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Datasheet for the decision of 9 September 2014

Case Number: T 0509/10 - 3.4.03

Application Number: 98112687.3

Publication Number: 0890739

IPC: F03H1/00

Language of the proceedings: EN

Title of invention:
Electrostatic propulsion system, spacecraft and propulsion method therefor

Patent Proprietor:
Hughes Electronics Corporation

Opponent:
Astrium Limited

Headword:

Relevant legal provisions:
EPC 1973 Art. 56, 100(a)

Keyword:
Inventive step - main request (yes)

Decisions cited:
T 0939/92, T 0072/95

Catchword:

Europäisches Patentamt
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Office européen des brevets

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Case Number: T 0509/10 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 9 September 2014

Appellant: (Opponent)	Astrium Limited Gunneis Wood Road Stevenage Hertfordshire SG1 2AS (GB)
Representative:	Walaski, Jan Filip Venner Shipley LLP 200 Aldersgate London EC1A 4HD (GB)
Respondent: (Patent Proprietor)	Hughes Electronics Corporation 200 N. Sepulveda Boulevard El Segundo, California 90245-0956 (US)
Representative:	Lindner, Michael Witte, Weller & Partner Patentanwälte mbB Postfach 10 54 62 70047 Stuttgart (DE)
Decision under appeal:	**Interlocutory decision of the Opposition Division of the European Patent Office posted on 30 December 2009 concerning maintenance of the European Patent No. 0890739 in amended form.**

Composition of the Board:

Chairman	G. Eliasson
Members:	T. M. Häusser
	T. Bokor

Summary of Facts and Submissions

I. The appeal of the opponent concerns the interlocutory decision of the opposition division to maintain the European patent EP-B-0 890 739 as amended during the opposition proceedings (Article 101(3)(a) EPC).

II. The opposition had been filed against the patent as a whole. Grounds of opposition were lack of novelty and inventive step (Articles 100(a), 54(1) and (2), and 56 EPC 1973).

III. Reference is made to the following documents:

D1: EP 0 550 250 A1,

D2: GB 2 248 727 A,

D3: Horowitz and Hill, "The Art of Electronics", second edition, 1989, Cambridge University Press, pages 360-368.

IV. Oral proceedings before the board took place in the absence of the duly summoned appellant (opponent), of which the board had been informed in the letter dated 13 August 2014. The appellant requested in writing that the decision under appeal be set aside and that the European patent No. 0 890 739 be revoked.

The respondent (patent proprietor) requests as the main request that the decision under appeal be set aside and the patent be maintained on the basis of the following:

Description:
Columns 1, 2, 5-8 of the patent specification,
Columns 3, 4, 9-11 as filed in the oral proceedings before the Board,

Claims:
Claims 1-7 filed with telefax on 14 August 2009,
Claim 8 filed during the oral proceedings on 15 September 2009,

Drawings:
Figures 1-6, 7A, 7B of the patent specification.

The respondent requests alternatively that the decision under appeal be set aside and the patent be maintained in an amended form on the basis of an auxiliary request filed with the letter dated 11 August 2014.

V. The wording of independent claims 1, 7, and 8 of the main request is as follows (board's labelling (i), (i)', and (i)''):

"1. An electrostatic propulsion system, comprising

a plurality of electrostatic thrusters (136, 137; 176, 177) which each generates a thrust when fed an ionizable gas and energized with a plurality of power forms;

a power supply system (148; 178) which generates said power forms and which is coupled to continuously deliver said power forms to said thrusters; and

a plurality of gas valves (150-153; 180-183), each coupled to control the flow of said ionizable gas to a respective one of said electrostatic thrusters (136, 137; 176, 177) and each opening in response to a respective valve control signal;

each of said electrostatic thrusters thus generating a thrust and drawing power from said power supply system (148; 178) in response to the control valve signal of its respective gas valve,

characterized in that

each of said electrostatic thrusters comprises a heater power supply system (222) configured to selectively apply a heater power form to any one of said electrostatic thrusters;

the power supply system is provided as a common power supply system (226) coupled to all of said electrostatic thrusters,

(i) said common power supply system generating all power forms required by said electrostatic thrusters except said heater power form,

each of said electrostatic thrusters thus generating a thrust and drawing power from said common power supply system in response to application of said heater power form and in response to the valve control signal of its respective gas valve."

"7. A spacecraft, comprising:

a body (125);

at least one solar cell array (127) carried on said body for generating energy from solar radiation; and

an electrostatic propulsion system (140), characterized in that the electrostatic propulsion system (140) includes:

a) a plurality of electrostatic thrusters (136, 137; 176, 177) which each generates a thrust when fed an ionizable gas, each of said electrostatic thrusters including:

1) an electron source (27) for supplying electrons;

2) an electrode system (28) for accelerating said electrons through said gas to generate a plasma source; and

3) a multiple-grid ion-optics system (22) for extracting an ion beam from said plasma source;

b) a heater power supply system (222) configured to selectively apply a heater power form to any one of said electrostatic thrusters;

c) a common power supply system (226) coupled to all of said electrostatic thrusters,

(i)' said common power supply system generating all power forms required by said electrostatic thrusters except said heater power form; and

d) a plurality of gas valves (150-153), each coupled to control the flow of said ionizable gas to a respective one of said electrostatic thrusters and each opening in response to a respective valve control signal;

each of said electrostatic thrusters (136, 137; 176, 177) thus generating a thrust and drawing power from said common power supply system in response to application of said heater power form and in response to the valve control signal of its respective gas valve."

"8. A method of applying selectable thrusts to a space craft (120), the spacecraft comprising a plurality of electrostatic thrusters, a heater power supply system (222) configured to selectively apply a heater power form to any one of said electrostatic thrusters; and

(i)'' a power supply system provided as a common power supply system coupled to all of said electrostatic thrusters and generating all power forms required by said electrostatic thrusters except said heater power form,

comprising the steps of:

coupling a plurality of electrostatic thrusters (136, 137; 176, 177) to said spacecraft (120), wherein

each of said electrostatic thrusters (136, 137; 176, 177) generates a thrust when fed an ionizable gas and energized with at least one heater power form and a plurality of other power forms;

continuously applying said other power forms to said electrostatic thrusters by said common power supply system;

applying said heater power form to a selected thruster of said electrostatic thrusters by said heater power supply system; and

feeding said ionizable gas to said selected thruster;

said applying step and said feeding step initiating the thrust of said selected thruster."

VI. The parties argue essentially as follows in relation to the main request:

a) Appellant's arguments

The subject-matter of claims 1, 7, and 8 of the main request did not involve an inventive step.

The subject-matter of claim 1 only differed from document D1 in that the common power supply system generated all power forms required by said thrusters except the heater power form. According to the patent the heater power supply system was separate from the common power supply, whereas in document D1 the heater power supply system was a subsidiary power supply system coupled with switches to the common power supply system.

The distinguishing feature provided no real technical improvement over and above that provided by D1. In the opposed patent it was explained in paragraphs [0049]

and [0050] that the separate heater supply units were provided so that non-selected heaters were not energized in order to limit power consumption, extend heater lifetime and prevent loss of all thrusters due to failure of one heater. The same effect was however provided by the switches of D1 fed from the common power supply. Furthermore, the overall power requirements of the common power supply unit would not be changed by transferring the heater supplies into a separate unit as the supplies would run from a constant voltage power bus with various load types. Moreover, even if a slightly less powerful common power supply could be used this would not result in a significantly less bulky common power supply as a major part of the power supply mass and volume was taken up by the mechanical housing. Furthermore, the potential need for auxiliary supplies and command interfaces had to be taken into account in this context. The overall supply system size and mass was therefore in fact increased. Therefore, the problem was to provide an alternative to the arrangement of document D1.

Faced with this problem the skilled person would understand that there was no technical difference between providing a switch from providing a common power supply and a separate supply. This was also supported by the opposed patent itself, where it was described in paragraph [0060] that a series of switches linked to a single supply was a substitute for a plurality of separate supplies. Moreover, document D3 showed that the skilled person would readily consider interchanging a separate supply for a branch from a main common supply. Although D3 related to a power supply to a computer, there was nothing in the case that would prevent the same general principles from applying. Furthermore, even though it was mentioned in

D3 that the temptation was overwhelming to hang another winding on transformer T1, the use of a separate linear supply was still mentioned as a viable alternative.

Moreover, the claimed separate supplies would have to be switched since otherwise the aim of selectively energising the cathode heaters could not be achieved. The claimed solution was to retain the switches in some form but power them from a different supply. Since the supply would in any case ultimately come from the spacecraft power supply, e. g. the solar panels, the skilled person would realize that feeding the heater power supply from the spacecraft supply was no different to feeding it from the common power supply.

The appellant referred in this regard to the decision T72/95 of the Boards of Appeal, in which it was held that an arbitrary modification could not involve an inventive step. Furthermore, reference was made to the decision T939/92, from which it followed that, where there were a number of alternative solutions to that in the prior art, all of them would be equally suggested to the skilled person.

b) Respondent's arguments

The subject-matter of claims 1 and 8 of the main request involved an inventive step.

The closest state of the art was document D1. In that document it was disclosed that the power supply unit PCU1 was used for energizing any electric load of the thrusters, also the heaters of the thrusters. Furthermore, subsidiary power units (negative accelerator grid 22, beam power supply unit 23, ...) were provided for each thruster separately, which

worked together with the power supply unit PCU1 to provide the power forms to the various electric loads.

In the claimed invention the common power supply provided all power forms except the heater power form. The object of the invention was to provide more flexibility and freedom in the design of the necessary power supplies and to increase their reliability. Furthermore, the arrangement of the power supply units could be chosen such that one did not affect the other, e. g. due to switching noise. Moreover, it was not necessary to duplicate the subsidiary power supply units thus simplifying the system.

The skilled person had no reason to change the configuration disclosed in D1 in a way corresponding to the invention. In particular, there was no teaching in D1 prompting the skilled person to divide the power supply unit PSU1 into two separate units.

In document D3 it was pointed out on page 365 to provide a further small winding so as to generate an additional supply voltage of 15V. This was however not comparable with the claimed separation of the power supply system into a common power supply and a heater power supply as the further winding was affected by the other windings of the circuit. Therefore, even when considering documents D1 and D3 in combination, the skilled person was not taught to separate the heater power supply system from the common power supply system.

Reasons for the Decision

1. The appeal is admissible.

2. Procedural matters

2.1 The duly summoned appellant was not represented at the oral proceedings. The proceedings were however continued without the appellant in accordance with Rule 71(2) EPC 1973.

According to Article 15(3) RPBA, the board "shall not be obliged to delay any step in the proceedings, including its decision, by reason only of the absence at the oral proceedings of any party duly summoned who may then be treated as relying only on its written case". The purpose of oral proceedings is to give the party the opportunity to present its case and to be heard. However, a party gives up that opportunity if it does not attend the oral proceedings.

2.2 As detailed below, the main request is found to meet the requirements of the EPC, in particular in relation to inventive step (Article 56 EPC 1973) and support in the description (Article 84 EPC 1973).

The claims of the main request are the claims on which the appealed decision is based. In the letter setting out the grounds of appeal the appellant had argued at length in relation to inventive step of the subject-matter of those claims.

During the oral proceedings before the board the description was amended in order to bring it into conformity with the claims. Since the claims had been amended during the opposition proceedings the appellant had to expect that the support in the description of the claims would be discussed at the oral proceedings before the board and that the description would

possibly be amended as a consequence. By not attending the oral proceedings the appellant gave up the opportunity to comment on these issues.

Consequently, the board saw no reasons for delaying the decision in view of Article 113(1) EPC 1973. The board was therefore in a position to decide at the conclusion of the oral proceedings, since the case was ready for decision (Article 15(5) and (6) RPBA).

3. Main request - inventive step

3.1 Closest state of the art

Both parties agree that document D1 is to be considered the closest state of the art. Indeed, that document is related to the same purpose as the claimed invention, namely electrostatic propulsion, and has the most relevant technical features in common with it as detailed below. Document D1 is therefore considered as the closest state of the art.

3.2 Distinguishing features

3.2.1 Document D1 discloses (column 2, line 56 - column 3, line 34; column 4, line 40 - column 5, line 24; Figures 3 and 5) a spacecraft having thrusters T1 to T4, which are supplied with propellant, e. g. xenon, argon or krypton, from a tank 1 of propellant via respective valves V1 to V4. Valves V1 and V2 are operated by a switch S1 controlled by a power supply unit PSU1, which also supplies the thrusters T1 and T2 in order to provide a supply to the electrodes of the thrusters. Redundant thrusters T3 and T4 are powered by redundant power supply unit PSU2, which also controls switch S3 for controlling the valves V3 and V4 of the redundant

thrusters. The thrusters T1 to T4 may be ion thrusters comprising a discharge chamber 8 to which propellant is supplied from a pipe via valve 10 and further valves 11, 12, and 13. An arc is initially struck in the ion thruster by providing a potential difference between hollow cathode 13 and cathode keeper 14 and electrons flow to annular anode 15 through a magnetic field generated by electro-magnets 16, 17 which cause the electrons to undergo a spiralling path and increase the probability of collision with the main propellant flow to provide the main ion beam. The latter passes through a perforated accelerator grid 19 which is maintained highly negative to the discharge chamber to accelerate the ion beam and hence provide the thrust to the thruster.

The power supply unit PSU1 feeds a number of subsidiary power supply units 22-29, namely the accelerator grid power supply unit 22, beam power supply unit 23, cathode heater power supply unit 24, cathode keeper unit power supply unit 25, etc. The power unit PSU1 also powers the thruster T2 provided with identical control circuitry, i. e. accelerator grid power supply unit 22a, beam power supply unit 23a, etc.

3.2.2 Hence, document D1 discloses - using the wording of claim 1 - an electrostatic propulsion system, comprising

a plurality of electrostatic thrusters (T1, T2) which each generates a thrust when fed an ionizable gas (xenon, argon or krypton) and energized with a plurality of power forms (delivered by the subsidiary power supply units);

a power supply system (power supply unit PSU1 and subsidiary power supply units 22, 22a, 23, 23a, ...) which generates said power forms and which is coupled

to continuously deliver said power forms to said thrusters; and

a plurality of gas valves (V1, V2), each coupled to control the flow of said ionizable gas to a respective one of said electrostatic thrusters (T1, T2) and each opening in response to a respective valve control signal (via switch S1);

each of said electrostatic thrusters (T1, T2) thus generating a thrust and drawing power from said power supply system (PSU1, 22, 22a, 23, 23a, ...) in response to the control valve signal of its respective gas valve (V1, V2),

wherein

each of said electrostatic thrusters (T1, T2) comprises a heater power supply system (cathode heater power supply units 24, 24a) configured to selectively apply a heater power form to any one of said electrostatic thrusters (T1, T2),

the power supply system is provided as a common power supply system (PSU1) coupled to all of said electrostatic thrusters (T1, T2),

each of said electrostatic thrusters (T1, T2) thus generating a thrust and drawing power from said common power supply system (PSU1) in response to application of said heater power form and in response to the valve control signal of its respective gas valve (V1, V2).

3.2.3 Document D1 does not disclose - as agreed by the parties - feature (i) of claim 1 of the main request, i. e. that the common power supply system generates all power forms required by said electrostatic thrusters except said heater power form.

3.3 Objective technical problem

3.3.1 The appellant argues that the advantages mentioned in the opposed patent in paragraphs [0049] and [0050], namely to limit power consumption, extend heater lifetime and prevent loss of all thrusters due to failure of one heater, were already achieved by the switches of D1.

The above advantages relate to a subjective technical problem as originally presented in the application as filed in relation to a specific embodiment of the application (see the original description of the application, page 3, lines 26-30). The subjective technical problem may need to be reformulated in view of prior art documents which are more relevant than those which had originally been taken into account by the applicant when drafting the application as filed.

However, the fact that a solution to the subjective technical problem has already been proposed in a more relevant prior art document does not imply that the problem of the invention is merely to provide an alternative solution. Rather, the technical effect of the difference between the claimed solution and the known solution has to be assessed in order to determine the objective technical problem.

Therefore, in the present case it has to be assessed what the technical effect is of said common power supply system generating all power forms required by said electrostatic thrusters except said heater power form, i. e. of distinguishing feature (i).

3.3.2 The appellant argued that due to the potential need for auxiliary supplies and command interfaces for the separate heater power supply system, the overall supply system size and mass was in fact increased.

However, a separate heater power supply system is already known from document D1. Moreover, whether the heater power supply system is fed from the common power supply unit as in document D1 or directly from the solar panel or battery of the spacecraft does not affect the overall size or mass of the power supply system but merely the arrangement of the power conversion.

Furthermore, as described above, in the system of document D1 the power supply unit PSU1 feeds a number of subsidiary power supply units 22-29 of thruster T1 and corresponding subsidiary power supply units 22a, 23a, ... of thruster T2. The different voltages provided within PSU1 are provided by a switched mode power converter (D1, column 5, lines 51-53). The various electrodes of the thruster T1 are thus powered by the corresponding subsidiary power supply units of thruster T1; similarly, the electrodes of the thruster T2 are powered by the corresponding subsidiary power supply units of thruster T2.

By contrast, according to the claimed system the common power supply system generates all power forms, i. e. voltage and current combinations (see paragraph [0011] of the opposed patent), required by said electrostatic thrusters except said heater power form. Contrary to the system of document D1, where each thruster T1 and T2 has its own set of subsidiary power supply units, all power forms except the heater power form are generated by a shared power supply unit. Hence, duplication of the subsidiary power supply units is avoided and the power supply system is simplified, thereby reducing the complexity of the system which

translates into weight, volume and cost savings of the spacecraft using the system.

The objective technical problem of the invention is therefore to achieve these effects.

3.4 Obviousness

3.4.1 The appellant is of the opinion that document D3 showed that the skilled person would readily consider interchanging a separate supply for a branch from a main common supply.

However, even if it were conceded that this was the case, it would merely induce the skilled person to feed the heater power supply system directly from the solar panel or battery of the spacecraft rather than from the common power supply unit. But there is no teaching in document D3 leading the skilled person to eliminate the duplication of the subsidiary power supply units of thrusters T1 and T2, except the heater power supply units.

3.4.2 Document D2 relates to an ion thruster for spacecraft whose various electrodes are powered by separate power supply units (see page 5, paragraphs 1 to 3 of document D2). The skilled person would therefore not be led by this document either to use a common power supply system generating all power forms required by the electrostatic thrusters except the heater power form.

3.4.3 In the decision T 72/95, cited by the appellant, it was held that a certain feature (presence of a carbon rod) was considered to be no more than an arbitrary modification which could not involve an inventive step.

In the other decision T 939/92 cited by the appellant the board was not satisfied that substantially all claimed compounds were likely to be herbicidally active. The claimed subject-matter extended therefore to compounds which were not inventive and therefore did not meet the requirement of inventive step (see Reason 2.7).

In the present case distinguishing feature (i) is however no arbitrary modification and has the technical effects discussed under point 3.3 above. The cited decisions are therefore not considered to be relevant for assessing inventive step in the present case.

3.4.4 Therefore, the subject-matter of claim 1 involves an inventive step.

Independent device claim 7 and independent method claim 8 correspond essentially to system claim 1, in particular feature (i)' of claim 7 and feature (i)'' of claim 8 correspond to distinguishing feature (i) of claim 1. Hence, the subject-matter of independent claims 7 and 8 involves an inventive step for the same reasons as set out above. Claims 2 to 6 are dependent on claim 1.

Accordingly, the subject-matter of claims 1 to 8 involves an inventive step (Article 52(1) EPC and Article 56 EPC 1973).

4. Main request - support in the description

The description has been brought into conformity with the claims of the main request. In particular, the description has been amended such that examples which do not fall under the wording of the claims are not

presented as embodiments of the invention. Furthermore, a general statement has been deleted. The board is thus satisfied that the claims are properly supported by the description and comply with the requirements of Article 84 EPC 1973.

5. Conclusion

For the above reasons, the main request is considered to meet the requirements of the EPC. The patent is therefore to be maintained as amended according to the main request (Article 101(3)(a) EPC and Article 111(1) EPC 1973). Consideration of the auxiliary request is therefore not necessary.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of first instance with the order to maintain the patent in amended form with the following documents:

Description:
Columns 1, 2, 5-8 of the patent specification,
Columns 3, 4, 9-11 as filed in the oral proceedings before the Board,

Claims:
Claims 1-7 filed with telefax on 14 August 2009,
Claim 8 filed during the oral proceedings on 15 September 2009,

Drawings:
Figures 1-6, 7A, 7B of the patent specification.

The Registrar: The Chairman:

S. Sánchez Chiquero G. Eliasson

Decision electronically authenticated