W. K. BOOTH.

ELECTRIC FURNACE.

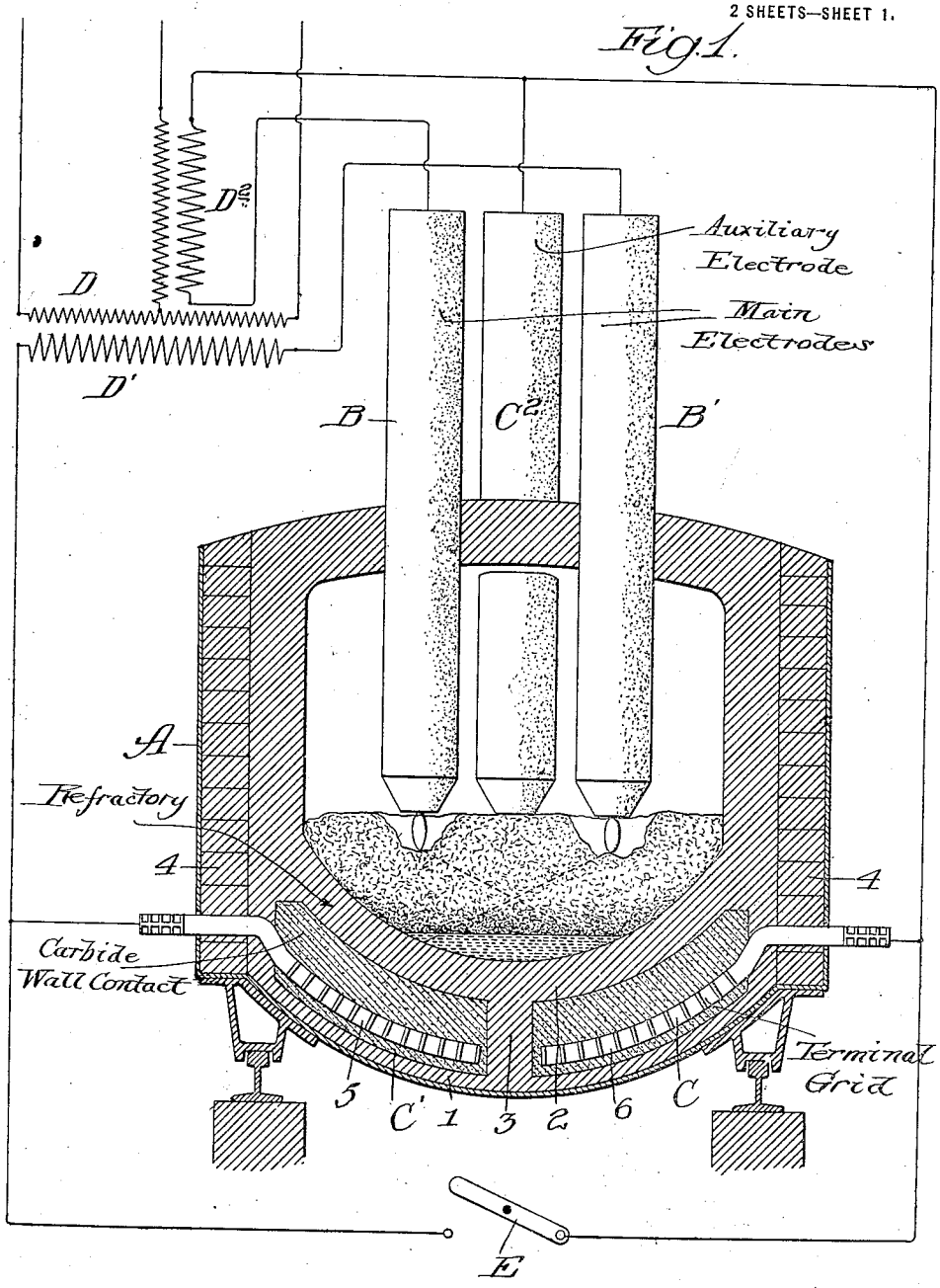
APPLICATION FILED APR. 4, 1918.

1,287,849.

Patented Dec. 17, 1918.

2 SHEETS—SHEET 1.

Fig. 1.



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E. E. Saylord.
Marvin O. Kahl

Inventor:
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2 SHEETS—SHEET 2.

Fig. 3.

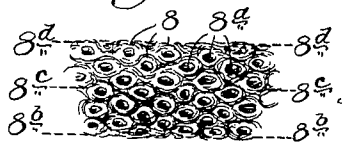


Fig. 4.

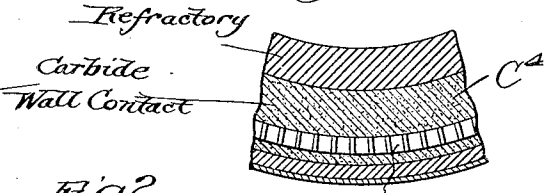


Fig. 2.

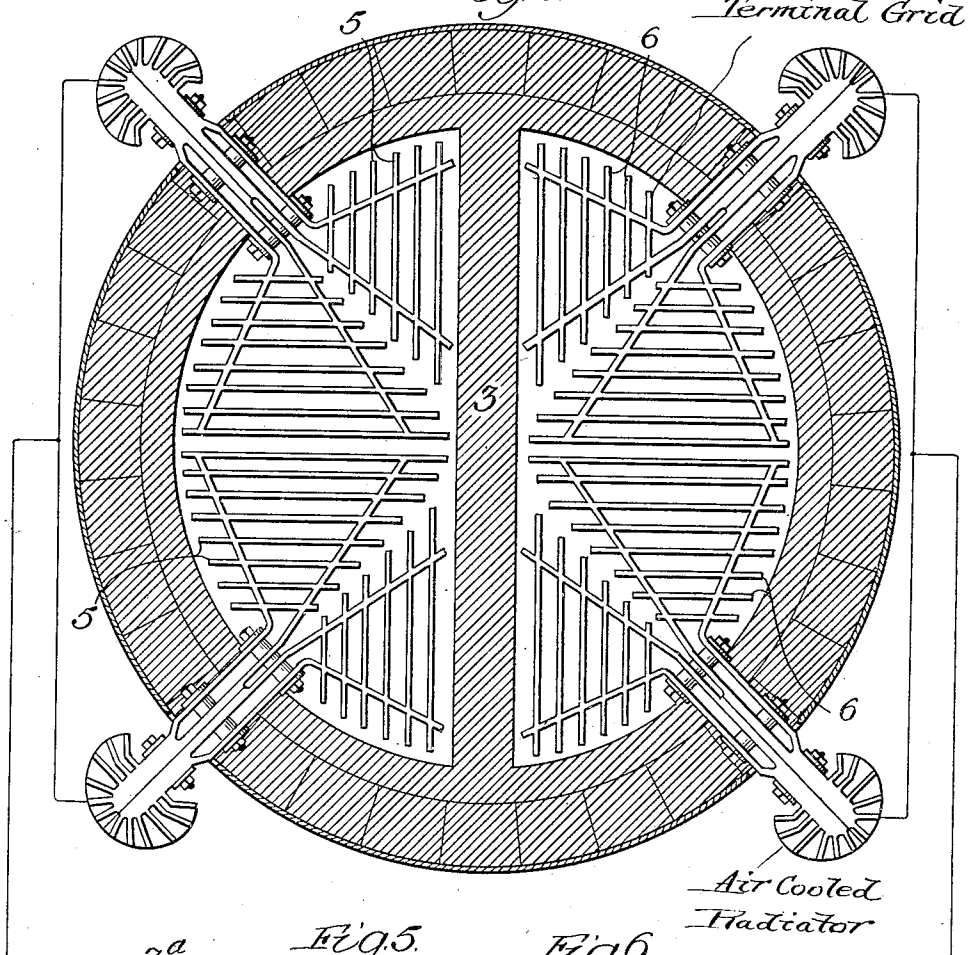


Fig. 5.

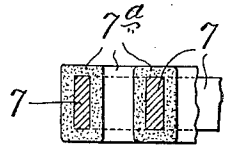
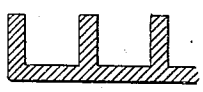


Fig. 6.



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UNITED STATES PATENT OFFICE.

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ELECTRIC FURNACE.

1,287,849. Specification of Letters Patent. Patented Dec. 17, 1918.

Application filed April 4, 1918. Serial No. 226,588.

To all whom it may concern:

Be it known that I, WILLIAM K. BOOTH, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented a new and useful Improvement in Electric Furnaces, of which the following is a specification.

This invention relates particularly to electric furnaces having the hearth or a portion of the hearth of conductive material, thus affording a wall-terminal, or wall-contact, which co-acts with an electrode or electrodes which extend into the heating or fusing chamber of the furnace. It is usual to provide the wall-contact, or wall-contacts, with facings which are highly refractory, but which become conductive of electricity when heated.

The primary object of the present invention is to provide an improved wall-contact, or wall-terminal, and an improved method of making the same.

A further object is to provide an improved method of constructing the hearth-portion of an electric furnace and embodying therein improved wall-contacts.

The invention is illustrated in the accompanying drawings, in which—

Figure 1 represents a vertical sectional view of an electric furnace constructed in accordance with the invention; Fig. 2, a plan sectional view through the lower or hearth-portion of the furnace, the section being taken immediately above the grids which form portions of the wall-terminals; Fig. 3, a diagrammatic sectional view illustrating the manner in which the wall-terminals are formed; Fig. 4, a broken vertical sectional view of the central portion of the bottom of the furnace, illustrating a modification; Fig. 5, a broken sectional view of a grid of modified construction; and Fig. 6, a broken sectional view of a modified form of grid.

It may be stated preliminarily that various methods have been employed heretofore for providing electric furnace hearths which are conductive of electricity when hot. In one such construction, a carbon-block is embedded in the hearth of the furnace a short distance from the inner surface, this block having a facing of highly refractory material, not carbonaceous, which is conductive when hot; and it is usual to make the carbon-block in such case by tamping in place carbon powder mixed with a binding material. Another method consists of mixing various refractory materials with carbon powder and a suitable binder, tamping the same in place, and facing this with refractory material, which is conductive when hot. These methods have the disadvantage that the conductive member, or wall-contact, the carbon-block in this case, disintegrates easily when hot metal comes in contact with it, because the carbon particles are held in place mechanically only by a binder, such as tar, molasses water, etc.

The present invention obviates the difficulty just referred to and provides a wall-terminal which is virtually an integral part of the hearth-portion of the furnace-body, which resists disintegration in a large degree, even when the molten metal comes in contact with it, as where the more refractory lining of the furnace has been partially destroyed, and which is an amply good conductor of electricity, and enables excellent electric connections to be made with the external electric circuit or circuits.

The invention will now be described with reference to the drawings. A represents the body of an electric furnace; B, B^1, main electrodes depending through the upper wall thereof; C, C^1, wall-contacts, or wall-terminals, embedded in and forming a part of the hearth of the body A and co-acting, in the normal operation of the furnace, with the electrodes B, B^1, respectively; and C^2, an auxiliary electrode which may be used to preliminarily heat the furnace until the lining of the hearth becomes conductive, after which the auxiliary electrode may be withdrawn from service.

The present invention is not particularly concerned with the arrangement of the electric circuits. It may be remarked, however, that Fig. 1 shows, diagrammatically, an arrangement of circuits which corresponds with that shown in Fig. 2 of United States patent to William K. Booth, No. 1,244,415, granted Oct. 23, 1917.

In Fig. 1 of the present application, D represents the primary windings of a two-phase transformer or transformers so connected as to deliver a two-phase secondary current, the primary current being a three-phase alternating current, if desired; and D^1 and D^2

represent the secondary windings of the transformer device, which are connected with the electrodes and wall-terminals. The electric circuit is equipped with a switch-device E, which is closed during the preliminary heating of the furnace, at which time current passes between the main electrodes B, B^1 and the auxiliary electrode C^2, the auxiliary electrode being of the same polarity as the wall-contacts. After the bottom of the furnace becomes sufficiently heated to render the lining conductive, the switch E is opened and the auxiliary electrode C^2 is withdrawn from operation, and the normal operation proceeds, with the current passing between the main electrode B and the wall-contact C and between the main electrode B^1 and the wall-contact C^1.

In constructing the body of the furnace in accordance with the preferred method, it is preferred to provide a bottom which has the outer portion 1, the inner portion 2, and the intermediate wall, or bridge 3, composed of a highly refractory material, such as dolomite, or magnesite, and to have the wall-contacts, or wall-electrodes C and C^1 embedded in such highly refractory material and virtually forming an integral part of the wall of the hearth. Certain metallic carbids are fairly good conductors of electricity when cold, and are also quite refractory. I have discovered that it is possible to form such carbids *in situ* in the wall of the furnace in such manner as to give a monolithic structure which is strong, very refractory, quite conductive of electricity, and capable of forming excellent electric connection with the grids which I employ as a means for connecting the wall-contacts with the external circuits of the furnace.

The following is an illustration of the preferred method of forming a basic hearth having wall-contacts disposed in the manner illustrated in Figs. 1 and 2:

In the bottom of the shell of the furnace there is first formed a layer of highly refractory material, such as dolomite or magnesite, this layer being designated 1. The circumferential wall of the shell of the furnace may be lined with fire-brick 4. The bridge, or central dividing wall, 3, between the wall-contacts C and C^1 may be constructed of fire-brick; or, preferably, a row of bricks is first placed in the space to be occupied by the wall 3, and chambers are formed to receive the wall-contacts C and C^1. These wall-contacts are then formed by introducing into said chambers shallow layers composed of a mixture of roasted dolomite, carbon, and tar, or hard roofing pitch, mixed together while hot and compacted in place in the furnace. The grids 5 and 6, which preferably are of metal and of open-work construction, are then placed in position, and another layer of the mixture is then introduced, preferably covering the grids to a depth of several inches, and these layers are thoroughly tamped down so as to fill the interstices of the grids and provide compacted layers above the grids. The material is then subjected to a fusing action by means of electric arcs above the layers of material, the mixture of materials being thus heated to a temperature ranging from in the neighborhood of 1500° C. to something less than 2000° C. In this fusing operation, a reaction takes place, converting the calcium of the calcium oxid in the roasted dolomite to calcium carbid, which acts as a matrix, holding the magnesium oxid and other materials present in the roasted dolomite embodied in the matrix, the whole forming virtually a monolithic mass.

It may be explained that roasted dolomite may comprise a high percentage of calcium oxid, a smaller percentage of magnesium oxid, and other materials, such as silica, alumina, and iron oxid, or compounds of aluminum and iron. The magnesium oxid does not combine readily with carbon, but the calcium oxid combines readily with carbon under the conditions noted above, forming a fused layer, which hardens upon cooling, thus forming a hard resistant matrix, in which is embedded the magnesium oxid and other materials of the roasted dolomite, which remain in the mass as highly refractory materials, thus giving a mass which is both highly refractory and suitably conductive of electricity. It is preferred to use a considerable excess of carbon in the mixture, which will remain as such, held in the matrix, and will increase the conductivity of the wall-contact thus formed. Successive layers of the mixture may be tamped in place and fused, until the wall-contacts are built up to the required thickness. As the wall-contacts are built up in this manner, each layer being fused upon or welded to the layer beneath, the central wall 3 of dolomite or magnesite may be formed; and this wall may be fused as it is built up and caused to weld itself to the adjacent surfaces of the wall-contacts. The inner lining 2 of the hearth may then be formed of a layer, or successive layers of dolomite or magnesite, which may be fused and welded to the upper surfaces of the wall contacts C and C^1, so that the whole bottom of the surface-body becomes practically a solid monolithic mass containing the grids 5 and 6.

The re-action which occurs may be illustrated by the following formulæ:

$$MgO+CaO+C=MgO+Ca+CO$$
$$MgO+Ca+2C=MgO+Ca+C_2$$

The foregoing formulæ show the magnesium oxid carried through the formulæ as a

non-reactive material. In the same way, the other impurities of the roasted dolomite will remain in the mass as resistant impurities. However, where small quantities of aluminum and iron are present, these may be converted into carbids, serving the same function as the calcium carbid.

Some dolomite which I have used contained about 30% magnesium oxid, 60% calcium oxid, and 10% of other materials. Using roasted dolomite of such composition I preferably take about 60% of dolomite, 40% of powdered carbon, and just enough coal tar, or hard roofing pitch to enable the mixture to be compacted in place readily and hold its shape until the fusing action can be performed. It is preferred to use a carbonaceous binder for this purpose, as this serves to give to each particle or grain of dolomite a coating of carbon, so that the reaction in forming the calcium carbid is more readily effected and rendered more complete. In the heating operation, under the action of the electric arc, the carbon monoxid which is formed is given off. The excess carbon remains embedded in the mass, as has been explained, thus rendering the mass more conductive.

As has been indicated, the foregoing explanation relates to the construction of a basic furnace. I may construct an acid furnace by employing a mixture of silica (SiO_2), carbon and tar, or the like, mixed together while hot, placed in the furnace in a manner similar to that described above, and then heated by means of the electric arc to a temperature between 1500° and 2000° C., whereby a re-action takes place, which may be indicated by the following formulæ:

$$SiO_2+2C=Si+2CO$$
$$Si+C=SiC$$

In this case, silicon carbid forms the matrix, in which impurities may be held. Preferably, an excess of carbon is used, so that the excess carbon will remain in the matrix and serve to increase the conductivity of the carbid layer. One may use a mixture of 60% silica and 40% carbon, which will provide for an excess of carbon. It is to be understood, however, that the proportions may be varied. If it is desired to introduce foreign material into the carbid layer to increase conductivity or refractoriness, this should be done before the carbid is formed, so that the foreign materials will be held in the matrix. In forming silicon carbid, the silicon is produced, fused, it is believed, and the carbon unites instantly with the fused silicon, the excess carbon remaining in the mass and being held disseminated throughout the matrix when the mass cools. In the heating operation, the temperature should be sufficient to fuse the silicon, but it should not be high enough to volatilize it. After the silicon carbid is formed as a monolithic mass it cannot be fused, but it may be destroyed by excessive heat.

After the silicon carbid wall-contacts are formed in the manner described, a layer of silica is fused in place on top of the carbid layers, thus forming the inner lining of the hearth.

In each of the illustrations given, the refractory lining of the hearth is conductive when hot, so that if the furnace is preliminarily heated, the electric current will be conducted through the linings to the wall-contacts and thence to the external electric circuits.

Other carbids, such as barium carbid, aluminum carbid, etc., can be used in the same manner, the character of the carbid used depending upon the purpose for which the furnace is to be used. Aluminum carbid is also very refractory and can be used where the refractory facing of the hearth is alumina, the aluminum carbid being formed in the wall of the furnace, that is, *in situ*, in a manner similar to that described above.

It is to be understood that the grids are simply a means of electrically connecting the carbid layers to a source of electrical energy. These grids may be of any suitable construction. They may be formed of steel, iron, copper or other suitable material, adapted to connect the hearth to the source of electrical energy. It is desirable that the grids be so constructed as to be free from danger of mechanical injury or breakage. In Fig. 5, C^3 represents a broken sectional view of a grid comprising metallic bars 7 and carbon sheaths 7^a enveloping said bars. It may be desirable, in some cases, to employ such carbon sheaths or envelops on the metallic portions of the grid, to prevent the metal bars from being fused in the operation of forming the carbid. However, this may be guarded against by having a sufficient layer of the mixture of materials above the grid before subjecting to the action of the electric arc. If the metal bars of the grid be unprotected by carbon layers, it may happen that the fusing action will affect the surfaces of the bars to some extent, and possibly convert the bars partially to carbid. This will constitute no serious detriment, however, so long as the action does not proceed far enough to wholly convert the metal of the bars. The chief importance attached to the exercise of care in forming the wall-contacts is to prevent the grids from being so altered as to become liable to breakage.

It is desirable to employ grids having the character of laminated structures, or employing comparatively small cross-sections, with a view to lessening skin effect, hysteresis and reactance. The grids illustrated in

Fig. 2 are described and claimed in my copending application No. 226,589, filed of even date herewith. Any suitable grids may be employed in the present construction, however.

Fig. 3 represents a broken sectional view, illustrating diagrammatically the action which occurs in forming the monolithic mass which constitutes the improved wall-contact. In this figure, the heavy lines 8 indicate the matrix formed of the metal carbid, and 8^a indicates the foreign matter, such as carbon and magnesium oxid, carried by the matrix. The dotted lines 8^b—8^b, 8^c—8^c, and 8^d—8^d, are intended to indicate the formation of the carbid in layers, but it is to be understood that these layers become so united in a solid mass as to give the same effect as a single monolithic mass.

Fig. 4 represents a broken vertical sectional view of the central portion of the bottom of the furnace, in a modified construction. In this construction, the central wall 3 is dispensed with, so that the bottom of the furnace is provided with what constitutes virtually a single wall-contact C^4.

It will be understood, by reference to the formulæ given above, that it is possible to form the carbid by starting with the metal, in some cases. For instance, one may take a mixture of silicon, carbon, and a suitable binder; form a pasty mass with these materials; place the same in position in the bed of the furnace; and then subject to the action of the electric arc to fuse the silicon and cause it to unite with the carbon to form the carbid.

While it is preferred, ordinarily, to employ a refractory facing 2 for the wall-contact, said facing becoming readily conductive of electricity after heating, in some cases it may be desirable to omit the refractory facing. For some purposes, silicon carbid is sufficiently refractory and sufficiently resists disintegration to enable the carbid block to be used without the facing 2.

If desired, highly refractory material may be mixed with the materials which form the carbid and may be carried in the matrix as an impurity; and, if desired, the inner facing of the wall-contact may carry a certain percentage of materials which are highly refractory and conductive when heated, and a certain percentage of materials which are normally conductive. Thus, virtually the whole bottom of the furnace may constitute the wall-contact, and very little, if any, preliminary heating will be necessary to render the bottom sufficiently conductive to carry the current.

In Fig. 5, the grid is shown composed of metal bars having carbon jackets. If desired, the grid may be composed wholly of carbon rods, the shank of the grid being constructed, however, in some suitable manner to prevent mechanical injury or breakage.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitation should be understood therefrom, but the appended claims should be construed as broadly as permissible, in view of the prior art.

What I regard as new and desire to secure by Letters Patent is:

1. The method of forming a furnace wall-contact which consists in mixing materials adapted to react and produce a metallic carbid, and subjecting the mixture to a temperature sufficient to effect reaction and form a monolithic mass.

2. The method of forming a furnace wall-contact which consists in placing in the wall of the furnace a mixture comprising materials adapted to react and produce a metallic carbid, and subjecting the mixture, *in situ*, to a temperature sufficient to effect reaction and form carbid in a monolithic mass.

3. The method of forming a furnace wall-contact which consists in placing in a bed in the furnace-wall a mixture of materials adapted to react and produce a metallic carbid, said mixture including a binder adapted to temporarily maintain the form of the mass, and subjecting the mixture, *in situ*, to the action of an electric arc to form a monolithic mass embodying such metallic carbid.

4. The method of forming a furnace wall-contact which consists in mixing carbon and a material adapted to react therewith to form a metallic carbid, said mixture being formed with a hydrocarbon binder, and subjecting the same to a sufficiently high degree of heat to form a monolithic mass with a metallic carbid forming a large constituent thereof.

5. The method of forming a furnace wall-contact which consists in mixing materials comprising two metallic oxids and carbonaceous material, one of said oxids being relatively more inert to the action of carbon than the other, and subjecting the mixture to a degree of heat sufficient to cause reaction between the carbon and the more reactive metallic oxid and form a fused carbid, which on cooling will form a matrix carrying the more resistant metallic oxid.

6. The method of forming a furnace wall-contact which consists in placing in a bed in the furnace wall a mixture of carbonaceous material and a material adapted to react therewith to form a metallic carbid, the carbonaceous material being used in excess, and subjecting the mixture, *in situ*, to a temperature sufficient to effect reaction and form a monolithic mass embodying such metallic carbid as a matrix holding excess carbon.

7. In an electric furnace, a wall-contact

comprising a metallic carbid in the form of a monolithic mass forming a matrix, and a refractory material carried in said matrix.

8. In an electric furnace, a wall-contact comprising a metallic carbid in the form of a monolithic mass forming a matrix, and carbonaceous material carried in said matrix.

9. In an electric furnace, a wall-contact comprising calcium carbid in the form of a monolithic mass.

10. In an electric furnace, a wall contact comprising calcium carbid in the form of a monolithic mass forming a matrix and refractory material carried by said matrix.

11. In an electric furnace, a wall-contact comprising calcium carbid in the form of a monolithic mass forming a matrix and conductive refractory material carried by said matrix.

12. In an electric furnace, a wall-contact comprising calcium carbid in the form of a monolithic mass forming a matrix and carbon carried by said matrix.

13. In an electric furnace, a wall-contact comprising calcium carbid in the form of a monolithic mass forming a matrix and carbon and magnesium oxid carried in said matrix.

14. In an electric furnace, in combination a monolithic carbid-body and a terminal member embedded in said body and having a shank extending through the wall of the furnace for connection with the external circuit of the furnace.

15. In an electric furnace, a carbid-body in the form of a monolithic mass, in combination with a grid embedded in said body and a shank extending through the wall of the furnace.

16. In an electric furnace, a calcium carbid-body in the form of a monolithic mass, and a grid embedded in said body and having a shank extending through a wall of the furnace.

17. In an electric furnace, the combination of a carbid-body in the form of a monolithic mass, and a carbon-jacketed metal grid embedded in said body and having a shank extending through a wall of the furnace.

18. In an electric furnace, a wall-contact comprising a metallic carbid-body in the form of a solid mass affording a matrix and carbon carried in said matrix, and a conducting member embedded in said body and having a shank extending through a wall of the furnace.

19. In an electric furnace, a wall-contact comprising a metallic carbid-body in the form of a solid mass affording a matrix and carbon carried in said matrix, and a skeleton grid embedded in said body and equipped with a shank extending through a wall of the furnace.

WILLIAM K. BOOTH.

Correction in Letters Patent No. 1,287,849.

It is hereby certified that in Letters Patent No. 1,287,849, granted December 17, 1918, upon the application of William K. Booth, of Chicago, Illinois, for an improvement in "Electric Furnaces," an error appears in the printed specification requiring correction as follows: Page 2, line 127, second formula, strike out the plus sign, last occurrence, and for the symbols "Ca + C_2" read *Ca* C_2; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of January, A. D., 1919.

[SEAL.]

F. W. H. CLAY,

Acting Commissioner of Patents.

Cl. 204—64.