April 2, 1957 D. A. BOGDAN 2,787,457

HIGH TEMPERATURE FURNACE

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Fig. 1.

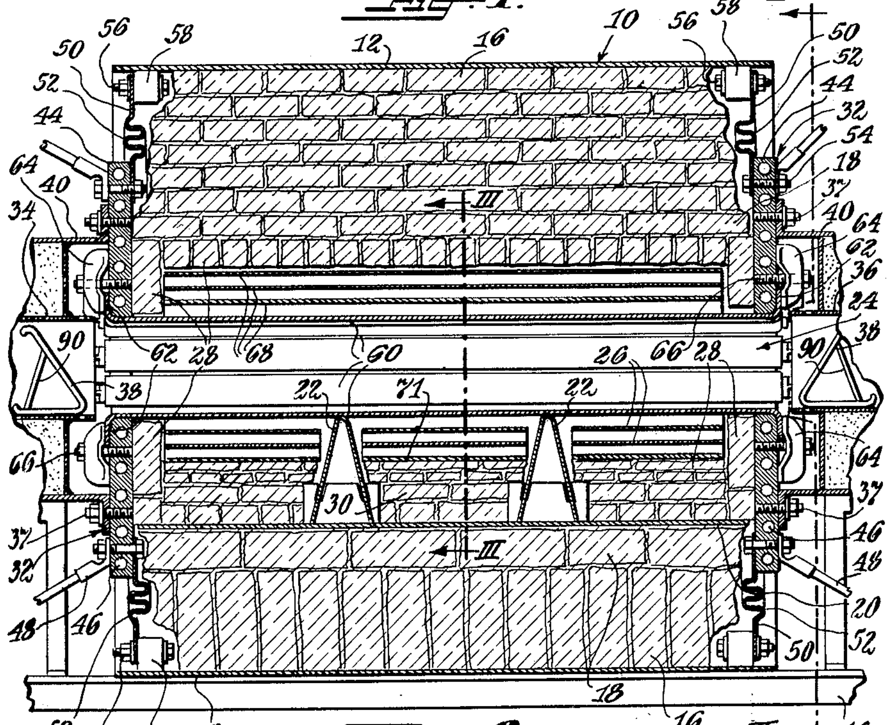
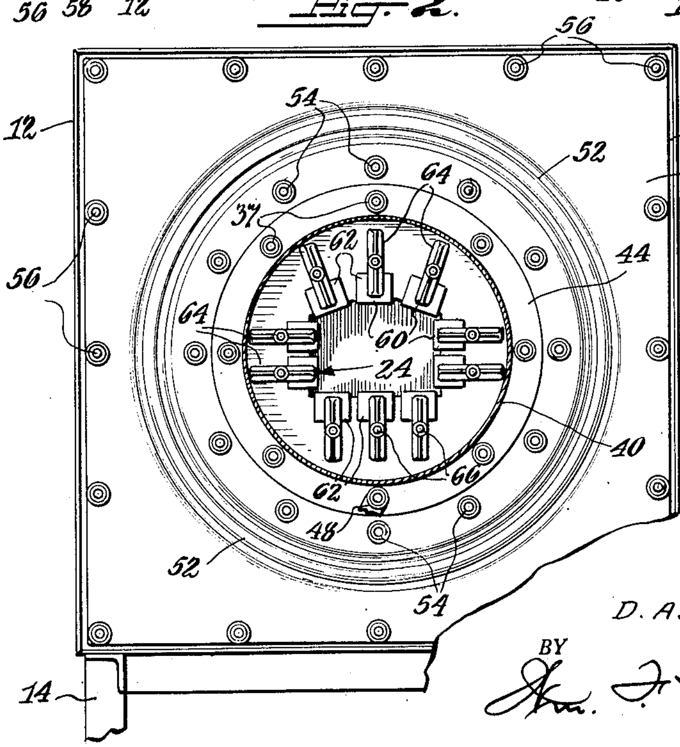


Fig. 2.



INVENTOR.
D. A. BOGDAN.

BY
Wm. F. Kelly
ATTORNEY.

HIGH TEMPERATURE FURNACE

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Fig. 3.

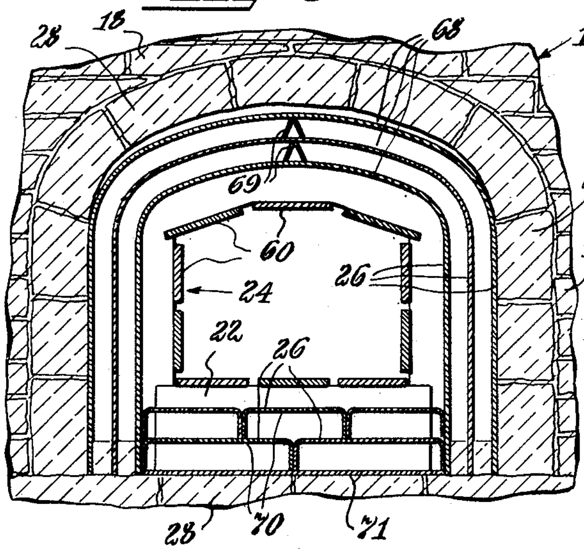


Fig. 4.

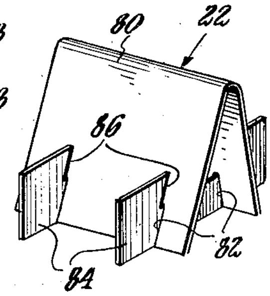
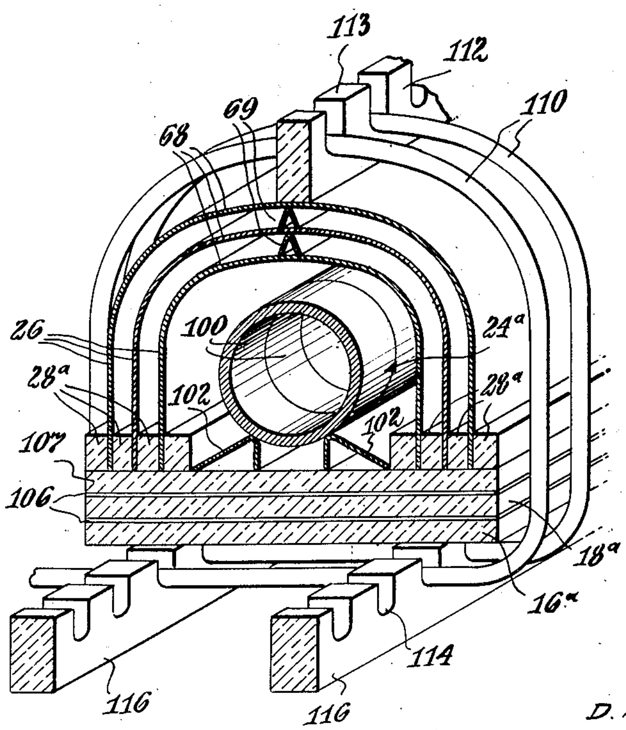


Fig. 5.



INVENTOR.
D. A. BOGDAN
BY
[signature]
ATTORNEY

United States Patent Office

2,787,457

Patented Apr. 2, 1957

2,787,457

HIGH TEMPERATURE FURNACE

David A. Bogdan, West Orange, N. J., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application May 14, 1954, Serial No. 429,930

4 Claims. (Cl. 263—41)

The present invention relates to furnaces and, more particularly, to a high temperature hydrogen furnace for treating projection lamp filaments.

In the manufacture of projection lamp filaments the sectional coil is first wound on a steel mandrel on a conventional automatic coil winding machine. The wound coil is then degreased and annealed in a hydrogen atmosphere at 1300° C. for about one half hour. The coil is then cut to length, as on a rubber wheel. After dissolving the steel mandrel in alternate solutions of hydrochloric acid and caustic and rinsing in hot and cold water the coils are dried and inspected.

Prior to bending the coil into a plurality of aligned sections to form a projection lamp filament, the coil may be mounted on a tungsten mandrel and pre-fired at a temperature desirably about 1800° C. in a hydrogen atmosphere. However, owing to the defects of the conventional high temperature (about 2000° C.) hydrogen furnaces (where it would be desirable to bake the coils) they are annealed instead on the aforementioned mandrels for 5 minutes. After bending the sectional coils into the plurality of sections desired, on an automatic bending machine, the coils are again baked at about 1650° C. for approximately ½ hour to set the bent coil. The baked bent coil is removed from the refractory metal mandrel and the now formed filament is then trimmed and prepared for mounting on a filament mount stem. At present these coils must be reset by hand at a subsequent flashing operation to obtain optimum spacing. This last operation would be eliminated, if the coils were rigidly set as would be accomplished by the subject invention.

The best coil condition for bending is the soft state. The bending operation tends to work harden and increase the rigidity of the coil. Further, it has been found that the prefiring operation at 1800° C. and the hydrogen bake after bending at about 1650° C. for at least ½ hour in the heat zone can be eliminated. Instead the bent coils may be baked at 2200° C. for about 10 minutes in hydrogen.

Conventional 2200° C. hydrogen furnaces are limited in size to about a ⅞" inside diameter and a 14" length of heating tube or muffle. This size is unsatisfactory for the handling of a large scale production of projection lamp filaments. In considering a 2200° C. hydrogen furnace of larger capacity it is impossible to fabricate a one piece muffle long enough to be practical and heavy enough to be sturdy. The maximum volume of tungsten capable of being worked is limited by present known methods of manufacture.

In addition conventional 2200° C. hydrogen furnaces must be rebuilt about fifteen times a year due to erosion of the tungsten tube, poor electrical contact and sagging. It has been felt that even the best of "refractories" or high temperature insulators, for example zirconia, tends to attack the tungsten tube in the region of about 2000° C. Refractories have been defined as "materials

of construction whose major purpose is the confinement of heat." The life of "refractories" in furnaces is affected by one or more of the following: mechanical abrasion, shrinkage expansion, deposition of solids in the pores by gases, chemical combination with gases, and other materials. Conventional furnaces, in which the tungsten tube is in contact with the high temperature insulation, zicronia, would be limited as to maximum temperature. Again, it is a known fact that all high temperature insulation becomes electrically conductive at very high temperatures. Thus, the electrical losses of high temperature insulation themselves, for example at 2200° C. result in diversion of energy from the work in the muffle and at the same time reduce the insulating value thereof.

The conventional high temperature hydrogen furnaces also suffer from a linear expansion of the muffle. At temperatures in the neighborhood of 2200° C. this linear expansion of the muffle may amount to about 5⁄16" change in muffle length per 36" of muffle length.

Hence, it has been found advantageous according to the present invention to provide a 2200° C. hydrogen furnace of sufficient capacity to handle large lots, for example, of projection lamp filaments, and which will overcome the defects of prior art high temperature hydrogen furnaces.

The non-sag muffle or the heating element of the furnace of the invention comprises a plurality of longitudinal refractory metal strips or slabs fabricated in the form generally of an open ended cage and clamped to terminal plates of the furnace by means of dogs. In addition, the terminal end plates are water cooled thus keeping the electrical connections at a substantially constant temperature and providing little change in clamping pressure. The thicker tungsten slabs employed in the muffle will prevent erosion of the heating muffle and will eliminate poor electrical contact.

To overcome the electrical conductivity of high temperature insulators, the lower slabs of the heating muffle are mounted on a plurality of bridges, the feet of which are relatively cool enough to safely be in contact with the high temperature insulation. In addition, the insulation is further protected by separating the tungsten muffle slabs from the insulation by molybdenum reflectors. Linear expansion of the heating muffle is compensated for by the employment of corrugated end portions affixed to the terminal cover plates of the furnace.

To reduce any additional throal losses at the unloading end of the furnace an insulated throat portion is disposed between the terminal plates and the water cooled end portion of the cooling chamber. In addition, a sled type baffle may be provided at each end of the furnace to prevent excessive end losses therefrom.

In its general aspect the present invention has as its objective a high temperature hydrogen furnace which prevents failure of the high temperature insulation and compensates for linear expansion of the refractory metal muffle.

A specific object of the invention is an improved heat muffle for a high temperature furnace of increased capacity and of restricted sagging.

Another object is a flexible terminal cover plate for a high temperature hydrogen furnace for providing constant temperature electrical contact and permitting the linear expansion of the heat muffle.

An additional object is a novel muffle bridge to protect the insulation from high temperature and to reduce electrical conductivity of said insulators.

Other objects of the present invention will become apparent to those skilled in the art to which it appertains as the description thereof proceeds both by direct recitation thereof and by implication of the context.

Referring now to the drawing in which like numerals of reference indicate similar parts throughout the several views:

Fig. 1 is a vertical sectional view of the high temperature hydrogen furnace of the invention.

Fig. 2 is a vertical sectional view of the high temperature hydrogen furnace of Fig. 1 along the line II—II of Fig. 1 in the direction of the arrows and showing the means for mounting the refractory metal slabs of a heat muffle of the furnace of Fig. 1 to a flexible water cooled terminal cover plate.

Fig. 3 is a vertical sectional view of the furnace along the line III—III of Fig. 1 in the direction of the arrows, and showing details of the heat muffle, the heat muffle mounting bridge and the refractory metal reflectors.

Fig. 4 is a perspective view of the novel heat muffle mounting bridge of the invention.

Fig. 5 is a view similar to Fig. 3 but showing an alternative embodiment of the furnace structure employing a sectional cylindrical heat muffle capable of heating by radio frequency or high frequency current.

Referring now to the drawings in detail the reference numeral **10** designates a high temperature hydrogen furnace. The furnace **10**, particularly Fig. 1, has a generally open ended box-like refractory metal shell **12** fabricated, for example, from a suitable moderate temperature iron, such as black iron, and secured for example to a frame **14**. A row of a plurality of upstanding refractory bricks **16** may rest on a bottom portion of the shell **12**. These bricks **16**, may for example, be suitably 2000° F. (1048° C.) brick. A layer of horizontal refractory bricks **18** suitably 3000° F. (1660° C.) brick may be juxtaposed between the bricks **16** and a refractory metal floor **20**, suitably molybdenum plate. It will be understood that a plurality, for example 2 in the present showing of Fig. 1, of heat muffle bridges **22** rest on the floor **20** and support, as hereinafter explained, a heat or heat container muffle **24**.

The heat muffle **24** is surrounded by a plurality of refractory metal reflectors **26**, suitably molybdenum, for example, 3 above and 2 below the heat muffle **24** in the present showing of Figs. 1 and 3. The lower reflectors **26** (Fig. 1) are broken or interrupted to permit the passage therethrough of the heat muffle bridges **22**. Below the lower refractory metal reflectors **26** a double layer of horizontally positioned zirconia bricks **28**, capable of withstanding 2400° C., may be positioned on a plural layer of horizontally positioned high temperature bricks **30**, capable of withstanding about 1800° C. As shown in Fig. 1 the end portions of the refractory metal reflectors **26** are insulated by vertical upstanding zirconia bricks **28** and are separated from a pair of resiliently mounted terminal plates **32** thereby.

It will be understood that above the upper refractory metal reflectors **26** (Fig. 1) a similar layer of zirconia bricks **28** followed by successive layers of bricks **18** and **16** is provided. Vertical upstanding zirconia brick **28** is likewise provided to shield the end portions of the refractory metal reflectors **26** and to separate them from the terminal plates **32**. As shown in Fig. 1 the furnace **10** is provided with a loading chamber or tube **34** on the left hand end of the furnace **10** and an unloading or cooling chamber **36** on the right hand end of the furnace **10** when viewed in Fig. 1.

As shown in Fig. 1, sled type baffles or heat retainers **38** may be provided in the loading tube **34** and the cooling chamber **36** to minimize end losses therefrom during the loading and unloading operations. Further, the portions of the loading tube **34** and the unloading tube or cooling chamber **36** adjacent to the terminal plates **32** may be suitably insulated, for example with fused alumina grains, capable of withstanding a temperature of 1800° C. The alumina is packed about the tubes **34** and **36** between the tubes themselves and their outer shells **40**. It will be understood that the outer shells **40** of the tubes **34** and **36** project inwardly and are secured by their peripheral flanges and bolts **37** to the terminal plates **32** to further minimize end losses therebetween.

Terminal plates

Each of the terminal plates **32** (Figs. 1 and 2) has a fenestrated casting or body **44**, of for example bronze, provided with a hollow spiral water cooling inner portion **46** for maintaining the body **44** and electrical connections **48** (Fig. 1) at a constant temperature. A generally rectangular resilient end mounting plate **50** provided with annular corrugations **52** is secured to the inner face of the ends of the body **44**, as by bolts **54** (Fig. 2), to permit expansion of the refractory metal heat muffle **24** during the high temperature operation of the furnace **10** in the neighborhood of 2200° C. The outer edges of the plate **50** are connected to the shell **12** of the furnace **10** by bolts **56** extending through insulators **58** carried by the shell **12**. The high temperature insulators **58** prevents a short circuit from one end of the furnace **10** to the other.

Heat muffle

The heat muffle **24** having an internal volume of, for example 4" x 4" x 36" comprises a plurality of 10 in the showing of Figs. 1 and 3, refractory metal slabs **60** arranged in the form of an open ended cage. Each of these slabs **60** extends beyond the shell **12** and is provided with L-shaped end portions **62** which are secured against the outer faces of the terminal plates **32** by suitable dogs **64** and bolts **66** which are threadable into the body **44** of the end plates **32**. It will be understood that two dogs **64** are provided, one at each end of the furnace **10**, for each of the slabs **60**. Each of the dogs **64** is provided with a suitable longitudinal adjustment slot (Fig. 2) for the proper positioning of the respective slabs **60** thereby.

Molybdenum reflectors

As shown particularly in Fig. 3 the molybdenum reflectors **26** have a plurality of, for example, 3 arch-like members **68** which surround the cage-like heat muffle **24** in spaced nesting relation by means of spacers **69**. The outer arch-like member **68** is independent of the self supporting zirconia brick **28**. Underneath the heat muffle **24** a plurality of layers, for example 2 in the showing of Fig. 3, of inverted refractory metal channels **70** are provided to form the bottom reflectors **26**. It will be understood that the bottom layer of the channels **70** rests on a flat reflector plate **71** of the furnace.

Bridges

Each of the refractory metal heat muffle bridges **22**, for example tungsten (shown in Figs. 1 and 4) may comprise an inverted V-like arch **80** provided with a plurality, for example 4, bridge retaining member locking slots **82**. The slots **82** may be aligned in pairs in a vertical plane suitably perpendicular to the longitudinal axis of the arch **80** and for the securement therein of transverse brick retaining members **84** by interlocking complementary registering inclined vertical slots **86** in the members **84** with the slots **82**. It will be understood that each of the bridges **22** may be assembled without riveting or welding thus preventing the collapsing of the arch **80** during the high temperature operation of the furnace **10** in the neighborhood of 2200° C.

Heat baffles

Each of the sled type baffles **38** (Fig. 1) is an A-like refractory metal member, suitably molybdenum. The baffles **38** have one inclined side resting on the bottom of the loading tube **34** (on the cooling chamber **36**) with its cross piece **90** disposed outwardly respectively toward the loading and unloading end of the furnace **10**. By this positioning of the baffles **38**, a hook may be inserted within either the loading chamber **34** or the unloading chamber **36** to withdraw the baffle **38** and to permit respectively either the loading or unloading operation. It will be understood that each of the baffles 38 is of sufficient size to substantially fill the end portions of the tubes 34 and 36 and thus prevent end losses therefrom.

Alternative embodiment

In the showing of the alternative embodiment of Fig. 5 a sectional refractory metal heat baffle 24a comprising a plurality of small cylinders 100 may be employed. Each of these refractory metal cylinders 100 may be hydraulically pressed from powdered tungsten with about 3" outside diameter, a 2½" length and ¼" wall thickness. To approximate the length of the heat muffle 24 of Figs. 1 and 3 it would be necessary to employ 14 of the cylinders 100.

The cylinders 100 of the heat muffle 24a are supported by a pair of refractory metal (handily tungsten) longitudinal supports 102 of generally inverted V-like cross section. The supports 102 in turn may rest on a plate of zirconia insulation 107. Refractory metal plates 106, for example of molybdenum, are disposed between the zirconia plates 107 and successive layers of high temperature insulation 18a and 16a respectively. The heat muffle 24a, as in the prior case, is surrounded by the arch-like members 68 of the molybdenum reflectors 26 separated one from the other at their upper portions by refractory metal spacers 69 of molybdenum. The bottom portions of the members 68 are separated and insulated, one from the other by high temperature insulation, such as zirconia bricks 28a. An R. F. coil 110, suitably copper tubing is disposed about the refractory metal reflectors 26 and the lower insulation 28a, 18a, and 16a. The coil 110 rests in transverse grooves 112 in a longitudinal asbestos spacer 113 resting on the outer member 68 and suitable transverse grooves 114 provided in a pair of bottom guides 116, of suitable high temperature insulation material, such as the bricks 16a.

Operation

After the slabs 60 of the heat muffle 24 (Figs. 1–3) have been heated by electrical power through the connectors 48 and the terminal plates 32 to the required high temperature operation in the neighborhood of 2200° C. and the desired hydrogen atmosphere within the furnace 10 has been produced, a hatch, not shown, on the outer end of the loading tube 34 is opened and the sled baffle 38 is withdrawn to permit the loading of a large number of work pieces through the loading tube 34 and into the heat muffle 24. The sled baffle 38 is then returned to its prior position within the loading tube 34 adjacent to the heat muffle 24, thus minimizing end losses from the heat muffle 24.

After the desired treatment at 2200° C. in the hydrogen atmosphere within the heat muffle 24, a hatch (not shown) on the outer end of the cooling chamber 36 is opened and the cooling chamber sled baffle 38 is withdrawn from the cooling chamber 36, as by means of a hook. The treated work pieces are then withdrawn from the heat muffle 24 into the cooling chamber 36 and allowed to cool for any predetermined length of time with the hatch (not shown) on the cooling chamber closed. At the end of the cooling period the hatch (not shown) of the cooling chamber 36 is again opened and the now treated cooled work pieces are withdrawn from the cooling chamber 36. The sled type heat baffle 38 is inserted into the cooling chamber 36 adjacent to the heat muffle 24 to again minimize end losses therefrom and the cycle is then repeated.

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

I claim:

1. A high temperature furnace comprising a shell, a resiliently mounted terminal plate about each end of said shell, high temperature insulation within said shell and said terminal plates, a refractory metal floor plate embedded within said insulation, a plurality of refractory metal bridges on and in contact solely with said floor plate, a refractory metal heat muffle on said bridges comprising a plurality of longitudinal slab-like members arranged in an open cage-like configuration and a plurality of refractory metal reflectors upstanding from said insulation in spaced nesting relation about said heat muffle.

2. A high temperature furnace comprising a shell, a resiliently mounted terminal plate about each end of said shell, high temperature insulation within said shell and said terminal plates, a refractory metal floor plate embedded within said insulation, a plurality of refractory metal bridges on and in contact solely with said floor plate, each of said bridges comprising an inverted V-like arch provided with bridge retaining member locking slots and a plurality of bridge retaining members in said slots.

3. A high temperature furnace comprising a shell, a resiliently mounted terminal plate about each end of said shell, each of said terminal plates having a body provided with means for water cooling and a resilient end mounting plate about said terminal plate and provided with annular corrugations thereon, high temperature insulation within said shell and said terminal plates, a refractory metal floor plate embedded within said insulation, a plurality of refractory metal bridges on and in contact solely with said floor member, a refractory metal heat muffle on said bridges comprising a plurality of longitudinal slab-like members arranged in an open cage-like configuration and a plurality of refractory metal reflectors upstanding from said insulation in spaced nesting relation about said heat muffle.

4. A high temperature furnace comprising a shell, a resiliently mounted terminal plate about each end of said shell, high temperature insulation within said shell and said terminal plates, a refractory metal floor plate embedded within said insulation, a plurality of refractory metal bridges on and in contact solely with said floor member, a refractory metal heat muffle on said bridges comprising a plurality of longitudinal slab-like members arranged in an open cage-like configuration, each of said slabs being mounted by means of adjustable dogs to said terminal plates, and a plurality of refractory metal reflectors upstanding from said insulation in spaced nesting relation about said heat muffle.

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