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D E C I S I O N
of 4 July 2006

Case Number: T 0022/04 - 3.4.01

Application Number: 00104547.5

Publication Number: 1041672

IPC: H01Q 13/02

Language of the proceedings: EN

Title of invention:

Multimode, multi-step antenna feed horn

Applicant:

NORTHROP GRUMMAN CORPORATION

Opponent:

-

Headword:

-

Relevant legal provisions:

EPC Art. 52(1), 54(1), (2)

Keyword:

"Novelty - no"

Decisions cited:

-

Catchword:

-



Case Number: T 0022/04 - 3.4.01

D E C I S I O N
of the Technical Board of Appeal 3.4.01
of 4 July 2006

Appellant: NORTHROP GRUMMAN CORPORATION
1840 Century Park East
Los Angeles, CA 90067-2199 (US)

Representative: Schmidt, Steffen J.
Wuesthoff & Wuesthoff
Patent- und Rechtsanwälte
Schweigerstrasse 2
D-81541 München (DE)

Decision under appeal: Decision of the Examining Division of the
European Patent Office posted 7 August 2003
refusing European application No. 00104547.5
pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: B. Schachenmann
Members: R. Bekkering
G. Assi

Summary of Facts and Submissions

- I. European patent application No. 00104547.5 (publication No. EP-A-1 041 672) was refused pursuant to Article 97(1) EPC by a decision of the examining division dispatched on 7 August 2003, on the ground of lack of inventive step (Articles 52(1) and 56 EPC).
- II. The applicant (appellant) lodged an appeal against the decision on 24 September 2003 and paid the appeal fee on the same day. The statement setting out the grounds of appeal was received on 2 December 2003.
- III. Oral proceedings, requested as an auxiliary measure by the appellant, were held on 4 July 2006.
- IV. The appellant requested that the decision under appeal be set aside and a patent be granted on the basis of the following documents:

Claims: No. 1 filed in the oral proceedings on
 4 July 2006;
 No. 2 to 7 filed with letter of
 12 December 2001;

Description: pages 1 to 3, 6 to 10 as originally
 filed;
 pages 4 and 5 filed with letter of
 12 December 2001;
 pages 4a, 11 and 12 filed with letter of
 25 June 2001;

Drawings: Sheet 1/1 filed with letter of 4 April
 2000.

4. Reference is made to the following document:

D3: US-A-4 122 446

V. Claim 1 reads as follows:

"1. A feed horn (10) for transmitting a signal having both E-plane and H-plane beamwidths, said horn comprising:

- an input section (14) configured to receive the signal,

- an output section (20) configured to shape the signal in a predetermined manner,

- a throat section (12) positioned between the input section (14) and the output section (20) so that the signal travels there through and

- a multiple transition step section (16) positioned between the throat section (12) and the output section and being connected to the throat section (12), said multiple transition section (16) including a plurality of step transitions (28,30,32,34) that are configured so that a minimum throat area is positioned on the side of the input section (14) and a maximum throat area is positioned on the side of the output section (20), characterised by

- first two (32,34) of the plurality of step transitions for creating propagation in multiple propagation modes and in substantially equal E-plane and H-plane beamwidths with suppressed sidelobes, and

- second two (28,30) of the plurality of step transitions for providing impedance matching between the first two (32,34) of the plurality of step transitions and the input section (14), wherein

- the second two step transitions (28, 30) are other transition steps than the first two step transitions (32,34)."

Independent claims 5 and 7 are directed to a satellite comprising a feed array and a method of forming a feed horn, respectively.

Reasons for the Decision

1. The appeal complies with the requirements of Articles 106 to 108 and Rule 64 EPC and is, therefore, admissible.

2. *Amendments*

Claim 1 as amended is based on original claims 1 and 3, and on the description as filed (see page 5, lines 1 to 7 and page 10, lines 4 to 8).

The Board is thus satisfied that the amendments comply with the requirements of Article 123(2) EPC.

3. *Novelty*

3.1 Document D3 discloses (using the terminology of claim 1) a feed horn (10) for transmitting a signal having both E-plane and H-plane beamwidths, comprising:

- an input section (11) configured to receive the signal,
- an output section (13) configured to shape the signal in a predetermined manner,

- a throat section (first section of segment 12 in figure 1) positioned between the input section and the output section so that the signal travels there through and
- a multiple transition step section (12) positioned between the throat section and the output section and being connected to the throat section, the multiple transition section including a plurality of step transitions (ie six step transitions) that are configured so that a minimum throat area is positioned on the side of the input section and a maximum throat area is positioned on the side of the output section (see document D3, figure 1 and column 1, line 50 to column 3, line 54).

In particular, in the embodiment of figure 1 of document D3, the first section, forming the throat section in accordance with the wording of claim 1, has an inner diameter of 1.159 inch and a length of 0.312 inch. The subsequent six steps provided in the multiple transition step section (12) have the following diameter and length:

Step No.	Diameter (inch)	Length (inch)
1	1.219	0.306
2	1.387	0.294
3	1.678	0.284
4	1.932	0.278
5	2.000	0.160
6	2.120	4.672

3.2 As explained in document D3, an abrupt transition of appropriate dimension in the wall of a waveguide converts a portion of the dominant TE₁₁ mode energy to the higher order TM₁₁ mode, thereby suppressing the side lobes and producing substantially equal beamwidths in the E and H planes. In order to generate the TM₁₁ mode, at least one of the abrupt steps in the horn must have a diameter of at least $3.83 \lambda/\pi$ (ie 1.22λ), where λ is the wavelength of the microwave energy passing through the horn. Thus, when operating at a frequency of 11.7 GHz, for example, the TM₁₁ mode is first generated when one of the abrupt steps in the feed horn increases the inside diameter to at least 1.231 inches (see document D3, column 2, lines 12 to 34). It is noted that this corresponds to the explanations provided in the application in this respect (see paragraph bridging pages 9 and 10 of the application as filed).

Accordingly, in the feed horn of document D3, at a frequency of 11.7 GHz, the TM₁₁ mode is generated by the above defined second step and each succeeding step (see column 3, lines 48 to 54).

Document D3, thus, provides "first two" of the plurality of step transitions for creating propagation in multiple propagation modes and in substantially equal E-plane and H-plane beamwidths with suppressed sidelobes, as per claim 1.

3.3 Furthermore, according to document D3 the reflection losses and VSWR are minimized at steps with an axial length between $1/8$ and $3/8$ of the wavelength of the microwaves (ie at 11.7 GHz between about 0.126 inch and 0.378 inch) (see document D3, column 2, lines 47 to 58).

In fact, the axial dimension of each step deviates physically from the theoretical 1/4 wavelength in order to compensate for the field fringing that occurs at the junction between steps. Steps with these dimensions thus provide impedance matching within the meaning of the application under consideration (see page 10, lines 5 to 8 of the application as filed).

Accordingly, the first four steps of section 12 as defined above, all of which have an axial length between 0.126 and 0.378 inch, provide impedance matching.

Document D3, thus, provides "second two" of the plurality of step transitions for providing impedance matching between the "first two" step transitions (for creating propagation in multiple propagation modes) of the plurality of step transitions (as defined above) and the input section, in accordance with claim 1.

As these "second two" step transitions may, for example, correspond to the above defined first and second steps providing impedance matching, and the "first two" step transitions, for example, may correspond to the above defined third and fourth steps creating propagation in multiple propagation modes, the "second two" step transitions are other transition steps than the "first two" step transitions as required by claim 1.

3.4 Accordingly, the subject-matter of claim 1 is fully anticipated by document D3.

3.5 The appellant held that in contrast to the teaching of document D3, claim 1, and indeed the application as a whole, defined step transitions only for mode conversion and step transitions only for impedance matching. Thus, the present invention was based on a separation of the functions.

The definition given in claim 1 having regard to the first two and second two step transitions, however, does not exclude that the first two step transitions may also provide for impedance matching and/or the second two step transitions may also create propagation in multiple propagation modes.

Furthermore, it would appear that in the only concrete embodiment of the application the first and second two step transitions are in fact not exclusively for impedance matching and mode conversion, respectively. The feed horn shown in figures 1 and 2, designed for operating in the Ka band at a frequency of 19.7 to 20.2 GHz, has four step transitions (28, 30, 32, 34) with inside diameters of 0.6 inch, 0.7 inch, 0.88 inch and 1.06 inch, respectively (see page 11, lines 14 to 19 of the application as filed). The axial lengths of the step transitions are 0.181 inch, 0.180 inch, 0.181 inch and 1.82 inch (section 18), as derivable from the distances given in the description (see page 11, line 20 to page 12, line 4 of the application as filed). Based on the same considerations above for TM_{11} mode generation and impedance matching, at an operating frequency of 19.7 GHz, TM_{11} mode generation takes places at step transitions with inside diameters exceeding 0.720 inch (ie 1.22λ) and impedance matching at step transitions with axial lengths between

0.075 inch and 0.281 inch (ie between 1/8 and 3/8 of the wavelength). Accordingly, the third and fourth step transitions (32, 34) provide mode transition and the first to third step transitions (28, 30, 32) provide impedance matching. In the sole concrete embodiment of the application the third step transition, thus, in fact provides both mode transition and impedance matching.

3.6 For the reasons above, the subject-matter of claim 1 is not novel with respect to document D3 (Articles 52(1) and 54(1) and (2) EPC).

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar:

The Chairman:

U. Bultmann

B. Schachenmann