

REPUBLIC OF SOUTH AFRICA



REPUBLIEK VAN SUID-AFRIKA

PATENTS ACT, 1978

# CERTIFICATE

In accordance with section 44 (1) of the Patents Act, No. 57 of 1978, it is hereby certified that

**MINTEK**

has been granted a patent in respect of an invention described and claimed in complete specification deposited at the Patent Office under the number

**2002/5502**

A copy of the complete specification is annexed, together with the relevant Form P2.

In testimony thereof, the seal of the Patent Office has been affixed at Pretoria with effect

from the **30th** day of **April 2003**

A handwritten signature in cursive script, appearing to read 'J. Goepa', written over a horizontal dotted line.

**Registrar of Patents**

REPUBLIC OF SOUTH AFRICA

PATENTS ACT, 1978

## REGISTRAR OF PATENTS

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54	IRON-NICKEL ALLOY PRODUCTION
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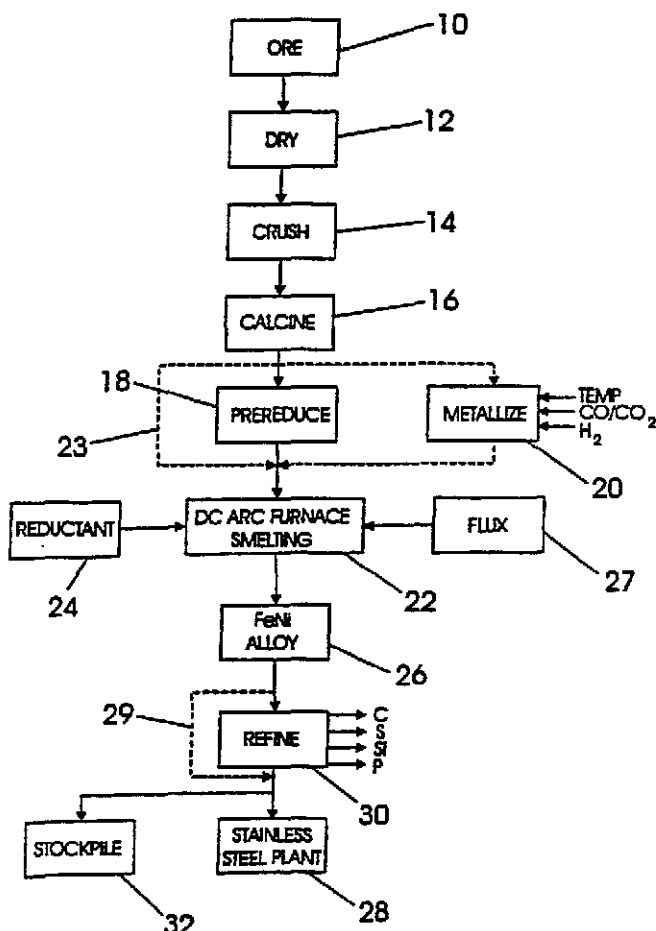
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(54) Title: IRON-NICKEL ALLOY PRODUCTION



(57) Abstract: A method of producing an iron-nickel alloy, with a nickel content of from 5% to 20%, which includes the step of reducing the iron oxide content of a slag in a DC arc furnace to less than 10%.

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## IRON NICKEL ALLOY PRODUCTION

### BACKGROUND OF THE INVENTION

This invention relates to the production of an iron-nickel alloy and more particularly is  
5 concerned with the production of such an alloy for use in a stainless steel plant.

South African patent No. 94/6071 describes a process for the production of ferro-nickel  
from nickel containing laterite. In the process feed material either in the form of pre-  
reduced nickel containing laterite or in the form of calcined nickel containing laterite is fed  
10 simultaneously with a carbonaceous reductant to a DC arc furnace. If the laterite is pre-  
reduced then this may be achieved by drying the laterite ore, milling and then calcining  
followed by a pre-reduction step preferably in a fluidised bed reactor. The material, which  
preferably is pre-heated, is then fed to the DC arc furnace and a nickel depleted slag and  
ferro-nickel are withdrawn from the furnace.

15 Nickel is the major cost item in stainless steel representing approximately 60% of material  
cost. On the other hand the iron content is the major component by mass making up in  
excess of 70% of the material mass. Scrap stainless steel is a low cost source of material  
for stainless steel production, but in some instances only small quantities of scrap  
20 stainless steel are available.

### SUMMARY OF INVENTION

The invention provides a method of producing an iron-nickel alloy, with a nickel content  
25 of from 5% to 20%, which includes the step of reducing the iron oxide content of a slag in

a DC arc furnace to less than 10%.

Preferably the nickel content of the alloy is of the order of from 10% to 15%.

- 5 The reduction may take place in the DC arc furnace with sufficient carbonaceous reducing agent to reduce the iron oxide content in the slag to about 2,5%. The iron oxide content may be selected to achieve a silicon content in the alloy of less than 2%.

10 The addition of fluxes to the slag should be minimized and, under certain conditions, may be eliminated.

According to a preferred aspect of the invention the iron-nickel alloy is fed directly in liquid form into a plant for the production of stainless steel.

- 15 The silicon content in the alloy should be minimized to reduce energy consumption in the furnace and to limit subsequent refining of the alloy to remove the silicon. To achieve this objective the invention provides for the operating temperature in the furnace, the FeO content of the slag, and the addition of flux to the furnace, to be adjusted to lower the silicon content of the alloy. Some silicon is acceptable as it would be used for reduction  
20 in the downstream process, but only if no dephosphirization step is required - if not the silicon must be removed first.

Normally it is not commercially attractive to further reduce the iron oxide in the slag below a level required to produce an alloy with a nickel content lower than 25%, with a desired  
25 content being as low as 10% to 15%, since no credit is given for the iron in commercial

grades of ferro-nickel. However there is significant value in this process if the additional iron units are fed, as indicated, in molten form directly to a stainless steel plant.

It is however possible to cast or granulate the iron-nickel alloy for sale or to stock-pile it for use as a coolant or in order to meet capacity requirements during downtime.

The iron-nickel may be produced from a laterite ore feed material. In this instance the aforementioned reduction step may be preceded by the steps of:

- (a) drying the laterite ore,
- (b) crushing the ore to an acceptable particle size for fluidised bed calcining,
- (c) calcining the crushed ore,
- (d) pre-reducing the calcined ore, and
- (e) melting the ore to produce an iron-nickel alloy and a slag.

In the pre-reduction step (d) substantially all of the ferric iron oxide may be reduced to ferrous oxide. Alternatively the iron and nickel may be metallised under more strongly reducing conditions. This latter step reduces the electrical energy consumption in the smelting stage in the DC arc furnace.

A further option provides for hot material after step (c) to be fed to the DC arc furnace.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The invention is further described by way of example with reference to the accompanying drawings in which:

Figure 1 is a flow sheet representation of a method of producing an iron-nickel alloy according to the invention;

Figure 2 illustrates diagrammatically aspects of a conventional process for the production of ferro-nickel;

5 Figure 3 is similar to Figure 2, but relates to the process of the invention; and

Figure 4 illustrates a relationship between silicon content in the iron-nickel alloy and FeO content in the slag.

### DESCRIPTION OF PREFERRED EMBODIMENT

10

As indicated in the preamble of this specification it is known that nickel is the major cost item in stainless steel, representing approximately 60% of the material cost. On the other hand iron units are the major component by mass. Further, scrap stainless steel is the lowest cost source of material but the supply thereof is limited.

15

South African patent No. 94/6071 describes a method for the production of commercial grades of ferro-nickel which is based on producing a nickel-depleted slag. The patent specification does not refer to the reduction of most of the iron-oxide in the slag to produce a lower grade nickel-containing iron alloy.

20

Figure 1 illustrates a process flow-sheet for the production of an iron-nickel alloy which is transferred in molten form directly to a stainless steel plant.

Referring to Figure 1 a laterite ore 10 is dried in a step 12 so that it can be crushed (step  
15 14) to an acceptable particle size for calcining in a fluidised bed calciner 16 at a



temperature which lies in a range of from 700°C to 900°C. Typically calcining takes place at a temperature in the range of 850°C to 900°C.

5 The calcined laterite is then pre-reduced in a fluidised reduction reactor (step 18) to reduce all the iron oxide as  $Fe^{3+}$  to iron oxide as  $Fe^{2+}$ . Alternatively, as is indicated by an alternative flow path in dotted lines, the iron is metallised under more strongly reducing conditions (step 20) at an appropriate temperature and by controlling atmospheric conditions. The reducing agent (18, 20) may be reformed natural gas, syngas or a solid carbonaceous material. This approach is taken to reduce electrical energy consumption  
10 in a subsequent smelting stage 22. A further option, indicated by a dotted line 23, is to pre-heat only so that the feed is at a temperature of about 900°C.

The calcined and pre-reduced feed material from the step 18, or the highly metallised feed material from the step 20, or the preheated material (step 23), as the case may be, which,  
15 as noted, should be hot charged to about 900°C, is then fed to a DC arc furnace (step 22) with sufficient carbonaceous reducing agent 24 to reduce the iron-oxide in the slag to less than 5%, and preferably less than 2%, to produce an iron-nickel alloy 26 with between 8% and 20% nickel, and preferably with a nickel content of the order of 10% to 15%.

20 Flux 27 (eg.  $CaO$  and  $Al_2O_3$ ) may be added, depending on the operating temperature of the furnace, to reduce the silicon content of the alloy. However, the furnace operation is also optimised to reduce the addition of fluxes. The silicon content in the alloy 26 should be kept as low as possible to minimise energy consumption in the furnace and to limit subsequent refining of the alloy to remove the silicon. As is apparent from test results  
25 presented hereinafter, the silicon content, at least to some extent, can be manipulated to

an acceptable low level through a choice of furnace operating temperature, and the judicious addition of fluxes.

5 A substantial economic benefit is achieved if the alloy is fed in liquid form (step 29) directly to an adjacent stainless steel plant 28. The alloy may however be refined, in a preceding step 30, to adjust the carbon, sulphur, silicon and phosphorus contents to appropriate levels. Generally the refining step 30 may only be omitted if the phosphorous content of the alloy is acceptable to the stainless steel plant.

10 Although the principal benefit of the invention lies in transferring the material directly to the stainless steel plant the material could alternatively be cast or granulated for sale or stock-piled for use as a coolant or for meeting capacity requirements during down-time, as is indicated by a block 32.

15 The smelting process (step 22) is run to extract the optimum amount of liquid iron units. The credit for the iron units is based on the additional iron produced since the iron in the standard grade of ferro-nickel does not normally attract any credit but helps to market the product. Thus the additional iron units for stainless steel production are available at a marginal incremental cost which is far lower than for bought-in iron units. The iron units  
20 are liquid and this avoids the energy cost and furnace capacity requirement to melt out-sourced iron units. The iron units are relatively clean after the refining step 30. The recovery of the iron units also helps to make the overall production of the nickel units more cost effective and justifies the shipment of laterite ore to the site of the stainless steel  
25 plant.

Figure 2 illustrates diagrammatically parameters of raw materials and output products in the production of 200 kt per annum of ferro-nickel containing 25% nickel, in a conventional process. Use is made of calcined laterite with a nickel-oxide content of 2,8% and an iron-oxide content of 23%.

5

The energy consumption of the electric arc furnace is 190 Megawatts and the reductant consumption is 135 kt coal.

10

Figure 3 illustrates parameters of raw materials and output products in the production of 400 kt per annum of ferro-nickel with a nickel content of 12,5%, using the process of the invention. The total electrical consumption of the arc furnaces is increased slightly to 220 Megawatts and the carbonaceous reductant consumption is substantially increased and is of the order of 220 kt coal.

15

The only additional costs for implementing the approach of the invention are the costs required for refining the alloy (step 30), for off-gas treatment, for refractory wear, additional manpower and maintenance.

20

The following tables contain a comparison between the calculated metallurgical results for an existing process to which Figure 2 relates and for the process of the invention to which Figure 3 relates.

PLANT PARAMETERS

	EXISTING PROCESS (Figure 2)	PROCESS OF THE INVENTION (Figure 3)
Capacity	200 kt/a	400kt/a
Ni grade	25% (25 to 45% range)	12,5% (10 to 20% range)
Ni content	50 kt/a at 25%	50 kt/a at 12,5%
Energy required	6,8 MWh/t alloy	3,9 MWh/t alloy
Furnace capacity	190 MW (90% efficiency)	220 MW (90% efficiency)

SLAG COMPOSITION, % (PREDICTED)

	Figure 2	Figure 3
MgO	35	40
SiO <sub>2</sub>	47	54
FeO	14	1
Al <sub>2</sub> O <sub>3</sub>	3	4
Cr <sub>2</sub> O <sub>3</sub>	1	2

ALLOY COMPOSITION, % (PREDICTED)

	Figure 2	Figure 3
Ni	25,3	12,6
Fe	74	86
Co	0,85	0,4
Si	-	2 to 4 (see Figure 4)
C	0,03	0,6
S,P	not given	not given

It is apparent that by carrying out the process of the invention adjacent a stainless steel

plant significant economic benefits result through the step of extracting additional iron units using a DC arc furnace with its inherent advantages. These advantages include an open bath and better metallurgical control which allows the reduction of the additional iron-oxide in a highly effective manner.

5

It is necessary to control the DC furnace, including the feeding of the exact amount of reductant to the furnace, to avoid unnecessary side-reactions such as  $\text{SiO}_2$  or  $\text{MgO}$  reduction. A conventional three phase three electrode furnace of the immersed electrode or shielded arc type would not be easy to control with the use of extra reductant as this would cause too much inter-electrode conduction above the bath, particularly since the slag volume and resistance are high. As the process of the invention, compared to the conventional approach, requires about 15% more energy which is consumed in the electric arc furnace, it is preferable to carry out the process in a furnace with a higher megawatt capacity. Another possibility is to transfer the  $\text{FeO}$ -containing slag to a second low power but large furnace from which the balance of the iron units would be produced. The first furnace would produce a standard ferro-nickel alloy (25% to 45% nickel) and the second furnace would produce an iron alloy which is very low in nickel. In this case both alloys would be refined separately prior to feeding to the stainless steel plant. However this would be a less preferred approach because of the cost of two furnaces. Greater flexibility is however possible by making use of two furnaces and this variation is intended to fall within the scope of the present invention.

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A number of small scale experiments were conducted to test the principles of the invention and to obtain data on the reduction of iron and nickel during the smelting of nickel-bearing laterite.

## Experimental Approach and Results

The bulk chemical composition for the Ni-bearing laterite used for this investigation is shown in Table 1.

5

Flux additions of analytical grade chemicals were made to the laterite. CaO was added in some experiments to ensure a low liquidus, while Al<sub>2</sub>O<sub>3</sub> was added to protect the alumina (Al<sub>2</sub>O<sub>3</sub>) crucible used for most of the tests. Graphite was added to the charges as reducing agent. The experimental conditions, together with flux and reductant additions, are shown in Table 2.

10

Smelting of Tests 1 to 9 was conducted at 1550°C using alumina (Al<sub>2</sub>O<sub>3</sub>) crucibles in an inert argon atmosphere. Light blue slags and metal alloys were collected. The slags were milled and submitted for chemical analysis. The results of the quantitative chemical slag analyses are shown in Table 3.

15

Test 10 was conducted in a magnesia (MgO) crucible without the addition of flux at a temperature of 1600°C. An alloy and a light coloured slag that appeared molten were obtained.

20

The alloys produced were extremely hard and could not milled for chemical analysis. Instead, polish sections of alloy from selected tests were prepared and these were examined using a Scanning Electron Microscope (SEM). Microanalysis of the alloys was performed using Energy Dispersive Spectrometry (EDS) coupled to the SEM. The results are shown in Table 4.

25

## Conclusion

The experimental results demonstrated that:

- 5 (A) It is possible, with flux additions, to produce a ferro-nickel alloy from Ni-bearing laterite at 1550°C. The FeO content of the resulting slag can be reduced to less than 1% through the addition of a suitable reductant and results in an alloy (test 9) containing 9.5% Ni, 84% Fe, 4.3% Si and 2.6%Cr.
- 10 (B) It is also possible to produce a ferro-nickel alloy without the use of any fluxes at a temperature of 1600°C. The resulting slag contained approximately 1% FeO and the alloy 8.9% Ni, 83% Fe, 5.5% Si and 2.2% Cr (test 10).
- 15 (C) The results indicate that it will be possible to manipulate the Si content of the alloy through the level of reduction of FeO in the slag via the reductant addition, the choice of operating temperatures and the use and choice of fluxes. Figure 4 illustrates in graphical form the relationship between the silicon content in the alloy and the FeO content in the slag obtained when working at an operating
- 20 temperature of about 1600°C. To achieve a silicon content of less than 1% the FeO content in the slag should not be lower than 4% to 5%, as is shown in Figure 4.

The smelting operation differs from conventional FeNi smelting in that the slag is depleted in FeO which increases the slag liquidus and viscosity at the usual smelting temperatures.

25 This greatly increases the likelihood of foaming slag formation that destabilizes the furnace

operation. Conventional AC furnaces are operated in two principal methods (as taught in the literature): either an immersed electrode whereby power is generated via slag resistance heating or a shielded-arc arrangement whereby the arc struck between the electrode and the molten slag bath is surrounded by a burden of solid feed materials to "shield" the arc. The slag resistance method is not able to reach the high smelting intensity of the shielded-arc method (typically  $200\text{kWm}^{-2}$  versus  $450\text{kWm}^{-2}$ ). This is due to the high side-wall heat fluxes encountered in the slag resistance method when attempting to increase the smelting intensity much above the  $200\text{kW/m}^2$  of hearth area level.

The shielded-arc method is therefore clearly advantageous in terms of furnace capital cost; however the shielding burden needs to be sufficiently porous to avoid eruptions from gas evolved during the smelting step and should not be electrically conductive to avoid electrical short-circuits between the electrodes through the burden material.

The high degree of reduction required in the claimed new process implies either well metallized feed material or significant additions of carbonaceous reductant. In either case the shielded-arc method is not suitable for this process.

In addition the consequences of slag foaming are very severe in the case of a shielded-arc method in terms of burden eruptions.

Therefore the use of a DC open arc method (as disclosed in SA Patent No. 94/6071) is preferably required to execute this process advantageously.



Table 1: Chemical analysis data for Ni-bearing laterite

	NiO	FeO	CoO	MgO	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	S	Cr <sub>2</sub> O <sub>3</sub>	MnO	P	H <sub>2</sub> O	Other	Total
Mean	2.0	20	0.04	26	44	2.5	0.03	1	0.3	0.003	0.4	2.6	100.00

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5 Table 2: Experimental conditions, and % of slag and alloy obtained.

Additions per 100g Ni-bearing laterite.

Test	CaO	Al <sub>2</sub> O <sub>3</sub>	C	Time*	Temp (°C)	%Slag	%Alloy
1	10	10	3.70	30	1550	Leak	Leak
2	10	10	4.00	30	1550	86.30	13.7
3	10	10	4.90	30	1550	83.70	16.3
4	10	20	2.80	30	1550	91.40	8.6
5	10	20	3.20	30	1550	90.00	10.0
6	10	20	3.60	30	1550	89.30	10.7
7	10	10	4.90	30	1550	85.60	14.4
8	10	10	5.30	30	1550	84.50	15.5
9	10	10	5.70	30	1550	84.00	16.0
10	0	0	4.86	30	1600	81.37	18.6

13

\* Reaction time in minutes at operating temperature - excludes 15°C per minute heating period.

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Table 3: *Bulk chemical composition of slags produced.*

Test	NiO	FeO	CoO	CaO	MgO	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Cr <sub>2</sub> O <sub>3</sub>	MnO	P	Other	Total
2	0.06	2.53	0.06	9.40	24.5	42.3	15.4	0.75	0.30	0.0036	4.70	100
3	0.06	1.91	0.06	9.86	26.2	43.8	14.1	0.49	0.30	0.0074	3.31	100
4	0.06	6.58	0.06	8.99	22.7	39.9	18.5	0.78	0.27	0.0022	2.16	100
5	0.06	5.60	0.06	9.13	22.9	40.7	19.4	0.72	0.28	0.0029	1.15	100
6	0.20	3.74	0.06	9.05	23.3	40.8	19.7	0.78	0.28	0.0026	2.09	100
7	0.11	2.26	0.06	9.58	26.3	45.2	14.2	0.52	0.30	0.0025	1.47	100
8	0.06	1.13	0.06	9.73	26.8	45.5	14.3	0.39	0.30	0.0005	1.73	100
9	0.06	0.77	0.06	9.87	27.3	45.7	14.5	0.31	0.28	0.0005	1.15	100
10	0.06	1.11	0.06	0.43	37.2	55.5	3.0	0.50	0.38	0.0035	1.75	100

\* The values in italics are lower than the reported values.

Table 4: *Chemical composition of selected alloys as determined by EDS.*

Test	Ni	Fe	Si	Cr	Total
3	8.46	86.32	1.70	2.74	99.22
5	11.16	88.57	0.07	0.20	100.00
8	9.03	86.72	2.48	2.73	100.95
9	9.44	83.76	4.31	2.61	100.11
10	8.89	83.43	5.52	2.15	100.00

CLAIMS

1. A method of producing an iron-nickel alloy, with a nickel content of from 5% to 20%, which is characterised in that it includes the step of reducing the iron oxide content of a slag in a DC arc furnace to less than 10%.  
5
2. A method according to claim 1 characterised in that the alloy has a nickel content of from 10% to 15%.
- 10 3. A method according to claim 1 or 2 characterised in that the reduction takes place in the DC arc furnace with sufficient carbonaceous reducing agent to reduce the iron oxide content in the slag to about 2.5%.
- 15 4. A method according to claim 3 characterised in that the iron oxide content in the slag is selected to achieve a silicon content in the alloy of less than 2%.
- 20 5. A method according to claim 3 or 4 which is characterised in that it includes the step of controlling the operating temperature of the furnace to limit the silicon content of the alloy.
6. A method according to claim 3, 4 or 5 which is characterised in that it includes the step of controlling the addition of flux or fluxes to the furnace to achieve an optimum operating temperature and to limit the silicon content of the alloy.
- 25 7. A method according to any one of claims 1 to 6 characterised in that the slag is

produced from a laterite ore feed material and wherein the said reduction step is preceded by the steps of:

- (a) drying the laterite ore,
- (b) crushing the ore to an acceptable particle size for fluidised bed calcining,
- 5 (c) calcining the crushed ore,
- (d) pre-reducing the calcined ore, and
- (e) melting the ore to produce an iron-nickel alloy and a slag.

8. A method according to claim 7 characterised in that in the pre-reduction step (d),  
10 substantially all of the ferric iron oxide is reduced to ferrous oxide.

9. A method of producing stainless steel which is characterised in that it includes the step of providing additional iron to a stainless steel plant by feeding the iron-nickel alloy, produced by the method of any one of claims 1 to 6, directly in liquid form to  
15 the stainless steel plant.

10. A method of producing stainless steel which is characterised in that the alloy which is produced by the method of any one of claims 1 to 8 is fed in molten form directly to a stainless steel plant.  
20

11. A method according to claim 10 characterised in that the DC arc furnace is operated to produce an optimum amount of liquid iron units required for stainless steel production in the stainless steel plant.

25 12. A method according to claim 10 or 11 characterised in that the alloy is refined,

before being fed to the stainless steel plant, to adjust the level of at least one of the following: the carbon, sulphur, silicon and phosphorus contents in the alloy.

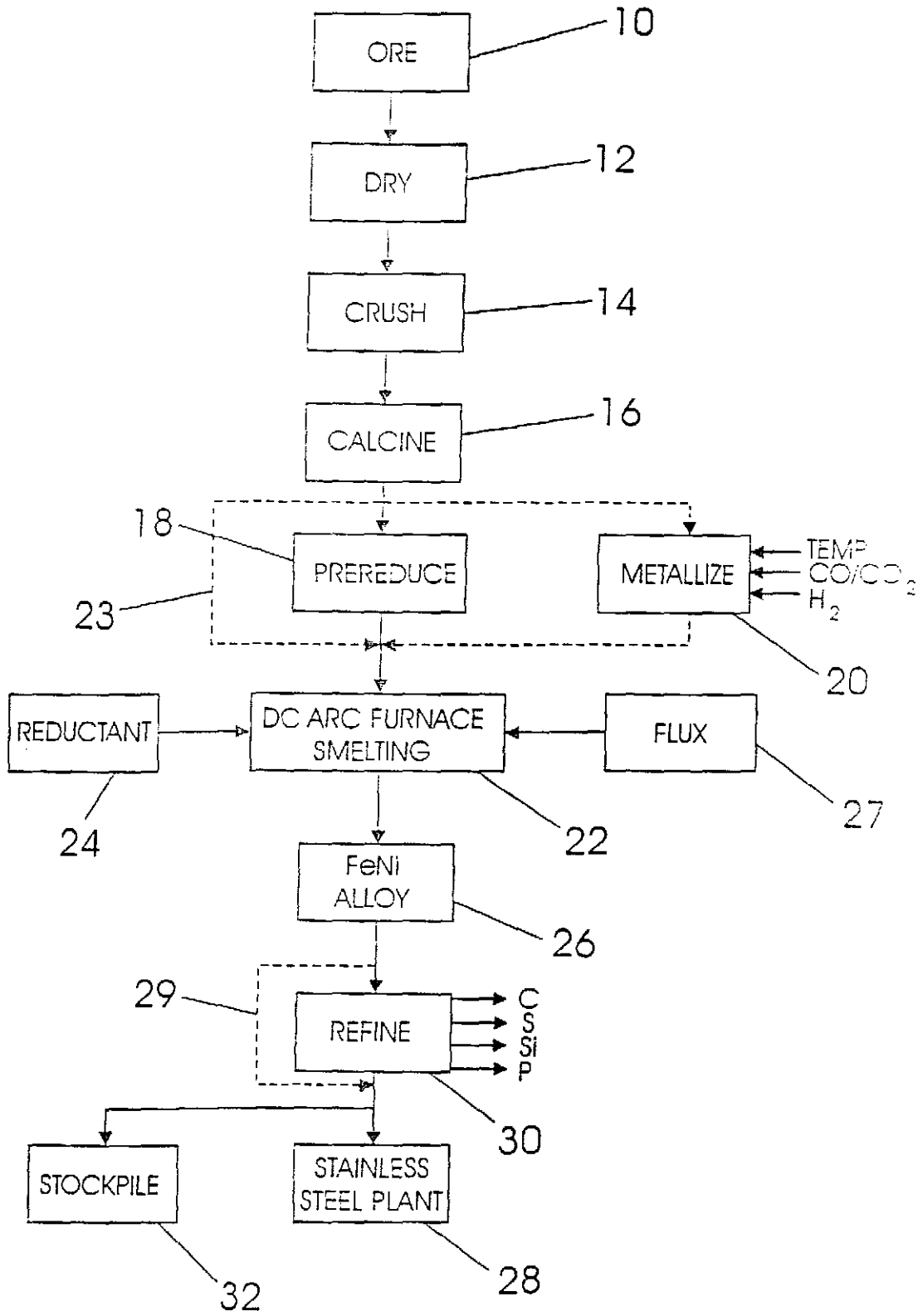


Fig 1

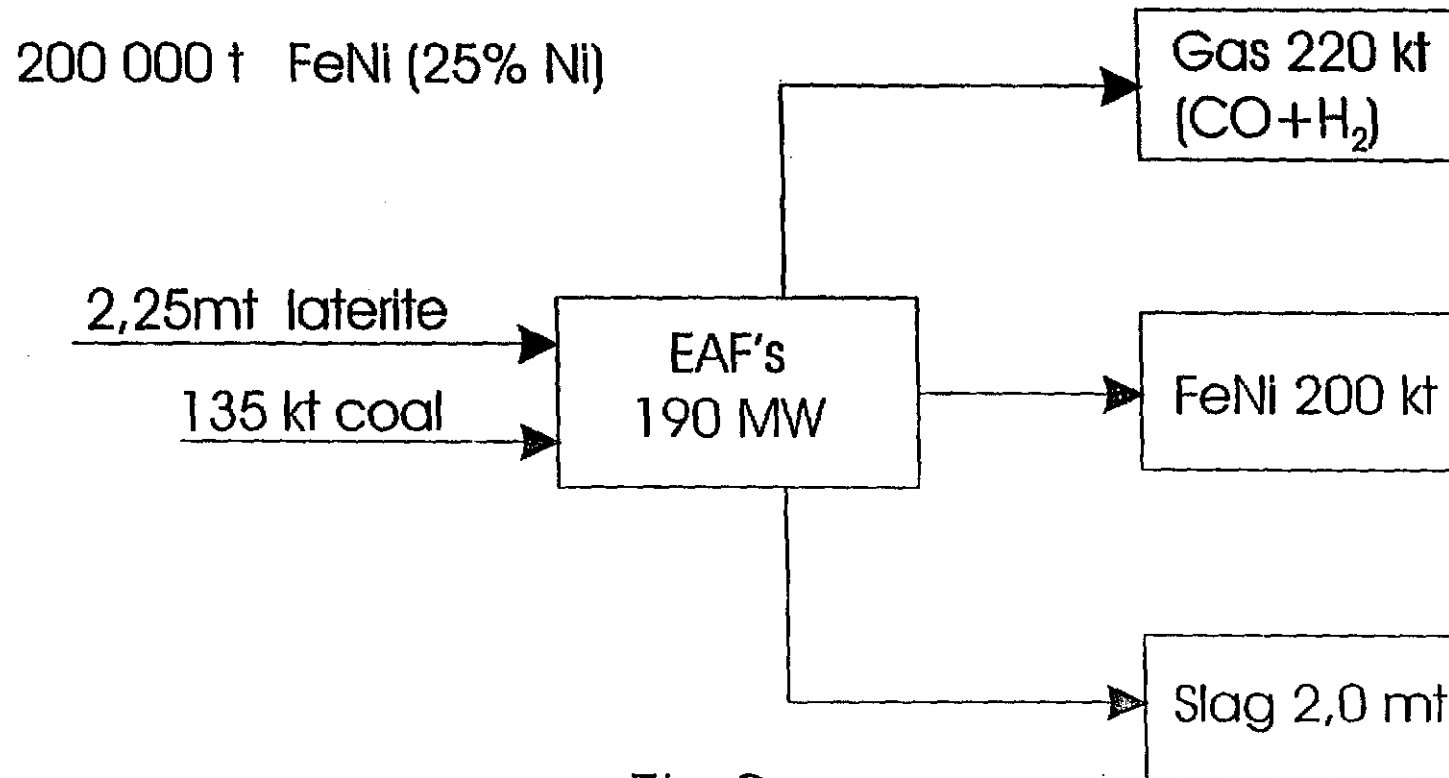


Fig 2

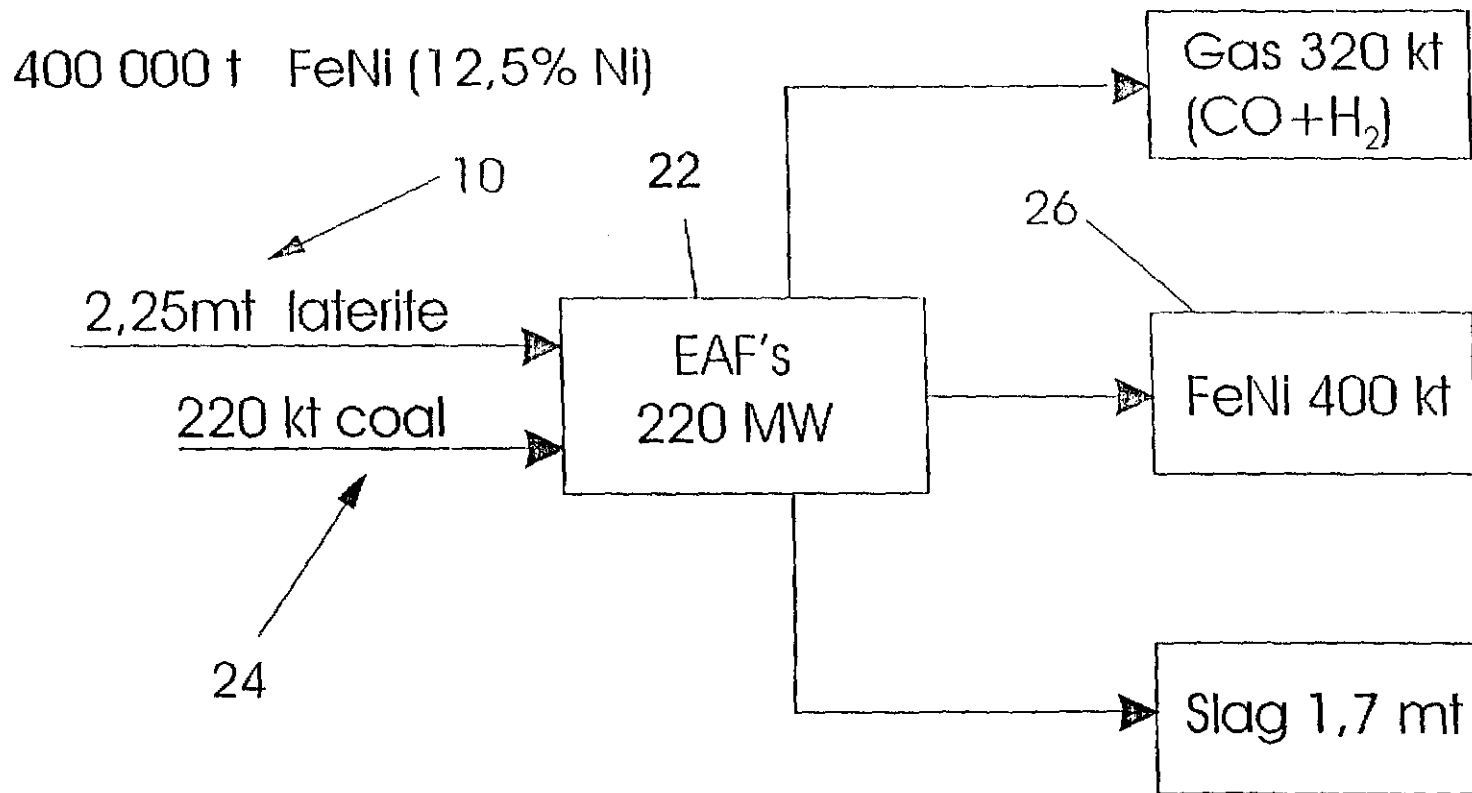


Fig 3



Si % in alloy

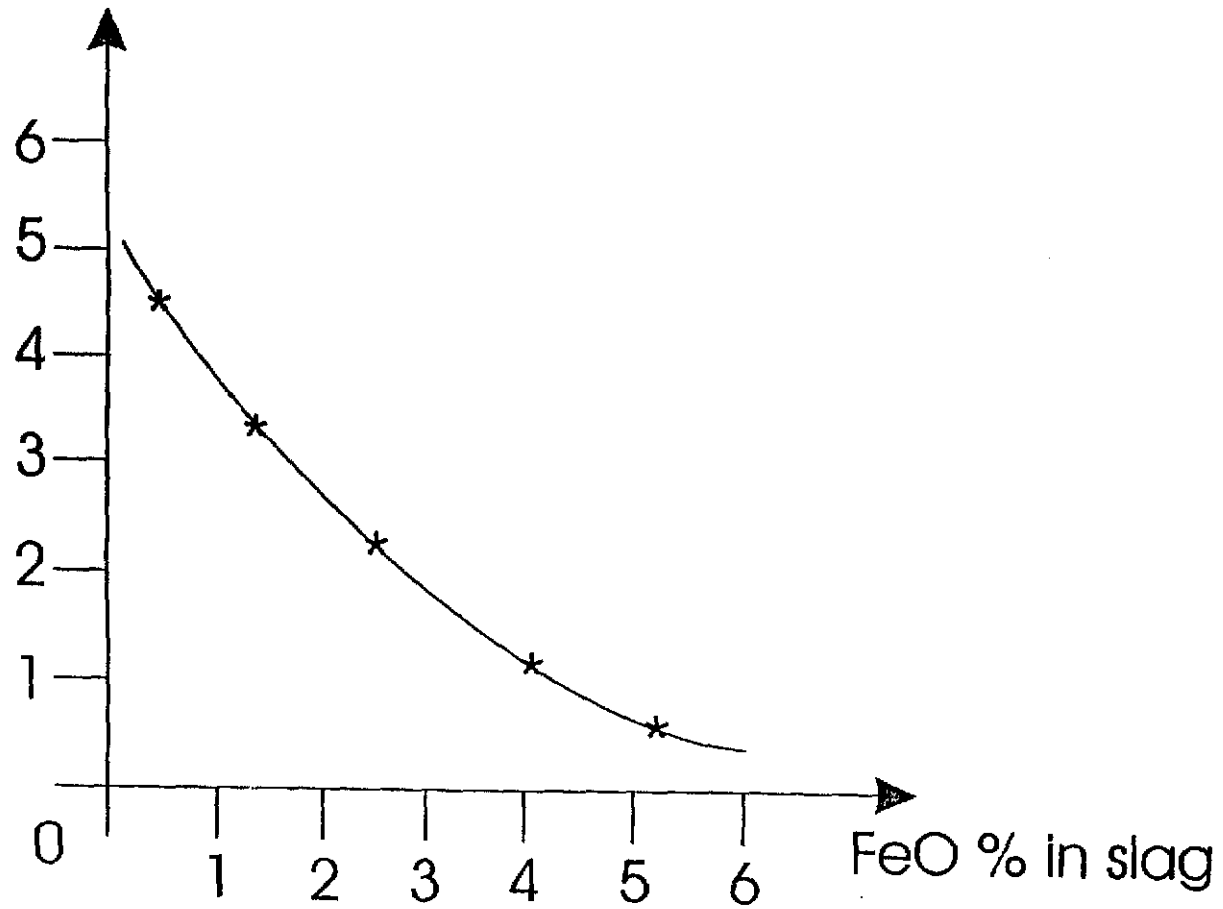


Fig 4

# INTERNATIONAL SEARCH REPORT

Intern. Application No  
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<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC 7 C22B23/02				
According to International Patent Classification (IPC) or to both national classification and IPC				
<b>B. FIELDS SEARCHED</b>				
Minimum documentation searched (classification system followed by classification symbols) IPC 7 C22B				
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched				
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, WPI Data, PAJ, COMPENDEX, INSPEC				
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>				
Category <sup>a</sup>	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.		
A	EP 0 643 147 A (MINTEK) 15 March 1995 (1995-03-15) cited in the application table 2C	1-12		
A	WO 97 20954 A (WMC RESOURCES LTD ;BLANDY CHARLES WILLIAM DOUGLAS (AU)) 12 June 1997 (1997-06-12) page 3 -page 4; claims 1,24,26	1-12		
A	WO 91 05879 A (AUSMELT PTY LTD) 2 May 1991 (1991-05-02) page 13, line 25 - line 30	1-12		
A	US 5 749 939 A (KUNDRAT DAVID M) 12 May 1998 (1998-05-12) column 2, line 66 -column 5, line 12	1-12		
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<input checked="" type="checkbox"/> Further documents are listed in the continuation of box C.				
<input checked="" type="checkbox"/> Patent family members are listed in annex.				
<sup>a</sup> Special categories of cited documents :				
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none; vertical-align: top;"> <ul style="list-style-type: none"> <li>*A* document defining the general state of the art which is not considered to be of particular relevance</li> <li>*E* earlier document but published on or after the international filing date</li> <li>*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</li> <li>*O* document referring to an oral disclosure, use, exhibition or other means</li> <li>*P* document published prior to the international filing date but later than the priority date claimed</li> </ul> </td> <td style="width: 50%; border: none; vertical-align: top;"> <ul style="list-style-type: none"> <li>*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</li> <li>*X* document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</li> <li>*Y* document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</li> <li>*Z* document member of the same patent family</li> </ul> </td> </tr> </table>			<ul style="list-style-type: none"> <li>*A* document defining the general state of the art which is not considered to be of particular relevance</li> <li>*E* earlier document but published on or after the international filing date</li> <li>*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</li> <li>*O* document referring to an oral disclosure, use, exhibition or other means</li> <li>*P* document published prior to the international filing date but later than the priority date claimed</li> </ul>	<ul style="list-style-type: none"> <li>*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</li> <li>*X* document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</li> <li>*Y* document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</li> <li>*Z* document member of the same patent family</li> </ul>
<ul style="list-style-type: none"> <li>*A* document defining the general state of the art which is not considered to be of particular relevance</li> <li>*E* earlier document but published on or after the international filing date</li> <li>*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</li> <li>*O* document referring to an oral disclosure, use, exhibition or other means</li> <li>*P* document published prior to the international filing date but later than the priority date claimed</li> </ul>	<ul style="list-style-type: none"> <li>*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</li> <li>*X* document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</li> <li>*Y* document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</li> <li>*Z* document member of the same patent family</li> </ul>			
Date of the actual completion of the international search  <p style="text-align: center; font-size: 1.2em;">23 April 2001</p>		Date of mailing of the international search report  <p style="text-align: center; font-size: 1.2em;">04/05/2001</p>		
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016		Authorized officer  <p style="text-align: center; font-size: 1.2em;">Badcock, G</p>		

# INTERNATIONAL SEARCH REPORT

Intern. Application No PCT/ZA 00/00260
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3 854 936 A (HUNTER W ET AL) 17 December 1974 (1974-12-17) claims 1-4  <hr style="width: 10%; margin: 10px auto;"/>	1-12

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Information on patent family members

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Patent document cited in search report	A	Publication date	Patent family member(s)	Publication date
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