

Filed April 18, 1961

TANDEM FURNACE

3 Sheets-Sheet 1

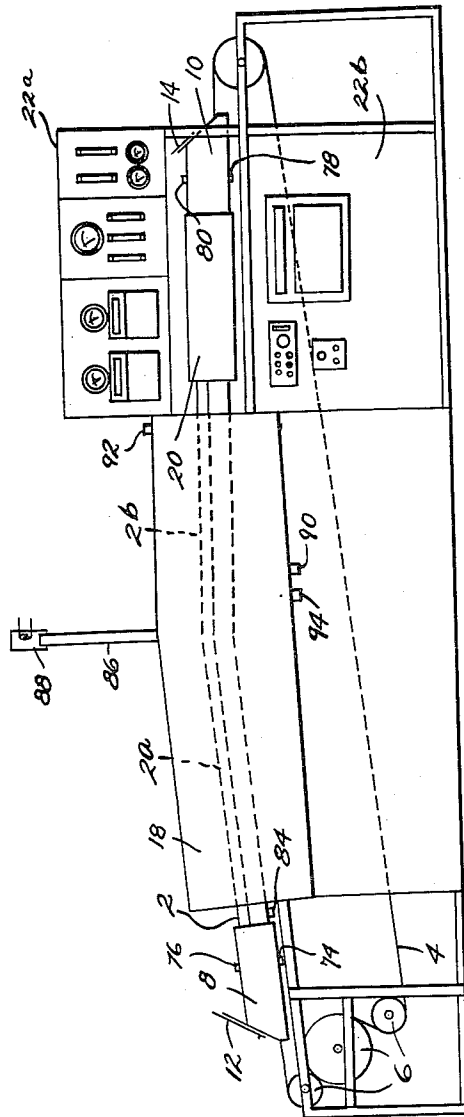


FIG. 1

J. HOWARD BECK

BY

Waggonen, Overbush + Paradise

ATTORNEYS

April 23, 1963

J. H. BECK
TANDEM FURNACE

3,086,764

Filed April 18, 1961

3 Sheets-Sheet 2

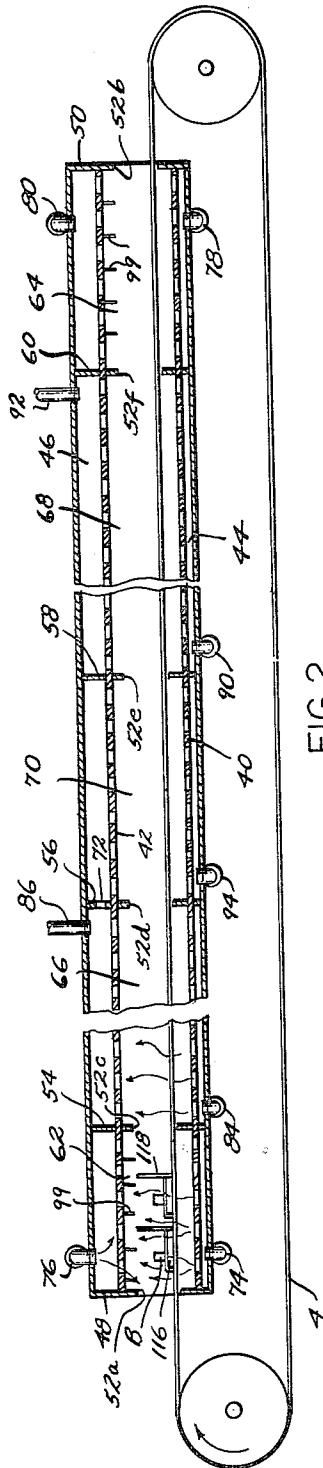


FIG. 2

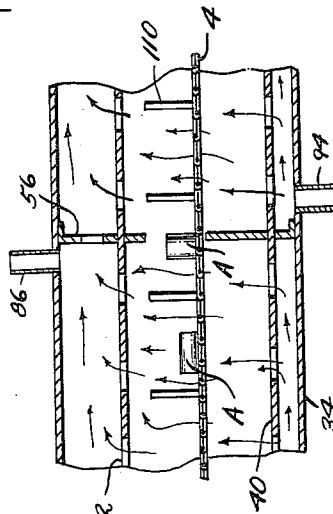


FIG. 3

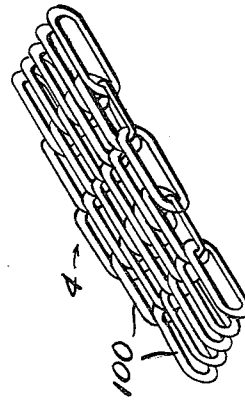


FIG. 4

INVENTOR.

J. HOWARD BECK

BY

Wangsten, Ormbeck & Pansino

ATTORNEYS

April 23, 1963

J. H. BECK
TANDEM FURNACE

3,086,764

Filed April 18, 1961

3 Sheets-Sheet 3

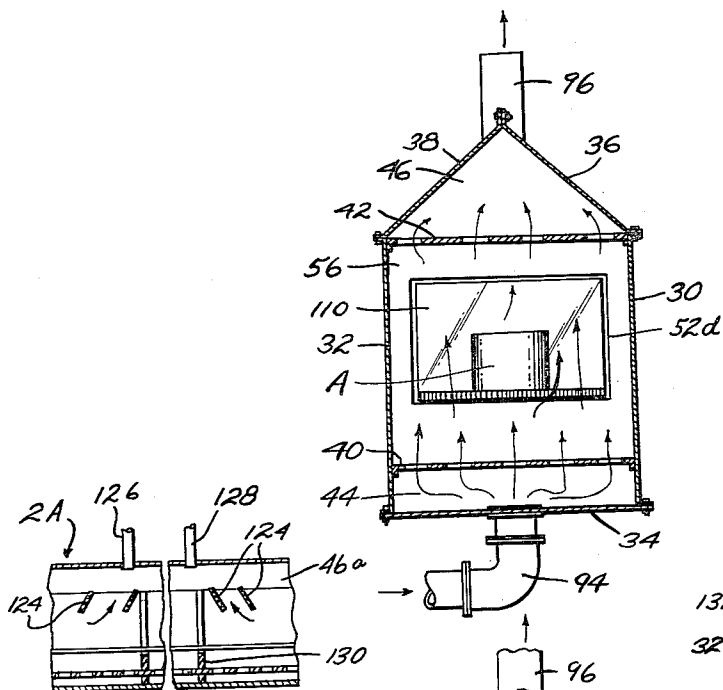


FIG. 7

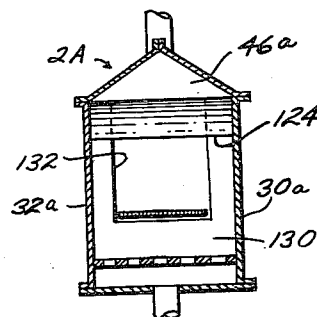


FIG. 8

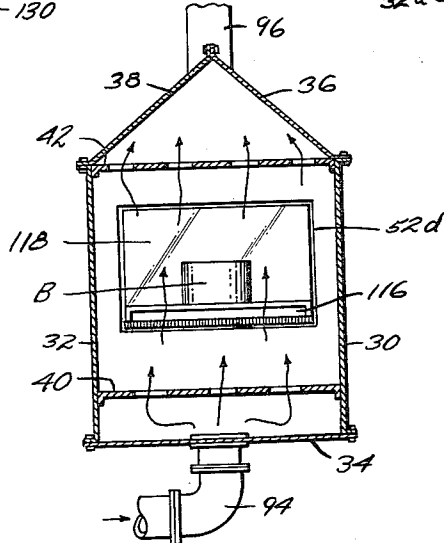


FIG. 6

INVENTOR.

BY J. HOWARD BECK

Wingston, Oronbush & Pandiscio
ATTORNEYS

1

3,086,764

TANDEM FURNACE

Jacob Howard Beck, 44 Varick Hill Road, Newton, Mass.

Filed Apr. 18, 1961, Ser. No. 103,881

12 Claims. (Cl. 263—8)

This invention relates to heat treating furnaces and more particularly to a novel furnace construction especially adapted to carry out two successive and distinct heat treating operations without interruption of production.

The present invention is a direct outgrowth of the current epoch of miniaturization of electronic and electromechanical components. In the manufacture of such devices as transistors, photo-diodes, miniature relays, and micro-switches, controlled heating is used to establish, modify, eliminate, or stabilize various physical and/or chemical characteristics. Thus, for example, heating may be used to assure formation of strong surface-to-surface bonds and high-pressure hermetic seals.

Heretofore there has been available various batch- and continuous-type furnaces which could be used with complete success to execute one-stage heat treating processes, as, for example, a simple reduction process, or multi-stage heat treating processes where the time interval and space between separate stages is not critical. However, a problem has existed where the heat treating process comprises two or more immediately successive heat-treating stages with each stage utilizing a different atmosphere. The latter situation requires a furnace wherein the various heat-treating steps may be executed in rapid succession without interruption of production and without removal of the heat treated materials or articles until the heat-treating process has been completed fully. Heretofore, such multi-stage processes could be executed on a batch basis, but at a relatively low production rate and at the expense of elaborate gas-handling mechanism. Prior efforts to provide a high production furnace with various stages have not been successful for various reasons, chief of which are the problems of isolating the gases in the different stages and attaining good gas diffusion in each stage. Prevention of migration of gas from one stage to another may be necessary to avoid formation of an explosive or gas mixture, to assure completion of the desired treatment, or to maintain proper temperature gradients between successive stages. Good gas diffusion and separation is essential in order to attain proper treatment of each article or piece of material at a given stage in the furnace. The usual approach to a solution of these problems is to provide a plurality of stationary gas barriers and baffles within the oven. However, gas barriers and baffles alone have been inadequate—they tend to retard the flow of gas through the oven, causing it to collect in some locations while flowing freely in others. To overcome this, high gas velocities have been used. However, these high gas velocities have inhibited rather than improved the diffusion and separation of the gases. Accordingly, it often has been necessary to extend the furnace length in order to assure proper diffusion and separation and assure proper contact of the treating gases with the materials being treated. This introduces other problems, including higher costs, more critical heat control, and complicated construction. It also required rapid transfer of materials which in many cases is not desirable.

Accordingly, the primary object of the present invention is to provide a tandem furnace which is free of the limitations and disadvantages of furnaces heretofore available for executing two or more heat-treating procedures on materials and objects.

A more specific object of the present invention is to provide a tandem furnace which is especially adapted to

2

execute two or more successive heat treatments using different gases, with the furnace adapted to provide precise control of gas flow, whereby the materials or articles being treated are fully contacted with the treating gases while the gases are prevented from reacting with each other in the muffle and also from migrating.

A further specific object of the present invention is to provide a tandem furnace which includes two or more separate heat-treating sections in which heat treating gases are introduced and caused to contact articles moving through the furnace, with mobile baffle means provided to assure full gas coverage of each article at a specific time and temperature.

Another specific object of the present invention is to provide a tandem furnace comprising two or more successive heat-treating sections, each filled with a different active gas, and an intermediate neutralizing gas section between each pair of heat-treating sections, said intermediate section having a gas which functions as a fluid barrier to prevent migration of active gas from one heat-treating section to another heat-treating section.

Other objects and many of the attendant advantages of the present invention will become readily apparent from a study of the following detailed specification when considered together with the accompanying drawings wherein:

FIG. 1 is a side elevation of a tandem furnace embodying the present invention;

FIG. 2 is a schematic longitudinal section of the muffle embodied in the furnace of FIG. 1;

FIG. 3 is an enlarged fragmentary longitudinal section illustrating the flow of gases through the muffle;

FIG. 4 is an enlarged perspective view of a typical type of conveyor employable in the apparatus of FIGS. 1-3;

FIG. 5 is a cross-sectional view of a muffle using a first type of mobile baffle;

FIG. 6 is a view similar to FIG. 5 but illustrating a second type of mobile baffle;

FIG. 7 is a fragmentary longitudinal section of a modified muffle; and

FIG. 8 is a cross-sectional view of the muffle of FIG. 7.

Referring now to FIG. 1, there is shown a tandem furnace embodying the present invention. This illustrated embodiment is designed to execute a specific two-stage heat treatment on special electronic parts. In the first stage, reduction and decarburization is effected by means of hydrogen gas, and in the second stage oxidation is effected by means of oxygen gas. However, it is to be understood that the furnace may be adapted to execute other processes without departing from the principles of the present invention. The illustrated furnace comprises a muffle identified generally at 2 through which articles to be treated are transported by an endless conveyor belt 4 that is driven by a conventional drive system which is shown in part at 6. Articles may be fed onto and removed from the conveyor by hand or by automatic material handling equipment. The upstream and downstream ends of the muffle are fitted with enlarged terminal sections 8 and 10, respectively, which preferably are provided with vertically slidable doors 12 and 14. These doors permit the inlet and outlet openings of the muffle to be adjusted in size. In practice, they are made just large enough to allow passage of the articles undergoing treatment. A major part of the muffle is encased in an insulated heating cabinet 18. Conventional electrical heating elements (not shown) are disposed in cabinet 18 in close surrounding relation to the muffle, whereby to efficiently heat the muffle to the desired temperatures. The heating elements may be disposed uniformly along the muffle; on the other hand, they may be arranged in discrete groups so as to cause different portions of the muffle to be heated to different

temperatures. A water jacket 20 functions to keep the downstream end of the muffler relatively cool, whereby to cool the treated articles as they pass out of the muffler. A control panel identified generally at 22a and 22b includes recording instruments in addition to controls for the conveyor belt, the heating elements, and the gases which are supplied to the muffler.

The internal construction and the cross-sectional configuration of the muffler will now be described with reference particularly to FIGURES 2, 3, 5, and 6. The muffler is of five-sided construction, comprising two parallel, vertically extending side walls 30 and 32, a horizontal bottom wall 34, and two inwardly inclined top wall sections 36 and 38. Disposed within the muffler and extending along its length are two perforated partition plates 40 and 42. The partition plate 40 is generally described as the "floor," while the partition plate 42 is generally described as the "ceiling." The space disposed between the bottom wall 34 and the floor 40 is generally described as the "basement." This passageway is identified generally at 44. The passageway 46 between the ceiling plate 42 and the two inclined top plates 36 and 38 is generally described as the "attic" or "upside down gutter" of the baffle. The ends of the muffler are provided with end plates 48 and 50 which have rectangular openings 52a and 52b respectively. A plurality of fixed vertical baffle plates 54, 56, 58, and 60 also are secured within the muffler. These baffles have like openings 52c-f corresponding to openings 52a and 52b. As illustrated in FIG. 2, the baffle 54 is mounted nearest to the end plate 48 and demarcates therewith a relatively short end section 62. The fourth baffle 60 is located nearest to the opposite end plate 50 and demarcates therewith a relatively short end section 64. The second and third baffles 56 and 58 are spaced to define two relatively long sections 66 and 68 and an intermediate shorter section 70. The upper end of baffle 56 is provided with one or more openings 72.

Three different gases—nitrogen, hydrogen, and oxygen—are supplied to the muffler. As stated previously, the hydrogen causes reduction and decarburization while the oxygen produces controlled oxidation of the articles being treated. The purpose of the nitrogen is to provide a neutralizing atmosphere which prevents formation of an explosive mixture by preventing undesired migration of the hydrogen and oxygen. The manner in which this is done is explained hereafter.

Referring now to FIGS. 1 and 2, nitrogen gas is supplied to the upstream end section 62 of the muffler via pipes 74 and 76. Nitrogen is also supplied to the downstream end section 64 via pipes 78 and 80. Although not shown, it is to be understood that the pipes 74, 76, 78, and 80 are connected to a suitable nitrogen reservoir via automatically controlled valves.

Hydrogen is admitted to the long upstream section 66 via a pipe 84 and is removed from that section via a second pipe 86. Pipe 86 extends up from the muffler and, as shown in FIG. 1, is provided at its free end with a hydrogen igniter and burn-off unit 88. This igniter and burn-off unit is of conventional construction and is well known to persons skilled in the art. Accordingly, no claim is made to the hydrogen igniter and burn-off unit per se.

Oxygen is supplied to the long downstream section 68 via a pipe 90 and is removed via a second pipe 92.

An additional pipe 94 is connected to the intermediate section 70. Nitrogen is introduced to the muffler via pipe 94 and is removed mainly by pipe 86. The openings 72 in baffle 56 facilitate removal of the nitrogen gas. Although as shown in FIG. 2 the muffler may be a straight unit, it is preferred to make it angular in length as shown in FIG. 1 with an inclined portion generally identified at 2a and a horizontal portion generally identified at 2b. The inclined portion includes the first two

sections 62 and 66, and the horizontal portion includes the remaining sections 70, 68, and 64. The reason for the inclined portion is to improve flow of hydrogen gas in section 66. The hydrogen gas tends to flow upward and the inclined section assists this normal flow, thereby helping to prevent backflow into the end section 62.

The nitrogen, which is introduced via pipes 74 and 76, effectively forms a curtain which also helps to prevent air from moving into the muffler and also to prevent hydrogen gas from flowing out of the upstream end of the muffler. Similarly, the nitrogen which is introduced via pipes 78 and 80 forms a curtain which prevents air from moving into the muffler and also prevents oxygen from flowing out of the downstream end of the muffler. Small baffles 99 help establish the nitrogen curtains. The nitrogen which is introduced via pipe 94 functions to prevent the hydrogen gas from mixing with the oxygen gas. In this manner, the quality of the gases in the muffler is effectively controlled while the danger of explosive mixtures flowing out of the muffler into the surrounding work area is eliminated. The major portion of the oxygen flows out of the muffler through pipe 92.

To the extent already described, the flow of gases within the muffler is as follows: Nitrogen introduced through the pipes 74 and 76 flows up through the floor 40 and down through the ceiling 42. Most of the nitrogen tends to flow out of the inlet end of the muffler while the remainder of the nitrogen tends to flow downstream along the basement, the gutter, and also the central portion of the muffler toward the hydrogen section 66. The amount of nitrogen which flows into the section 66 is relatively small. The hydrogen which is introduced through the pipe 84 tends to flow up through the floor 40 into the central portion of the muffler and then up through the ceiling 42 into the gutter 46. At the same time, the general flow of the hydrogen is in a downstream direction. However, due to the absence of baffles within section 66, a substantial portion of the hydrogen tends to immediately reach the gutter section 66 instead of flowing downstream along the central portion of the muffler.

In this connection, it is to be observed that the conveyor 4 must have a plurality of openings so as to allow the gas to pass from the basement to the gutter. A satisfactory type of endless conveyor is formed of metallic links. This type of conveyor belt is illustrated in FIG. 4, the links being identified generally at 100. The advantage of an articulated metal conveyor belt is that it is strong and will withstand elevated temperatures while at the same time allowing easy passage therethrough of gases.

The oxygen gas flows into section 68 through the pipe 90 and tends to flow immediately toward the outlet pipe 92. Some oxygen tries to flow upstream but is prevented from doing so freely by the nitrogen gas in the intermediate section 70. No oxygen can reach the hydrogen section 66. Only a little oxygen reaches the end section 64, and this is blocked by the nitrogen introduced through the pipes 78 and 80. As a result, substantially all of the oxygen introduced via pipe 90 is confined within the oxidation stage.

To the extent heretofore described, the furnace is capable of heat treating articles at a relatively rapid rate. However, due to the fact that the hydrogen and oxygen gases tend to flow directly from the inlet pipes to the outlet pipes instead of diffusing evenly within the heat-treating sections 66 and 68, not all of the articles on the conveyor may be fully contacted by the gases, and as a result, the reduction or oxidation treatment may be incomplete.

This difficulty is obviated by the use of moving baffles which cause the gases flowing from the inlet pipes to the outlet pipes to be channeled alongside individual articles on the conveyor, thereby diffusing the gas fully within

5

the treatment chamber so as to contact all of the articles uniformly. These baffles are of two forms. One form is illustrated in FIGS. 3 and 5; the second form is illustrated in FIGS. 2 and 6.

Referring now to FIGS. 3 and 5, the moving baffles may consist of metallic plates 110 which are fixed to the conveyor 4 at fixed intervals. These plates 110 are sized to just pass through the openings 52a-f which are formed in the end plates 48 and 50 and the baffle plates 54-60. The spacing between these moving baffle plates is determined by the size of the articles to be treated. Generally, the smaller the articles to be treated, the narrower the spacing between baffle plates 110. These baffles actually serve a second function. They periodically block the openings in the fixed baffles 54-60, thereby assisting in prevention of migration of gases between adjacent treatment sections and helping in removal of gases through pipes 86 and 92.

The articles to be treated may be placed directly on the conveyor 4, as shown, for example, in FIGS. 3 and 5 where articles A are disposed on the conveyor between the adjacent plates 110. Alternatively, the articles may be supported in small holders, commonly called "boats."

It is to be noted that the mobile baffle plates need not be physically attached to the conveyor. Instead, they may be attached to or formed integral with the boats in which the articles to be treated are supported. This variation is illustrated in FIGS. 2 and 6 where articles B are supported in boats 116 to each of which is secured a flat metallic baffle plate 118 (sometimes called a "sail"). One advantage of this variation is that the spacing of the baffle plates is not fixed. Another advantage of this variation is that the conveyor can follow a tortuous path as in FIG. 1 instead of being mounted as in FIG. 2 so that one surface thereof never engages a drive pulley or a guide pulley.

The muffle construction need not be exactly as illustrated in FIGS. 2, 3, 5, and 6, but can be varied. One important modification is illustrated in FIGS. 7 and 8. The muffle construction 2A shown in these figures is essentially the same as the one illustrated in FIGS. 2, 3, 5, and 6, except that the ceiling plate 42 is omitted. Substituted for the ceiling plate is a series of transversely extending baffle plates 124 whose ends are secured to the vertical side walls 30a and 32a. Baffle plates 124 are inclined, the direction of inclination depending upon the direction of gas flow which is required. Thus, in FIG. 7, some of the baffle plates 124 are inclined left to right so as to direct gas downstream toward an outlet pipe 126 and other baffle plates 124 are inclined right to left to direct gas flow upstream toward an outlet pipe 128. The upper edges of baffle plates 124 collectively function to demarcate the "attic" 46a of the muffle. In this construction additional vertical baffles 130 may be utilized to demarcate separate compartments. Like the baffles 54-60 of FIG. 2, baffles 130 have openings through which the articles and the supporting conveyor can pass. These openings are identified generally at 132.

The advantage of the construction of FIGS. 7 and 8 resides in the fact that it avoids the need for a perforated ceiling plate, thereby cutting down both weight and cost.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings. For example, the overall length of an oven embodying the present invention can be varied as desired. Similarly, the number of processing stages may be varied according to the process to be carried out. It is to be understood, therefore, that the invention is not limited in its application to the details of construction and arrangement of parts specifically described or illustrated, and that within the scope of the appended claims it may be practiced otherwise than as specifically described or illustrated.

I claim:

1. A furnace for heat treating articles comprising, an elongate unitary muffle adapted to be heated and pro-

6

viding a continuous open-ended passageway of predetermined minimum cross-section, means for introducing a continuous flow of gas to the interior of said passageway at one point and removing said gas at another point, means for providing gaseous curtains at either end of said passageway for isolating said gas from the outer atmosphere, a continuous perforated web conveyor passing through said passageway, and a plurality of transversely extending baffle elements on said conveyor for channeling said gas vertically around individual articles to be treated disposed on said conveyor, said baffle elements sized to substantially fill said passageway at the minimum cross section thereof, whereby to hinder migration of gas longitudinally of said passageway.

2. A furnace comprising an elongate unitary muffle adapted to be heated and providing an elongated open-ended passageway of predetermined minimum cross-section, means for introducing a continuous flow of a first gas to the interior of said passageway at a first predetermined location, means for introducing a continuous flow of a second gas to the interior of said passageway at a second predetermined location, means for providing a gaseous curtain in said passage between said two predetermined locations, whereby to isolate said first gas from said second gas, a continuous web conveyor passing through said passageway, said conveyor having openings therein through which said gases may flow vertically, and a plurality of imperforate baffle elements on said conveyor for channeling said gases vertically around articles disposed on said conveyor, whereby to fully contact said articles with said gases, said baffle elements having an outline which substantially fully fills said passageway at points of said minimum cross-section.

3. A furnace as defined by claim 2 wherein said baffle elements are physically attached to said conveyor.

4. A furnace as defined by claim 2 wherein said baffle elements are attached to holders for articles to be treated.

5. A furnace as defined by claim 4 wherein said article holders are removable from said conveyor.

6. A furnace comprising an elongated unitary muffle adapted to be heated and provided with first and second parallel perforated longitudinally extending plates subdividing its interior into (1) a central main passageway, (2) a bottom passageway, and (3) a top passageway, means subdividing said bottom and top passageways into a like number of compartments, means for introducing a first gas into a first one of said bottom compartments and for removing it from a corresponding first one of said top compartments, means for introducing a second gas into a second one of said bottom compartments and for removing it from a corresponding second one of said top compartments, means for introducing a third gas into a third one of said bottom compartments located intermediate said first and second bottom compartments and for removing said third gas from a corresponding third top compartment located intermediate said first and second top compartments, whereby said first and second gases will pass from said first and second bottom compartments to said first and second top compartments respectively through said central passageway with said third gas isolating said first gas from said second gas.

7. A furnace as defined by claim 6 further including an endless conveyor extending through said central passageway, said conveyor having a series of perforations through which said gases may pass, whereby articles mounted on said conveyor will be exposed to and contacted by said first and second gases as said articles are transported through said central passageway.

8. A furnace as defined by claim 7 further including a plurality of transversely-extending baffle elements disposed on said conveyor, said baffle elements sized to just pass through said central passageway and spaced from each other so as to channel said gases vertically around articles disposed on said conveyor, whereby to fully contact said articles with said gases.

9. Apparatus for heating articles first in a reducing atmosphere and then in an oxidizing atmosphere comprising a unitary elongate muffle adapted to be heated and providing a continuous open-ended passageway, said passageway having a first inclined portion and a second horizontal portion, means forming a first elongated open-ended gas chamber in said inclined portion of said passageway, means forming a second elongated open-ended gas chamber in the horizontal portion of said passageway, a perforated partition defining a gas distributing channel in each of said gas chambers, a perforated partition defining a gas collecting channel in each of said gas chambers, means for establishing a continuous flow of hydrogen gas in said first chamber, means for establishing a continuous flow of oxygen gas in said second chamber, and means providing a gaseous curtain between said two chambers whereby the gas in one chamber is prevented from migrating into the other chamber.

10. Apparatus as defined by claim 9 further including individual mobile baffle elements within said open-ended passageway for channeling said gases around articles traveling through said passageway, whereby to fully contact said articles with said gases.

11. A muffle for use in subjecting individual articles to heat treatment first in a reducing atmosphere and thereafter in an oxidizing atmosphere comprising, an elongated unitary structure open at both ends, a pair of elongated perforated plates disposed within said structure at the top and bottom thereof and subdividing said structure into a first top passageway, a second central passageway, and a third bottom passageway, means subdividing said top

and bottom passageways into five manifold sections, means for introducing nitrogen gas into the first and last of the top and bottom manifold sections, whereby to provide an isolating gaseous curtain for said central passageway at both ends thereof, means for introducing a continuous flow of hydrogen gas to the second bottom manifold section and for removing said hydrogen gas from the second top manifold section, means for introducing oxygen gas into the fourth bottom manifold section and for removing said oxygen gas from the fourth top manifold section, and means for introducing a third gas into the third bottom manifold section and for removing said third gas from the third top manifold section, the gas in said third sections effectively preventing mixing of said oxygen and hydrogen gases in said central passageway.

12. Apparatus as defined by claim 11 further including an endless article conveyor mounted to travel through said central passageway, and individual baffle elements on said conveyor for channeling said hydrogen and oxygen gases around individual articles disposed on said conveyor, whereby to fully contact said articles with said gases.

References Cited in the file of this patent

UNITED STATES PATENTS

1,385,365	Dreyfoos	July 26, 1921
1,779,622	Dreffein	Oct. 28, 1930
2,083,638	Cope	June 15, 1937
2,543,710	Schmidt et al.	Feb. 27, 1951
2,701,712	Gilbert	Feb. 8, 1955