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Marles Franco

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[54] **PROCESS FOR MELTING A METAL CHARGE IN A ROTARY FURNACE AND ROTARY FURNACE FOR IMPLEMENTING SUCH A PROCESS**

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[51] **Int. Cl.**[7] **C21C 1/08**; F27B 7/20

[52] **U.S. Cl.** **75/414**; 75/571; 266/213; 266/248; 266/900

[58] **Field of Search** 75/476, 571, 581, 75/414; 266/213, 248, 900, 901

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Primary Examiner—Melvyn Andrews
Attorney, Agent, or Firm—Burns, Doane, Swecker & Mathis, LLP

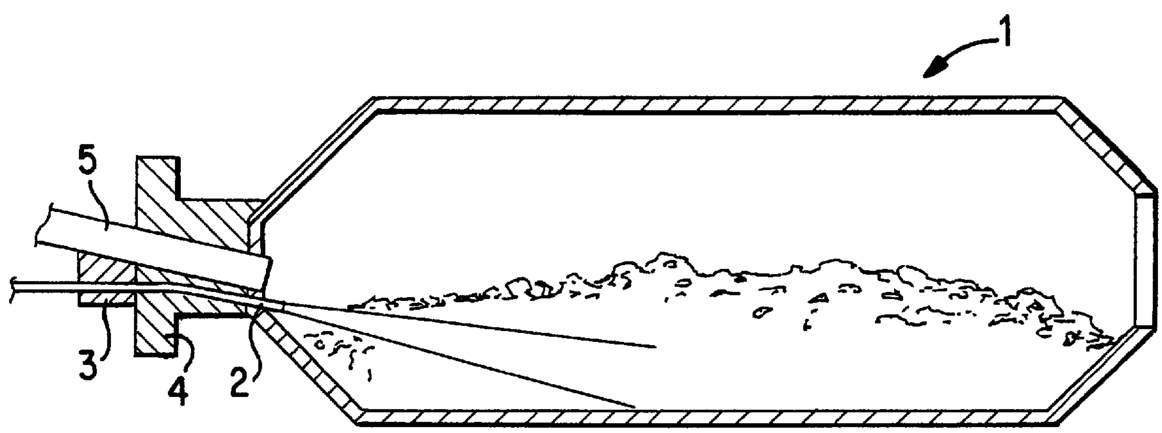
[57] **ABSTRACT**

Process for melting a metal charge in a rotary furnace equipped with at least one oxygen burner, comprising the steps of:

(i) adding between 1.5 and 9% of a charge of solid fuel to the metal charge to form a combined charge; and

(ii) injecting at least one jet of oxygen in a direction of the combined charge in the furnace.

17 Claims, 8 Drawing Sheets



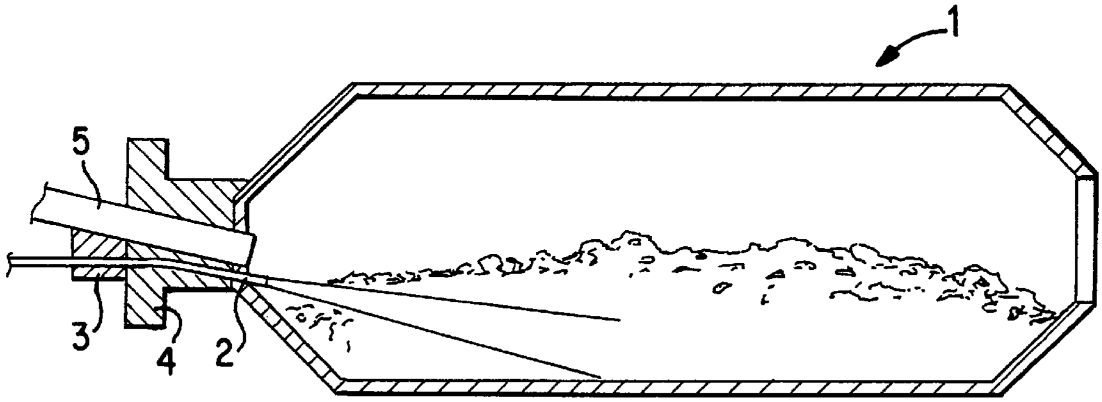


FIG. 1

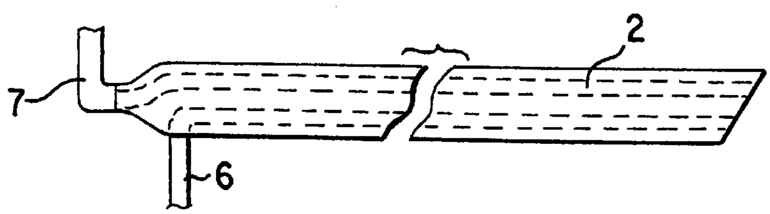


FIG. 2

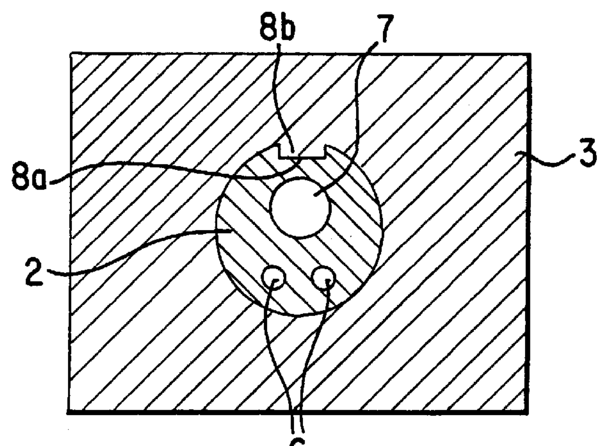


FIG. 3

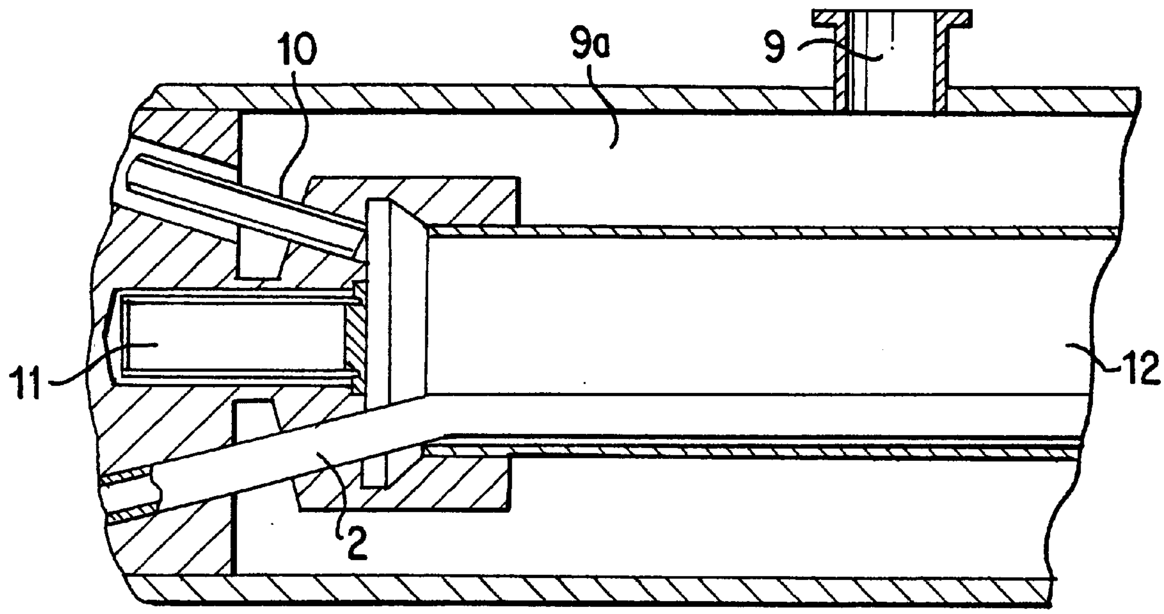


FIG. 4

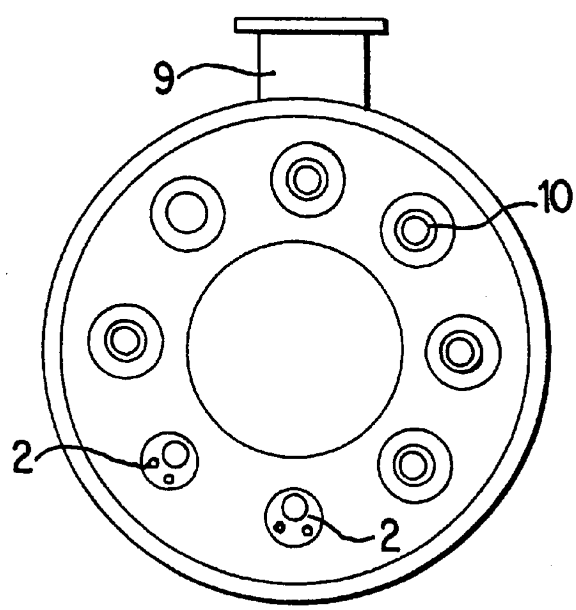


FIG. 5

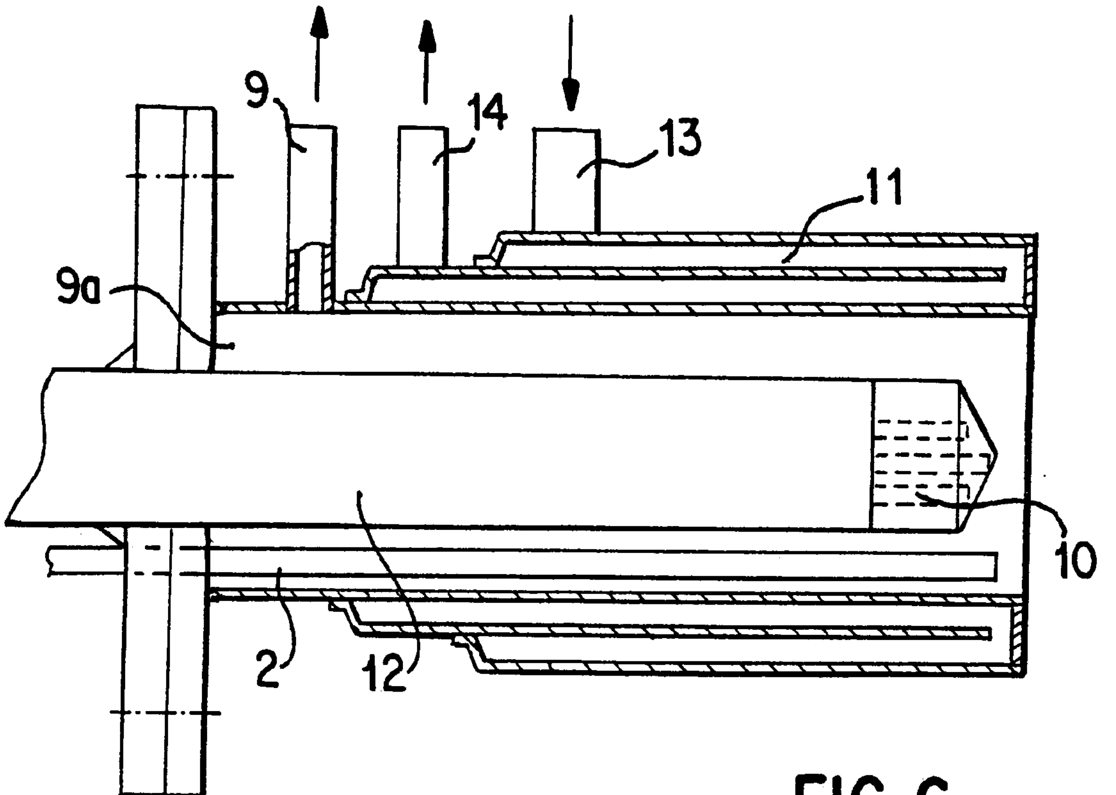


FIG. 6

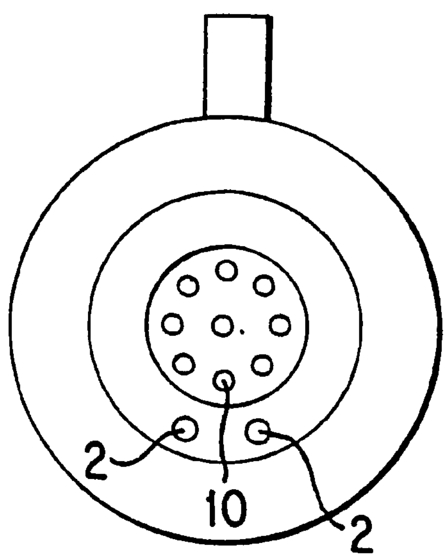
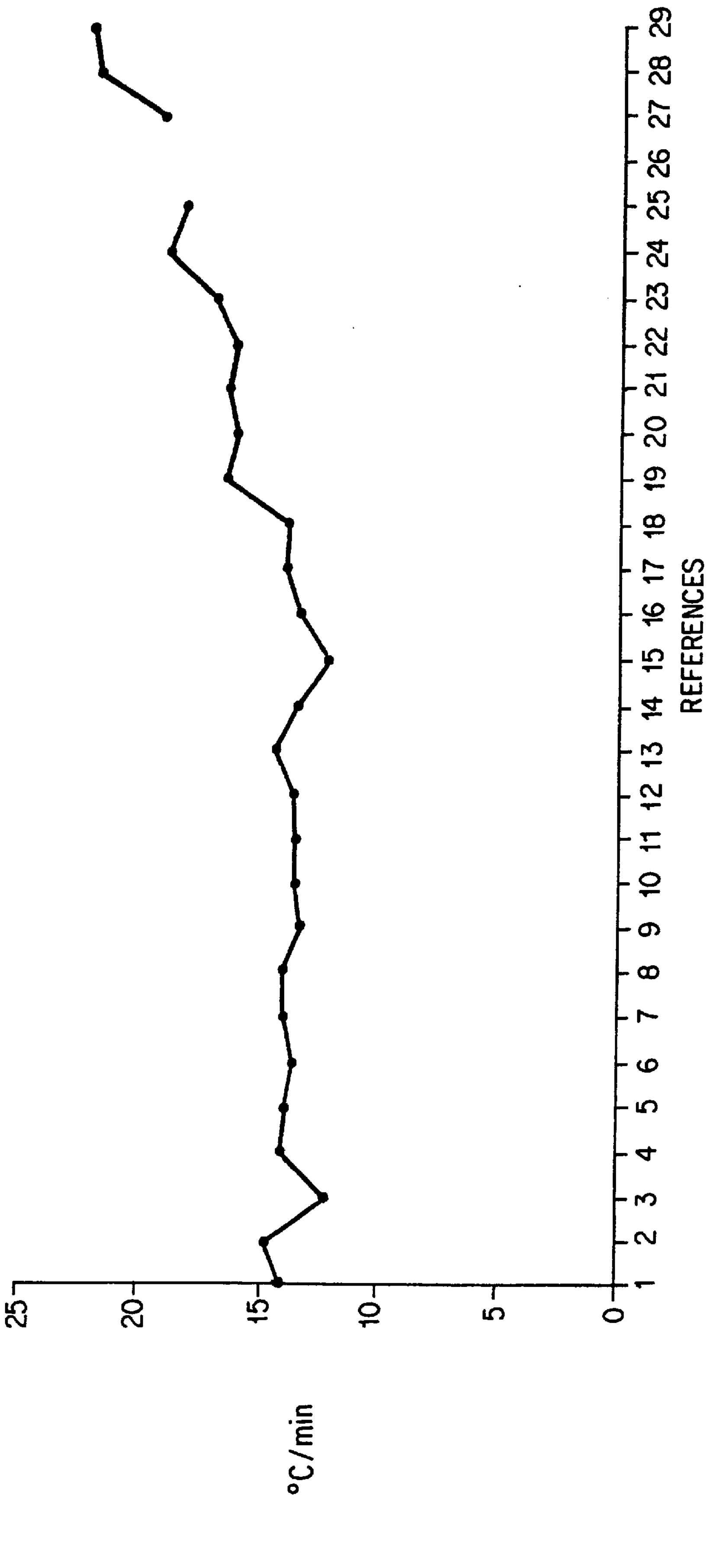


FIG. 7


°C/min
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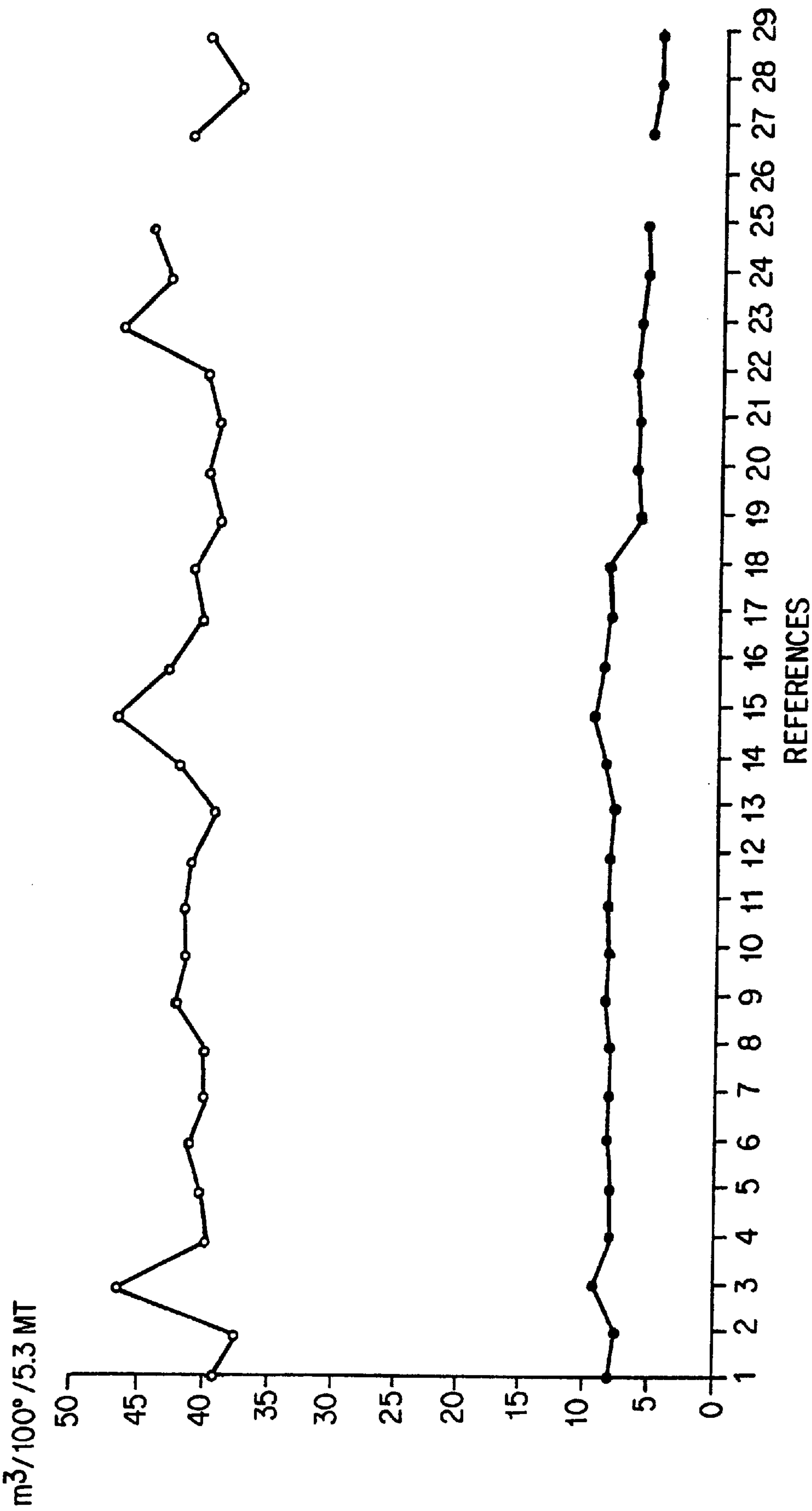
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
REFERENCES

FIG. 8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REFERENCES

FIG. 9

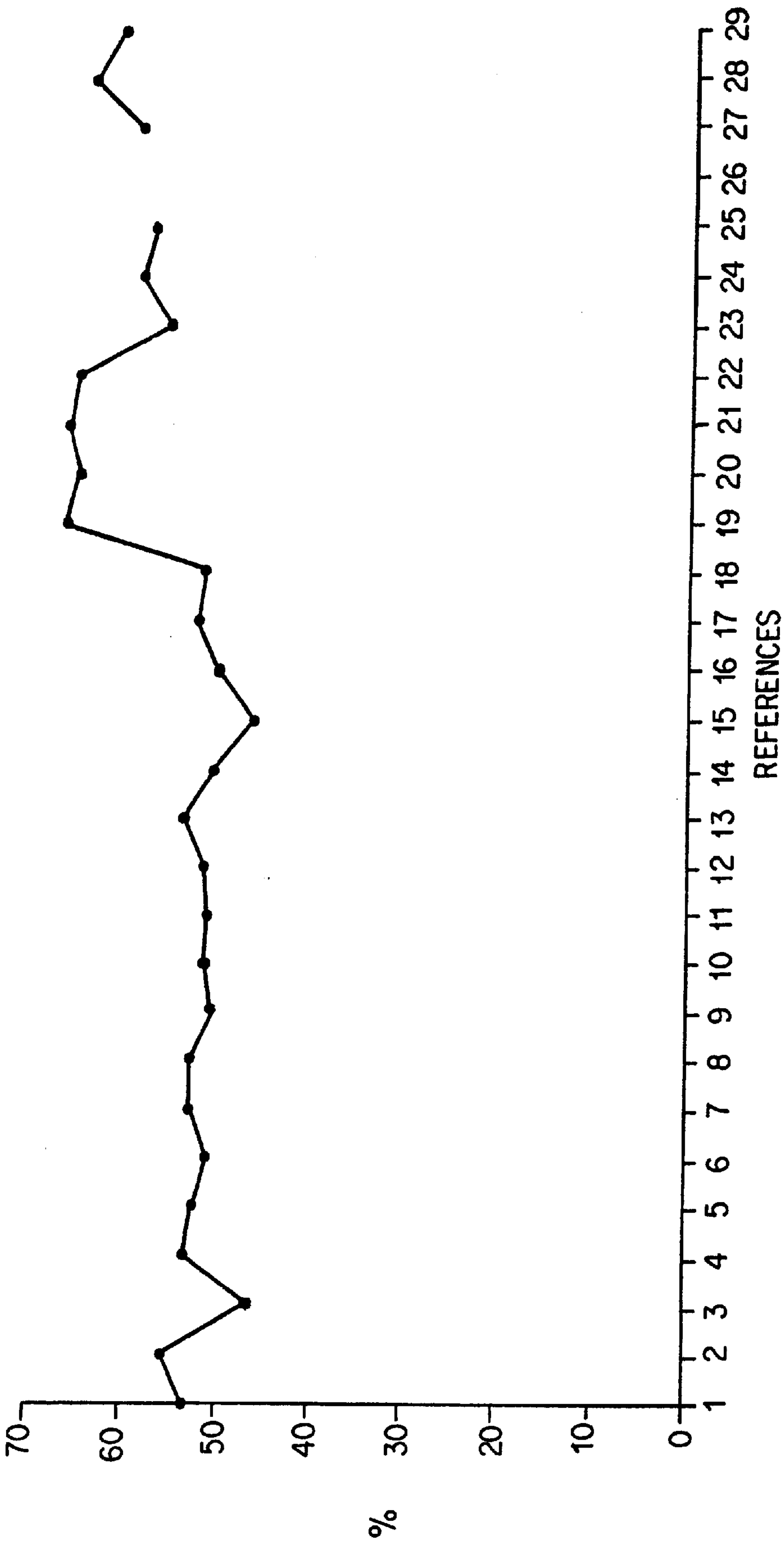
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FIG. 10

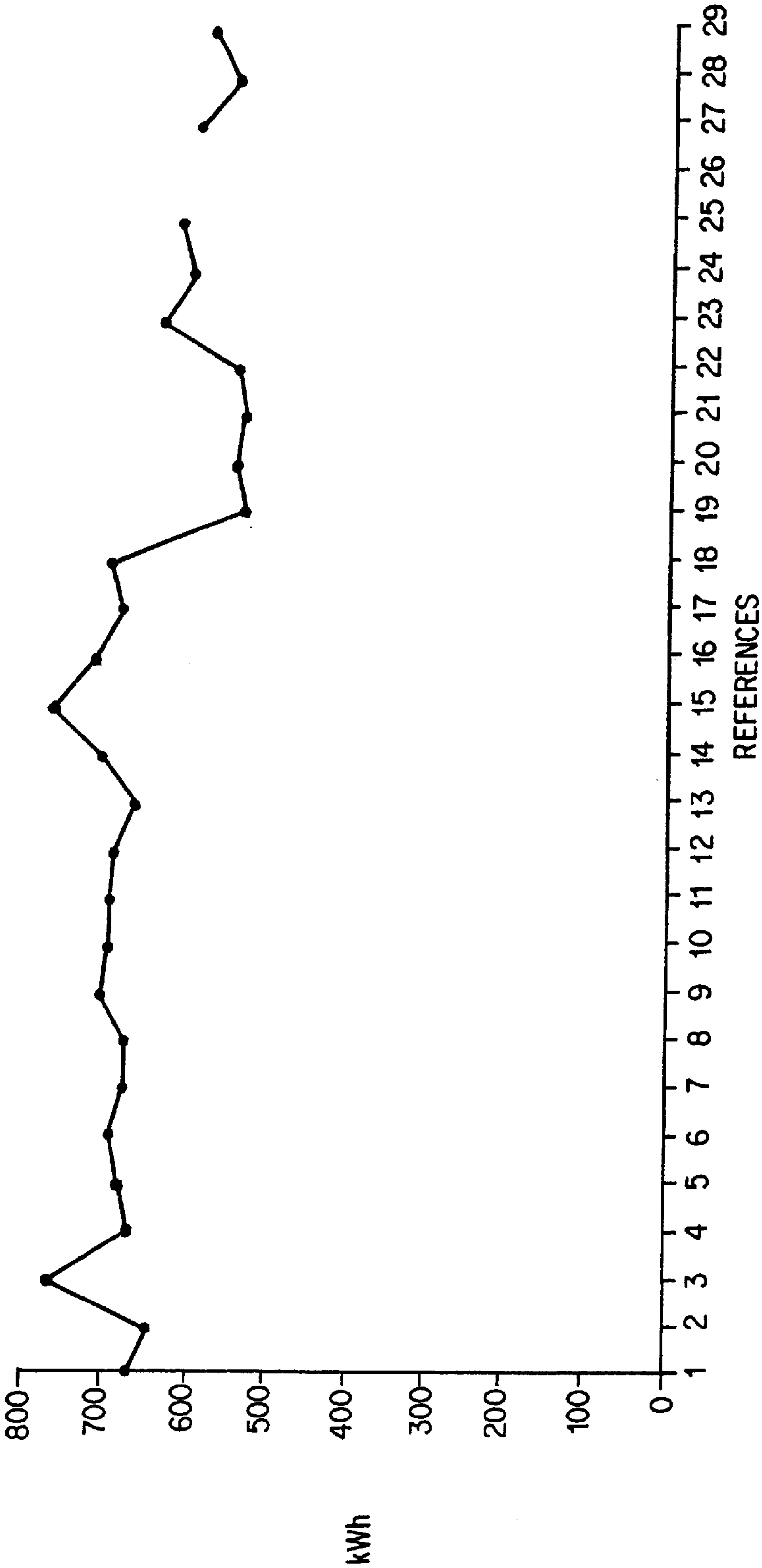
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FIG. 11

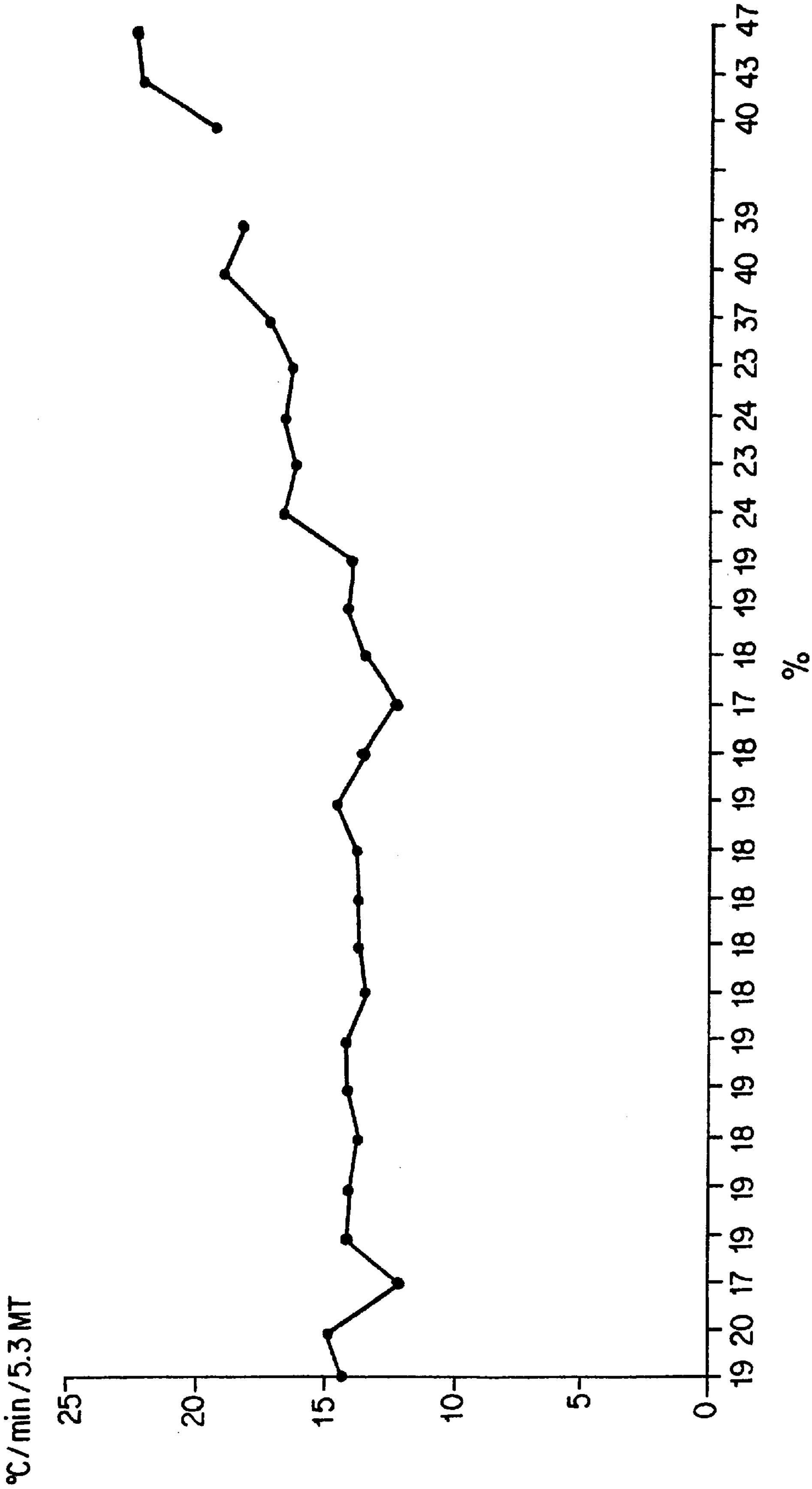
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FIG. 12

PROCESS FOR MELTING A METAL CHARGE IN A ROTARY FURNACE AND ROTARY FURNACE FOR IMPLEMENTING SUCH A PROCESS

BACKGROUND OF THE INVENTION

(i) Field of the Invention

The present invention relates to processes for melting metal charges in a rotary furnace equipped with at least one oxygen burner.

(ii) Description of Related Art

In known processes the oxygen burner, controlled in stoichiometric conditions, ensures the melting of the metal charge containing, optionally and for purely metallurgical reasons, small quantities of solid fuels, generally not exceeding 1% of the metal charge, in order to limit the formation of undesirable unburnt volatile compounds which, also where the oxygen burner is sued, limit the conditions in which the combustion is performed and, consequently, the rate of melting of the charge in the furnace.

A process for melting solid materials using an air or oxycombustible burner well under stoichiometric is known in DE-A-4142301, in which process oxygen is added in the oven with the aid of nozzles.

SUMMARY AND OBJECTS OF THE INVENTION

The objective of the present invention is to create an improved process enabling the rate and efficiency of melting in a given furnace to be significantly increased, while reducing the overall energy consumption.

To do this, according to one characteristic of the invention, the process includes the stages of adding a charge of solid fuel included between 1.5 and 9% to the metal charge to be melted and of injecting at least one jet of oxygen in the direction of the combine charge in the furnace.

According to other characteristics of the invention:

- the proportion of charge of solid fuels in the metal charge is between 1.5 and 9%, advantageously between 2 and 6%;
- the oxygen is injected at a speed close to the speed of sound or supersonic;
- the oxygen jet is injected, as soon as the burner is brought into action, between the flame of the burner and the combined charge in the furnace.
- the oxygen is injected at a speed which is close to the speed of sound or supersonic;
- the jet of oxygen is injected, as soon as the burner is brought into action, between the flame of the burner and the combined charge in the furnace.

Another objective of the present invention is a rotary furnace for implementing such a process, including, besides an oxygen burner, at least one oxygen lance placed so as to direct at least one jet of oxygen towards the bottom of the furnace.

With the process according to the invention the combustion is extended into the charge itself, where the oxygen injected by the lance interacts with the solid fuel which burns in direct contact with the metal, thus extremely considerably increasing the reaction surface and thus promoting accelerated melting without affecting the temperature conditions at the furnace refractory and therefore not reducing the lifetime of the latter. Furthermore, since an appreciable proportion, exceeding 35%, of the total combustion energy is provided in the charge by the solid fuel, the power of the burner and hence its cost can be significantly reduced.

Other characteristics and advantages of the present invention will emerge from the following description of embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagrammatic view, in lengthwise section, of an embodiment of a furnace for melting metal according to the invention;

FIGS. **2** and **3** are, respectively, side and sectional views of an embodiment of a multitube oxygen lance;

FIG. **4** is a partial view in lengthwise section of a burner with integrated lance according to the invention;

FIG. **5** is an end view of the burner of FIG. **4**;

FIG. **6** is a view in lengthwise section of another embodiment of a burner with integrated lance according to the invention;

FIG. **7** is an end view of the burner of FIG. **6**;

FIGS. **8** to **11** are graphs illustrating the operating parameters according to the conditions of Tables 1 to 3;

FIG. **12** is a graph illustrating the relationships between the rate of melting and the percentage of energy of combustion in the combined charge of the furnace.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. **1** a rotary furnace **1** is shown, in the end door **4** of which are fitted an oxygen burner **5** pointing towards the charge and an oxygen lance **2** which can be positioned adjustably by virtue of a guiding device **3**. According to the invention the lance **2** is pointed so as to direct, in the furnace **1**, a high-speed, typically supersonic jet of oxygen towards a combined charge of metal, typically of steel, to be melted and of a solid fuel in proportions which are typically higher than 2% of the metal charge. This solid fuel is typically anthracite, graphite, especially electrode graphite, or other products containing carbon and hydrogen, especially solid polyolefins. Examples of operating conditions are given later in relation to Tables 1 to 3 and FIGS. **8** to **12**. FIGS. **2** and **3** show a particular embodiment of an oxygen lance **2** including an upper main oxygen delivery **7** and two lower oxygen deliveries **6** enabling differentiated oxygen jets to be ejected in the direction of the charge and below the flame of the burner **5**. The lance body **2** comprises a groove **8*a*** interacting with a rib **8*b*** of the guiding device **3** for maintaining a correct orientation of the tubes **6** and **7** when the lance **2** is being adjusted forward or backward in the furnace **1**.

FIGS. **4** and **5** show an oxygen burner comprising a central delivery **12** of fuel gas into a shell forming a channel **9*a*** for oxygen introduced via an entry **9**, the fuel gas being ejected by the injectors **10** lying in the oxygen exit orifices in the nozzle of the burner, which are here angularly distributed around the axis of the burner. In the lower part of the latter the combined oxygen/gaseous fuel ejection orifices are replaced by at least one lance **2**, as described in relation to FIGS. **2** and **3**, and the upstream portion of which lies in the central fuel delivery **12**. The end of a central circuit for cooling the nozzle of the burner is shown at **11**.

FIGS. **6** and **7** show a cooled oxygen burner comprising a peripheral jacketing **11** for circulating water, introduced at **13** and discharged at **14**. As in the embodiment of FIGS. **4** and **5**, the burner includes a central fuel gas delivery **12** lying in an oxygen ejection channel **9***a* and opening outwards via a series of ejectors **10**, here distributed angularly and regularly. Here, at least one, in this case two oxygen lances **2** lie in the lower portion of the main oxygen channel **9***a* and open out to the exterior of the burner below the ejectors **10**. In this embodiment the main oxygen in the channel **9***a*, cooled by the jacketing **11**, takes part in the cooling of the oxygen lances **2**.

Depending on the geography of the furnace, the oxygen lance is adjusted so as to eject the jets of oxygen in the direction towards the charge at an angle of between 5 and 25° in relation to the axis of the furnace. The flow rate of the oxygen jets ejected by the lance is chosen to be between 25 and 150% of the flow rate of oxygen in the oxygen burner.

Depending on the dimensions of the furnace, a second oxygen lance may be provided, also directed towards the charge, in the opposite end of the furnace to the burner.

The oxygen being fed, both to the lance and to the oxygen burner, is advantageously oxygen with a purity of between 88 and 95%, supplied on site by a unit for separating gas from the air using adsorption, of the type known as PSA.

Particular operating conditions will now be described. The solid fuel, in proportions of 3.2% of the steel charge, in this case approximately 5.3 tons, is anthracite, and the oxygen injected by the lance **2** is ejected at a supersonic speed at an angle of approximately 10° in relation to the axis of the furnace.

The generalized combustion of the anthracite charge is obtained approximately 10 minutes after the full power of the burner is applied, in order to redistill thus the 7% of volatile compounds which the charge contains. Subsequently, when the combined charge in the furnace reaches the proper temperature, the 86.5% of carbon in the solid charge are converted to carbon monoxide while rising towards the surface of the charge. Under the flame of the burner the oxygen ejected by the lance produces an intense combustion zone which is particularly radiant and which is virtually entirely reflected towards the charge by the screening effect provided by the flame of the burner, which thus protects the walls of the furnace.

Thus, in accordance with the objectives of the invention, a high thermal efficiency of combustion of the unburnt residues by the injected oxygen is obtained, with a consequent increase in the energy yield per unit of time throughout the duration of the process, a reduced usage of the furnace refractory and smaller losses of the metal components of the charge.

In the Tables which follow, references 1 to 18 correspond to melting processes without oxygen injection with reduced anthracite charges, references 19 to 22 using an oxygen injection directed towards a metal charge containing 1.5% of anthracite, raised to 3% in references 23 to 28.

The values shown in Tables 1 to 3 are the following:

anthracite: weight in kg per one charge of metal,

time: respectively: melting/holding at temperature/total time,

temperature: ° C.,

melting rate: ° C./minute/5.3 ton of charge total consumption: propane/oxygen,

specific consumption: m^3/100° C./5.3 t (burner+lance),

steel analysis: Ce/C/Si.

TABLE 1

Ref.	Anthracite	Time	Temperature	Rate of melting	Total consumption
1	80	55/41/96	1.361	14.18	107/536
2	80	55/37/92	1.367	14.86	103/514
3	80	55/55/110	1.321	12.00	123/614
4	80	55/42/97	1.370	14.i2	108/542
5	80	55/42/97	1.346	13.88	108/542
6	80	55/42/97	1.321	13.62	108/542
7	80	55/43/98	1.376	14.05	109/547
8	80	55/42/97	1.362	14.04	108/542
9	80	55/46/101	1.341	13.28	113/564
10	80	55/44/99	1.340	13.50	111/553
11	80	55/49/104	1.405	13.50	116/581
12	80	55/42/97	1.324	13.60	108/542
13	80	55/35/90	1.291	14.34	101/503
14	80	55/44/99	1.324	13.37	111/553
15	80	55/53/108	1.298	12.02	121/603
16	80	55/50/105	1.379	13.30	117/586
17	80	55/44/99	1.377	13.91	111/563
18	80	55/43/98	1.345	13.72	109/547
19	80	55/30/85	1.399	16.46	83/542
20	80	55/30/85	1.364	16.05	83/542
21	80	55/29/84	1.381	16.44	82/536
22	80	55/30/85	1.370	16.12	83/542
23	150	40/40/80	1.360	17.00	79/397
24	150	40/32/72	1.360	18.90	72/358
25	150	40/35/75	1.367	18.20	75/375
26	150	Change			
27	150	40/35/75	1.436	19.15	75/375
28	150	33/32/65	1.422	21.90	65/325
29	170	33/27/60	1.330	22.17	60/300

TABLE 2

Ref.	Anthracite	Time	Temp.	Spec. consumption Propane/ oxyg.	Oxygen lance	Total oxygen
1	80	55/41/96	1.361	7.88/39.38		
2	80	55/37/92	1.367	7.50/37.60		
3	80	55/55/110	1.321	9.30/46.48		
4	80	55/42/97	1.370	7.90/39.56		
5	80	55/42/97	1.346	8.05/40.27		
6	80	55/42/97	1.321	8.20/41.03		
7	80	55/43/98	1.376	7.95/39.75		
8	80	55/42/97	1.362	7.95/39.75		
9	80	55/46/101	1.341	8.41/42.06		
10	80	55/44/99	1.340	8.25/41.27		
11	80	55/49/104	1.405	8.26/41.35		
12	80	55/42/97	1.324	8.18/40.94		
13	80	5s/35/90	1.291	7.79/38.96		
14	80	55/44/99	1.324	8.35/41.77		
15	80	55/53/108	1.298	9.29/46.47		
16	80	55/50/105	1.379	8.50/42.49		
17	80	55/44/99	1.377	8.02/40.16		
18	80	55/43/98	1.345	8.13/40.67		
19	80	55/30/85	1.399	5.93/38.74		
20	80	55/30/85	1.364	6.09/39.74		
21	80	55/29/84	1.381	5.94/38.81		
22	80	55/30/85	1.370	6.06/39.56		
23	150	40/40/80	1.360	5.81/29.19	233	630
24	150	40/32/72	1.360	5.29/26.32	223	581
25	150	40/35/75	1.367	5.49/7.43	230	605
26	150	change				
27	150	40/35/75	1.436	5.22/26.11	219	594
28	150	33/32/65	1.422	4.57/22.86	203	528
29	170	33/27/60	1.330	4.51/22.41	234	532

TABLE 3

Ref.	Anthracite	Time	Temp.	Spec. consumption	Steel analysis
1	80	55/41/96	1.361		
2	80	55/37/92	1.367		
3	80	55/55/110	1.321		
4	80	55/42/97	1.370		
5	80	55/42/97	1.346		
6	80	55/42/97	1.321		
7	80	55/43/98	1.376		
8	80	55/42/97	1.362		3.81/3.13/1.38
9	80	55/46/101	1.341		3.59/3.09/1.18
10	80	55/44/99	1.340		3.63/3.19/1.27
11	80	55/49/104	1.405		
12	80	55/42/97	1.324		3.64/3.09/1.88
13	80	55/35/90	1.291		3.70/3.16/1.99
14	80	55/44/99	1.324		3.67/3.17/1.44
15	80	55/53/108	1.298		3.52/3.09/1.34
16	80	55/50/105	1.379		3.62/3.04/1.68
17	80	55/44/99	1.377		
18	80	55/43/98	1.345		
19	80	55/30/85	1.399		
20	80	55/30/85	1.364		
21	80	55/29/84	1.381		
22	80	55/30/85	1.370		3.85/3.23/1.80
23	150	40/40/80	1.360	46.32	3.58/3.03/1.56
24	150	40/32/72	1.360	42.72	3.51/3.01/1.44
25	150	40/35/75	1.367	44.26	3.74/3.21/1.51
26	150	change			
27	150	40/35/75	1.436	41.36	3.71/3.17/1.55
28	150	33/32/65	1.422	37.13	3.58/3.06/1.51
29	170	33/27/60	1.330	40.00	

FIG. **8**, which illustrates the rates of melting in ° C./minute for a 5.3 t charge for each of references 1 to 29 of the above Tables, shows that the rate changes from above 15 to more than 20 in the case of references 28 and 29, which enables the period of noncontinuous rotation of the furnace to be reduced from 55 minutes to 33 minutes and the interval between rotations from 5 to 3 minutes.

FIG. **9**, which illustrates the consumption of propane (bottom curve) and of oxygen (top curve) for each of the references 1 to 29, shows that the specific consumption of propane can go down as far as 4.6 m^3 with an appreciably stable oxygen consumption.

FIG. **10** shows that the efficiency of melting moves from slightly more than 50% to more than 60–65%.

FIG. **11** shows that the energy consumption in kWh can be brought down from approximately 700 kWh to less than 600 kWh.

FIG. **12** shows that, according to references 1 to 29, the percentage of energy in the charge changes from less than 20 to more than 40 with a corresponding increase in the rate of melting from 15 to 22° C./minute.

I claim:

1. Process for melting a metal charge in a rotary furnace equipped with at least one oxygen burner, comprising the steps of:

(i) adding between 1.5 and 9% by weight based on the metal charge of a charge of solid fuel to the metal charge to form a combined charge; and

(ii) injecting at least one jet of oxygen in a direction of the combined charge in the furnace at an angle in a range from 5 to 25 degrees in relation to the axis of the furnace.

2. Process according to claim **1**, wherein the charge of solid fuel in the metal charge is present in a proportion between 1.5% and 9%.

3. Process according to claim **2**, wherein the charge of solid fuel in the metal charge is present in a proportion between 2 and 6%.

4. Process according to claim **1** wherein the oxygen is injected at a supersonic speed.

5. Process according to claim **1** wherein the jet of oxygen is injected between a flame of the burner and the combined charge in the furnace.

6. Process according claim **1** wherein the oxygen is injected as soon as the burner is brought into action.

7. Process according to claim **1**, further comprising supplying at least the injected oxygen from a unit for separating gas from air using adsorption.

8. Rotary furnace for melting a metal charge, comprising:

(i) at least one oxygen burner at an end of the furnace; and

(ii) at least one oxygen lance disposed at an angle in a range from 5 to 25 degrees in relation to the axis of the furnace to direct at least one jet of oxygen towards a bottom of the furnace.

9. Furnace according to claim **8**, wherein the lance comprises at least two oxygen injection channels.

10. Furnace according to claim **8** wherein the lance is disposed below the burner.

11. Furnace according to claim **8** wherein the lance is disposed in the burner.

12. Furnace according to claim **8** wherein the burner further comprises a plurality of angularly distributed injectors.

13. Furnace according to claim **9**, wherein the lance is disposed below the burner.

14. Furnace according to claim **9**, wherein the lance is disposed in the burner.

15. Furnace according to claim **9**, wherein the burner further comprises a plurality of angularly distributed ejectors.

16. Furnace according to claim **10**, wherein the burner further comprises a plurality of angularly distributed injectors.

17. Furnace according to claim **11**, wherein the burner further comprises a plurality of angularly distributed injectors.

* * * * *