J. R. HARBECK & E. G. NORTON.

ELECTRIC FURNACE AND METHOD OF OPERATING THE SAME.

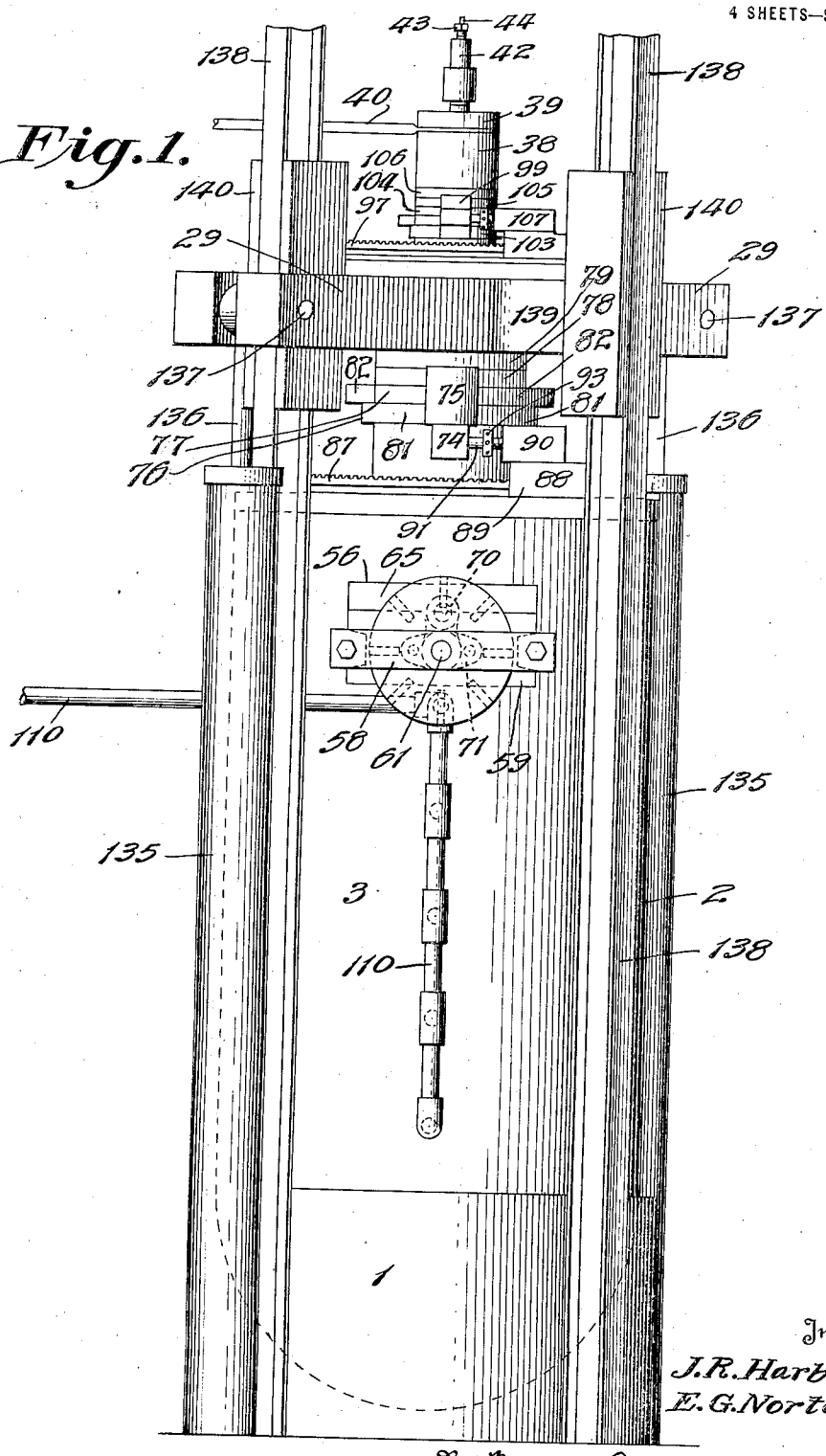
APPLICATION FILED APR. 24, 1917.

1,295,309.

Patented Feb. 25, 1919.

4 SHEETS—SHEET 1.

Fig. 1.



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4 SHEETS—SHEET 2.

Fig. 2.

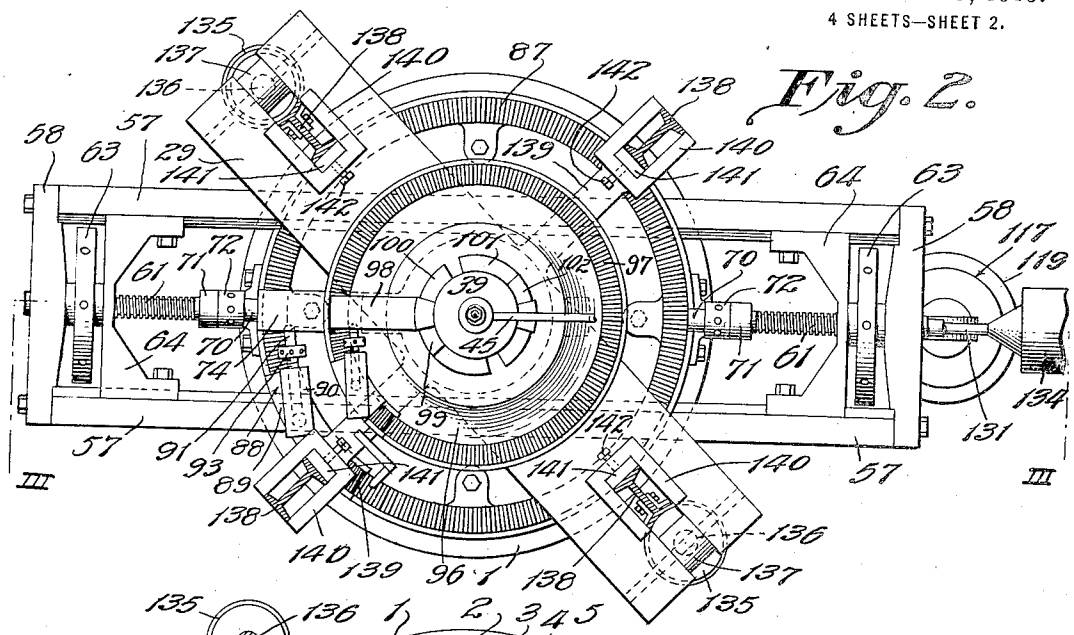


Fig. 4.

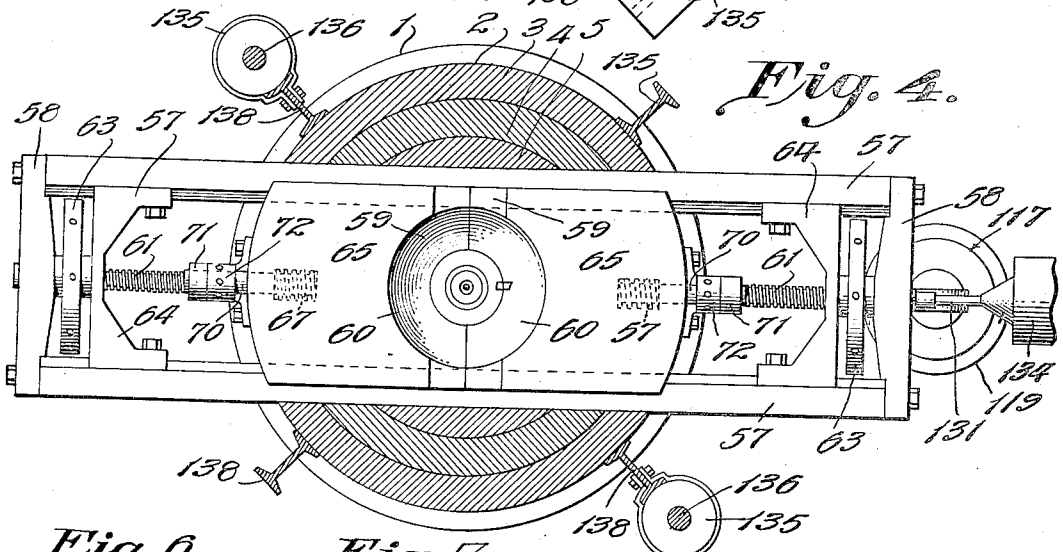


Fig. 6.

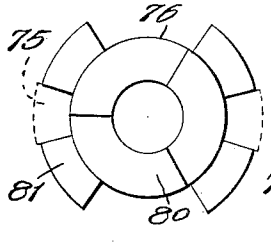


Fig. 7.

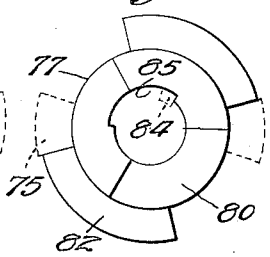


Fig. 8.

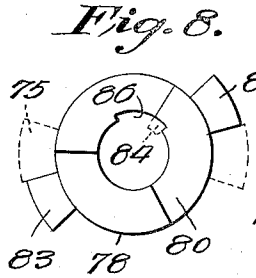
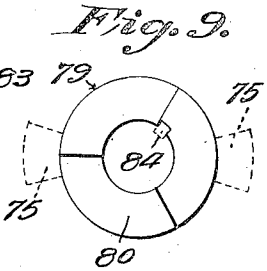


Fig. 9.



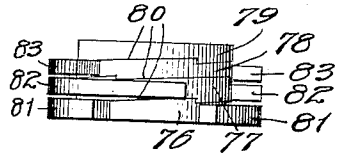


Fig. 10.

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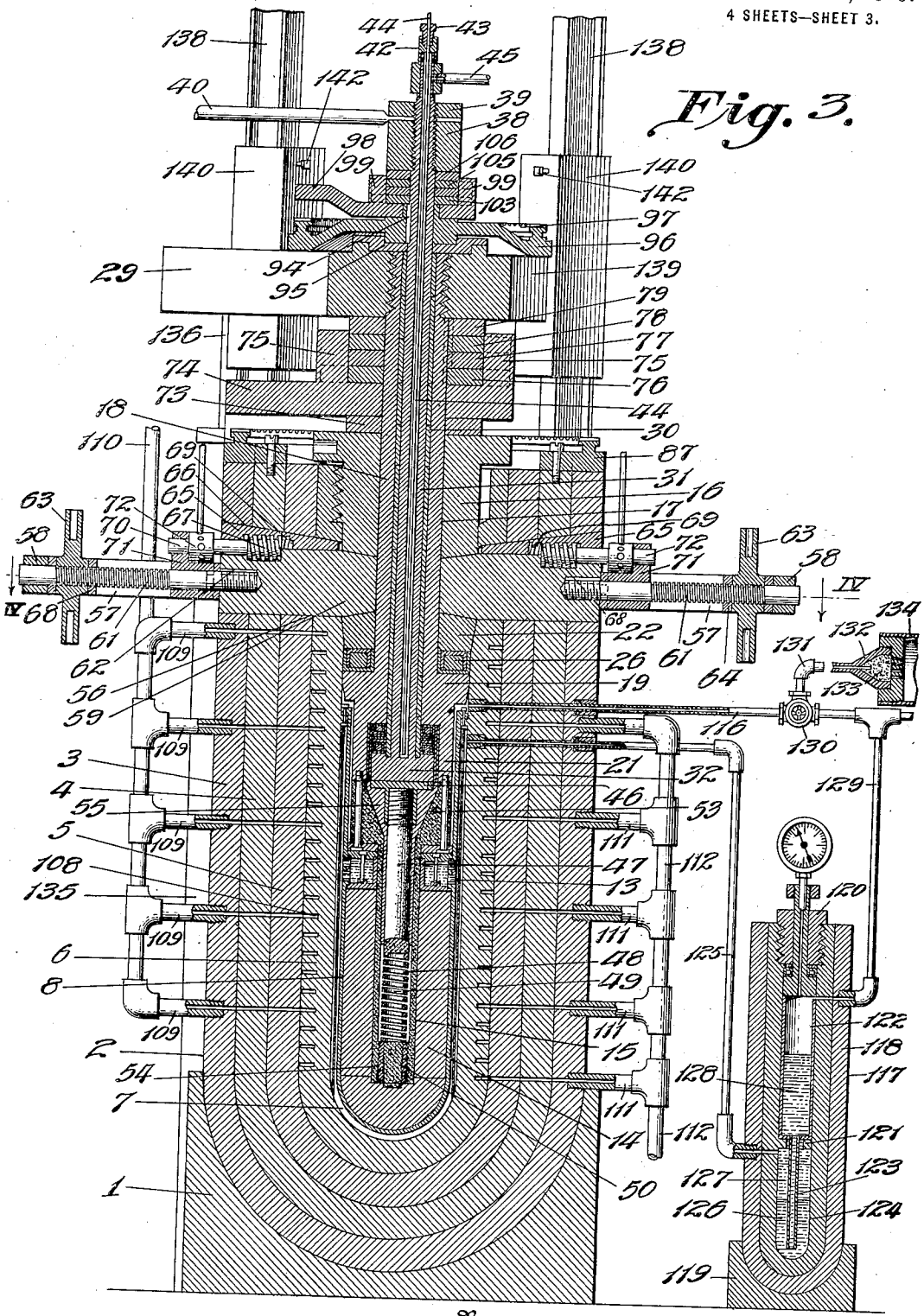
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4 SHEETS—SHEET 3.

Fig. 3.



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ELECTRIC FURNACE AND METHOD OF OPERATING THE SAME.

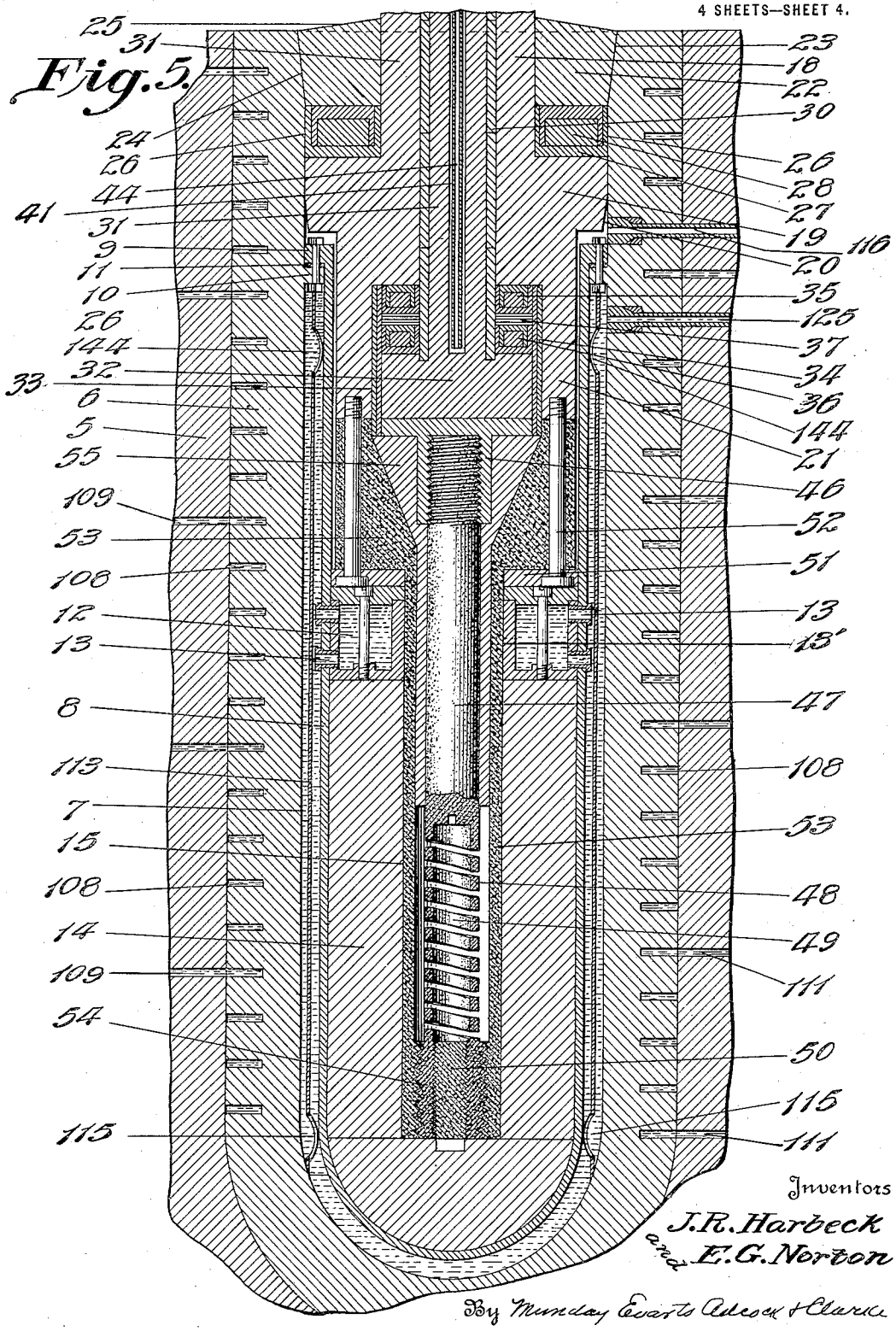
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4 SHEETS—SHEET 4.

Fig. 5.



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UNITED STATES PATENT OFFICE.

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ELECTRIC FURNACE AND METHOD OF OPERATING THE SAME.

1,295,309. Specification of Letters Patent. Patented Feb. 25, 1919.

Application filed April 24, 1917. Serial No. 164,109.

To all whom it may concern:

Be it known that JERVIS R. HARBECK, a citizen of the United States, residing at New York, in the county and State of New York, and EDWARD G. NORTON, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Electric Furnaces and Methods of Operating the Same, of which the following is a specification.

The invention relates to high pressure electric furnaces. Heretofore great difficulty has been encountered in constructing a furnace of this character that would withstand a great internal pressure at a high temperature for a prolonged length of time owing to the inability to prevent local uneven heating, and the consequent melting or warping of the furnace parts and structure.

The object of the invention is to provide a furnace of the above type that will successfully withstand a high temperature under a great internal pressure for a long period of time.

Another object is to provide a static fluid cooling system that will distribute and equalize the heat throughout the most highly heated parts of the furnace and prevent the concentration or localization of the heat with destructive effect.

A further object is to provide means for balancing the pressure of the static fluid heat distributing system against the pressure of the furnace gases.

A further object is to provide a circulating fluid cooling system independent of and supplementary to the static fluid system.

Another object is to provide improved means for hermetically closing the furnace against great internal pressure.

With such objects in view, as well as other advantages which may be incident to the use of the improvement, the invention consists in the parts and combinations thereof hereinafter set forth and claimed, with the understanding that the several necessary elements constituting the same may be varied in proportions and arrangement without departing from the nature and scope of the invention.

In order to make the invention more clearly understood there are shown in the accompanying drawings means for carrying the same into practical effect, without limiting the improvements, in their useful applications, to the particular constructions which, for the purpose of explanation, have been made the subject of illustration.

In the said drawings:—

Figure 1 is an elevational view of an electric furnace embodying the invention.

Fig. 2 is a top plan view of Fig. 1.

Fig. 3 is a vertical sectional view taken on line III—III of Fig. 2.

Fig. 4 is a horizontal sectional view taken on line IV—IV of Fig. 1, the furnace-closing devices being shown in plan view.

Fig. 5 is an enlarged vertical section of the central part of the furnace showing the heating, fluid heat distributing and fluid cooling systems.

Figs. 6 to 9 are plan views of the furnace-closing disks.

Fig. 10 is a side view of the same assembled.

The following is a description of the said drawings, and of the preferred construction illustrated therein:

Supported in a suitable base 1 is the main furnace casing 2 preferably comprising a plurality of cylindrical steel shells 3, 4, 5 and 6 formed with hemispherical lower ends and arranged one within the other and secured together in any preferred manner, preferably by the shrinkage of each outer shell upon the next inner shell. Within the innermost shell 6 and in spaced relation with the wall thereof so as to form a water compartment 7 is a similarly shaped shell 8 having a relatively thin wall and provided adjacent its upper end with a peripheral flange 9 which is bolted to and is supported by an annular flange 10 of the shell 6. The joint between these flanges is rendered hermetic by means of a packing or gasket 11 interposed therebetween. Suitably secured within the shell 8 is an annular water jacket 12 provided with openings 13 communicating with the water compartment 7 and provided with a central opening 13′. The space beneath the water jacket 12 within the shell 8 is filled with a non-heat conducting material 14, preferably alundum, and provided with a central vertical bore or chamber 15 in axial alinement with the opening 13′ of the water jacket 12. The upper portion of the shell 6 is closed by means of a screw plug 16 provided with interrupted threads so as to effect a complete threaded connection by

a comparatively slight rotation of the same. The plug 16 is further provided with a central aperture 17 through which extends a vertical tubular bolt 18 which projects downwardly into the shell 6 and is provided at its lower extremity with a head 19. The head 19 is circumferentially beveled as at 20 to facilitate the entry of the same into the shell 6 and is provided with a reduced portion 21 which partially enters the inner shell 8 when in place.

Surrounding the bolt 18 and above the head 19 is a thrust ring 22 provided with a tapered periphery 23 adapted to engage a beveled portion 24 of the shell 6. The upper surface of the ring 22 is tapered upwardly as at 25 for a purpose presently to be described. Interposed between the head 19 and the thrust ring 22 is an expansion gasket 26 formed of two annular channel members 27 of copper or other suitable metal which fit one within the other in inverted relation and incase a softer metal core 28, preferably of lead. This construction permits the flow or deformation of the soft core 28 thus forcing the confining sides of the gasket into intimate contact with the walls of the casing 6 and bolt 18 under the pressure exerted by the initial closing pressure and internal gas pressure, as will be presently described.

Above the plug 16 the bolt extends upwardly and is threaded into a transverse cross beam 29 which serves to both support and remove the bolt from the furnace in a manner hereinafter to be described. Vertically disposed within the bolt 18 and insulated therefrom as at 30 by a non-heat conducting material preferably soap-stone is an electric conductor 31 provided with a head 32 which seats within a recess 33 in the head 19, being insulated therefrom preferably by means of porcelain-coated sheet metal plates 34 and expansion gaskets 35 and 36 and interposed mica disks 37. The conductor 31 extends upwardly beyond the end of the bolt 18 and is threaded into a supporting nut 38 which, together with a nut 39, also serves as a binding post for an electric supply wire 40.

The conductor 31 is provided with an axial tubular bore 41 extending substantially its entire length and closed at its upper end by means of a screw cap 42 and packing nut 43. Within the bore 41 is a centrally located water supply pipe 44 which extends from a point near the lower extremity of the bore vertically through the cap 42 and packing nut 43 to a source of supply. Water when admitted will flow down the pipe 44 to the bottom of the bore 41 and thence upward within the said bore and around the pipe 44 to an outlet pipe 45. The conductor is thus cooled and prevented from becoming overheated by the passage of an electric current therethrough.

Secured to the head 32 of the conductor 31 is an electrode holder 46 into which is threaded an electrode 47, preferably of graphite, which extends downwardly through the aperture 13′ of the water jacket 12, and into the cylindrical chamber 15 in the member 14. The electrode 47 is spirally formed near its lower extremity as at 48 to create the necessary resistance, and which forms a crucible chamber 49, access to which may be had by a graphite screw plug 50. Secured between a metal disk 51 and the head 19 of the bolt 18, by means of bolts 52, is a conducting member 53 which projects through an aperture in the disk 51 and extends downwardly around the electrode 47 and is united therewith at its lower end by the threaded connection 54.

The electrode 47 is insulated from the said conducting member 53 by an insulating member 55, preferably of a non-heat conducting material, such as alundum, which extends down to a point adjacent the crucible chamber 49.

When an electric current is introduced to the furnace through the supply wire 40 and binding post, it will traverse the vertical conductor 31 to the electrode holder 46, thence to the electrode 47, through the same to the reduced spiral resisting portion 48, thence to the conducting member 53 and up through the same to the head 19, of the bolt 18, from which it travels to the casing 2, and back to the main circuit.

The interior of the furnace is closed by the following means: Adjacent the upper portion of the furnace casing 2 there is provided a diametrical aperture 56, in the sides of which are supported in any preferred manner, a pair of transverse guide members 57, which are connected at their ends by cross bars 58. The guide members 57 carry two diametrically opposed locking bolts 59 adapted to be inserted into the aperture 56 from opposite sides, and over the thrust ring 22, thus locking the same securely in place against any vertical displacement. The inner extremities of the bolts 59 are recessed so as to surround and engage the vertical bolt 18, and are also recessed on their top and bottom surfaces as at 60 to accommodate the portions of the screw plug 16 and thrust ring 22 that extend into the transverse aperture 56. This construction is to facilitate the withdrawal of the bolts 59 from engagement with the thrust ring 22 which might otherwise become slightly embedded in or jammed against the bolts 59 under the action of the internal pressure. The bolts 59 are laterally operated by means of non-rotary screw-threaded shafts 61 fixed in the outer ends of the locking bolts 59, and held therein against rotation by keys 62. The outer ends of the shafts 61 are slidably supported in the cross bars 58, and are moved laterally by means of

capstan nuts 63 confined between the cross bars 58 and braces 64. In order to eliminate all lost motion between the locking bolts 59 and their supporting guides 57, when they are inserted in locking position within the aperture 56, there are provided locking wedges 65 interposed between the locking bolts 59 and an inclined top wall 66 of the aperture 56. The wedges 65 are designed to ride upon the bolts 59 and to engage the upper inclined wall 66, and to take up any lost motion that may be present or may later develop. These wedges are actuated by means of worms 67, which are so disposed between the bolts 59 and wedges 65, that the lower halves of the worms 67 rest in sockets 68 in the bolts 59, and the upper halves engage interiorly screw-threaded recesses 69 in the wedges 65.

The worms 67 are mounted upon short shafts 70 which project outwardly from between the bolts 59, and wedges 65, and are journaled in bearings 71 secured to the outer faces of the bolts 59. The worms are rotated by means of capstan hubs 72 interposed between the bearings 71 and the bolts 59. When it is desired to loosen the wedges 65, so that the bolts may be withdrawn, the worm shafts are each turned clockwise; thus causing the wedges to recede from the apertures 56 enough to permit the free movement of the bolts 59.

Owing to the great pressure maintained within the chamber 6, it is essential that a very strong and tight closure be obtained. This is accomplished in the following manner: Rotatably mounted on the vertical bolt 18 and spaced from the screw plug 16 by a bearing washer 73, is a cam operating lever 74 provided with two vertical diametrically opposed lugs 75. Interposed between the operating lever 74 and the cross beam 29, and mounted on the bolt 18, is a series of superposed cam disks 76, 77, 78 and 79 provided with coacting cam faces 80. The disks 76, 77 and 78 are further provided with laterally extending lugs or projections 81, 82 and 83 respectively, circularly arranged in stepped relation relative to and in the path of the operating lever lugs 75. The lowermost disk 76 is mounted free upon the bolt 18, but the uppermost disk 79 is keyed thereto by a feather key 84, which extends down through arcuate key ways 85 and 86, in the disks 77 and 78, thus limiting the rotary movement of the same to the arc of the said key ways 85 and 86. The successive rotary movement of the disks naturally commences between the two disks where the least amount of frictional resistance occurs. Supposing that this resistance exists between the disks 76 and 77, the disk 76 will be turned through an arc of 60° until the lug 75 of the cam lever 74 engages the lug 82 of the disk 77 and turns the same in an arc of 60°, along with the disk 76, until the lugs 83 of the disk 78 are engaged by the lugs 75 and turn the same along with the disks 76 and 77 and continue until arrested by the key 84. It will thus be seen that the disks 76, 77, 78 and 79 have a relative movement of 60° causing the coacting cam faces 80 of the same to separate the disks vertically and draw the bolt 18 upward, exerting an initial sealing pressure upon the head 19 and the gasket 26 interposed between the said head and the thrust collar 22.

Fixed to the top wall of the furnace casing 2 is an annular rack bar 87 which supports a cam lever operating jack 88 comprising a jack carriage 89 which rides directly upon the rack 87 and which supports a swivel socket 90, into which is threaded a jack screw 91 adapted to abut the cam lever 74. The carriage 89 has mounted therein a pinion 92 in engagement with the rack 87, and which is rotated in any suitable manner, when it is desired to move the carriage and its associated parts along the rack to operate the cam lever and disks. When the jack 88 has moved the lever 74 sufficiently to tighten the cam disks, it is made secure to the rack 87 in any preferred manner and the jack screw 91 is turned by means of a capstan collar 93, thus exerting a secondary tightening force of greater leverage upon the cam disks.

The conductor bolt 31 is also tightened in a manner similar to the bolt 18 by the following construction: Fixed to the bolt 31 by a key 94 and insulated from the bolt 18 and cross beam 29 by a soap-stone disk 95 is a circular rack plate 96, which carries an annular rack 97. Mounted upon the rack plate 96 is a rotary cam actuating lever 98 provided with vertical diametrically opposed lugs 99 adapted to engage lugs 100, 101 and 102 of the cam disks 103, 104 and 105, respectively, disposed between the lever 98 and the nut 38 of the binding post. The lever 98 and cam disks 103, 104, 105 and 106 are operated in a manner similar to the lever 74 and disks 76, 77, 78 and 79 by means of a screw jack 107, which is similar in construction and operation to the jack 88. The head 32 of the conductor is thus tightened within its recess 33 and exerts an initial pressure upon the gaskets 35 and 36.

In order to provide a water cooling system for the furnace the outer surface of the inner shell 6 is formed with a spiral groove 108 which is connected at intervals by means of pipes 109 with a common supply pipe 110 and by means of pipes 111 with a common outlet pipe 112. This construction is adopted so that when water is admitted from one of the connecting pipes 109, it will flow around the spiral groove 108 only a few times and then flow off through one of the outlet pipes 111 and 112, before it has had time to become overheated. By this ar-

rangement there is a continual flow of cold water about the furnace at intervals corresponding in number to the pairs of inlet and outlet pipes. In order to prevent local heating of the parts subjected to the greatest heat and the consequent disastrous results, the following means are provided to distribute the heat equally throughout the walls of the furnace. Fixed within the water compartment 7 and in spaced relation with the sides thereof is a cylindrical baffle plate 113 provided with openings 114 and 115 at the top and bottom thereof and arranged to direct the convection currents of the static water within the said compartment. The water in the compartment 7 is in a static state, but is subject to circulation by convection within the said compartment. The water between the baffle plate 113 and the wall of the shell 8 being at a temperature higher than the water between the baffle plate 113 and the relatively cool surface of the shell 6, consequently rises and flows through the openings 114, comes into contact with the wall of the shell 6, becomes cool and sinks through the opening 115 in the baffle plate, and again comes in contact with the wall of the shell 8. This constant circulation of the water is not strictly a cooling system, but rather serves as stated, to distribute the heat equally throughout the furnace and prevents the heat from concentrating at any one point.

An inert or neutral gas, such as hydrogen, nitrogen or carbon monoxid is forced into the interior of the shell 6 and communicating interstices, through a pipe 116 by any suitable means (not shown). The pressure within the furnace does, or may, vary from atmospheric to 3500 atmospheres and therefore there must be an equal counteracting pressure exerted upon the water within the compartment 7 to prevent the rupturing of the shell 8. To obviate this difficulty, there is provided an equalizer designated as a whole at 117. This equalizer comprises a cylindrical casing 118, constructed in any preferred manner, which is supported upon a base 119 and closed at its top by a screw plug 120. The interior of the casing is provided with an annular flange 121, which supports a sheet metal casing 122 having a depending pipe 123 which extends downwardly into a lower chamber 124. Communicating with the lower chamber is a pipe 125 which communicates at its other end with the static water compartment 7 of the furnace. The lower portion of the chamber 124 is filled with mercury as indicated at 126 which completely surrounds and seals the pipe 123 from the static water in the same chamber as indicated at 127. The casing 122 is also partially filled with mercury as at 128, and communicates with the mercury 126 in the lower chamber 124 through the pipe 123. The pressure of the gas in the furnace is transmitted to the surface of the mercury 128, and thence through the mercury 126 and to the static water by means of a pipe 129, which connects the pipe 116 with the casing 122. The equalizer thus performs three functions, viz. It transmits the pressure of the gas in the furnace to the static water in the compartment 7, thus causing a state of equilibrium; it allows for the expansion of the static water when heated, and allows for the contraction of the static water due to pressure and varying temperatures.

The pressure of the gas within the furnace tends to seal the same, as the great pressure exerted against the head 19 of the bolt 18 and the head 32 of the conductor 31 causes the gaskets 26, 35 and 36 to expand and hermetically seal the furnace.

When it is desired to open the furnace the electric current is turned off and the furnace allowed to cool. A valve 130 in the pipe 116 is then opened and the confined gas permitted to escape through a pipe 131 having a flared end 132, provided with a porous gas retarding and cooling medium 133 preferably of porous unglazed porcelain through which the gas filters, thereby expanding and cooling before finally escaping into a pipe 134. This porcelain filter should be of finer texture and closer formation than the porcelain filter ordinarily used for filtering liquids.

The furnace is opened by means of hydraulic jacks, comprising two cylinders 135 in which operates pistons to which are secured piston rods 136, which in turn are pivotally secured to the cross arm 29 at 137. The vertical movement of the cross arm 29, bolt 18 and its associated parts is steadied against lateral displacement and retained in axial alinement with the furnace casing 2, by means of vertical guides 138, secured to the sides of the said casing 2, and which extend upward a suitable distance above the furnace.

The cross beam 29 has extending therefrom two arms 139, the extremities of which are provided with vertical slides 140 as are also the extremities of the beam 29 which engage the guides 138. Interposed between the slides 140 and the guides 138 are shoes 141 adapted to take up any lost motion that exists or may develop and which are supported and adjusted against the said guides by means of set screws 142.

The pipes 116 and 125 connecting with the equalizer are preferably one-half inch in diameter having a two-millimeter bore, so as to withstand the pressure. Mercury is preferably used in the equalizer, to prevent the production of oxidizing vapor or access of the same to the furnace chamber.

The pressure within the furnace may be

indicated by a suitable pressure gage located at the top of the equalizer or other convenient point and connecting with the furnace chamber or with the static liquid system.

It will be understood that an electrical resistance heater, as illustrated, may be used, or an arc heater may be employed for certain purposes if preferred.

One use of the invention shown on the drawings as embodying our invention and for the purposes of illustration is to crystallize carbon into the form of diamond. In this use of the furnace the carbon is introduced into the crucible chamber in amorphous form together with a solvent, which is preferably molten iron. The furnace is then set in operation and first heated to a high temperature and then permitted to cool until a part of the carbon separates out in the form of diamond, the pressure being maintained throughout the operation.

What is claimed is:

1. The herein described method of operating high pressure and high temperature electric furnaces, which consists in distributing and equalizing the higher temperatures by convection of heat in a static body of liquid and lowering the temperature by an independent circulating body of liquid.

2. The herein described method of operating high pressure and high temperature electric furnaces, which consists in distributing and equalizing the higher temperatures by convection of heat in a static body of liquid and maintaining balanced against each other and equalized the pressure in said body of liquid, and the pressure in the gases of the furnace.

3. The herein described method of operating high pressure and high temperature electric furnaces, which consists in surrounding the high temperature part of the furnace by a body of liquid and maintaining equal pressures in said body of liquid and in the gases of the furnace.

4. The combination in an electric furnace, of a static body of liquid for distributing and equalizing the temperatures and a flowing body of liquid for lowering the temperatures.

5. In an electric furnace the combination of a casing forming a furnace chamber, a static fluid heat distributing system, and a circulating fluid cooling system.

6. The combination in an electric furnace, of a static body of liquid for distributing and equalizing the temperatures, a flowing body of liquid for lowering the temperatures, and a pressure equalizer connected with said body of liquid and with the furnace chamber.

7. The combination in an electric furnace, of a hermetic casing, a closure for the same, and a deformable gasket interposed between said casing and closure and consisting of a relatively soft metal core and a relatively harder metal surrounding said core.

8. The combination in an electric furnace, of a furnace casing, a closure for the same and a deformable gasket interposed between said casing and closure and consisting of a relatively soft metal core and channel members of relatively harder metal inclosing said core.

9. The combination in an electric furnace, of a casing, a closure for said casing, superposed coacting cam disks for forcing the closure into sealing position and means for turning said disks.

10. The combination in an electric furnace, of a casing, a closure for said casing, a plurality of coacting cam elements acting on said closure and means for operating said elements.

11. In an electric furnace, the combination of a casing comprising concentric shells formed with hemispherical ends, means for closing the other end of said casing, and electric heating means within the casing.

12. The herein described method of operating high pressure and high temperature electric furnaces, which includes the distribution and equalization of the hinge temperature by convection of heat through a static box of liquid.

In testimony whereof we affix our signatures hereto.

JERVIS R. HARBECK.
EDWARD G. NORTON.

Witnesses:
ELEANOR F. CASEY,
H. C. NOWLING.