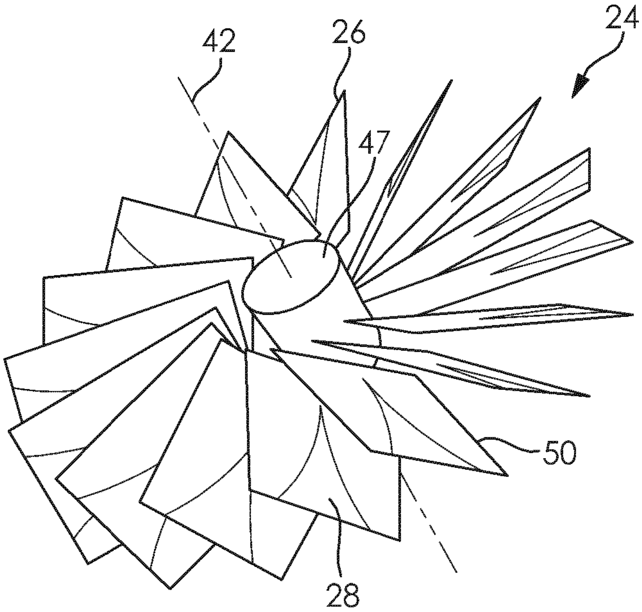

FIG. 4A

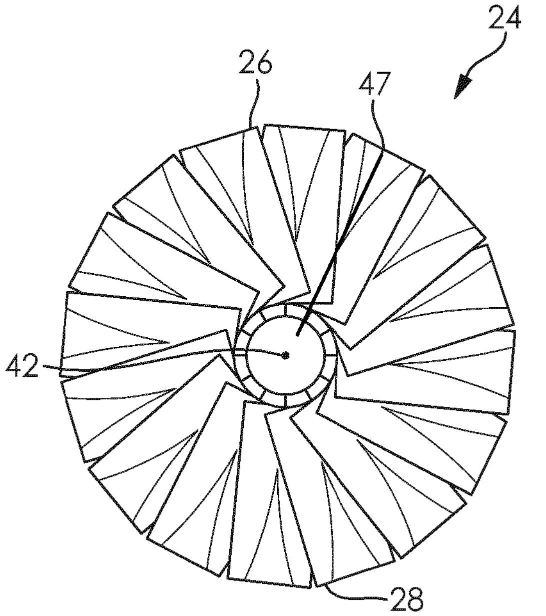

FIG. 4C

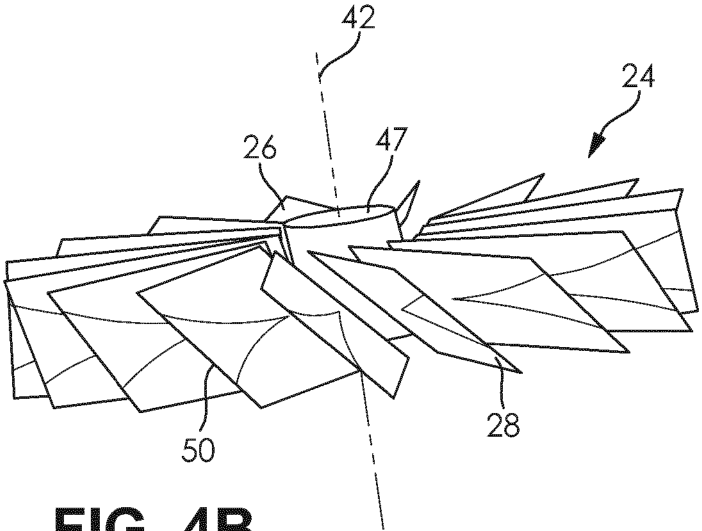

FIG. 4B

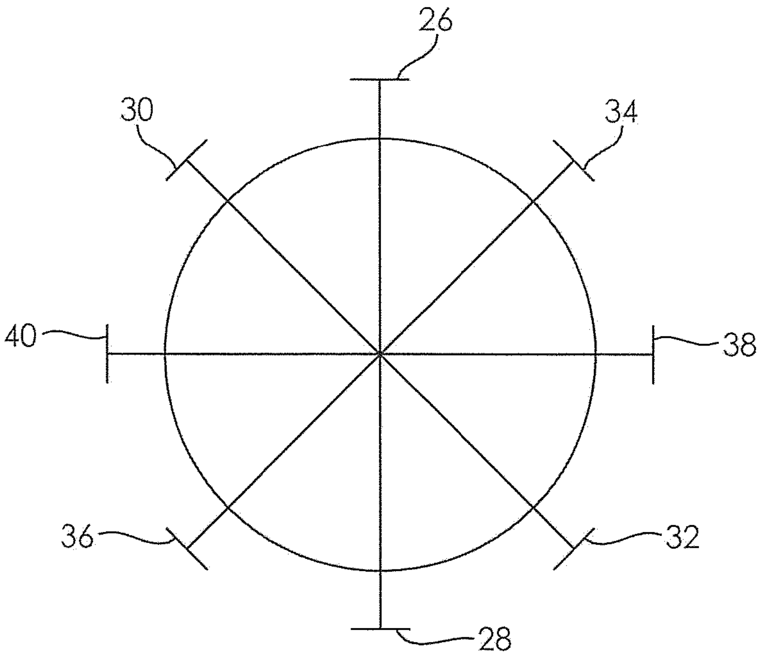

FIG. 5

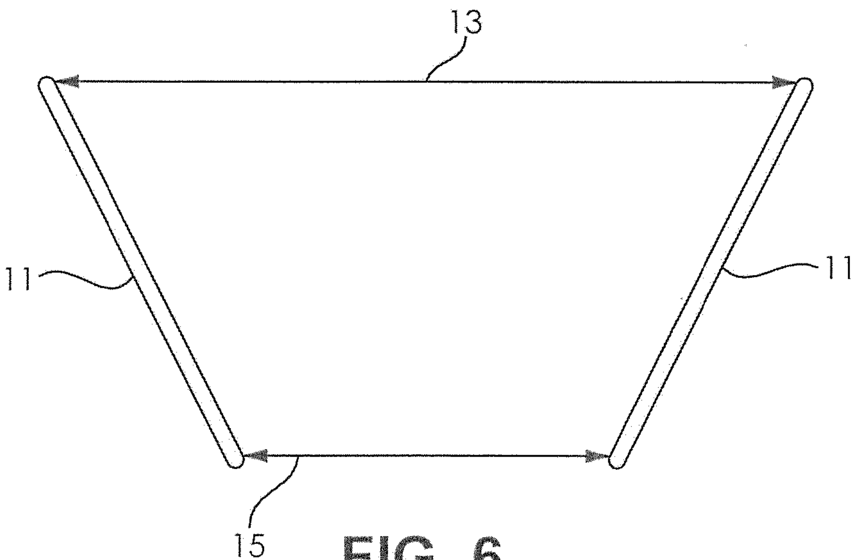

FIG. 6

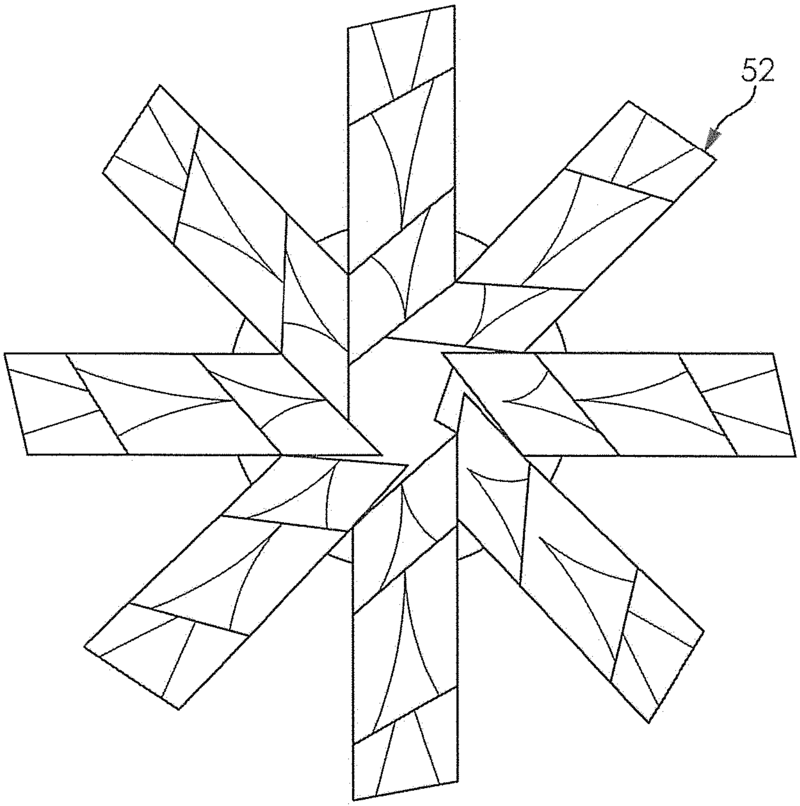

FIG. 7A

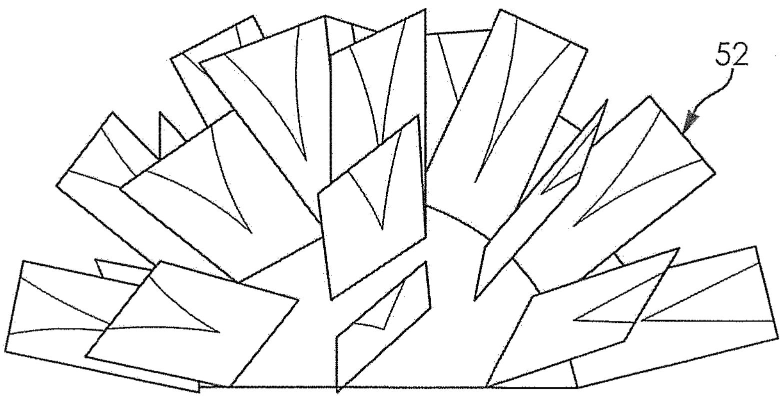

FIG. 7B

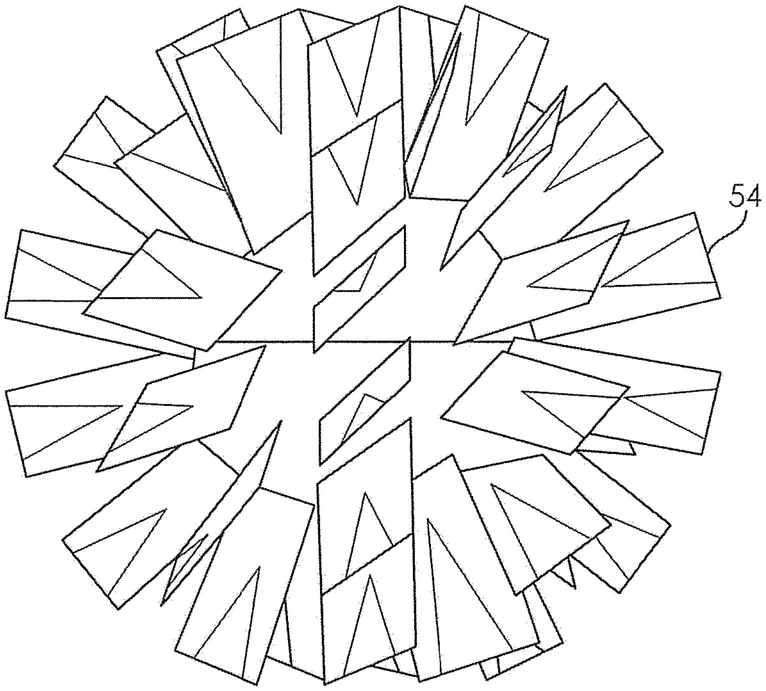

FIG. 8A

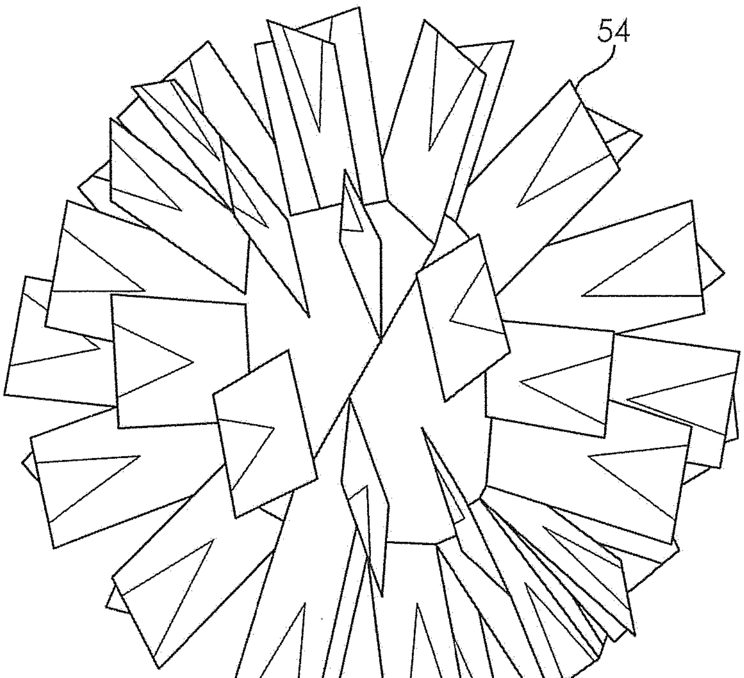

FIG. 8B

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

- US 7518565 B **[0003]**
- WO 20100066622 A **[0003]**
- DE 102005003685 **[0003]**
- WO 2008065311 A **[0003]**
- GB 2431050 A **[0003]**