

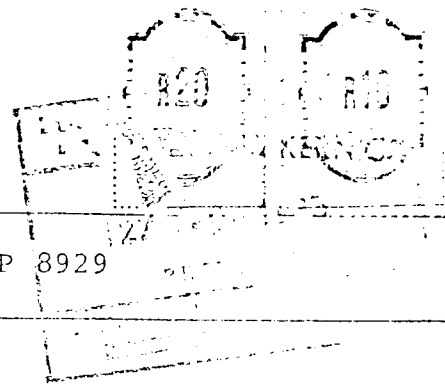
P. 2772.

John & Kernick

REPUBLIC OF SOUTH AFRICA  
PATENTS ACT, 1973  
APPLICATION FOR A PATENT AND  
ACKNOWLEDGEMENT OF RECEIPT  
(Section 30(1) - Regulation 22)

FORM P 1

The grant of a patent is hereby requested by the undermentioned applicant on the present application filed in duplicate.



Official application No. <b>837183</b>		J & K Ref: P 8929
21	01	

71 Full name(s) of applicant(s) .....

**COUNCIL FOR MINERAL TECHNOLOGY**

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54 Title of invention

**"THE TREATMENT OF FERROMANGANESE"**

<input checked="" type="checkbox"/>	The applicant claims priority as set out on the accompanying form P2	
<input type="checkbox"/>	This application is for a patent of addition to Patent/Application No.	24 01
<input type="checkbox"/>	This application is a fresh application in terms of section 37 and based on Application No.	21 01

This application is accompanied by:

<input type="checkbox"/>	1a	A single copy of a provisional specification of ..... pages	
<input checked="" type="checkbox"/>	1b	Two copies of a complete specification of <u>18</u> pages	
<input type="checkbox"/>	2a	Informal drawings of ..... sheets	
<input type="checkbox"/>	2b	Formal drawings of ..... sheets	
<input checked="" type="checkbox"/>	3.	Publication particulars and abstract (form P8 in duplicate)	
<input type="checkbox"/>	4.	A copy of figure ..... of the drawings for the abstract	
<input checked="" type="checkbox"/>	5.	Assignment of invention (from the inventor) or other evidence of title	
<input type="checkbox"/>	6.	Certified priority documents (..... documents)	
<input type="checkbox"/>	7.	Translation of priority documents (..... documents)	
<input type="checkbox"/>	8.	Assignment of priority rights	
<input checked="" type="checkbox"/>	9.	A copy of the form P2 and the specification of S. A. Patent Application 21 01	21 01 82/7253
<input checked="" type="checkbox"/>	10.	A declaration and power of attorney on form P3	
<input type="checkbox"/>	11.	Request for ante-dating on form P4	
<input checked="" type="checkbox"/>	12.	Request for classification on form P3	
<input type="checkbox"/>	13a	Request for delay of acceptance on form P4	
<input type="checkbox"/>	13b		

27th September 1983

*[Signature]*

## Complete Specification

(Section 30(1) — Regulation 28)

21 01	Official application No.	22	Lodging date	J&K reference
	837183		27.09.1983	P 8929
51	International classification			
	C 22 b			
71	Full Name(s) of applicant(s)			
	COUNCIL FOR MINERAL TECHNOLOGY			
72	Full Name(s) of inventor(s)			
	THOMAS ROBERT CURR and INGRID EVELYN SCHMIDT			
54	Title of invention			
	"THE TREATMENT OF FERROMANGANESE"			

THIS INVENTION relates to the treatment of ferromanganese alloys which have been partially or fully processed and which may be in a basically unacceptable physical form such as the form of "fines", to yield ferromanganese alloys with improved physical forms and/or chemical composition.

Two basic processes which are applicable to the treatment of ferromanganese alloys include the remelting of fines or other physically unacceptable forms of the alloys, and the refining of the alloys in order to obtain a product with a lower carbon or silicon content than is initially produced.

When conventional submerged arc furnaces are employed for the above described processes, various problems become manifest. For example, in the process in which refining takes place, it is extremely difficult, if at all possible, to exclude the carbonaceous reductant material from the reaction zone. One reason for this is that, in any event, the electrodes of a submerged arc furnace are made of carbonaceous material which is in

close physical contact with the reaction mass and thus adds carbon to the system.

Melting and refining in a submerged-arc furnace takes place beneath a burden of feed material which automatically feeds into the reaction zone under the influence of gravity. This type of feeding denies any sort of reasonable control over the rate at which the raw materials are fed to the reaction zone. Control of the conditions in the reaction zone cannot thus be exercised to any appreciable degree.

Also, in the case of finely sized materials, it is often inadvisable to feed such materials to a submerged- arc type of furnace unless they are briquetted or otherwise agglomerated in order to maintain a suitable porosity throughout the burden. This porosity is required so that the product gases from the reaction zone may smoothly pass through the burden. Failure to maintain a suitable porosity usually results in a building up of gas pressure within the burden followed by an explosive release of this gas, commonly known as an eruption.

The presence of a high proportion of electrically conductive metal fines in the burden of existing

submerged-arc furnaces results in lowered furnace resistance and hence lower power operation at maximum current.

The use of existing three-phase a.c. open-arc furnaces such as steelmaking electric-arc furnaces for the remelting and refining of ferromanganese alloy "fines" is not currently practised. The small size (typically less than 6 mm) of the ferromanganese "fines" would mean that the side walls would be exposed to the "arc flare" from the three electrodes throughout the process which is considered bad practice.

It is the object of this invention to provide an improved method of treating ferromanganese alloys in which the disadvantages outlined above are, at least to some extent, obviated.

In accordance with this invention, there is provided a method of treating ferromanganese alloys in which the alloy is treated in a suitable reactor having a substantially non-oxidizing atmosphere whilst being heated by a transferred arc thermal plasma, as herein defined, wherein the treatment is primarily accomplished in the said bath; and wherein feed material is fed directly to the bath.

A thermal plasma arc is defined as: a plasma

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sustained by the passage of an electric current; in which the ion temperature lies in the range 5 000 K to 60 000K; which is bounded by at least two electrode surfaces; and to which controlled amounts of material may be added.

An electrode surface is defined as the interface between matter in a plasma state and matter in a solid or liquid state across which interface an electric current is passing. A transferred-arc thermal plasma is defined as a thermal plasma arc in which at least one electrode surface comprises at least a part of the surface of a continuous molten bath of process material, and wherein the bath is primarily liquid and may include some solid feed material.

The above definitions shall apply whenever the terms therein defined and used in this specification, including the accompanying claims.

A further feature of the invention provides for the feed material to pass through the area defined by the thermal plasma arc in order to expedite feeding to said bath.

Still further features of the invention provide for air to be substantially excluded from the system to avoid oxidation of consumable electrodes and unwanted

oxidation of metal by providing a suitable sealed closed reactor and optionally by purging the feed materials with inert gas such as Argon. The furnace may be operated at a slight positive pressure with respect to prevailing atmospheric pressure in order to enhance the exclusion of air which may, otherwise, tend to leak into the reactor. This can be achieved by restricting the flow passage for off-gases.

The feed materials are fed, in their solid state, in suitable proportions, directly to the molten bath in the hearth of the reactor.

It will be understood that the reactor in which the melting, refining, or reduction of feed materials takes place could assume many different physical forms and that the lower regions may embody a number of electrodes for establishing an electrical connection to the molten bath and may additionally employ a number of cooled essentially non-consumable electrodes or consumable electrodes above the bath. Also, the electrodes may be arranged in any geometric relationship which provides the required transferred-arc thermal plasma, and the electrodes above the bath could be made to precess at a preselected speed or to oscillate at a preselected frequency.

In all cases, the feed rate of optionally

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pre-mixed materials and the energy input are adjusted to achieve and maintain desired temperatures of slag and molten metal. In cases where fluxing additions are made to the feed materials, these are chosen so that a suitable liquidus temperature and chemical state (such as the ratio of calcium oxide to silica) of the slag results. Carbonaceous reductants may optionally also be included.

From the above it will be understood that the process of this invention can be employed to remelt ferromanganese alloy fines (defined for the purposes of this specification as being less than 6mm in particle size), resulting from the physical sizing and handling of ferromanganese products to yield a physically more massive form of the alloy, and optionally to refine this alloy, or indeed any other ferromanganese alloy, suitable for refining, by the addition of at least one suitable metal oxide to yield a product wherein the content of at least silicon or carbon is lowered. The metal oxide is mixed with the feed material as an oxidant generally without the addition of a carbonaceous reductant. The metal oxide is preferably an oxide of at least iron or manganese and is preferably chosen from the group of materials comprising ore, discard slag and gas plant dust.

The following examples illustrate the operation

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of the invention in the three basic types of operation concerned.

EXAMPLE 1 REMELTING OF HIGH CARBON FERROMANGANESE METAL FINES USING A NON-CONSUMABLE ELECTRODE.

Tests were conducted in a 1400kV.A furnace manufactured by Tetronics Research and Development Limited (TRD) substantially in accordance with their issued British Patent nos. 390351/2/3 and 159526. The furnace generated a transferred-arc plasma which fulfilled the criteria above and employed a single, water-cooled, non-consumable plasma gun located centrally above the molten bath. The gun was of the precessive type and a precession speed of 50 RPM was employed throughout these tests. A direct-current power supply was employed in which the molten bath formed the anodic contact while the plasma gun comprised the cathode.

The furnace was operated at slightly positive pressures (20Pa. gauge) and the feed material consisted solely of ferromanganese metal fines as detailed in Table 1. These metal fines contain a small percentage of slag which is included in the manganese, iron and silicon reported analyses given in Table 1. The liquid products were tapped continuously in two campaigns lasting a total of 8,0 hours at between 400 and 500 kW gross power input which yielded a specific energy consumption of 795kWh/t of metal product. The relatively small scale of the furnace resulted in a thermal efficiency of 75 per cent.

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compared with an expected 90 per cent on a larger scale, so that the specific energy consumption would more closely approach the theoretical value on a larger scale. The masses of feed, metal, slag and dust, together with the metal analyses are given in Table 2. The loss of manganese in the dust stream comprises only 0,65 per cent of the input manganese to the furnace, while 8,3 per cent of the feed was tapped as slag.

TABLE 1

Raw material analyses (%)

<u>Ferromanganese</u>	Mn	Fe	Si	C	S	P
<u>Metal Fines</u>						
Metal fines (50%-4mm)	75,5	14,5	0,68	6,95	0,006	0,07

TABLE 2

Re-melting of ferromanganese metal fines (kg)

Test no.	Feed	Metal	Slag	Dust
A	1335	1389	131	7
B	3310	3153	297	13

Metal Analyses	Mn	Fe	Si	C	S	P (% by mass)
A	74,0	17,9	0,22	6,00	0,003	0,09
B	76,2	15,6	0,16	6,51	0,003	0,09

EXAMPLE 2 REMELTING OF HIGH CARBON FERROMANGANESE METAL  
FINES USING A CONSUMABLE ELECTRODE.

Tests were carried out on a small d.c. 100 kV.A furnace equipped with a hollow graphite electrode as the cathode. The molten bath constituted the anode and electrical contact was established via three stainless steel anodes in the hearth refractory. The graphite electrode was free to move axially in order to vary the arc length, argon and/or nitrogen was injected down the electrode, and the feed was gravity fed into the bath directly. A total of 180 kg of metal fines were fed to the furnace and the product and feed analyses appear in Table 3. The specific energy consumption was comparable to the value achieved in Example 1 after adjusting for the lower thermal efficiency of this smaller furnace (55%).

TABLE 3

Analyses of feed and products for remelting campaign of ferromanganese metal fines

Element	Feed metal %	Product metal (Average) %
Manganese	73,7	75,32
Iron	13,5	17,08
Silicon	1,8	0,5
Carbon	6,6	5,75
Sulphur	0,025	0,01
Phosphorus	0,12	0,084

EXAMPLE 3 REFINING OF HIGH-CARBON FERROMANGANESE METAL FINES

These tests were carried out in a small d.c. 100kV.A transferred-arc plasma furnace utilizing a water-cooled non-consumable plasma gun mounted centrally above the molten bath. The plasma gun only moved axially in order to alter the plasma arc length.

The furnace which had an outside diameter of 600 mm, and a wall thickness of 120 mm, was lined with a refractory material wherein the MgO content was approximately 95%. The hearth was lined with the same material to a thickness of 300 mm and three stainless steel rods were used to make the d.c. (anode) electrical connection to the molten bath through the hearth refractory. The furnace was heated to a temperature of between 1750°C and 1950°C with an initial metal charge to establish the molten bath. The compositions of the raw materials are given in Table 4, together with the masses of each component actually fed to the furnace. Considerable refining was achieved in that the carbon and silicon contents of the metal dropped from 6,6 per cent and 1,33 per cent to 0,80 per cent and 0,36 per cent respectively.

TABLE 4

Refining materials

Material	ANALYSES (% by mass)								
	Mn	Fe	SiO <sub>2</sub>	CaO	MgO	Al <sub>2</sub> O <sub>3</sub>	C	Si	Mass feed (kg)
Mamatwan ore	36,7	5,84	8,57	16,7	3,01	0,19	-	-	16,5
Dolomite	0,81	0,57	1,77	30,4	20,0	0,35	-	-	3,3
FeMn Metal fines	74,7	13,8	-	-	-	-	6,6	1,33	33,0

EXAMPLE 4 THE REFINING OF HIGH CARBON FERROMANGANESE

Tests were carried out in refractory lined vessels using a hollow graphite electrode as the cathode and the molten bath as the anode at powers of 30 kW, yielding bath temperatures from 1590°C to 1620°C. The feed consisted of a synthetic ore (prepared previously) and ferromanganese metal fines with a metal:ore ratio of 2:1. The analyses of the feed materials are given in Table 5 and the results of the refining tests showing a lowering of the carbon and silicon contents of the metal for each of the synthetic ore compositions are given in Table 6.

TABLE 5

Feed material analyses (%)

	Mn	Fe	Si	C		
Ferromanganese metal fines	73,8	13,4	0,8	6,6		
	MnO	FeO	MgO	CaO	SiO	Al <sub>2</sub> O <sub>3</sub>
Synthetic ore A	54,6	13,7	4,22	10,7	10,8	0,82
Synthetic ore B	52,1	12,2	3,6	17,5	6,9	0,93

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TABLE 6

Refining test results

Synthetic Ore	Mn Recovery	Metal Analyses (%)			
		Mn	C	Si	S
A	80	67	3,0	0,17	0,01
B	82	70	1,8	0,12	0,01

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It is to be understood that the method according to this invention and exemplified above may also include the use of an alternating current power supply to generate the transferred arc thermal plasma.

The invention therefore provides an effective and simple process for refining, melting and otherwise treating ferromanganese alloys.

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WHAT WE CLAIM IS :-

1. A method of treating ferromanganese alloys in which the alloy is treated in a suitable reactor having a substantially non-oxidizing atmosphere whilst being heated by a transferred-arc thermal plasma, as defined; wherein the treatment is primarily accomplished in the molten bath; and wherein feed material is fed directly to the bath.
2. A method of treating ferromanganese alloys according to Claim 1 wherein the feed material passes through the area defined by the thermal plasma arc.
3. A method of treating ferromanganese alloys according to either Claim 1 or Claim 2 in which the reactor is operated with the interior thereof at a slight positive pressure with respect to prevailing atmospheric pressure.
4. A method of treating ferromanganese alloys according to any one of the preceding claims in which the feed material added to the



reactor is purged with inert gas prior to entering the reactor.

5. A method of treating ferromanganese alloys according to any one of the preceding claims in which the transferred arc thermal plasma is generated by a direct current power supply.
6. A method of treating ferromanganese alloys according to any of the preceding claims in which the transferred arc thermal plasma is generated by an alternating current power supply.
7. A method of treating ferromanganese alloys according to any one of the preceding claims wherein an electrical connection to the molten bath is made using at least one electrode embodied in the lower regions of the reactor.
8. A method of treating ferromanganese alloys according to any one of the preceding claims wherein at least one cooled essentially non-consumable electrode is employed above the bath.
9. A method according to any one of the preceding


claims wherein at least one consumable electrode is employed above the bath.

10. A method according to any one of the preceding claims wherein the electrodes employed above the bath can be made to precess at a preselected speed.
11. A method according to any one of the preceding claims wherein the electrodes employed above the bath can be made to oscillate at a preselected frequency.
12. A method of treating ferromanganese alloys according to any one of the preceding claims wherein the feed material includes ferromanganese alloy fines.
13. A method of treating ferromanganese alloys according to any one of the preceding claims wherein carbonaceous<sup>a</sup> reductant is used.
14. A method of treating ferromanganese alloys according to any one of the preceding claims wherein the ferromanganese alloy is refined in that the content of at least carbon or silicon

is lowered by the addition of at least one suitable metal oxide.

15. A method of treating ferromanganese alloys according to Claim 14 wherein the metal oxide is an oxide of at least iron or manganese.
16. A method of treating ferromanganese alloys according to any one of the preceding claims wherein a suitable flux is used.
17. A method of treating ferromanganese alloys according to any one of the preceding claims in which the feed rate and the energy input are adjusted to achieve and maintain desired temperatures of slag and molten metal.
18. A method as claimed in Claim 1 and substantially as exemplified in any one of the accompanying examples.
19. A ferromanganese alloy whenever it has been treated by a method as claimed in any one of the preceding claims.

DATED this 27th day of SEPTEMBER 1983

  
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JOHN S. KBRIFOK  
for the Applicants