June 2, 1953 H. C. KREMERS 2,640,861

RESISTANCE FURNACE

Filed Nov. 27, 1950

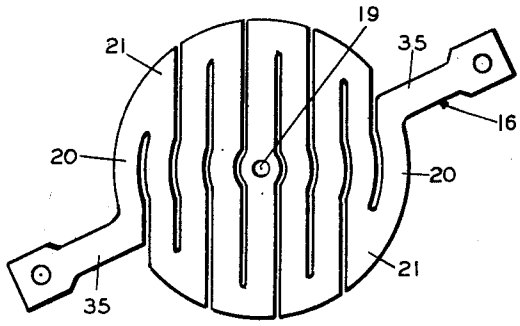


FIG. 1

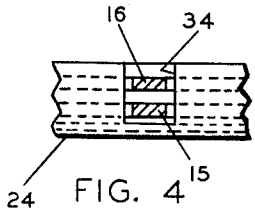


FIG. 4

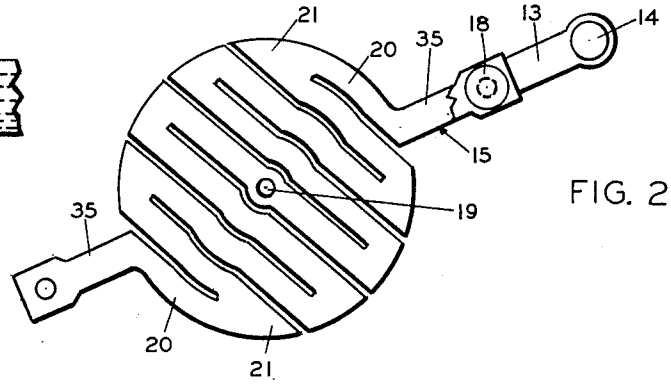


FIG. 2

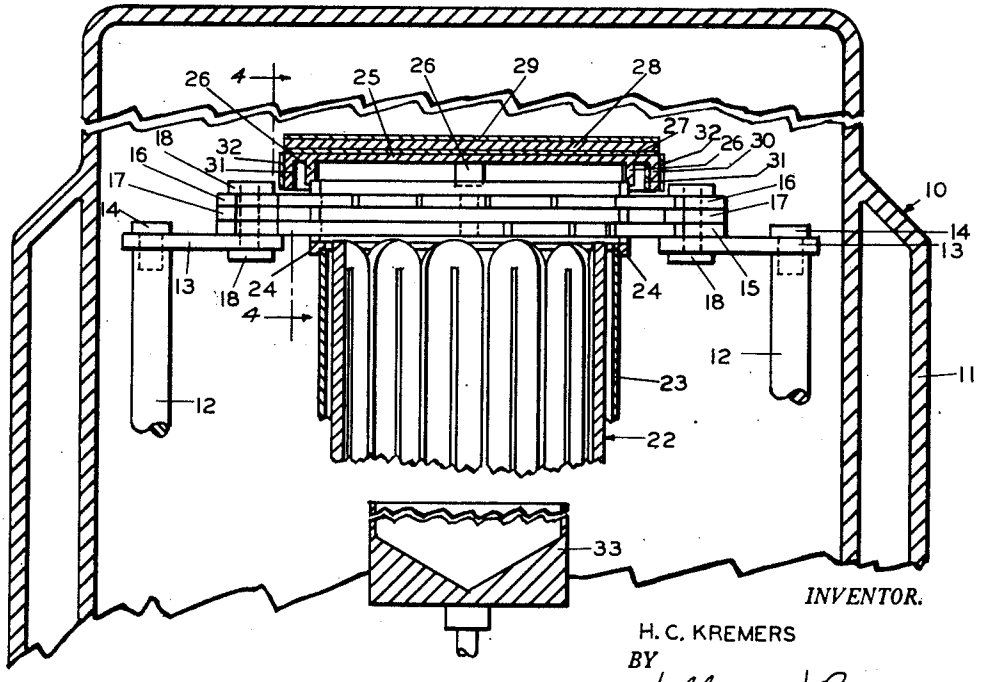


FIG. 3

INVENTOR.

H. C. KREMERS

BY

William H Brown

ATTY.

Patented June 2, 1953

2,640,861

UNITED STATES PATENT OFFICE

2,640,861

RESISTANCE FURNACE

Harry C. Kremers, Mentor, Ohio, assignor to The Harshaw Chemical Company, Cleveland, Ohio, a corporation of Ohio

Application November 27, 1950, Serial No. 197,684

6 Claims. (Cl. 13—25)

1

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 a furnace which may be referred to as a "top 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 present invention has reference to improvements in the top heater and to its relation to other elements in the furnace, having as its principal object the provision of a novel top heater which will present to the top surface of the material in the crucible a substantially uniformly heated surface covering substantially the entire area within the cross section of the side heater. A further object is to provide a shield surrounding the top heater and tending to smooth out any slight irregularities not removed by the heating element design, whereby to maintain within the heated compartments as much as possible of the heat generated within the furnace. Other objects will become apparent as the description proceeds.

In the accompanying drawings, Figs. 1 and 2 are top plan views of the two complementary heating elements making up the top heater; Fig. 3 is a vertical fragmentary sectional view through a furnace embodying the invention, and Fig. 4 is a fragmentary view corresponding approximately to the line 4—4 of Fig. 3, omitting everything except the two heating elements and the supporting ring for the top shield.

In the drawings, the numeral 10 indicates generally a furnace shell which may be composed of steel and provided with a jacket 11 for the circulation of cooling fluid, suitably water. Within the shell 10 are cylindrical conductors 12, only the upper ends of which are shown, but which it will be understood are connected with a suitable source of electric current. The conductors 12 may be maintained at a temperature approximating that of the inner surface of the shell 10, preferably a little higher, by adjusting its cross section to avoid any great heating due to passage of current, or by water cooling by means of internal passages, or by being composed of material of good heat conducting properties. Secured to the upper ends of the conductors 12 are supporting links 13 which may be attached to the conductors 12 by means of studs 14. At their other ends, the links 13 serve to support and energize a pair of top heater elements 15 and 16. These may be spaced apart by means of blocks 17; and the elements 13, 15, 16, and 17 may all be secured together by means of bolts 18. All these elements, 12 to 18, inclusive, may be composed of carbon, preferably graphite.

2

By reference to Figs. 1 and 2, it will be seen that the heating elements 15 and 16 are converted by means of saw-cuts into substantially ribbon form, the various reaches of which are of approximately the same width and cross section with the exception that at the turns the width is not uniform. It will be seen that the saw-cuts in the element 15 extend at an angle to those in the element 16 whereby when they are superposed, the saw-cuts will intersect at substantial angles so that the minimum of area in the composite will be uncovered. Preferably said saw-cuts will make an angle with an axis passing through the projections 35 of from 20° of arc to 35° of arc. These angles are not critical, it being important only that the saw-cuts in the upper and lower heaters 15 and 16 intersect at a substantial angle. In no case can the angle exceed 90° since if the two plates were superposed and rotated, as soon as the angle of intersection would reach 90°, there would be upon further rotation, an intersection at an angle of less than 90°. A small opening 19 in the center of each of the elements 15 and 16 is useful for receiving a probe, not shown, which may be employed for determining the height of the solid-liquid boundary in the material being treated, and also results in a saw-cut following an arcuate path whereby the outside reaches 20 are of substantially uniform width. It will be seen that when the elements 15 and 16 are superposed, the cold corners 21 will not lie one above the other but will be positioned in spaced angular relation to each other. Inas-

much as the outer-most edges of the elements 15 and 16 project beyond the side-heater, which is generally indicated by the numeral 22, the irregularities of heating surface not compensated for by the angularity of the saw-cuts in elements 15 and 16 will be located at points far enough from the center that such irregularities will be unimportant in the general combination illustrated.

The side heater 22, which, per se, forms no part of the present invention, may also consist of carbon, preferably graphite, sawed to ribbon form, suitably connected to a source of current, not shown. Outside the side-heater 22 is a carbon shield 23 suitably supported and on the top of which rests a ring 24, having formed therein notches 34 through which the arms 35 of the heaters 15 and 16 may pass without contacting the shield or the ring 24 and which supports a top shield 25, preferably also composed of carbon. Superposed upon the top shield 25, which rests on the ring 24, being supported in spaced relation thereto by lugs 26, is a molybdenum sheet 27. Superposed on the sheet 27 is another disc of carbon 28 upon which rests another sheet of molybdenum 29. The flange 30 of the shield 25 carries inner and outer molybdenum sheets 31 and 32. The molybdenum sheets may be relatively much thinner than shown and are provided with bright surfaces whereby to reflect the radiant heat instead of transmitting it.

Within the side heater 22 is an elevator 33 which is movable up and down therein, and which is adapted to support a crucible containing the material to be heated.

The structure illustrated and described has been designed with primary reference to use in a vacuum type furnace and the structure other than the top heater and related structure has been shown in a diagrammatic fashion. For example, the shell 10 would actually be, in practice, provided with means at the top to facilitate handling by means of hoisting equipment and the supports 12 might be provided with passages for cooling fluid which have not been shown. Again, the cylindrical shield 23 may be covered with molybdenum sheet or a pair of spaced molybdenum sheets covering the entire cylindrical surface thereof.

The principal feature of the invention is to be seen in Figs. 1 and 2, it being understood that the element 16 is superposed on the element 15, the right hand projection as seen in Fig. 1 being superposed on the right hand projection as seen in Fig. 2, and the left hand projection as seen in Fig. 1 being superposed on the left hand projection as seen in Fig. 2 whereby the saw-cuts which divide the circular portion of these elements will intersect each other at fairly sharp angles, leaving only the smallest possible area which is not covered by a highly heated portion of one of the elements, 15 or 16. Such slight irregularities as result from small uncovered portions at the intersections of the saw-cuts and the central opening 19 will be smoothed out by the shield 25 and the molybdenum sheets 27 and 29.

Another feature of the structure disclosed is that the cross section of the links 13 is less than the combined cross sections of the projections 35 so that the links 13 will be relatively highly heated by the passage of the curent so as to supply heat to the cooled conductors 12 without pulling such heat from the heating elements 15 and 16. Thus, the cooling of the conductors 12 will maintain them at a temperature sufficiently near the temperature of the inner surface of the shell 10 to avoid irregular heating of the material in the crucible without interfering with the function of the top heater elements 15 and 16.

Having thus described my invention, what I claim is:

1. A heater comprising a pair of spaced, approximately parallel, carbon plates of approximately the same size, each plate having deep, narrow slits formed therein and spaced to form therebetween a ribbon, the slits in one of said plates extending at a substantial angle not exceeding 90° to the slits in said other plate at all points at which said slits overlie each other, the active heating areas of said plates together substantially completely covering an approximately circular area and substantially only such circular area, and means electrically connecting said plates to a source of current.

2. A heater comprising a pair of spaced, approximately parallel, carbon plates of approximately the same size, each plate having deep, narrow slits formed therein and spaced to form therebetween a ribbon, the slits in one of said plates extending at a substantial angle not exceeding 90° to the slits in said other plate at all points at which said slits overlie each other, the active heating areas of said plates together substantially completely covering an approximately circular area and substantially only such circular area, and means electrically connecting said plates, in parallel circuit, to a source of current.

3. A furnace comprising a generally cylindrical side heater, a top heater covering the upper end of said side heater and comprising a pair of spaced, approximately parallel, carbon plates of approximately the same size, each plate having deep, narrow slits formed therein and spaced to form therebetween a ribbon, the slits in one of said plates extending at a substantial angle not exceeding 90° to the slits in said other plate at all points at which said slits overlie each other, the active heating areas of said plates together substantially completely covering an approximately circular area of approximately the size of but not of less diameter than the upper end of said side heater, means for supporting a receptacle containing material to be heated within said side heater and below said top heater, and means electrically connecting said plates to a source of current.

4. A heater comprising a pair of spaced, approximately parallel, carbon plates of approximately the same size, each plate having deep, narrow slits formed therein and spaced to form therebetween a ribbon of a width not less than about ten per cent of the diameter of said plate, the slits in one of said plates extending at a substantial angle not exceeding 90° to the slits in said other plate at all points at which said slits overlie each other, and means electrically connecting said plates to a source of current.

5. The invention as defined in claim 1 wherein further a heat reflecting shield is provided in spaced relation to one of the plates and covering the circular portion thereof for reducing loss of heat in one direction, said shield being provided with at least one heat reflecting surface covering the circular portion of said plate.

6. A heater comprising a pair of carbon plates of similar dimensions superposed one upon the other but spaced apart, each of said plates having an approximately circular portion and oppositely extending projections, said circular portion

having deep, narrow, approximately equidistantly spaced slits formed therein and extending transversely thereof and making an angle with an axis passing through said projections and the center of said circular portion of from 85 to 20 degrees of arc, being approximately parallel to each other and alternate said slits communicating with opposite edges and each terminating short of the edge opposite that with which it communicates a distance approximating the distance between said slits, thereby dividing said circular portion into a grid continuous with said projections offering approximately uniform heating characteristics over the whole heater area except at the two return bends nearest each said projection, one of said plates being a mirror image of the other as viewed from the top whereby said

slits in the respective plates intersect at substantial angles and said return bends of non-uniform characteristics are oppositely located.

HARRY C. KREMERS.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
761,204	Carpenter	May 31, 1904
1,318,028	Thomson	Oct. 7, 1919
1,418,496	Van Dyke	June 6, 1922
1,581,829	Berry	Apr. 20, 1926
2,009,732	Harper et al.	July 30, 1935
2,161,916	Erdmann	June 13, 1939
2,404,060	Hall et al.	July 16, 1946
2,476,916	Rose et al.	July 19, 1949