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Case Number: T 0019/98 - 3.2.2

Decision of 3 March 1999
correcting errors in the Interlocutory decision
of the Technical Board of Appeal 3.2.2
of 3 December 1998

Appellant: (Opponent)
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Representative:
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Respondent: (Proprietor of the patent)
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Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 25 November 1997 rejecting the opposition filed against European patent No. 0 287 657 pursuant to Article 102(2) EPC.**

Composition of the Board:

Chairman: W. D. Weiß
Members: R. Ries
J. C. M. De Preter

In application of Rule 89 EPC, the decision of the Technical Board of Appeal given on 3 December 1998 is hereby corrected as follows:

Page 6, line 10: After the words "target area" and before the word "so that" insert:

"for controlling the temperature of sintered and unsintered powder at the target area (26)"

The Registrar: The Chairman:

S. Fabiani W. D. Weiß

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D E C I S I O N
of 3 December 1998

Case Number: T 0019/98 - 3.2.2

Application Number: 88900160.8

Publication Number: 0287657

IPC: B23K 26/00

Language of the proceedings: EN

Title of invention:
Method and apparatus for producing parts by selective sintering

Patentee:
Board of Regents, The University of Texas System

Opponent:
EOS GmbH Electro Optical Systems

Headword:
-

Relevant legal provisions:
EPC Art. 54, 56, 84, 123(2), 123(3)

Keyword:
"Novelty (yes)"
"Inventive step (yes) after amendment"

Decisions cited:
-

Catchword:
-

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Summary of Facts and Submissions

I. European patent No. 0 287 657 was granted with effect from 28 December 1994 on the basis of the European patent application No. 88 900 160.8 and claimed two priority dates of 17 October 1986 and 5 October 1987.

II. An opposition was filed against the grant of the patent on the grounds of

- lack of novelty and lack of inventive step (Articles 100(a), 52 and 56 EPC) and

- extension of the subject matter of the patent beyond the content of the application as originally filed (Articles 100(c), 123(2) EPC).

III. In the decision dated 25 November 1997, the opposition division held that the grounds of opposition mentioned in Articles 100(a) and 100(c) EPC did not prejudice the maintenance of the patent in the form as granted and, consequently, the opposition was rejected.

During the opposition procedure, the following documents were taken into consideration:

D1: EP-A-0 289 116 (prior art according to Article 54(3) EPC)

D2: US-A-4 247 508

D3: US-A-2 435 273

D4: Deckard, Thesis Mai 1986, published 24 July 1987

D5: JP-A-61-52373 (and translation into English)

D6: JP-A-57 160975 (and translation into English)

D7: DE-C-3 445 613

D8: Deckart, Thesis "Selective laser sintering", published December 1988,

D9: Manufacturing Technology Review, vol. 2, 1987, Fifteenth North American Manufacturing Research Conference, 27 to 29 May 1987, Lehigh University, Bethlehem, Pennsylvania , pages 636 to 641

IV. An appeal against this decision was lodged on 18 December 1997 by the opponent (in the following called the appellant).

Enclosed with its response to the appeal of 28 August 1998, the patentee (the respondent) submitted further subsidiary requests, and in a letter dated 24 September 1998 reference was made to the documents

D10: Chemical Engineering Volume 2, J. M. Coulson et al., third edition, Pergamon Press, 1978, page 230

D11: Fundamentals of Fluidized-bed Chemical Processes, by J. G. Yates, Butterworths, London, 1983, pages 4 and 5.

V. Oral proceedings took place on 3 December 1998.

VI. The appellant requests that the decision under appeal be set aside and that the patent be revoked in its entirety.

The respondent requests that the appeal be dismissed and that the patent be maintained in amended form on the basis of:

- claims 1, 9 and 18 as submitted at the oral proceedings of 3 December 1998;

- claims 2 to 8, 10 to 17 as granted;

- description column 1 an 2 as submitted on 28 August 1998;

- description column 3 to 16 of the European patent specification No. 0 287 657;

- figures 1 to 11 as granted.

VII. Independent claims 1, 9 and 18 read as follows:

"1. A method of producing a part (52) comprising the steps of depositing a first layer of sinterable powder (22) onto a target surface (26); scanning the aim of a directed energy beam (64) over the target surface (26) to fuse selected portions of the first layer (54) of the powder corresponding to a first cross-sectional region of the part (52) by operating the beam (64) when the aim of the beam (64) is within boundaries defined by said first cross-sectional region;

depositing a second layer of sinterable powder (22) onto the first layer (54);

scanning the aim of a directed energy beam (64) over the target surface (26) to sinter selected portions of the second layer (55) corresponding to a second cross-sectional region of the part (52) by operating the beam (64) when the aim of the beam is within boundaries defined by said cross-sectional region, so that sintered portions of the first and second layers (54, 55) are joined during the sintering of said second layer (55); and

depositing further successive layers of sinterable powder (22) onto the previous layers and sintering a layer of each successive portion to produce a part (52) comprising a plurality of sintered layers (54, 55, 56, 57);

characterised by:
directing a flow of controlled temperature air to the target area to transfer heat between said air flow and each top layer of powder to be sintered in order to control the temperature of the sintered and unsintered powder at the target surface so as to moderate temperature differences between the powder not yet scanned by the directed energy beam and the previously scanned layer.

9. An apparatus for performing a method according to claim 1 comprising:

an energy source (12) operable to emit a focused energy beam (64);

a structure (28) having a target surface (26) at which a part (52) is to be produced in layerwise fashion;

means for dispensing a layer of sinterable powder (22) into said target area (26); and

a controller (16) operable to direct the aim of the focused energy beam (64) to selectively sinter within defined boundaries a portion of each layer (54, 55, 56, 57) of powder (22) dispensed in said target surface (26),

the controller (16) including a scanning system (42) to move the aim of the energy beam (64) in said target area (26) in a repetitive pattern (66), and a computer (40) programmed with the defined boundaries of each layer (54, 55, 56, 57) of the part (52) to turn on the energy beam (64) with the aim of the beam (64) within the defined boundaries for each layer (54, 55, 56, 57) as the aim of the beam (64) is moved in the target area (26), being operable to direct the energy beam (64) over the target surface (26) to sinter selected portions of sequential layers (54, 55, 56, 57) of powder (22) within respective defined boundaries corresponding to sequential cross-sectional regions of a part; and

the dispensing means (14) being operable to dispense successive layers of powder (55, 56, 57), each after the selective sintering of a prior layer (54, 55, 56), so that sintered selected portions of one of the successive layers are joined to sintered portions of a prior layer, to produce a part (52) comprising a plurality of layers (54, 55, 56, 57) sintered together;

the apparatus being characterised by

means for directing controlled temperature air to the target area for controlling the temperature of sintered and unsintered powder at the target area so that, in use, heat is transferred between the controlled temperature air and each top layer of powder to be sintered.

18. Use of an apparatus for performing a method according to claim 1, the apparatus comprising:

an energy source (12) operable to emit a focused energy beam (64);

a structure (28) having a target surface (26) at which a part (52) is to be produced in a layerwise fashion;

means (14) for dispensing a layer of a sinterable powder (22) into said target area (26); and

a controller (16) operable to direct the aim of the focused energy beam (64) to selectively sinter within defined boundaries a portion of each layer (54, 55, 56, 57) of powder (22) dispensed in said target surface (26),

the controller (16) being operable to direct the energy beam (64) over the target surface (26) to sinter selected portions of sequential layers (54, 55, 56, 57) of powder (22) within respective defined boundaries corresponding to sequential cross-sectional regions of a part;

the dispensing means (14) being operable to dispense successive layers of powder (55, 56, 57), each after the selective sintering of a prior layer (54, 55, 56), so that sintered selected portions of one of the successive layers are joined to sintered portions of a prior layer, to produce a part (52) comprising a plurality of layers (54, 55, 56, 57) sintered together; and characterised by

means for directing controlled temperature air to the target area so that, in use, heat is transferred between the controlled temperature air and each top layer of powder to be sintered.

VIII. The appellant argued as follows:

- The wording used in the amended independent claims 1, 9 and 18 is confusing, since two different terms i.e. "target area" and "target surface" are used which, in the claims, appear to have the same meaning. However, the specification as originally filed seems to use these terms in a different context. On page 11, line 36 bridging page 12, line 1 and on page 15, lines 18 to 22 of the originally filed specification, a support defines the "target area 26" (cf. Figures 9 and 10) where the aim of the beam is directed to. On the other hand, on page 6, lines 4 to 9, a first layer of powder is deposited on the "target surface" and then the aim of a laser beam is scanned over the target surface to sinter the first layer on the target surface. Objection therefore, arises under Article 84 EPC.

- The subject matter of the independent claims 1, 9 and 18 is anticipated by the method and apparatus shown in document D1, which is comprised in the state of the art according to Article 54(3) EPC.

The technical features of the precharacterizing part of claim 1 are found in D1, column 3, lines 56, column 4, lines 37 to 42, 45 to 55, column 6, lines 22 to 32, column 5, lines 30 to 33, 41 to 57, and those of the characterizing part are disclosed in column 8, lines 30 to 45 and column 4, lines 47, 48. In D1, a laser or electron gun fuses powder from a fluidised bed that has been thrown and collected onto a surface, where it solidifies to form a cross section of the shape being formed. Additional powder is fed by the fluidizing action on the top of the cross-sectional layer until the entire shape is formed. In a preferred embodiment, the powder (alone) or the powder in the fluidized bed may be preheated to keep the part at a more uniform temperature and thereby provide heat treatment and stress relief. By the step of preheating the gas in D1, heat is transferred to the target area and, consequently, helps to control the temperature of part being produced. If, as described in D1 column 5, lines 9 to 12, a higher layer should overhang the preceding layer, this new layer must be supported by the powder and fluidization is stopped. It is, therefore, clear that the target area in this specific embodiment in D1 comprises sintered and unsintered powder. In case of producing e.g. a "hollow" body, the unsintered powder in the interior voids remains undestroyed by the fluidised bed gas and forms a support for the overhang, as disclosed in D1 column 5, lines 35 to 39. Hence, the subject matter of claims 1 and 9 lacks novelty with respect to document D1.

- The subject matter of the independent claims 1, 9 and 18 does not involve an inventive step with respect to the technical teaching of document D9 which represents the closest state of the art.

Document D9 already addresses the problems associated with heat by high power input during selective powder sintering, such as three-dimensional shrinkage, warpage and curling up of the layers at the edges as described for instance in D9, page 639, right hand column, item 4 and page 640, left hand column, items 5 and 6. As a solution to these problems, D9 proposes to moderate the temperature difference between the upper layer and the previous layer by cooling and by adjusting the layer thickness as set out on page 640, end of item 5. Thus, compared with D9, the only remaining feature of the claimed process is seen in the step of directing controlled air to the target surface to provide heat transfer. In the Research Issues on page 640 of D9, right hand column, item 2, however, transferring heat out of the system is held to be the limiting factor of the process. It is, therefore, obvious to a skilled person to moderate the temperature of the system. The claimed solution to moderate the temperature of the surface by directing controlled air to the target area merely represents the easiest way for transferring heat and does not involve an inventive step.

IX. The respondent argued substantially as follows:

- As to the appeal ground under Article 100(c) EPC, the embodiment described in the originally filed application contained an explicit disclosure of the technical feature set out in the characterizing part of the independent claims. Thus, a person skilled in the art is not being presented with anything he could not have derived clearly and unambiguously from the originally filed document. The amendments to the claims are, therefore, allowable.

- Although the term "target surface" and "target area" are used simultaneously in the claims and description, it is clear from the whole content of the specification that both terms have the same meaning. The amendments, therefore, satisfy the requirements of Article 84 EPC.

- It is clear from the wording of claim 1 that as a matter of construction the first layer after the scanning step will include both sintered and unsintered parts. By contrast, there is always fluidisation forming an essential part of the process described in D1 between the sintering steps, whereby the unsintered powder is completely fluidised. There is nothing in D1 to suggest that the subsequent layer of particles is deposited onto unsintered parts of the previous layer. In the downward flow according the claimed process, however, no relative movement of the unsintered particles occurs. No reference is made in D1 to temperature differences between the sintered and unsintered powder at the target area and, consequently, there is no suggestion to control the temperature of both the sintered and unsintered powder. Hence, the subject matter of claims 1, 9 and 18 is novel with respect to document D1.

- With respect to inventive step, the basic problem the claimed process and apparatus try to solve is concerned with thermally induced distortion in an object formed by layerwise selective irradiation of a powder with a direct energy beam (in-built layer curl). As further set out in the specification, undesirable shrinkage of the article being produced occurs due to differences between the temperature of the particles not yet scanned by the directed energy beam and the

temperature of the previously scanned layer. This particular problem is not addressed in document D9 which is concerned essentially with shrinkage and warpage problems resulting from the sintering mechanism itself, i.e. by the movement of the particle centers toward one another during the sintering process, and not with the shrinkage due to the cooling from sintered and unsintered powder. Given that there is nothing in document D9 to suggest a temperature control of both the sintered and unsintered powder in order to mitigate in-built layer curl, the subject matter of the independent claims involves an inventive step.

X. At the conclusion of the oral proceedings, the Board's decision was announced.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

In comparison with the granted claims each of the independent claims 1, 9 and 18 have been restricted by including the wording "directing a flow of controlled temperature air to the target area to transfer heat between said air flow and each top layer of the powder to be sintered". This restriction is amply supported by the original disclosure and is found on page 1, lines 23 to 25, page 7, lines 22 to 24, page 12, line 28 bridging page 13, line 4 as well as in original claims 7 and 32.

Hence, there are no objections to these amendments under Articles 123(2) or (3) EPC.

3. *Article 84 EPC*

At the oral proceedings, the clarity of the subject matter of amended claims 1, 9 and 18 has been challenged by the opponent. In particular, it has pointed to the fact that two different terms "target area" and "target surface" which could be interpreted differently are used simultaneously in the claims. The patentee, however, confirmed that both terms in fact have the same technical meaning.

As is clearly apparent from the specification as filed, a support or confinement structure defines the target area (cf. page 7, line 21; page 9, lines 22 to 24) on which, i.e. on its surface, powder is deposited (cf. page 6, lines 5, 6). The high energy laser beam is then scanned over the target surface (cf. page 6, lines 6 to 8) or, put the other way, the aim of the laser beam is controlled in the target area (cf. page 11, lines 15 to 17; page 8, lines 14 to 17). Therefore, when seen in the context of the claims and the patent specification as a whole, it is apparent that no fundamental difference exists between the meaning of the wording "target surface" and "target area" and that the wording of the amended claims is intelligible to the expert. Accordingly, the amended set of claims submitted at the oral proceedings meets the requirements of Article 84 EPC.

4. *The prior art*

Given that in claims 1, 9 and 18 the step of directing a flow of controlled temperature air to the target area is only disclosed in the second priority document US 105316, the European application 88900160.8 as filed is entitled to claim the priority of the US priority document of 5 October 1987. Therefore, this is the decisive date for determining whether or not a public

disclosure is to be regarded as prior art. Thus, in this decision "prior art" refers to documents made available to the public before the priority date of 5 October 1987.

Consequently, document D1 claiming priority of 4 March 1987 and published on 2 November 1988 represents a state of the art under Article 54(3) EPC.

Document D8 has been published in December 1988 i.e. after the priority date of the disputed patent and is, therefore, of no legal relevance with respect to the patent in suit.

5. *Novelty*

Document D1 discloses a computer controlled method of casting a shape in which a laser beam or electron gun fuses powder from a fluidised bed. The powder is repeatedly thrown and collected onto a (target) surface, where it is solidified to form a cross section of the shape being produced (cf. column 2, lines 4 to 11). In general, the fluidised gas supply is permanently maintained even when the laser is operative to fuse a layer of the article to be produced. In the case, however, that a higher layer of the part is to overhang lower layers of the part, the fluidizing gas supply is stopped in order to provide a powder level high enough to support the overhang (cf. column 5, lines 30 to 41). In a further preferred embodiment, preheating of either the powder or the fluidizing gas, or alternatively, heating the powder in the fluidized bed is recommended to provide heat treatment and stress relief of the part (column 8, lines 30 to 45).

It is unambiguously clear from document D1 that powder fluidization is an essential feature of the process and that there is always fluidization between the sintering steps. Given that the gas is passed through the diffuser plate 3 in an upwardly directed motion through the particle bed, upheaval of the bed occurs and, as a consequence, the unsintered layer of particles is destroyed. By contrast, according to the method defined in claim 1 of the patent at issue, "the second layer of sinterable powder is deposited on the first layer", said first layer comprising sintered and undisturbed unsintered powder. There is nothing in D1 to propose that a fresh powder layer should be deposited on the sintered **and** unsintered parts of the previous layer, as does the claimed method. It may be possible that, in case of producing parts having inner or outer overhanging layers, unsintered powder remains in the inner or outer voids. However, document D1 does not disclose specific examples for producing parts comprising inner or outer overhanging layers, and there is nothing in D1 to conclude that any part of the previously deposited unsintered powder should remain unfluidized when new powder is thrown onto the surface, as alleged by the opponent. To the contrary, both Figures 1 and 2 of D1 show complete fluidization of the powder all over the target area including the central zone of the annular body 16. Moreover, in the process according to D1, the heated fluidizing gas flows **over** the surface of the sintered layer. Thus, the gas flow in document D1 is not directed **to** the target area, as is required by the method of the disputed patent. In view of these considerations, the method defined by claim 1 of the patent at issue is clearly distinguished from that described in document D1. Given that none of the remaining documents discloses all the technical features defining the claimed process, the subject matter of claim 1 is novel with respect to D1 to D11.

This is also true for independent claims 9 and 18 which comprise a means for directing controlled temperature air **to** the target area.

6. *Inventive Step*

Turning now to the issue of inventive step, the subject matter of independent claims 1, 9 and 18 was held by the opponent to be obvious from the technical teaching of document D9 alone.

6.1 The closest prior art

There is common agreement that document D9 represents the closest prior art. Like the patent in suit, document D9 is concerned with a selective powder sintering (SPS) process, in which a first layer of powder is deposited on the target area. A raster pattern is produced by laser irradiation to become a first sintered layer. In the region which is not irradiated, the powder remains loose. Once the beam has completed with one scanning action, another layer of fresh powder is deposited onto and is sintered into the previous layer. This process is repeated until the desired object is completed (cf. D9, page 639, Experimental Procedure). Two sintered objects surrounded by unaffected powder are shown in Figure 7 on page 639 and the experimental apparatus is depicted on page 638 of D9. Although this document in general addresses various problems associated with high energy input by the laser, such as three-dimensional distortion (warpage) caused by shrinkage, vertically directed shrinkage and layer curl-up at the edges (cf. page 639, right hand column, item 4; page 640, left hand column, items 5 and 6), the problem of undesirable

shrinkage due to temperature differences between the temperature of the particles not yet scanned and the temperature of the previously scanned layer is not specifically mentioned.

6.2 Problem and solution

Starting from D9, the problem underlying the patent at issue, therefore, resides in providing a method which helps to prevent or mitigate the thermal shrinkage phenomen resulting from temperature differences between the powder particles not yet scanned and the previously scanned layer.

The solution to this problem consists in a flow of controlled temperature air which is directed to the target surface to transfer heat between said air flow and each top layer of powder to be sintered in order to control the temperature of the sintered and the unsintered powder at the target surface, thereby moderating the temperature differences between the unscanned powder and the previously scanned layer.

Although document D9 already advocates to ensure that the previously scanned layers are cool enough to act as a heat sink and thereby to help maintain dimensional control, it does not suggest to moderate the difference between the temperature of the particles not yet scanned and temperature of the previously scanned layer by a flow of controlled temperature air as does the disputed patent.

The measures suggested by D9 to reduce warpage and shrinkage comprise adjusting the layer thickness so that each layer will just grow into the previous layer and reducing three-dimensional shrinkage which causes the part to warp by selecting particles exhibiting a small size and a high aspect ratio (see D9, page 640, left hand column, items 5 and 6).

The statement on page 640, item 2 of the Research issues of document D9 according to which the transfer of heat out of the system is regarded to be the limiting factor which could be influenced by directing a flow of controlled temperature air to the part cannot render the claimed solution obvious either. No indication whatsoever can be found in document D9 suggesting to moderate the temperature differences between the powder not yet scanned by the energy beam and the previously layer by directing a flow of controlled temperature air to the target area. Given that the remaining documents D1 to D7 and D10, D11 which are more remote neither address the specific problem underlying the disputed patent nor suggest a solution leading to that claimed, the subject matter of claim 1 also involves an inventive step.

The same applies in analogy to the subject matter of claims 9 and 18.

7. In view of all these considerations, the claims as a whole meet the requirements of Articles 123(2), (3), 84, 54 and 56 EPC.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the first instance with the order to maintain the patent on the following basis:

claims: 1, 9 and 18 as submitted at the oral proceedings of 3 December 1998;
2 to 8, 10 to 17 as granted;

description: column 1 and 2 as submitted on 28 August 1998;
column 3 to 16 of the European patent specification No. 0 287 657;

Figures: 1 to 11 as granted.

The Registrar: The Chairman:

S. Fabiani W. D. Weiß

K. 2.11.99