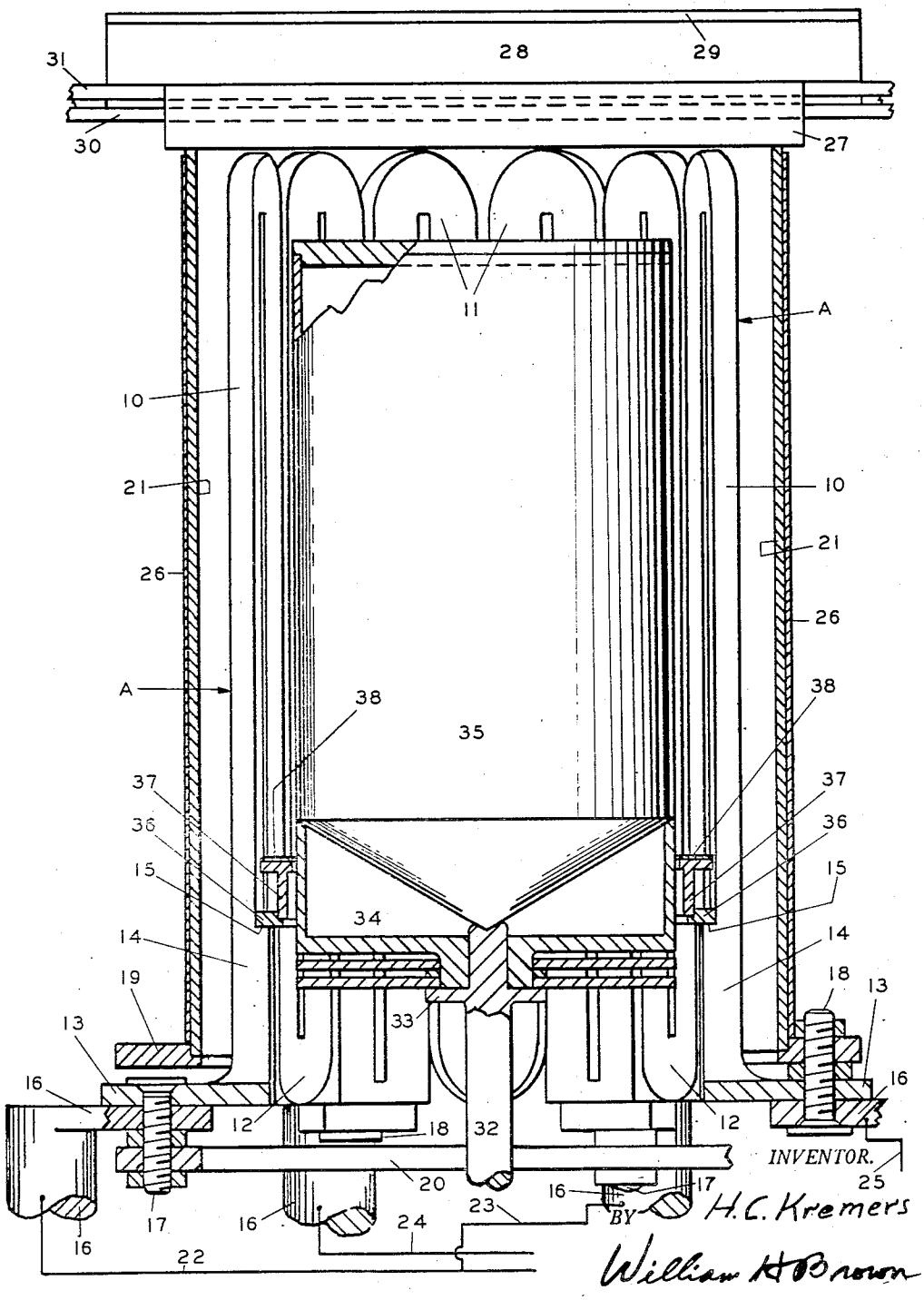
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SIDE HEATER

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SIDE HEATER

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This invention relates to a furnace suitable for use in producing macrocrystals, especially those which are produced at high temperatures. More specifically, the invention relates to a portion of such furnace which may be referred to as a "side heater."

In the production of macrocrystals, the material from which the crystal is to be produced is melted in a crucible, and the crucible containing the melt is moved from a compartment which is maintained at a temperature above the melting point of the material slowly into a compartment which is maintained at a temperature somewhat below the melting point of the material. By adjusting the speed at which the crucible moves to the rate at which the crystal grows, the liquid-solid boundary can be maintained at the junction of the two compartments mentioned. Prior to the present invention it has been proposed to use graphite heating elements in furnaces of this kind, both generally cylindrical elements for heating the vertical walls of the cylindrical crucible and flat, circular elements for heating the top of the crucible. Accordingly, I do not claim broadly the general arrangement of the heating elements, but only the specific construction as set forth in the appended claims.

The furnace herein described may make use of the novel side heater which will be hereinafter described in detail with reference to the accompanying drawings, and it may make use of any suitable top heater. However, it is desirable that the top heater have in general the characteristics of the top heater disclosed in my co-pending application, Serial No. 197,684 filed November 27, 1950. It is also desirable that the side heater and top heater should be enclosed in a furnace shell which may be evacuated, and that a suitable vacuum pump should be provided, as well as means for conducting electric current to the respective heaters. Inasmuch as the essence of the present invention resides in the particular construction of the side heater and reflecting baffle in combination with other furnace elements, especially the crucible, the furnace shell, vacuum pump, etc., have not been shown in the drawing. The top heater has been indicated in a general fashion and the details thereof may be exactly the same as those shown in my said co-pending application.

One object of the invention is to provide a side heater made up of vertically extending ribbons of carbon resistor material whereby there will be less tendency toward sagging when the heater has been brought to a high temperature. If, for example, the heater were made up of a helical ribbon winding from bottom to top, the convolutions would sag at high temperatures and alter the distribution of the heat from that which would be expected, and especially, would widen the space between convolutions at the upper supporting terminal and narrow it at the lower supporting terminal. Since it is desirable that the distribution of heat be as nearly as possible uniformly perfect, such deviation from true shape is highly undesirable. By running the ribbons vertically, or nearly so, and providing a support at the bottom at frequent intervals around the circumference of the heating grid, and electrically connecting alternate supports by carbon rings secured thereto, heat distortion can be reduced to a negligible quantity. It is desirable also to have the supports at the bottom, as as to avoid carrying current conducting elements alongside the heating element. A further object is to provide a combined support and current supplying element and to provide as many of such as may be desired to give adequate support to the heating grid, that is, to provide support at an adequate number of points, more than two, as would be the maximum number which could be conveniently provided in the case of the helical heater referred to. A further object is to provide a heating grid wherein the lower portions of each ribbon forming the grid is thickened so as to reduce the heating effect and concentrate the principal portion of the highly heated resistor above the junction between the furnace compartment to be maintained above the melting point of the material to be crystallized and the compartment to be maintained at a temperature below the melting point of such material. In a heater of such a construction the heat distortion effect of the connecting support lugs becomes minimized and a uniform isotherm results in the thickened section of the heater. A further object is to utilize the difference in thickness between the upper and lower portions of the grid to form a shoulder on the inner surface thereof, suitable for supporting a heat reflecting baffle which is effective to form a sharp heat gradient between the two compartments. I have found that it is most desirable to position the heat reflecting baffle somewhat above the shoulder referred to and, accordingly, it is a further object of the invention to provide a novel supporting means for such baffle.

Other and more specific objects will be in part apparent from the following description and in part pointed out specifically in connection with

the accompanying drawing wherein the figure is a central vertical section through a heater embodying the various features of the invention.

Referring now to the accompanying drawing, the heating grid is referred to generally by the reference character A. It will be seen that the grid A is made up of twenty-four vertical ribbons 10, connected together integrally to form one continuous ribbon. At the upper ends the ribbons 10 are connected by rounded transverse portions 11, and at the bottom, alternate pairs are connected by similar rounded transverse portions 12, while the remaining connections are made through the supporting and current carrying lugs 13 which are integral with the vertically extending ribbons 10. It will be understood that each vertically extending ribbon is connected at the top to the ribbon on one side of it and at the bottom to the ribbon on the other side. Grid A may be made by turning a carbon cylinder from a solid block of carbon, leaving a flange from which the lugs 13 may be cut, and then sawing out the material between the ribbons as indicated. Portions of the flange referred to may be then cut away, leaving the lugs 13. In turning out the grid, the upper portion of the ribbons 10 are of one thickness, as indicated, while the lower portions 14 thereof are thicker, as indicated, leaving shoulders 15 at the junction between the upper and lower portions of the ribbons 10.

The grid may be supported by current carrying supports 16 which I have shown as being six in number, spaced 60° apart, and connected, one to each of the lugs 13, by means of carbon bolts 17 and 18. It will be understood that alternate supports 16 will be connected to one side of a current supply, the remaining ones being connected to the other side thereof. Also supported on the conducting supports 16 are rings 19 and 20. The uppermost ring 19 serves the dual function of supporting a carbon cylinder 21 and connecting alternate supports 16 for the purpose of smoothing out the current. The lower ring 20 is connected to the remaining current-supplying supports 16 so that they are all connected together for smoothing out the current. Alternate supports 16 are connected to one side of a current supply by means of conductors 22 and 23, while the remaining supports 16 are connected to the other side of such current supply by means of conductors 24 and 25. It will be understood that the supports 16 which are not seen in the drawing are similarly connected to the current source.

The carbon cylinder 21 has applied to its outside surface a heat reflector which may be a thin sheet 26 of molybdenum having a bright surface presented inwardly and, preferably, also having a bright surface presented outwardly so as to act as a barrier to the transfer of radiant heat in both directions. The carbon cylinder 21 serves not only as a support for the heat reflecting element 26 but also supports a shield for the top heater comprising a carbon ring 27 which in turn supports a cover 28 which carries a reflecting element 29, also desirably a heat reflecting molybdenum sheet having at least its lower surface polished and preferably its upper surface also. The heating elements proper of the top heater are indicated at 30 and 31, and these are independently supported on posts which also serve as current supply. As above indicated, the top heater construction may be identical with that shown in my said co-pending application. Inasmuch as the top heater is only incidental to the present invention, it is believed unnecessary to describe or illustrate it in any further detail.

Within the furnace there is provided an elevator comprising a post 32 provided with a flange 33 and a conical recess in its upper end. Received on the post 32 and resting on the flange 33 is a support 34 for the outer edge of the bottom of a crucible 35. The crucible 35 has a conical bottom, as indicated, the apex of which is received in the conical depression in the upper end of the post 32. It will be seen that the amount of contact between the elevator and the crucible 35 is, by the indicated construction, held to a minimum.

Resting on the shoulders 15 of the ribbons 10 is a carbon ring 36 having a shoulder adjacent its inner edge and on which is supported a carbon ring 37 which has an L-shaped cross section providing an upper surface for the support of a heat reflecting baffle 38 substantially completely traversing the space between the heating ribbons 10 and the crucible 35 or its support 34 as the case may be. The heat reflecting baffle 38 may be a ring of sheet molybdenum having at least its upper surface polished and preferably its lower surface also.

It will be understood that in operation the temperature above the baffle 38 is maintained somewhat higher than the melting point of the material in the crucible 35, and that the temperature below the baffle 38 is maintained somewhat below the melting point of the material in the crucible. The elevator post 32 is slowly lowered, whereby the element 34 and the crucible 35 are lowered with respect to the heating ribbons 10 and the heat reflecting baffle 38. The rate of lowering is chosen with respect to each material so that, as experience may indicate, the rate of freezing prevents formation of new crystallization centers. I have found that in a furnace constructed as indicated in the drawing, it is better to space the heat reflecting baffle 38 somewhat above the shoulders 15, inasmuch as the liquid-solid interface was found to be somewhat above the shoulders 15, and the height of the baffle support 37 was accordingly chosen so as to locate the sharp heat gradient produced by the baffle 38 approximately at the liquid-solid interface.

From the foregoing, it will be seen that I have provided a furnace construction well adapted for high temperature production of macrocrystals and, while I have shown and described the present preferred embodiment, it is obvious that changes may be made without departing from the spirit of the invention and, accordingly, I wish it understood that I am limited only in accordance with the scope of the appended claims.

Having thus described my invention, what I claim is:

1. In an electric furnace of the character described a heating grid comprising vertically extending substantially parallel ribbons of carbon resistor material, each vertically extending ribbon of said grid being connected to and integral with another vertically extending ribbon at the top, and means for mechanically supporting and supplying current to a plurality of ribbons of said grid adjacent the bottom thereof, the inner and outer surfaces of said heating grid conforming substantially to cylindrical shape, the inner such surface having a major upper portion of one diameter and a minor lower portion of a smaller diameter, upper and lower portions of said rib-

bons forming said cylindrical inner surfaces defining at their junction shoulders all at one horizontal level and an annular heat reflecting baffle supported by said shoulders.

2. In an electric furnace of the character described a heating grid comprising vertically extending substantially parallel ribbons of carbon resistor material, each vertically extending ribbon of said grid being at its upper end connected to and integral with another vertically extending ribbon and at its lower end with a third such vertically extending ribbon, and means for mechanically supporting and supplying current to a plurality of ribbons of said grid adjacent the bottom thereof, the inner and outer surfaces of said heating grid conforming substantially to cylindrical shape, the inner such surface having a major upper portion of one diameter and a minor lower portion of a smaller diameter, upper and lower portions of said ribbons forming said cylindrical inner surfaces defining at their junction shoulders all at one horizontal level and an annular heat reflecting baffle supported by said shoulders.

3. In an electric furnace of the character described a generally cylindrical heating grid comprising vertically extending substantially parallel ribbons of carbon resistor material, each vertically extending ribbon of said grid being integrally connected to another such ribbon at the top thereof and to a third such ribbon at the bottom thereof, each of such ribbons having bottom parts of increased thickness as compared with their upper parts whereby to reduce the heat output near the bottom of said grid, a shoulder formed on the inner surface of each of such ribbons forming the junction between said bottom parts and said upper parts, an annular heat reflecting baffle within said grid and supported by said shoulders, means for connecting said grid to one side of a source of electric current at a plurality of spaced points below said shoulders and means for connecting said grid to the other side of said source at a plurality of points, each spaced from each of the first mentioned points and located between two thereof, said means including lugs integral with said grid and each located at the junction of two of said ribbons and extending outwardly therefrom.

4. In an electric furnace of the character described a generally cylindrical heating grid comprising vertically extending substantially parallel ribbons of carbon resistor material, each vertically extending ribbon of said grid being integrally connected to another such ribbon at the top thereof and to a third such ribbon at the bottom thereof, each of such ribbons having bottom parts of increased thickness as compared with their upper parts whereby to reduce the heat output near the bottom of said grid, a shoulder formed on the inner surface of each of such portions forming the junction between said bottom parts and said upper parts, an annular, carbon baffle support within said grid and supported by said shoulders, an annular, heat reflecting baffle supported by said baffle support, means for connecting said grid to one side of a source of electric current at a plurality of spaced points below said shoulders and means for connecting said grid to the other side of said source at a plurality of points, each spaced from each of the first mentioned points and located between two thereof, said means including lugs integral with said grid and each located at the junction of two of said ribbons and extending outwardly therefrom.

5. An electric furnace as defined in claim 4 further characterized in that a cylindrical carbon member is positioned in surrounding relation to said grid, a heat reflecting cylindrical covering applied to said cylindrical carbon member, and a top-heater supported by said cylindrical carbon member.

6. In an electric furnace of the character described a generally cylindrical heating grid comprising vertically extending, substantially parallel ribbons of carbon resistor material, each of said ribbons being integrally connected at top and bottom with other ribbons whereby the entire cylindrical grid is made up of one continuous, endless ribbon, and an even number of integral lugs at the lower end of said grid and evenly spaced therearound, there being one lug for each two ribbons, each lug being formed at the junction of two of said ribbons and means for connecting alternate lugs to one side of a current supply and the remaining lugs to the other side thereof.

7. A device in accordance with claim 4 wherein further said carbon baffle support includes an annulus of angular cross-section comprising a vertical portion and an outwardly extending flange, said baffle resting on said flange.

HARRY C. KREMERS.

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