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D E C I S I O N
of 14 September 1994

Case Number: T 0131/93 - 3.2.2

Application Number: 85904175.8

Publication Number: 0190313

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Language of the proceedings: EN

Title of invention:
Method and apparatus for continuous steelmaking

Patentee:
INTERSTEEL TECHNOLOGY, INC.

Opponent:
VOEST-ALPINE Industrieanlagenbau Ges.m.b.H.

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (yes) - after amendments"

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-

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Case Number: T 0131/93 - 3.2.2

D E C I S I O N
of the Technical Board of Appeal 3.2.2
of 14 September 1994

Appellant: (Proprietor of the patent)
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Decision under appeal: **Decision of the Opposition Division of the European Patent Office dated 10 November 1992, issued in writing on 22 December 1992, revoking European patent No. 0 190 313 pursuant to Article 102(1) EPC.**

Composition of the Board:

Chairman: M. Aúz Castro
Members: R. Lunzer
P. Dropmann

Summary of Facts and Submissions

I. European patent No. 190 313 was granted on 16 May 1990 on the basis of application No. 85 904 175.8 filed on 30 July 1985, claiming priorities of 2 August 1984, and 5 April 1985 based on US Applications Nos. 636 944 and 720 225.

Claims 1 and 23 of the patent as granted were in the form shown below, the words added to these Claims by amendment during the oral proceedings on appeal being shown in bold type.

"1. A method for the continuous refining of steel, comprising:

segregating iron bearing scrap according to its composition;

preheating said scrap;

feeing said iron-bearing scrap, direct reduced iron, or a mixture thereof to an electric **arc** steelmaking furnace for melting and refining therein;

feeding slag formers to the steelmaking furnace **into the bath**;

introducing carburizers into the steelmaking furnace **through the bath**;

heating the charge electrically **through said electrodes** to melt the charge and form a molten metal bath within the furnace with a molten slag layer on said molten metal bath;

maintaining said slag in a foaming condition during the steelmaking process;

continuously feeding metallics, slag formers, and carburizers to said furnace;

maintaining full electric power to said furnace at all times during the charging, melting, refining and **tapping** operations; and

intermittently tapping said furnace while continuously feeding said furnace,

while keeping a heel (76) of molten metal within said bath, said heel having approximately the same volume as that of the molten metal removed at each tapping.

23. Apparatus for the continuous refining of steel comprising:

an electric arc steelmaking furnace **(10)** for melting and refining a metallic charge therein;

electrodes **(12)** extending into said furnace **(10)** a distance beneath the slag level of a molten metal bath to be contained therein;

feed means **(16)** connected to said furnace for introducing charge materials **into** the interior of said furnace **without removing said electrodes**;

heating means **(20)**cooperatively associated with said feed means for preheating charge materials within said feed means **(16)**;

a gas curtain **(48)** for providing a controlled atmosphere within said feed means **(16)**;

gas injection means **(78)** communicating with said furnace **(10)** beneath the normal molten metal bath level **(72)**;

means for tilting said furnace up to 15° from the vertical without removing said electrodes **(12)**, for the purposes of slagging and tapping, and

means for tapping (80) which are arranged such, that tilting said furnace up to 15° from the vertical will keep a heel (76) of molten metal within said bath, said heel having approximately the same volume as that of the molten metal removed at each tapping."

II. On 13 February 1991 an opposition was filed by the Respondent on the ground of Article 100(a), alleging lack of novelty (Article 54 EPC), and lack of any inventive step (Article 56 EPC). The Opponent relied in particular on the following document:

(4) Stahl und Eisen 95 (1975) No.1 pp. 16-23 of 8 January 1975.

III. By its decision given orally on 10 November 1992 and issued in writing on 22 December 1992, the Opposition Division revoked the patent. It regarded document (4) as the closest prior art, which it found disclosed a tilting angle of at least up to 15°. Gas injection means which communicated with the furnace had to be present in the apparatus of Figure 1 of document (4) in order to be able to carry out the oxygen blowing step mentioned in Figure 3. Either it was implicit that there was blowing beneath the metal bath, in which case the claim lacked novelty, or if it was not implicit, there was still no inventive step. The features added by the auxiliary request considered by the Opposition Division, which were essentially the same as those shown above, did not

confer inventiveness. Regarding the process Claim 1, the novel features over document (4) were (i) maintaining full electric power, and (ii) tapping while continuously feeding the furnace. It was held that as running a steel making process continuously was an obvious desideratum, it was obvious not to interrupt the process, while a comparison of the electric power consumed showed that the alleged invention was less economical than the process disclosed in document (4). As for the amended Claim 1 proposed by way of an auxiliary request, the additional features were either disclosed in document (4), or did not solve any problem which in principle was not already solved by that document. Accordingly it was held that the subject-matter of Claim 1, whether in accordance with the main or the auxiliary request, lacked any inventive step.

IV. An appeal against that decision was filed on 3 February 1993, the appeal fee was paid on the same day, and the Statement of Grounds of Appeal was filed on 22 April 1993. In that Statement, and during oral proceedings held on 14 September 1994, the Appellant argued that the alleged invention had significant advantages over the prior art. By finding a way of operating an electric arc furnace continuously it became possible for the first time to obtain electricity more cheaply by virtue of the constant load, and the total energy consumption was much reduced compared with that reported in document (4). The total energy consumption in accordance with document (4) Figure 3 was 645 kWh/t, made up of 325 kWh/t of energy supplied in the form of combustible gas, and 320 kWh/t in the form of electrical power, as contrasted with the Appellant guaranteeing in newly signed contracts a power consumption of 340 kWh/t together with an oxygen consumption of 25 Nm^3/t. There was great interest in the process on the part of the industry, as shown by the fact that there were already actual and prospective

licensees. Four plants were already in operation in the USA and Japan. Document (4) clearly related to an essentially batch process, as was to be seen from Figure 3. It was also clear that the period of oxygen blowing was only some 13 minutes out of a total time from charge to charge of 2 hours ten minutes. Only during that brief interval could it be said that there was a slag in a foaming condition. The oxygen used in accordance with document (4) could be fed in accordance with conventional practice from above the bath, while the disclosure of a tilting furnace did not amount to the disclosure of the limited tilting to a maximum of 15°. Furthermore, the gas curtain, which was an essential feature of Claim 23, was not disclosed in document (4).

V. With its counterstatement, filed on 22 July 1994, the Respondent sought to introduce into the appeal the following documents:

(9) WORCRA (Continuous) Steelmaking by Worner et al, Journal of Metals, June 1969, pages 50-56, and

(10) GB-A-2 133 125.

It argued in its written submissions and during the oral proceedings, that all the features of the alleged invention were to be found in document (9), apart from the feature of tilting the furnace to the extent of 15° or less, which was clearly disclosed in document (10). The addition of the feature that pouring was incomplete did not add any inventive subject-matter to Claim 23. It was clear from document (9) Figure 1 illustrations C and D that the tilting electric arc furnace of illustration C could be used in place of the fixed furnace shown in illustration D. Figure 5 of document (9) indicated by means of arrows that slag flowed from right to left, and

would therefore cover the whole of the bath. Even if it were accepted that the alleged invention was not obvious in the light of documents (4) or (9) taken singly, it would have been obvious to the skilled reader taking into account the combined teachings of documents (4) and (9).

The retention of a heel of metal in the furnace could not be ascribed alone to the use of a tilting angle limited to 15°, because in fact the size of the retained pool of metal depended both on the angle of tilt, and the time for which the furnace was tilted. Figure 1 of document (4) in fact showed an electric arc furnace which was tilted to an extent of no more than 15°.

VI. The Appellant (patentee) requested that the decision under appeal be set aside and that the patent be maintained on the basis of Claims 1 and 23 filed during the oral proceedings, Claims 2 to 22 and 24 to 36 as granted and the description and drawings as granted.

The Respondent (opponent) requested that the appeal be dismissed.

Reasons for the Decision

1. *Admissibility of the appeal*

The appeal is admissible.

2. *Procedural matters*

Having regard to their relevance, documents (9) and (10) were admitted into the appeal.

3. *Admissibility of amendments*

3.1 The proposed amendments involve limitations to Claims 1 and 23 which involve the introduction of features which were all disclosed in the application as filed.

3.2 In particular:

- the limitation of Claim 1 to an "arc" furnace is supported inter alia by column 4 line 15 of the patent as granted, corresponding to page 5 line 24 of the application as filed;

- the introduction of carburisers "through the bath" is disclosed by column 7 lines 12 to 15 of the patent as granted, corresponding to page 9 lines 35 to 38 of the application as filed;

- heating "through said electrodes" is disclosed by column 4 line 16 of the patent as granted, corresponding to page 5 line 25 of the application as filed;

- pouring "intermittently" is disclosed by column 5 line 27 and column 7 lines 5 to 6, of the patent as granted, corresponding to page 7 line 14 and page 9 lines 29 and 30 of the application as filed;

- retaining a molten metal heel, which amendment has been introduced into both Claims 1 and 23, is disclosed by column 5 lines 21 to 30, and column 6 line 31 to 33 of the patent as granted, corresponding to page 7 lines 9 to 16, and page 8 lines 34 to 37 of the application as filed, the effect of the degree of tilting, and also the time for which the furnace is tilted, both being

implicit in the original disclosure of a heel of metal being retained;

- feed means capable of feeding "without removing" the electrodes is implicit in the application as filed from the fact that the furnace operates at full power during charging, melting and refining as stated in Claim 1 of the patent as granted, and also in Claim 1 of the application as filed.

3.3 As these amendments do not add subject-matter to the application as originally filed, nor extend the scope of protection, the requirements of Articles 123(2) and 123(3) EPC are satisfied.

4. *Novelty*

Having reviewed the cited documents, the Board is satisfied that none of them discloses a method or apparatus having all the features defined in Claims 1 and 23 as amended. Therefore the subject-matter of these claims is novel within the meaning of Article 54 EPC. As novelty was not seriously contested at the appeal stage, more detailed reasons are unnecessary.

5. *The alleged invention*

5.1 The patent in suit relates to the problem of adapting the well known electric arc steel refining process to continuous operation. Electric arc furnaces have been used in steel making to an ever increasing extent throughout the present century. Such processes are almost exclusively batch processes, and in the present appeal the Respondent was only able to cite a single prior proposal for the continuous refining of steel in an electric arc furnace, which is that contained in document (9) considered in detail below.

5.2 Claim 1 defines a process which includes a number of steps which are commonplace in the industry, such as segregating iron bearing scrap, preheating the scrap, and feeding the essential steel making constituents to the furnace. The significant features of the claimed process which distinguish it from the prior art are that the feeding of the metallics, slag formers, and carburisers is continuous, that the slag is maintained in a foaming condition during the whole of the steelmaking process, that full electric power is maintained, and that intermittent tapping is limited to about half the bath, so that a heel of molten metal remains which promotes the rapid fusion of added scrap.

5.3 In accordance with the unchallenged evidence of the Appellant, the alleged invention is already in use in a number of countries. Production of steel by the claimed method was at a level of 2.6m tons per annum in August 1994, with a further 1m tons of refining capacity under construction, and another 2m tons under negotiation with potential licensees. The advantages of the alleged invention include greater economy in terms of the use of energy per ton of steel produced; being able to obtain electrical energy from the producer more cheaply than is usual in electric arc refining by reason of the non-fluctuating character of the load; greater thermal efficiency of the process due to the heat energy of the arc being conveyed directly to the slag and the bath, rather than a substantial proportion of that energy being lost to the furnace walls through radiation as in a normally operated electric arc furnace; greater productivity for a given size of furnace due to the fact that, unlike in normal operation of an arc furnace, the power is not turned off during the pouring and charging part of the working cycle; the ability to produce steels having lower nitrogen contents than are attainable with normally operated electric arc furnaces, because the arc

is submerged in the foaming slag, and not in contact with atmospheric nitrogen; and finally, environmental advantage because charging the furnace does not entail opening it, with a consequent escape of furnace gases into the surrounding atmosphere.

6. *The closest prior art, document (9)*

6.1 Document (9) is regarded as the closest prior art. Published in 1969, it is an article relating to proposals for possible ways of achieving continuous steelmaking, taking pig iron directly from a blast furnace, or using reduced iron sponge or scrap. The article uses a considerable number of acronyms, and in Figure 1 on page 51 it illustrates five possible processes, labelled A to E, of which the most pertinent is illustration D, subtitled the "Electric W.S.M. Process", the letters standing for Worcra Steel Making. That process is designated the EWSM process at page 52 right hand column. The other process, shown in illustration E, is entitled "Worcra-CIMAS Fuel Fired Process" the letters in this case standing for Continuous Iron Making and Steel Making.

6.2 Greater detail regarding these two processes is to be found at page 53, Figures 5 and 6 respectively relating to the electric arc and the fuel fired variants of the processes.

6.3 Where at pages 53 to 54 pilot plant studies on a furnace with a throughput of 3.5 tph are discussed, it is not altogether clear which of those two processes was used. Taking into account the data given in Table 1 on page 55, where the feeds in the two runs there reported were respectively pig irons containing 4.1 and 3.5% carbon, together with normal impurities, the rate of addition of cold scrap as coolant at the rates of 11 and

14%, the substantial amounts of oxygen used in the refining, and the absence of any mention of electricity consumed, it seems likely that the pilot plant was not run in accordance with the EWSM proposal, but instead it used the CIMAS process. However, for the purposes of the present decision, that point does not need to be decided.

6.4 The essential idea common to the two processes identified as EWSM and CIMAS is that a novel kind of furnace is to be used which is divided into three zones. There is a more or less circular central turbulent melting-smelting zone, an elongated refining or converting zone (also turbulent) in which the slag flows generally countercurrent to the metal, and a more quiescent slag conditioning and settling zone (page 51 centre column).

6.5 More detail of the electric arc furnace proposed for the EWSM process is given at pages 52 and 53 in association with Figure 5. The charging of hot metallised feed, and furnace tapping, are both truly continuous, the outflow of steel from the refining zone of the furnace being the result of simple displacement in the bath effected by the hot solids entering the melting-smelting zone (page 52 right hand column). Figure 5 illustrates a furnace shaped like a conventional arc furnace, save that there are elongated refining and slag clean-up zones extending from opposite sides of the furnace, each of a length substantially the same as the diameter of the furnace. Lances injecting oxygen and lime are illustrated in the refining zone, where the consequent turbulence and foaming is illustrated, while in the slag clean-up section, the floor of the bath is shallow, and slopes back towards the centre, so that any metal entrained in the slag can return to the bath. That zone of the bath is described as "quiescent" (page 51 centre

column) and its surface is illustrated as flat. On the left of the central refining zone there is shown a supply of metal, as well as oil, gas or coal, while in a feed coming from the right there is shown a supply of scrap, heated by the gases coming from the furnace.

6.6 The plan view in Figure 5 shows arrows indicating that in the refining zone there is a counterflow of metal and slag, whereas in the slag clean-up zone there is a unidirectional flow of slag.

6.7 Other possible furnace shapes are shown in Figure 4, including a "U" shaped furnace, and an "L" shaped furnace, which latter was the one used in the process of the pilot plant illustrated in Figure 6. In all of these furnaces, the essential features are the three distinct zones as described above, fully continuous feed with tapping as a consequence of displacement; i.e. there is no tilting of the furnace, which in any event would destroy the equilibrium of counter- flow which is essential to these proposals.

7. *Comparison of Claim 1 with document (9)*

7.1 From the above it is clear that many of the features of Claim 1 are to be found in document (9), more particularly in relation to the EWSM process shown in Figure 1 illustration D and Figure 5. An electric arc furnace is run continuously at full power, the materials essential to steel making are continuously fed to the bath, there is a slag layer covering the whole of the bath, part of which is foaming. The differences are that the carburisers in accordance with the alleged invention are introduced through the bath, a foaming slag is maintained over the bath, which the Board interprets in this context as meaning over the whole of, as contrasted

with only a part of, the bath, and the bath is tapped intermittently.

7.2 So far as concerns the presence of a foaming slag in document (9), although it is to be expected that in the EWSM process the direct injection of oxygen into the refining zone will result in a foaming slag covering that part of the bath, and some foam might be expected to cover a part, but the whole of the central zone, it would not extend into the slag clean-up zone which is intended to be quiescent. So far as tapping is concerned, it is essential to the EWSM process that the furnace should remain level at all times, so as to maintain the counterflow of slag and metal, and to secure the advantage of continuous tapping though displacement. Keeping the furnace level would be compatible with intermittent tapping, such as if a tap-hole were to be provided below the bath level, but such a modification would result in the loss of the benefit of continuous flow of steel through displacement, as well as non-uniform conditions of refining due to fluctuating bath levels.

8. *Inventiveness of Claim 1 over document (9)*

8.1 The question of the inventiveness of the subject-matter of Claim 1 over the disclosure of the EWSM process of document (9) turns on whether a skilled worker, starting with that disclosure, and seeking a commercially useful and effective continuous steel refining process based on an electric arc furnace, would have thought of making the modifications to the process of document (9) which distinguish it from the alleged invention, i.e. having a foaming slag over the whole of the bath, and making tapping intermittent, instead of continuous. The Board answers those questions in the negative.

8.2 The supposed benefits of the zonal EWSM furnace stem from the fact that different operations are carried out in different zones, and that a foaming slag covers a part of, but not the whole of the bath. A foaming slag in the slag clean-up zone would destroy its intended effect. Likewise, rejecting continuous tapping of document (9) in favour of intermittent tapping would not suggest itself, because it would amount to a rejection of one of the salient advantages of the EWSM system.

9. *Inventiveness of Claim 23 over document (9)*

9.1 Whether the subject-matter of Claim 23 is inventive over the EWSM apparatus turns on whether a skilled worker, starting with that disclosure, and seeking a commercially useful and effective apparatus for steel refining based on an electric arc furnace, would have thought of adapting the apparatus disclosed in Figure 5 by making it capable of tilting. Again the Board answers that question in the negative. Claim 23 as now amended is limited to a tilting furnace so designed that when tilting up to 15° from the vertical, a heel of metal as defined is retained. Such an apparatus is not suggested by document (9), and is in fact contrary to its teachings directed to the usefulness of the unusual three zone furnace, the beneficial effects of which stem from its being kept horizontal at all times, and would be destroyed by tilting.

9.2 Similarly, even if the skilled reader of document (9) were to observe that what appears to be a tilting electric arc furnace is shown in Figure 1 illustration C (identified as the SL/RN Electric Arc Process but not described) it could not suggest substitution of that tilting furnace for the special furnaces of the methods described in greater detail because the advantages of the three zone furnaces would be lost.

9.3 Document (10) was introduced by the Respondent to demonstrate that electric arc furnaces which tilt less than 15° from the vertical were known (page 1 line 54). However, that document does not disclose tilting in such a way as to leave a substantial heel of metal. There is mention of leaving a pool of slag (page 2 lines 2 to 7) and that proposal was made in connection with an unconventional arc furnace, designed for bottom pouring through a plug-hole located substantially at the level of the base of the furnace (cf. Claim 1). An arc furnace so designed as to pour a half of the molten metal through tilting is regarded as non-obvious in the light of all the prior art available to the Board.

10. *Document (4)*

10.1 Document (4) is an article published in 1975 which describes a batch process for making steel using a tilting electric arc furnace, in which scrap is fed to the furnace through a rotary kiln heated by the waste gases escaping from the furnace. The apparatus is illustrated in Figure 1 on page 17, and although the word "continuously" is used in relation to charging (left hand column page 17) it is clear from Figure 3 on page 18 that the term is only used in a relative sense. Out of a process time from charge to charge totalling some two and a half hours, charging occupied the period from 8.35 to 9.36, i.e. one hour.

10.2 Relative to conventional arc furnace practice, in which cold scrap is normally charged in the course of a minute or two, the charging of document (4) is justly described as continuous. However, compared with the alleged invention, in which the furnace runs for up to six or seven days (column 6 line 26), the charging disclosed in document (4) is essentially a batch process. Figure 1 of document (4) illustrates an alternative to the gas

curtain mentioned in Claim 23 of the patent in suit. The scrap being fed to the kiln is heaped in a hopper to such a level that it prevents the flow of gas through the scrap. As was suggested by the Appellant, the waste gases coming from the kiln may also be drawn into the gas outlet by reduced pressure.

10.3 Oxygen blowing is indicated as being used in the final refining lasting for 13 minutes from 10.04 to 10.17, and it is inferred that during that phase, but not during the rest of the 2.5 hours, a foaming slag is present.

11. *Comparision of the invention with document (4)*

11.1 Although many of the features of Claim 1 are disclosed or implicit in the disclosure of document (4), missing features are a truly continuous process, tapping so as to leave a substantial heel of hot metal in the furnace, and a foaming slag present at all times. These features are fundamental to the invention as defined in Claim 1, and are not suggested at all by this disclosure. Consequently the invention as defined by Claim 1 as amended is not rendered obvious by this disclosure.

11.2 As for the apparatus Claim 23, there is scope for argument as to whether it could be inventive to provide a gas curtain in place of the seal disclosed in document (4). Greater significance is attached by the Board to the fact that the apparatus of document (4) has no gas injection means communicating with the furnace beneath the normal molten metal bath level, nor any means for tilting the furnace up to 15° from the vertical having the effect that a heel of metal of the size defined is left in the furnace. In its context in Claim 23, the feature "means for tilting said furnace up to 15° from the vertical" is interpreted as meaning that the furnace cannot normally tilt beyond 15°. In combination with the

feature that some 50% of the metal is kept back as a heel, the combination is thus novel over a disclosure of what is apparently a conventional arc furnace in document (4), tapping of which requires tilting to the extent of up to 30° or 40°.

11.3 So far as concerns the gas injection feature, although no gas injection means is disclosed in document (4), as Figure 1 does not show an oxygen supply fixed to the furnace, and as it is indicated at page 18 at the top of the right hand column that the process used is conventional, apart from the preheating of the charge and the overlapping of the melting and refining phases, the Board draws the inference that a conventional oxygen lance was used. There is no evidence before the Board that the skilled worker would think of associating a bath level gas tuyere with an electric arc furnace. In addition, there is no evidence that it was known to leave a heel of metal having approximately the same volume as that of the molten metal removed. As indicated above in paragraph 9.3 when dealing with document (10), its disclosure is limited to retaining a substantial volume of slag, but not metal, when using an arc furnace with an unusually shaped hearth.

11.4 Accordingly, the Board rejects the attack on both Claims 1 and 23 based on document (4).

12. *The combination of documents (4) and (9)*

12.1 The Respondent sought to base an attack on the combination of documents (4) and (9), contending that it was obvious to combine the tilting furnace of document (4) with the continuous process of document (9). However, this does not advance its argument, because as the Appellant pointed out, a tilting electric arc furnace is actually disclosed in document (9) Figure 1

illustration C, and the Board has already indicated in paragraph 9.2 above why, in its view, the skilled worker would not have thought of replacing the special three zone EWSM furnace of Figures 1 illustration D and Figure 5 with a tilting furnace.

12.2 In the light of all the prior art considered above, the Board is satisfied that the subject-matter of Claims 1 and 23 involve an inventive step as is required by Article 56 EPC.

13. *Conclusion*

Claims 1 and 23 being allowable, the same applies to dependent Claims 2 to 22 and 24 to 36 which are directed to preferred embodiments falling within the scope of the main claims, and whose inventiveness is supported thereby.

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 basis of Claims 1 and 23 filed during the oral proceedings, Claims 2 to 22 and 24 to 36 as granted and the description and drawings as granted.

The Registrar: The Chairman:

S. Fabiani M. Aúz Castro