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[54] **METHOD OF HEATING OBJECTS AND DEVICE FOR THE PERFORMANCE OF THE METHOD**


[76] Inventor: **Horst Edmund Rordorf,** 8104 Weiningen, Ifang, 12, Switzerland



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[62] Division of Ser. No. 154;127, June 17, 1970, abandoned.

[52] **U.S. Cl.** .................................. **13/31,** 219/121 R

[51] **Int. Cl.** .............................................. **H05b 7/16**

[58] **Field of Search** ...................... 13/31; 219/121 R


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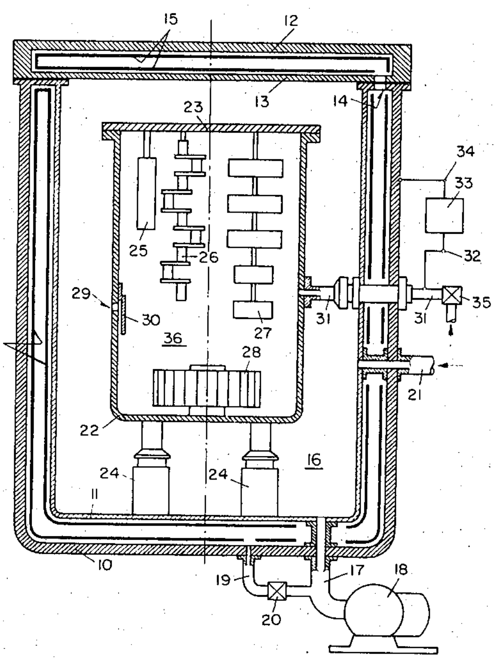
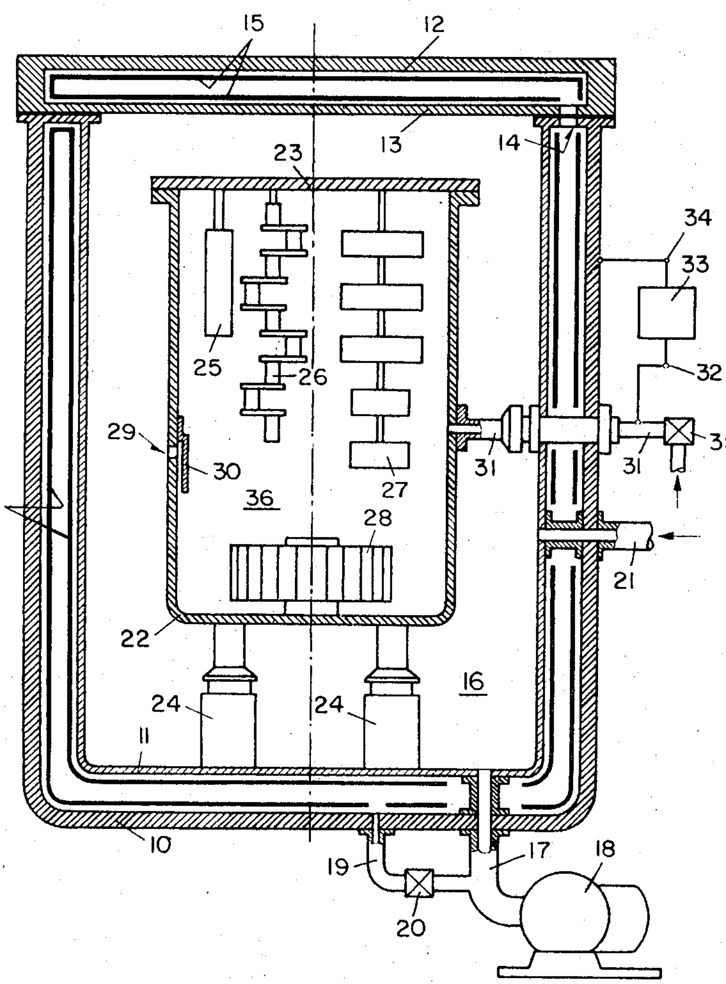
*Primary Examiner*—Roy N. Envall, Jr.
*Attorney, Agent, or Firm*—Bacon & Thomas


[57] **ABSTRACT**


A heating furnace, at least the outer surface of which is metallic, is placed in a metallic chamber, spaced and electrically insulated therefrom. An electrical glow discharge is produced in the space between the furnace and the chamber, with the metallic surface of the furnace serving as the cathode. The furnace is thus held at a high temperature for heating objects therein.


**7 Claims, 2 Drawing Figures**

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## METHOD OF HEATING OBJECTS AND DEVICE FOR THE PERFORMANCE OF THE METHOD

This is a division of application Ser. No. 154,127, filed June 17, 1971, now abandoned.

The industrial arts frequently demand that objects, such as metal parts, be heated and kept at a predetermined temperature for a certain space of time. Depending on the purpose contemplated, heating may be effected in a largely evacuated furnace or also in air and, respectively, in a buffer gas.

Such annealing processes are by way of example used for bright annealing or also to eliminate interior stresses in metal parts as well as for a number of other purposes.

The furnaces commonly employed for such annealing purposes may by way of example be heated by gas or be equipped with electrical heating windings. Since the temperature in such annealing processes must frequently be kept at a predetermined level, the most rational possible generation of the required thermal energy is of importance and any saving of energy in such annealing furnaces constitutes an advantage.

The present invention relates to a method of heating objects located in a furnace. The said furnace is heated by electrical energy in a particularly heat-saving manner. The method is characterized in that the metallic outside of the furnace is heated in a metallic low-pressure chamber and a gas atmosphere of low pressure by means of an electrical glow discharge which is generated by an electric voltage applied to the furnace on the one hand and the inner walls of the chamber on the other, the outside of the furnace operating as a cathode at least temporarily.

The invention further relates to a device for the performance of the said method which is characterized by a fully enclosed chamber in the interior of which a gas atmosphere of a predetermined pressure can be maintained by means of a pump and a gas supply line and of which the walls are insulated against thermal losses to the surrounding area, by a furnace located in the chamber at a distance from its walls and electrically insulated relative to the same, the said furnace being designed to accommodate the objects to be heated and provided with a metallic outside, and by an insulated current lead-in located in a wall of the chamber for connection of the said metallic outside with one pole of a voltage source of which the other pole is connected to the chamber.

An embodiment of this invention will now be described with reference to the drawing which shows a longitudinal section of a device according to this invention in a diagrammatic view.

In this embodiment a double-walled chamber consists of the outside wall **10** and the inside wall **11** which may both be made of iron or steel and are here of cylindrical configuration. At its top the chamber is closed, again by a double-walled cover comprising the outside wall **12** and the inside wall **13** so as to be gas and airtight. The spaces between the chamber walls **10** and **11** and the cover walls **12** and **13** communicate via the passage **14**. The inside wall **11** of the chamber as well as the inside wall **13** may be propped against the outside wall **10** and, respectively, the outside wall **12** by members made of a material of poor conductivity. The insides of the inside wall **11** and the outside wall **10** should have a surface that reflects thermal radiation, by way of example a polished surface, or be lined with a bright metal foil **15**. The insides of the cover walls **12** and **13** are also provided with such a metal foil **15** which reflects the heat. The interior of the chamber, designed at **16** in the drawing is connected, via a tubular conduit **17** passing through both the inside wall **11** and the outside wall **10**, with a pump **18** and can thus be evacuated. Connected to this tubular conduit **17** via a valve **20** and the tubular conduit **19** is also the space between the chamber walls **10** and **11** and, respectively, the cover walls **12** and **13** so that underpressure may also be obtained within this space. In the present embodiment the interior **16** of the chamber does not communicate with the space between the chamber walls **10** and **11** and, respectively, the cover walls **12, 13.** In the interior **16**, however, a gas atmosphere of any type may be created via a gas supply line **21** passing through the inside wall **11** and the outside wall **10**, adjustment of the pump **18** and the gas supply enabling any predetermined underpressure to be maintained in the space **16.**

Located in the space **16** of this double-walled metallic chamber is an annealing furnace **22** with a cover **23.** The annealing furnace **22, 23** is here also formed of iron. It is supported by the two electrically insulating pillars **24** which in turn rest on the inside wall **11** of the chamber. Such insulated pillars for use in a space **16** in which a glow discharge under low pressure is to be obtained are already known and they are provided with a protective gap system for all joints between metal and insulating material which may be subjected to the glow discharge (U.S. Pat. No. 3,207,941). Arranged in the furnace space **36** are the workpieces **25, 26, 27** and **28** to be heated which are partly suspended from the cover **23** or may stand on the bottom surfaces of the furnace **22.**

The furnace space **36** of the present embodiment communicates with the interior **16** of the chamber via an opening **29** so that the same pressure and the same gas atmosphere are found in both spaces. The opening **29** on the inside of the wall of the furnace **22** is so electrically shielded by means of a metal plate **30** that, while unimpeded gas exchange is possible between the furnace space **36** and the space **16** of the chamber, an electrical glow discharge generated on the outside of the furnace **22** cannot penetrate into the furnace space **36.** Connected to the wall of the furnace **22** is an insulated current lead-in which here consists of a metal tube **31** which is passed through the inside wall **11** and the outside wall **10** of the chamber so as to be electrically insulated and sealed against gas and connected to one pole **32** of a voltage source **33** of which the other pole **34** is connected to the outside wall **10** of the metallic housing. If desired, a treatment gas may be introduced, through the current lead-in **31** which is hollow in the present embodiment, into the furnace space **36** and thence, via the opening **29**, into the interior **16** of the chamber in which case a gas supply through the line **21** becomes unnecessary.

The embodiment, described above and shown in the drawing, of the device according to this invention enables the method of heating the objects **25, 26, 27** and **28** arranged in the furnace **22, 23** to be performed. The metallic outside of the furnace **22, 23** is heated by an electrical glow discharge which is generated in the interior **16** of the metallic chamber by an electrical voltage applied between the furnace **22, 23** on the one hand

and the inside wall 11 of the chamber on the other and which allows the outside of the furnace 22, 23 as the cathode at least temporarily. By way of example, if a direct current source 33 with an adjustable voltage between about 400 and 1,500 Volts is used of which the negative pole 32 is connected to the insulated current lead-in 31 of the furnace 22, 23 while the positive pole 34 is connected to the outside wall 10 of the metallic chamber and thus also to the metallic inside wall, an electrical glow discharge is generated in the interior 16 of the chamber in the event that, by way of example, a nitrogen atmosphere with a pressure in the range of 0.1 to 10 mm Hg is maintained. Such a glow discharge produces a negative glow covering the outside of the furnace 22, 23 and the so-called cathode fall between the metallic outside of the furnace and the said glow results in a violent bombardment of the outside with gas ions of which the energy is passed on to the metal wall and heats it. For the present method it is of advantage that the transformation of energy in this glow discharge process occurs virtually exclusively in the so-called cathode fall space, i.e., directly on the metallic outside of the furnace 22, 23, while no noticeable transformation of energy occurs in the interior 16 itself and on the inside wall 11 of the chamber or inside wall of the cover 13. Accordingly, the transformation of electrical energy into thermal energy is performed virtually without losses, which constitutes the advantage of the present method of heating the furnace 22, 23 with the purpose of heating the objects 25, 26, 27 and 28 located in it.

The initiation and maintenance of a high-intensity and highly energetic glow discharge on the metallic outside of the furnace 22, 23 and the adjustment of the operating voltage as well as of the gas pressure and gas atmosphere are known from other applications of electrical glow discharges for metallic processes so that a more detailed description is not required (U.S. Pat. Nos. 3,018,409, 3,004,133, 3,228,809).

In order effectively to utilize the advantages of the virtually loss-free transformation of electrical energy into thermal energy by the glow discharge on the metallic outside of the furnace 22, 23 and not adversely to affect them by thermal losses of the metallic chamber to the surrounding area, the embodiment of such a chamber described above incorporates a space between the inside wall 11 and the outside wall 10 as well as the inside cover wall 13 and the outside wall 12, the said space being capable of being evacuated by the tubular line 19. This largely diminishes heat conduction from the inside walls 11 and 13 to the outside walls 10 and 12. Again, heat transfer by radiation from the inside walls 11, 13 to the outside walls 10, 12 is greatly reduced by the heat-reflecting bright surface of the metal foil 15. With a double-walled chamber of this design and with a corresponding cover, experience shows that outside thermal insulation of the outside walls 10 and 12 with respect to the surrounding atmosphere can be dispensed with since no considerable heating of the said outside walls 10 and 12 occurs during operation. Located in the interior 16 is a dilute gas atmosphere so that heat conduction from the heated outside of the furnace 22, 23 to the inside walls 11, 13 is only small and the heat losses of the furnace 22, 23 are due only to heat radiation to the inside walls 11, 13. However, since these inside walls 11, 13 are thermally insulated relative to the outside walls 10, 12 by the double-walled design of the chamber, only small heat losses occur. Care must of course be taken to ensure that the props, if any, between the inside walls 11, 13 and the corresponding outside walls 10, 12 are formed of a material of poor conductivity such as porcelain. In addition, the lines 17, 21 and 31 passing between the inside wall 11 and the outside wall 10 must be so designed that no undesirable heat conduction occurs between the inside wall 11 and the outside wall 10.

The above device for heating the furnace 22, 23 by means of a glow discharge obtained on its outside may be operated so that the interior 16 is first evacuated by the tubular line 17 and the pump 18 and that a treatment gas is supplied via the tubular line until an underpressure is obtained which is desirable for the maintenance of the electrical glow discharge. The opening 29 ensures that the same gas atmosphere is encountered in the furnace space 36 and in the interior 16. The valve 35 for the hollow current lead-in 31 is closed during this process. The space between the inside walls 11, 13 and the outside walls 10 and 12 is evacuated by the tubular line 19 after the valve 20 has been opened. It is of advantage to operate this device and to heat the furnace 22, 23 in a buffer gas atmosphere in the interior 16 and, respectively, the furnace space 36 although this is not absolutely necessary since an electrical glow discharge of adequate energy can be obtained also if the pump 18 brings the interior 16 and thus the furnace space 36 to the desired underpressure of about 0.1 to 10 mm Hg and the supply of a special buffer gas via the line 21 is dispensed with. It is naturally also possible to do entirely without the tubular line 17 if appropriate orifices in the inside wall 11 ensure connection between the interior 16 and the space between the inside wall 11 and the outside wall 10. Evacuation of this space and the interior 16 as well as the furnace space 36 is then effected simply via the tubular line 19 and by the pump 18. However, this mode of operation is less recommended since it is of advantage to evacuate the space between the inside wall 11 and the outside wall 10 as thoroughly as possible, independently of the gas pressure obtaining in the interior 16, which must be adjusted to the operating conditions of the electrical glow discharge.

In the event that a gas atmosphere is to be created in the interior 16 and in the furnace space 36, it is also possible to pass the gas involved into the furnace space 36 via the valve 35 and the hollow current lead-in 31 and, through its opening 29, into the interior 16 of the chamber. In this case it may be possible to dispense with the gas supply line 21. However, it should be noted that the current lead-in 31 and the valve 35 are at a comparatively high negative potential relative to the outside wall 10 of the metallic chamber so that adequate measures must be taken in respect of the gas supply line, such as the connection of the valve 35 to the gas supply plant via a tubular line made of an insulating material.

With the embodiment disclosed it is contemplated to heat the objects 25, 26, 27 and 28 in a low-pressure atmosphere that obtains in the furnace 36 and corresponds to the interior 16. There is naturally also the possibility of dispensing with an opening 29 in the furnace 22 and to close the cover 23 so as to be air and pressure tight so that the furnace space 36 is separated from the interior 16 of the chamber. In that case, a gas atmosphere can be created in the interior 16 as is necessary for the initiation and maintenance of the electrical glow discharge for the purpose of heating the furnace **22, 23** while the space in the furnace **36** can be either evacuated or supplied with a gas atmosphere of some other composition by the hollow current lead-in **31** and the valve **35.** In that case it is also possible to maintain an atmosphere of a far higher pressure in the furnace space **36** via the hollow current lead-in **31** and the valve **35** than in the interior **16** of the metallic chamber where a certain underpressure must prevail for the maintenance of the electrical glow discharge. The closure of the furnace space **36** relative to the interior **16** is also desirable for applications of the present device where the surface of the objects **25, 26, 27** and **28** must be influenced during the annealing process, by way of example by a chemical reaction with the gas atmosphere in the furnace space **36** or by an additional material located in the furnace space **36** and evaporating at the annealing temperature.

What is claimed is:

**1.** An apparatus for heating objects within a furnace comprising:

a metallic furnace arranged within and electrically insulated from a metallic chamber provided with a gas pipe leading into said chamber and connected to a pump and a gas supply pipe for maintaining a gas atmosphere of a predetermined pressure in the interior of said chamber;

a current source connected, as one terminal, to said chamber and, as its other terminal, to a current lead-in insulated from the metallic walls of said chamber and contacting said furnace for maintaining an electric glow discharge between said chamber and furnace with the inner wall of said chamber and the outer side of said furnace as electrodes; and

at least one separate gas supply pipe communicating with the interior of the said furnace and sealed against the interior of the said chamber for maintaining a desired gas atmosphere within said furnace.

**2.** A device according to claim **1,** characterized by the fact that the said gas supply pipe for the said furnace is formed of metal and constitutes said current lead-in to the said furnace.

**3.** Apparatus according to claim **1** characterized by a double-walled chamber of which the inside wall is attached to the outer wall by means of thermally insulating props while the inside surfaces of the inside and outside walls facing one another are provided with surfaces that reflect thermal radiation.

**4.** Apparatus according to claim **3** characterized by the fact that a polished foil is provided on the said inside surfaces.

**5.** Apparatus according to claim **1** characterized in that a conduit is provided from the space between the two walls of the said chamber and the said pump.

**6.** Apparatus according to claim **1** characterized by a passageway from the space between the two walls of the said chamber and the interior of said furnace.

**7.** Apparatus according to claim **1** characterized by supporting insulators with a protective gap system for all joints subjected to the glow discharge between metal and insulating material between the said furnace and the inside wall of the said chamber.

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