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(71) Applicant: **COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION**
[AU/AU]; Limestone Avenue, Campbell, Australian Capital Territory 2612 (AU).

(72) Inventor: **DUNNING, Alexander Ray**; Unit 3/13 King Street, Ashfield, New South Wales 2131 (AU).

(74) Agent: **SHELSTON IP**; Level 21, 60 Margaret Street, Sydney, New South Wales 2000 (AU).

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(54) Title: QUAD RIDGED FEED HORN INCLUDING A DIELECTRIC SPEAR

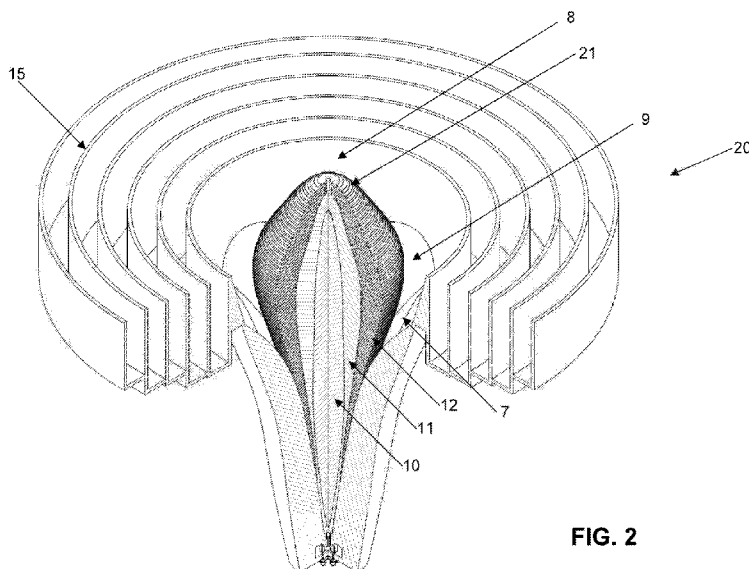


FIG. 2

(57) Abstract: A microwave feed horn including: a central resonant elongated cavity open at a distal end and including a series of electromagnetic emission or reception sources at a proximal end and having a series of ridges along a wall thereof; and an axial elongated dielectric spear element extending from the distal to proximal end, the spear element acting to increase the beam width of any transmitted or received electromagnetic energy at high frequencies.



Quad Ridged Feed Horn including a Dielectric Spear

FIELD OF THE INVENTION

[0001] The present invention relates to the field of antenna designs, and, in particular, discloses a quad ridged microwave feed horn having a tapered dielectric spear.

BACKGROUND

[0002] Any discussion of the background art throughout the specification should in no way be considered as an admission that such art is widely known or forms part of common general knowledge in the field.

[0003] Dual and quad feed horn antenna designs are known. Examples of feed horn antenna designs can be found as:

[0004] J. Y. Chung,” ULTRA-WIDEBAND DIELECTRIC-LOADED HORN ANTENNA WITH DUAL-LINEAR POLARIZATION CAPABILITY”, Progress In Electromagnetics Research, PIER 102, 397-411, 2010;

[0005] Robert J. Bauerle, Robert Schrimpf, Eric Gyorko, and John Henderson, “The Use of a Dielectric Lens to Improve the Efficiency of a Dual-Polarized Quad-Ridge Horn From 5 to 15 GHz” IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 57, NO. 6, JUNE 2009;

[0006] M. Moshiri, H. Abiri, and A. A. Dastranj,”Design and Simulation of a Wideband Dualpolarized Conical Doubleridged Horn Antenna“, PIERS Proceedings, Moscow, Russia, August 18-21, 2009;

[0007] Clark, P. R.; James, G. L. “Ultra-wideband hybrid-mode feeds”, Electron. Lett. 31, 1968-1969, 1995;

[0008] United States Patent Number 7161550 to McLean et al entitled: “Dual- and quad-ridged horn antenna with improved antenna pattern characteristics”;

[0009] United States Patent Number 6624792 to Chu et al entitled: “Quad-ridged feed horn with two coplanar probes”;

[0010] Existing quad ridged feed horn designs have been found to suffer from the following failings which desirably require alleviation:

[0011] A beam width that narrows as the frequency increases;

[0012] A beam that is asymmetric in the X and Y planes resulting in reflector over illumination in one plane and under illumination in the other plane.

SUMMARY OF THE INVENTION

[0013] It is an object of the invention, in its preferred form to provide an improved form of quad ridged feed horn structure.

[0014] In accordance with a first aspect of the present invention, there is provided a microwave feed horn including: a central elongated cavity open at a distal end and including a series of electromagnetic emission or reception sources at a proximal end and having a series of ridges along a wall thereof; and an axial elongated dielectric spear element extending from the distal to proximal end, the spear element acting to increase the beam width of the transmitted electromagnetic energy at high frequencies.

[0015] The dielectric spear preferably can include a dielectric material along a radial portion of the spear which has a dielectric constant that decreases in the outward radial direction. The series of ridges are preferably tapered or flared near the distal end of the cavity so as to reduce spurious transmission modes. The spurious transmission mode preferably can include the TE_{31} mode. The number of ridges can be four.

[0016] In some embodiments, the spear preferably can include at least three layers of concentric dielectric material, with a high dielectric constant first layer, an intermediate second layer and a lower dielectric constant third layer. In other embodiments, the spear can be constructed from a radially graduated dielectric material or a substantially constant dielectric material.

[0017] The spear preferably can include a rounded tip. In some embodiments, the spear preferably can include a tip projecting out of the cavity.

[0018] The cavity further preferably can include a corrugated skirt around the distal end of the cavity. The corrugated skirt preferably can include a series of concentric grooves. The corrugated skirt preferably can include a series of five concentric grooves of substantially $1/3$ wavelength

depth by substantially $1/15$ wavelength wide at the lowest intended frequency of operation. The grooves are preferably separated by a wall of substantially $1/100$ wavelength thickness at the lowest intended frequency of operation. In some embodiments the spear element can include a series of voids cut into a contiguous material, to approximate a change in dielectric value near an external region of said spear element.

In accordance with a further embodiment of the present invention, there is provided a method of improving the high frequency response of a quad ridged feed horn having a central elongated cavity open at a distal end and including a series of electromagnetic emission or reception sources at a proximal end and having a series of ridges along a wall thereof, the method including the step of: locating an axial elongated dielectric spear element extending from the distal to proximal end, said spear element acting to increase the beam width of the transmitted electromagnetic energy at high frequencies.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

[0020] Fig. 1 illustrates the a side perspective view of the preferred embodiment;

[0021] Fig. 2 illustrates side perspective view, partly in section through the lines A-A' of Fig. 1;

[0022] Fig. 3 illustrates a top plan view of the feed horn of the preferred embodiment;

[0023] Fig. 4 illustrates a sectional view through the line B-B' of Fig. 3;

[0024] Fig. 5 is an enlarged sectional view of a portion of Fig. 4;

[0025] Fig. 6 is a further sectional view through the feed horn of the preferred embodiment; and

[0026] Fig. 7 is an enlarged sectional view of a portion of Fig. 6.

DETAILED DESCRIPTION

[0027] The preferred embodiment provides a quad-ridged feed horn structure containing a dielectric spear which is used to illuminate a reflector antenna with a circular aperture. The feed

horn may be used in either transmitting or receiving applications. The transmitting case is described here.

[0028] Turning initially to Fig. 1, there is illustrated the feed horn structure 20 which includes a dielectric spear 21. The preferred embodiment consists of a differentially fed quad ridged feed horn which includes a central elongated cavity 8 having a series of ridges 7 along the wall of the cavity. The horn further includes a triple layered dielectric spear 21 along the central axis and an axially corrugated outer skirt 15.

[0029] Fig. 2 illustrates a sectional view along the line A-A' of Fig. 1 showing the cut away portions of the feed horn structure.

[0030] Typically quad ridged feed horns produce an illumination pattern that narrows as the frequency of operation increases. The design of the preferred embodiment avoids the narrowing of the illumination pattern with the addition of a layered dielectric spear 21 located in the centre of the feed horn. This dielectric spear concentrates the electromagnetic fields towards the centre of the feed horn at high frequencies. This reduces the apparent aperture of the feed horn and increases the beam width. With careful design of the dielectric spear it is possible to maintain a nearly constant beam width over a 6:1 bandwidth.

[0031] The other problem usually observed with quad ridged feed horns is the asymmetry of the feed pattern at high frequencies. This also is greatly improved by the addition of the dielectric spear in the centre of the feed horn as the excitation of high order modes is reduced. At intermediate frequencies however, the quad ridged structure may still produce an asymmetric illumination pattern. To alleviate this, a flaring of the ridges 7 is provided toward the aperture of the feed such that the ridges are wider close to the aperture 9.

[0032] The addition of the dielectric spear has the added benefit that as the fields are concentrated towards the centre of the feed horn at high frequencies, there is more freedom to add a structure around the feed horn to improve the low frequency behaviour of the feed horn. Hence a series of radially corrugated sections 15 at the mouth of the feed horn are provided to improve the low frequency pattern. This would usually negatively affect the high frequency performance of the feed where a dielectric spear was not present.

[0033] In the preferred embodiment, the dielectric spear 21 consists of three concentric layers of a dielectric material 10, 11, 12 with dielectric constants of 3.8 for the central section 10 which

can be formed from quartz, 2.1 for the intermediate section 11, which can be formed from polytetrafluoroethylene (PTFE) and 1.4 for the outer section 12 which can be formed from slotted PTFE to approximate the dielectric constant. In alternative embodiments, the spear 21 could equally have been formed with a continuously graded material or, where poorer performance is acceptable, a spear with a single dielectric constant. The tip of each layer of the dielectric spear is rounded with a profile which is shaped for optimum illumination pattern.

[0034] Commonly, quad ridged feed horns smoothly reduce the height of the ridge to achieve a transition between quad ridged waveguide and circular or square waveguide. This results in the production of a large amount of the TE_{31} mode at the waveguide aperture. This is not apparent from an examination of the structure. The TE_{31} mode is unwanted and commonly results in an antenna radiation pattern which is broader in one axis than the other. In the preferred embodiment, the width of the ridge 7 is increased 9 as its height is decreased to reduce the amount of the TE_{31} mode that is produced at intermediate frequencies. This feature is displayed in the preferred embodiment where the ridge flares 9 towards the aperture of the feed horn.

[0035] The feed horn accepts two linear polarisations at its input ports and produces a propagating wave with a Gaussian beam shape suitable for illuminating a reflector with a circular aperture. The feed is intended to operate over a bandwidth of greater than 5:1

[0036] In the forward direction the ridges 7 of the quad-ridged waveguide are smoothly reduced in height until the ridge surface meets the cylindrical inner wall of the waveguide 8. Thus a transition is made to circular waveguide. The diameter of the cylindrical inner wall of the waveguide 8 is smoothly increased throughout this section such that the cut-off frequency of the waveguide remains just below the minimum frequency of operation of the feed horn. Towards the end of this transition the ridges increase in width 9.

[0037] Fig. 3 illustrates a front plan view of the feed horn, illustrating the ridge transition 9 and spear 21. Fig. 4 illustrates a sectional view through the line B-B' of Fig. 3.

[0038] As shown in Fig. 4, the dielectric spear 21 is placed along the central axis of the feed horn from the junction of the coaxial section 23 to the mouth of the feed horn. This dielectric spear consists of three coaxial layers of dielectric material 10,11,12 where the central layer 10 has the highest dielectric constant, the intermediate layer 11 has an intermediate dielectric constant and the outer layer 12 has the lowest dielectric constant. The ridges of the quad-ridged waveguide penetrate the dielectric spear towards the coaxial junction 16. The tip of the dielectric spear 14, which

extends beyond the mouth of the feed horn, is rounded with a quadratic profile for optimum beam shape. One example embodiment has the dielectric constants of 3.8 for the central section 10, 2.1 for the intermediate section 11, and 1.4 for the outer section 12, although other ranges of values can be used.

[0039] The feed horn is surrounded with an axially corrugated skirt 15 to improve the low frequency radiation pattern. In one example embodiment, the skirt can consist of five axial grooves of approximately $1/3$ wavelength deep by $1/15$ wavelength wide at the lowest frequency of operation. These grooves are separated by a wall of approximately $1/100$ of a wavelength thickness, also at the lowest frequency of operation.

[0040] Fig. 5 illustrates an enlargement of the feed region 23 of Fig. 4. The TE_{11} mode is excited in a quad ridged waveguide, in each polarisation, via a pair of probes (one pair for each orthogonal polarization) located at the end 23 of the quad ridged waveguide.

[0041] For a single polarisation two differentially fed coaxial lines 24,25 enter a junction through the rear wall of the feed horn 26. The outer conductors of these coaxial lines are terminated on the inner surface of the rear wall. Each of the inner conductors of these coaxial lines is coupled to a ridge through a capacitive junction formed by a probe entering a hole in the end of the ridge 27. The probe is electrically isolated from the ridge by a thin insulating PTFE sleeve. The capacitance of this junction is adjusted to achieve a high return loss at the lowest frequencies of operation.

[0042] A notch is cut into the end of each ridge 28 having a length and width of approximately $1/4$ of a wavelength at the highest frequency of operation. This notch functions as a short length of high impedance shorted line between the junction and the rear wall of the feed horn allowing the ridge to be directly connected to the rear wall 29.

[0043] By way of further illustration, Fig. 6 illustrates a further side sectional view of the feed horn with Fig. 7 illustrating the corresponding enlargement of the portion 33 of Fig. 6.

[0044] . In alternative embodiments, a variety of techniques can be provided for realising the graduated dielectric which comprises the axial spear. It is not necessary for the operation of the feed horn that the spear consist of three layers of different dielectric constants. In the simplest case the spear might consist of only a single dielectric constant. It is also possible that the spear could be constructed with a smoothly varying dielectric constant.

[0045] The method via which the dielectric is formed may also be achieved in several ways. The dielectric may be formed (with the exception of the outer layer) from a solid material. The dielectric may also be formed as a foamed material, a filled material, a filled foam or a material with engineered voids. The arrangement of the preferred embodiment includes the outer dielectric having a series of slots which assist in approximating a desired dielectric value.

[0046] In alternative embodiments, other profiling of the ridges is possible. For example alternative embodiments might have wider ridges and wider tapering of the ridges. Of course, other forms of tapering are also possible.

[0047] Further enhancements are possible. For example, a radio frequency inert cover, made from foam or the like, can be placed over the device to protect it from environmental conditions.

Interpretation

[0048] Reference throughout this specification to “one embodiment”, “some embodiments” or “an embodiment” means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrases “in one embodiment”, “in some embodiments” or “in an embodiment” in various places throughout this specification are not necessarily all referring to the same embodiment, but may. Furthermore, the particular features, structures or characteristics may be combined in any suitable manner, as would be apparent to one of ordinary skill in the art from this disclosure, in one or more embodiments.

[0049] As used herein, unless otherwise specified the use of the ordinal adjectives "first", "second", "third", etc., to describe a common object, merely indicate that different instances of like objects are being referred to, and are not intended to imply that the objects so described must be in a given sequence, either temporally, spatially, in ranking, or in any other manner.

[0050] In the claims below and the description herein, any one of the terms comprising, comprised of or which comprises is an open term that means including at least the elements/features that follow, but not excluding others. Thus, the term comprising, when used in the claims, should not be interpreted as being limitative to the means or elements or steps listed thereafter. For example, the scope of the expression a device comprising A and B should not be limited to devices consisting only of elements A and B. Any one of the terms including or which includes or that includes as used herein is also an open term that also means including at least the

elements/features that follow the term, but not excluding others. Thus, including is synonymous with and means comprising.

[0051] As used herein, the term “exemplary” is used in the sense of providing examples, as opposed to indicating quality. That is, an “exemplary embodiment” is an embodiment provided as an example, as opposed to necessarily being an embodiment of exemplary quality.

[0052] It should be appreciated that in the above description of exemplary embodiments of the invention, various features of the invention are sometimes grouped together in a single embodiment, FIG., or description thereof for the purpose of streamlining the disclosure and aiding in the understanding of one or more of the various inventive aspects. This method of disclosure, however, is not to be interpreted as reflecting an intention that the claimed invention requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment. Thus, the claims following the Detailed Description are hereby expressly incorporated into this Detailed Description, with each claim standing on its own as a separate embodiment of this invention.

[0053] Furthermore, while some embodiments described herein include some but not other features included in other embodiments, combinations of features of different embodiments are meant to be within the scope of the invention, and form different embodiments, as would be understood by those skilled in the art. For example, in the following claims, any of the claimed embodiments can be used in any combination.

[0054] In the description provided herein, numerous specific details are set forth. However, it is understood that embodiments of the invention may be practiced without these specific details. In other instances, well-known methods, structures and techniques have not been shown in detail in order not to obscure an understanding of this description.

[0055] Similarly, it is to be noticed that the term coupled, when used in the claims, should not be interpreted as being limited to direct connections only. The terms "coupled" and "connected," along with their derivatives, may be used. It should be understood that these terms are not intended as synonyms for each other. Thus, the scope of the expression a device A coupled to a device B should not be limited to devices or systems wherein an output of device A is directly connected to an input of device B. It means that there exists a path between an output of A and an input of B which may be a path including other devices or means. "Coupled" may mean that two or more

elements are either in direct physical or electrical contact, or that two or more elements are not in direct contact with each other but yet still co-operate or interact with each other.

[0056] Thus, while there has been described what are believed to be the preferred embodiments of the invention, those skilled in the art will recognize that other and further modifications may be made thereto without departing from the spirit of the invention, and it is intended to claim all such changes and modifications as falling within the scope of the invention. For example, any formulas given above are merely representative of procedures that may be used. Functionality may be added or deleted from the block diagrams and operations may be interchanged among functional blocks. Steps may be added or deleted to methods described within the scope of the present invention.

CLAIMS:

1. A microwave feed horn including:

a central elongated cavity open at a distal end and including a series of electromagnetic emission or reception sources at a proximal end and having a series of ridges along a wall thereof; and

an axial elongated dielectric spear element extending from the distal to proximal end, said spear element acting to increase the beam width of the transmitted or received electromagnetic energy at high frequencies.

2. A microwave feed horn as claimed in claim 1 wherein said dielectric spear element includes a dielectric material along a radial portion of the spear element and said dielectric material has a dielectric constant that decreases in the outward radial direction.

3. A microwave feed horn as claimed in any previous claim wherein said series of ridges are tapered or flared near the distal end of the cavity so as to reduce spurious transmission or reception modes.

4. A microwave feed horn as claimed in claim 3 wherein said spurious transmission or reception mode includes the TE_{31} mode.

5. A microwave cavity as claimed in any previous claim wherein the number of ridges is four.

6. A microwave feed horn as claimed in any previous claim wherein said spear element includes at least three layers of concentric dielectric material, with an inner first layer having a high dielectric constant, an intermediate second layer having an intermediate dielectric constant and an outer third layer having a lower dielectric constant.

7. A microwave feed horn as claimed in any of claims 1 to 5 wherein said spear element is constructed from a radially graduated dielectric material.

8. A microwave feed horn as claimed in claim 1 wherein said spear element is constructed from a substantially constant dielectric material.

9. A microwave feed horn as claimed in any previous claim wherein said spear element includes a series of voids cut into a contiguous material, to approximate a change in dielectric value near an external region of said spear element.
10. A microwave feed horn as claimed in any previous claim wherein said spear element includes a rounded tip.
11. A microwave feed horn as claimed in any previous claim wherein said spear element includes a tip projecting out of said cavity.
12. A microwave feed horn as claimed in any previous claim wherein said cavity further includes a corrugated skirt around the distal end of said cavity.
13. A microwave feed horn as claimed in claim 12 wherein said corrugated skirt includes a series of concentric grooves.
14. A microwave feed horn as claimed in claim 12 wherein said corrugated skirt includes a series of five concentric grooves of substantially $1/3$ wavelength depth by substantially $1/15$ wavelength wide at the lowest intended frequency of operation.
15. A microwave feed horn as claimed in claim 13 wherein said grooves are separated by a wall of substantially $1/100$ wavelength thickness at the lowest intended frequency of operation.
16. A microwave feed horn as claimed in any previous claim wherein the dielectric of the spear element is substantially between 1.4 and 4.0.
17. A method of improving the high frequency response of a quad ridged feed horn having a central elongated cavity open at a distal end and including a series of electromagnetic emission or reception sources at a proximal end and having a series of ridges along a wall thereof, the method including the step of:

locating an axial elongated dielectric spear element extending from the distal to proximal end, said spear element acting to increase the beam width of the transmitted electromagnetic energy at high frequencies.

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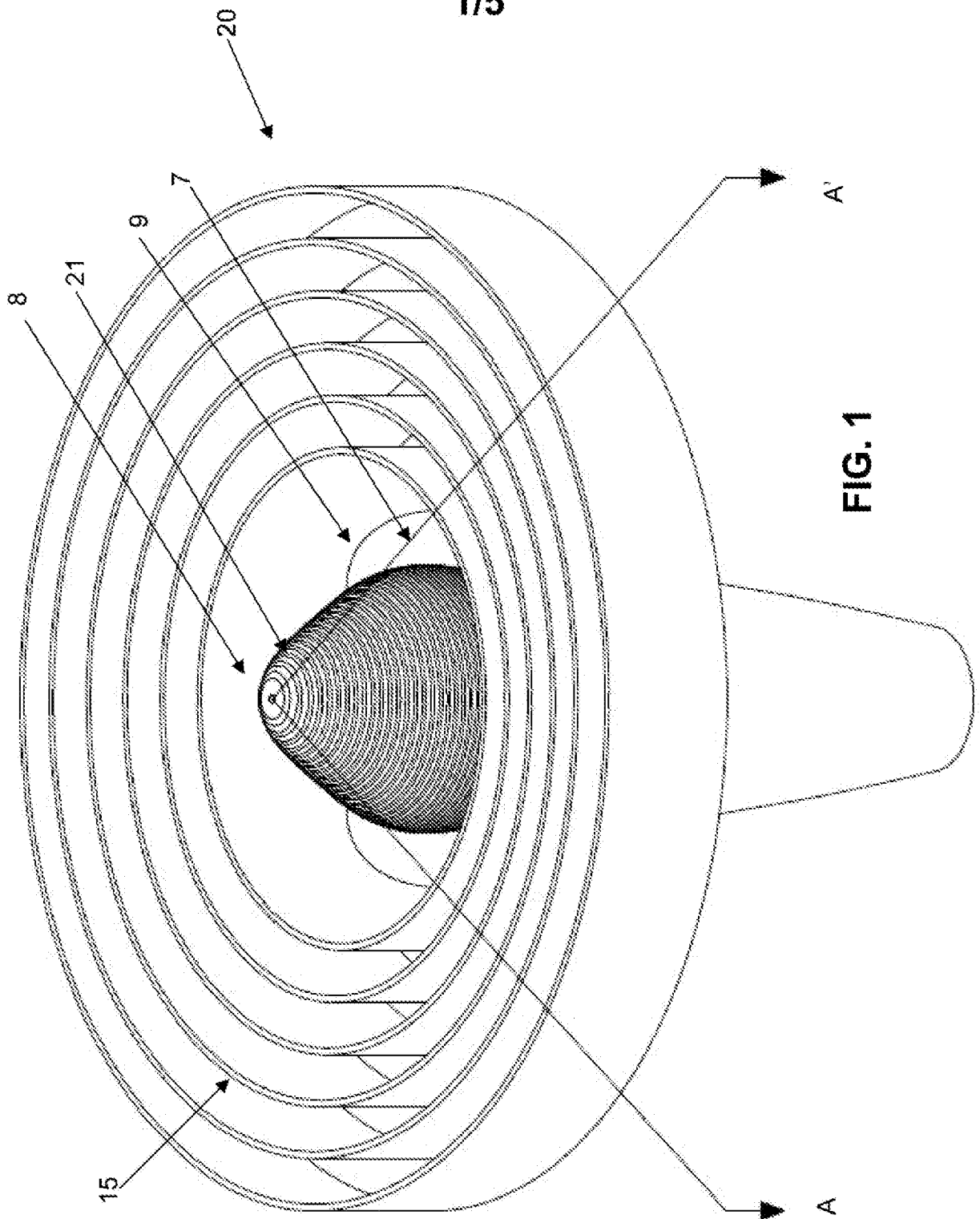


FIG. 1

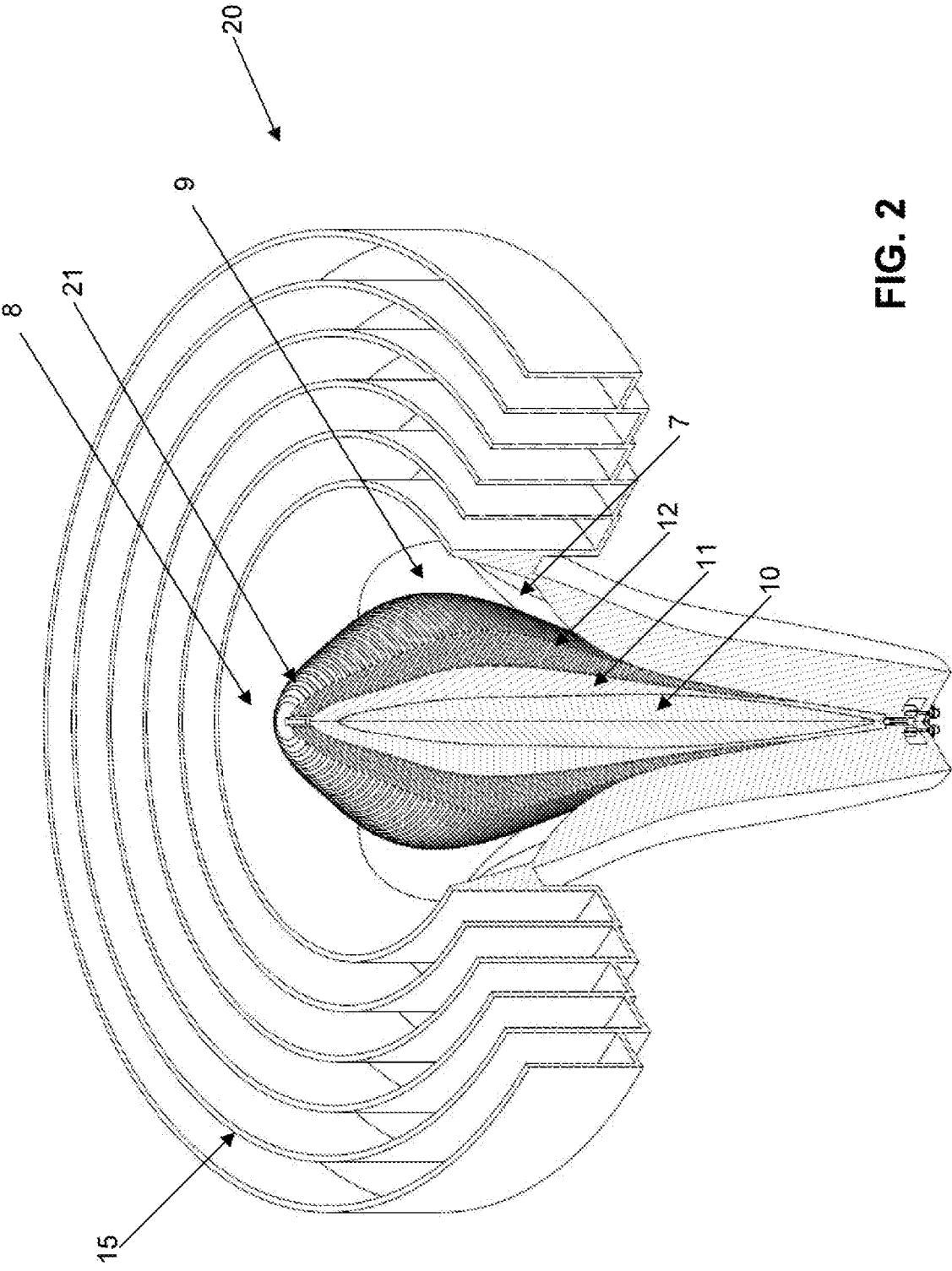


FIG. 2

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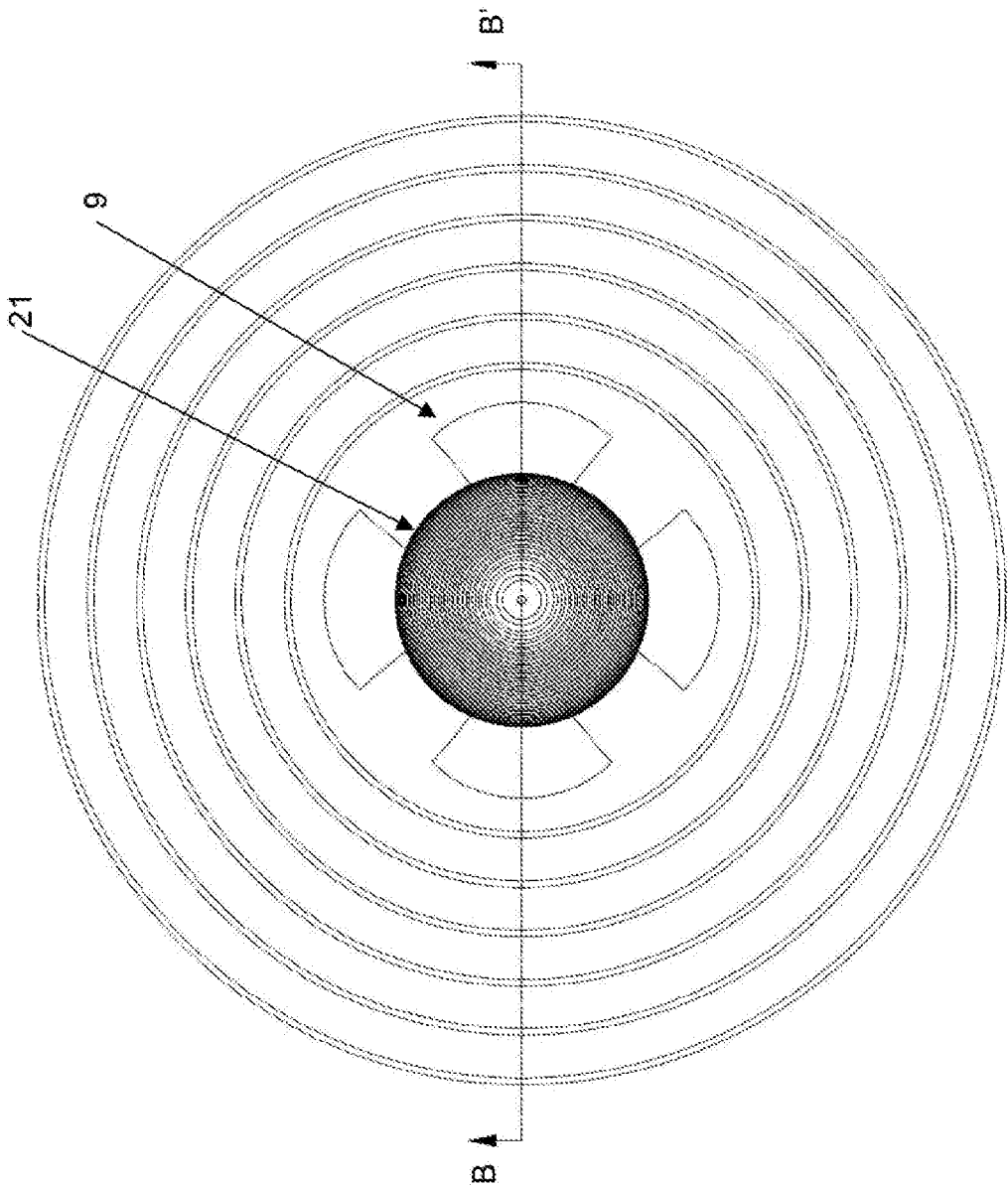


FIG. 3

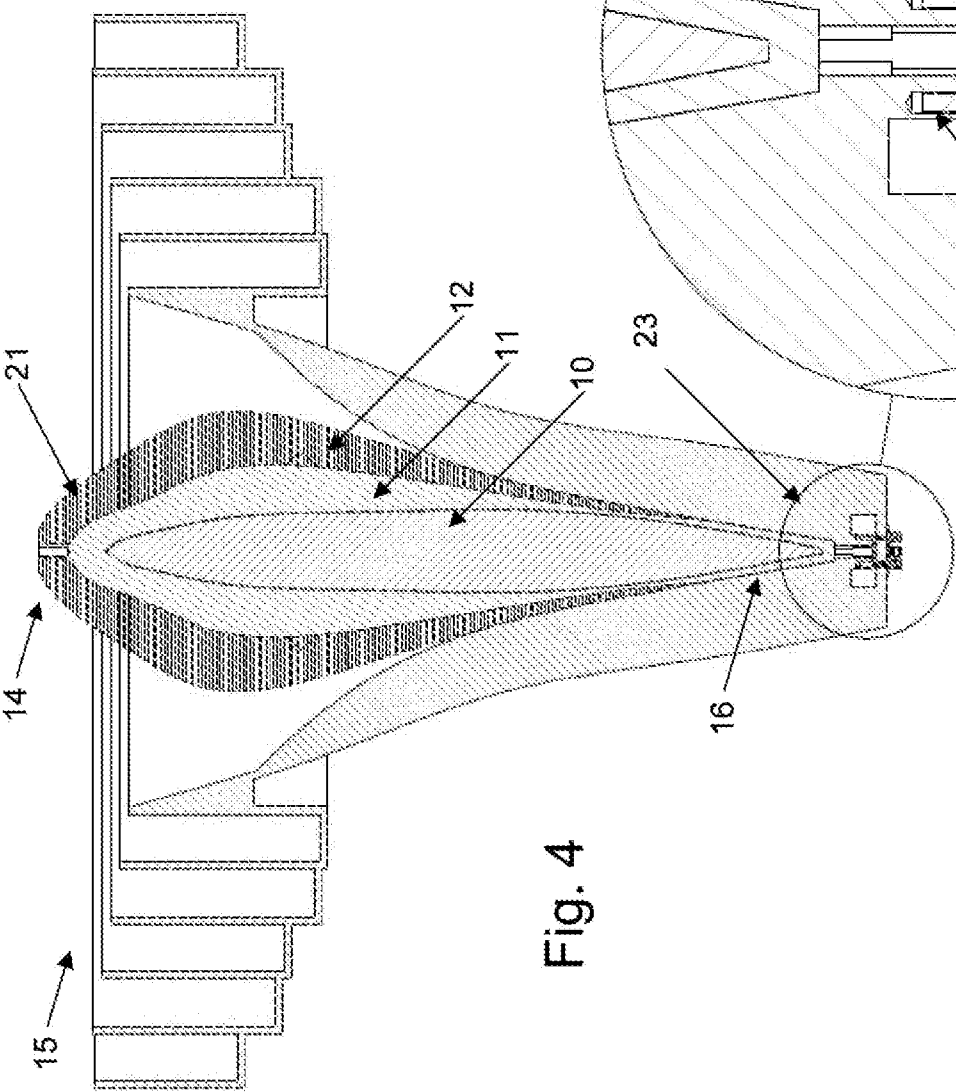


Fig. 4

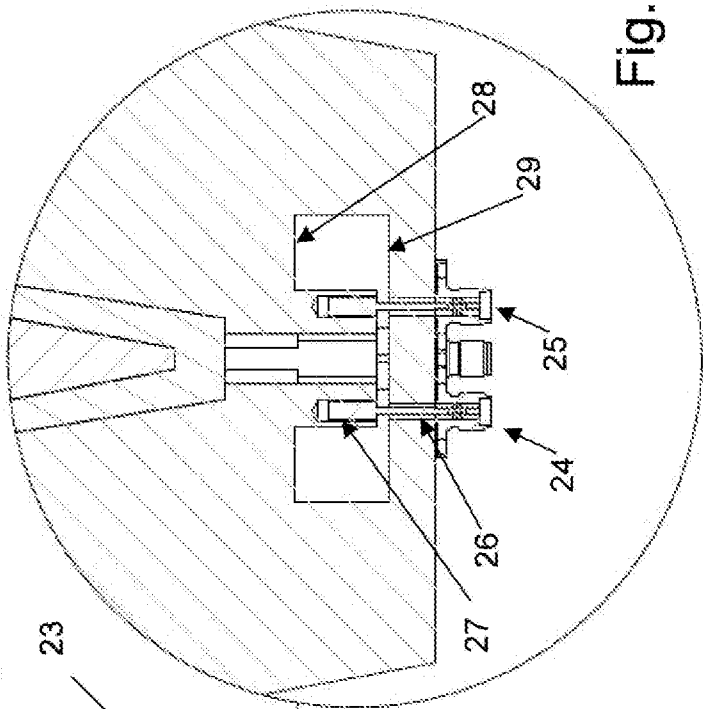
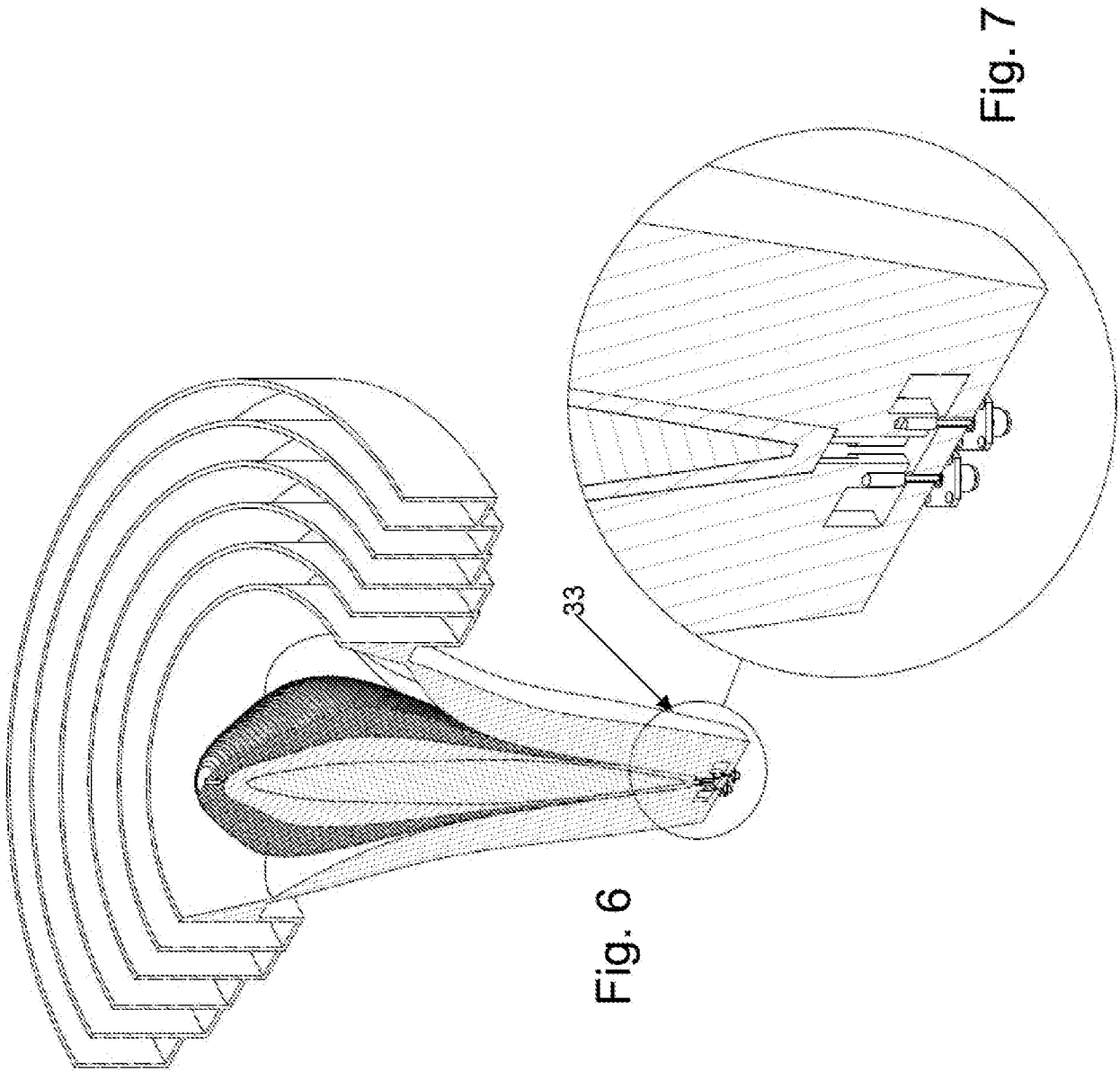


Fig. 5

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2014/000910

A. CLASSIFICATION OF SUBJECT MATTER

H01P 3/123 (2006.01) H01P 3/00 (2006.01) H01Q 13/00 (2006.01) H01Q 19/08 (2006.01)

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)

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)

EPODOC and WPI, with keywords: increase, bandwidth, antenna, microwave, horn, spear and similar terms.

Google Patents, Google Scholar, and IEEE Xplore: ridge horn antenna, increase bandwidth at high frequencies.

Lens: Alexander Ray Dunning, Commonwealth Scientific and Industrial Research Organisation.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

☒ Further documents are listed in the continuation of Box C

☒ See patent family annex

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"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
"E"	earlier application or patent but published on or after the international filing date	"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
"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)	"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
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search
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Date of mailing of the international search report
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Name and mailing address of the ISA/AU

AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
Email address: pct@ipaustalia.gov.au

Authorised officer

Ronaldo Sanchez
AUSTRALIAN PATENT OFFICE
(ISO 9001 Quality Certified Service)
Telephone No. 0262832653

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/AU2014/000910
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008/0309571 A1 (DIAZ et al.) 18 December 2008 See the whole document in particular the abstract, fig 3-5 and 11, and para 0004, 0005, 0014, 0028, 0060, 0066-0068 and 0081.	1-17
A	US 6720932 B1 (FLYNN et al.) 13 April 2004 See the whole document in particular the abstract, fig 1, and col 5-7.	1-17
A	US 2011/0050527 A1 (ANDERSON et al.) 03 March 2011 See the whole document in particular the abstract, fig 2-3, and para 0024-0036.	1-17

Form PCT/ISA/210 (fifth sheet) (July 2009)

INTERNATIONAL SEARCH REPORT Information on patent family members		International application No. PCT/AU2014/000910	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	Publication Date	Publication Number	Publication Date
US 2008/0309571 A1	18 December 2008	US 7889148 B2	15 Feb 2011
US 6720932 B1	13 April 2004	AU 1883700 A	24 Jul 2000
		BR 0007421 A	04 Dec 2001
		CN 1337077 A	20 Feb 2002
		EP 1142062 A1	10 Oct 2001
		EP 1142062 B1	16 Mar 2005
		WO 0041266 A1	13 Jul 2000
US 2011/0050527 A1	03 March 2011	US 8248321 B2	21 Aug 2012
		EP 2474071 A1	11 Jul 2012
		JP 2013504222 A	04 Feb 2013
		WO 2011028323 A1	10 Mar 2011
End of Annex			
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001. Form PCT/ISA/210 (Family Annex)(July 2009)			