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Datasheet for the decision of 2 July 2009

Case Number: T 1724/06 - 3.4.01

Application Number: 01400990.6

Publication Number: 1152484

IPC: H01Q 13/02

Language of the proceedings: EN

Title of invention:
High performance multimode horn

Applicant:
MacDonald, Dettwiler and Associates Corporation

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 123(2)

Relevant legal provisions (EPC 1973):
EPC Art. 84, 83, 54(1)(2), 56

Keyword:
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Decisions cited:
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Catchword:
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Case Number: T 1724/06 - 3.4.01

D E C I S I O N
of the Technical Board of Appeal 3.4.01
of 2 July 2009

Appellant: MacDonald, Dettwiler and Associates Corporation
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 1 June 2006 refusing European application No. 01400990.6 pursuant to Article 97(1) EPC 1973.**

Composition of the Board:

Chairman: B. Schachenmann
Members: G. Assi
P. Fontenay

Summary of Facts and Submissions

I. The appellant (applicant) lodged an appeal against the decision of the examining division refusing European patent application No. 01400990.6 (publication number 1152484).

II. The examining division considered the following prior art documents:

(D1) US-A-4,792,814;
(D2) GB-A-2 148 607;
(D3) Electronics Letters, 16 March 2000, Vol. 36, No. 6, B. Du at al., "*Restraint of Unwanted Higher-Order Modes in Wideband Tracking Corrugated Horn*", pages 490 and 491;
(D4) EP-A-0 483 686;
(D5) US-A-4,764,775;
(D6) JP-A-54-058336;
(D7) "*Microwave Horns and Feeds*" by A.D. Olver et al., IEE Electromagnetic Waves Series 39, Series Editors: Prof. P.J.B. Clarricoats et al., 1994, London, pages 229-246.

III. Oral proceedings before the Board took place on 2 July 2009.

The appellant requested that the decision under appeal be set aside and a patent be granted on the basis of claims 1 to 4 filed at the oral proceedings, with the description and the figures to be adapted.

IV. The wording of claim 1 reads as follows:

"*A multiple beam antenna including either reflectors or lens for either transmitting or receiving an electromagnetic signal therethrough, said antenna including a plurality of multimode feed horns (20), each of said plurality of horns (20) generating a respective beam of said antenna and each of said horns (20) including a hollow conical structure (22) for feeding the beam therethrough, wherein the structure (22) is flaring radially outwardly from a throat section (24) to an aperture (26), the aperture (26) having a size constrained by presence of adjacent feed horns generating other beams, said structure (22) defining an internal wall (28) having a plurality of discontinuities (30) for altering the mode content of the signal, wherein for each of said horns (20) the discontinuities (30) excite higher order TE1n modes supported by the aperture size with such amplitude and phase that each of said horns (20) has an aperture efficiency greater than that of dual-mode horns using the TE11 and TM11 modes only, over a pre-determined frequency range of the signal.*"

Claims 2 to 4 depend on claim 1.

V. The revised version of the European Patent Convention or EPC 2000 entered into force on 13 December 2007. In the present decision, reference is made to "*EPC 1973*" or "*EPC*" for EPC

2000 (EPC, Citation practice, pages 4-6) depending on the version to be applied according to Article 7(1) of the Revision Act dated 29 November 2000 (Special Edition No. 1 OJ EPO 2007, 196) and the decisions of the Administrative Council dated 28 June 2001 (Special Edition No. 1 OJ EPO 2007, 197) and 7 December 2006 (Special Edition No. 1 OJ EPO 2007, 89).

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

2.1 Present claim 1 is essentially based on claim 10 of the application as filed with the addition of features concerning the constraint of the size of the aperture of the feed horns, the excitation of higher order TE1n modes and the aperture efficiency of the horns. With regard to the description as filed, the first of these features is disclosed on page 1, lines 15-18, the second one on page 9, lines 9-20 and page 14, lines 1-5, and the third one on page 9, lines 13-16 and page 16, Table 1.

Present claims 2 and 4 correspond to claims 12 and 11 as filed. Present claim 3 is disclosed on page 11, lines 15-23 of the description as filed.

2.2 Therefore, the claims on file have not been amended in such a way that they contain subject-matter which extends beyond the content of the application as filed (Article 123(2) EPC).

3. *Clarity and support by the description*

3.1 It results from the description that the essence of the invention consists in selecting the correct types and interactions of discontinuities in each of the horns feeding a multiple beam antenna so as to excite higher order TE1n modes supported by the horn aperture in order to produce an aperture field distribution that gives the desired high aperture efficiency of the horn. This was also Prof. Bornemann's understanding in his affidavit of 28 September 2006 filed with the grounds of appeal.

Present claim 1 reflects this invention. It concerns a multiple beam antenna including a plurality of multimode feed horns, each of which generates a respective beam of the antenna. Moreover, it recites all the features necessary for achieving high horn aperture efficiency. Thus, each of the horns includes a hollow conical structure flaring radially outwardly from a throat section to an aperture, the size of which is constrained by the presence of adjacent feed horns. The internal wall of the horns has a plurality of discontinuities for altering the mode content of the signal.

The discontinuities excite higher order TE1n modes supported by the aperture size with such amplitude and phase that each of the horns has aperture efficiency greater than that of dual-mode horns using the TE11 and TM11 modes only, over a pre-determined frequency range of the signal.

It should be noted that the mention of dual-mode horns using the TE11 and TM11 modes only is necessary for defining a term of comparison for the increased horn aperture efficiency according to the invention.

Present claims 2 to 4 do not give rise to any problem.

3.2 Hence, the claims on file are clear and supported by the description (Article 84 EPC 1973).

4. *Disclosure of the invention*

4.1 The invention must be disclosed in such a way that it enables a person skilled in the art to carry it out. In the present case, a first question concerns the modal content required to optimize the aperture efficiency, i.e. the determination of amplitude and phase of each mode which should be present at the aperture of the horn in order to provide said effect. A further question concerns whether the skilled person can design a plurality of geometrical discontinuities so as to excite higher order TE1n modes supported by the aperture size with amplitude and phase as required, so that the horn has high aperture efficiency over a pre-determined frequency range of the signal.

Concerning the determination of the appropriate modal content, the appellant convincingly argued that commonly available computer software permitted to define, for a given combination of modes, the resulting radiation pattern. Although requiring extensive computation, the determination of proper relative amplitudes and phases was a matter of trial and error.

Concerning the second aspect as to the geometry of the horn, the appellant submitted that the application disclosed three embodiments of a high performance multimode horn according to the invention (Figures 7, 8 and 9). Moreover, the skilled person was aware of what was common general knowledge in the relevant technical field at the time of filing the application and had at his disposal the normal means and capacity for routine work and experimentation. To achieve the desired modal content, the skilled person would start from a given configuration of discontinuities on the basis of his experience, of the generally known physical principles underlying the generation of modes and of the information given by the application. The skilled person would then tailor the performance of the horn by software analysis of the amplitude and phase effect of each mode on the specific pattern required at the horn aperture.

Analytical tools based on software were commonly used in the technical field because of extensive computation required (application as filed, page 10, lines 21-25). However, the computational work was not part of the invention. The availability of software tools permitted to achieve a result on a trial-and-error-basis without undue burden.

The Board agrees with these submissions which are considered to be both credible and convincing.

4.2 Therefore, the present application discloses the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art (Article 83 EPC 1973).

5. *Novelty*

5.1 None of the prior art documents on file discloses a multiple beam antenna according to present claim 1. The novel feature consists in that the plurality of discontinuities of each horn "*excite higher order TE1n modes supported by the aperture size with such amplitude and phase that each of said horns (20) has an aperture efficiency greater than that of dual-mode horns using the TE11 and TM11 modes only, over a pre-determined frequency range of the signal*".

5.2 Hence, the subject-matter of claim 1 on file is new over the available state of the art (Article 54(1),(2) EPC 1973).

6. *Inventive step*

6.1 The appellant substantially submitted that in a multiple beam antenna, the skilled person aiming at increasing the horn aperture efficiency would only consider the solution of a larger horn aperture which, however, revealed to be of difficult realization because of geometrical constraints in the antenna due to the presence of a plurality of adjacent feed horns. The invention offered another surprising solution relying on the excitation of higher order TE1n modes supported by the horn aperture size. The performance of a larger horn was thus achieved with a smaller one. This solution was not taught by any of the prior art documents on file.

The Board agrees with this evaluation. Indeed, the available prior art documents do not disclose or suggest a link between the excitation of higher TE1n modes supported by the horn aperture and the increase of the horn aperture efficiency over a pre-determined frequency range.

D1 discloses a plural mode horn antenna. The document discusses improvements in cross-polarization performance and pattern symmetry by the use of TM11 and TE12 modes without generating any unnecessary higher mode (column 10, lines 21-38; claims 1 and 2).

D2 discloses a corrugated feed horn for a microwave reflector antenna. In operation, the horn provides low cross-polar performance over a pre-determined bandwidth (Abstract; page 1, lines 83-89; page 2, lines 67-71).

D3 (Introduction and Conclusions) concerns a mode filter for restraining unwanted higher-order modes in a wideband tracking corrugated horn in a shipboard antenna. The envisaged working modes are the TE11 and TE21 modes. By using the mode filter, an improvement in cross-polarization is obtained.

D4 concerns a multiple beam antenna system. The document does not provide information on modal content of the horns.

D5 discloses a multiport multimode feed horn for a reflector type antenna. The horn is arranged to generate and combine preferred modes such as TE10, TE20 and EM11. Undesired higher order modes are suppressed. Multiple beams are obtained, each in a different pointing direction (Abstract; column 4, lines 6-42; Figures 1 and 2A).

D6 shows in Figure 2 a plural mode horn antenna corresponding to that shown in Figure 3 of D1 (column 2, lines 31-68) as prior art (communication dated 28 December 2005, page 2, point II.1). The horn relies on the control of modes TM11 and TM12 for obtaining good radiation pattern over a wide band (D1, column 2, lines 62-68).

D7 is an extract from a book concerning microwave horns and feeds. As Prof. Shafai, a co-author of the book, submitted in his declaration of 26 September 2006 filed as Annex 1 with the grounds of appeal, the numerous statements on aperture efficiency improvement with multimode horns (pages 229, 230, 234 and section 8.4.2) referred to the aperture efficiency of the reflector antenna, not the aperture efficiency of the multimode horn. The Board has no reason to doubt this statement. Thus, the disclosure concerning the desirability of adding higher order modes, in particular the modes TE12 and/or TM12, with appropriate amplitude and phase (page 229, lines 12-16; page 234, last paragraph; page 238) should be read in the light of the understanding mentioned above. A horn using these modes (TE12 and/or TM12) can produce a copolar main beam which has a flatter top and a steeper falloff. This would entail reduced, not enhanced, horn aperture efficiency which in turn implies increased reflector aperture efficiency. Indeed, such a flattened beam provides a more uniform illumination of the reflector (Prof. Shafai's declaration of 26 September 2006 confirmed by Prof. Bornemann's affidavit of 28 September 2006, page 5).

In conclusion, none of these documents teaches that the discontinuities of the horn can be used to excite higher order TE1n modes supported by the horn aperture so as to

increase the horn aperture efficiency over an operating bandwidth.

6.2 Hence, the subject-matter of claim 1 on file involves an inventive step (Article 56 EPC 1973).

7. It is noted that the arguments mentioned in the decision under appeal are not relevant with regard to the claims on file which substantially differ from those underlying the appealed decision. In particular, the examining division's conclusions are based on the assessment that the then claimed subject-matter was mainly characterized by a result to be achieved and included non limiting features (Reasons, point II.1). This assessment is not valid for the present claims due to their amended wording.

8. Before grant of a patent the description has to be adapted to the amended claims on file.

Order

For these reasons it is decided that:

The decision under appeal is set aside.

The case is remitted to the examining division with the order to grant a patent on the basis of claims 1 to 4 filed at the oral proceedings on 2 July 2009, with the description and the figures to be adapted.

The Registrar: The Chairman:

R. Schumacher B. Schachenmann