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Anthony et al.

[11] **3,709,998**

[45] **Jan. 9, 1973**

[54] HEATING ELEMENT FOR AN ELECTRIC FURNACE

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[22] Filed: **Dec. 16, 1970**

[21] Appl. No.: **98,831**

Related U.S. Application Data

[62] Division of Ser. No. 825,306, May 16, 1969.

[30] **Foreign Application Priority Data**

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Oct. 24, 1968 France.....68171236
Dec. 31, 1968 France.....68182837

[52] **U.S. Cl.**.....**13/25**
[51] **Int. Cl.**.....**H05b 3/06**
[58] **Field of Search**.....13/25; 219/426

[56] **References Cited**

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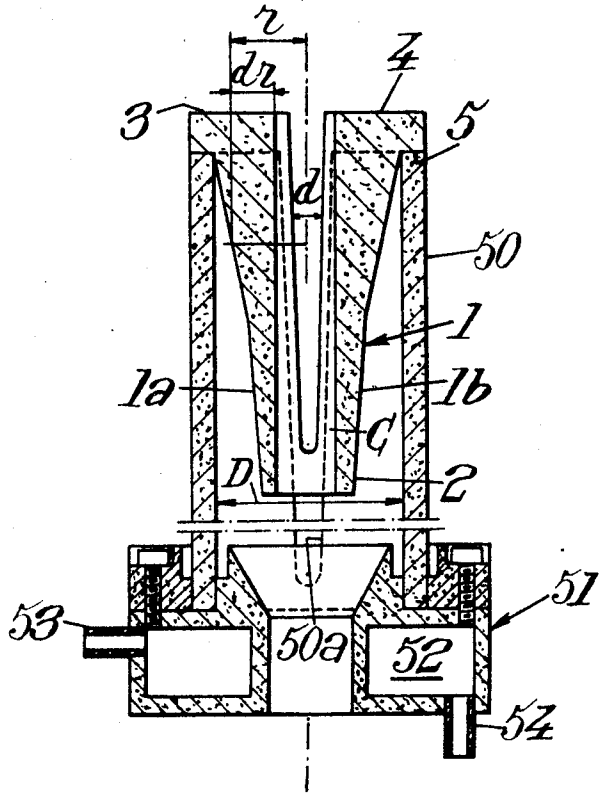
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Primary Examiner—Roy N. Envall, Jr.
Attorney—Larson, Taylor & Hinds

[57] **ABSTRACT**

The heating element is made of a refractory material resistant to oxidation, and comprises two hollow hemicylindrical parts disposed face to face by their concave portions at a slight distance from each other. These two parts are supplied with electric current at one of their ends and are connected together at their other end by a common cylindrical part. The exterior radii of the hemicylindrical parts and of the common cylindrical part, and the thicknesses of these parts, as well as the distance between the corresponding opposing edges of the two hemicylindrical parts, all decrease from the end by which the current is supplied to the end which is connected together by the common cylindrical part.

4 Claims, 12 Drawing Figures



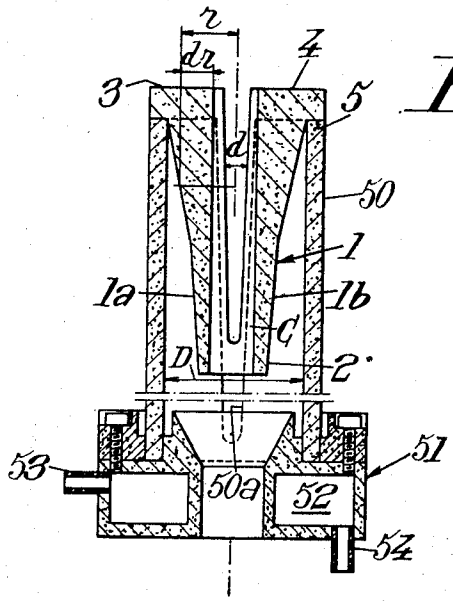


Fig. 1.

Fig. 2.

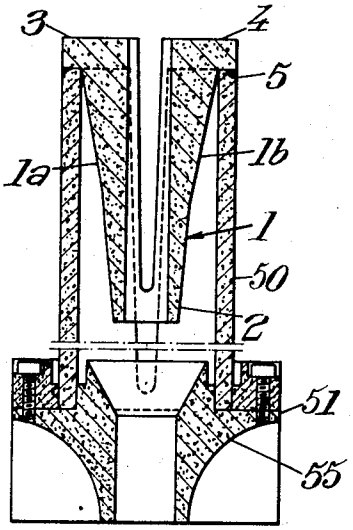


Fig. 3.

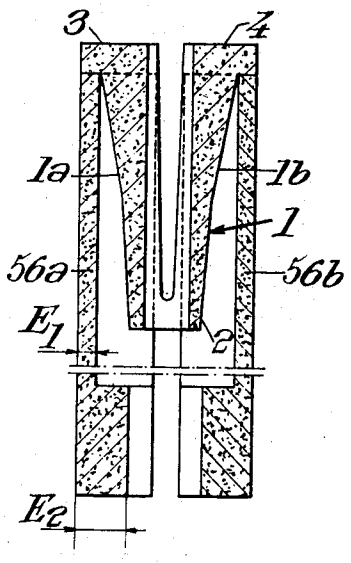
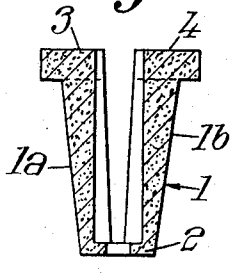


Fig. 3a.



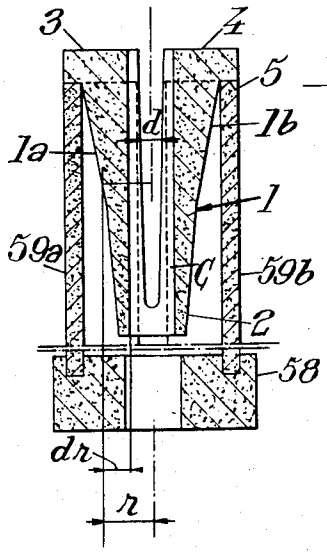


Fig. 4.

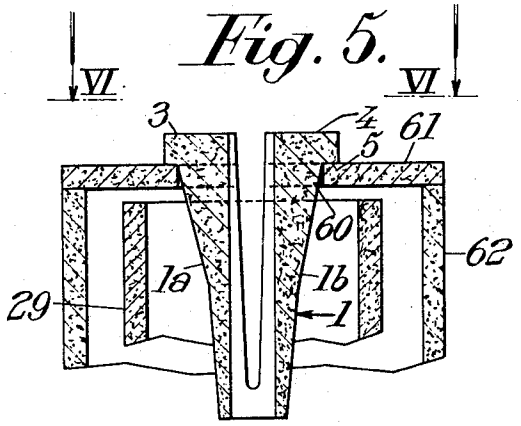


Fig. 5.

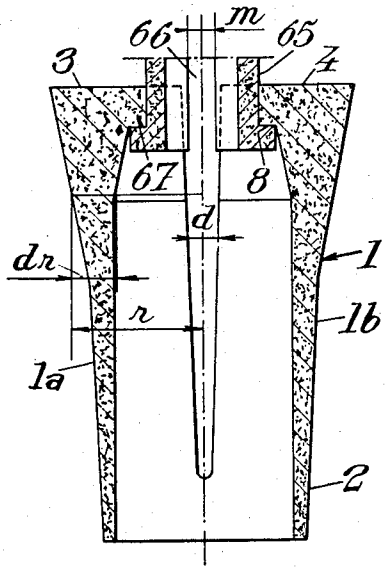


Fig. 7.

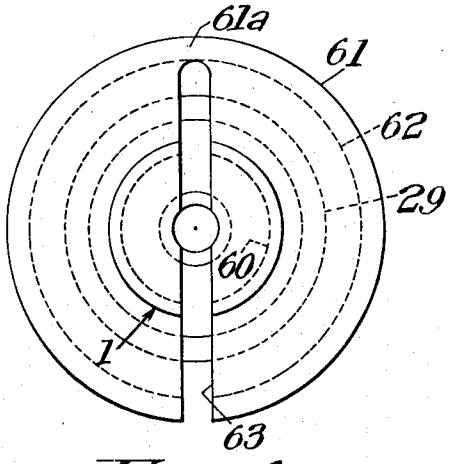


Fig. 6.

Fig. 8.

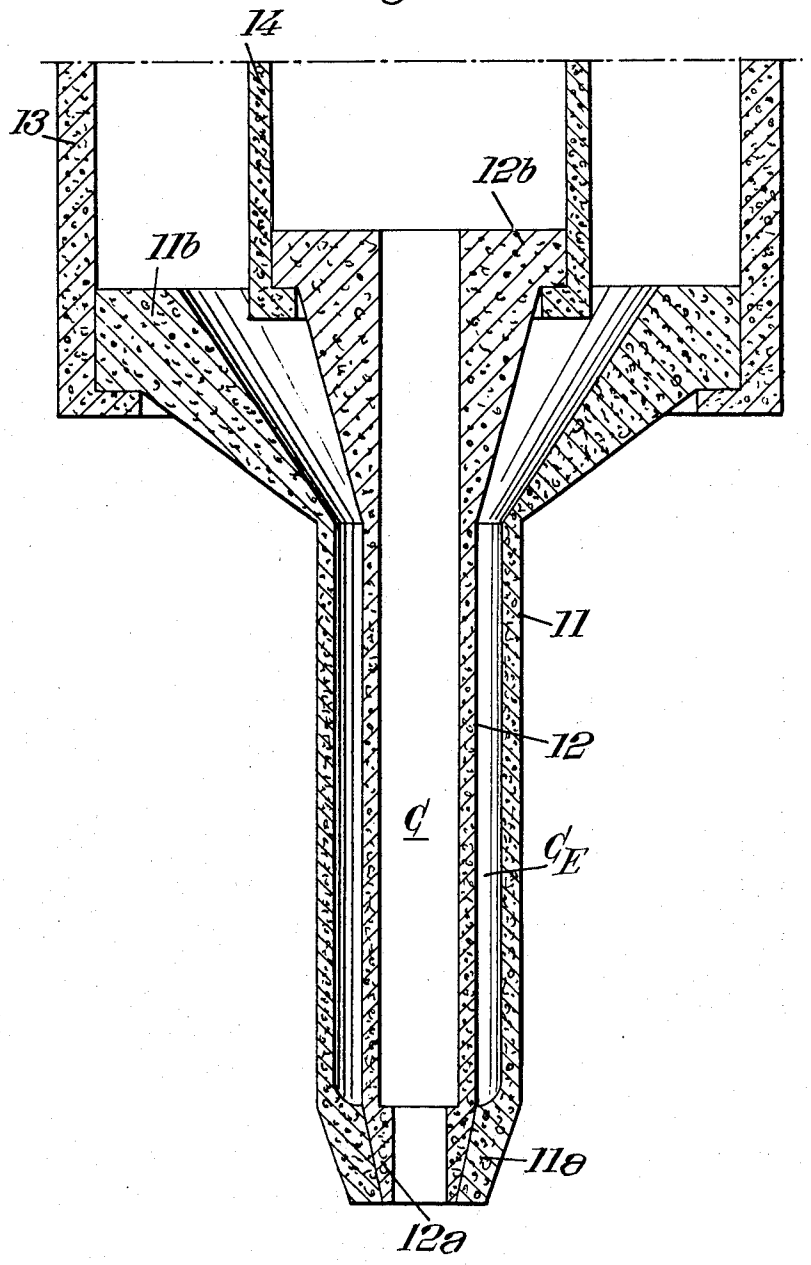


Fig. 9.

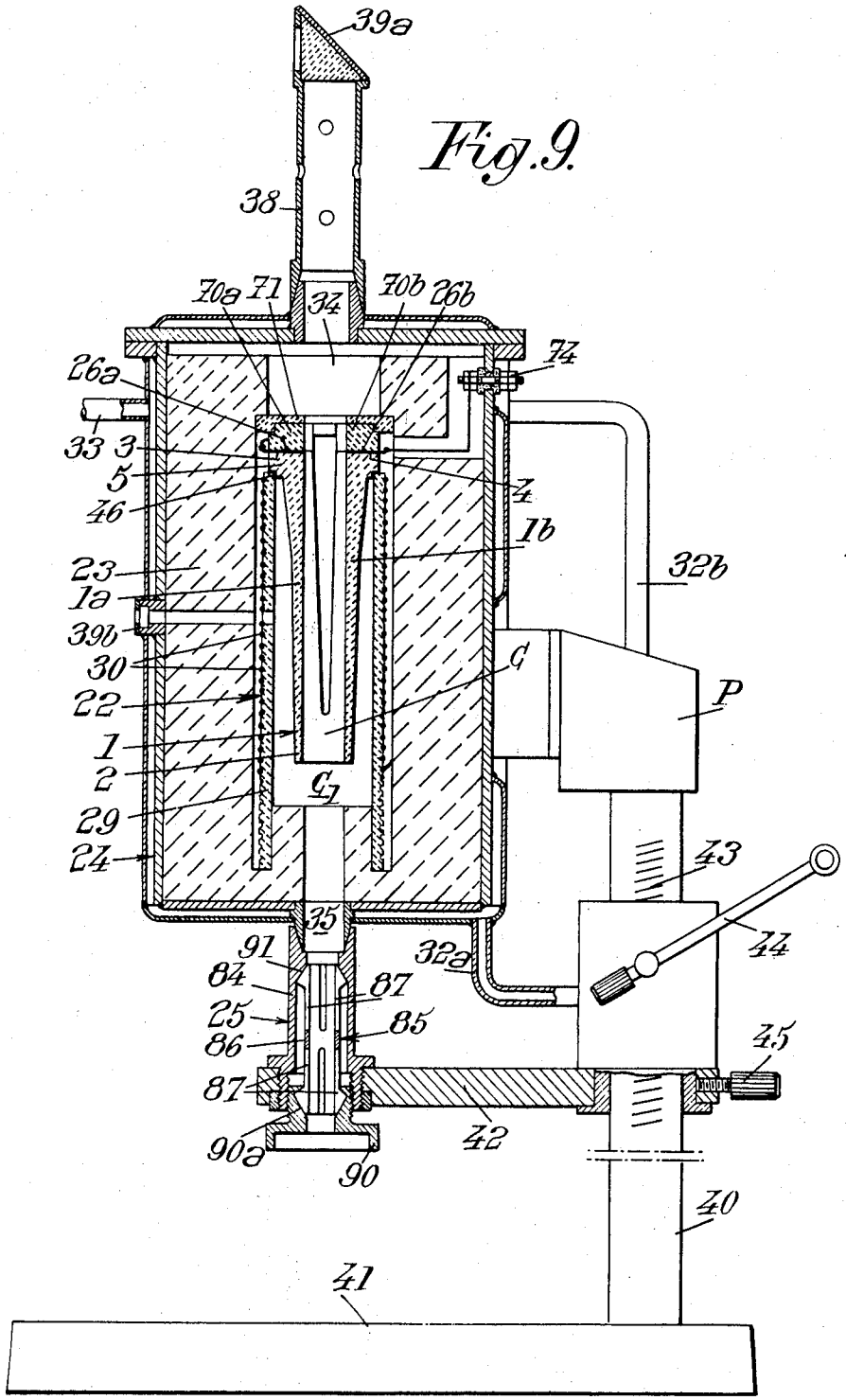

39a
38
70a
71
34
70b
26b
74
26a
33
3
5
46
4
1b
32b
23
1a
39b
30
22
G
P
1
2
G1
29
24
43
44
35
91
32a
84
87
25
85
86
45
87
42
90a
90
40
41

Fig. 10.

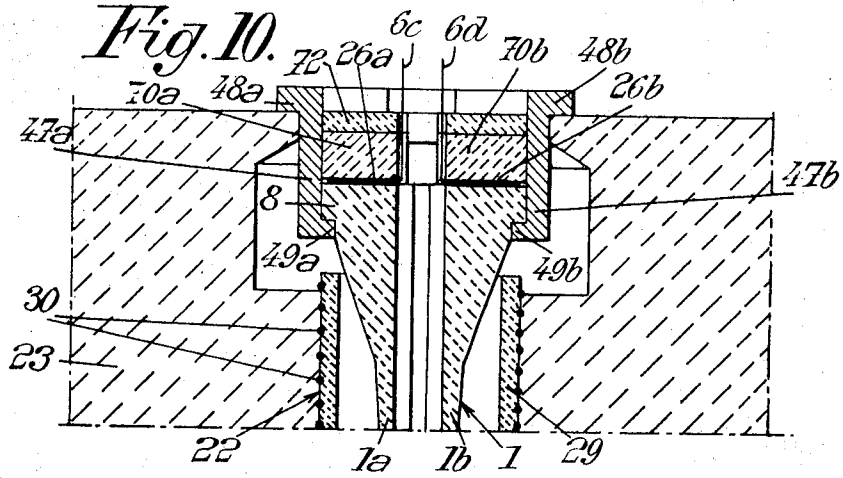
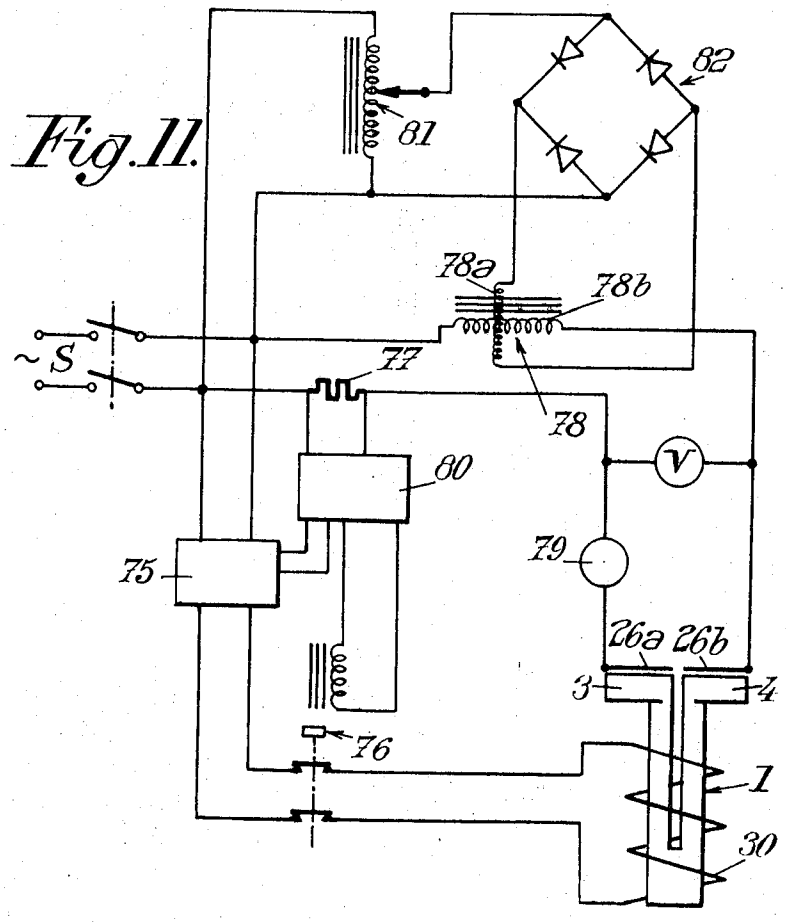

6c
6d
72
26a
70b
48b
26b
70a
48a
47a
47b
8
49a
49b
30
23
22
1a
1b
1
29

Fig. 11.


82
81
78a
78b
S
77
78
V
80
79
75
26a
26b
3
4
76
1
30

HEATING ELEMENT FOR AN ELECTRIC FURNACE

This is a division of our copending application Ser. No. 825,306, filed May 16, 1969.

This invention relates to a heating element made of a refractory material resistant to oxidation for an electric furnace.

Heating elements of the type in question and electric furnaces comprising heating elements made of refractory materials are known, as well as pre-heating means and heat insulating means.

The known heating elements do not give satisfaction when it is necessary to reach very high temperatures, in particular temperatures which exceed 2,000°C.

An object of this invention is to remedy this disadvantage.

A heating element, for use in an electric furnace, in accordance with this invention has the form of two hollow hemicylindrical parts, disposed face to face by their concave portions at a slight distance from each other, these two hemicylindrical parts being supplied with current at one of their ends and connected together at their other end by a common cylindrical part; and this heating element is characterized by the fact that, on the one hand, the exterior radii of the hemicylindrical parts and of the common cylindrical part, as well as the thicknesses of these parts, decrease from the end of the two hemicylindrical parts by which these latter parts are supplied with electric current, to the end of the common cylindrical parts, and by the fact that, on the other hand, the distance between the corresponding opposing edges of the two hemicylindrical parts decreases in the direction of the common cylindrical part.

The heating element may be constituted in the form of a compound element, comprising two tubular elements disposed coaxially one inside the other and joined together by one of their ends, the other end of each of these two elements constituting one of the terminals of the compound element.

An electric furnace equipped with a heating element, in accordance with the invention, comprises pre-heating means surrounding the heating element, the assembly being disposed inside a heat-insulating container, and this furnace is characterized by the fact that it comprises means on which the heating element is suspended inside the cavity formed by the container, by the ends of this heating element through which the electric current is supplied, the other end of the heating element being free, these suspension means being such that they prevent direct contact between the heating element and the constituent parts of the preheating means.

The invention will be able to be well understood from the following complementary description as well as from the accompanying drawings,

FIGS. 1 to 6, of these drawings, show in section a first embodiment of a heating element according to the invention, as well as six variants of the suspension means according to the invention;

FIG. 7 shows in section a second embodiment of the heating element according to the invention, as well as the corresponding suspension means;

FIG. 8 shows in axial section a heating element according to a modification of the invention;

FIG. 9 shows in axial section an electric furnace including one embodiment of a heating element according to the invention;

FIG. 10 is a sectional view of a part of the furnace of FIG. 9, arranged according to a modification; and

FIG. 11 is a schematic diagram showing the means for supplying electricity to the various parts of that furnace.

In the furnace embodiment illustrated by FIGS. 1 to 6, the heating element, designated as a whole by 1, comprises two concave hemicylindrical parts 1*a* and 1*b* disposed face to face at a slight distance from each other, and connected together by one of their ends by a common cylindrical part 2; the two hemicylindrical parts 1*a* and 1*b* are supplied with electric current via their respective free ends 3 and 4.

By the co-operation of the parts 1*a* and 1*b*, a heating cavity C is delimited.

At the level of the ends 3 and 4, a collar 5 is provided, directed towards the exterior, and permitting the element 1 to be supported at the interior of the electric furnace (which will be described later on) by suspension means (which will also be described later on).

It has been demonstrated that, when it is desired that the temperature at the level of the ends 3 and 4 be lower than 1,700°C whereas the temperature of the cavity C exceeds 2,000°C, it is necessary that the resistance of the element per unit length at the level of the ends be half of the resistance per unit length at the level of the heating cavity, that is to say:

$$R_{2,000} = 2\,R_{1,700}$$

with $R_{2,000} = \rho_{2,000} \times 1/s_{2,000}$ and $R_{1700} = \rho_{1,700} \times 1/s_{1,700}$ (ρ = resistivity of the element, 1 = length and s = cross-section). This can be written:

$$\frac{R_{2000}}{R_{1700}} = \frac{\rho_{2000}}{\rho_{1700}} \times \frac{s_{1700}}{s_{2000}} = 2$$

When the element is constituted of the ceramic zirconia,

$\rho_{2,000} = 1\ \Omega\text{cm}$.

$\rho_{1,700} = 10\ \Omega\text{cm}$,

which leads to

$s_{2,000}/s_{1,700} = 20$

If r is the exterior diameter of the element at a given level and dr its thickness (see FIG. 1), then

$s = 2\pi r\,dr$

and consequently,

$r_{1,700} = 20\,r_{2,000}$

if the thickness of the tube were constant.

Needless to say, it is not possible to respect this equality in practice, and consequently, in accordance with this invention, r and dr are made to decrease from the free ends to the common part 2.

Still in accordance with this invention, in order to avoid the production of arcs in the cool parts by reason of the segregation of the impurities and of their volatilization, and in order not to disturb the transverse thermal gradient, the element 1 is established such that the distance d separating the corresponding opposing edges of the parts 1*a* and 1*b* decreases from the free ends to the common part 2.

In general, the common part 2 is given a length such that the cross-section for the passage of current from one of the hemicylindrical parts to the other — this passage cross-section being obtained by cutting the heating element through a diametrical plane passing

through the slot separating the corresponding opposing edges of the parts 1*a* and 1*b* — is at least equal to the cross-section for the passage of current in the useful part of the heating element (which corresponds to the level of the part indicated by C in FIG. 4).

Nevertheless, in order to obtain an isothermal zone of very small thickness — for example for the purpose of zone melting — the part 2 is given a very short length, this part 2 being then reduced to a ring as can be seen in FIG. 3*a*.

Experience shows that the thickness of the wall at the level of the useful part of the cavity C should be chosen smaller than 8 millimeters.

By way of numerical example, a heating element, made of zirconia, which has given excellent results (it has not shown any sign of deterioration after having been maintained for more than 500 hours in service at a temperature of 2,000°C in air) has the following characteristics:

total length	150 mm.
diameter of the cavity C	20 mm.
length of the parts 1*a* and 1*b*	120 mm.
width of the slot separating 1*a* and 1*b*:	
at the level of the collar	10 mm.
at the level of the common cylindrical part	3 mm.
thickness of the wall:	
at the level of the collar	8 mm.
at the beginning of the useful part	3 mm.
at the level of the common cylindrical part	2 mm.

Another heating element which has given excellent results has the following characteristics:

total length	150 mm.
length of the common cylindrical part	20 mm.
interior diameter	36 mm
width of the slot:	
at the level of the collar	10 mm
at the level of the common cylindrical part	3 mm
thickness of the wall:	
at the level of the collar	17 mm
at the level of the useful part	6 mm
at the level of the common cylindrical part	4 mm

In the embodiment of FIG. 7, the characteristics which have just been stated with respect to *r*, dr and *d* are also present. This embodiment is distinguished from the preceding one in that the collar for placing it on the suspension means is, in the embodiment of FIG. 7, directed towards the interior of the cavity C. This collar is designated by 8.

In certain cases, it is necessary to have heating elements of the type in question whose heating cavity constitutes a very large isothermal zone.

One can then use a variant of the heating element (FIG. 8) which has the form of a compound element comprising two tubular elements 11 and 12 disposed coaxially one inside the other and joined together by one of their ends, designated respectively by 11*a* and 12*a*, the other end of each of these elements — these ends are designated respectively by 11*b* and 12*b* — constituting the terminals of the compound element.

As visible in FIG. 8, the tubular elements 11 and 12 are constituted such that the ratio of the cross-sections taken respectively at the level of the end forming the terminal and at the level of the heating cavity — designated by C and delimited by the tubular element 12 — is greater than 1.5. Moreover, in order to avoid a non-continuous gradient of resistivity, the cross-section of each of the tubular elements varies in a continuous manner between the heating cavity and the end forming the terminal.

In FIG. 8, the current inputs have not been represented, but the suspension means 13 and 14 have been indicated, which maintain the compound element at the interior of the electric furnace.

In order to solidly join together the tubular elements 11 and 12 by their ends 11*a* and 12*a* which advantageously have the form shown in FIG. 8, there can be interposed between the mutually contacting surfaces of these ends, some powder of the constituent material of the tubular elements in question (for example zirconia-lime of formula ZrO_2 - 6% CaO), and the ensemble can be brought to a sufficient temperature to cause the joining by melting of the powder (temperature higher than 1,700°C). In place of the powder which has just been indicated, there can also be used a powder of a compound (for example Al_2O_3) which forms with the zirconia a eutectic (1,700°C for Al_2O_3).

Due to this construction — the element 12 which delimits the cavity C being itself disposed at the interior of a heated cavity C_E delimited by the element 11 —, the conditions of heating in the cavity C are excellent from the isothermal point of view.

The electric furnace (FIG. 9) equipped with a heating element 1 such as described above, comprises pre-heating means designated as a whole by 22 which surround the heating element, the assembly of the heating element and the pre-heating means being disposed at the interior of a cavity C_1 coaxial with the cavity C of the heating element 1 and formed by this heat-insulating container designated as a whole by 23.

The heat-insulating container is surrounded by a metallic envelope 24 which can be cooled by circulation of water, and the samples to be studied are put in place at the interior of the furnace and extracted from this furnace by means of a movable sample-holder designated as a whole by 25.

Current inputs 26*a* and 26*b* are maintained, under the influence of clamping means, in intimate contact with the free ends 3 and 4 of the parts 1*a* and 1*b*.

This furnace comprises suspension means on which the element 1 is suspended by the collar mentioned above at the interior of the cavity formed by the heat-insulating means 23, these suspension means being such that they prevent direct contact between the element 1 and the constituent parts of the pre-heating means 22.

The pre-heating means 22 can be constituted as shown by a tube 29 in the form of a cylinder of revolution, made for example of sintered alumina, and comprising a winding constituted by an electric resistance 30 made, for example, of platinum, rhodium platinum, or of an alloy such as kanthal or the like; these pre-heating means should be capable of bringing the temperature of the element 1 to more than 1,000°C.

The heat-insulating container 23 can be made of ceramic bricks for high temperatures, for example of the IRAD type, and this container 23 is such that the temperature prevailing at the interior of the cavity C_1 is in the neighborhood of the temperature of the element 1.

Moreover, the pre-heating means and the heat-insulating means are such that the heating element can be brought to its starting temperature — that is to say the temperature at which it becomes electrically conductive, — without the pre-heating winding becoming overheated, and such that the temperature around the heating element is homogeneous and relatively high. In this connection, good operation of the heating element requires that the following relation be satisfied

$T_o > T(1-4T/A)^{1/4}$

with

A = the exponent of the exponential in the expression of the resistivity

$$\rho = \rho e^{A/T}$$

T_o = temperature at the interior of the cavity C_1

T = temperature of the heating element.

The metallic envelope **24** which surrounds the heat-insulating container **23** has a double wall, as visible in FIG. **9**, which permits circulation of cooling liquid brought in by supply conduits **32***a*, **32***b* and evacuated by an evacuation conduit **33**.

Still as visible in FIG. **9**, the cavity C_1 communicates with the exterior via an upper opening **34** and a lower opening **35** both of which pass through the container **23** and the envelope **24**. Due to these openings, it is possible to bring into the cavity *C* a sample (not shown) intended to be studied.

In the furnace shown in FIG. **9**, it is via the lower opening **35** that the samples to be studied are introduced, by using the above-mentioned sample holder **25** which will be described later on. Still in this embodiment, the opening **34** is provided with an apertured tube **38** comprising a sighting device **39***a* for permitting the observation of the cavity *C* and the determination of the temperature which prevails there.

At the level of the cavity *C*, a second sighting device **39***b* is advantageously provided, passing through, as shown in FIG. **9**, the envelope **24**, the heat-insulating means **23** and the tube **29**. (The sighting device **39***b* permits in reality the interior of the cavity *C* to be observed via the slot formed by the parts **1***a* and **1***b*; in FIG. **9** the element **1** has been shown in a position which is not its normal position and which is obtained by a rotation of 90° about its axis.)

The furnace and the sample holder **25** can be mounted on a common vertical support **40** fixed on a foot **41**. (In practice, the foot **41** can comprise passages, not shown, for the inlet and the outlet of the water and for the electric supply.) The furnace is preferably maintained in a fixed position on the support **40**, as shown, by a bracket P, whereas the sample holder **25** is connected to the support **40** by an arm **42** which can be moved along the support **40**, for example by means of a rack system **43**, known per se; this system is controlled by a handle **44**. By means of a clamping screw **45**, it is possible to immobilize the arm **42** in different positions around the support **40**.

In the furnace of FIG. **9**, the suspension means, which prevent direct contact between the element **1** and the pre-heating means **22** and on which is suspended the element **1**, are constituted by elements **46** made of a metal resistant to oxidation, for example a metal of the platinum group. In the absence of such a precaution, a eutectic between the zirconia of the element **1** and the alumina of the tube **29** would be formed at high operating temperatures.

In this case, it is appropriate to choose the dimensions of the various constituent elements of the furnace such that the value of the diameter of the tube **29** is greater or equal to the value of the diameter of the element **1** in its useful part multiplied by the factor 1.5.

In the embodiment of FIG. **10**, the suspension means which prevent direct contact between the element **1** and the pre-heating means **22** and on which is suspended the element **1**, are constituted by two semicylindrical elements **47***a* and **47***b* whose form is visible in the figure and which comprise:

a first collar, respectively **48***a* and **48***b*, directed towards the exterior and by which the semicylindrical elements **47***a* and **47***b* are suspended on parts of the heat-insulating means,

a second collar, respectively **49***a* and **49***b*, directed towards the interior and on which rests the collar **8** of the element **1**.

In the embodiments illustrated by FIGS. **1** to **7**, the suspension means which prevent direct contact between the heating element and the constituent parts of the pre-heating means and on which is suspended the heating element, comprise two parts, made of refractory oxides, bearing respectively the two hemicylindrical parts of the heating element; the ensemble is arranged such that no electric current can circulate between the two constituent parts of these suspension means, even if, by reason of temperatures of more than 2,000°C reached by the heating element, certain zones of these constituent parts of the suspension means become conductive of electricity. The refractory oxides constituting respectively the suspension means and the heating element are chosen in such a manner that no reaction is possible between them; otherwise, metal elements resistant to oxidation are interposed.

When the heating element is made of zirconia, this same material can advantageously be used for constituting the suspension means.

In the embodiment represented in FIGS. **1** and **2**, the suspension means comprise a tube **50**, made of refractory oxide, slotted parallel to its axis along a certain part of its length by two tronconical slots **50***a* which open at one of its ends; the interior diameter D of the tube is chosen such that the two hemicylindrical parts of the element **1** can rest respectively by the collar **5** on the ends of the two parts of the tube **50**, separated by the slots **50***a*. By its other end, the tube **50** is disposed as shown in FIGS. **1** and **2** in a support, designated as a whole by **51**, which comprises water- or air-cooling means due to which it is avoided that the end of the tube becomes conductive of electricity.

In the case of FIG. **1**, the cooling means use water, and the ensemble **51** comprises for this purpose an annular circuit **52** through which can be made to flow the water brought in via an inlet **53** and flowing out via an outlet **54**.

In the embodiment of FIG. **2**, the cooling is by air, and the ensemble **51** comprises cooling fins **55** disposed in a star.

In the case of the embodiment of FIG. **3**, the suspension means comprise two hemicylindrical pieces **56***a* and **56***b* of refractory oxide. These pieces are disposed face to face by their concave portion, the distance

separating the corresponding opposing edges being at the least 1 millimeter in order to avoid any possible contact following deformation due to the elevation of the temperature. These two pieces **56***a* and **56***b* are each composed of two parts of different thicknesses, E_1 and E_2. By the one of its parts whose thickness is smaller, each of these pieces supports one of the hemicylindrical parts of the heating element **1** in the same manner as the tube **50** of the embodiment of FIGS. **1** and **2**.

In the embodiment of FIG. **4**, the suspension means comprise an annular base **58** on which are fixed, as shown, for example cemented, two hemicylindrical parts **59***a* and **59***b*. The relative disposition of the two parts **59***a* and **59***b* is such that their corresponding opposing edges are distant by at least **1** mm for the same reasons as indicated above. It is by the free end of the two hemicylindrical parts that are supported the hemicylindrical parts of the heating element **1** by the collar **5**.

In the embodiment represented in FIGS. **5** and **6**, the heating element **1** rests by the collar **5** on the edge of a hole **60** formed in a plate **61** which is placed on a tube **62** and which is separated by a slot **63** into two portions joined together by a zone **61***a* situated in a region sufficiently cool so that there is no current leakage between the two portions of the plate.

In the case of FIG. **5**, there has been shown, schematically, the tube **29** which is housed at the interior of the tube **62**, on which rests the plate **61**, the ensemble being placed in the cavity C_1 of the electric furnace.

The thickness of the plate **61** is small but at least equal to **2** millimeters.

It has been possible to maintain, for several hours, a temperature of 2,200°C in a furnace according to the invention equipped with the heating element and the suspension means of the embodiment of FIGS. **5** and **6**.

Finally, in the case of the embodiment of FIG. **7**, the suspension means are constituted by a tube **65** slotted parallel to its axis along a certain part of its length by two slots **66** diametrically opposed, of width *m*, this tube **65** comprising at the end where the slots **66** open, a collar **67** directed towards the exterior. The two hemicylindrical parts of the element **1** can bear by their interior collar **8** on the collar **67** of the two parts of the tube **65**. For the same reasons as indicated above, the value of *m* is at least 1 millimeter. There again, the cylindrical part of the tube **65** is situated in a region where the temperatures are sufficiently low to avoid any current leakage.

In the case of the embodiments of FIGS. **1** to **4**, on the one hand, and FIG. **7**, on the other hand, the ensemble constituted by the element **1** and the suspension means is placed at the interior of the tube **29**. (Needless to say, in the case of the embodiment of FIGS. **1** to **4**, the suspension means have a sufficient length below the part **2** of the element **1** so that their end which must not become conductive is placed outside the influence of the winding **30**.)

The clamping means shown in FIGS. **9** and **10**, which maintain the current inputs **26***a* and **26***b* against the ends **3** and **4** can be constituted by two semicylindrical elements **70***a* and **70***b* whose form can be seen from FIGS. **9** and **10**. These elements are maintained in place, either by a centering member **71** whose form appears in FIG. **9** with regard to the first embodiment, or by a centering member **72** whose form appears in FIG. **10** and which co-operates with the elements **47***a* and **47***b* with regard to the second embodiment.

The electric current arrives at the current inputs **26***a* and **26***b* as well as at the resistance **30** from an electric socket **74**, indicated schematically in FIG. **9**.

The means for supplying electricity to the pre-heating resistance **30** on the one hand, and to the heating element **1** on the other hand, are arranged such that they assure the stability of the temperature of the element **1**.

In FIG. **11** there is schematically shown an advantageous embodiment of these means which comprise a pre-heating circuit and a circuit for supplying the element **1**, both of these circuits being connected to a source S of alternating current.

The pre-heating circuit supplies the resistance **30** by the intermediary of a mechanism **75** comprising a multi-output transformer which permits medium or high pre-heating according to the position of the setting of a time counter which is also contained in the mechanism **75**. For, in order to guaranty a long life for the heating element, it is necessary to bring it slowly and regularly to the operating temperature. A double contactor **76** is also provided on this circuit.

At the beginning, the time counter controls a medium pre-heating for 1 hour, then a high pre-heating until the temperature of starting of the element **1** is reached.

The circuit for supplying the element **1** comprises, in series, besides the element **1** itself, an element **77** and a self-inductance of variable saturation **78** which will be described hereafter, as well as an amperemeter **79**.

The element **77** is chosen such that it is capable of detecting the starting of the element **1**. It can be constituted, for example, by a resistance, as shown. The starting of the element **1**, — that is to say, the starting of current flow through the element **1**, — produces a difference of potential at the terminals of the resistance **77**. This difference of potential energizes a relay, not shown, provided in a conventional circuit-breaker device **80**, which actuates the double-contactor **76**; this double-contactor **76** then cuts off the pre-heating supply circuit.

The above-mentioned self-inductance of variable saturation comprises a control winding **78***a* and a work winding **78***b* which is mounted in series with the element **1**. By acting on the intensity of the continuous current which flows through the control winding **78***a*, the magnetizing field in the work winding, and consequently, the impedance of this work winding, are varied. The continuous current of variable intensity supplying the control winding is obtained with the aid of a variable autotransformer **81** and a rectifier bridge **82**.

At the beginning of an operational run, the autotransformer **81** is regulated so that the saturation voltage is such that the temperature of the element **1** stabilizes towards 1500°C. Once this temperature is reached, the temperature increase is continued by acting manually on the autotransformer **81**.

Between the terminals of the element **1**, a voltmeter V is placed.

With regard now to the sample-holder **25** (FIG. **9**), it comprises essentially a tubular element **84** fixed on the

arm 42, for example by screwing as shown; the tubular element 84 comprises a member 85, in accordance with the invention, which is constituted by a tube element 86 which carries at each of its ends a plurality of jaws 87 (four in the present embodiment) which are operated in the manner of the jaws of a chuck and which are consequently capable of ensuring the clamping of a given sample along two circles, due to which it is possible to use the same member 85 for samples of different diameters varying within much wider limits than it would be possible to do with a conventional chuck having a single clamping circle.

The actuation of the jaws of the member 85 is obtained by the action of a screw 90 which can be screwed on the element 84, this screw then co-operating, due to an inclined plane 90*a*, with the jaws carried by one of the ends of the tube 86, the jaws carried by the other end of the same tube 86 co-operating with an inclined plane 91 provided at the interior of the element 84.

In order to put a given sample in place at the interior of the cavity C, first of all the sample-holder 25 is descended by acting on the handle 44. By unscrewing the screw 45, the arm 42 is made to pivot about the support 40 in order to free the furnace. The screw 90 is then unscrewed in order to put the sample in place in the member 85 and the screw is screwed up again. It is sufficient then to pivot the arm 42 in the opposite direction in order to bring the sample-holder below the opening 35 of the furnace and to make this sample-holder move back up again with the aid of the handle 44. At the end of the upward movement, the sample-holder fits, for example as shown in FIG. 9, on the opening 35, and the sample proper is then positioned at the interior of the cavity C. In order to adjust with precision the position of the end of the sample, whatever be the length of this sample, it is advantageous to use a hollow screw 90 such as the one which is shown in FIG. 9.

Once the sample is thus put in position, it is sufficient to connect the means for supplying the electricity.

The furnace thus established has numerous advantages, in particular:

the advantage of permitting a sample in a container to be brought to a high, homogeneous, adjustable and very stable temperature, in an oxidizing or neutral atmosphere, without using costly or badly suited techniques;

the advantage of permitting measurements to be effected by sighting the interior of the heating cavity due to the slot of the element 1, without introducing measuring probes.

What we claim is:

1. Heating element made of a refractory material resistant to oxidation, comprising two hollow hemicylindrical parts disposed face to face by their concave part at a slight distance from each other, one end of each said hemicylindrical part constituting a terminal via which electric current can be supplied, the other end of each said hemicylindrical part being connected together by a common cylindrical part, in which heating element the exterior radii of the hemicylindrical parts and of the common cylindrical part, as well as the thicknesses of these parts, decrease from the end of the two hemicylindrical parts by which these two hemicylindrical parts are supplied with electric current to the end of the common cylindrical part, and the distance between the corresponding opposing edges of the two hemicylindrical parts also decreases from the end of the two hemicylindrical parts by which these two hemicylindrical parts are supplied with electric current, in the direction of the common cylindrical part.

2. Heating element according to claim 1, further comprising, at the free end of the hemicylindrical parts, a collar by which collar said heating element can be suspended.

3. Heating element according to claim 1, in which the thickness of the hemicylindrical parts is less than 8 millimeters at the level of the useful part of the heating cavity of said heating element.

4. Heating element according to claim 1, in which the common cylindrical part is reduced to a ring.

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