DECISION
of 17 September 1997

Case Number: T 0091/97 - 3.4.2
Application Number: 90907995.6
Publication Number: 0469083
IPC: G01N 21/71

Language of the proceedings: EN

Title of invention:
Transient spectroscopic method and apparatus for in-process analysis of molten metal

Patentee:
Lehigh University

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (after amendments) yes"

Decisions cited:
-

Catchword:
-
Case Number: T 0091/97 - 3.4.2

DECISION
of the Technical Board of Appeal 3.4.2
of 17 September 1997

Appellant: LEHIGH UNIVERSITY
526 Brodhead Avenue
Bethlehem, PA 18015 (US)

Representative: Bardehle, Heinz, Dipl.-Ing.
Patent- und Rechtsanwälte
Frohwitter . Geissler & Partner
Galileiplatz 1
81679 München (DE)

Decision under appeal: Decision of the Examining Division of the European Patent Office posted 21 August 1996 refusing European patent application No. 90 907 995.6 pursuant to Article 97(1) EPC.

Composition of the Board:
Chairman: E. Turrini
Members: M. Chomentowski
          B. J. Schachenmann
Summary of Facts and Submissions

I. European patent application No. 90 907 995.6 (publication No. 0 469 083) was refused on the grounds of lack of inventive step, having regard to D2 = GB-A-2154315 and A1 = "Direct molten metal analysis by transient spectroscopy of laser produced plasmas", Intelligent Processing of Materials and Advanced Sensors, Symposium Proceedings ASM, Florida 1986, published by the Metallurgical Society, of the only independent claims 1 and 21 of the submitted set of 50 claims concerning a technique of spectroscopic analysis of the contents of molten metals which comprised immersing an end of a probe into said molten metal and irradiating it with a laser beam.

The Examining Division took the following view:

D2 concerned a similar technique for analysing the contents of molten metals, but wherein no rangefinder means for determining a distance were disposed in the probe to be immersed in the molten metal and wherein the spectrometer for detecting the signals from the plasma produced by the laser was not located inside of the probe. However, it was known from A1, in the same technical field, to make the measurement at a predetermined distance, i.e. the focal distance of the lens of the laser means. Moreover, the known technique of D2 could be complemented in an obvious way by bringing together in the probe other means of the apparatus such as the spectrometer, as also suggested in A1. Therefore, the subject-matter of the submitted
independent claims lacked an inventive step.

II. The appellant (applicant) lodged an appeal against this decision.

III. The appellant requested that the decision under appeal be set aside and a patent be granted on the basis of the new independent claims 1 and 21 annexed to the statement of grounds of appeal of 30 December 1996 and of dependent claims and description to be adapted by the Examining Division. The independent claims 1 and 21 read as follows:

"1. A method for spectroscopic analysis of a molten metal, comprising:

providing a probe including a casing having an open end adapted to be immersed in the molten metal, laser means disposed in said casing for irradiating the surface of the molten metal adjacent the open end with a laser beam, spectroscopic detector means for detecting spectral components of light emitted from a plasma produced by the laser means;

immersing the open end of the casing into a molten metal bath with pressurized inert gas;

irradiating the molten metal with a laser beam from said laser means to produce a plasma of the molten metal;

detecting spectral components of radiation emitted by the plasma by means of the spectroscopic detector means
and producing signals corresponding to the detected spectral components; and

withdrawing said open end of said casing from the molten metal after irradiating the molten metal and detecting the spectral components;

**characterized in that** the pressurized inert gas is introduced into the open end of the casing to prevent entry of molten metal and surface impurities into the open end as the open end enters the molten metal bath, the molten metal is then drawn into the open end of the casing during further immersion into the molten metal, a rangefinder disposed in the casing detects without contacting the molten metal the distance between the molten metal and the laser means during immersion of the casing, the molten metal drawn into the open end is irradiated with a laser pulse of predetermined energy density and focal spot size when the molten metal reaches a predetermined distance from the laser means as detected by the rangefinder to produce a plasma representative of the composition of the molten metal, and the detecting of spectral components is performed by spectroscopic detector means disposed in the casing."

"21. An apparatus for spectroscopic analysis of a molten metal for performing the method according to claim 1, comprising:

a probe including a casing having an open end adapted to be immersed in the molten metal;
means for immersing and withdrawing said open end of said casing into the molten metal with pressurized inert gas;

laser means disposed in said casing for irradiating the surface of the molten metal adjacent to the open end of the casing with a laser beam during immersion of said open end of said casing so as to produce a plasma of the molten metal;

spectroscopic detecting means optically coupled to the plasma for detecting spectral components of radiation emitted by the plasma and producing signals corresponding to the detected spectral components;

characterized in that means for controlling the pressure of the inert gas in the open end of the casing acts to prevent entry of molten metal and surface impurities into the open end and further acts to draw the metal into the casing, a rangefinder means and the spectroscopic detecting means being disposed in said casing, and the rangefinder means being spaced from contact with the molten metal for detecting the distance between the laser means and the molten metal during immersion of said open end of said casing into the molten metal and for directing the laser means to irradiate the molten metal to produce a plasma representative of the composition of the molten metal when a predetermined distance between said laser means and the molten metal has been detected."

IV. The appellant also requested oral proceedings auxiliarily and submitted the following arguments in
support of its main request:

Present claims 1 and 21 comprise the additional features that the open end of the casing of the probe is immersed into a molten metal bath with pressurized inert gas introduced into the open end of the casing to prevent entry of molten metal and surface impurities into the open end as the open end enters the molten metal bath, the molten metal being then drawn into the open end of the casing during further immersion into the molten metal, which features are disclosed in particular in page 9, lines 29 to 34 and in dependent claims 10 and 12 of the original application.

The present technique uses pressurized inert gas and a rangefinder to control the spatial relation between the laser means and the surface of the molten metal and also the timing for firing said laser means. Thus, more reliable measurement results are obtained. Said features are not mentioned in D2 or A1. More reliability is also obtained by bringing together in the probe the spectrometer and the laser, thereby avoiding the problems caused by transferring spectral signals by light guides as in D2; this measure, mentioned in vague, general terms in A1, would not be seriously considered by a person skilled in the art since in that document the computer means, generally known as being sensitive to heat, are also mentioned in the same terms for bringing together. Since neither D2 nor A1 teaches the feature of drawing the molten metal into the open end of the probe by using pressurized inert gas under the control of a rangefinder in the probe, the subject-matter of the present independent
claims involves an inventive step.

Reasons for the Decision

1. The appeal is admissible.

2. Allowability of the amendments

The present independent claims 1 and 21 are based on the only independent claims 1 and 21 of the set of 50 claims as originally filed. Present claim 1 comprises, as compared to original claim 1, the additional feature that, in the method for spectroscopic analysis of a molten metal, pressurized inert gas is introduced into the open end of the casing to prevent entry of molten metal and surface impurities into the open end as the open end enters the molten metal bath, that the molten metal is then drawn into the open end of the casing during further immersion into the molten metal, and that a rangefinder disposed in the casing detects without contacting the molten metal the distance between the molten metal and the laser means during immersion of the casing at which the molten metal drawn into the open end is irradiated with a laser pulse. As indicated in the statement of grounds of appeal, these additional features are disclosed in particular on page 9, lines 29 to 34 and in dependent claims 10 and 12 of the original application. The corresponding amendments resulting in present independent claim 21, in particular the means for controlling the pressure of the inert gas in the open end of the casing acts to
prevent entry of molten metal and surface impurities into the open end which further acts to draw the metal into the casing, are derivable from the same original text locations. Therefore, present claims 1 and 21 satisfy the requirement of Article 123(2) EPC that a European patent application may not be amended in such a way that it contains subject-matter which extends beyond the content of the application as filed.

3. **Clarity of the claims**

Since according to the wording of present claim 1 the pressurized inert gas prevents entry of in particular the molten metal in the open end of the casing as the open end enters the molten metal and since then molten metal is drawn into said open end of the casing, it is directly and unambiguously derivable from the claim that it is by controlling the pressure of said pressurized inert gas, in particular for adjusting the distance from the surface of the molten metal to the laser means, said distance corresponding to said pressure, that the molten metal is drawn into the casing for measurement of the constituents of said molten metal. Said information is given again, in a more precise way, in dependent apparatus claim 21 and in the description. Therefore, claim 1 and claim 21 are clear in the sense of Article 84 EPC.

4. **Novelty**

A method comprising all the features of present claim 1 does not form part of the state of the art. The same conclusion applies to the apparatus of present...
claim 21, which is for performing the method of claim 1 and which comprises corresponding apparatus features. Therefore, the subject-matter of present claims 1 and 21 is new in the sense of Article 54 EPC.

5. **Inventive step**

5.1 A method for spectroscopic analysis of a molten metal (1) is known from D2 (see the whole document and, in particular, the embodiment illustrated by Figure 2); the known method comprises:

- providing a probe (4, 5) including a casing (4, 5) having an open end adapted to be immersed in the molten metal (1), laser means (13) disposed in said casing (4, 5) for irradiating the surface of the molten metal (1) adjacent the open end with a laser beam, spectroscopic detector means for detecting spectral components of light emitted from a plasma produced by the laser means (13);

- immersing the open end of the casing (4, 5) into a molten metal bath (1) with pressurized inert gas;

- irradiating the molten metal with a laser beam from said laser means (13) to produce a plasma of the molten metal (1);

- detecting spectral components of radiation emitted by the plasma by means of the spectroscopic detector means and producing signals corresponding to the detected spectral components; and
withdrawing said open end of said casing (4, 5) from the molten metal (1) after irradiating the molten metal and detecting the spectral components.

5.2 In the method known from D2 (see in particular page 2, lines 2 to 12 and 33 to 36), a flow of inert gas is introduced into the probe through an opening (6) located at the top of the probe (4, 5) and exits through a lateral, "restricted port (7)" near the bottom of the probe and, as derivable from Figures 1 and 2, through the open end, i.e. the tubular opening (no reference numeral) at the bottom of the probe; according to the mentioned text location, this is for preventing entry of metal. The appellant has convincingly stressed that the presently claimed method does not comprise any such feature of the known method such as the lateral "restricted port (7)". Indeed, since the flow of inert gas exits through the lateral "restricted port (7)", it is not derivable from D2 that the shown technique is such that the pressurized inert gas is capable of preventing entry of the slag and surface impurities as the open end enters the molten metal bath in the sense of the present application (see page 9, lines 29 to 34), whereby the bottom end of the probe is rendered to have a solid-like property during the penetration through the slag. Moreover, for the same reason, i.e. that pressurized gas exits through the lateral "restricted port (7)" of the probe, the known technique is not such that the bottom end of the probe, once in the molten metal pool, becomes a hollow tube into which the metal is drawn to a predetermined level suitable for laser excitation, as required by the same text location of the present application. In any...
case, the only indication in D2 is about the flow of inert gas exiting the lateral "restricted port (7)"; and there is no indication whatsoever about drawing the molten metal in the probe.

Moreover, contrary to the method of present claim 1, the method of D2 is not derivable as comprising the feature that, during further immersion into the molten metal, a rangefinder disposed in the casing detects without contacting the molten metal the distance between the molten metal and the laser means during immersion of the casing, the molten metal drawn into the open end is irradiated with a laser pulse of predetermined energy density and focal spot size when the molten metal reaches a predetermined distance from the laser means as detected by the rangefinder to produce a plasma representative of the composition of the molten metal.

It is also to be noted that, in the method of D2, detecting of spectral components is not performed by spectroscopic detector means disposed in the casing, as in present claim 1, but by spectroscopic detector means located outside of the probe (4, 5), the spectral components being transmitted thereto by a light guide (16) exiting from the probe.

5.3 It has not been disputed that D2 constitutes the nearest prior art. Starting from the method of D2, a first problem to be solved, credibly stressed in the present application (see the paragraph bridging pages 3 and 4) and in the statement of grounds of appeal is that of possible poor transmission of optical signals...
by light guides. The question, whether taking into account the teaching of A1 (see in particular the abstract), this problem can be solved in an obvious way by "bringing together" i.a. the laser source and spectroscopic instrumentation in a survivable probe package, can be left aside for reasons given here under in paragraph 5.4.

It is derivable from Figures 1 and 2 of D2 (see also page 2, lines 2 to 6) that the laser means are activated just before the surface of the molten metal reaches the lower part of the restricted, lateral port (7) of the casing of the probe, i.e. before said lateral port is closed by molten metal in the casing. Although a predetermined distance to the laser means for irradiating the molten metal surface with said laser means is thus established and although ranging and firing of the laser at the moment when the molten metal surface is presented at the focal distance from the laser beam focusing lens is mentioned as a general information in A1 (see page 108, penultimate paragraph), the question, whether the person skilled in the art of D2 would have been incited to use unspecified ranging means mentioned in A1 in place of the lateral restricted port (7) of D2, can also be left aside for the reasons given here under in paragraph 5.4.

5.4 In any case, there is no indication in A1 about any means using pressurized inert gas initially to prevent the entry of the slag in the probe and then for drawing the molten metal in a controllable way into said probe. This measure in combination with at least one of the
two other features mentioned above, i.e. the rangefinder means, allows a strict control of the spatial relationship between the laser and the surface of the molten metal and of the timing for firing the laser means, and thus credibly results in more reliable measurements. Therefore, since for the person skilled in the art of D2 the necessity for this feature is derivable neither from D2 nor from A1, the subject-matter of present claim 1 is not obvious having regard to the state of the art, so that the subject-matter of present claim 1 involves an inventive step in the sense of Article 56 EPC.

5.5 Present claim 21 expresses in apparatus terms the technique of present claim 1 and thus uses apparatus means which are not derivable or obvious from the teaching of D2 and A1. Therefore, it also involves an inventive step within the meaning of Article 56 EPC.

6. Since a patent can be granted on the basis of present claims 1 and 21 and of dependent claims and a description to be adapted by the Examining Division, i.e. in accordance with appellant's request, its auxiliary request for oral proceedings needs not be followed.
Order

_for these reasons it is decided that:_

1. The decision under appeal is set aside.

2. The case is remitted to the Examining Division with the order to grant a patent on the basis of claims 1 and 21 filed by the appellant with the statement of grounds of appeal and with dependent claims and description to be adapted and with the original drawings.

The Registrar: The Chairman:

P. Martorana   E. Turrini