July 16, 1946. R. D. HALL ET AL 2,404,060

HIGH TEMPERATURE FURNACE

Filed Feb. 3, 1944

Fig. 1.

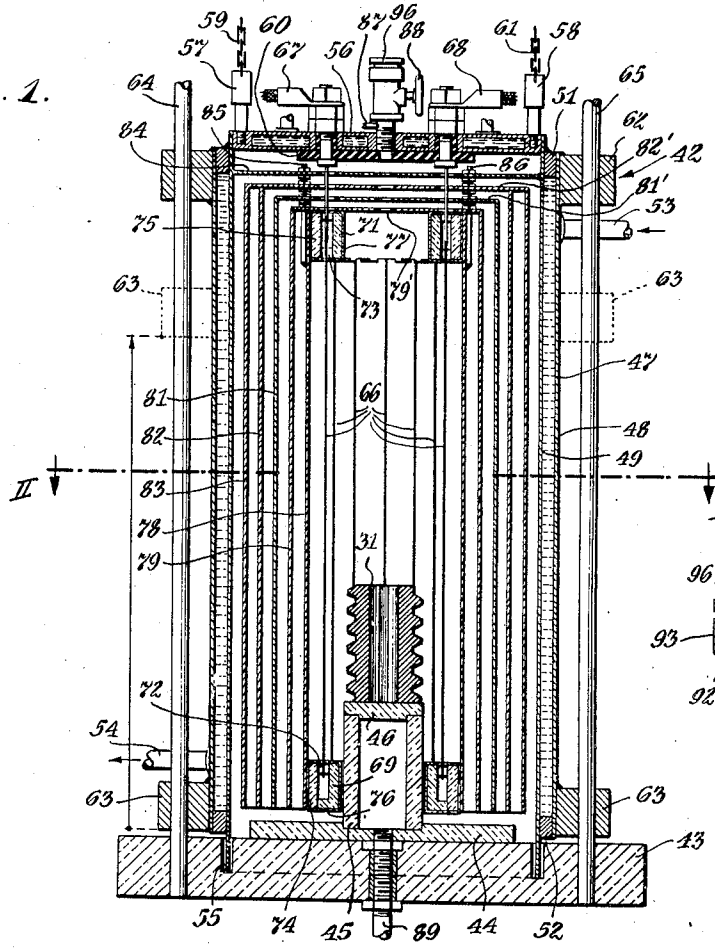


Fig. 3.

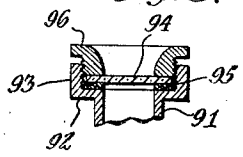
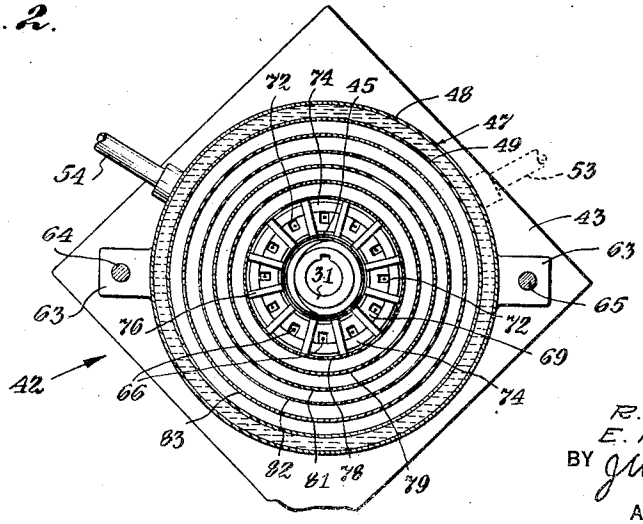


Fig. 2.



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HIGH TEMPERATURE FURNACE

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Application February 3, 1944, Serial No. 520,874

7 Claims. (Cl. 13—20)

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This invention relates to furnaces, and more particularly, to such adapted for temperatures high enough to sinter and otherwise heat treat, tungsten and molybdenum.

The principal object of our invention, generally considered, is a furnace adapted to efficiently produce temperatures above 1700° C., whereby it may be used for sintering and/or heat treating refractory metals such as tungsten and molybdenum.

Another object of our invention is a furnace for high tempertures comprising an element formed of tungsten or molybdenum wire or rods adapted to be heated to incandescence by the passage of electric current therethrough and arranged to surround the material to be heated, and a series of enclosing reflecting baffles and associated cover plates supported on a refractory block, with means for sealing said enclosure and admitting protective atmosphere thereto, as well as means for conveniently removing the enclosure for the application and withdrawal of the material being treated.

Other objects and advantages of the invention, relating to the particular arrangement and construction of the various parts, will become apparent as the description proceeds.

Referring to the drawing:

Fig. 1 is an axial sectional view, partly in elevation, of a furnace embodying our invention and showing an article in place therein, as representative of material which may be heat treated.

Fig. 2 is a horizontal sectional view on the line II—II of Fig. 1, in the direction of the arrows.

Fig. 3 is an axial sectional view of the peep-hole eyepiece assembly.

Furnaces designed for temperature above about 1700° C. cannot contain the usual type of refractories because the latter are incapable of withstanding such high temperatures.

Beryllia, zirconia and thoria will withstand higher than usual temperatures, but the first is very expensive and zirconia and thoria are difficult to use because of the lack of shock resistance. Carbon resistor furnaces, known as Arsem furnaces, are not usable with hydrogen or other protective atmosphere required for fabrication of such materials as tungsten and molybdenum.

Tube furnaces involving molybdenum or tungsten tubes may be heated electrically and material such as wire drawn through such tubes so heated. These are satisfactory for small long articles but cannot be adapted for larger work. Induction furnaces are difficult to use with protective atmospheres at high temperatures.

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We have designed a furnace capable of providing temperatures up to 2000° C. where molybdenum is used as a heating element, and up to about 2500° C. where tungsten is so used. These furnaces are particularly adapted for treatment of refractory articles, as in following the invention described and claimed in the Hall et al. application, Serial No. 511,392, filed November 23, 1943, now replaced by Serial No. 579,080, filed February 21, 1945, which refers to the furnace which is here claimed.

The principle involved in our furnace is to use the radiant heat from wires, bars or slabs of molybdenum or tungsten disposed around the body to be heated. Such heating means is, for insulating purposes, surrounded by reflectors disposed at appropriate distances, the first reflector being of sheet molybdenum or tungsten, the former of which is generally satisfactory, the remaining reflectors being of molybdenum and/or stainless steel either chromium plated or not, finally ending up with one or more silver plated steel and/or copper reflectors. The last reflecting means may be either a separate unit or part of a water-cooled jacket used as an outer cover for the furnace. The heating element is enclosed in these layers of reflectors and a peep hole is desirably provided at the end of a tube for purposes of temperature measurement. The covering of such a peep hole device is preferably of quartz or high melting point, low expansion glass, and removable for purposes of cleaning.

The heating elements of such furnaces are mounted so as to take up the expansion upon heating without distortion. It is desirable to have two half windings of approximately parallel elements. These wires or rods, being parallel, form elements of a cylindrical surface of such diameter that the article to be treated, when placed at or near the axis of said surface, will get relatively uniform heat. If necessary, the wires or rods may be wound with tungsten or molybdenum wire at the points where supported in order to cool them, so that refractories such as alumina can be used for support. Where rods of tungsten or molybdenum are used, connectors of drilled bars can be employed. The entire furnace and shell or jacket is desirably mounted as a unit and designed to be placed on a flat plate of refractory material. The shell must be extended far enough below the heated elements to use the furnace for protective atmospheres such as hydrogen, nitrogen, argon or a mixture of gases, or evacuated and used as a vacuum furnace. For vacuum purposes the outer contact

of this furnace shell and plate can be sealed, as by means of a suitable cement.

The stand carrying the base plate is desirably equipped for exhausting or introducing the atmospheres required and the plate carries on its face a container or stand for supporting the material, article, or articles, to be heat-treated. This stand may be made of molybdenum or tungsten coated with beryllium oxide or thoria, either as discs or powder at the point of contact with the material to be heat-treated to prevent welding. The purpose of this stand is to carry in the optimum heat zone the materials undergoing treatment.

For purposes of loading the furnace, arrangements can be made for either raising the insulating housing or lowering the stand, whichever is more convenient. Furnaces of this type are satisfactory to furnish temperatures sufficiently high to sinter or coalesce tungsten to high density for fabrication purposes if the proper protective and/or reactive atmosphere is used during the treatment.

Referring to the scale drawing in detail, like parts being designated by like reference characters, there is shown one embodiment of our invention comprising a radiation type furnace **42** consisting of a base **43** which may be formed of "transite," other suitable refractory, or even a metal plate where a vacuum is desired, upon which is supported a preferably circular plate **44** of Alundum, or the like. The plate **44**, in turn, holds a hollow cylinder **45** of beryllia or zirconia, carrying a supporting cap **46** of similar material, on which during the sintering operation the treated articles, (or article) such as the refractory metal worm **31**, rests.

The furnace **42** comprises an outer fluid-cooled casing **47**, which may consist of hollow copper cylinders **48** and **49** coaxially arranged and connected by annular spacing elements **51** and **52** of brass, or other suitable material, brazed or otherwise suitably connected thereto, forming an annular space through which water may be circulated, as from the inlet pipe **53** to the outlet pipe **54**. The inner plate **49** may extend into the annular cavity **55** at the base **43** for support and sealing, as by said cavity holding a sealing liquid, not shown, or if evacuated or holding gas under pressure, by a suitable cement. The inner surface of the water jacket plate **49** is desirably silver plated to minimize the radiation absorbed thereby, and closed at its upper end by a water-cooled hollow plate **56** formed of suitable metal, such as copper or steel.

The top plate **56** may be sealed inside of and to the cylinder **49**, carry a refractory or transite plate **60**, and be provided with studs **57** and **58** to which chains or cables **59** and **61** connect for raising and lowering the same with respect to the base and any article, or articles, being treated. To facilitate this raising and lowering operation, the water jacket has upper and lower stiffening rings **62** and **63** secured thereto, as by welding or other suitable means, and through which guides **64** and **65** pass, the lower ends of said guides being embedded in the base **43**. Alternatively, the studs **57** and **58** may connect directly with one of the elements **51** and **62**.

The heating means for the furnace, in the present embodiment, comprise a molybdenum or tungsten resistance device, which may be a wire **66** (or if of a large size, rods suitably connected in series) receiving power from leads **67** and **68** passing through the water-cooled plate **56** and suitably insulated therefrom, said device being strung down and up over the annular, desirably Alundum, lower and upper spool members **69** and **71** formed with radial elements **72** and **73** around which the individual loops pass between slots therebetween, said slots being subsequently closed by desirably Alundum retainer rings **74** and **75**. The spools and rings are desirably bound together by covering plates **76** and **77**, of molybdenum or other suitable material.

The heat developed by the resistance element is conserved by a series of baffles, the inner one **78** desirably comprising sheet molybdenum polished on both sides, or if very high temperatures are desired similarly polished sheet tungsten may be used. The next baffle **79** is desirably formed of stainless steel, chromium plated on both sides or of molybdenum. The remaining three baffles **81**, **82** and **83** are desirably formed of steel sheet, silver plated on both sides, all of the baffles being supported from the upper plate **84** of the cylindrical water jacket, also desirably formed of steel, silver plated on both sides, as by means of bolts **85** and **86** and top cover plates **79'**, **81'** and **82'**, desirably respectively formed of material like that of the plates **79**, **81** and **82**.

In order to allow for inspection of the article, such as that designated **31**, during the heat treatment thereof, the upper plates **79'**, **81'**, **82'** and **84**, as well as the plate **60**, are all provided with aligned apertures preferably coaxial with the furnace and the vertical section of the inlet pipe **87**, to the top of which a valve **88** is shown applied.

The housing **91** of this valve is desirably provided with a horizontal annular web portion **92** terminating at its outer end in an upstanding threaded flange portion **93** providing a socket or bezel for the reception of a transparent eyepiece **94**, desirably formed of quartz or high-melting-point glass, as shown in Fig. 3. The eyepiece **94** desirably rests on packing means **95** and is secured in place by an annular retainer **96**, thereby providing a peep hole device for sighting down axially of the furnace, through the eyepiece **94**, the valve **88** when opened, the vertical section of the inlet pipe **87**, and the apertures previously referred to in the upper horizontal plates.

From the foregoing disclosure it will be seen that the furnace may be used to heat articles of tungsten or other refractory metal, to the high temperatures necessary to effect the final sintering operation, by radiation from an incandescent refractory resistance element, the heat being conserved by polished and/or bright plated baffles, the whole enclosed in a water jacket, and the articles or material during treatment being surrounded by a protective atmosphere, such as wet hydrogen, introduced through the upper pipe **87**, and exhausted through the lower pipe **89**.

Although a preferred embodiment of our invention has been disclosed, it will be understood that modifications may be made within the spirit and scope of the appended claims.

We claim:

1. A furnace for high temperatures comprising a refractory metal element consisting of a series of sections, to be heated by the passage of electricity therealong, disposed as the elements of a hollow cylindrical surface and arranged to directly radiate heat upon material to be treated, and a series of reflecting hollow cylindrical elements coaxial with said metal element, the inner of said elements being formed of polished molybdenum, intermediate elements consisting of stain-

less steel, chromium plated on both sides, and outer elements consisting of sheet steel, silver plated on both sides.

2. A furnace for high temperatures comprising a refractory metal device to be heated to incandescence by the passage of electricity therealong, elements thereof being arranged to surround and directly radiate heat upon material to be treated, a base of refractory material formed with a groove, a series of vertically movable reflecting baffles and an outer casing surrounding said heated element, a pair of stiffening rings secured to said outer casing, rods with their lower ends embedded in said base and guidably passing through holes in said rings, and at least one of said baffles extending below the lower edges of the others and telescopingly received in said groove when in normal position.

3. A furnace for high temperatures comprising a refractory metal element consisting of a series of sections, to be heated by the passage of electricity therealong, disposed as the elements of a hollow cylindrical surface and arranged to directly radiate heat upon material to be treated, a series of surrounding reflecting hollow cylindrical elements and an outer casing disposed coaxially therewith, stiffening means secured to said casing, means closing the upper ends of said reflecting elements, a base, rods with their lower ends embedded in said base and guidably passing through holes in said rings, and means for lifting said reflecting elements and associated refractory metal element, with the stiffening means sliding on said rods, in order to allow for the introduction and removal of the material to be treated.

4. A furnace for high temperatures comprising a refractory metal element to be heated to incandescence by the passage of electricity therealong, arranged to surround and directly radiate heat upon material to be treated, a series of reflecting baffles and an outer casing surrounding said refractory metal element, means closing the upper end of said series of baffles, a series of peep holes through said closing means, a pipe alined with said peep holes and passing through said casing, a valve the housing of which is secured to said pipe, said housing having an outer socket, and an eye piece in said socket and through which the material undergoing treatment may be viewed when the valve is open.

5. A furnace for high temperatures comprising a refractory metal element shaped as a series of sections, to be heated by the passage of electricity therealong, and arranged to directly radiate heat upon material to be treated, and a series of reflecting hollow cylindrical elements successively surrounding said metal element, the inner of said elements being formed of molybdenum, intermediate elements consisting of stainless steel, and outer elements consisting of sheet steel.

6. A furnace for high temperatures comprising a refractory metal device, to be heated to incandescence by the passage of electricity therealong, arranged to form elements of a hollow generally cylindrical surface to surround and directly irradiate heat upon material to be treated, a base of refractory material formed with a groove, a series of reflecting baffles surrounding said device, at least one of said baffles extending below the remainder and telescopically receivable in said groove, and means for guiding said baffles during raising and lowering thereof with respect to said base.

7. A furnace for high temperatures comprising a refractory metal device, to be heated to incandescence by the passage of electricity therealong, arranged to form elements of a hollow generally cylindrical surface to surround and directly irradiate heat upon material to be treated, a series of surrounding reflecting hollow cylindrical elements of varying diameters disposed coaxially with respect to said surface, a base for said furnace, means for lifting said reflecting elements and associated refractory metal device with respect to said base, and means to guide said elements during raising and lowering operations.

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