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(54) **ELECTRODE, IN PARTICULAR FOR SIDERURGICAL ELECTRIC ARC FURNACES AND THE LIKE, AND RELATED OPERATION METHOD**

ELEKTRODE, INSBESONDERE FÜR ELEKTROLICHTBOGENÖFEN DER STAHLINDUSTRIE UND DERGLEICHEN, UND ENTSPRECHENDE OPERATIONSMETHODE

ELECTRODE DESTINEE EN PARTICULIER AUX FOURS SIDERURGIQUES A ARC ELECTRIQUE ET PROCEDE DE FONCTIONNEMENT CONNEXE

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EP 1 446 984 B1

Description

[0001] The present invention refers to an electrode and related operation method, addressed in particular to siderurgical electric arc furnaces and the like.

[0002] For siderurgical plant steelmaking electric furnaces are used which melt primary material, like e.g. metal scrap and the like, by the heat coming (directly or indirectly) from one or more AC or DC electric arcs.

[0003] Said arcs are generated by effect of the voltage between the graphite electrodes and the metal charge.

[0004] These electric furnaces use electrodes whose bottom end, defined electrode tip, is located at a distance from the metal (scrap or bath) under melting which increases proportionally to the value of the voltage applied between the electrodes and the charge.

[0005] Conventional electrodes are subject, during their operation, to wear phenomena on the tip (tip consumption) and on the electrode sidewall (oxidative consumption).

[0006] As it is inferrable from several technical papers, among which 'The Electric Arc Furnace - 1990' published by *International Iron and Steel Institute*, oxidative consumption depends up on the temperature and on the atmosphere surrounding the same electrodes, whereas tip consumption increases proportionally to the value of the current density crossing the electrodes.

[0007] In general, graphite consumption of an electrode in a steelmaking electric furnace may be quoted as follows:

* oxidative consumption: accounting for about the 50 ÷ 70% of the total consumption for high-productivity furnaces; and
* tip consumption: the remaining 30% ÷ 50%.

[0008] These consumptions, when too high, also imply frequent downtimes required to restore electrode functionality.

[0009] Consumptions and downtimes, together with electrical energy consumption, account for the most significant costs of steelmaking.

[0010] In order to reduce the problems highlighted above, and in particular the oxidative consumption, electrodes were developed providing cooling of their outer surface by water sprays. However, the latter fail to reach the electrode portion that is internal to the furnace.

[0011] For metallurgic and process aims, there were also developed electrodes having a duct coaxial thereto for introducing solid materials towards the bath and directly inside of the electric furnace.

[0012] These solid materials, like e.g. coal, have been used to generate foaming slags and to carry out the metallurgical reduction of the oxides present in the chemical composition of the slag produced during steelmaking.

[0013] However, the introducing of these solid materials causes further problems, in fact tending to make the operation of the electric arc instable, as well as frequently obstructing the optional axial hole of the electrode from which said materials are introduced.

[0014] US-A-3,730,961 (Bryce) discloses a method for igniting an arc furnace wherein a fuel oil or a gas is introduced through the electrode body into the space between the electrode and the furnace charge.

[0015] US-A-4,827,487 (Brotzmann et al.) discloses an electric arc furnace wherein a carbonaceous fuel is introduced through one or more hollow electrodes.

[0016] The technical problem underlying the present invention is that of providing novel electrodes allowing to overcome the abovementioned drawbacks, in particular allowing to reduce the consumption thereof and therefore the maintenance interventions.

[0017] This problem is solved by an electrode as defined in appended claim 1.

[0018] The main advantage of the electrode and of the related operation method according to the present invention lies in allowing a relevant reduction in the consumption, both the tip and the oxidative one, of the conductive bottom (graphite) component of the electrode, thereby increasing the service life and reducing the number of changeouts thereof .

[0019] The present invention will hereinafter be described according to a preferred embodiment thereof, given by way of a non-limiting example and with reference to the attached drawings, wherein:

* figure 1 is a schematic view of a DC electric furnace incorporating a mono electrode according to the present invention;
* figure 2 is a schematic view of the electrode of figure 1 in a longitudinal section thereof;
* figure 3 shows an enlarged detail of the electrode shown in figure 2.
* figure 4 shows an enlarged detail of the electrode tip from which two fluids are concomitantly injected.
* figure 5 shows a temperature change diagram of an electrode cooled according to the present invention.

[0020] With reference to figure 1, a siderurgical electric arc furnace is indicated by 1.

[0021] In particular, the furnace 1 is a DC mono electrode arc furnace, lying in a so-called flat bath operative section,

and being continuously fed, e.g. scrap metal 2, via a feed duct 3.

[0022] The furnace 1 comprises a case bottom portion 4, consisting of a shaft 5, housing a metal bath 12 in which the scrap metal 2 is discharged, a conducting hearth 6 for current passing, whereat the resulting molten steel pools, and a case top portion 7. The latter forms the crown of the melting chamber 8 and it has a port 9 apt to allow the insertion of an electrode 10. In the present embodiment, the electrode 10 acts as the cathode (negative pole), and the conductive members 11 of the conducting hearth act as the anode (positive pole).

[0023] The electrode 10 and the conductive members 11 are electrically connected to a generator 13.

[0024] By effect of the voltage, an electric arc 15 is struck between the bottom tip 14 of the electrode 10 and the bath surface 12. The electrode 10 comprises first means for ejecting at least one fluid towards the metal bath 12 contained in the electric furnace 1, which will be detailed hereinafter.

[0025] With reference to Fig. 2, the electrode 10 in its top portion comprises a cylinder-shaped column body 16 made of graphite or metallic conductive material. In this latter case the column body 16 is water-cooled and partially coated with a protective layer of ceramics insulating material 17.

[0026] In any variant embodiment the bottom portion 26 of the electrode 10, including the tip 14, is made of graphite.

[0027] Moreover, at the bottom portion 26 the electrode 10 is provided with an axial hole 19, first means for ejecting a fluid comprising a nozzle 20 being housed therein. The nozzle 20, water-cooled by means of a cooling duct 18 running therethrough, is slidable inside of the hole 19.

[0028] Between the nozzle 20, having a minimum diameter of 40 mm, and the axial hole 19 of the electrode 10, there is a gap 40 with a clearance ranging from 0.5 to 2.0 mm.

[0029] Bottomwise, the lance 20 ends in a nozzle head 21 of a shape suitable to give the desired fluid dynamics characteristics, and preferably those of a compact jet, to a fluid 22 outletted therefrom. The distance between the nozzle head 21 and the electrode portion 10, consisting of the end of the tip 14 nearer to the metal bath, ranges from 100 to 1000 mm and it is such that the fluid 22 undergoes no significant chemical or physical changes inside of the electrode 10.

[0030] The fluid 22 comprises at least one heat decomposable Carbon-rich combustible component, in particular a gaseous hydrocarbon selected from the group comprising methane, ethane, propane, butane and mixtures thereof, and it is denominated 'reactive fluid' as it is apt to carry out a reducing/combustible action, with metallurgic functions analogous to those of coal usually found inside of an electric furnace.

[0031] The fluid 22 exits the ejecting nozzle, crossing the end section of the axial hole of the electrode at a suitable rate, heating up, yet not slowly enough to undergo substantial chemical transformations, until reaching the tip 14 of the electrode 10 whereat its molecular breaking is carried out by the heat provided by an electric arc.

[0032] Subsequently to the molecular demolition of the fluid 22 by the electric arc heat, the arc 15 turns into a plasma arc AP (at very high temperatures, ranging from 15.000 to 20000°C) due to the presence of the gas at the ionic state which, departing from the tip 14 of the electrode 10, oxidizes in the furnace atmosphere, thermally contributing to the latter and thereby allowing a power-saving in steelmaking.

[0033] In order to enable all the fluid 22 to reach the electrode tip, without rising back via the space, by a suitable annular system there is provided a tight seal onto the top section of the same electrode whereat the lance is inserted.

[0034] With reference to figure 2, the electrode 10 (graphite and metallic material versions) further comprises second means 23 for ejecting a second fluid 24. Said means 23 is positioned onto the cylinder-shaped surface of the electrode 10, bottomwise to the body 16.

[0035] The second fluid 24 stands out for its antioxidant properties, and it may comprise, or be replaced by, Carbon-based combustible compositions, like e.g. combustible oil, coal dust and other carbides like carbides of Calcium, of Silica, of Aluminum.

[0036] Combustible oils may comprise: gas oil, diesel oil, petrols, light oils from petrol refining, or even drain oils deriving from lubrication of mechanical components, sludges, cutting oils, Carbon- and Hydrogen-containing emulsions.

[0037] Lastly, the ejected fluid 24 may wholly or partially comprise water.

[0038] Said fluid interacts with the cylinder-shaped graphite surface, so as to carry out a protective action which strongly reduces the oxidation of the graphite onto the surface of the body 26.

[0039] Furthermore, besides from said reducing agents (made of Hydrogen-containing Carbon-based materials), the fluid 24 may also comprise, optionally suspended, highly stable oxides like, e.g. CaO, MgO, Al_2O_3 or carbonates thereof, whose function is that of coating the graphite surface of the electrode with a layer of protective material. Due to the high temperature of the furnace, this fluid thus made, sliding along the electrode surface lets its fluid phase evaporate depositing the solid fraction onto the electrode and thereby generating an Oxygen-tight coating defined 'antioxidant barrier' 27.

[0040] This prevents contact with the oxidizing atmosphere optionally present in the furnace.

[0041] The second means 23 for ejecting consist of a ring of peripheral nozzles which are fed separately with respect to the nozzle 20 by a suitable feeding loop indicated by 25 in figure 2.

[0042] With reference to figures 2, 3 and 4, via the nozzle head 21 there is ejected the first fluid 22, which reacts with the metal bath and with the atmosphere thereabove in an environment having a very high temperature.

[0043] The nozzle head 21 may comprise a single inlet, from which a fluid, optionally in a mixture formed with at least

one fluid reactive component is injected, or it may comprise a plurality of outlets, each corresponding to a reactive fluid ejected and fed separately from the other fluids.

[0044] The nozzle head 21 can vary its position inside of the axial hole 19 in connection with the consumption of the tip 14. Hence, the nozzle 20 should be slidable along the hole 19 rather than stationary with respect to the electrode.

[0045] Purely by way of example, figure 4 depicts a section of the electrode tip 10 and of the nozzle head 20 when it be desirable to concomitantly inject a second fluid 24 (e.g., oil) and a first fluid 22 (gas) inside of the electrode hole, yet keeping the two fluids separate down to the lance tip.

[0046] The injecting of the first and of the second fluid produces a region 28 hosting chemical transformations, at the projection of the nozzle head 21 between the tip 14 of the electrode 10 and the bath surface 12, and a exhaust volume 29, generated by the reaction gas of the two fluids which carries solid/liquid particles captured by the free surface of the molten bath 12 and solid particles evolved from the molecular demolition of fluids. Rising back along the electrode, such exhaust volume 29 deposits said particles onto the surface thereof, forming a layer of solid material having a function analogous to that of said antioxidant barrier 27 and coating the entire surface of the bottom portion of the electrode 10 which comprises the tip 14.

[0047] With reference to figures 2, 3 and 4, hereinafter there will be described the operation method of the novel electrode subject-matter of the present invention, highlighting the main technical characteristics thereof subdivided according to aspects concerning electrode consumption, electric arc length, metallurgy and ecology.

Electrode consumption

[0048] In order to reduce the oxidative consumption of the electrode, due to the presence of air or of oxygen, the following operation steps were carried out.

- generating, about the graphite electrode, a layer of reducing (or at least of non-oxidizing) gas extended to the full length of the electrode
- generating a thin solid material barrier 27, such as to physically and chemically separate the graphite surface of the electrode from the surrounding atmosphere.

[0049] The antioxidant barrier 27 can be made by the oxides present in the second ejection fluid 24, or by the gas resulting from the molecular demolition of the fluid formed by gases/liquids outletted from the nozzle 20 when said gases/liquids interact with the plasma arc 15 and with the free surface of the bath, where there generally is a slag. In this latter case, in order to generate the solid antioxidant barrier 27, the inletting of solid substances in the fluid 24 outletted from the nozzle 20 by the inlet 30 is unnecessary since said solid substances are already largely present in the slag.

[0050] The reaction of the combustible (gas) 22 and of the fluid (oil) 24 with the slag, and the Carbon deriving from the demolition of the combustible 22 and of the fluid 24 generate a volume of opaque exhaust 29, which also protects the tip 14 of the electrode 10 from the radiance of the electric arc 15.

[0051] The chemical reactions taking place in the region 28 underlying the nozzle 14 of the electrode 10 are valid for all hydrocarbons of suitable ratios, and are exemplified as follows making reference to the injection of methane fuel.

(1) $CH_4 \rightarrow C + 2H_2$ endothermic reaction

(2) $C + 2H_2 + 3/2O_2 \rightarrow CO + 2H_2O$ exothermic reaction

[0052] The first reaction (1), defining the breaking (crack) of the Carbon-Hydrogen bonds, allows a cooling of the tip 14, reducing its consumption.

[0053] The second reaction (2), occurring when the products of the first reaction (1) meet the Oxygen present in the furnace atmosphere or contained in the metal bath due to the reduction under way, concurs to heat the metal bath, most conveniently so when the latter is fed scrap.

[0054] The temperatures of the electric arc being very high, Oxygen required for carrying out the second reaction may partially be provided by the oxides (FeO, SiO_2, MnO, etc.) present in the slag, the latter being thereby reduced.

[0055] This entails positive metallurgic effects, like steel desulfurization, Manganese, Chrome and Silica recovery, via the reduction of the corresponding slag oxides.

[0056] The reactions 1 and 2 generate the exhaust volume 29, which is opaque due to the presence of solid particles and is such as to limit also the radiation of the plasma arc 15 towards the tip 14, concurring to lower the temperature of the latter and therefore to reduce graphite consumption.

[0057] The water-cooled nozzle 20 concurs to reduce oxidative consumption as it lowers the average temperature of the electrode.

[0058] To that lower temperature there corresponds a lower electrical resistivity of the graphite of the electrode 10 and hence, a lesser heating up thereof by Joule effect.

[0059] An exemplary computation, considering merely the cooling and the Joule effect, shows the average temperature of the electrode 10 to be of about 250°C lower with respect to that of an uncooled electrode (figure 5).

[0060] With this lower temperature value, the corresponding electrical resistance of the graphite, as well as the heating power, is of about 5% lower.

[0061] A further cooling of the electrode 10 may be attained extracting the electrode at the end of each casting, before it reaches its steady thermal state, and putting it in a container having a non-oxidizing atmosphere in which it is left to cool down prior to reuse. In the meantime, for the production there will be used a second electrode, previously cooled or new and placed in a working position by a second electrode bearing arm independent from the first one.

[0062] Thus, prior to reinserting the electrode into the furnace the temperature thereof can be lowered to values in the vicinities of 600÷800 °C, values corresponded to a resistivity of about the 20% lower than that of an unextracted one kept in-furnace.

[0063] Hence, the electrode set forth allows to attain an increase in furnace productivity by increasing the thermal power transferred to the metal bath and due to the option of using, current strengths being equal, higher voltages of the electric arc, and hence greater electrical powers.

[0064] Shortly, the consumption of the electrode, which depends on the temperature and is proportional to the current density insisting on the tip thereof and causing its heating, is reduced by virtue of the following three combined effects:

1. Greater diameter of the tip 14 due to the lesser oxidative consumption obtained over the entire electrode 10.
2. Depositing, onto the surface of the electrode 10 and onto the tip 14, the Carbon generated by the molecular demolition of the fluids injected via the lance nozzle, which oxidizes in lieu of the graphite of the former in case of reaction with an oxidizing atmosphere.
3. Tip cooling effect induced by the dissociation reactions of the injected fluid. Said dissociation reactions, being endothermal ones, reduce the graphite sublimation effect due to the very high temperatures of the electric arc.

Electric arc length

[0065] The injection of fluids through the electrode allows to attain a 20%-60% shortening of the electric arc 15.

[0066] Thus, the electric arc 15 radiates less towards the refractory walls of the furnace 1, reducing the entailed damage thereto and also improving heat transmission to the bath 12.

[0067] The mentioned results have been constantly sought in steelshop electric furnaces, during flat bath operation steps, by generating foaming slags or reducing the electrical power, entailing bath oxidation and productivity decrease, respectively.

[0068] In the case of Carbon steels, the shortening of the electric arc attained by this method reduces the need to employ materials (C, $CaCO_3$, carbides) to generate foaming slags.

[0069] In the case of stainless steelmaking, foaming slag generation is extremely difficult and costly in terms of Cr yield, Cr being oxidized by the generation-required Oxygen.

[0070] Hence, by this novel method the desired shortening of the electric arc 15 is attained, concomitantly improving the Cr yield.

Metallurgic aspects

[0071] Employing the electrode subject-matter present invention the reaction products of the injected fluids, mainly consisting of gases from hydrocarbon cracking, have the effect of limiting, with respect to a normal atmosphere, the air content in the arcing atmosphere in a melting furnace.

[0072] In this novel atmosphere, the Nitrogen ions generated by effect of the very high temperatures of the electric arc, have a partial pressure (concentration) lower than that had with an open-air generated arc. This entails that also the steel that is being made be exposed to a lesser extent, at the electric arc impact zone, to Nitrogen inletting.

[0073] The advantage of this effect is that the final Nitrogen content of the steel made in the melting electric furnace may reach values comparable to those attainable in integrated cycle steelmaking (20 ÷ 50 ppm).

[0074] Thus, there is reduced the need of denitrifying treatments required to attain the analytical aims for most steels. In fact, for the latter the Nitrogen content should be the lowest possible.

[0075] Moreover, the products of the inletting of these fluids, being essentially made of substances capable of combining with the Oxygen present, have a reducing effect in their interaction with the slag present above the molten bath 12.

[0076] This effect entails the following metallurgic consequences:

* steel grade improvement, in particular for the reduction of Nitrogen and Sulfur contents;

* recovery of metals (Cr, Si, Fe, Mn) from the slag

[0077] Hence, a general improvement of the steel grade was noticed.

Ecological aspects

[0078] The employ of the electrode subject-matter of the present invention allowed to generally decrease the environmental impact, owing to reduced:

- NO_x generation, due to the scarcer presence of Nitrogen ions in the plasma arc;
- CO_2 generation, as the electric arc shortening reduces the need to generate carbon oxides to form foaming slags. Moreover, the need to inlet coal in order to carry out slag reduction is decreased.

EXAMPLE

[0079] In order to check the effects of an electrode according to the object of the present invention, tests were carried out on a DC flat bath mono electrode electric furnace, testing electrodes object of the present invention as well as traditional ones.

Operative parameter	Traditional electrode	Invention Electrode	EXAMPLE
Electric power	0.5-60 MW	0.5-60 MW	1.5 MW
Graphite electrode diameter	650 mm	650 mm	250 mm
Electrode column length	8000 mm	8000 mm	4100 mm
Fuel oil flow rate	-	20 and 200 kg/h	27 kg/h
Gas flow rate	-	3 and 300 Nm^3/h	15 Nm^3/h
Gas outlet rate from electrode hole	-	0.5 and 50 m/s	2.5 m/s
Gas nozzle diameter	-	1-5 mm	3 mm
60 MW furnace			
Graphite tip consumption	≈ 80 kg/h	≈ 30 kg/h	≈ 7 kg/h
Graphite oxidative consumption	≈ 120 kg/h	≈ 50 kg/h	
Productivity	60 t/h	60 t/h	-
Steel grade	(Mn, Si, Cr) < >	(Mn, Si, Cr) >	(Mn, Si, Cr) >
"	(S,N_2) < >	(S,N_2)<	(S,N_2) <
NOx fume	Present	Absent	Absent

[0080] It is understood that analogous advantages may be attained with different electrode configurations and with the adoption of the abovedescribed related operation method. To the abovedescribed electrode a person skilled in the art, in order to meet further and contingent needs, may effect several further modifications and variants, all however falling within the protective scope of the present invention, as defined by the appended claims

Claims

1. An electrode (10), in particular for siderurgical electric arc furnaces and the like, comprising: a cylinder-shaped column body (16) of conductive material, partially coated with a protective layer (17) of insulating material, and an axial hole (19) formed in a bottom portion (26) of said column body (16), means (20, 23) for ejecting fluid (22) towards the metal bath thereof, said fluid comprising a heat decomposable Carbon-rich combustible component, **characterized in that** said means for ejecting fluid comprises: a lance (20) slidably housed inside said axial hole (19), ending with a nozzle head for ejecting said fluid so as to produce a cloud which shields the tip (14) of the electrode (10) and coats with a solid layer (27) the surface of the electrode; and nozzles positioned onto the cylinder-shaped surface of the electrode (10) for ejecting a further fluid (24), bottom wise to the column body (16) for interacting with

the surface, so as to carry out a protective action.

2. The electrode (10) according to claim 1, wherein said Carbon-rich combustible component is a gaseous hydrocarbon selected from the group consisting of methane, ethane, propane, butane and mixtures thereof.

3. The electrode (10) according to claim 1, wherein said nozzle head (21) comprises a plurality of outlet sections, each corresponding to at least one component ejected and fed separately from the others.

4. The electrode (10) according to claim 2 wherein said gaseous hydrocarbon is apt to carry out a reducing/combustible action, with metallurgic functions analogous to those of coal usually found inside of an electric furnace.

5. The electrode (10) according to claim 1, wherein said fluid comprises liquid and/or solid combustibles.

6. The electrode (10) according to claim 1, wherein said further fluid comprises a water flow rate.

7. The electrode (10) according to claim 2, wherein the gaseous hydrocarbon flow rate ranges from 3 to 300 Nm^3/h, with a gas outlet rate from the axial hole of the electrode ranging from 0.5 to 50 m/s.

8. The electrode (10) according to claim 2, wherein the gaseous hydrocarbon outlet section is $\geq 80\ mm^2$.

9. The electrode (10) according to claim 3, wherein the nozzle head (21) has a rectilinear jet

10. The electrode (10) according to claim 3, wherein the distance between the nozzle (21) and the tip (14) of the electrode (10) ranges from 100 to 1000 mm.

11. The electrode (10) according to claim 1, wherein the clearance between the lance (20) and the hole (19) ranges from 0.5 mm to 2.0 mm.

12. The electrode (10) according to claim 11, wherein the lance (20) has a minimum diameter of 40 mm.

13. The electrode (10) according to claim 1, wherein said further fluid (24) comprises Carbon-based fuel compositions and/or carbides.

14. The electrode (10) according to claim 13, wherein said Carbon-based fuel compositions comprise coal dust, combustible oils, i.e.: gas oil, diesel oil, petrols, light oils from petrol refining, drain oils deriving from lubrication of mechanical components, sludges, cutting oils, Carbon- and Hydrogen-containing emulsions; and wherein said carbides comprise carbides of Calcium, of Silica, of Aluminum.

15. The electrode (10) according to claim 1, wherein said fluid and/or said further fluid comprises highly stable oxides (CaO, MgO, Al2O3) or carbonates thereof.

Patentansprüche

1. Elektrode (10), insbesondere für Stahl-Lichtbogenöfen und dergleichen, die umfasst:

einen zylinderförmigen Säulenkörper (16) aus leitendem Material, der teilweise mit einer Schutzschicht (17) aus isolierendem Material überzogen ist, und ein axiales Loch (19), das in einem unteren Abschnitt (26) des Säutenkörpers (16) ausgebildet ist, eine Einrichtung (20, 23) zum Ausstoßen von Fluid (22) auf das Metallbad desselben zu, wobei das Fluid eine durch Wärme zersetzbare, kohlenstoffreiche brennbare Komponente umfasst, **dadurch gekennzeichnet, dass** die Einrichtung zum Ausstoßen von Fluid umfasst:

eine Lanze (20), die verschiebbar im Inneren des axialen Lochs (19) aufgenommen ist und in einem Düsenkopf endet, der das Fluid ausstößt, um eine Wolke zu erzeugen, die die Spitze (14) der Elektrode (10) abschirmt und die Oberfläche der Elektrode mit einer festen Schicht (27) überzieht, und Düsen, die auf die zylinderförmige Fläche der Elektrode (10) positioniert sind, um ein weiteres Fluid (24) auszustoßen, am unteren Ende des Säulenkörpers (16), um in Wechselwirkung mit der Oberfläche zu treten und eine schützende Wirkung auszuüben.

2. Elektrode (10) nach Anspruch 1, wobei die kohlenstoffreiche brennbare Komponente ein gasförmiger Kohlenwasserstoff ist, der aus der Gruppe ausgewählt wird, die aus Methan, Ethan, Propan, Butan und Gemischen daraus besteht.

3. Elektrode (10) nach Anspruch 1, wobei der Düsenkopf (21) eine Vielzahl von Auslassabschnitten umfasst, die jeweils wenigstens einer Komponente entsprechen, die separat zu den anderen ausgestoßen und zugeführt wird.

4. Elektrode (10) nach Anspruch 2, wobei sich der gasförmige Kohlenwasserstoff eignet, um eine reduzierende/verbrennende Wirkung auszuüben, und metallurgische Funktionen hat, die analog zu denen von Kohle sind, die sich normalerweise im Inneren eines Elektroofens befindet.

5. Elektrode (10) nach Anspruch 1, wobei das Fluid flüssige und/oder feste Brennstoffe umfasst.

6. Elektrode (10) nach Anspruch 1, wobei das weitere Fluid einen Wasserdurchfluss umfasst.

7. Elektrode (10) nach Anspruch 2, wobei der Durchfluss des gasförmigen Kohlenwasserstoffes von 3 bis 300 Nm^3/h reicht und eine Gasauslassgeschwindigkeit aus dem axialen Loch der Elektrode von 0,5 bis 50 m/s reicht.

8. Elektrode (10) nach Anspruch 2, wobei für den Auslassquerschnitt des gasförmigen Kohlenwasserstoffs $\geq 80\ mm^2$ gilt.

9. Elektrode (10) nach Anspruch 3, wobei der Düsenkopf (21) einen geradlinigen Strahl hat.

10. Elektrode (10) nach Anspruch 3, wobei der Abstand zwischen der Düse (21) und der Spitze (14) der Elektrode (10) von 100 bis 1000 mm reicht.

11. Elektrode (10) nach Anspruch 1, wobei der Abstand zwischen der Lanze (20) und dem Loch (19) von 0,5 mm bis 2,0 mm reicht.

12. Elektrode (10) nach Anspruch 11, wobei die Lanze (20) einen minimalen Durchmesser von 40 mm hat.

13. Elektrode (10) nach Anspruch 1, wobei das weitere Fluid (24) Brennstoffzusammensetzungen auf Kohlenstoffbasis und/oder Karbide umfasst.

14. Elektrode (10) nach Anspruch 13, wobei die Brennstoffzusammensetzungen auf Kohlenstoffbasis Kohlenstaub, brennbare Öle, d.h, Gasöl, Dieselöl, Benzine, Leichtöle aus der Erdölverarbeitung, Ablauföle, die von der Schmierung mechanischer Bauteile stammen, Aufschlämmungen, Schneidöle, kohlenstoff- und wasserstoffhaltige Emulsionen umfassen; und wobei die Karbide Karbide von Kalzium, von Siliziumoxid und von Aluminium umfassen.

15. Elektrode (10) nach Anspruch 1, wobei das Fluid und/oder das weitere Fluid hoch stabile Oxide (CaO, MgO, Al_2O_3) oder Karbonate derselben umfasst.

Revendications

1. Electrode (10), en particulier pour des fours à arc électrique sidérurgiques et analogue, comportant : un corps de colonne en forme de cylindre (16) constitué d'un matériau conducteur, partiellement revêtu d'une couche protectrice (17) constituée d'un matériau isolant, et un trou axial (19) formé dans une partie inférieure (26) dudit corps de colonne (16), des moyens (20, 23) pour éjecter un fluide (22) en direction du bain de métal de ceux-ci, ledit fluide comportant un composant combustible riche en carbone décomposable sous chaleur, **caractérisée en ce que** lesdits moyens pour éjecter un fluide comporte : une lance (20) enfermée de manière coulissante à l'intérieur dudit trou axial (19), se terminant par une tête de buse destinée à éjecter ledit fluide afin de produire un nuage qui protège la pointe (14) de l'électrode (10) et recouvre d'une couche solide (27) la surface de l'électrode, et des buses positionnées sur la surface en forme de cylindre de l'électrode (10) pour éjecter un fluide supplémentaire (24), vers le bas du corps de colonne (16), pour interagir avec la surface, de manière à effectuer une action protectrice.

2. Electrode (10) selon la revendication 1, dans laquelle ledit composant combustible riche en carbone est un hydrocarbure gazeux sélectionné parmi le groupe constitué de méthane, éthane, propane, butane et mélanges de ceux-ci.

3. Electrode (10) selon la revendication 1, dans laquelle ladite tête de buse (21) comporte une pluralité de sections de sortie, chacune correspondant à au moins un composant éjecté et alimenté séparément des autres.

4. Electrode (10) selon la revendication 2, dans laquelle ledit hydrocarbure gazeux est capable d'effectuer une action réductrice/combustible, avec des fonctions métallurgiques analogues à celles du charbon habituelle trouvé à l'intérieur d'un four électrique.

5. Electrode (10) selon la revendication 1, dans laquelle ledit fluide comporte du combustible liquides et/ou solides,

6. Electrode (10) selon la revendication 1, dans laquelle ledit fluide supplémentaire présente un débit d'eau.

7. Electrode (10) selon la revendication 2, dans laquelle le débit d'hydrocarbure gazeux se trouve dans la plage de 3 à 300 Nm^3/h, avec une vitesse de sortie de gaz depuis le trou axial de l'électrode dans la plage de 0,5 à 50 m/s.

8. Electrode (10) selon la revendication 2, dans laquelle la section de sortie d'hydrocarbure gazeux est $\geq 80\ mm^2$.

9. Electrode (10) selon la revendication 3, dans laquelle la tête de buse (21) a un jet rectiligne.

10. Electrode (10) selon la revendication 3, dans laquelle la distance entre la buse (21) et la pointe (14) de l'électrode (10) se trouve dans la plage de 100 à 1000 mm.

11. Electrode (10) selon la revendication 1, dans laquelle le jeu entre la lance (20) et le trou (19) se trouve dans la plage de 0,5 mm à 2,0 mm

12. Electrode (10) selon la revendication 11, dans laquelle la lance (20) a un diamètre minimum de 40 mm.

13. Electrode (10) selon la revendication 1, dans laquelle ledit fluide supplémentaire (24) comporte des compositions de carburant à base de Carbone et/ou carbures.

14. Electrode (10) selon la revendication 13, dans laquelle lesdites compositions de carburant à base de Carbone comportent une poussière de charbon, des huiles combustibles, c'est-à-dire une huile gazeuse, un carburant diesel, des pétroles, des huiles légères provenant de raffinage de pétrole, des huiles de drainage dérivées d'une lubrification de composants mécaniques, des boues, des huiles de coupe, des émulsions contenant du Carbone et de l'Hydrogène, et dans laquelle lesdits carbures comportent des carbures de Calcium, de Silice, d'Aluminium.

15. Electrode (10) selon la revendication 1, dans laquelle ledit fluide et/ou ledit fluide supplémentaire comportent des oxydes fortement stables (CaO, MgO, Al_2O_3) ou carbonates de ceux-ci.

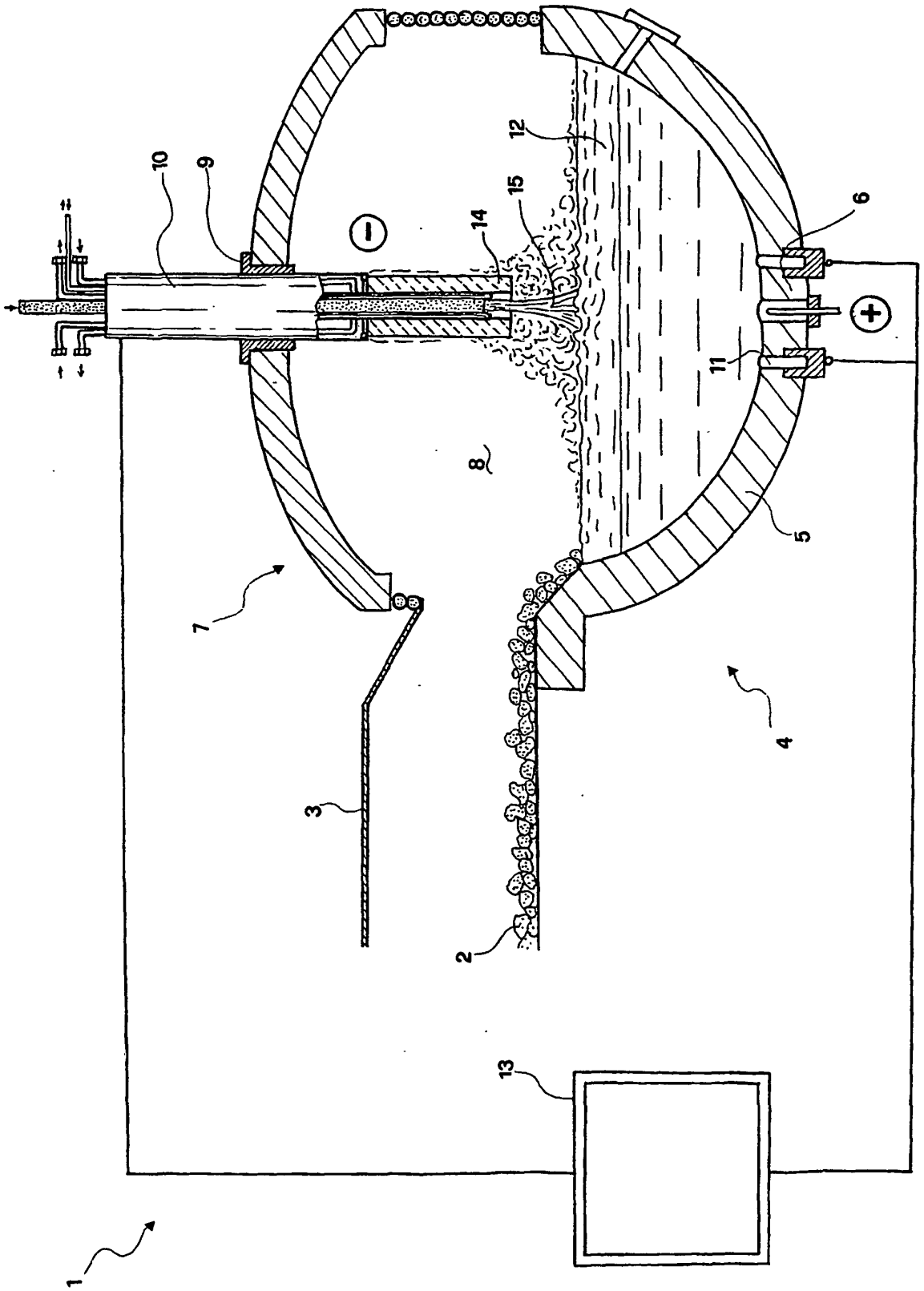


fig.1

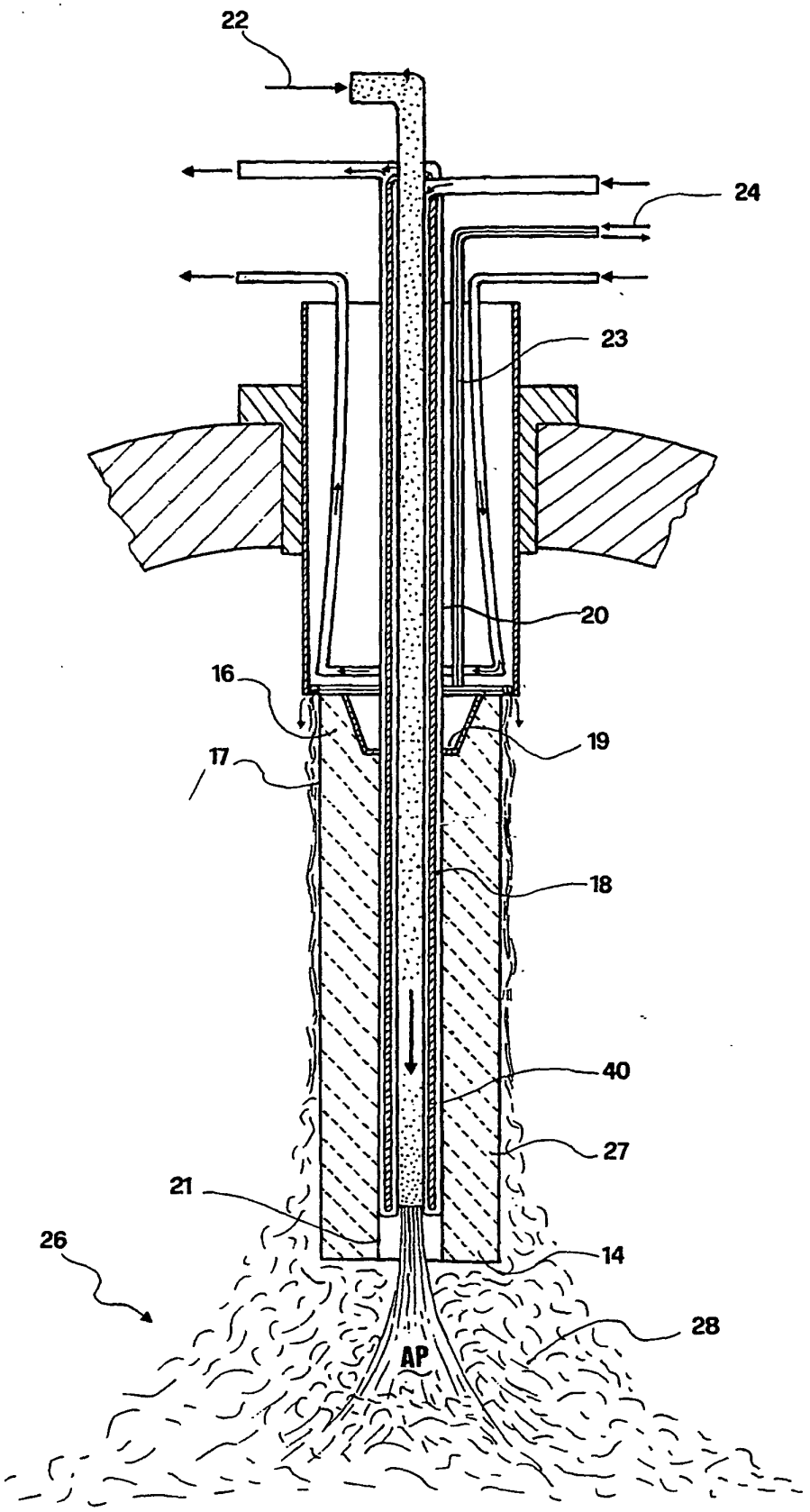


fig.2

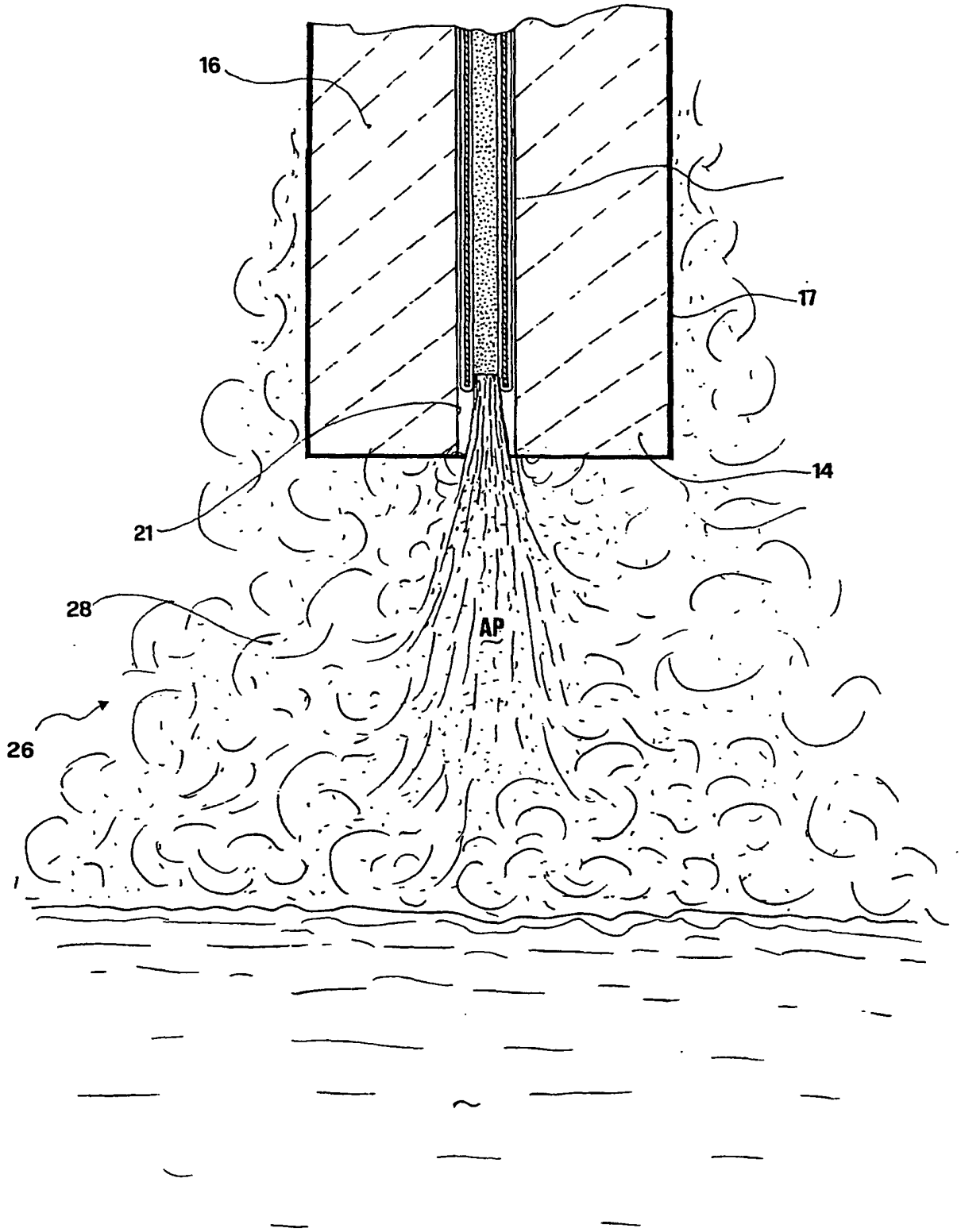


fig.3

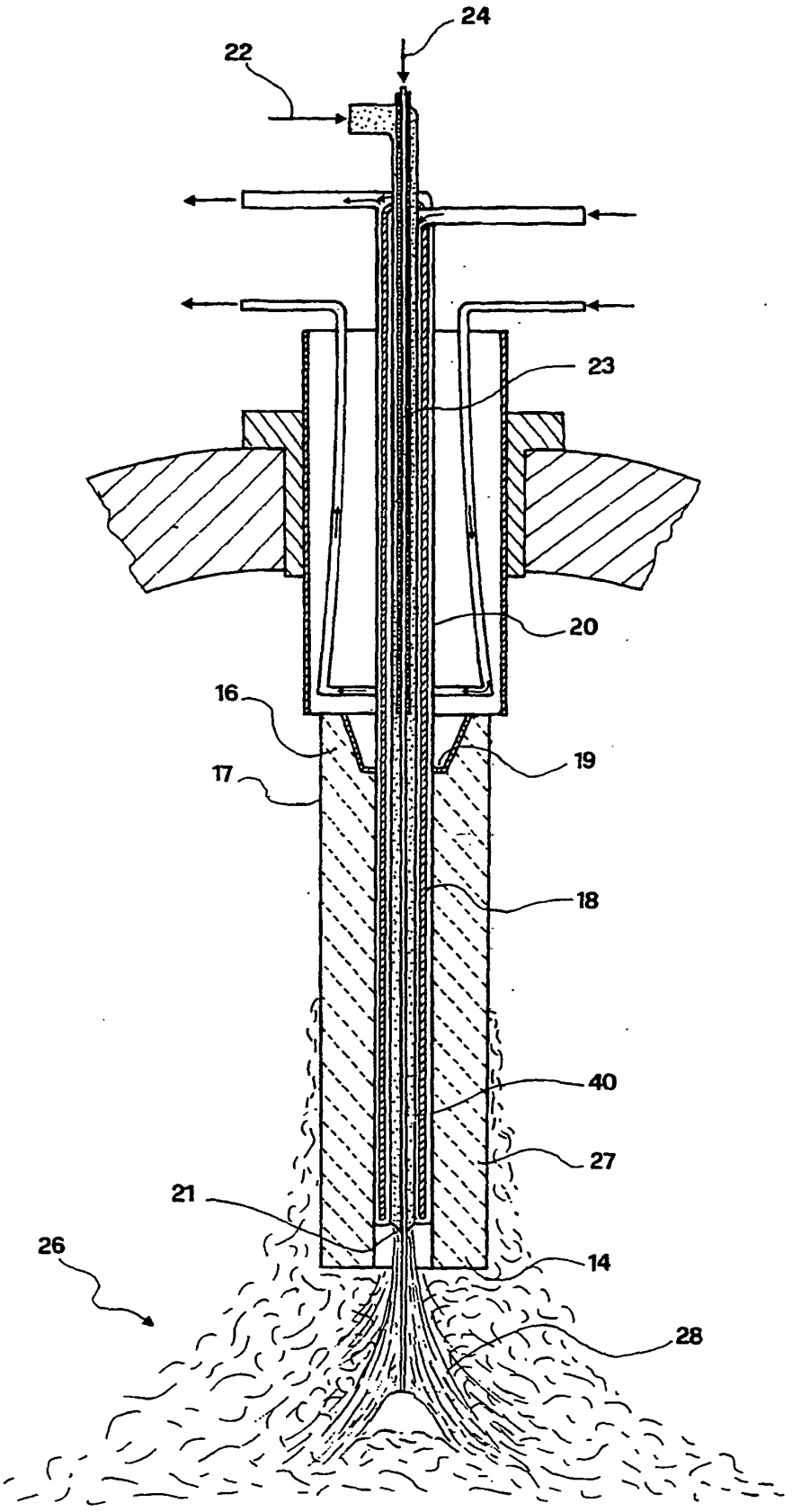


fig.4

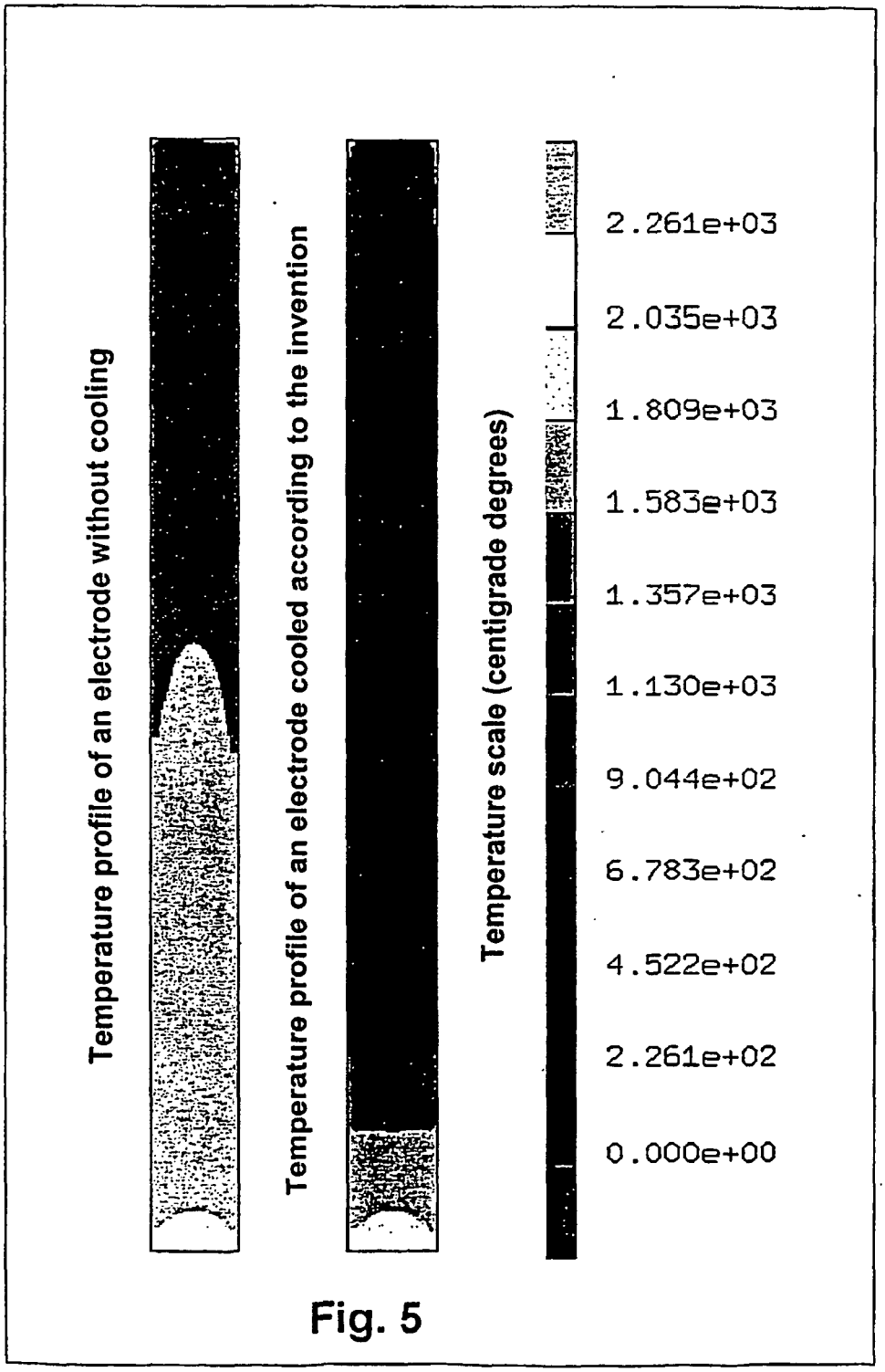

Temperature profile of an electrode without cooling
Temperature profile of an electrode cooled according to the invention
Temperature scale (centigrade degrees)
2.261e+03
2.035e+03
1.809e+03
1.583e+03
1.357e+03
1.130e+03
9.044e+02
6.783e+02
4.522e+02
2.261e+02
0.000e+00

Fig. 5