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GRAPHITIZATION OF CARBON ARTICLES

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Fig. 1.

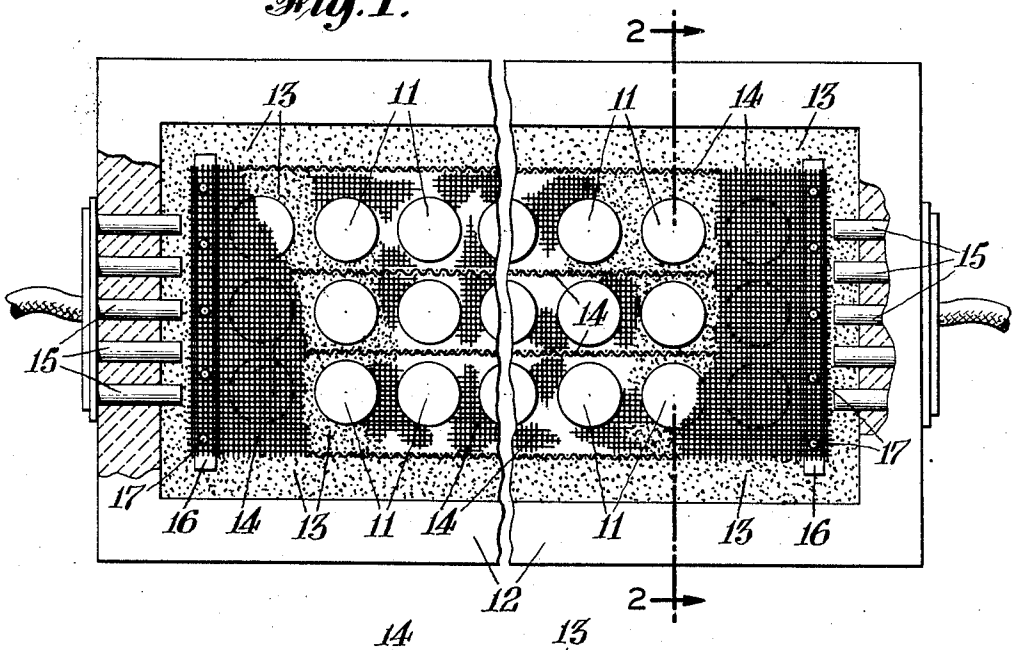
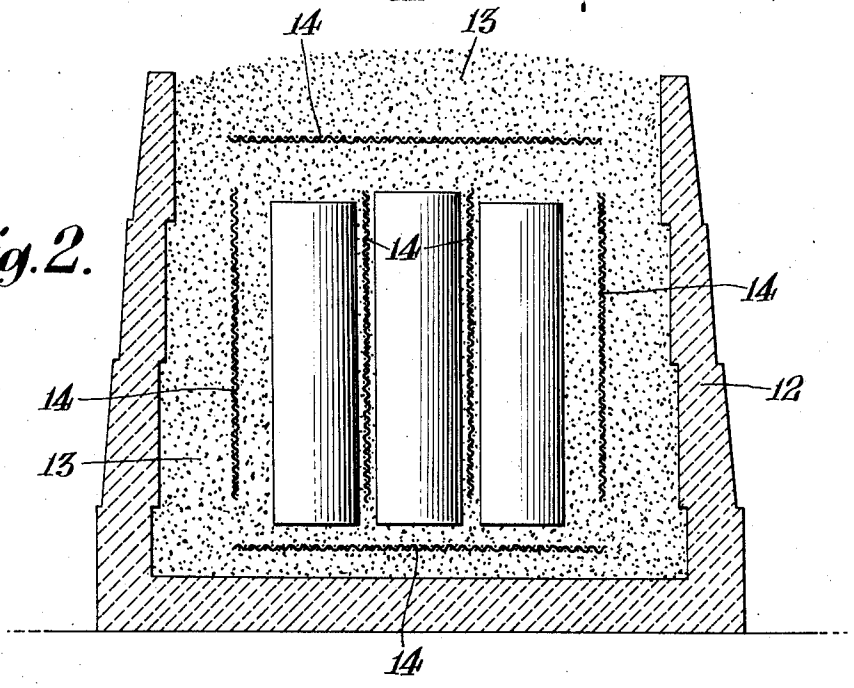


Fig. 2.



INVENTOR
VICTOR C. HAMISTER
BY
D. C. Harrison
ATTORNEY

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GRAPHITIZATION OF CARBON ARTICLES

Victor Carl Hamister, Lakewood, Ohio, assignor to Union Carbide and Carbon Corporation, a corporation of New York

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8 Claims. (Cl. 13—7)

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This invention relates to an improved method or baking and graphitizing shaped carbon articles and is particularly useful in the graphitization of furnace electrodes. The invention will be described in detail with respect to the graphitization of furnace electrodes although the invention is not limited to this use.

Conventionally, green electrodes, formed from carbon and a binder, are baked in a gas-fired furnace at a temperature of from 700° C. to 1000° C., and then, after cooling, are transferred to an electric furnace and packed in a granular carbonaceous conductive material which acts as a resistance element. The pre-baked electrodes are heated in the electric furnace to about 2,700° C. and converted to graphite. This is known in the art as the duplex process.

Another process which has been suggested eliminates the preliminary baking in the gas-fired furnace. The green electrodes are heated to graphitization temperatures in one operation in an electric furnace. Again, granular carbonaceous conductive material is used as the resistance element in the electric furnace. The high incidence of broken electrodes occurring in this process detracts from its utility, which is otherwise good because of advantages in savings of fuel, time and equipment.

The granular carbonaceous conductive packing material, such as is used as the resistance element in electric furnaces, has a negative coefficient of resistance, i. e., its electrical resistance decreases as its temperature increases. If for any reason one part of the furnace becomes hotter than other parts, the flow of current through that part increases thereby aggravating the condition. The liberation of heat in the furnace, particularly at temperatures below about 700° C., is not uniform. The large number of broken electrodes obtained in the single heating process is attributable to the fact that green electrodes cannot endure the non-uniform heating of the electric furnace. The pre-baked electrodes which are heated in the electric furnace in the duplex process are stronger and more resistant to the uneven heating.

The primary object of the invention is to provide a method whereby shaped carbon articles, such as green electrodes, can be heated to graphitization temperatures in a single heating operation in an electric furnace without undue breakage.

A further object of the invention is to provide a method of baking carbon articles at temperatures less than that required for their conversion to graphite. More particularly, it is an object of the

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invention to provide a method of baking carbon articles at temperatures higher than that which can be maintained satisfactorily in a gas fired furnace but not necessarily high enough to convert them to graphite.

The manner in which the objects of the invention are accomplished will be apparent from a description of the graphitization of furnace electrodes in accordance with the method of the invention.

Green electrodes which are to be graphitized, are baked in an electric furnace which has embedded in a granular carbonaceous conductive packing material an auxiliary resistance element such as a metallic grid. The auxiliary resistance element has a lower resistance than the granular packing at temperatures up to about 600° C. and also has a positive thermal coefficient of resistance. Until the temperature of the furnace reaches about 600° C., the current passes through the auxiliary resistance element. If any part of this element becomes hotter than the rest of the element, its resistance increases and the current is diverted to cooler areas insuring a uniform liberation of heat. After the temperature in the furnace reaches about 600° C., the current is carried by the packing material. Thus, the electrodes are raised evenly to their graphitization temperature without the danger of excessive breakage.

The drawing is illustrative of the manner in which the invention is practiced. In the drawing:

Fig. 1 is a plan view, parts being broken away, of an electric furnace containing electrodes to be heated to graphitization temperatures in accordance with the invention.

Fig. 2 is a view taken along the line 2—2 of Fig. 1.

In preparation for heating, the green electrodes 11 are placed, preferably upright, in the electric furnace 12. Surrounding the green electrodes 11 is a granular carbonaceous packing material 13, such as ground coke, in which are embedded metallic grids 14, suitably of chicken wire. The granular material 13 is in close contact with the green electrodes 11 and the furnace electrodes 15. The metallic grids 14 extend almost the length of the furnace 12 terminating near the furnace electrodes 15. Best results have been obtained when a rod or bar of graphite 16 is attached to the ends of the grids 14 as, for example, with copper rivets 17. The joining of the graphite rods or bars 16 to the grid 14 facilitates the flow of current, when it is turned on, from the furnace electrodes 15 to the grids 14, but such an arrangement is optional.

The number and arrangement of the grids 14 will depend in part upon the size of the furnace 12 as well as the disposition and size of the green electrodes 11 being graphitized. In most instances, grids 14 should be above and below as well as on both sides of the green electrodes 11, as is illustrated in the drawing.

Preferably, the resistance of the grids 14 should be less than that of the packing material 13 at temperatures up to about 600° C. The resistance of the grids 14 must be less than that of the packing material 13 at temperatures below 400° C., otherwise the number of broken electrodes is excessive. In general, a wire netting, commonly called chicken wire, with up to 15 or 20 openins per foot and a wire diameter of from 10 to 40 mils will serve as a suitable grid.

When the green electrodes 11, granular carbonaceous packing material 13, and the metallic grids 14 have been arranged in the furnace 12, as described above, the current is turned on. Practically all of the current travels through the grids 14 which are heated and in turn heat the adjacent packing material 13 and the green electrodes 11. As the temperatures in the furnace rises, the resistance of the grids 14 increases and that of the packing material 13 decreases. At the temperature at which the resistance of the grids 14 is of greater than that of the packing material 13, suitably about 600° C., most of the current passes through the packing material 13. From this point until the electrodes 11 are graphitized the packing material will serve as the primary source of heat in the furnace. Current is supplied to the furnace until the graphitization tempearture of about 2,700° C. is reached.

In a typical graphitization run in which the initial firing stage was carried up to a temperature of 1000° C., the time required to bring the furnace up to this temperature was about 250 hours. The high temperature or graphitization stage, in which the temperature was increased to about 2700° C., required about 65 hours.

In addition to furnace electrodes, other shaped articles that can be graphitized according to the invention include carbon plates for motor generator brushes, cylinders and rods for mercury arc rectifiers, and graphite bars used in electrolytic cells.

It will be understood that the invention is not limited to the graphitization of carbon articles but is also useful when it is desired to bake the carbon article at temperatures less than those at which graphitization occurs. It has been found to be particularly advantageous for baking articles at temperatures above 1500° C. which are difficult or impossible to maintain in a gas fired furnace.

I claim:

1. In a process of baking shaped carbon articles in an electric furnace of the kind having a packing of granular carbon which serves as an electrical heating resistor between the furnace electrodes, which kind of furnace is characterized by slow and non-uniform heating of the packing until the average temperature thereof is about 400° C. and by more rapid and more uniform heating thereabove, the improvement which comprises embedding an auxiliary resistance element in said granular carbon, said granular carbon having a negative temperature coefficient of resistance, said auxiliary resistance element having a positive temperature coefficient of resistance and having a resistance lower than that of said packing material at temperatures below 400° C., disposing said auxiliary resistance element in said furnace in such a manner that it provides a path for electric current through said furnace at temperatures below 400° C., passing an electric current through said furnace whereby the temperature of said carbon articles is raised substantially uniformly to 400° C., and continuing the flow of current through said furnace to elevate the temperature of said carbon articles above 400° C., the resistance of said packing becoming less than that of said auxiliary resistance during said continued flow of current.

2. In a process of baking shaped carbon articles in an electric furnace of the kind having a packing of granular carbon which serves as an electrical heating resistor between the furnace electrodes, which kind of furnace is characterized by slow and non-uniform heating of the packing until the average temperature thereof is about 600° C. and by more rapid and more uniform heating thereabove, the improvement which comprises embedding an auxiliary resistance element in said granular carbon, said granular carbon having a negative temperature coefficient of resistance, said auxiliary resistance element having a positive temperature coefficient of resistance and having a resistance lower than that of said packing material at temperatures below 600° C., disposing said auxiliary resistance element in said furnace in such a manner that it provides a path for electric current through said furnace at temperatures below 600° C., passing an electric current through said furnace whereby the temperature of said carbon articles is raised substantially uniformly to 600° C., and continuing the flow of current through said furnace to elevate the temperature of said carbon articles above 600° C., the resistance of said packing becoming less than that of said auxiliary resistance during said continued flow of current.

3. In a process of baking shaped carbon articles in an electric furnace of the kind having a packing of granular carbon which serves as an electrical heating resistor between the furnace electrodes, which kind of furnace is characterized by slow and non-uniform heating of the packing until the average temperature thereof is about 400° C. and by more rapid and more uniform heating thereabove, the improvement which comprises embedding a plurality of metallic grids in said granular carbon, said granular carbon having a negative temperature coefficient of resistance, said metallic grids having a positive temperature coefficient of resistance and having a resistance lower than that of said packing material at temperatures below 400° C., disposing said metallic grids in said furnace in such a manner that they provide a path for electric current through said furnace at temperatures below 400° C., passing an electric current through said furnace whereby the temperature of said carbon articles is raised substantially uniformly to 400° C., and continuing the flow of current through said furnace to elevate the temperature of said carbon articles above 400° C., the resistance of said packing becoming less than that of said metallic grids during said continued flow of current.

4. In a process of baking shaped carbon articles in an electric furnace of the kind having a packing of granular carbon which serves as an electrical heating resistor between the furnace electrodes, which kind of furnace is characterized by slow and non-uniform heating of the packing until the average temperature thereof is about

600° C. and by more rapid and more uniform heating thereabove, the improvement which comprises embedding a plurality of metallic grids in said granular carbon, said granular carbon having a negative temperature coefficient of resistance, said metallic grids having a positive temperature coefficient of resistance and having a resistance lower than that of said packing material at temperatures below 600° C., disposing said metallic grids in said furnace in such a manner that they provide a path for electric current through said furnace at temperatures below 600° C., passing an electric current through said furnace whereby the temperature of said carbon articles is raised substantially uniformly to 600° C., and continuing the flow of current through said furnace to elevate the temperature of said carbon articles above 600° C., the resistance of said packing becoming less than that of said metallic grids during said continued flow of current.

5. In a process of graphitizing carbon electrodes in an electric furnace of the kind having a packing of granular carbon which serves as an electrical heating resistor between the furnace electrodes, which kind of furnace is characterized by slow and non-uniform heating of the packing until the average temperature thereof is about 400° C. and by more rapid and more uniform heating thereabove, the improvement which comprises embedding strips of chicken wire in said granular carbon, said granular carbon having a negative temperature coefficient of resistance, said chicken wire having a positive temperature coefficient of resistance and having a resistance lower than that of said packing material at temperatures below 400° C., disposing said chicken wire in said furnace in such a manner that it provides a path for electric current through said furnace at temperatures below 400° C., passing an electric current through said furnace whereby the temperature of said electrodes is raised substantially uniformly to 400° C., and continuing the flow of current through said furnace to elevate the temperature of said electrodes to their graphitization temperature, the resistance of said packing becoming less than that of said chicken wire during said continued flow of current.

6. In a process of graphitizing carbon electrodes in an electric furnace of the kind having a packing of granular carbon which serves as an electrical heating resistor between the furnace electrodes, which kind of furnace is characterized by slow and non-uniform heating of the packing until the average temperature thereof is about 600° C. and by more rapid and more uniform heating thereabove, the improvement which comprises embedding strips of chicken wire in said granular carbon, said granular carbon having a negative temperature coefficient of resistance, said chicken wire having a positive temperature coefficient of resistance and having a resistance lower than that of said packing material at temperatures below 600° C., disposing said chicken wire in said furnace in such a manner that it provides a path for electric current through said furnace at temperatures below 600° C., passing an electric current through said furnace whereby the temperature of said electrodes is raised substantially uniformly to 600° C., and continuing the flow of current through said furnace to elevate the temperature of said electrodes to their graphitization temperature, the resistance of said packing becoming less than that of said chicken wire during said continued flow of current.

7. In a process of graphitizing "green" carbon electrodes in an electric furnace of the kind having a packing of granular carbon which serves as an electrical heating resistor between the furnace electrodes, which kind of furnace is characterized by slow and non-uniform heating of the packing until the average temperature thereof is about 400° C. and by more rapid and more uniform heating thereabove, the improvement which comprises embedding strips of chicken wire in said granular carbon, said granular carbon having a negative temperature coefficient of resistance, said chicken wire having a positive temperature coefficient of resistance and having a resistance lower than that of said packing material at temperatures below 400° C., disposing said chicken wire in said furnace in such a manner that it provides a path for electric current through said furnace at temperatures below 400° C., passing an electric current through said furnace whereby the temperature of said "green" electrodes is raised substantially uniformly to 400° C., and continuing the flow of current through said furnace to elevate the temperature of said "green" electrodes to their graphitization temperature, the resistance of said packing becoming less than that of said chicken wire during said continued flow of current.

8. In a process of graphitizing "green" carbon electrodes in an electric furnace of the kind having a packing of granular carbon which serves as an electrical heating resistor between the furnace electrodes, which kind of furnace is characterized by slow and non-uniform heating of the packing until the average temperature thereof is about 600° C. and by more rapid and more uniform heating thereabove, the improvement which comprises embedding strips of chicken wire in said granular carbon, said granular carbon having a negative temperature coefficient of resistance, said chicken wire having a positive temperature coefficient of resistance and having a resistance lower than that of said packing material at temperatures below 600° C., disposing said chicken wire in said furnace in such a manner that it provides a path for electric current through said furnace at temperatures below 600° C., passing an electric current through said furnace whereby the temperature of said "green" electrodes is raised substantially uniformly to 600° C., and continuing the flow of current through said furnace to elevate the temperature of said "green" electrodes to their graphitization temperature, the resistance of said packing becoming less than that of said chicken wire during said continued flow of current.

VICTOR CARL HAMISTER.

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