

ELECTRIC FURNACE

Filed Dec. 7, 1928

4 Sheets-Sheet 1

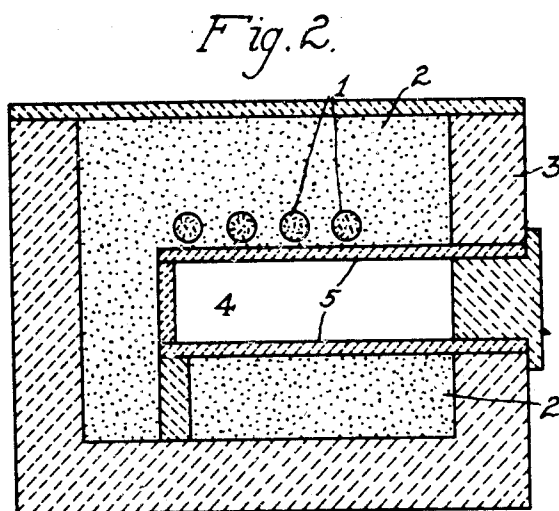
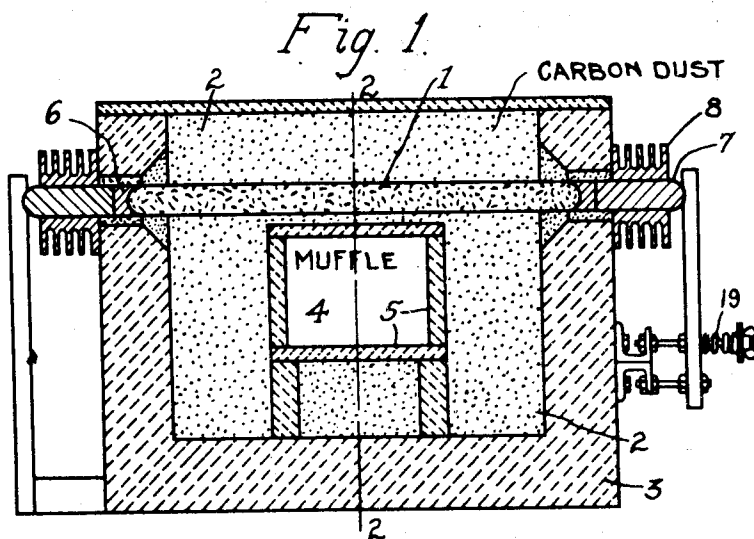


Fig. 3.

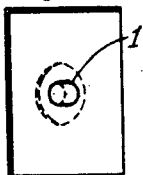


Fig. 4.

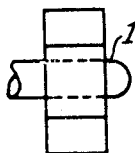
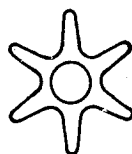


Fig. 5.



INVENTORS

Raymond C. Benner
BY George J. Easter
Charles E. Hawke
Thomas C. Mackay

ATTORNEY

Dec. 15, 1931.

R. C. BENNER ET AL

1,837,178

ELECTRIC FURNACE

Filed Dec. 7, 1928

4 Sheets-Sheet 2

Fig. 6.

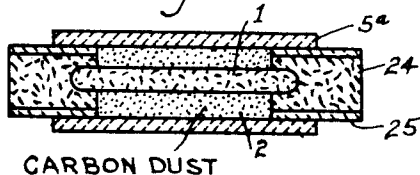


Fig. 7.

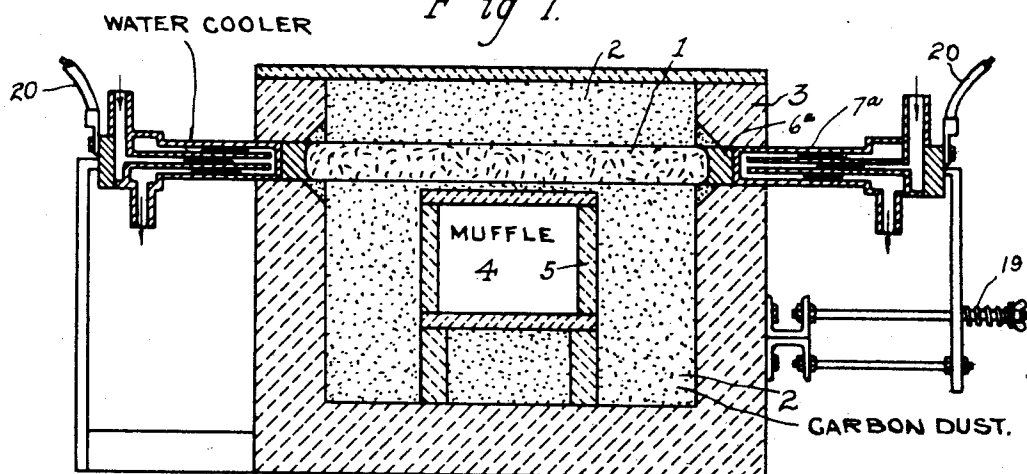
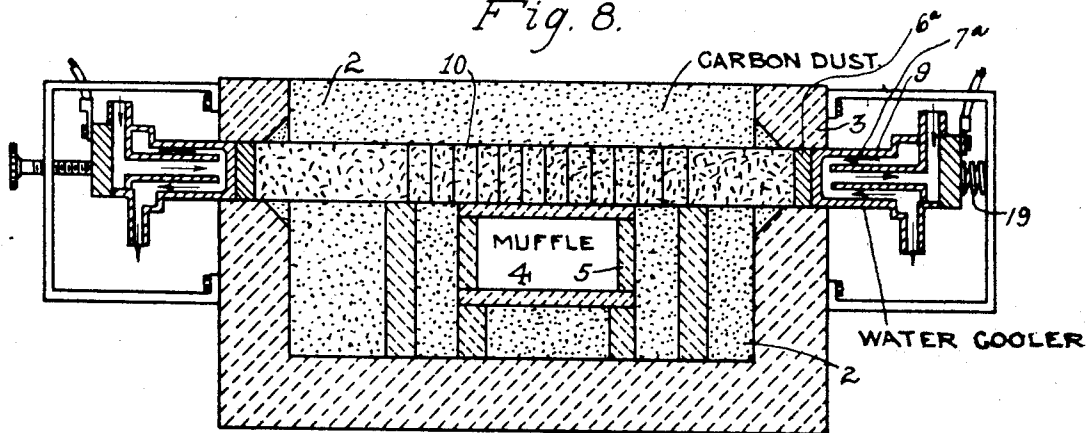


Fig. 8.



INVENTORS

Raymond C. Benner

BY George J. Easter

Clarence E. Hawke

Thomas C. Mackay

ATTORNEY

Fig. 9.

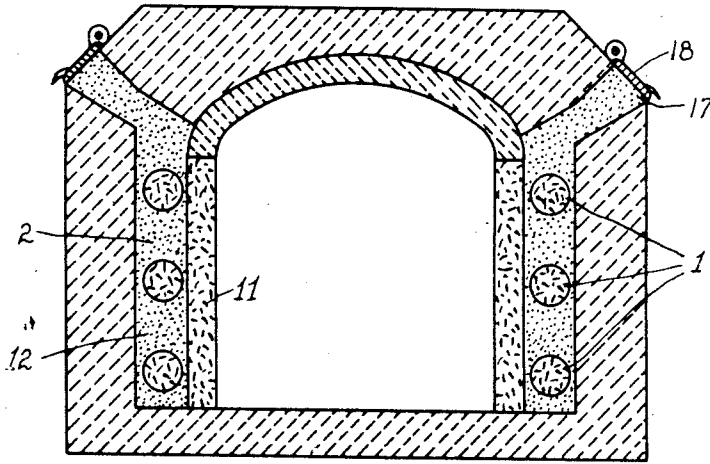
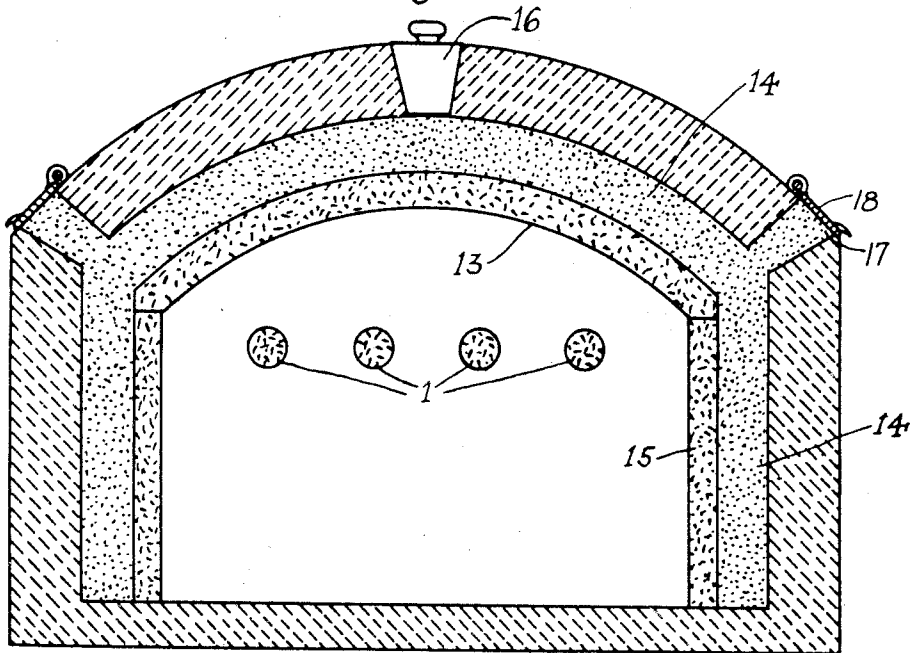


Fig 10.



INVENTORS
 Raymond C. Benner
 BY George J. Easter
 Clarence E. Hawke
 Thomas C. McKay
 ATTORNEY

Dec. 15, 1931.

R. C. BENNER ET AL

1,837,178

ELECTRIC FURNACE

Filed Dec. 7, 1928

4 Sheets-Sheet 4

Fig. 11.

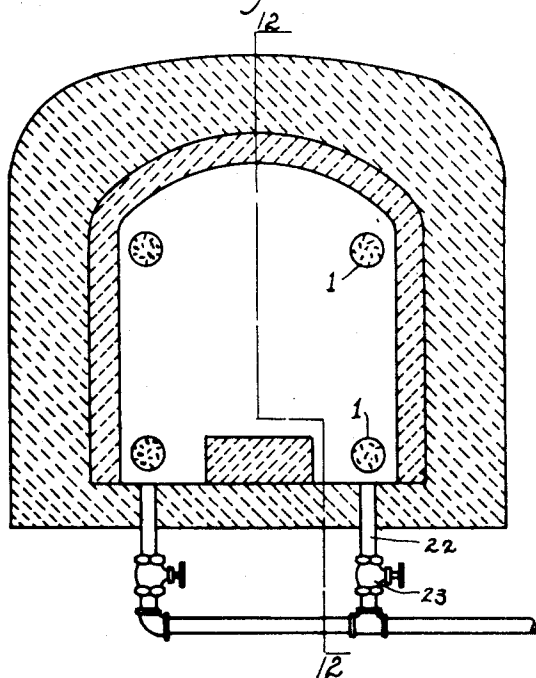
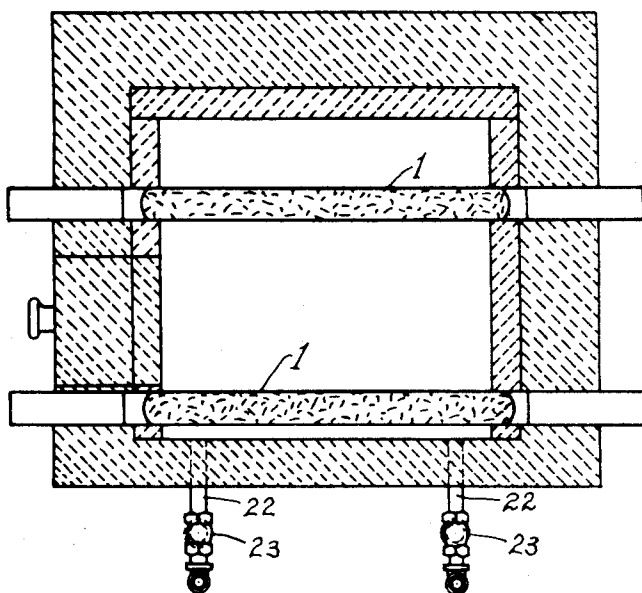


Fig. 12.



RAYMOND G. BENNER
INVENTORS GEORGE J. EASTER
CLARENCE E. HAWKE

BY *Thomas C. MacKay*

ATTORNEY

UNITED STATES PATENT OFFICE

RAYMOND C. BENNER AND GEORGE J. EASTER, OF NIAGARA FALLS, NEW YORK, AND
CLARENCE E. HAWKE, OF METUCHEN, NEW JERSEY, ASSIGNORS TO THE CARBORUN-
DUM COMPANY, OF NIAGARA FALLS, NEW YORK, A CORPORATION OF PENNSYL-
VANIA

ELECTRIC FURNACE

Application filed December 7, 1928. Serial No. 324,416.

Our invention relates to the prolongation of the useful life of non-metallic resistors such as are employed in electric furnaces for temperatures up to 1400°C . A related object of our invention is to raise the temperature limit at which such resistors can be profitably used in a commercial way up to 1600°C .– 1800°C .

Our invention applies particularly to rigid resistors of silicon carbide. Such resistors possess much higher specific resistance than carbon, graphite or metals and may, accordingly, be utilized in a form which is much more convenient to handle.

From a purely thermal standpoint such resistors can be used at very high temperatures, silicon carbide for instance can be subjected to a temperature of 2200°C . before decomposing. It has been found however, that at temperatures above 1100°C . the resistors have slowly increased in resistance due to the oxidation of the carbide by gases in contact therewith. In the case of some silicon carbide rods the resistance doubles in the course of 1000 hours of use due to this phenomenon. The operating temperatures for such rods for any reasonable life is ordinarily found to be limited to about 1400°C .

The useful life of such resistors also depends greatly on the avoidance of arcing at the point of contact between the non-metallic resistor and the metallic conductors supplying current thereto. This tendency to arcing and the seriousness of its effects are materially increased as the temperature of the contact is increased so that it is necessary to adopt means for keeping this contact as cool as possible, particularly where as, in our invention, the temperature of the resistors is raised above 1400°C . It has accordingly been necessary to provide means for cooling the ends, which will be hereinafter described.

We have found that these resistors can be protected from oxidation in such a manner as to greatly increase their useful life at the temperatures heretofore used and that the possible operating temperature can be increased as noted above by surrounding the heated portion of the resistor with a gas, for

example producer gas, nitrogen or carbon monoxide, which is incapable of reacting with it to oxidize the carbide. Such a gas may be introduced as such in the vicinity of the rod or may in other cases be conveniently formed from the air adjacent the resistor, by embedding the resistor in granular or powdered carbonaceous material which we find is more readily oxidized than the carbide, resulting in the formation of an atmosphere of carbon monoxide around the resistor.

It is known that electric furnaces heated by wire resistors of platinum, molybdenum, tungsten, etc. have been filled with hydrogen for protecting the resistors from oxidation at extremely high temperatures, the hydrogen being permitted to diffuse outwardly through the walls of the compartment containing material to be heated and around the resistors which in such furnaces are wound upon said walls. It is also known that for limited service such metallic windings have been protected by embedding them in powdered charcoal, which is sometimes mixed with powdered oxides such as alumina or magnesia; and that graphite resistors have also been embedded in lampblack or similar materials to increase their life. We have no knowledge however of any utilization of similar means for protection of carbide resistors despite the fact that the latter have been in common use and the difficulties attendant upon their oxidation well known for a number of years.

The various means which we use for protecting the resistor rods and increasing the temperature at which they can be used are illustrated in the accompanying drawings in which:

Figure 1 is a vertical section of a furnace in a plane parallel to a resistor rod protected in accordance with our invention and showing one of the resistor rods and terminal cooling means for the same;

Figure 2 is a vertical section through the center of the furnace taken on the line 2—2 of Figure 1;

Figure 3 is a perspective view of a metal radiator plate;

Figure 4 is a view in a radial direction of a modified form of radiator plate on the end of a metal terminal;

Figure 5 is an axial view of the same form of radiator plate as is shown in Figure 4;

Figure 6 is an axial section of a resistor rod surrounded by a modified form of enclosure which may be described as a cartridge type;

Figure 7 is a view similar to Figure 1 illustrating a different method of cooling the terminals;

Figure 8 is a view similar to Figure 1 illustrating a modification in which resistor plates are used under adjustable pressure;

Figure 9 is a vertical section of a modified furnace in which the interior of the muffle is kept subjected to a reducing atmosphere, the resistors being embedded in the side walls;

Figure 10 is a vertical section of another form of furnace in which the muffle is subjected to a reducing atmosphere, the resistors being directly in the muffle;

Figure 11 is a vertical section of a modified furnace in which reducing gas is introduced directly into the heating chamber; and

Figure 12 is a vertical section through the center of the furnace taken on line A—A of Figure 11.

Throughout the drawings 1 designates rigid resistor rods consisting mainly of some form of carbide, such as silicon carbide. In Figures 1, 2, 6, 7 and 9 these rods are surrounded for a greater part of their length by granular carbon or carbon dust 2. This carbon may be made for example of crushed petroleum coke which may act as a mechanical support for the rod as well as protecting it from oxidation as previously explained. Adjacent the resistor rods is placed muffle 4 whose walls 5 are made of a suitable refractory material having a thermal conductivity in excess of 0.006 calories/cm.²/sec./°C. Fused alumina is an example of such a refractory, although we prefer to use recrystallized silicon carbide, such as is described in U. S. patent to F. J. Tone, No. 709,808, or silicon carbide bonded in any of the manners well known in the manufacture of refractories, bonds containing halides of the alkaline earths being particularly desirable on account of their stability in reducing atmospheres as described in copending application Serial No. 269,075, filed April 11, 1928, by Benner and Baumann. It is further desirable that the walls be protected with a glaze of a reduction resistant type such as one composed of alumina and an alkaline earth halide as described by Benner and Baumann's copending application Serial No. 228,492 filed October 24, 1927, in order to continuously protect them against oxidation and also to minimize the penetration of air into the space adjacent the resistor. The

muffle is shown in the drawings as surrounded by granular carbon or carbon dust, although this is not essential to our invention. The supports for the muffle and outer wall 3 of the furnace are made of any suitable refractory material, preferably a good thermal insulator, such for example as high grade calcined kaolin or diatomaceous earth.

Spring contacts designated generally as 19 are shown in Figures 1, 7 and 8. These take care of change of length of the resistor and contact due to thermal expansion and maintain an even pressure of the contact against the resistor at all times.

Figure 1 shows a furnace equipped with an improved type of air cooler for the contacting terminals for the purpose of preventing arcing as previously described. These terminals consist of a tip 6 hollowed to receive the end of the resistor and composed of chrome iron (approximately 27% chromium) or other high heat resisting metal welded to a portion 7 composed of a cheaper metal of greater thermal electrical conductivity to which electricity is supplied through a suitable lead not shown. The portion 7 is surrounded by a corrugated metal radiator 8 in as close contact as possible therewith. Other suitable types of radiator for this purpose are the plate form shown in Figure 3 or the axial fin type shown in Figures 4 and 5. The inner end of this radiator may serve to retain the carbon within the furnace, although it is desirable that the dimensions of the carbon particles and the clearance of the terminal where it passes through the outer wall of the furnace be such that the carbon can not become wedged between the terminal and the wall as it is essential that the terminal move freely to permit it to maintain perfect contact with the resistor. In furnaces having a number of rods there may be individual metal radiators for each rod, or a single radiator may be in contact with the terminals of several rods. Cooling may be increased by directing a blast of air against the radiator if desired.

Figure 7 is similar to Figure 1 except that the cooling of the contacts is accomplished by means of a water cooler thus permitting the furnace to be operated at materially higher temperatures than is possible with the furnace shown in Figure 1. The water cooler in Figure 7 is made up of a portion 6^a of chrome iron (approximately 27% chromium) or other high heat resisting metal welded to a better conducting portion 7^a which is directly cooled by water flowing therethrough and through which electrical contact is made by lead-in wires 20. While both air cooling and water cooling means are illustrated alone, these two methods may be combined by placing water coolers at the outer ends of 7 shown in Figure 1.

A special form of our invention is shown

in Figure 6 whereby the resistor, together with the carbon surrounding it, is assembled in cartridge form making a unit which can be inserted or removed from a furnace with a minimum amount of inconvenience and loss of time. In this form the resistor 1 surrounded by carbon 2 is carried within a shell 5* of silicon carbide, either recrystallized or suitably bonded as above described. Contact with the resistor is made through suitable conducting plugs 24 of the same material as the resistor or of graphite inserted in the ends of the outer shell and separated therefrom by a layer of insulating material 25. One of these plugs may be fastened securely in place, but at least one must be free to yield slightly to compensate for differences in expansion of the resistor and the outer shell upon heating. An additional advantage of this type of construction is that the end plugs have a larger cross section than the resistor rod causing less localized heating near the metal contacts.

In the modification shown in Figure 8, resistor plates 10 of silicon carbide, which are subjected to adjustable pressure in order to permit variation of the over-all resistance, are used to replace the resistor rods in Figure 7. The silicon carbide plates may be interspersed with graphite plates at suitable points in order to reduce the total resistance and vary the heat distribution as may seem desirable. Carbon dust is used as before to embed the resistor.

In the form of furnace shown in Figure 9 the side walls 11 of the heating chamber are made of porous recrystallized silicon carbide so that in addition to protecting the resistor rods the atmosphere of carbon monoxide passes through the walls 11 into the heating chamber and maintains a reducing atmosphere therein. This tendency may be increased by introducing air through ducts to maintain a slight gas pressure in the chamber 12 surrounding the resistor rods to assist the production of carbon monoxide from the carbon grains and its diffusion through the walls 11. The supply of carbon may be replenished as required through the openings 17 which are ordinarily closed by the doors 18.

In the form of furnace shown in Figure 10 the resistors 1 are placed adjacent a porous wall 13 of recrystallized silicon carbide which conducts the heat to granular carbon contained within a chamber 14 within the wall of the furnace. This carbon is also shown extending down through the side walls of the furnace where it is separated from the interior of the heating chamber by wall 15 similar to the wall 13. With this construction carbon monoxide is formed and diffuses through the porous walls to the interior of the muffle affording protection to the resistors. Fresh carbon may be added through

an opening which is ordinarily closed by the plug 16, or through the openings 17 as described in connection with Figure 9. An air pressure may also be maintained in the compartment which is filled with carbon as described in connection with Figure 9.

Figures 11 and 12 show the direct use of a non-reacting gas independent of granular carbon to afford protection for the resistors. Producer gas or other suitable gas is introduced into the muffle through conduits 22 preferably in the vicinity of the ports where the resistors enter the furnace wall. The flow of this gas may be controlled by means of valves 23 so that the desired atmosphere will be maintained within the heating chamber without waste of gas. This type of furnace is particularly well adapted for heat treating work in which the metal must be protected from scaling.

A continuation in part of the present application, U. S. Serial No. 471,714, filed July 30, 1930, claims specifically a furnace in which resistor elements are mounted inside the heating chamber.

We claim:

1. In an electrical resistance furnace a silicon carbide resistor, an adjacent muffle whose walls are composed of silicon carbide, and means for maintaining a non-oxidizing atmosphere around the resistor and muffle.

2. In an electrical resistance furnace rigid silicon carbide resistors, a muffle having walls of recrystallized silicon carbide, and permeable mass of granular carbon adjacent said resistors, whereby a reducing atmosphere diffuses through the wall into the muffle to protect ware in the muffle.

3. In an electrical resistance furnace a plurality of silicon carbide resistor elements mounted in series, means for subjecting said elements to adjustable pressure for varying the resistance and means for protecting said elements from oxidation.

4. In an electric furnace, a heating chamber for ware to be treated, a compartment containing granular carbon adjacent said heating chamber, silicon carbide resistor elements in said compartment, and a wall of conducting refractory separating said chamber and compartment, said conducting wall being permeable to gases, whereby gases produced by the oxidation of the granular carbon may pass into the heating chamber.

5. In an electric furnace, a heating chamber for ware to be treated, a compartment containing granular carbon adjacent said heating chamber, silicon carbide resistor elements in said compartment, a wall of conducting refractory separating said chamber and compartment, said conducting wall being permeable to gases, and means for maintaining gas pressure within said compartment, whereby gas from the compartment passes into said heating chamber.

6. In an electric furnace, the combination of a silicon carbide heating resistor, means for preventing oxidation thereof, means for cooling the contacts through which electricity is supplied to said resistor, and a heating chamber adjacent said resistor, said chamber having a wall of refractory material possessing a thermal conductivity in excess of 0.006 calories/cm.³/sec./° C.

7. A resistor unit for electric furnaces comprising a heating resistor embedded in granular carbon within an annular casing of refractory material of high heat conductivity, end plugs forming electrical contact with the resistor but insulated from the annular casing, said end plugs also serving to retain the carbon in position around the heating resistor.

8. An electric furnace containing silicon carbide resistors, cooled terminals for said resistors, a compartment having silicon carbide walls, and powdered carbon around said resistors and between said resistors and said walls, whereby the resistors and at least a portion of the walls are protected from oxidation during the operation of the furnace.

9. The electric furnace described in claim 8 in which the walls of the compartment are porous whereby reducing gases from the heated carbon dust may pass through the walls to protect also the ware being heated in the furnace.

10. In an electric furnace, a heating chamber, a silicon carbide resistor in close proximity to the outer wall of said chamber, granular carbon surrounding said resistor, the amount of carbon between the resistor and the outer portions of the furnace being large in comparison with the amount interposed between the resistor and the heating chamber.

RAYMOND C. BENNER.
GEORGE J. EASTER.
CLARENCE E. HAWKE.