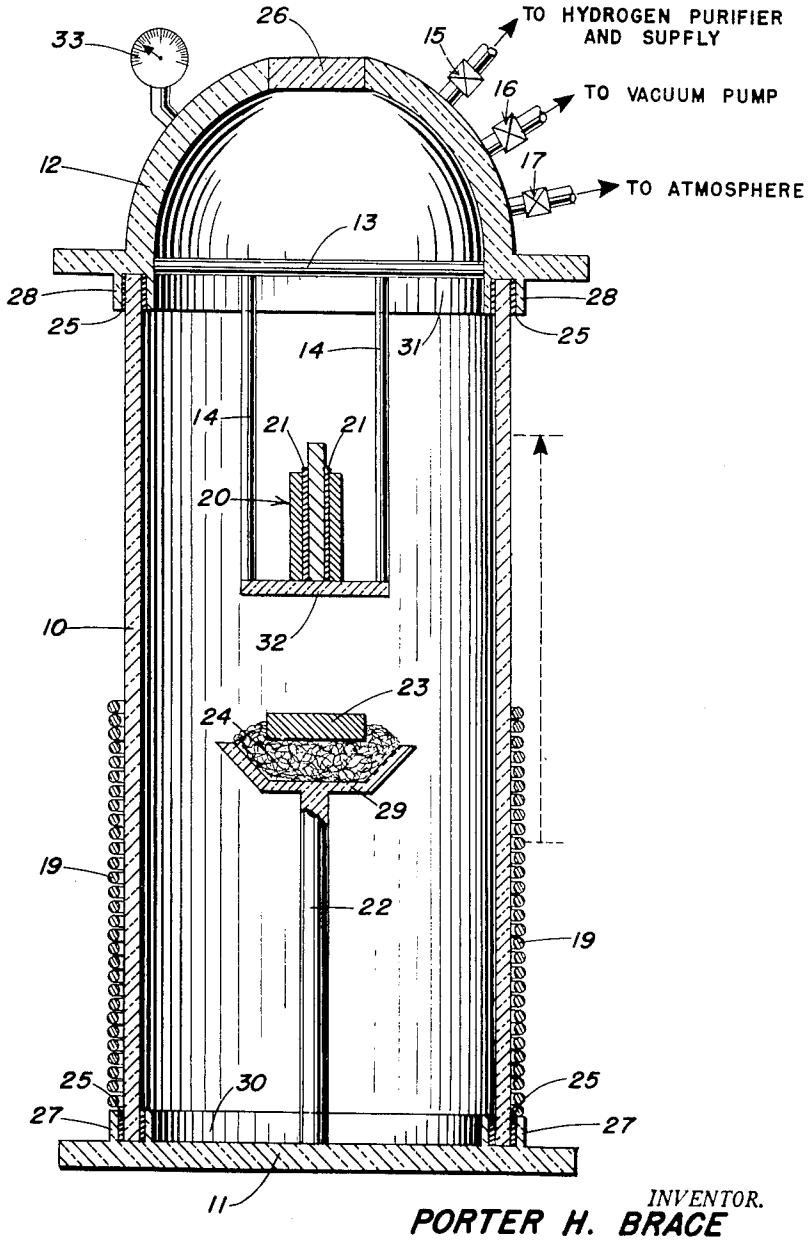
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HEAT TREATING APPARATUS

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HEAT TREATING APPARATUS

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This invention relates to heat treating, and particularly to apparatus facilitating application of heat to either of two metallic bodies, selectively, or to both simultaneously. This application is a division of my application Serial No. 127,858, filed November 17, 1949, now Patent No. 2,638,426, issued May 12, 1953.

The present invention is concerned with the problems of furnace brazing, bright annealing and coating of metals or alloys when these metals comprise, as the sole element or as a major or minor constituent, readily oxidizable metals whose oxides are difficultly reducible. The following constitute examples of metals that are readily oxidizable and whose oxides are difficultly reducible: titanium, beryllium, aluminum, chromium, magnesium, tantalum, columbium, cerium, and silicon. The foregoing elements are frequently alloyed with various base metals such as iron, copper, nickel or cobalt to impart desirable and advantageous properties to the resultant metal, but when present therein, being readily oxidizable metals whose oxides are difficultly reducible, result in brazing and bright annealing difficulties which are not overcome by the usual reducing atmosphere furnaces. For example, iron, cobalt, and nickel form an alloy of low expansivity known as Kovar and may be readily furnace brazed in a commercial tank hydrogen atmosphere. The addition of a small percentage of titanium to Kovar confers age hardening properties that greatly enhance the usefulness of the alloy; however, an attempt to braze or bright anneal titanium-Kovar in a tank hydrogen atmosphere results in the formation of a tough black adherent oxide film that prevents wetting thereof by a brazing metal, and obviously no bright anneal can be obtained. Even in vacuums of less than 10^{-3} millimeters of mercury and in hydrogen atmospheres of much better than ordinary purity, filming and tarnishing of the alloy occurs which effectively prevents brazing and bright annealing. The present invention contemplates a method whereby alloys such as titanium-Kovar and other alloys containing readily oxidizable metals whose oxides are difficulty reducible, such as those metals aforelisted, may be furnace brazed, bright annealed, or coated with a lower melting metal or alloy; and the present invention further contemplates the use of preferably a high vacuum furnace having preferably a reducing atmosphere beneficiated with the vapor of a readily oxidizable metal in order to accomplish the above furnace treatments, the atmosphere comprising, for one example, highly purified hydrogen gas beneficiated in reducing quality by the vapor of metallic chromium.

It is, therefore, one object of the present invention to provide for the furnace treating of metals or alloys comprising a readily oxidizable metal whose oxide is difficultly reducible.

It is another object of the present invention to provide for the furnace brazing, the bright annealing, or the coating with lower melting metals or alloys of such metals as titanium, beryllium, aluminum, chromium, magnesium, tantalum, columbium, cerium, and silicon, or alloys or

mixtures of metals containing one or a group of such metals.

It is a further object of the present invention to facilitate the foregoing objects by providing a furnace with a beneficiated reducing atmosphere.

It is a further object of the present invention to facilitate the foregoing objects by providing a beneficiated reducing low pressure atmosphere comprising a highly purified reducing gas, such as hydrogen, beneficiated by the vapor of a readily oxidizable metal such, as, for example, titanium, beryllium, aluminum, chromium, magnesium, tantalum, columbium, cerium, or silicon.

It is a still further object of the present invention to provide a furnace for brazing, bright annealing, or the like, designed to facilitate the provision of a low pressure beneficiated reducing atmosphere as aforementioned.

Another object of the invention is to provide a furnace for the purposes indicated, and incorporating therein, as a means to the attainment of said purposes, heating facilities that are movable to each of several positions, successively, to direct the major heating effort to different parts of the furnace selectively, to better achieve the beneficiating effect referred to.

Other objects and advantages of the present invention will become apparent to those skilled in the art from a consideration of the following detailed description thereof.

In general, the process of the present invention contemplates introducing into a furnace an object or objects of, or containing, a readily oxidizable metal whose oxide is difficulty reducible, or several such metals, which it is desired to furnace braze, bright anneal, coat with a lower melting metal or alloy, or otherwise furnace treat, evacuating the enclosure while applying a relatively low heat thereto to remove a substantial portion of the oxygen contained therein by degassing the materials to be treated, introducing into said enclosure a preferably highly purified reducing atmosphere to preferably a relatively low pressure, vaporizing a supply of readily oxidizable beneficiator metal in said enclosure for beneficiating the atmosphere by the application of heat to said supply, and then heating the workpiece or pieces to complete the brazing, bright annealing, or other heat treating operation.

More specifically, when it is desired to accomplish one of the above-mentioned operations on a workpiece of titanium, beryllium, aluminum, chromium, magnesium, tantalum, columbium, cerium, or silicon, or a similar metal having a difficultly reducible oxide, or on an alloy of metals containing such a metal as one of its constituents, the workpiece is first cleaned to remove sensible contamination and is then mounted in a furnace enclosure which can be exhausted to a high vacuum, preferably to a few microns of mercury. A supply of vaporizable and readily oxidizable metal such as, for example, one of those metals above enumerated as having a difficultly reducible oxide, and preferably of the more readily vaporizable metals of that group, is introduced into said furnace. The furnace is then exhausted to a high vacuum of preferably a few microns of mercury, and the workpiece is lightly heated to drive out adsorbed gases, yet avoiding temperatures high enough to cause noticeable oxidization thereof, a temperature range of 100° to 300° C. for a few minutes usually being satisfactory. The heating may be obtained by any desired means as, for example, by induction or resistance heating, or by electron bombardment. With the enclosure thus exhausted and the workpiece degassed, a supply of reducing gas such as hydrogen of high purity is introduced into the enclosure through an efficient purifier, as for example by diffusion through a palladium septum, up to a pressure of a few centimeters of mercury. Thereupon the supply of readily oxidizable

beneficiator metal is heated by any suitable means to afford an appreciable vaporization thereof, thereby beneficiating the reducing atmosphere by scavenging nitrogen, oxygen, or other contaminants thereof. The workpiece is then heated independently of or concurrently with the beneficiating metal to complete the brazing, bright annealing, or other heat treating operation.

One particular example of the present process is as follows: A titanium-Kovar alloy containing approximately 2.5% titanium is to be furnace brazed. The pieces to be treated are first cleaned and then introduced into the furnace or enclosure wherein the operation is to be carried out. A quantity of metallic chromium, the beneficiator metal, having approximately 10 square centimeters of surface is also introduced into the furnace. The furnace is then evacuated to a few microns of mercury and heated to approximately 100° C. to effectuate the degassing operation. Thereupon, palladium filtered hydrogen is introduced to a pressure of approximately 4 centimeters of mercury, and the chromium is heated at from 1200° to 1400° C. for approximately 20 minutes to beneficiate the reducing atmosphere. The workpiece is then heated above the fusion point of the brazing alloy, which may be, for example, a copper base alloy with 6% nickel, 1% silicon, and 0.5% molybdenum. After suitable fusion of the brazing alloy has been obtained the furnace is cooled and the brazed work is removed, the entire operation requiring approximately 40 minutes.

In another specific application of the present process, the foregoing steps were applied with excellent success in the brazing of steel and molybdenum parts to titanium-containing alloys with high strength silicon-nickel-copper-molybdenum brazing alloy.

The pressure of the atmosphere in which the operation is carried out and the amount of vaporization of the beneficiating metal necessary to obtain a suitable atmosphere are interdependent factors, for it is desirable to adjust the pressure within the furnace to values which favor vaporization of the beneficiating metal, and yet it is desirable to cause an appreciable portion of the vaporized atoms to collide with the molecules of the atmosphere before encountering the walls of the furnace. Therefore, small variations in vacuum pressure may be compensated for by variations in beneficiating temperature, and vice versa. Further, with regard to the beneficiating action, the present invention also contemplates, when desired, the production of a glow discharge through the furnace to accelerate the action.

The present invention also contemplates a continuous process wherein the workpieces are brought successively into the system through a gas lock, moved countercurrent to a flow of beneficiated hydrogen or other reducing atmosphere through a preheating and scavenging chamber, thence into an operation chamber wherein the brazing, bright annealing, or other heat treating operation is carried out in a beneficiated atmosphere, and thence moved into a cooling zone and out through a gas lock. The details of such a continuous process will be apparent to those skilled in the art.

The foregoing is a description of the process of the present invention; the following is a description of a furnace for carrying out the same made in conjunction with the accompanying drawing which is a longitudinal sectional view of the furnace.

The following description is given by way of example of one embodiment of a furnace designed to carry out the above-described process. Referring to the drawing, numeral **10** indicates the main portion of the furnace, which is shown in the present embodiment as cylindrical in shape and is preferably constructed of some non-metallic heat resistant inert material such as silica glass. The cylinder **10** is closed at its lower end by a base **11**, and at its upper end with a cover dome **12**, both being preferably constructed of the same material as the cylinder. The base **11** has the stand **22** extending upwardly therefrom which has the cup **29** formed on its upper end, the stand and cup likewise being preferably constructed of an inert material such as silica glass. Also, the base **11** is provided close to its periphery with the pair of circular flanges **27** and **30**, forming an annular groove about the base into which one end of the cylinder **10** is fitted, the flanges being preferably formed of a similar inert material. The cover dome **12**, like the base **11**, is provided with a similar pair of circular flanges **28** and **31** forming an annular groove wherein the other end of the cylinder **10** is positioned, and is further provided with the crossbar **13** from which depends the brackets **14** supporting the shelf **32**, all of these elements being likewise formed from a similar inert material. The cover may be provided with a pressure gauge **33**, and valves **15**, **16**, and **17** for connection to the hydrogen purifier and supply, to the vacuum pump, and to the atmosphere, respectively, and may have an observation window **26** formed of transparent material. The seating of the cylinder in the base and cover is made vacuum tight by inserting between the cylinder and the several circular flanges, **27** and **30**, and **28** and **31**, any suitable sealing compound **25**, as is well known in the art. The present furnace is further provided with the inductor coil **19**, movable axially along the cylinder, for heating the contents thereof as desired.

To briefly describe the operation of the present furnace in carrying out the foregoing process, a description is here made thereof in its application to the above-described first specific example of the process. With the cover removed, the cup **29** is filled with granular alumina or other similar material **24** for supporting the metallic chromium block **23** placed thereon. The titanium-Kovar workpiece, indicated generally by the numeral **20**, having the copper base brazing alloy **21** inserted in the joint between the two portions of the workpiece to be brazed, is positioned upon the shelf **32** and the cover is placed upon the cylinder thus closing the furnace. The lead pipe from the hydrogen supply and palladium purifier, not shown, is connected to the valve **15**, and the lead line to the vacuum pump, not shown, is connected to the valve **16**. Valve **17** vents to atmosphere.

With the hydrogen inlet valve **15** and the atmosphere valve **17** closed, the furnace is evacuated while the workpiece **20** is gently heated at a temperature of about 100° C. by the inductor coil **19**. For this degassing operation the inductor coil is first moved upwardly along the cylinder until it encompasses both the workpiece **20** and the chromium block **23**. After the degassing operation is completed, the pressure within the furnace having been reduced to but a few microns of mercury, the vacuum valve **16** is closed and highly purified hydrogen is permitted to enter the furnace through the valve **15** until the pressure within the furnace has reached about 4 centimeters of mercury, as indicated by the pressure gauge **33**. Then inductor coil **19** is returned to its lowermost position as shown in the drawing, and the chromium block **23** is heated to a temperature of between 1200° and 1400° C. for approximately 20 minutes. After the hydrogen atmosphere of the furnace has been thus beneficiated, the inductor coil is again moved upwardly to encompass the workpiece and the temperature thereof is raised above the fusion point of the brazing alloy **21**. After fusion occurs the furnace is cooled, the chamber vented to the atmosphere through valve **17**, and the workpiece removed.

The herein described specific embodiments of the process and apparatus comprising the present invention are presented merely by way of example, and modifications thereof within the spirit and scope of the appended claims will be apparent to those skilled in the art and are within the monopoly there defined.

What is claimed is:

1. A furnace for low pressure heat treating of a metallic workpiece comprising a means for evacuating the

furnace, a means for introducing therein a furnace atmosphere gas, a workpiece supporting shelf supported at one end of said furnace, a beneficiator metal supporting cup carried by the other end of said furnace and spaced apart from said shelf, and an induction heating means cooperating with said furnace and movable therealong for heating either the shelf containing portion or cup containing portion or both as desired.

2. A furnace having a principal metal supporting member at one end and an auxiliary metal supporting member at its opposite end, and means including an induction heating coil wound about said furnace and movable to different positions between said furnace ends to apply the major heating effort toward a selected one of said metal supporting members.

3. In a furnace for heating treating metals having difficulty reducible oxide; a heat resistant gastight housing having an upper and a lower end, valve and conduit means connected to the upper portion of said housing for the transmittal of gases to and from said housing, a

principal metal supporting member depending from the upper portion of said housing, an auxiliary metal supporting member upstanding from the lower end of said housing and spaced apart from said principal member, and an induction coil surrounding said housing and movable thereon to become adjacent to one or both said supporting members whereby different temperatures may be created within said housing relative to the positioning of said induction coil.

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