United States Patent [19]

Anthony et al.

[11] **3,786,165**

[45] **Jan. 15, 1974**

[54] **PREHEATING METHOD FOR FURNACES**

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[73] Assignee: **Agence Nationale De Valorisation De La Recherche (Anvar),** Paris-Defense, France

[22] Filed: **Nov. 30, 1972**

[21] Appl. No.: **310,790**

Related U.S. Application Data

[62] Division of Ser. No. 91,847, Nov. 23, 1970.

[30] **Foreign Application Priority Data**

Nov. 24, 1970 France 7040379

[52] **U.S. Cl.** **13/34,** 13/20

[51] **Int. Cl.** **F27d 23/00**

[58] **Field of Search** 13/1, 20, 25, 34

[56] **References Cited**

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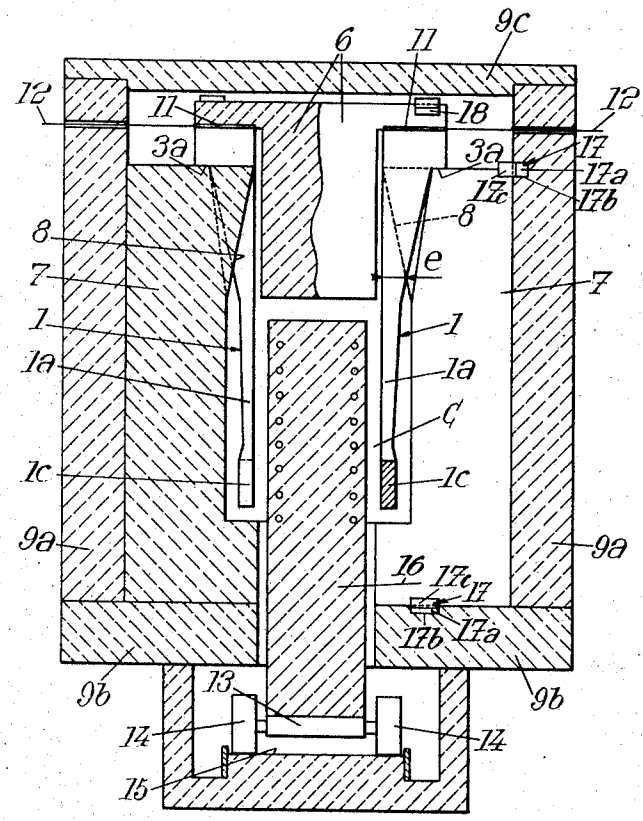
Primary Examiner—Roy N. Envall, Jr.

Attorney—Marvin Petry

[57] **ABSTRACT**

The furnace has *n* superposed rows of *m* heating elements suspended on supports, the assembly bounding a heating cavity in the form of a tunnel. The elements are U-shaped and suspended at the ends of their arms. At least some of these elements are heated to 2000° to 2200°C by a movable preheating element, supplemented by radiation from the initially preheated elements to the others progressively.

2 Claims, 14 Drawing Figures



PATENTED JAN 15 1974

3,786,165

SHEET 1 OF 3

Fig. 1.

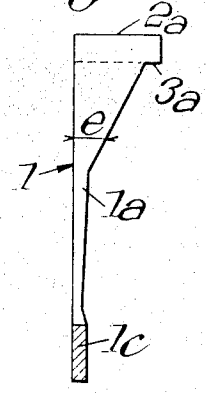


Fig. 2.

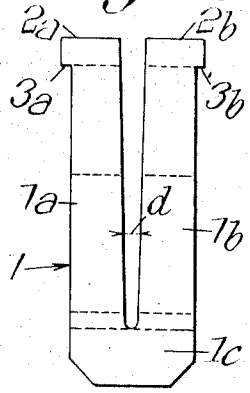


Fig. 3.

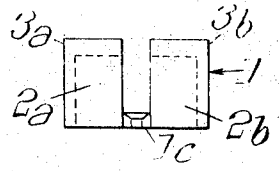


Fig. 6.

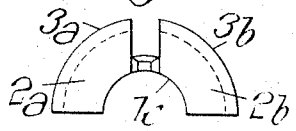


Fig. 4.

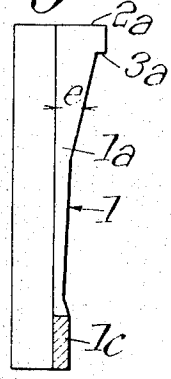


Fig. 5.

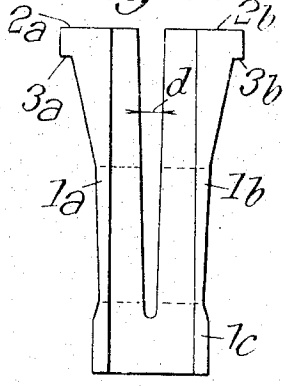


Fig. 9

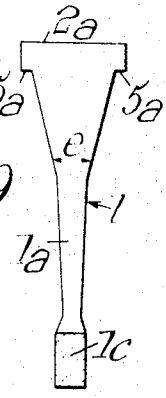


Fig. 7.

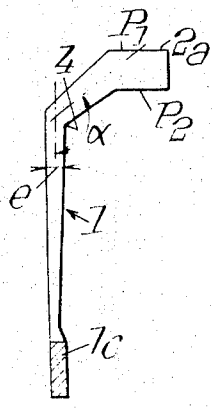


Fig. 8.

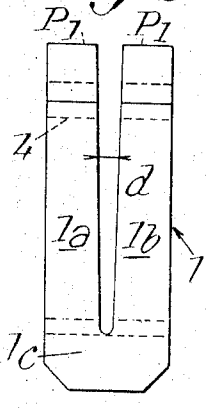


Fig. 10.

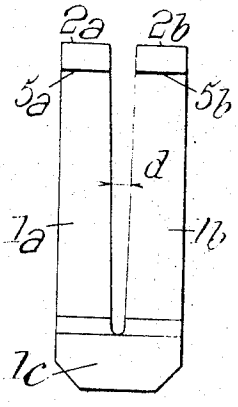


Fig. 12.

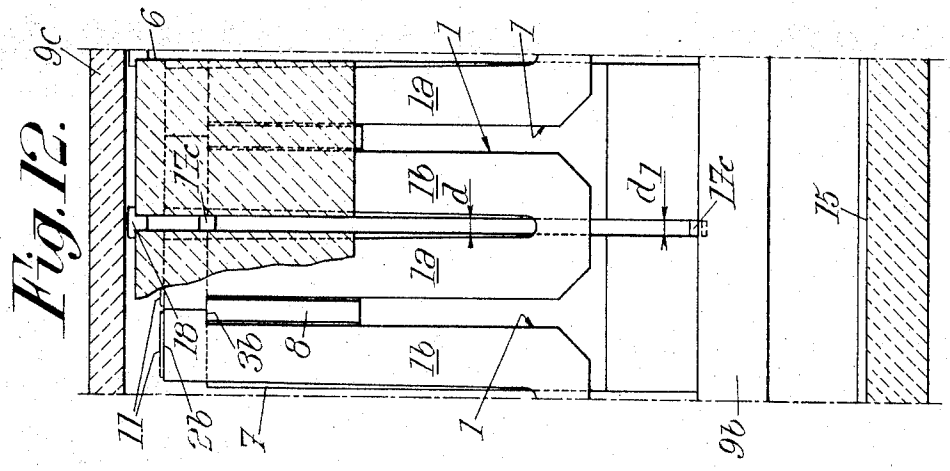

9c
6
1
1
1a
17c
1b
d
d1
17e
15
1a
18
3b
8
1b
11
9b
7
1
9b

Fig. 11.

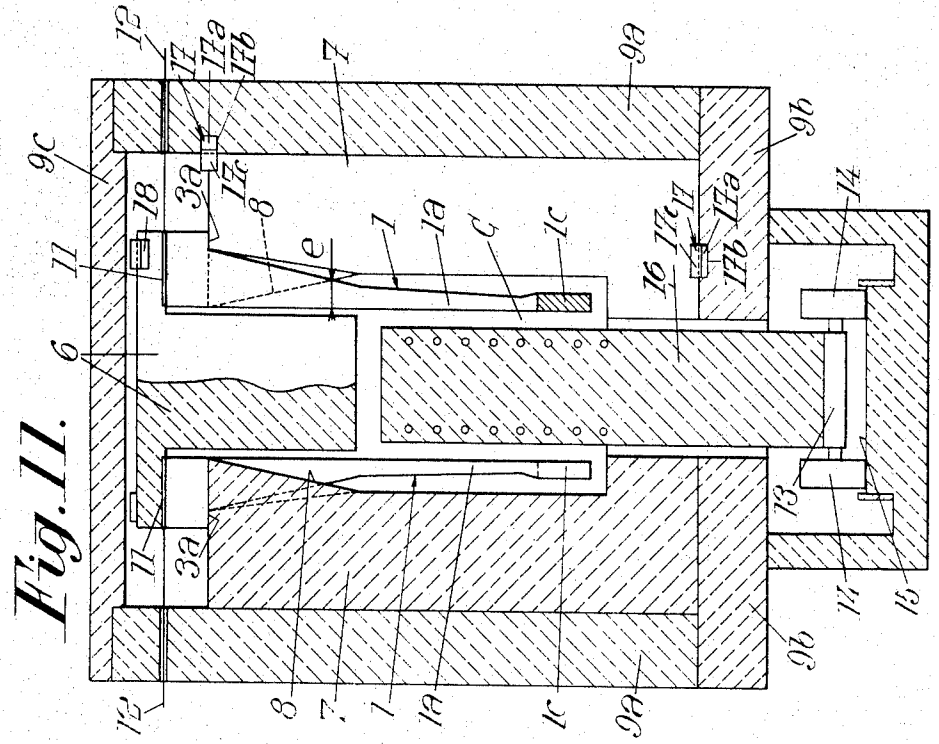

12
17
17a
17b
7
9a
9b
9c
18
3a
17c
8
1
1a
C
1c
e
17
17a
17b
16
14
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3a
11
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9b
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1a
1c
9a

Fig. 14.

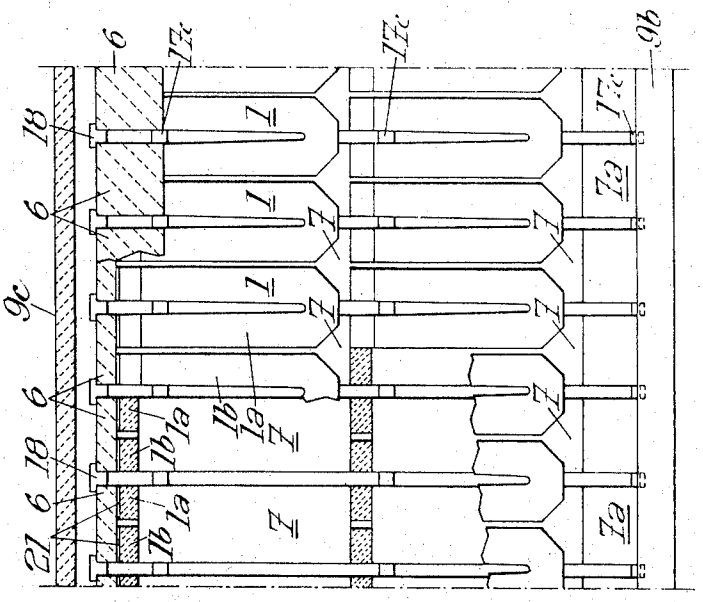
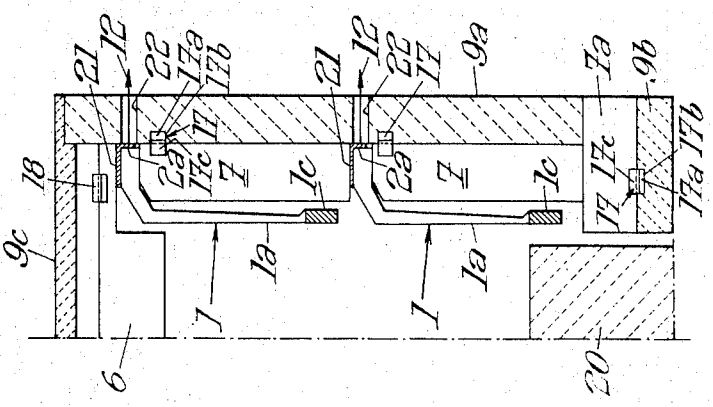

6
17a
17c
9b
18
6
9c
6
18
6
21
1
7
1b
1a
17a

Fig. 13.


21
12
22
17a
17b
9a
17a
9b
18
9c
23
17c
7
1c
1a
1
6
20
17
17a
17b

PREHEATING METHOD FOR FURNACES

This is a division, of application Ser. No. 91,847 filed Nov. 23, 1970.

This application is a division of our copending application Ser. No. 91,847 filed Nov. 23, 1970, relating to a heating element of the type of those which are constructed of a refractory material with a melting point above 2200°C, resistant to oxidation; of positive coefficient of resistivity and which are generally called "resistors," and also relating to the assemblies obtained by combining several of the abovesaid elements and the furnaces constructed by means of the abovesaid elements or assemblies.

The present invention relates to a method of preheating such furnaces.

The method of preheating according to the invention is characterised by the fact that recourse is had to a movable preheating element acting either on the assembly of heating elements entering into the constitution of the furnace according to the invention, or on some only of the said heating elements; the preheating of the other elements being then ensured more and more by means of radiation from the initially preheated elements, whose temperature is brought to 2,000°–2,200°C.

The invention consists, apart from the above-mentioned features, of other features which are preferably used at the same time and which will be more explicitly considered below.

In order that the invention may be more fully understood, several embodiments thereof are described below purely by way of illustrative but non-limiting example, with reference to the accompanying drawings, in which:

FIGS. **1, 2** and **3** represent respectively a section, a view in elevation and a plan view of a heating element of a furnace to which the method according to the invention can be applied;

FIGS. **4, 5** and **6** show in similar manner a second heating element;

FIGS. **7** and **8** represent respectively in section and in elevation a third heating element;

FIGS. **9** and **10** show respectively in section and in elevation a fourth heating element; and

FIGS. **11** and **12,** just as FIGS. **13** and **14,** show respectively a section, with portions removed, perpendicular, and a section with portions removed parallel, to the axis of a furnace in the form of a tunnel.

As regards first of all the heating element which is constituted of a refractory material resistant to oxidation, in general of completely or partially stabilised zirconia, it comprises two elongated arms **1***a* and **1***b* parallel to a plane or incurved parallel along their largest dimension. These two arms, which are facing along their narrow side parallel to their largest dimension, are connected at one of their ends by a common part **1***c* and supplied with electric current through their other free end, and denoted respectively by **2***a* and **2***b*. The free end concerned is arranged in such a manner that it enables suspension of the said heating elements.

To obtain a gradient of resistivity in the sense of the length and to avoid any arc formation in the cold portions, the thickness e of the arms and the distance *d* which separates them decreases from the free ends in the direction of the common part **1***c*.

As regards this common part **1***c*, it is advantageous to confer on it, as shown in the drawings, a thickness greater than the least value of *e*, due to which the risk of thermal shock is avoided by rendering the temperature uniform in the part **1***c* and the life of the element is prolonged. This same object could be achieved by thermally insulating the part **1***c*. In practice, the above-said increase in thickness commences at a distance of 3 to 4 mm above the common part **1***c*.

In FIGS. **1** to **3,** the arms **1***a* and **1***b* are parallel to a plane. The free ends **2***a* and **2***b* are of rectangular shape and comprise respectively a small collar **3***a* and **3***b* on two of their sides, as seen in FIG. **3,** due to which it is possible to suspend them.

In FIGS. **4** to **6,** the arms **1***a* and **1***b* are incurved parallel along their largest dimension. The free ends **2***a* and **2***b* are portions of circular crowns and comprise respectively a small collar **3***a* and **3***b* to enable their suspension.

In the case of FIGS. **7** and **8,** the two arms **1***a* and **1***b* are parallel to a plane over a portion of their length and bent at the same level, at **4,** along an angle α which does not exceed 165°. The free ends **2***a* and **2***b* of the two arms present two flat surfaces P_1 and P_2 substantially parallel between themselves and substantially perpendicular to the general direction determined by the largest dimension of those of the portions of the two arms which are connected by the common portion **1***c*. The particular application of this embodiment would emerge from the following description.

In the case of FIGS. **9** and **10,** the arms **1***a* and **1***b* are parallel to a plane. The ends **2***a* and **2***b* each have two ledges, respectively **5***a* and **5***b* on each of the faces determined by the group of the two arms. In the following description an advantageous mode of application will be given for heating elements of this type.

The useful part of the heating elements which have just been described correspond substantially to that of the portions of the arms **1***a* and **1***b* which comprise the common part **1***c*. In present practice, it can reach 2,200°C. The heating elements which have been described enable the construction of furnaces of any size and of any shape, that is to say of cylindrical shape or, on the other hand, in the form of a tunnel.

In FIGS. **11** and **12,** there is constructed a furnace in the shape of a tunnel comprising an elongated heating cavity C, lined laterally with heating elements **1,** closed overhead by heat insulating means **6,** generally of the same material as the elements **1,** that is to say of completely or partly stabilised zirconia and downwardly open.

As seen in FIG. **11,** the heating elements **1,** which are for example of the type of those of FIGS. **1, 2, 3** rest by their collars **2***a* and **2***b*, on one hand on the upper edge of support elements **7** and, on the other hand on projecting portions **8** for example in the form of a beak, as shown, comprised by the said support elements and entering between the neighbouring arms of two neighbouring elements **1,** it being understood that each element **1** rests by its two arms on two distinct neighbouring support elements separated by the distance d_1, due to which the short-circuiting of the said heating element is avoided.

The elements **7** are constructed of a material compatible with that of the heating elements at the temperature of operation of the latter, or separated from the latter by shims of platinum, or constructed, in the case

if operation at very high temperature, of the same material as the heating elements.

When the furnace is required to operate at a relatively low temperature, the heating cavity being at 1,800°–1,900°C, the risks of short-circuiting are eliminated and, instead of distinct supports **7**, there can then be contemplated a continuous support in the form of a bar of alumina on which rests the assembly of heating elements, plates being interposed between the bar and the elements **1**.

The overhead heat insulating means **6**, which are supported on the free ends of the elements **1**, can be constituted by distinct neighbouring elements, also spaced by d_1 from one another and such that a given element **6** is supported on the neighbouring arms of two neighbouring elements **1**, which neighbouring arms are of the same potential. However, when the furnace is required to operate at relatively low temperatures, of the order of 1,800°–1,900°C, it is possible to confer on the element **6** dimensions such that it rests on several elements **1**, this element being then constructed of refractory material such as alumina and platinum plates being interposed between the element **6** and the various elements **1**.

As seen in FIGS. **11** and **12**, the elements **6** and **7** are, in section, respectively in the shape of a T and of an L. As regards the elements **6**, the portion which corresponds to the horizontal bar of the T enables their suspension on the free ends of elements **1** and the portion which corresponds to the leg of the T is inserted between the two rows of elements **1** corresponding to the two walls of the tunnel and hence ensures heat insulation at the level of that of the portions of the heating elements which does not correspond to the useful portion of the latter.

As regards the elements **7**, the space which occurs between the horizontal leg and vertical leg of the L serves to receive the elements **1**. The spacing between the neighbouring elements **7** can be maintained by means of spacing shims **17** provided in the regions of the said elements **7** seen in FIGS. **11** and **12** and in which the latter are not conductive.

The spacing of the neighbouring elements **6** can be maintained at their side by shims **18** of which the shape and positioning are apparent in FIGS. **11** and **12**.

The assembly constituted by the elements **1** and the elements **6** and **7** is placed inside heat insulating means comprising, as shown, lateral **9***a* and lower **9***b* bricks, as well as a cover **9***c*, constructed of an insulating refractory material such as alumina.

The shims **17** are advantageously composed of a part **17***a* located in a cavity **17***b* provided in the bricks **9***a* and **9***b* and by a part **17***c* engaged between two given elements **7**.

The supply of the elements **1** with electric current can be ensured by means of platinum contacts **11** arranged on the surface of the free ends **2***a*, **2***b* —at which level the temperature does not reach 1,600°C — and connected to a source of current by wires **12**.

To introduce into the heating cavity, downwardly open as indicated above, of the furnace thus constituted, the parts which have to be subjected to the thermal treatments, recourse can be had to supports **13** adapted to be moved parallel to the axis of the tunnel constituting the heating cavity by means of any system, for example by rollers **14** which run on a rolling track **15** provided under the opening of the heating cavity as shown.

To reheat the elements **1**, recourse is had, according to the invention, to a movable preheating element **16** (preheated in suitable manner known in itself, for example electrically) capable of acting, either over the whole, or over some only of the said elements **1**, the preheating of the elements **1** being then ensured more and more by means of radiation of the initially preheated elements whose temperature is brought to 2,000°–2,200°C.

In the case of FIG. **11**, there is shown the element **16** placed on the support **13**.

When a preheating element is used which acts simply on some opposite elements **1**, there is provided on both sides of the said element **16**, heat insulating means also borne by the support **13**. Under these conditions, as soon as the elements **1** directly preheated have reached the temperature at which they become conductive, the preheating means is gradually moved outwardly, and as soon as, due to the fact of their operation, the preheated elements **1** have reached a temperature close to their proper temperature, they cause by heat exchanges by radiation the increase in temperature of neighbouring elements which are hence automatically preheated more and more, without any intervention of the preheating element, whose supply can be cut off.

Of course, the withdrawal of the preheating element and of the heat insulating means between which it is placed at the start must be effected very gradually to avoid any sudden temperature gradient capable of leading to deterioration of the elements **1**.

In the type of furnace which has just been described, the height of the heating cavity in the form of a tunnel is limited by the dimensions of the useful portion of the elements **1**.

To constitute heating cavities, for example in the form of a tunnel, of any desired height, recourse is had to assemblies of heating elements which can be called "modules" and which constitute in a way construction units which are assembled to one another.

These assemblies comprise n superposed rows of m heating elements **1** as well as as many rows of m-1 support elements of the type of support elements **7**, which have been considered above, and which are constructed of a material compatible with that of the heating elements at the temperature of operation of the latter, or separated from the latter by shims of platinum, or constructed, in the case of operation at very high temperature, of the same material as the heating elements.

Here again, when the furnace is called upon to operate at a relatively low temperature, of the order of 1,800°–1,900°C, the risks of short-circuiting are eliminated and, instead of distinct supports **7**, recourse can be had to a continuous suport of alumina on which rests the assembly of heating elements, platinum plates being interposed between this support and the various elements **1**. The constituent arms **1***a* and **1***b* of a given heating element **1** rest on two distinct neighbouring support elements, and support in their turn two neighbouring and distinct support elements, all the arms which are in contact with superposed support elements being at the same potential, the outer arms of the heating elements situated at the end of a row being supported on supports **6** of width twice as small as the

other supports **6**, this being to enable juxtaposition of the various assemblies or modules.

In FIGS. **13** and **14**, there is shown an oven with two stages which can be constructed by means of modules of two rows of superposed heating elements. The length of the tunnel is given by the number of modules used.

Due to this construction, there is obtained a tunnel of which the heating cavity is open downwardly, as in the case of the furnace of FIGS. **11** and **12**, and of which the two walls are lined with heating elements **1**. To arrange that the two heating surfaces present the minimum of possible discontinuities, recourse is had to heating elements of FIGS. **7** and **8**, by means of which configuration the heating elements of two superposed rows allow only one interval reduced to the maximum, as emerges from FIGS. **13** and **14**.

In the case shown, there is again found the upper heat insulating element which is in the form of a T for the same reasons as explained above, as well as support **7** which rest individually on elements **7***a*, capable of being constructed of the same material as the supports **7**.

There is also again to be found the heat insulating means constituted for example by bricks of alumina **9***a* and **9***b* and a cover **9***c*.

The supports **7** and **7***a* and, if necessary, the elements **6** are held separated from one another, as seen in FIGS. **13** and **14**, by shims **17**, **18** similar to those described with regard to FIGS. **11** and **12** and placed in the spots seen from the figures and corresponding to the conditions indicated with regard to FIGS. **11** and **12**.

In FIG. **13**, there is shown a bearing element **20** adapted to bring into the tunnel constituting the heating cavity and to extract from this tunnel, the parts intended to be subjected to the thermal treatment as well as the preheating element.

The supply of electricity to the heating elements **1**, is effected by platinum contacts **21** which are connected to the outside by electric wires **12**.

For the passage of the electric wires, it is advantageous to provide in the bricks **9***a* holes **22** of sufficient size to enable them, if necessary, to serve to ensure the cooling of the free ends of the elements **1**.

In the case of FIGS. **13** and **14**, it relates to a furnace in the form of a tunnel, but it is well understood that there can be constructed, by means of the elements and assemblies described, staged circular furnaces also.

To fix ideas, it is indicated that in practice, good results are obtained with elements **1** which weigh less than 200 g, of which the length is 150 mm and the width 40 mm, the useful zone having a length of 80 mm. These elements dissipate at 2,000°C less than 1 KW and can be taken to 2,200°C.

Always by way of example, it is indicated that a furnace of the type of those of FIGS. **11** and **12** constructed by means of six elements of zirconia with 3 percent of CaO, of which the total power is hence 6 KW and of which the dimensions of the heating cavity are 200 × 30 × 40 mm, is always in perfect condition after an operation of 200 hours at 2,050°C.

As regards the heating elements of FIGS. **9** and **10**, they enable the constitution of tunnels which are traversed by gases which it is desired to bring to high temperatures. In the tunnels concerned, the elements **1** considered are suspended on two walls bounding the tunnel by their edges **5***a* and **5***b* and thus project into the heating cavity. The support elements which constitute at the same time the walls of the heating cavity respond to the same conditions as the support elements **7** which have been considered above.

As a result of which and whatever the embodiment adopted, there is thus available, a method of preheating of which the characteristics and the advantages emerge sufficiently from the preceding description for it to be unnecessary to dwell on this subject and which can be adapted in selecting their characteristics as a function of the preceding description, to operate at temperatures which can reach 2,200°C or again at lower temperatures of the order of 1,800°–1,900°C.

As is self-evident and as emerges already besides from the preceding description, the invention is in no way limited to those of its methods of application, nor to those of its methods of production of its various parts which have been more especially indicated; it embraces, on the contrary, all variations.

We claim:

1. A method of preheating a furnace of the type comprising an assembly of a plurality of heating elements, each heating element being a resistor heating element of oxidation-resistant refractory material having two arms connected at one end by a common part, said arms being in the form of elongated parallel strips having narrow facing sides along their longest dimension, the other ends of said arms being free and adapted so that they can be suspended and adapted to be supplied with electric current, the thickness of said arms as well as the distance which separates them decreasing from the free ends in the direction of the common part; each said element of the furnace resting by its two arms on separate neighbouring supports constructed of a material compatible with that of the heating elements at the temperature of operation of the latter, heat-insulating means being provided to protect the said elements and supports:

said method comprising the steps of heating to 2,000° – 2,200°C at least some of said heating elements by a movable preheating element, preheating of the other elements then occurring from one to the next by radiation from the initially preheated elements.

2. Method of preheating according to claim **1**, comprising heating only some opposite heating elements by said preheating element, heat insulating means being provided on both sides of the preheating element, gradually moving said insulating means and said preheating elements outwardly from the time when the heating elements directly preheated have reached the temperature at which they become conductive, and cutting off the supply of the preheating elements from said time.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,786,165 Dated January 15, 1974

Inventor(s) Anthony, Anne-Marie; Dembinski, Krzysztof; Faucher, Michele and Dupont, Lucien

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the heading, please delete the present reference to the foreign priority and substitute therefor:

[30] Foreign Application Priority Data

November 24, 1969 France 69/40379

Signed and sealed this 24th day of September 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

USCOMM-DC 60376-P69

UNITED STATES PATENT OFFICE

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