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John & Kernick
FORM P1

REPUBLIC OF SOUTH AFRICA
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APPLICATION FOR A PATENT AND
ACKNOWLEDGEMENT OF RECEIPT.
Section 30(1) - Regulation 39

The grant of a Patent is hereby requested by the undementioned applicant(s) on the present application filed in duplicate

21	01	Official application No.	22	Lodging date	J&K Reference
917598			24th September, 1991		P 11295 ZA/MvS

71 Full Name(s) of applicants:
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54 Title of Invention
THE RECOVERY OF PLATINUM GROUP METALS AND GOLD FROM SOURCES CONTAINING SAME.

The applicant claims priority as set out in the accompanying form P2. The earliest priority claimed is - ZA 90/7892 3rd October, 1990.

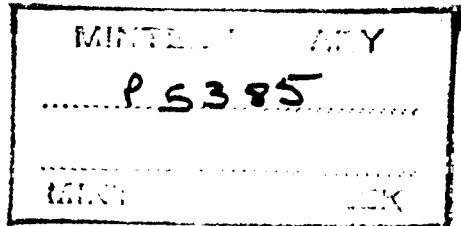
This application is for a Patent of Addition to Patent/Application No.

This application is a fresh application in terms of S 37 and based on application no.

This application is accompanied by:

- 1a A single copy of a provisional specification of _____ pages
- 1b Two copies of a complete specification of 27 pages
- 2a Informal drawings of _____ sheets
- 2b Formal drawings of 1 sheets
- 3. Publication particulars and abstract (form P8 in duplicate)
- 4. A copy of Figure 1 of the drawings for the abstract
- 5. Assignment of invention (from the inventors) or other evidence of title
- 6. Certified priority documents (_____ documents)
- 7. Translation of priority documents (_____ documents)
- 8. Assignment of priority rights
- 9. A copy of the form P2 and the specification of S.A Patent Application
- 10. A declaration and power of attorney on form P3
- 11. Request for ante-dating on form P4
- 12. Request for classification on form P9
- 13a Request for delay of acceptance on form P4
- 13b

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21	01	90/7892
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74 Address for Service: JOHN & KERNICK, PRETORIA.

Date 24th September, 1991

The duplicate will be returned to the applicant for service as proof of lodging but is not valid unless endorsed with official stamp.

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COMPLETE SPECIFICATION
(Section 30(1) - Regulation 28)

21	01	Official application No.	22	Lodging date	J&K Reference
917598			24th September, 1991		P 11295 ZA/MvS
51	International classification				
C22B					
71	Full Name(s) of Applicant(s)				
MINTEK . A legal body organised and existing under the laws of the Republic of South Africa.					
72	Full name(s) of Inventor(s)				
Eugene Barend PRETORIUS, Lawrence Bruce McRAE.					
54	Title of invention				
THE RECOVERY OF PLATINUM GROUP METALS AND GOLD FROM SOURCES CONTAINING SAME.					

- 2 -

"THE RECOVERY OF PLATINUM GROUP METALS AND GOLD
FROM SOURCES CONTAINING SAME"

FIELD OF THE INVENTION

THIS INVENTION relates to the recovery of platinum
group metals and gold from source materials containing
same and, more particularly, but not exclusively, from
source materials that are derived from the processing
5 of naturally occurring ores. Still more particularly
the invention is concerned with the recovery of
platinum group metals and gold from source materials
containing same and wherein the source material

/contains insufficient

contains insufficient sulphur, nickel, or copper, singly or collectively, to produce the usual PGM and gold collecting sulphide matte phase.

BACKGROUND TO THE INVENTION

Platinum group metals and gold occur in minor quantities in a number of different ore bodies. One of the most well known, in South Africa, is that of the Merenksy Reef in which case a flotation concentrate is formed containing the PGM's and gold. This concentrate contains extremely low quantities of chromite and appreciable quantities of nickel, copper and sulphur. Smelting of such a concentrate results in the formation of a matte phase in which the bulk of the PGM's and gold collect, and the matte phase is then processed further for the recovery of the PGM's and gold.

In the case of another ore body, known as UG-2 Reef, appreciable quantities of chromite are present in a PGM and gold containing concentrate derived from the processing of the above Reef. These quantities of chromite have given rise to considerable difficulties

/in the

in the recovery of the PGM's and gold. The main reason for this is that the chromite, during smelting, tends to cause the formation of a secondary spinel which is deleterious to the operation of the process and also to the furnace itself. Processing of such a concentrate generally involves steps to decrease the amount of chromite present.

A process has been proposed in which carbon is employed as a reductant and a matte is obtained in which the bulk of the PGM's and gold are collected and, in some cases, a ferro-nickel alloy phase is sometimes formed.

Various other processes have been proposed in which copper, iron, nickel or ferro-nickel are employed as collector metals, such processes generally being applicable to certain types of concentrates obtained from naturally occurring sources, as well as from subdivided carriers of PGM's and gold originating in scrap industrial items such as discarded motor vehicle exhaust catalysts and components from the electronics industry.

/As far

As far as the applicant is aware, and probably due to the perceived unfavourable composition thereof (principally high chromite content), certain types of concentrates which are available from natural sources have not been treated for the recovery of PGM's and gold therefrom simply by virtue of their inherent composition which makes it totally unattractive to do so by conventional means.

One such material is the tailings from chromite producing plants employed for extracting chromite from the so called LG and MG Reefs in South Africa. The tailings from the chromite production process contain, in many instances, between 1 and 4 ppm of PGM's and gold, which is significant when compared to the PGM content of a Merensky or UG-2 Reef concentrate which contains between 3 and 11 ppm. The difficulty with this type of material is that it contains high proportions of chromite (or Cr_2O_3), insignificant quantities of copper and nickel and, generally a low content of sulphur.

It has now been found that a material of this general nature, irrespective of its origin (ie whether natural

/or in

or in scrap form) can indeed be effectively treated for the recovery of its PGM and gold content by a relatively simple pyrometallurgical process.

SUMMARY OF THE INVENTION

In accordance with this invention there is provided a
5 process for the recovery of PGM's and gold from source materials containing same, and wherein the source material contains:-

- (i) less than about 0.7% by weight copper (Cu);
- (ii) less than about 0.5% by weight nickel (Ni) and;
- 10 (iii) at least 20 ppm PGM's and gold;

the process comprising the steps of:-

- (i) forming a feed mixture of subdivided materials wherein the feed mixture comprises:

- (a) said source material;

- / (b) a source

(b) a source of chromium (Cr) sufficient to provide Cr in the amount of from 2% to 30% by weight of the feed mixture;

5 (c) a source of iron (Fe) sufficient to provide Fe in an amount of from 5% to 15% by weight of the feed mixture;

10 (d) silica (SiO_2), or lime (CaO or CaCO_3), or other slagging agents, or mixtures thereof, in amounts chosen to provide a basicity from about 0,4 to 1,5 and;

15 (e) a reductant in the form of carbon (C) or silicon (Si), or a mixture thereof, in a quantity sufficient to reduce the greater proportion of the iron oxide and some of the Cr present in the feed mixture;

(ii) smelting the feed mixture at a temperature of at least 1400° to form a molten Fe-Cr-Ni-Si-C, alloy as a collector phase, and a slag; and,

/(iii) recovering for

(iii) recovering for further processing the Fe-Cr-Ni-Si-C alloy collector metal together with PGM's and gold contained therein.

5 Further features of the invention provide for the source material to be a concentrate obtained from subdivided naturally occurring ores, in particular chromite ores; for the concentrate to be obtained by
10 the treatment of the tailings of a chromite ore by the process of attrition, optional screening, and flotation; for such chromite tailings to be those obtained from the treatment of the LG5, LG6 or MG chromitite layers of the Bushveld Complex of South Africa; and for the conditions of obtaining the
15 concentrate to be adjusted to provide a chromic oxide (Cr_2O_3) content of from 4% to 20% by weight Cr_2O_3 (ie 2,7% to 14% by weight Cr).

Still further features of the invention provide for the source material to contain more than about 100 ppm
20 PGM's and gold; for at least the major part, and preferably all, of both the Cr and Fe to be present in the source material itself as oxides and generally as

/chromite; for

chromite; for chromium to be present in the feed mixture in an amount of from 2,7% to 14% by weight and iron in an amount of from 3% to 15% by weight; for the basicity of the mixture to be from 0,4 to 1,0, and preferably about 0,7, the adjustment being made, as stated, by suitable additions of SiO₂, CaO, or other slagging agents; for the reductant to include carbon in an amount chosen to produce a carbon content of the Fe-Cr-Ni-Si-C alloy collector from 2% to 8% by weight; for the smelting to be carried out under an inert atmosphere, such as an argon or nitrogen atmosphere; for smelting to be carried out at a temperature of from 1500 to 1550°C or higher; and for the smelting to be carried out preferably in a plasma furnace or, alternatively, in a submerged arc furnace.

The invention also provides the additional, optional steps of:-

- (i) (a) roasting the source material to reduce the sulphur content thereof prior to forming the feed mixture; and/or

/ (b) pelletizing or

(b) pelletizing or otherwise agglomerating the feed mixture; and/or

(ii) crushing the final Fe-Cr-Ni-Si-C alloy collector in the event that it is crushable or granulating same in the event that it is not crushable, and

(iii) recovering the PGM's and gold from the crushed or granulated ferrochromium alloy collector by suitable hydrometallurgical processes.

In contradistinction to prior processes in which PGM's and gold are recovered from chromite containing ores and where the chromite content is limited as much as possible, the present process operates more effectively at somewhat higher chromite contents.

Figure 1 is a graph illustrating this aspect and the fact that the PGM recovery increases with increasing chromite content of a flotation concentrate, in this case obtained from the tailings of a process for extracting chromium from the aforementioned LG-6 reef.

It will be seen, and will become more apparent for the

/following, that

following, that optimum recoveries are expected to take place where the chromium oxide (Cr_2O_3) content of the flotation concentrate is about 12% by weight. At this point the PGM recoveries are highly acceptable.

5 It will be clear to those skilled in the art that a composition of the concentrate can thus be optimised for any particular starting material by using appropriate flotation techniques and conditions.

Whilst the precious metals are recovered predominantly in the metal alloy collector phase, where sulphur is present, a small amount of sulphide inclusions may be formed.

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In order that the above and other features of the invention will be more fully understood, various tests which have conducted to date will now be described.

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BRIEF DESCRIPTION OF THE DRAWING

The accompanying drawing is a graph illustrating the recovery of PGM's in a concentrate made from tailings of a chromium recovery process.

/DETAILED DESCRIPTION

DETAILED DESCRIPTION OF TESTS CONDUCTED

Initially a large number of laboratory scale experiments were conducted to test the process of the invention. In these tests several different flotation concentrates obtained from three different sources (in some cases part of which was roasted), in particular different tailings from chromium producing plants, were tested. The composition of these concentrates are given in Table 1 below:-

Table 1

Conc. No.1	Conc. No.2	Conc. No.3	Conc. No.4	Roasted Conc. No.1	Roasted Conc. No.2	
Wt% MgO	23.13	24.88	26.62	22.37	23.65	25.04
Wt% Al ₂ O ₃	5.08	5.76	3.06	5.60	5.21	5.73
Wt% SiO ₂	37.94	48.14	47.8	38.55	39.83	46.13
Wt% CaO	1.59	1.83	1.14	2.33	1.81	2.02
Wt% TiO ₂	0.28	0.71	0.29	0.40	0.35	0.76
Wt% Cr ₂ O ₃	12.48	7.91	6.57	13.48	13.79	8.57
Wt% Fe ₂ O ₃	13.44	9.26	7.47	13.39	14.76	9.95
Wt% MnO	n.d.	n.d.	n.d.	<0.20	<0.15	<0.15
Wt% S	0.79	0.59	0.14	0.10	0.16	0.09
Wt% Ni	0.32	0.21	570 ppm	0.10	n.d.	n.d.
Wt% Cu	0.15	0.18	380 ppm	315 ppm	n.d.	n.d.
Total PGM's + Au	519 ppm	220 ppm	375 ppm	11 ppm	520 ppm	201 ppm

/Small quantities

Small quantities of these concentrates were smelted at 1500 to 1550°C under an argon atmosphere. The results are given in the table below. The feed mixture in each case comprised the concentrate itself as well as the various additions of C, Si, SiO₂, Al₂O₃ and CaO, as shown in the column headed "Addition" in Table 2.

/

Table 2

Concentrate	Addition	% Collector	% Loss to Slag	PGM's in collector (ppm)	% Cr in collector alloy	Basicity % %MgO + %CaO % SiO ₂	Recovery of PGM's
No.1	4% Si	9.35	0.13	5509	7.69	0.44	99.87
No.1	4% Si	9.97	0.07	-	-	0.39	99.93
No.1	4% Si	9.83	0.63	4995	10.90	0.45	99.37
	+5% Al ₂ O ₃						
No.1	5% Si	12.78	0.14	2736	22.0	0.42	99.86
Roasted No.1	5% Si	9.07	0.65	3997	7.11	0.43	99.35
No.1	4% C	4.0	3.86	5717	4.03	0.45	96.14
	+5% SiO ₂						
No.1	4% C	9.75	2.50	4558	17.8	0.42	97.50
	+10% SiO ₂						
No.1	5% C	12.84	1.80	3171	30.20	0.54	98.2
Roasted No.1	4% C	5.91	1.09	6403	3.99	0.40	98.9
	+10% SiO ₂						
Roasted No.1	5% C	7.24	8.15	3817	12.6	0.49	91.85
Roasted No.1	5% C	11.37	0.24	-	-	0.42	99.76
	+10% SiO ₂						
No.2	2% Si	3.72	6.31	5557	2.67	0.46	93.67
No.2	3% Si	7.13	5.67	2453	11.30	0.44	94.33
Roasted No.2	3% Si	4.46	7.4	4581	2.31	0.44	97.16
No.2	2% C	4.55	1.26	-	-	0.48	98.74
No.2	2% C	3.83	4.80	5134	3.08	0.49	95.20
No.2	2% C	3.85	4.97	5247	3.05	0.45	95.03
	+5% SiO ₂						
No.2	2% C	4.02	5.02	4151	3.73	0.55	94.98
	+5% CaO						
Roasted No.2	2.5% C	4.0	2.61	-	-	0.42	97.39
No.2	3% C	7.73	5.14	1426	20.50	0.51	94.86
Roasted No.2	3% C	3.43	5.07	3371	2.21	0.50	94.93
No.3	2% Si	4.12	1.50	8649	4.73	-	98.50
No.4	4% C	8.91	<3.79	116	19.9	0.50	95.00
No.4	4% C	8.74	<3.79	168	19.2	0.49	>99
No.4	4% C	8.26	<3.74	232	19.7	0.48	>99
	+4% SiO ₂						
No.4	4% C	8.14	<3.95	-	-	0.45	>99
	+7% SiO ₂						

/It will

It will be seen that in all cases the PGM's were effectively collected.

Subsequent larger scale tests were then carried out. In these tests, the following concentrates were treated 5 similarly to the above, but in quantities of from 7,5 to 10kg. The flotation concentrates had the following compositions. (Table 3)

Table 3

Conc. No.	MgO	Al ₂ O ₃ %	SiO ₂ %	CaO %	Cr ₂ O ₃ %	FeO %	PGM ppm
5	22.8	3.7	41.8	2.3	9.3	10.7	103
6	24.9	3.5	46.1	2.4	7.0	8.7	43
7	23.5	3.2	44.6	2.5	6.6	8.9	95

The concentrate was pelletized in these tests and the additions made are given in Table 4 below.

Table 4

Run No.	Conc No.	Additions made (as a % of the concentrate)			
		Carbon %	SiO ₂ %	CaCO ₃ %	Al ₂ O ₃ %
1	5	5	6	-	-
2	5	8	-	30	-
3	5	3	3	-	-
4	6	2	2	-	-
5	7	3	2	-	-
6	6	2	2	-	-
7	7	5	12	-	15
8	7	5	12	-	15

The results are given in Table 5 below.

/

Table 5

Run No.	Fe %	Cr %	C %	Si %	Cu %	Ni %	S %	Pt g/t	Pd g/t	Rh g/t	Ru g/t	Ir g/t	Au g/t	Ag g/t	Total precious metal g/t	Crushing behaviour	Recovery of precious metals alloy (%)
1	54.3	28.7	5.3	2.84	0.95	2.88	0.55	495	168	112	219	11.0	4.27	12.6	1022	Easy	100
2	58.5	24.9	6.75	0.7	0.51	2.64	0.18	450.5	93	<100	<100	--	15	15	800	Easy	83.3
3	79.1	10.2	2.4	<0.2	0.90	4.77	1.20	834	199.5	144.0	340.5	30*	15*	15	1550	Difficult	65.0
4	66.0	9.3	1.2	5.08	1.26	12.7	0.8	1750	430	535	535	50*	5*	10*	3153	Moderately difficult	44.36
7	65.1	21.5	6.1	0.9	0.80	4.2	0.5	718	163	163	163	50*	5*	77	1357	Easy	90.60
8	79.0	6.7	3.0	<0.1	1.0	7.5	1.35	1045	300	330	330	50*	5*	10*	1765	Very difficult	47.2

* Estimated because "less than" analytical values were quoted.

The tests provided the following components of the collector alloy. The non-PGM and PGM components are given separately in Tables 8a and 8b:

Table 8a

Batch No	Fe %	Cr %	Cu %	Ni %	Si %	Al %	Mg %	C %	S %	Crushing	Basicity
1	81.1	8.56	1.33	6.53	<0.2	<0.1	<0.05	3.5	0.91	Difficult	0.98
2	60.6	27.75	1.00	2.87	1.58	<0.1	0.06	5.3	0.22	OK	0.96
3	57.9	28.40	1.02	2.74	3.35	<0.1	0.12	5.4	0.15	OK	0.70
4	71.3	18.10	0.72	2.30	0.34	<0.1	0.18	6.2	0.39	OK	0.71
5	84.6	4.74	0.80	3.52	<0.02	<0.1	<0.05	4.6	0.8	Difficult	0.97
6	86.4	4.20	0.93	3.80	<0.02	<0.1	<0.05	3.9	1.5	Difficult	0.75
7	49.1	37.15	0.54	1.74	4.54	<0.1	0.59	4.9	0.1	OK	1.01
8	66.4	21.7	0.57	1.89	2.50	<0.1	0.63	5.0	0.2	OK	0.75

Table 8b

Batch No.	Pt ppm	Pd ppm	Rh ppm	Ru ppm	Ir ppm	Au ppm	Ag ppm	Total ppm	Recovery of precious metals in alloy (%)
1	1133	305	248	610	65	5	2	2368	40.9
2	470	135	67	255	28	5	2	962	79.2
3	477	140	87	250	33	5	2	994	88.7
4	410	110	56	225	26	5	2	834	90.6
5	653	185	136	322	30	5	2	1333	75.2
6	720	190	120	390	30	5	2	1457	50.3
7	375	99	51	190	24	5	2	746	87.3
8	334	91	73	180	22	5	2	707	74.5

/It will

It will be noted that good PGM recoveries were experienced in most of the tests.

A further test was carried out at the 150kW level in a transferred plasma-arc furnace, and some 5t of concentrate was smelted.

To facilitate the feeding of the concentrate it was pelletized, using a 3% bentonite addition as a binder. The oxide content of the concentrate is given in Table 9a, and the precious metal content is given in Table 9b.

Table 9a

The oxide content of the concentrate used in the larger scale test

MgO %	Al ₂ O ₃ %	CaO %	SiO ₂ %	Cr ₂ O ₃ %	Fe ₂ O ₃ %
22.3	3.85	1.83	41.05	8.96	12.05

Table 9b

The precious metal content of the concentrate used in the larger scale test

Pt ppm	Pd ppm	Rh ppm	Ru ppm	Ir ppm	Au ppm	Ag ppm	Total ppm
130.9	32.5	23.9	63.9	10./0	0.2	3.6	265.0

It was considered from the analysis shown in Table 9a that this concentrate would be self-fluxing so no other additions, except coal, were made. The basicity in this case was 0,59.

5 In all, 45 heats were done. Samples of slag from each tap were taken for analysis. The dust from the furnace was collected and also submitted for analysis. All the alloy produced was crushed and then milled. A sample of this was also taken for analysis. Also,
10 once the furnace had cooled, it was dug out and samples of the remaining slag, alloy and slag contaminated refractory were taken.

The average slag analysis is given in Table 10.

Table 10

Average slag analysis

MgO %	Al ₂ O ₃ %	SiO ₂ %	CaO %	Cr ₂ O ₃ %	FeO %	Basicity	PGM-Au %
32,5	7,25	52,0-	3,34	4,0	1,0	0,69	0,468

/The base

The base metal content of the alloy is shown in Table 11a and the precious metal content of the alloy is shown in Table 11b.

Table 11a

Base metal content of the alloy.

Iron %	Chromium %	Silicon %	Carbon %	Sulphur %
49.4	29.2	5.9	3.4	0.9

Table 11b

The precious metal content of the alloy.

Pt ppm	Pd ppm	Rh ppm	Ru ppm	Ir ppm	Au ppm	Ag ppm	Total ppm
794	153	160	357	70	<5	<10	1549

Of the precious metal recovered the proportion reporting to the various possible recipients are:

In slag	0,186%
In furnace	3,255%
In dust	5,806%
In alloy	90,729%

/It will

It will be understood that the exact operating conditions will vary fairly widely and, in particular, according to the composition of the concentrate or source material being treated.

WHAT IS CLAIMED IS :-

1. A process for the recovery of PGM's and gold from source materials containing same, and wherein the source material contains:-

(i) less than about 0.7% by weight copper (Cu);

5

(ii) less than about 0.5% by weight nickel (Ni) and;

(iii) at least 20 ppm PGM's and gold;

the process comprising the steps of:-

(i) forming a feed mixture of subdivided materials wherein the feed mixture comprises:

10

/ (a) said source

- 5
- (a) said source material;
- (b) a source of chromium (Cr) sufficient to provide Cr in the amount of from 2% to 30% by weight of the feed mixture;
- (c) a source of iron (Fe) sufficient to provide Fe in an amount of from 5% to 15% by weight of the feed mixture;
- 10 (d) silica (SiO_2), or lime (CaO or CaCO_3), or other slagging agents, or mixtures thereof, in amounts chosen to provide a basicity from about 0,4 to 1,5 and;
- 15 (e) a reductant in the form of carbon (C) or silicon (Si), or a mixture thereof, in a quantity sufficient to reduce the greater proportion of the iron oxide and some of the
- 20 Cr present in the feed mixture;

/ (ii) smelting the

(ii) smelting the feed mixture at a temperature of at least 1400° to form a molten Fe-Cr-Ni-Si-C, alloy as a collector phase, and a slag; and,

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(iii) recovering for further processing the Fe-Cr-Ni-Si-C alloy collector metal together with PGM's and gold contained therein.

10 2. A process as claimed in claim 1 in which said source material provides a part or all of any one or more of constituents (b), (c) and (d) of the feed mixture.

15 3. A process as claimed in either of claims 1 or 2 in which the source material is a concentrate obtained from subdivided, naturally occurring ores.

4. A process as claimed in claim 3 in which the naturally occurring ore is a chromite ore.

/5. A process

5. A process as claimed in claim 4 in which the concentrate is obtained by the treatment of the tailings of a chromite ore by the process of attrition, optional screening, and flotation.

- 5 6. A process as claimed in any one of the preceding claims in which the chromium content of the feed mixture is from 2,7 to 14% by weight.

7. A process as claimed in claim 6 in which the chromium content of the feed mixture is about
10 12% by weight.

8. A process as claimed in any one of the preceding claims in which the iron (constituent (c)) content of the feed mixture is from 3 to 15% by weight.

- 15 9. A process as claimed in any one of the preceding claims in which the basicity of the feed mixture is from 0,4 to 1,0.

/10. A process

10. A process as claimed in claim 9 in which the basicity of the feed mixture is from about 0,6 to about 0,8.
- 5 11. A process as claimed in any one of the preceding claims in which the carbon is present in an amount chosen to provide a carbon content of the collector alloy of from 2 to 8% by weight.
- 10 12. A process as claimed in any one of the preceding claims in which smelting is carried out under an argon or nitrogen atmosphere.
13. A process as claimed in any one of the preceding claims in which smelting is carried out at a temperature of at least 1500°C.
- 15 14. A process as claimed in any one of the preceding claims in which the smelting is carried out in a plasma furnace.
15. A process as claimed in any one of the preceding claims in which the source material is roasted prior to the formation of the feed mixture.

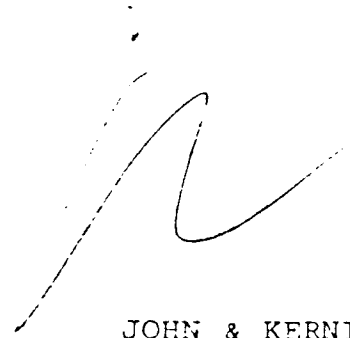
/16. A process

16. A process as claimed in any one of the preceding claims in which the feed mixture is pelletized or otherwise agglomerated.

5 17. A process as claimed in any one of the preceding claims in which the collector metal produced in the process is crushed or granulated (if it is not crushable) and the PGMS and gold are recovered therefrom hydrometallurgically.

10 18. A process substantially as herein described and exemplified by any of the test results provided.

DATED THIS 24 DAY OF SEPTEMBER 1991



JOHN & KERNICK
FOR THE APPLICANT

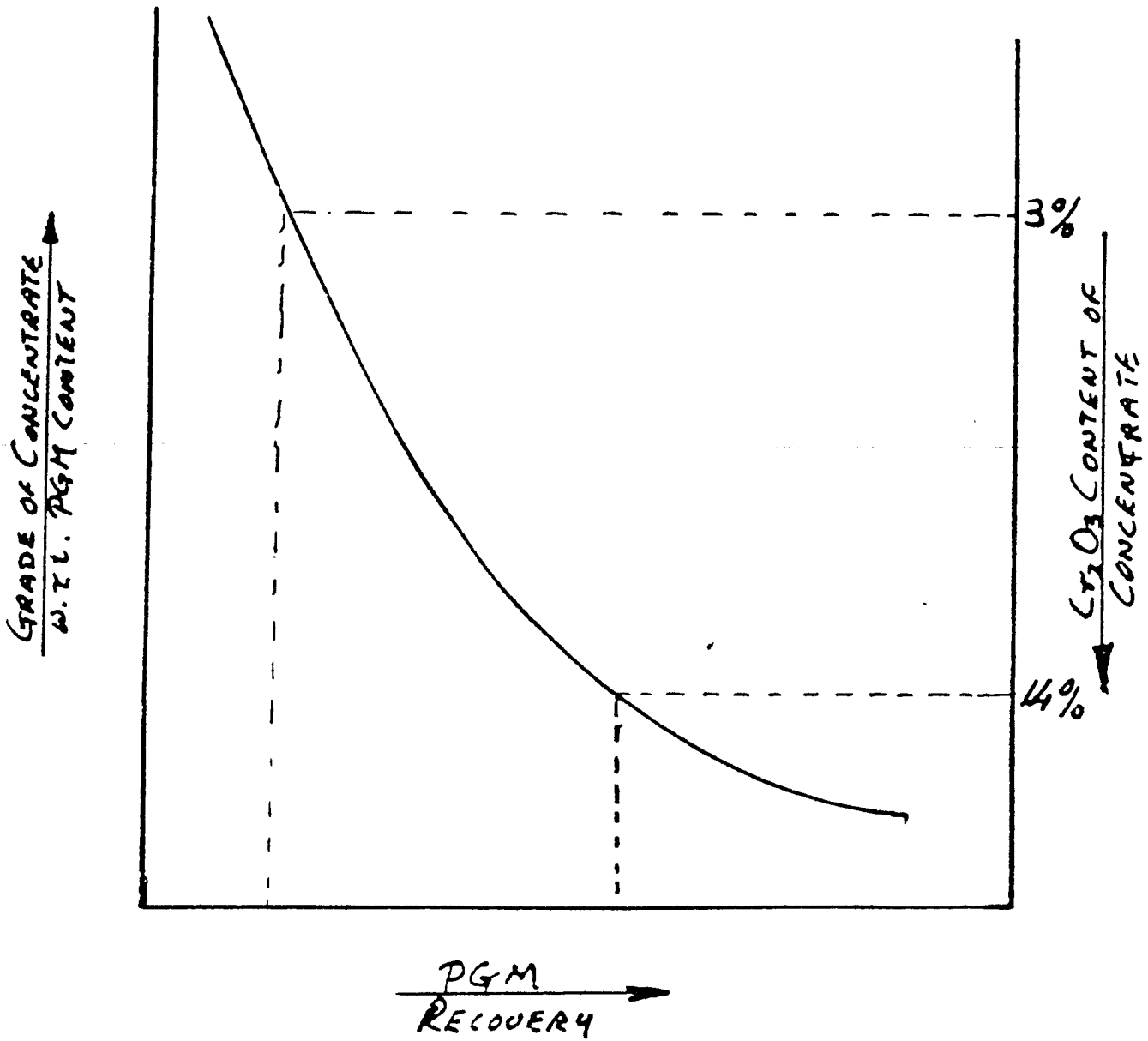


FIG 1

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