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(54) **Reflector, and antenna comprising said reflector**

(57) A reflector (12) adapted to be fitted to a Cassegrain-type antenna system, wherein said reflector is paraboloid-shape extending between a vertex (12a) and a peripheral rim (12b) about an axis of rotation (x), and wherein said rim presents a superelliptical shape when projected against a plane lying in a plane orthogonal to said axis of rotation.

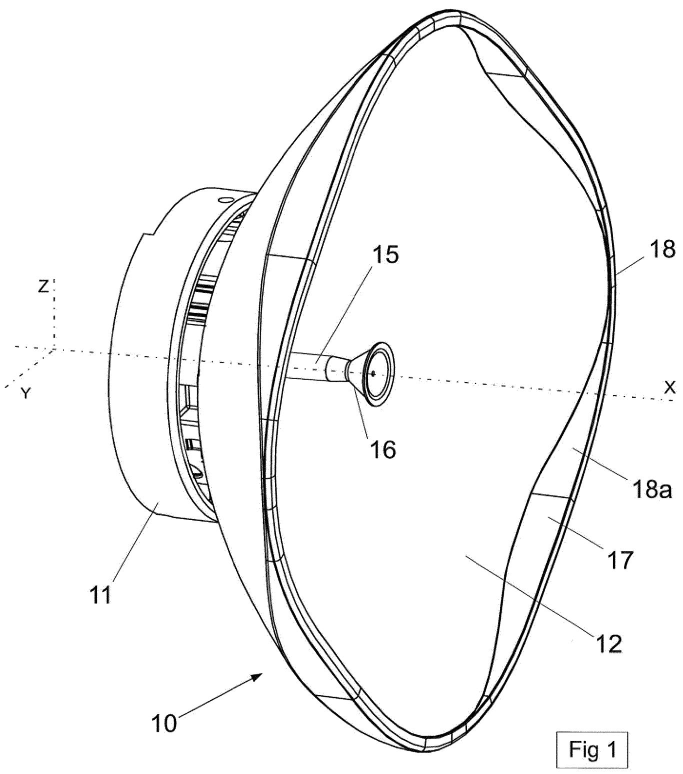

Fig 1

EP 2 854 220 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to the field of microwave antennas.

BACKGROUND

[0002] This section introduces aspects that may be helpful in facilitating a better understanding of the invention. Accordingly, the statements of this section are to be read in this light and are not to be understood as admissions about what is in the prior art or what is not in the prior art.

[0003] Modern communication applications like video streaming, mobile TV and other smart phone applications result in exponential increase of data rates. Specifically in urban areas the data density requires new network topologies including micro cells. Consequently, the number of point-to-point radio links is also increasing and solutions matching the needs of the micro cell application are required.

[0004] The shorter link distances seen in urban environments allows the application of point-to-point antennas offering lower gain than solutions adapted specifically to mid- and long-distance backhauling.

[0005] Getting allowance for RF equipment installation in urban areas remains however sometimes challenging. Smaller, less obtrusive solutions or antennas integrating with the radio into one unit increases acceptance of people living in the area, and consequently of decision makers: regulatory bodies, landlords, and the public.

[0006] The specifications derived from the requirement of providing microwave cells in a dense urban environment is generally thought to require low-mid gain, high side lobe suppression (ETSI Class 3) and antennas with small outline to make them unobtrusive.

[0007] Planar antenna array technology is generally proposed for such requirements, due to their low extension in the z-direction (ie. axially along the direction of radiation), causing a small outline. Nonetheless, there are drawbacks to the planar array technology compared to the more common parabolic reflector technology. Some of these drawbacks are long feed lines which increase losses, limited bandwidth, limited matching and input return loss, lower gain, and higher cost. Furthermore, in the upper frequency ranges that also incorporate large relative bandwidth, such as the E-Band (60-90 GHz) amongst others, many of these drawbacks become critical limitations.

[0008] In urban areas, such point-to-point antennas entail frequencies in the 25GHz range and diametric dimensions less than 20 cm.

[0009] A solution is sought to better address this situation.

SUMMARY

[0010] In view of the foregoing, an embodiment herein provides for a reflector adapted to be fitted to a Cassegrain-type antenna system, wherein said reflector is paraboloid-shape extending between a vertex and a peripheral rim about an axis of rotation, and wherein said rim presents a superelliptical shape when projected against a plane lying in a plane orthogonal to said axis of rotation.

[0011] According to a non-limiting variants of the embodiments, one may have recourse to one or more of the following features :

- the projection of said superelliptical rim is defined by the hollowing equation: $\left|\frac{x-a}{r_a}\right|^n + \left|\frac{y-b}{r_b}\right|^n = 1$, wherein r_a and r_b are the dimensions of the semi-major and semi-minor Cartesian axes centered on the axis of rotation, and a, b are the Cartesian centre of the super-ellipse, and wherein n is the variable affecting the angularity of the projection of said superelliptical rim;
- n is between 2 and 4;
- n is approximately equal to 3;
- the dimensions of the semi-major and semi-minor Cartesian axes r_a and r_b respectively, are substantially equal;
- the reflector presents a ratio of focal length of the reflector to the dimension of the semi-major axes r_a between 0.3 and 0.4 ($0.3 < f / D < 0.4$), and even more preferably said ratio is approximatively equal to 0.34 ($f / D \sim= 0.4$);
- the semi-major axis dimension is less than 10 cm, and preferably less than 7.5 cm; and/or
- the ratio of the dimension of the semi-major axes r_a to the wavelength of the signal adapted to be transmitted by said reflector is greater than 8 ($r_a / \lambda > 8$).

[0012] In another embodiment, it is provided for an antenna system disposed in a Cassegrain geometry, comprising:

- a primary reflector according to any one of the features described hereabove;
- a secondary reflector positioned coaxially to the axis of rotation of said primary reflector;
- a feed device adapted to generate or sense electromagnetic signals to or from said secondary reflector,

Wherein said secondary reflector is positioned in such as way as to reflect said electromagnetic signals to said primary reflector

Wherein said primary reflector is positioned in such as way as to reflect said electromagnetic signals from said secondary reflector to a sensibly parallel signal.

[0013] Advantages of one or more of the preceding embodiments is to provide for microwave antennas with a low profile for substantially the same radio electrical performances as parabolic antennas for the same antenna dish diameter. Indeed, the depth in the z-direction (along the axis of symmetry) of parabolic antennas greatly increases as a function of diameter of the antenna, to the contrary of the depth of array antennas which vary little as a function of diametric size.

[0014] This is particularly important to customers in dense urban network architectures where low visibility is important; the above-mentioned embodiments may blend more easily in urban architecture in order to be less obtrusive.

Furthermore, the embodiments recited above allow for a solution that improves the form factor when compared to traditional round parabolic antennas having an absorbing shroud and enables tight integration with the customer radio box needed for point-to-point telecommunication systems.

[0015] Indeed, the embodiments recited above allow for a Cassegrain-type radio link antenna in which the aperture extension in the smaller dimension may be reduced by up to 10-15% by sacrificing negligible radio frequency (RF) performance. Indeed, the patterns and side lobe suppression is stable, with minimal gain reduction in low band. This optimized compromise also delivers a pleasing outline easily integrated with rectangular radio box designs.

The present embodiments also outperform flat array technology in nearly all RF parameters and cost for a given size.

[0016] These and other aspects of the embodiments herein will be better appreciated and understood when considered in conjunction with the following description and the accompanying drawings.

BRIEF DESCRIPTION OF THE FIGURES

[0017] The embodiments herein will be better understood from the following detailed description with reference to the drawings, in which:

FIG. 1 illustrates a schematic perspective view of an antenna according to an embodiment;
FIG. 2 illustrates an axial cross sectional view of the antenna of figure 1;
FIGS. 3 and 4 are curves representing variants of the projection of the rim of the antenna of figure 1;
FIG. 5 illustrates the radiation pattern gain plotted against radiation angle for an antenna according to another embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

[0018] The embodiments herein and the various features and advantageous details thereof are explained more fully with reference to the non-limiting embodiments that are illustrated in the accompanying drawings and detailed in the following description. Descriptions of well known components and processing techniques are omitted so as to not unnecessarily obscure the embodiments herein. The examples used herein are intended merely to facilitate an understanding of ways in which the embodiments herein may be practiced and to further enable those of skill in the art to practice the embodiments herein. Accordingly, the examples should not be construed as limiting the scope of the embodiments herein.

[0019] Turning now to the drawings and referring first to the schematic illustration of figure 1, of an antenna 10 configured in the Cassegrain reflector geometry, shown in perspective view.

[0020] The antenna 10 comprises a mounting structure 11, onto which is fitted a main concave parabolically shaped reflector 12 defining a central axis of symmetry 14. The mounting structure 11 is adapted for mounting the antenna 10 to an external structure such as a building wall, a pole, etc. The central axis 14 will be considered to be coaxial to the Cartesian z-axis in the present description.

[0021] The antenna 10 further comprises a secondary convex parabolically shaped reflector 16. The secondary reflector 16 is preferably coaxially about central axis 14 in vis-à-vis with the main dish 12, and may be suspended in place by any known means, for example a truss structure, with guide wires, a single rigid arm, etc. In the illustrated embodiment, the secondary reflector 16 is supported by a waveguide pipe 15 extending about the central axis 14 between the main reflector 12 and the secondary reflector 16.

[0022] The antenna 10 further comprises a feed device 20 (not illustrated) aimed at the reflector 16 and adapted to sense and radiate electromagnetic energy from and to, respectively, the secondary reflector 16. The feed device 20 is normally positioned at the base of the waveguide pipe 15.

[0023] The feed device 20 is connected to a transmitter device, adapted for converting electrical signals to and from electromagnetic signals.

[0024] Referring more particularly to figure 2 representing an axial cross section view of the antenna of figure 1, the dish 12 extends from a vertex 12a to a circumferential rim 12b of the dish 12.

[0025] The region of the dish 12 around the vertex 12a (also known as the base 12a) is shaped as a paraboloid, generated by revolving a parabola around central axis 14. The region around the vertex 12a thus inscribes a circle in the x-y plane perpendicular to the central axis 14. For example, the equation is given by $z = x^2 / (2*f)$, revolved 360° around the central axis 14 (the 'z axis'). The variable f is the focal length of the dish 12.

According to a preferential embodiment, the focal length f may be approximately 25 mm, with a dish diameter D of approximately 150mm, such that the ratio f/D is approximately 0.17. This value of f/D allows for a depth of the parabola greater than the focal distance f, such that the antenna feed 20 is near the vertex 12a of the dish 12. This configuration limits the lateral radiation without the needs for an absorbent shroud at the extremity 12b of the dish. Of course, such an antenna would also be suitable for very high frequency transmission greater than 30 GHz.

[0026] In another preferential embodiment, the ratio of the dish diameter D and the wavelength λ of the radiated radio waves from the feed device 20 signal (ie. D / λ) is greater than 16.

[0027] The circumferential rim 12b of the dish 12 describes a super-ellipse extending in the x-y plane, perpendicular to the central axis 14. The super ellipse may have for general equation :

$$\left|\frac{x-a}{r_a}\right|^n + \left|\frac{y-b}{r_b}\right|^n = 1,$$

where r_a and r_b are the semi-major and semi-minor Cartesian axes centre on the central axis 14, and (a,b) are the Cartesian centre of the super-ellipse. r_a and r_b are preferably approximately equal in magnitude, and n is the variable affecting the super-ellipticality inscribed by the formula.

[0028] The dimension of the diameter D will hereinunder be used to mean twice the dimension of either of the semi-major and semi-minor axes dimension.

[0029] Thus, the main reflector 12 extends from a base 12a having a circular cross-section to a circumferential rim 12b having a super-elliptical cross-section in the x-y plane. In the z-direction, the reflector 12 describes a smooth transition from the base 12a to the rim 12b.

[0030] It is to be noted that the paraboloid-shaped main reflector 12 extending in the z-direction, when intersected with a super-ellipse extending in the x-y plane, creates a rim 12b whose extension in the z-dimension varies. In other words, the rim 12b is not planar, ie. the rim 12b is not contained in a plane.

[0031] Indeed, there will be apparent gaps 17 between the rim 12b and a hypothetical plane resting in the x-y plane, as is apparent in figures 1 and 2.

[0032] According to a variant of the embodiment, a leveling rim 18 may be fitted to the antenna 10. The leveling rim 18 is planar and exactly mirrors antenna rim 12b as projected along the z-direction onto the x-y plane. The leveling rim 18 allows for the antenna to present a flat support for the antenna, onto which to affix a shroud, a radome, or anything else.

The space between the leveling rim 18b and the dish rim 12b may be dosed or linked by tightening, gluing or molding in one part.

[0033] It is further advantageous to keep the gap 17 to a minimum, since the gap 17 may provide for electromagnetic leaks towards the backside of the antenna 10 which may perturb the signal.

[0034] Figures 3 and 4 illustrates a projection of a super elliptical rim 12b along a plane lying in the x-y plane, when m = 3 (figure 3), and when m = 5 (figure 4), showing different aperture sizes in terms of parameter m, and wherein a and b are equal to zero (a,b=0), and wherein r_a and r_b are both equal to one hundred (r_a, r_b = 100) for illustrative purposes.

[0035] Figure 3 illustrates a base line curve 31 showing a perfect circular (or a super-ellipse wherein n=1), and a super-ellipse curve 33 having n equal to three. Apparent is the compression of the sides along the semi-minor and semi-major axes, representing here about 11% horizontal profile savings.

[0036] Similarly, figure 4 illustrates the same base line curve 31 as figure 3, and a super-ellipse curve 33 having n equal to five. Apparent is the compression of the sides along the semi-minor and semi-major axes, representing here about 19% horizontal profile savings.

[0037] This is particularly advantageous, as the parameter n may be chosen to balance the size reduction and the radio performances such as gain and radiation patterns. In particular, a small value of n generates a super-ellipse close to that of a circle, and a large value of n generates a super-ellipse which is more rectangular. The inventors have found a good compromise of aperture size reduction and performances to be found for values 2 < n < 4, and more advantageously, 2.5 < n < 3.5.

[0038] In particular, the semi-major axis r_a can be reduced by up to 11% with respect to a comparable classical parabolic antenna while keeping approximately the same radiation characteristics and acceptable low gain variation, as is illustrated on figure 5, wherein a plot of the radiation pattern gain R in dB is plotted against radiation angle in degrees (°), for a an antenna operating at the E-band frequency and having the following parameters: a dish diameter D = 120mm (ie. $r_a = r_a = D/2 = 60$ mm) and m=3 (curve 101), and for a traditional circular antenna with diameter D=120mm and m=1 (curve 103).

[0039] One can note the very close performance match achieved between the two antennas despite a reduction maximum surface area around the rim 12b of 11 %. Indeed, the opening at 3dB (representing the half power beam width) between the embodiments illustrated by curves 101 and 103, remains close and therefore the directivity thereof also remains close.

[0040] Furthermore, such a super-elliptical shape is also advantageous with respect to volume and fit problems encountered in urban settings. Indeed, such an antenna dish better fits rectangular outline of radio boxes and therefore supports also visually pleasing integration.

[0041] Therefore, the proposed embodiment proposes a new shape for classical pencil beam radio link antennas having a cassegrain feed principle. The new shape is not any longer a pure paraboloid, being not rotation symmetric and results in an antenna aperture resembling a square with 'cut-away' rounded corners.

[0042] The illustrated RF performance and size reduction (10+ percent in some axis) are applicable to all microwave frequency ranges. This new antenna shape fulfills the performance requirements for the micro cells of dense urban networks and associated needs for low visible unobtrusive contours easily hidden against walls or to be seamless integrated with radio boxes. Although currently triggered by the application for short distance links in micro cells and corresponding need for small antennas the shape of the solution itself is not limited to any size and the material saving associated with the diameter reduction in specific planes might be applied to larger diameters as well.

[0043] The present inventions may be embodied in other specific apparatus and/or methods. The described embodiments are to be considered in all respects as only illustrative and not restrictive. In particular, the scope of the invention is indicated by the appended claims rather than by the description and figures herein. All changes that come within the meaning and range of equivalency of the claims are to be embraced within their scope.

Claims

1. A reflector (12) adapted to be fitted to a Cassegrain-type antenna system, wherein said reflector is paraboloid-shape extending between a vertex (12a) and a peripheral rim (12b) about an axis of rotation (x), and wherein said rim presents a superelliptical shape when projected against a plane lying in a plane orthogonal to said axis of rotation.

2. A reflector according to claim 1, wherein the projection of said superelliptical rim is defined by the following equation:

$$\left|\frac{x-a}{r_a}\right|^n + \left|\frac{y-b}{r_b}\right|^n = 1,$$

wherein r_a and r_b are the dimensions of the semi-major and semi-minor Cartesian axes centered on the axis of rotation, and a, b are the Cartesian centre of the super-ellipse, and wherein n is the variable affecting the angularity of the projection of said superelliptical rim.

3. A reflector according to claim 2, whereby n is between 2 and 4.

4. A reflector according to any one of claims 2 or 3, whereby n is approximately equal to 3.

5. A reflector according to any of the preceding claims 2 to 4, wherein the dimensions of the semi-major and semi-minor Cartesian axes, r_a and r_b respectively, are substantially equal.

6. A reflector according to claim 5, wherein the reflector presents a ratio of focal length of the reflector to the dimension of the semi-major axes r_a between 0.3 and 0.4 ($0.3 < f / D < 0.4$), and even more preferably said ratio is approximatively equal to 0.34 ($f / D \sim= 0.4$) .

7. A reflector according to any one of preceding claims 5 or 6, wherein the semi-major axis dimension is less than 10 cm, and preferably less than 7.5 cm.

8. A reflector according to any one of the preceding claims 2 to 7, wherein the ratio of the dimension of the semi-major axes r_a to the wavelength of the signal adapted to be transmitted by said reflector is greater than 8 ($r_a / \lambda > 8$).

9. An antenna system (10) disposed in a Cassegrain geometry, comprising:

   - a primary reflector (12) according to any one of the claims 1 to 8;
   - a secondary reflector (16) positioned coaxially to the axis of rotation of said primary reflector;
   - a feed device adapted to generate or sense electromagnetic signals to or from said secondary reflector,

   Wherein said secondary reflector is positioned in such as way as to reflect said electromagnetic signals to said primary reflector

   Wherein said primary reflector is positioned in such as way as to reflect said electromagnetic signals from said secondary reflector to a sensibly parallel signal.

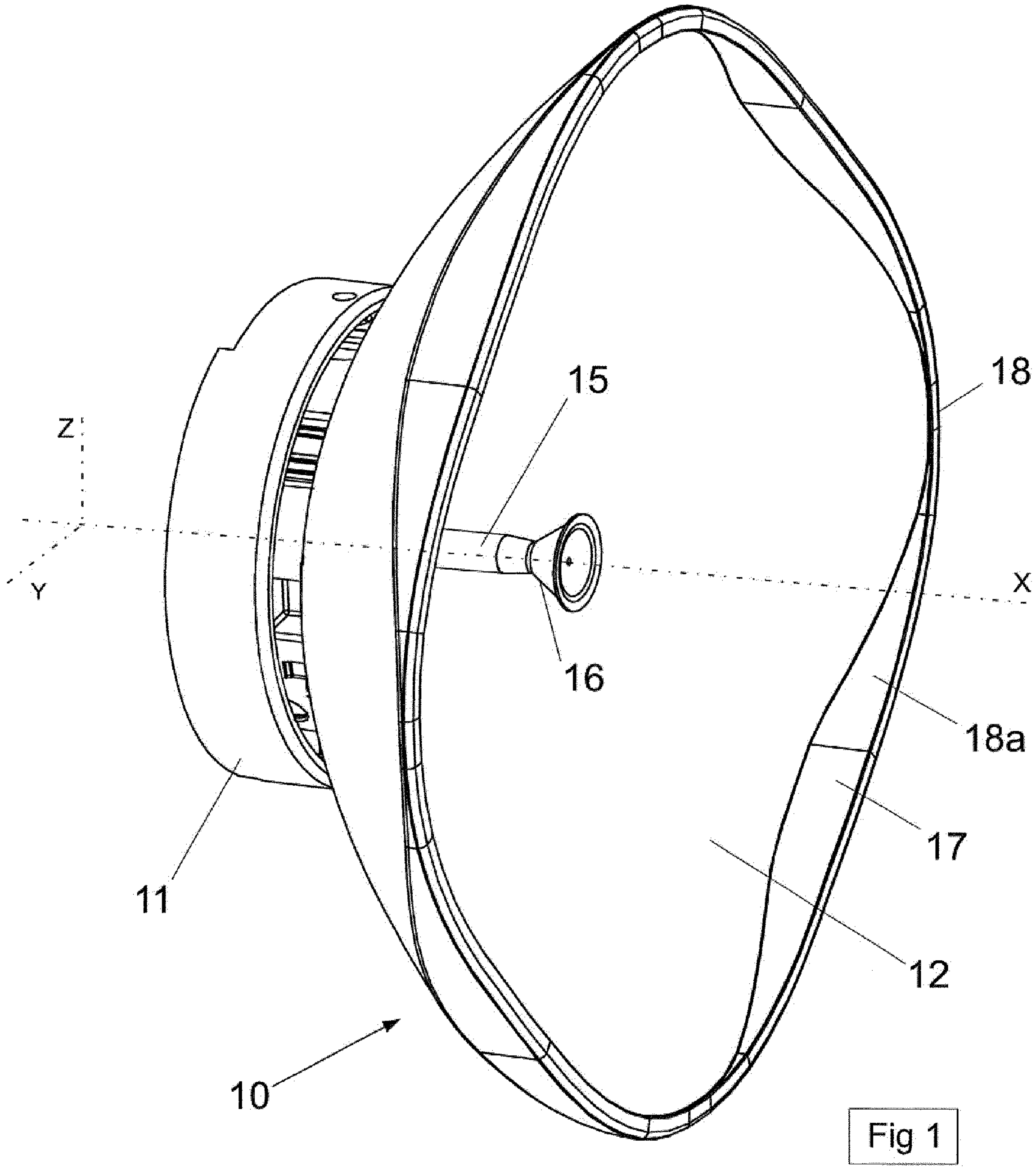

Fig 1

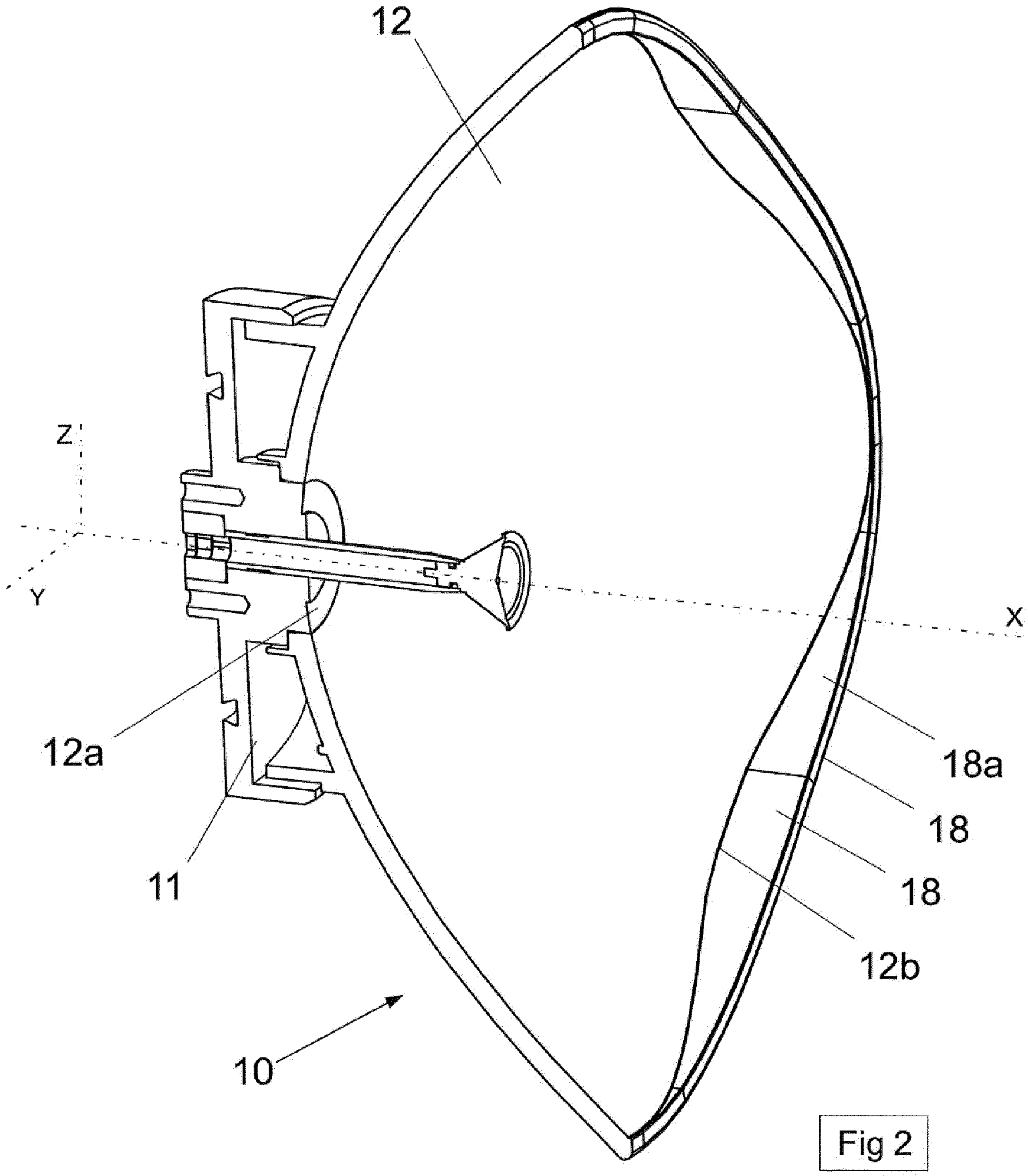

Fig 2

n=3

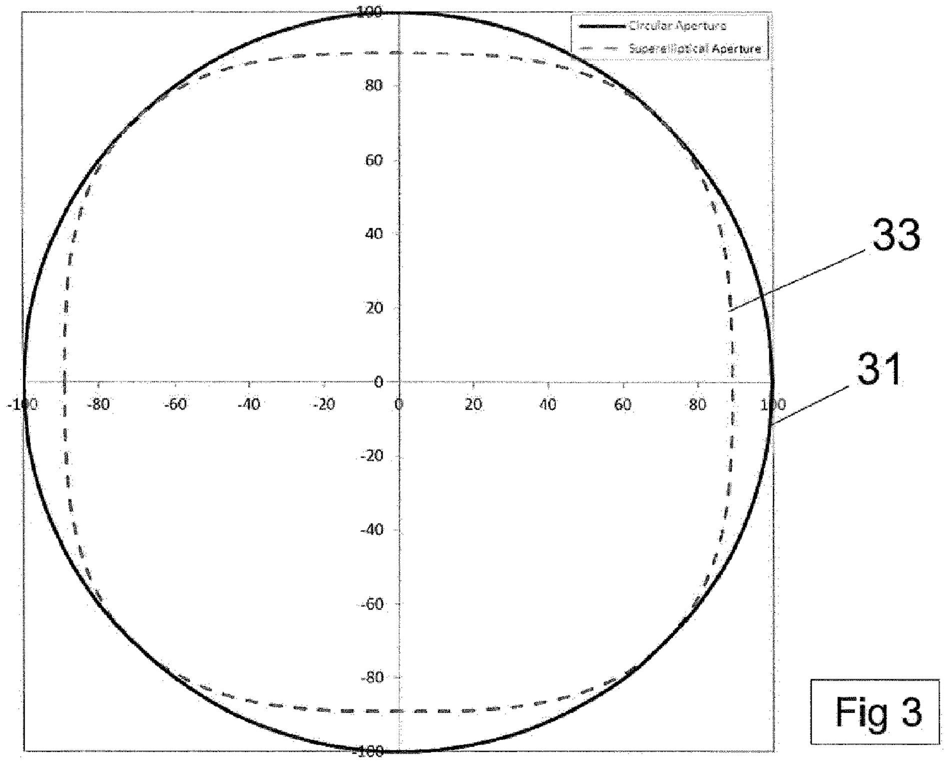

Fig 3

n=5

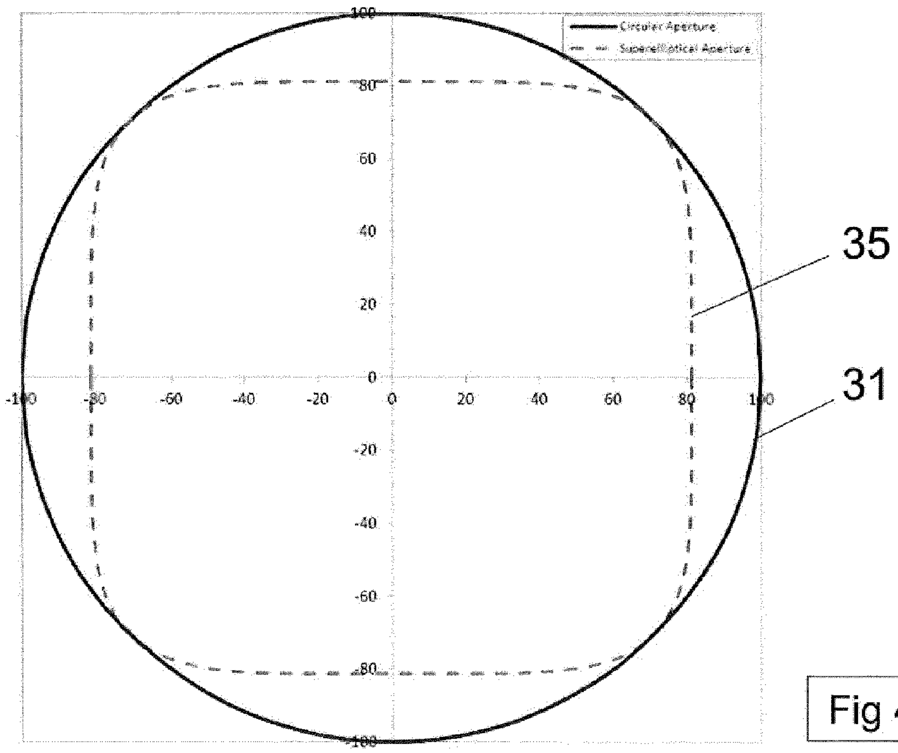

Fig 4

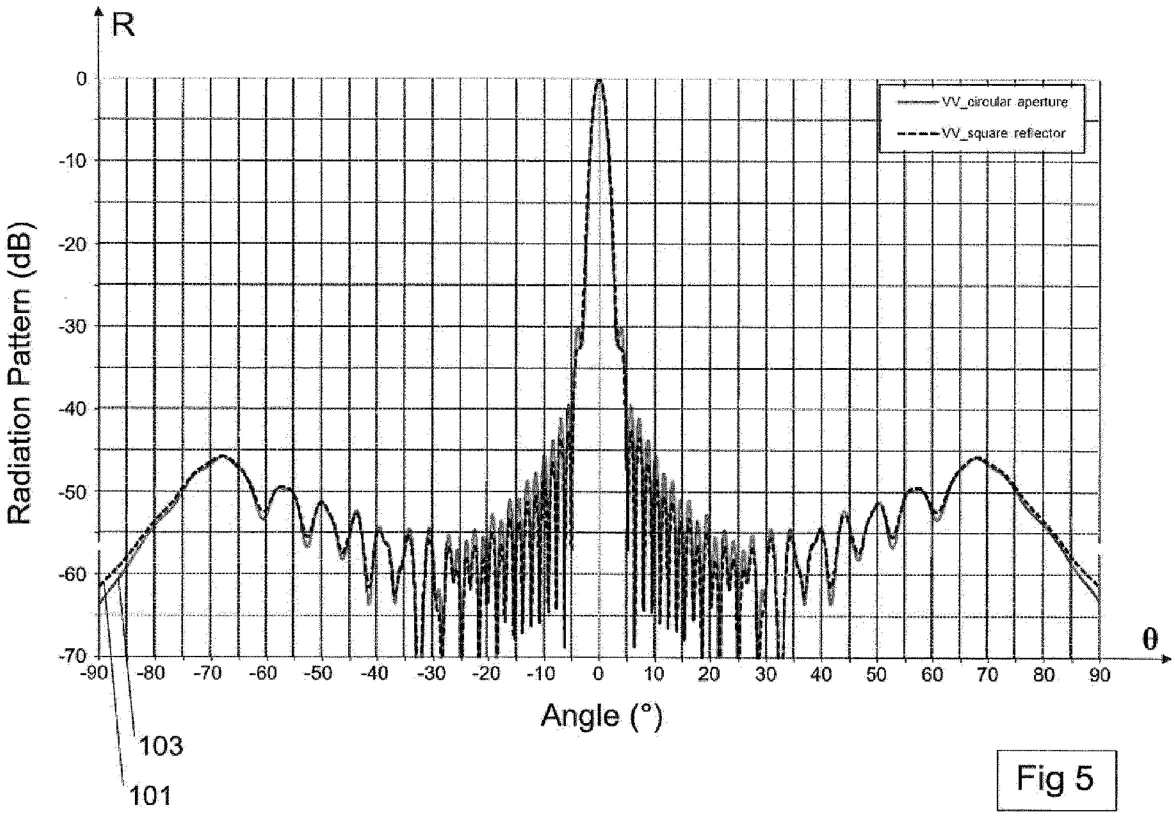
R
0
-10
-20
-30
-40
-50
-60
-70
Radiation Pattern (dB)
VV_circular aperture
VV_square reflector
θ
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60
70
80
90
Angle (°)
103
101

Fig 5

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EUROPEAN SEARCH REPORT

Application Number
EP 13 30 6346

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2008/094298 A1 (KRALOVEC JAY [US] ET AL) 24 April 2008 (2008-04-24) * paragraphs [0024], [0026]; figures 1,2 * -----	1-9	INV. H01Q15/14 H01Q15/16 H01Q19/19
X	US 6 512 486 B1 (DESARGANT GLENN JOSEPH [US] ET AL) 28 January 2003 (2003-01-28) * column 3, line 12 - line 25; figure 4 * -----	1-9	
X	SORENSEN S B: "MANUAL FOR POS", MANUAL FOR POS. PHYSICAL OPTICS SINGLE REFLECTOR SHAPING PROGRAM, TICRA ENGINEERING CONSULTANTS, COPENHAGEN, DK, 1 February 1991 (1991-02-01), pages 1-01,2, XP002118529, * the whole document * -----	1-9	

TECHNICAL FIELDS SEARCHED (IPC)
H01Q

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	24 February 2014	Moumen, Abderrahim

CATEGORY OF CITED DOCUMENTS

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24-02-2014

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