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Brede, III et al.

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[54] **METHOD AND APPARATUS FOR SINTERING ANNULAR COMPACTS**

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Related U.S. Application Data

[62] Division of Ser. No. 105,167, Jan. 11, 1971.

[52] **U.S. Cl.** **432/163,** 432/125, 432/128, 432/200

[51] **Int. Cl.** **F27b 5/02**

[58] **Field of Search** ... 432/125, 128, 163, 164, 205, 432/200

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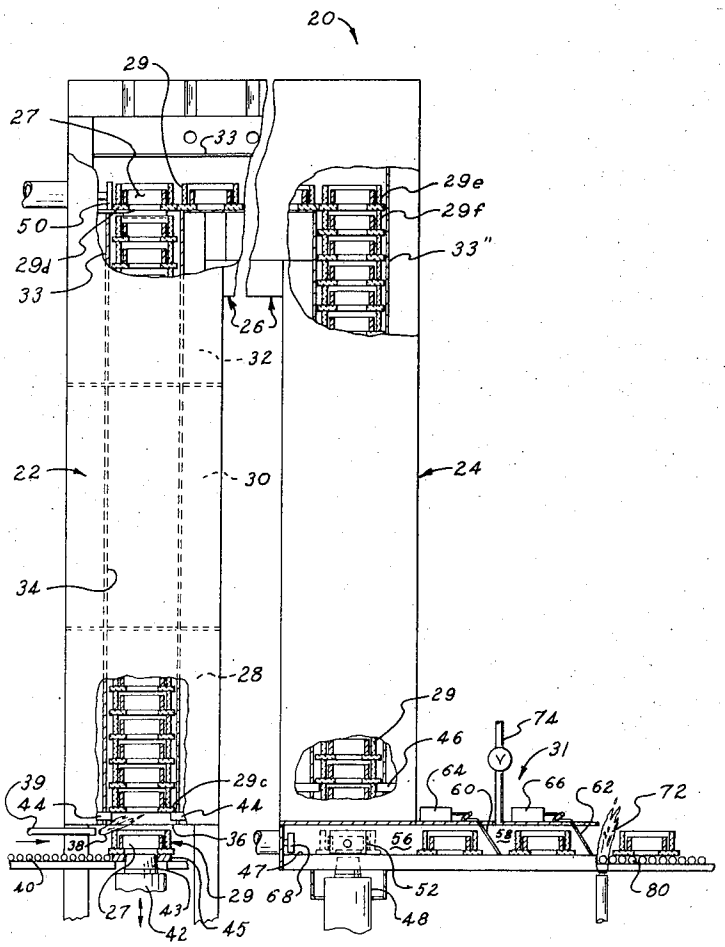
Primary Examiner—John J. Camby

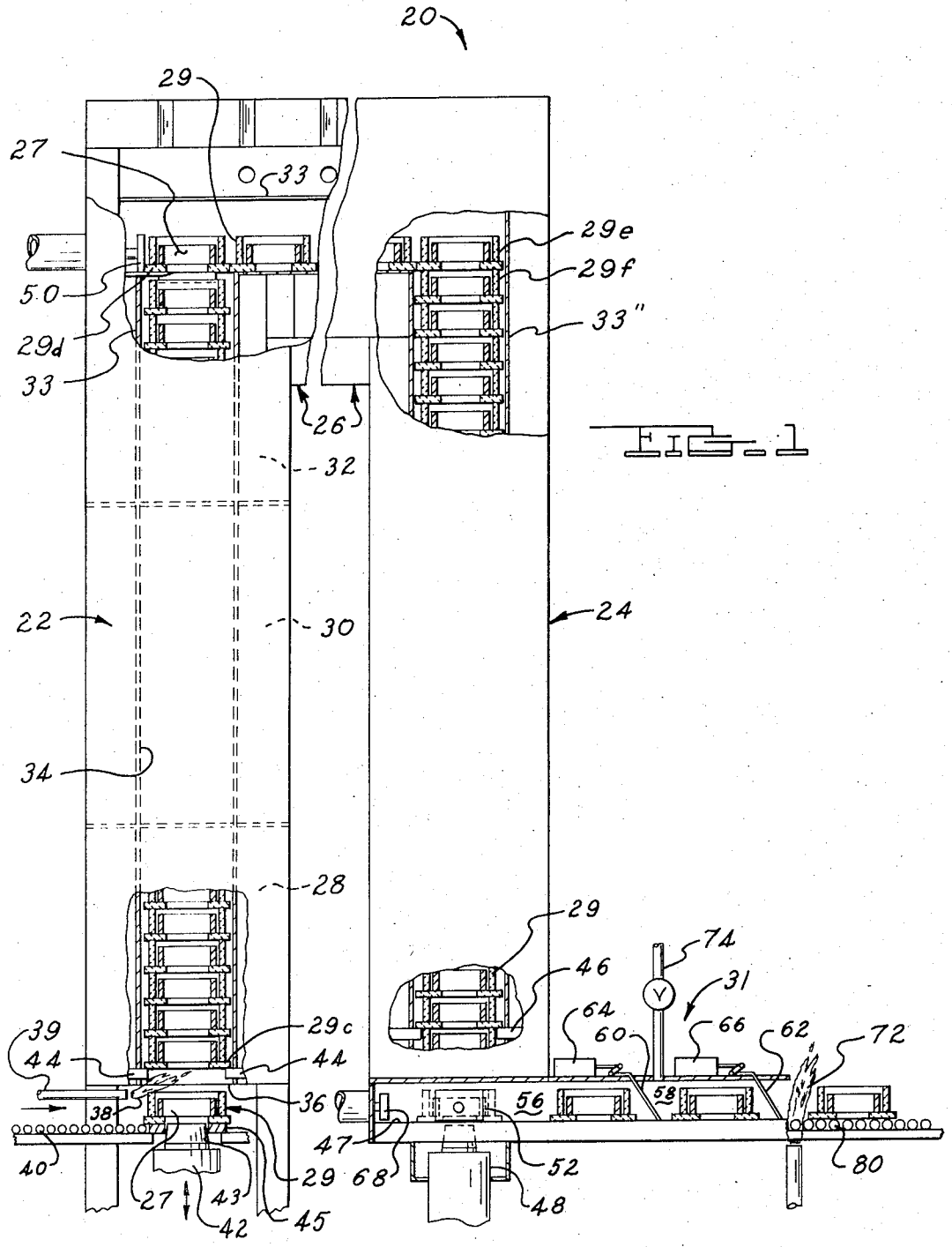
Attorney, Agent, or Firm—Barnes, Kisselle, Raisch & Choate

[57] **ABSTRACT**

A method and apparatus for sintering annular compacts without any substantial temperature gradients through the compacts. The method involves axial movement of the compact through vertical heating and cooling towers of a controlled atmosphere furnace with lateral movement of the compact through a crossover conduit interconnecting the upper ends of the towers. The lower end of the heating tower is provided with an inlet opening in constant communication with the exterior of the furnace and the lower end of the cooling tower has an outlet connected via a sealable exit chamber with the exterior of the furnace.

10 Claims, 7 Drawing Figures




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29f
33"
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29d
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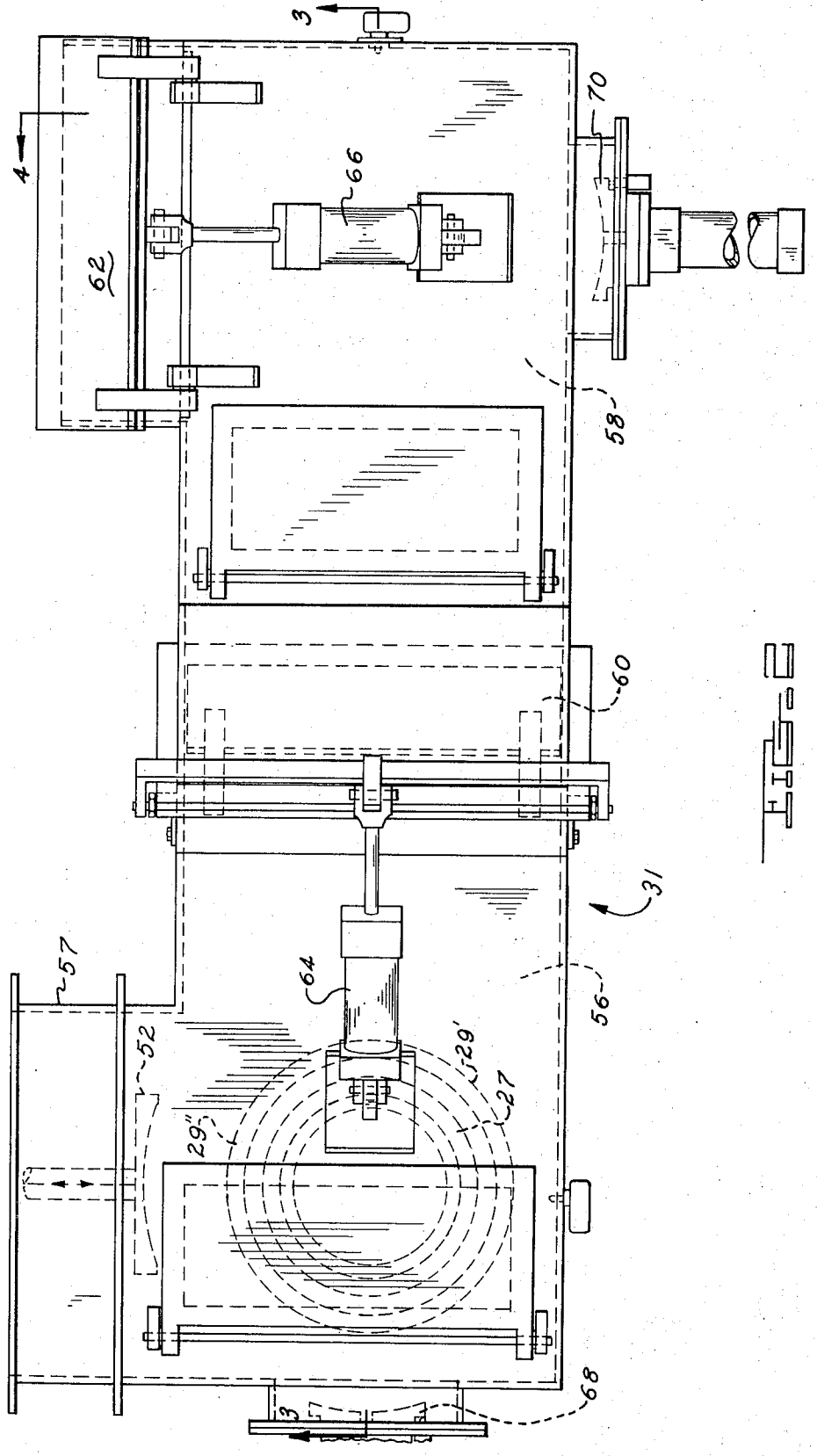


FIG. 2

FIG. 3

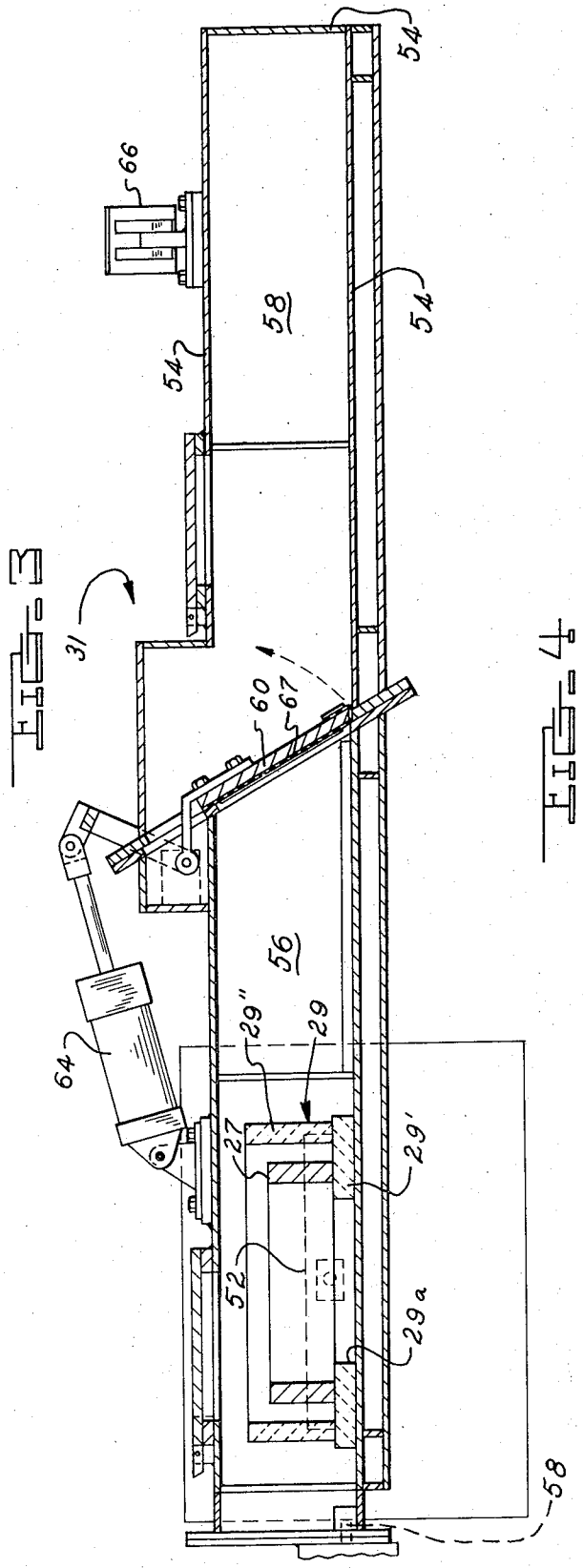
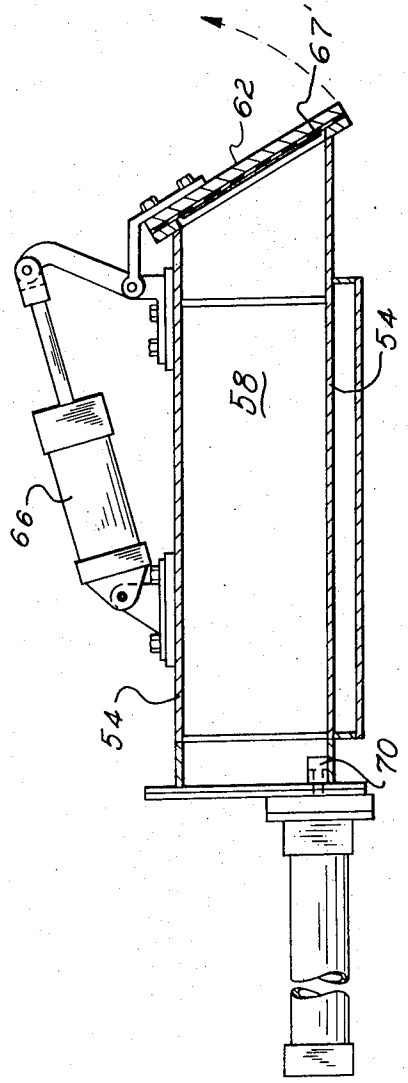


FIG. 4



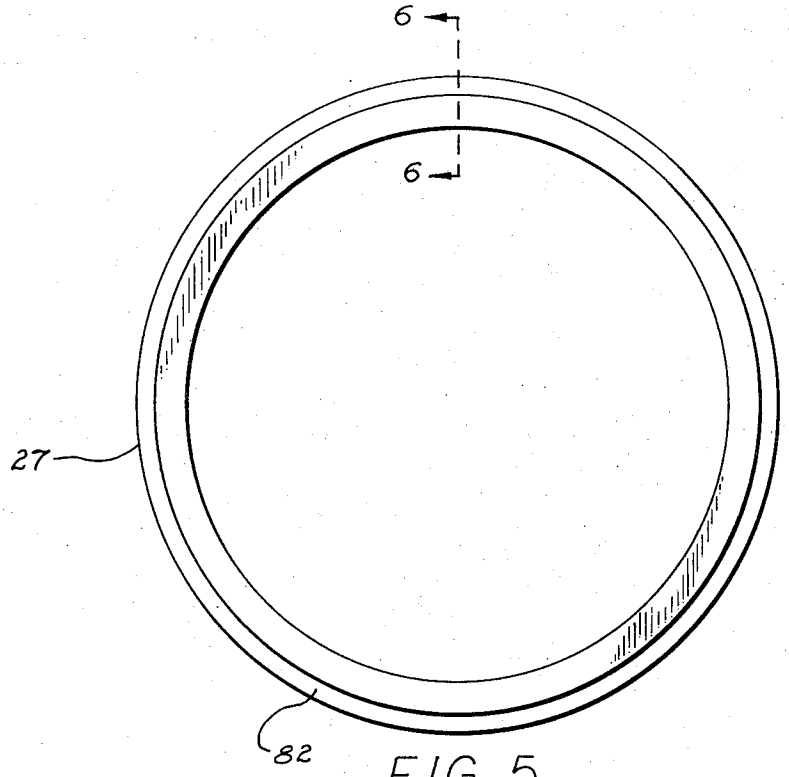


FIG. 5

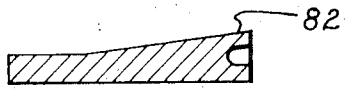


FIG. 6

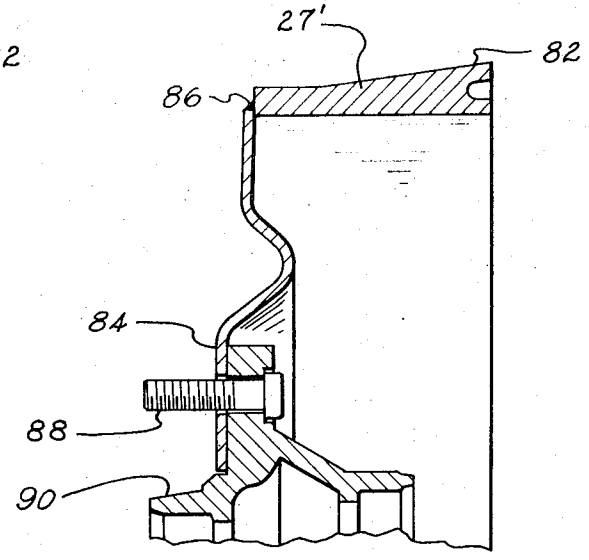


FIG. 7

METHOD AND APPARATUS FOR SINTERING ANNULAR COMPACTS

This is a division of application Ser. No. 105,167, filed Jan. 11, 1971.

This invention relates to a method and apparatus for heating an annular ring and more particularly to a method of sintering brake drum rings and an improved vertical sintering furnace for practicing the method.

Objects of this invention are: (1) to provide an improved heat treating and/or sintering furnace capable of more uniformly heating and cooling objects treated and/or sintered in the furnace and of providing more uniformity in the controlled atmosphere utilized in the furnace; (2) to increase the retention rate of the controlled atmosphere in a vertical furnace due to positive control of the convection currents created by operation of the furnace (3) to minimize the chance of an explosion occurring within a vertical furnace utilizing a controlled atmosphere of an explosive nature; (4) to minimize the damage to a vertical furnace and the injury to personnel operating the furnace in the event of an explosive ignition of the controlled atmosphere within the furnace; (5) to facilitate the loading and unloading of materials from a vertical furnace; (6) to provide a vertical controlled atmosphere furnace with a relatively simple material loading and unloading mechanism; and (7) to provide a method of making a brake drum wherein a drum ring of the brake is compacted from metal powder, uniformly heated and cooled while undergoing a sintering process and then attached to a non-sintered back.

These and other objects, features and advantages of the invention are described in this specification and illustrated in the accompanying drawings in which:

FIG. 1 is a semi-schematic fragmentary elevational view of a controlled atmosphere vertical furnace embodying this invention with portions broken away to illustrate details and with the last chamber of multiple chamber exit tunnel thereof rotated into the plane of the drawing.

FIG. 2 is a plan view of the multiple chamber outlet tunnel of the controlled atmosphere furnace of this invention.

FIGS. 3 and 4 are sectional views on line 3—3 and line 4—4 respectively of FIG. 2 illustrating in more detail the structure of the multiple chamber outlet tunnel of the controlled atmosphere furnace.

FIG. 5 is a plan view of a ferrous metal compact of an annular ring for a brake drum assembly.

FIG. 6 is a sectional view on line 6—6 of FIG. 5.

FIG. 7 is a fragmentary vertical center sectional view of the ring assembled in a brake drum.

Referring in more detail to the drawings, FIG. 1 illustrates a controlled atmosphere furnace designated generally as **20** particularly adapted for sintering ferrous metal powder compacts such as brake drum rings in accordance with the method of this invention. Furnace **20** has a generally vertical heating tower **22** and a generally vertical cooling tower **24** which are interconnected at their upper ends by a crossover tunnel **26.** Workpieces **27** (herein illustrated as annular ferrous powder compacts which are to be sintered to form the drum ring of a brake drum assembly described in more detail hereinafter) are carried on circular graphite pallets **29** in a stacked array for travel axially up through vertical heating tower **22,** then horizontally in side-to-side relation for lateral movement (perpendicular to the axis of the workpiece) through cross-over tunnel **26,** then axially again in a stacked array downwardly through cooling tower **24,** and finally laterally again horizontally in side-to-side relation out of furnace **20** through an outlet tunnel **31.** Heating tower **22** is provided with conventional refractory and heating elements (not shown) arranged to form a preheating zone **28,** a heating zone **30** and a preliminary cooling zone **32.** The towers contain internal casings **33, 33'** and **33''** which are interconnected to form one continuous sealed chamber which is imperforate except at its ends and extends in an inverted U-shaped path from the open inlet of tower **22** to the outlet of tower **24.** Preferably casings **33** and **33''** are complementary in cross section to the contour of the part traveling therethrough, i.e., cylindrical in the case of circular rings **27** and trays **29.** Both preheating zone **28** and heating zone **30** are arranged with the heat generating units disposed circumferentially outside the portions of casing **33** extending through these zones so the heading units are isolated from a controlled atmosphere which is confined within the cylindrical chamber **34** defined within casing **33.** The heating units are thus not exposed to any open flame or atmosphere present at the entrance or within preheating and heating areas **28** and **30.** If, for example, furnace **20** is used to sinter a powder ferrous metal compact, preheating zone **28** will raise the temperature of the compact from ambient to between 800°F. to 1,800°F., to say 1,400°F., heating zone **30** will raise the temperature of the compact from 1,400°F. to a sintering temperature between 2025°F. to 2080°F., say to 2,050°F., and precooling zone **32** will lower the temperature of the compact from 2,050°F. down below 1,500°F., to say 1,400°F. to 1,000°F. A water jacket (not shown) is provided around the portion of casing **33** in zone **32** as well as around casing **33'** in tunnel **26** and around casing **33''** in tower **24.**

The lower end of chamber **34** in heating tower **22** communicates with the atmosphere outside of furnace **20** through a continuously open inlet **36.** The protective atmosphere used in this furnace is substantially less dense than air and is flamable. The controlled atmosphere tends to rise in furnace tower **22,** but the interface between the controlled atmosphere and the outside air is maintained by constant replenishment at the top of furnace tower **22.** A gas pilot light flame **38** fed by a gas line **39** is directed across and beneath opening **36** to establish and maintain a flame front at the interface between the combustible controlled atmosphere and the outside air. This flame front, fueled by the controlled atmosphere flowing down chamber **34** and outside atmosphere, helps to prevent oxygen in the outside air from entering chamber **34.** The flame front also helps purge any entrapped oxygen from workpieces **27** and pallets **29** as they pass upwardly through the flame front. The controlled atmosphere, preferably hydrogen or disassociated ammonia, is continuously introduced into chamber **34** via an inlet in casing **33'** at a point above casing **33** so as to flow continuously down casings **33** and **33''**, but at a much slower rate down casing **33''** to make up for what little atmosphere escapes via exit tunnel **31** and what is bled from casing **33''** via an outlet pipe (not shown) connected to the bottom of casing **33''.** The controlled atmosphere (hydrogen) flowing down casing **33** causes a gravitational displacement of the oxygen, carbon monoxide, carbon dioxide

and/or other gases entrained in the minute voids in compact 27 so that compact 27 is washed or purged of such contaminants as it moves up into preheating zone 28. These contaminants thus flow downwardly in casing 33 and are flushed out of chamber 34 at the continuously open bottom inlet thereto, and then are swept up in the convection currents created outside tower 22 by the products of combustion issuing from the flame front generated beneath the inlet.

Pallets 29 are constructed of structural grade graphite and comprise an annular horizontal tray 29′ (FIG. 3) and a ring 29″ which rests on the tray so that the pallets or fixtures can be stacked on top of each other (FIG. 1) and transferred through furnace 20 by a series of pallet pushing devices. The trays 29′ are formed with a central opening 29*a* so that the furnace controlled atmosphere can flow through the pallets and around and through the annular workpieces 27 carried by the pallets.

As shown in FIG. 1, a vertically movable loading ram 42 is adapted to engage each pallet 29 after the same has been pushed laterally on conveyor 40 into loading position beneath inlet opening 36 so that it overlies ram 42. Ram 42 may have a locator nose 43 as shown in FIG. 1, or nose 43 may be omitted and ram 42 made flat-ended with a suitable guide to engage the edge of pallet 29 and locate it in vertical alignment with the vertical stack of pallets 29 in tower 22. Ram 42 lifts pallet 29 vertically upwardly (axially of the pallet and workpiece therein) into the lower part of heating tower 22 where it engages the lowermost pallet 29c of a vertical stack of pallets 29 which completely fill the tower, which in turn up to this point has been supported by a set of diametrically opposed, horizontally movable fingers 44. Both of the fingers 44 are momentarily retracted after the pallet 29 on ram 42 engages the lowermost pallet 29*c* resting on fingers 44 so that the lower protruding tray portion 29′ of the pallets can pass by the fingers. When the pallet being loaded has been lifted just above the elevation of the retracted fingers 44, the fingers are extended so that they again underlie the stack of pallets, which then are lowered onto the fingers so that the fingers once again support the entire stack of pallets. Ram 42 continues its downward retraction until it clears the loading platform 45 so that noather pallet can be moved on conveyor 40 into position on platform 45. In a similar but reversed manner, retractable fingers 46, platform 47 and an unloading ram 48 cooperate to remove pallet 29 from the bottom of cooling tower 24.

After the stack of pallets is so elevated by the addition of one pallet to the bottom of the stack, horizontally movable pusher 50 at the upper end of heating tower 22 transfers the uppermost pallet 29*d* from the top of the stack in heating tower 22 onto the floor of crossover tunnel 26, thereby advancing the pallets in side-to-side relation so that the leading pallet in the crossover tunnel is pushed onto the uppermost pallet 29*f* in the stack in cooling tower 24. It is to be understood that pallet 29*f*, prior to pallet 29*e* being superimposed thereon, has been dropped to the elevation shown in FIG. 1 by the removal of the lowermost pallet from the stack of pallets in tower 24. This is accomplished by another pusher 52 (FIGS. 2 and 3) at the bottom of tower 24 which transfers each pallet 29 to outlet tunnel 31 after it has been unloaded by ram 48 from the bottom of the stack in cooling tower 24. Since retractable fingers 46 only directly support the lowermost pallet at the bottom of the stack in cooling tower 24, it is necessary during set-up to initially completely fill towers 22 and 24 and tunnel 26 with pallets 29 so that when pallets are transferred by pusher 50 from tower 22 to tower 24 they do not drop part or all of the way to the bottom of tower 24.

FIGS. 2, 3 and 4 illustrate, by way of description and not by way of limitation, the structural details of outlet tunnel 31 and the mechanism for transferring pallets 29 through the outlet tunnel of furnace 20. Outlet tunnel 31 is fabricated from a plurality of sheet metal plates to form a hermetically sealed enclosure which has a smooth floor 54 and which is separated into two chambers 56 and 58 by a pivotally mounted door 60, the outlet of chamber 58 being controlled by another pivotally mounted door 62. Doors 60 and 62 are respectively actuated and controlled by rams 64 and 66. Door 60 is an interior door disposed between chambers 56 and 58 whereas door 62 is an exterior door at the exit end of chamber 58. A gasket 67 (FIG. 3) is attached to door 60 to provide an airtight seal between the door and the tunnel and a similar gasket 67′ attached to door 62. Chamber 56 is always in communication with the lower end of cooling tower 24 via the entrance end 57 of chamber 56 (FIG. 2) and can be considered an extension of cooling tower 24. Chamber 58 communicates with chamber 56 when door 60 is pivoted to a raised open position by fluid cylinder 64, and chamber 58 communicates with the outside atmosphere or exterior of furnace 20 when door 62 is likewise opened by fluid cylinders 66. Pusher 52 (FIGS. 1, 2 and 3) operates to push a pallet 29, after it has been unloaded from the stack in tower 24, laterally and horizontally through end 57 into chamber 56 so that the pallet is positioned in front of a pusher 68 (as shown in phantom in FIG. 2). Pusher 68 then transfers pallet 29 laterally and horizontally from chamber 56 to chamber 58, and another pusher 70 transfers the pallet laterally and horizontally from chamber 58 to the exterior of the furnace onto a suitable conveyor 80 (FIG. 1). As shown in FIG. 1, an open gas pilot flame 72 burns continuously outside and adjacent door 62 to ignite the combustible gases in the controlled atmosphere within chamber 58 and to prevent oxygen in the air from entering chamber 58 when door 62 is open. If desired, a mixture of gases similar to the controlled atmosphere of furnace 20 can be injected under pressure into chamber 58 through a tube 74 as needed to further assure that no oxygen enters chamber 58 when door 62 is open.

Since chamber 34 is cylindrical and the heating elements of the furnace are disposed circumferentially about the outside of the circular casing 33, there is substantially no difference in the temperature at any point on any given imaginary circular path drawn concentric with chamber 34 and disposed in a horizontal plane within chamber 34. Hence, the circumferential temperature gradient in workpiece 27 is substantially zero. In addition, although workpiece 27 is subjected to different temperatures as it moves vertically and axially through the heating and cooling towers, the height or axial dimension of the workpiece is so small when compared to the height of the heating or cooling tower that at any one instant there is no substantial difference in the temperature of the workpiece measured axially between the top and bottom ends of the workpiece. In other words, at any given instant a workpiece in the fur-

nace has a substantially zero vertical temperature gradient, i.e., it is substantially the same temperature at both the top and bottom portions of its vertically or axially extending surfaces. Because of these two factors, i.e., zero circumferential and minimum axial temperature gradients in the heating environment relative to a given workpiece, at any one instant the various points or portions of an annular or ring-like workpiece (supported in the furnace so that its axis of rotation extends vertically as shown in FIG. 1) are not subjected to substantially different temperatures, and hence there is no substantial temperature gradient developed between the various portions of such a workpiece both during sintering and cooling in this furnace. This in turn decreases the amount of distortion or out-of-roundness attributable to such heat processing or treating of the annular ring approximately tenfold as compared to the use of a conventional horizontal furnace in sintering ferrous metal compacts. For example, annular ferrous metal compacts for a brake drum assembly which are approximately 12 inches in diameter have been found to be out-of-round approximately 0.010 of an inch or less when sintered in this type of up and down furnace as compared to approximately 0.100 of an inch in a conventional horizontal path controlled atmosphere furnace.

FIGS. 5 and 6 illustrate one such ferrous metal compact for a brake drum ring. Compact 27 may be formed by a powder metallurgy process from a preparation of a powder mix which, by way of illustration, comprises the following proportion by weight: 96 parts iron powder, 3 parts copper powder, 1 part graphite, 1 part stearate or other lubricant. The powder mix can be compressed into a suitable die to form compact 27 as an annular ring having a generally rectangular cross section with a diverging outer wall 82 to provide greater metal thickness and increased strength adjacent the outer or free edge of the brake drum assembly. By compacting the ring from powder, much finer section details can be imparted and machining costs eliminated. Such a brake drum ring usually has an inside diameter of approximately 9 to 12 inches and a width or brake track of approximately 2 to 4 inches.

As shown in FIG. 7, after workpiece 27 has been sintered pursuant to the vertical sintering method utilizing the furnace 20 disclosed herein to form the brake drum ring 27', a cold worked, pre-formed sheet metal (steel) backing plate 84 is arc or friction welded to form a circumferential welded joint attachment at 86 with the brake drum ring 27'. Backing plate 84 has a large central aperture and a plurality of circumferentially spaced bolt holes to receive mounting bolts 88 and a central hub 90 which are secured to the backing plate to complete the brake drum assembly.

In operating furnace 20, preferably door 62 is closed, door 60 is opened, and towers 22 and 24 and tunnel 26 are filled with pallets 29 and shown in FIG. 1. Open flames 38 and 72 are ignited and heating tower 22, cooling tower 24, crossover tunnel 26 and chambers 56 and 58 are filled with the controlled atmosphere which is to be used in sintering the workpieces to be placed in the furnace. Door 60 is then closed. Preheating section 28, heating section 30, cooling section 32, crossover tunnel 26 and cooling tower 24 are raised to their proper temperatures. Then workpieces 27 carried in pallets 29 are loaded in the lower end of heating tower 22 through inlet opening 36 by ram 42 which transfers pallets 29 into the lower end of heating tower 22 where they are retained by retractable fingers 44. Most of the oxygen entrained in workpieces 27 and carrier 29 is purged by the flame front burning at and below inlet 36 as carriers 29 pass through the flame front. After tower 22 has been completely filled with pallets 29, pusher 50, in synchronism with rams 42 and 48, transfers the pallets one at a time from the upper end of heating tower 22 into crossover tunnel 26 so that they push the preceding pallets one at a time to the upper end of cooling tower 24. Ram 48 in cooperation with retractable fingers 46 removes pallets 29 one at a time from the lower end of cooling tower 24 where they are transferred one at a time into chamber 56 by pusher 52. With door 62 closed, door 60 is then opened by ram 64 and pusher 68 transfers a pallet from chamber 56 to chamber 58. After a pallet has been transferred from chamber 56 to 58, door 60 is closed to seal chamber 58 from chamber 56 and cooling tower 24. Door 62 is then opened by ram 66, and pusher 70 thereupon moves the pallet from chamber 58 to the exterior of furnace 20 through open flame 72. Open flame 72 ignites the controlled atmosphere and prevents any oxygen from entering chamber 58 while door 62 is open. After the pallet has been transferred from chamber 58, door 62 is closed to seal chamber 58 from the outside atmosphere and door 60 is opened to admit another pallet into chamber 58 from chamber 56.

If the optional charging tube 74 is used, it injects a make-up quantity of controlled atmosphere mixture into chamber 58 whenever the pressure in chamber 58 is less than the pressure of the controlled atmosphere in furnace 20. Outlet tunnel 31 and flame 72 reduce the risk of an explosion by preventing oxygen from entering furnace 20 as the pallets are transferred from the cooling tower to the exterior of the furnace.

The controlled atmosphere, such as hydrogen, used in furnace 20 is lighter than air and thus tends to rise in both towers 22 and 24. However, the atmosphere in tower 22 has a greater tendency to rise because it is hotter and therefore lighter or lower in density than the atmosphere in tower 24. Accordingly, exit tunnel 31 also provides an atmosphere locking system which prevents a convection flow of the furnace atmosphere up the heating tower 22 and down the cooling tower 24 which otherwise would occur due to the temperature differential between the heating and cooling towers. Hence the atmosphere lock controls the exit flow of atmosphere at the outlet of the furnace and thus reduces the amount of make-up atmosphere that must be introduced into the furnace during normal operations, and also prevents oxygen from being swept into heating tower 22 through inlet opening 36 by a convection flow which would create an explosive mixture within furnace 20. The open pilot flame 38 cooperates with the down-flowing hydrogen at inlet 36 to establish and maintain a flame front enveloping inlet opening 36 of heating tower 22 which purges oxygen and other entrained gaseous contaminants from the workpieces and pallets. The down-flowing hydrogen and inlet flame front also prevent air from entering the furnace through inlet opening 36 so that an explosive condition is not created within the furnace. The continuously open inlet 36 also provides an adequate vent or outlet for the washing stream of hydrogen as well as a pressure relief opening so that if the atmosphere in the furnace should ever explode, the resulting explosive pres-

sure developed would not severely damage the furnace or injure personnel operating the furnace.

The openings **29***a* in the bases **29'** of the pallets or trays **29** provide an interior passageway through the vertical stack of pallets which makes the pallets and workpieces easier to adequately purge with the flame front at inlet **36** and improves the venting for purging the workpieces **27** of entrained contaminants and decreases the resistance to the pressure developed by any rapid combustion or explosion within the furnace. The openings in the trays also improve the circulation of the heat conducting controlled atmosphere within the furnace to insure more uniform heating and cooling fluid flow around the workpieces. By using a flame front at the continuously open inlet **36** and a sealable chamber and an open flame at the outlet end of furnace **20,** the usual operations of evacuating and purging the inlet chamber of prior art furnaces with the comparatively expensive controlled atmosphere are eliminated. In addition, the material loading and unloading mechanism and operations are greatly simplified and the quantity of controlled atmosphere required to operate the furnace is reduced. Even if the outlet structure is optionally purged, the required quantity of the controlled atmosphere mixture is still substantially reduced because only the outlet chamber needs to be purged, and the use of the open flame substantially reduces the amount of oxygen that could possibly enter the outlet chamber.

The method of the present invention is also advantageous for many of the above stated reasons, and also because the distortion of an annular workpiece, i.e., brake drum ring **27,** due to the heating and cooling to which it is subjected in the sintering process, is substantially decreased by processing the annular ring **27** in the vertical controlled atmosphere furnace of the invention, and then subsequently welding it at room temperature to the preformed stamped steel back **84.**

We claim:

1. A vertical furnace with a controlled atmosphere for heating and cooling workpieces comprising:

a. a heating tower extending generally vertically with a vertical length many times the vertical height of one of the workpieces, said heating tower having an inlet for workpieces adjacent its lower end continuously open to, and in communication with, the exterior of the furnace;

b. a cooling tower extending generally vertically with a vertical length many times the vertical height of one of the workpieces, said cooling tower being adjacent to, and generally parallel with, said heating tower with said towers being interconnected adjacent their upper ends, said cooling tower having an outlet for workpieces adjacent the lower end thereof;

c. an atmosphere lock connected with said outlet of said cooling tower and having an outlet in communication with the exterior of the furnace for transferring workpieces from said cooling tower to the exterior of the furnace without permitting said cooling tower to directly communicate with the exterior of the furnace through said outlet of said cooling tower;

d. means for supplying a controlled atmosphere of a combustible gas to the interior of said towers such that said controlled atmosphere flows downwardly through at least said heating tower to the inlet thereof;

e. means for causing the controlled atmosphere to continuously burn in a flame front interface with outside air adjacent said inlet; and

f. means for moving the workpieces through said flame front interface as each workpiece enters said heating tower so that the workpieces are washed or purged of contaminating gases entrained therein as they move into said heating tower and contaminating gases are prevented from entering said heating tower through said inlet by said flame front interface.

2. The furnace of claim **1** wherein said inlet for workpieces and said flame front interface extend generally horizontally, each workpiece is moved generally vertically upwardly through said flame front interface and inlet for workpieces into said heating tower, and the contaminating gases are flushed generally downwardly out of said heating tower via the flame front interface.

3. The furnace of claim **1** wherein the controlled atmosphere comprises hydrogen.

4. The furnace of claim **1** wherein said heating tower has a cylindrical casing therein having a source of heat circumferentially disposed about the outer periphery of said casing, said source of heat providing a heating zone in said cylindrical casing extending generally vertically many times the vertical extent of one of the workpieces with a vertically extending temperature gradient in said heating zone such that the vertical temperature gradient in each workpiece passing generally vertically upwardly therethrough is reduced to a minimum while said heat source simultaneously maintains a substantially uniform temperature in said heating zone at all points on any given circular path concentric with, and in a plane perpendicular to, the vertical axis of each workpiece passing upwardly through said heating zone such that the circumferential temperature gradient in each workpiece passing generally vertically upwardly through said heating zone is substantially eliminated.

5. The furnace of claim **4** wherein said cooling tower has a cylindrical casing therein providing a cooling zone within said cooling tower such that as each workpiece is moved generally vertically downwardly through said cooling zone the temperature of the workpiece is decreased.

6. A furnace for heating and cooling annular workpieces comprising a generally vertically extending heating tower having an inlet for workpieces adjacent its lower end opening to the exterior of the furnace, a generally vertically extending cooling tower having an outlet for workpieces adjacent its lower end, said towers being adjacent to, and generally parallel with, each other and interconnected adjacent their upper ends, a source of heat providing a heating zone within said heating tower extending generally vertically with a vertical length many times the axial extent of one of the annular workpieces to provide a temperature condition in said heating zone during passage of the workpieces therethrough such that a vertically extending temperature gradient is maintained in said heating zone such that the axial temperature gradient in each annular workpiece is reduced to a minimum while passing through said heating zone, while simultaneously maintaining a uniform temperature at all points on any given circular path concentric with the axis of an annular workpiece passing therethrough and in a plane perpendicular to the axis thereof such that the circumferential

temperature gradient in each annular workpiece passing upwardly through said heating zone is substantially eliminated, and means for elevating the annular workpieces upwardly through said heating zone with the axis of each annular workpiece disposed generally vertically with the annular workpieces superimposed over each other in a generally vertical row and downwardly through said cooling tower with their axes oriented generally vertically to thereby substantially decrease distortion of the workpieces due to the heating and cooling thereof in the furnace.

7. The furnace of claim **6** wherein said heating zone is defined by a cylindrical casing and said heat source is disposed about the outer periphery of said casing.

8. The furnace of claim **7** which also comprises a cylindrical casing defining a cooling zone in said cooling tower and said casings in said towers are interconnected adjacent the upper ends thereof.

9. The furnace of claim **6** wherein said inlet for workpieces of said heating tower is continuously open to the exterior of the furnace and also comprises an atmosphere lock connected with said outlet of said cooling tower and having an outlet communicating with the exterior of the furnace for transferring annular workpieces from said cooling tower to the exterior of the furnace without allowing said cooling tower to communicate with the exterior of said furnace through said outlet of said cooling tower.

10. The furnace of claim **9** which also comprises means for providing a controlled atmosphere of a combustible gas in said towers which flows generally downwardly through said heating tower toward said inlet thereof, means for causing the controlled atmosphere to continually burn in a flame front interface with outside air adjacent said inlet for workpieces, and means for moving each annular workpiece through said flame front interface into said heating tower, whereby each annular workpiece is washed or purged of contaminating gases entrained therein as it moves into said heating tower and contaminating gases are prevented from entering said heating zone through said inlet for workpieces by said flame front interface.

* * * * *

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,790,336 Dated February 5, 1974

Inventor(s) Alexander Brede III, et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Please add to the title page the assignee of record, Motor Wheel Corporation of Lansing, Michigan.

Signed and sealed this 19th day of November 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents