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Westeren et al.

[11] **3,718,324**

[45] **Feb. 27, 1973**

[54] VACUUM FURNACE AND WORK CART FOR USE THEREIN

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[22] Filed: **Nov. 12, 1971**

[21] Appl. No.: **163,057**

Related U.S. Application Data

[62] Division of Ser. No. 770,779, Oct. 25, 1968, Pat. No. 3,599,946.

[52] **U.S. Cl.**.....**266/5 R,** 266/4 A, 266/4 B

[51] **Int. Cl.**.....**C21d 1/12**

[58] **Field of Search**.....266/4 R, 4 A, 4 B, 5 R, 6 R

[56] **References Cited**

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3,441,452 4/1969 Westeren.....266/4 A

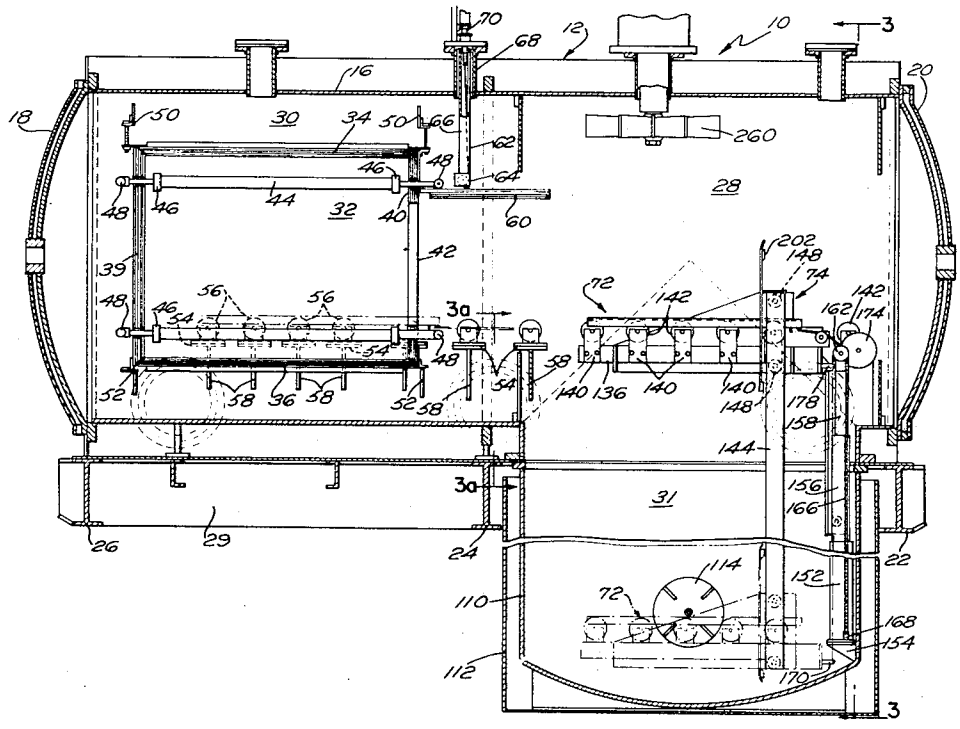
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[57] **ABSTRACT**

A high vacuum electric furnace for heat treating metallic articles having a work cart mounted for movement therein and including a heating chamber for receiving said work cart during the heat treating operation, said work cart having heat shielding means fixed thereto, and roller assembles located in said furnace over which said work cart moves for transfer to and from said heating chamber.

9 Claims, 12 Drawing Figures



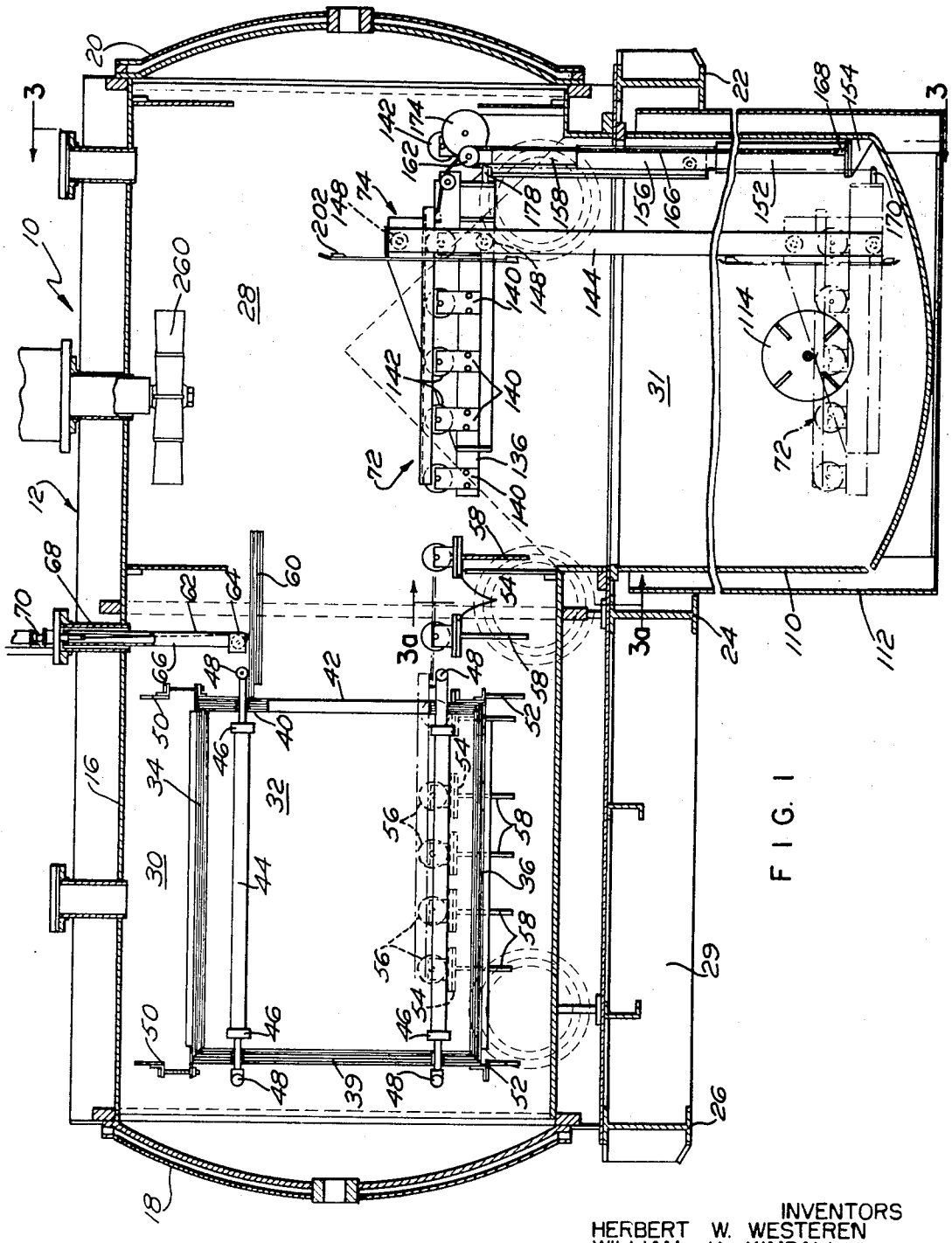


FIG. 1

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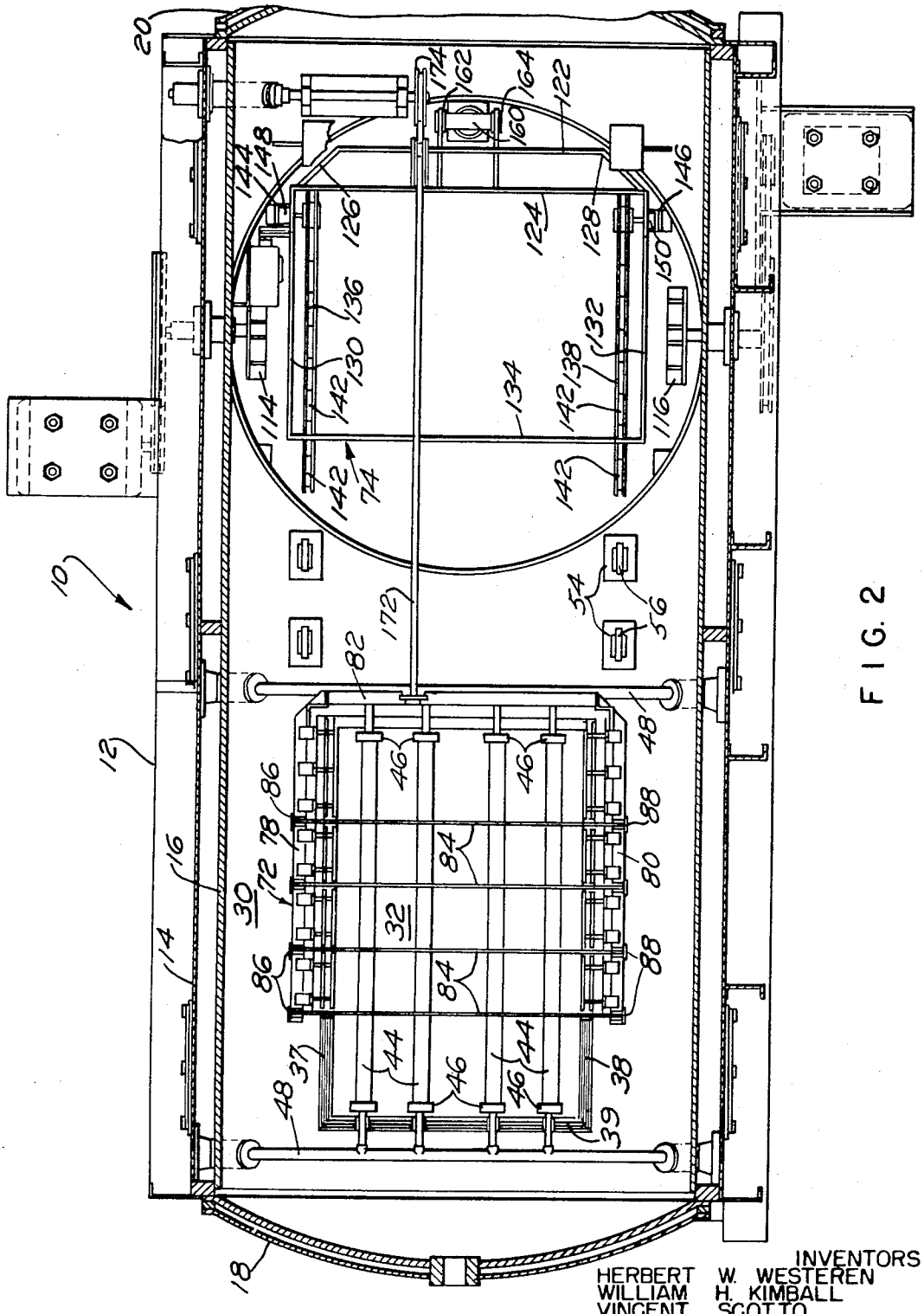


FIG. 2

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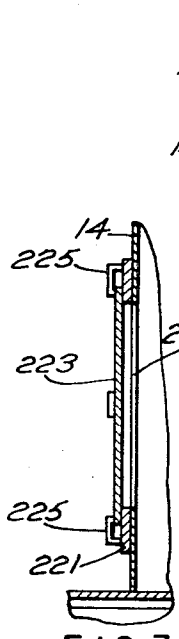


FIG. 3a

FIG. 3

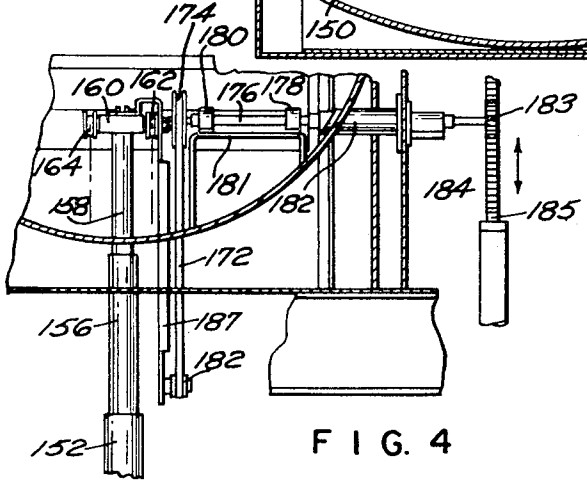


FIG. 4

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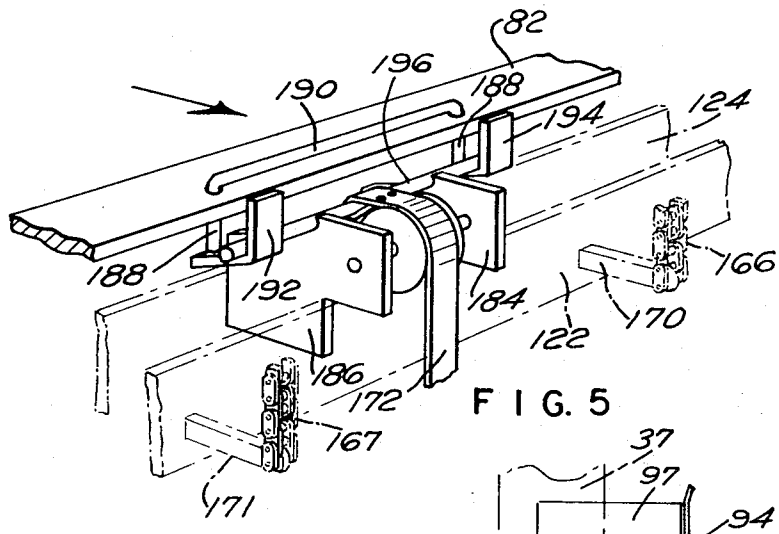


FIG. 5

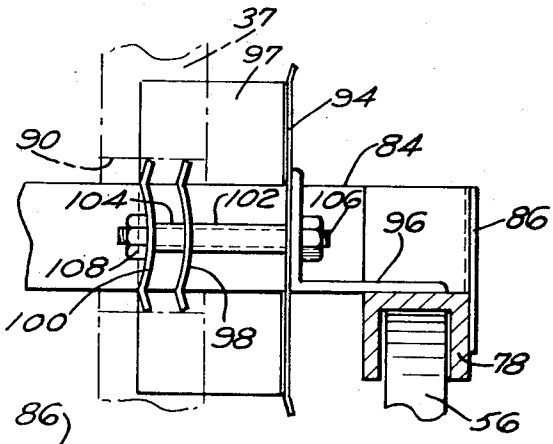


FIG. 7

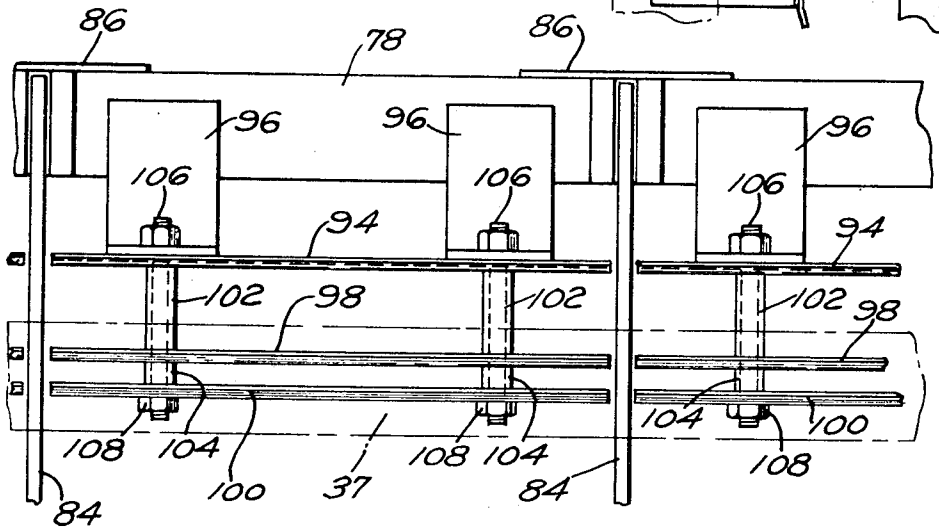


FIG. 6

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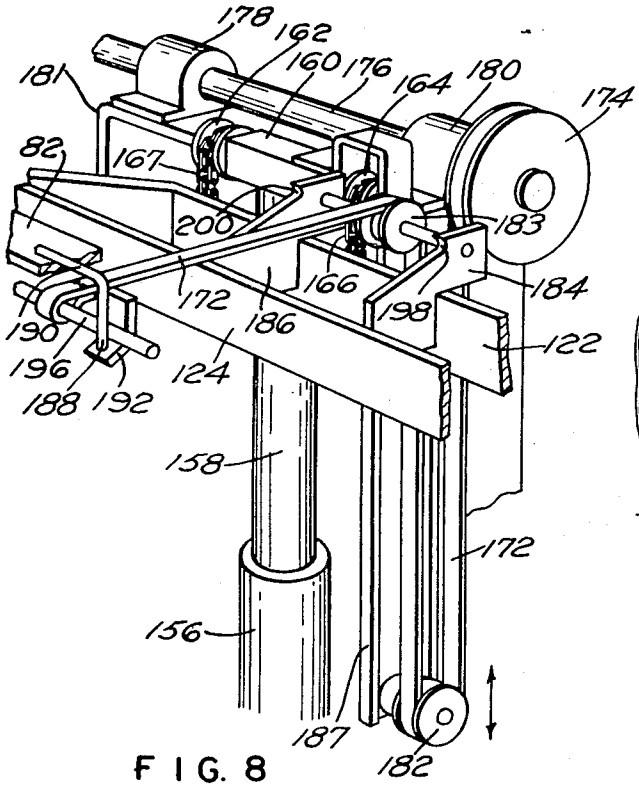


FIG. 8

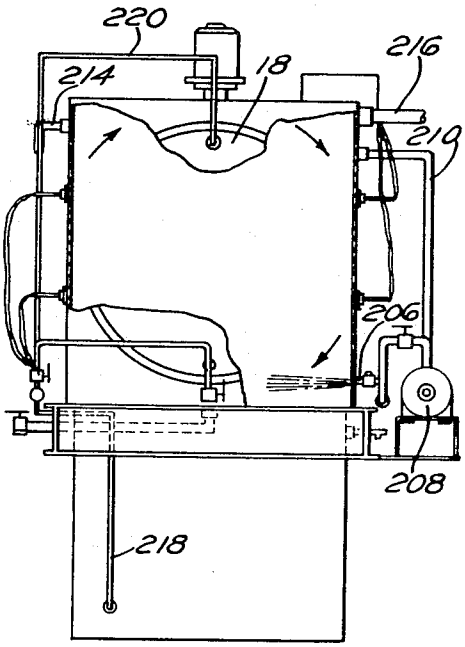


FIG. 10

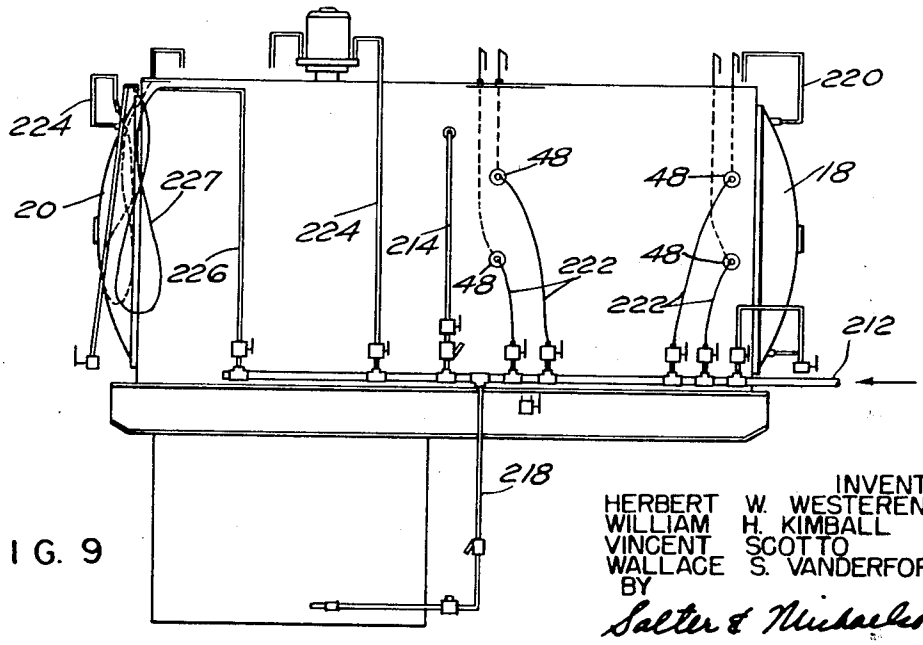


FIG. 9

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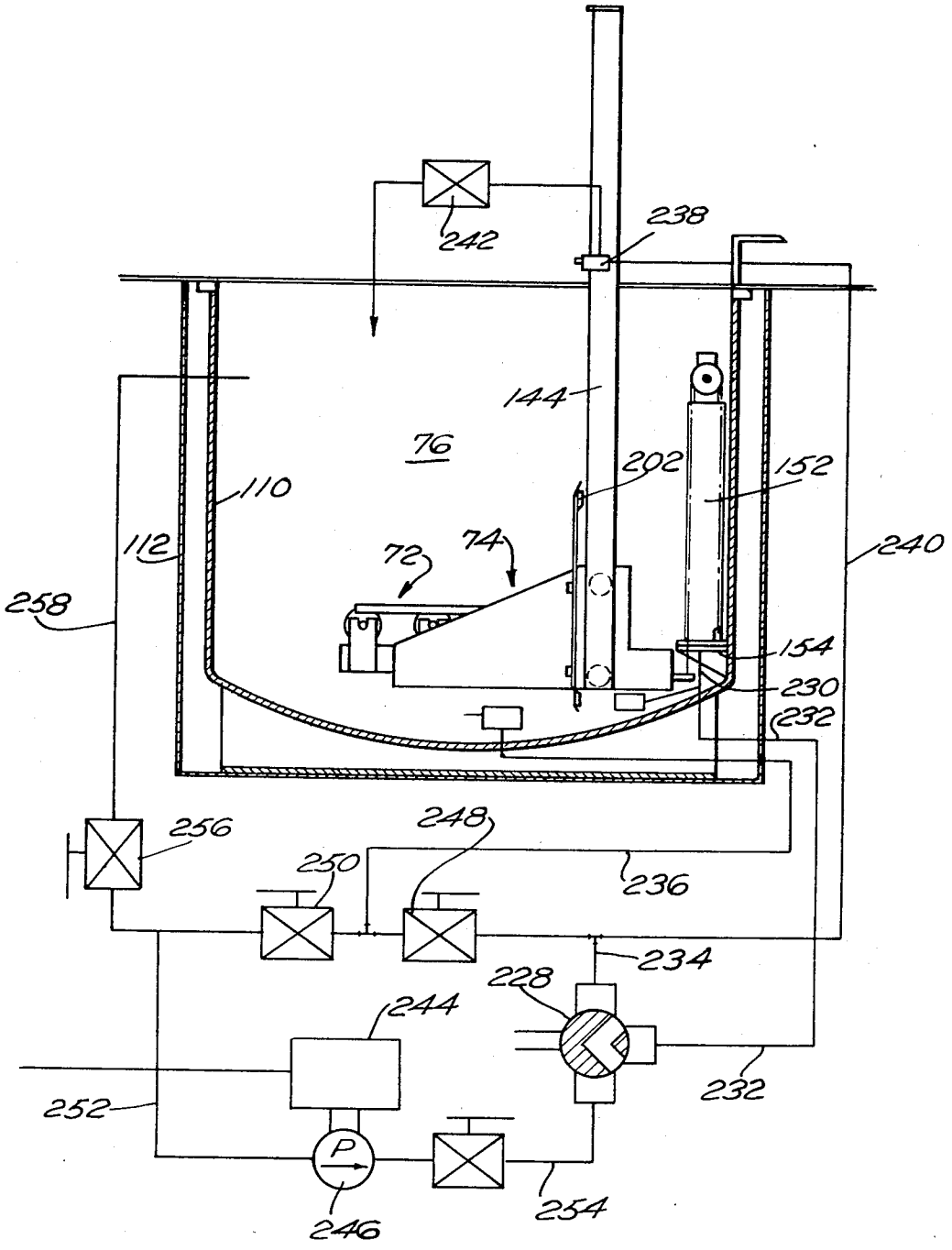


FIG. 11

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VACUUM FURNACE AND WORK CART FOR USE THEREIN

BACKGROUND OF THE INVENTION

This is a division of co-pending application Ser. No. 770,779 filed Oct. 25, 1968 and entitled Vacuum Furnace with Elevator Oil Quench and now patent No. 3,599,946.

The present invention relates to furnaces for heat treating metallic articles.

In the heat treatment of metallic articles, such as carbon and stainless steels and the like, it is critical in certain conditions of use thereof that the surfaces of the articles be maintained free from contamination that results from oxidation and/or decarborization. The technique employed for heat treating articles heretofore has normally consisted of heat treating in a subatmospheric environment and then moving the articles to a cooling zone through which a cooling atmosphere was circulated. Although cooling in an atmosphere was effective in certain heat treating procedures, proper hardening of certain materials could not be obtained by atmosphere cooling since this procedure required a relatively long quench cycle and the desired metallurgical structure necessitated a quick quench.

As described in U.S. Pat. No. 3,441,452, the technique of quenching the heat treated article in a liquid, such as oil, provided for dumping of the heat treated articles from a transfer zone into an oil quench tank located directly below the transfer zone. Although the prior techniques of quenching in oil under vacuum as disclosed in the above noted patent resulted in the desired hardening and bright surface, the dumping process was usable only with certain small articles and could not be employed for machined parts

SUMMARY OF THE INVENTION

The present invention relates to a method and apparatus for vacuum heat treating metallic articles and provides for extracting of the heat treated articles from a heating zone after the heating cycle for movement to a transfer zone at which they are located on an elevator. With the heat treated parts mounted on the elevator in positive relation, the elevator is then quickly moved downwardly from the transfer zone to a quench zone at which the quenching operation is carried out in a liquid, such as oil. Since the metallic articles are retained in a fixed position on the elevator as they are moved to the quench zone, a great variety of relatively large articles can be oil quenched without risk of mechanical damage, which would normally occur in a dump quench operation.

In carrying out the invention, a unique transfer mechanism is employed for retracting a work cart, on which the articles are contained, from the heating zone to the elevator. The retracting mechanism which, in effect, tethers the work cart, cooperates with the means for operating the elevator so that the work cart is retained in a fixed position on the elevator as it is moved therewith from the transfer zone to the quench zone during the quenching operation. Since it is necessary to quickly move the articles into the quench liquid, means are further provided for controlling the rate of descent of the elevator so that as it approaches the surface of the quench liquid, it is caused to rapidly descend therethrough. The movement of the elevator is

then controlled so that after it moves substantially through the quench liquid, it is caused to move to a lower position in the quench tank without shock, and then after the quenching operation is completed, the elevator is moved upwardly to the transfer zone for removal of the articles from the furnace.

Quenching of the heat treated articles is carried out by the elevator mechanism of the present invention by rapid transfer of the articles from the transfer zone to the quench tank, thus insuring that rapid quenching of the articles is achieved. Since the articles are continuously exposed to a subatmospheric environment prior to introduction thereof into the quench liquid contained in the quench tank, surface contamination of the articles is prevented, and an unusually clean and bright surface on the articles is obtained.

The vacuum furnace as embodied herein is essentially concerned with the heat treatment of articles under vacuum and transfer of the heat treated articles to a quench tank without removal of the articles from within the vacuum vessel. However, in order to obtain the results as set forth hereinafter, various constructional features, including a unique transfer elevator, are embodied in the vacuum furnace that provide for the efficient operation thereof, and such features and constructions are described hereinafter.

Accordingly, it is an object of the invention to provide a high vacuum furnace for heat treating and quenching metallic articles in such a manner as to prevent contamination of the surfaces thereof.

Another object of the invention is to provide a high vacuum electric furnace in which articles to be heat treated are moved within the furnace by remotely controlled means for automatic transfer from the heating zone to a transfer zone and thereafter into a quenching zone.

Still another object is to provide a control mechanism for withdrawing a work cart on which the articles are located from the heating zone to a transfer zone, the control mechanism including a device for locking the work cart on the elevator when the elevator is moved into the quench zone for the quenching of the articles therein.

Still another object is to provide means for controlling the vertical movement of an elevator such that the articles are rapidly moved to the quenching medium for the quick quenching thereof.

Still another object is to provide a unique cooling system for the housing of the furnace which includes means for continuously circulating a cooling fluid in circular relation around an inner shell of the housing.

Other objects, features and advantages of the invention will become apparent as the description thereof proceeds when considered in connection with the accompanying illustrative drawings.

DESCRIPTION OF THE DRAWINGS

In the drawings which illustrate the best mode presently contemplated for carrying out the present invention:

FIG. 1 is a vertical sectional view of the high vacuum electric furnace embodied in the present invention;

FIG. 2 is a horizontal sectional view of the vacuum furnace illustrated in FIG. 1;

FIG. 3 is a sectional view taken along lines 3—3 in FIG. 1;

FIG. 3*a* is a sectional view taken along lines 3*a*—3*a* in FIG. 1;

FIG. 4 is a fragmentary sectional view of a portion of the furnace showing the control device that is employed for retracting the work cart from the heating zone to the transfer zone;

FIG. 5 is a perspective view of an end of the work cart and showing the interconnection thereof to a tape that is operable to retract the cart from the heating zone;

FIG. 6 is a fragmentary side elevational view of the work cart showing the heat shields that are associated therewith;

FIG. 7 is a partial end view, with portions shown in section, of the heat shields that are illustrated in FIG. 6;

FIG. 8 is a perspective view, showing the elevator lite mechanism and the retract mechanism for the work cart that retains the cart on the elevator in locked relation;

FIG. 9 is a side elevational view of the furnace showing the exterior piping for the cooling system;

FIG. 10 is an end elevational view of the furnace housing with portions broken away showing the circulation of the cooling fluid in the cooling space as defined between the inner and outer shells of the housing; and

FIG. 11 is a diagrammatic view showing the elevator as located in the quench zone and the system for controlling the vertical movement of the elevator within the quench zone.

DESCRIPTION OF THE INVENTION

Referring now to the drawings and more particularly to FIGS. 1, 2 and 3, the vacuum furnace embodied in the present invention is illustrated and is generally indicated at 10. Since the vacuum furnace 10 is operated at a predetermined vacuum, any suitable vacuum equipment may be connected thereto for evacuating the interior thereof as required, and as illustrated in FIG. 3 as a vacuum pipe 11 is fixed in the furnace housing and communicates with a vacuum pump (not shown). As illustrated in FIGS. 1–3, the vacuum furnace 10 includes a housing generally indicated at 12 that is defined by an outer shell 14, an inner shell 16 to which an end wall 18 is fixed and on which a door 20 is removably mounted. The removable door 20 is slidable on suitable tracks (not shown) and is movable transverse to the longitudinal axis of the furnace to expose the furnace interior when a work load is introduced therein or removed therefrom after a heat treating operation.

As will be described hereinafter, the outer shell 14 of the housing 12 that surrounds the inner shell 16 is substantially rectangular in cross section as compared to the circular cross section of the inner shell 16, the spacing between the inner and outer shells defining a cooling space through which a cooling fluid, such as water, is continuously circulated for maintaining the temperature of the housing walls at a prescribed level. As further illustrated in FIG. 1, both the door 20 and end wall 18 are jacketed to receive a cooling fluid therein for maintaining these parts at the prescribed temperature level.

The furnace 10 is of such size as to require a substantial support therefor, and, accordingly, spaced transverse beams indicated at 22, 24 and 26 and longitudinal beams 27 and 29 are positioned beneath the outer shell 14 for supporting the furnace thereon. The beams 22, 24, 26, 27 and 29 may be fixed in a flooring or the like or located in any suitable manner. As will be further described, the housing 12 includes a quench zone into which the heat treated articles are moved during the quenching operation. Since the quench zone must be located remote from the heating zone and if the housing 12 is mounted directly on a flooring, a suitable cavity must be formed in the flooring for receiving the quench tank as illustrated in FIG. 1 and as will be further described.

Located within the housing 12 and adjacent to the door 20 is a transfer zone 28, while located adjacent to the transfer zone 28 is a heating zone 30. The articles to be heat treated are moved into the transfer zone 28 prior to introduction thereof into the heating zone 30, and following the heating cycle the articles are returned to the transfer zone for movement therefrom into a quench zone 31 that is located directly below the transfer zone 28. As shown more clearly in FIG. 1, the heating zone 30 includes an enclosed heating chamber 32 that is defined by a casing formed of flexible insulating graphite material. The graphite insulating material is arranged in layers and, as shown in FIGS. 1, 2 and 3 includes a top wall 34, a bottom wall 36, side walls 37 and 38, a rear wall 39, and a front wall 40 in which an opening 42 is formed. Located within the heating chamber 32 are a plurality of tubular resistance heating elements 44 that are disposed in spaced relation and are interconnected at the ends thereof to suitable terminals 46. As described in U.S. Pat. No. 3,525,795 issued Aug. 25, 1970, and entitled ELECTRIC FURNACE AND TUBULAR HEATING ELEMENT FOR USE THEREWITH, the tubular heating elements 44 are formed of a flexible woven graphite material and are arranged in tubular formation, the terminals 46 of the tubular heating elements being fixed to bus bars 48 that extend exteriorly of the furnace housing 16 through connections (not shown) for communication with a suitable source of current. Upper hanger brackets 50 and lower support brackets 52 are fixed in the heating zone for mounting the insulating walls of the heating chamber 32 in place.

Located within the heating zone 30 and fixed to the inner shell 16 of the housing 12 are a plurality of spaced roller supports 54 on which rollers 56 are mounted. The rollers 56 are rotatable in suitable bearings that are positioned in the supports 54; and, as will be described, the rollers 56 are provided for receiving a work pedestal or cart that is moved into the furnace housing during the heating cycle. In order to fix the supports 54 within the heating zone, a plurality of plates 58 are joined to the shell 16 and receive the supports 54 in secure relation thereon.

After the heating cycle has been completed and the work load removed from the heating chamber 32, it is desirable to seal the heating chamber so as to effectively retain the heat therein during the cooling and quenching cycles. In order to seal the heating chamber 32, a door 60 is pivotally mounted on the front wall 40 of the chamber and, as illustrated in FIG. 1, the door 60 also includes a plurality of insulating layers that preferably are formed of a graphite material. In order to automatically control the movement of the door 60

exteriorly of the furnace, a metal tape **62** is connected to the door **60** and extends over a pulley **64** and through a tube **66** at the bottommost portion of which the pulley **64** is mounted. The tube **66** extends through a vacuum seal **68** that spans the inner and outer shells of the housing, and the tape **62** that extends through the seal **68** is operatingly connected to a piston rod **70** of a control cylinder that is preferably operated exteriorly As will be described when the work load is moved out of the heating chamber **32** following the heating cycle, the door **60** is automatically closed by the control cylinder to effectively retain the heat within the heating chamber **32**.

As previously mentioned, the door **20** is movable to an open position during unloading or loading of the articles to be heat treated. With the door **20** in an open position, a basket is placed on a work pedestal or cart generally indicated at **72**, which, as shown in FIG. **1**, is located in the transfer zone **28** on an elevator generally indicated at **74**. As will be described hereinafter, the elevator **74** is adapted to move the work cart **72** and articles thereon to the quench zone **31** below the transfer zone **28**, but, for the purpose of moving the work cart and the articles thereon to the heating zone **30**, the elevator **74** is disposed in the uppermost position thereof, as illustrated in full lines in FIG. **1**.

As shown in FIG. **2**, the cart **72** is essentially a three-sided construction and is defined by spaced channel shaped side members **78** and **80** and an end member **82**. As illustrated in FIG. **7**, the side members **78** and **80** have a reversely formed channel configuration that receive the rollers **56** therein, the rollers **56** thus defining tracks over which the cart **72** is moved between the transfer zone **28** and the heating zone **30**. Interconnecting the side members **78** and **80** are a plurality of spaced bars **84** that are preferably formed of a molybdenum material, the outer ends of the molybdenum bars **84** being received in convenient vertical slots formed in the sides **78** and **80** and being locked in place therein by outer flanges, as indicated at **86** and **88** in FIGS. **2** and **6**.

Since the width of the cart **72** is greater than the width of the heating chamber **32** as defined by the walls **37** and **38**, the side members **78** and **80** extend outwardly of the heating chamber walls **37** and **38**. In order to accommodate the bars **84** that support the work basket and load thereon, the walls **37** and **38** are formed with slots, as indicated at **90** and **92** in FIG. **3**. Referring now to FIGS. **6** and **7**, a portion of the work cart is illustrated as it is located in the heating chamber **32**, the bars **84** extending through the slots **90** and **92** formed in the walls **37** and **38** respectively. Since considerable heat can escape through the slots **90** and **92** during the heating cycle, a heat shield assembly is provided that effectively shields the heating chamber **32** for retaining the heat therein. As shown in FIGS. **6** and **7**, a plurality of outer heat shields **94** are joined to the side members **78** and **80** through brackets **96** that may be welded to the upper surfaces of the side members, each of the outer shields **94** being spaced between the bars **84**. An end plate **97** is joined to the end most of the outer shields **94** and defines an end barrier. Fixed to the outer shields **94** and spaced therefrom for location within the slots **90** and **92** are spaced inner shields **98** and **100**, the inner shields **98** and **100** being located between spacer tubes **102** and **104** and being fixed in position by a bolt **106** on which a nut **108** is received. It is seen that the outer shield **94** and the inner shields **98** and **100** effectively prevent heat radiation through the slots **90** and **92** when the cart **72** is located within the heating chamber **32** during the heating cycle.

In carrying out the heat treating of the metallic articles within the furnace **10**, the present invention provides for quick quenching of the heat treated articles in the quenching zone **31** after completion of the heat treating cycle. As shown more clearly in FIG. **1**, the quenching zone **31** is defined by a quench tank **110** that is located within a jacket **112** through which a cooling fluid is continuously circulated. The quench tank **110** is disposed directly below the transfer zone **28**, and it is contemplated that in the installation of the furnace **10**, the quench tank **110** will be located below floor level so as to properly accommodate the quench tank with respect to the transfer zone **28** and heating zone **30**. In this connection the height of the quench tank **110** is arranged such that the quench medium, which is preferably oil, is disposed at a sufficient level below the transfer zone **28**. Thus, during the quenching cycle, any vaporization of the oil will be effectively trapped at the upper level of the quench tank, and contamination of the transfer zone and heating chamber will be effectively prevented. In order to condense any vaporized oil molecules and to prevent contamination of the transfer zone and heating zone, the upper level of the quench tank is enveloped by the jacket **112** for circulation of the cooling fluid therebetween, wherein the upper portion of the quench zone is effectively cooled. Purifying the quench medium and aiding in the cooling action is also produced by agitation of the quench medium by opposed impellers **114** and **116** that are located within the quench tank adjacent to the side walls thereof. As shown in FIG. **3**, the impeller **114** is driven by a motor **118** supported from the housing support beam **27** located exteriorly of the quench tank **110**, while the impeller **116** is driven by a motor **120** supported from the beam **29**. Suitable seals **119** and **121** are provided for receiving the impeller shafts that are interconnected to the motors **118** and **120**.

As previously described, the elevator **74** is provided for moving the work cart **72** and the articles as contained in a basket thereon into the quench zone **76** for the quick quenching of the articles following the heating cycle. As shown in FIGS. **1** and **2**, the elevator **74** is defined by a frame that includes spaced front frame members **122** and **124** that are interconnected by bracing elements **126** and **128**, side frame members **130** and **132**, and a rear frame member **134**. Joined to the frame members **124** and **134** are elongated supports **136** and **138** on which a plurality of vertical roller brackets **140** are mounted for supporting rollers **142** thereon. Fixed within the transfer zone **28** by upper brackets **143** and **145** and extending downwardly within the quench tank **110** are spaced channel shaped tracks **144** and **146**. Followers **148** and **150** are received within the tracks **144** and **146** and are operatively joined to the frame members **130** and **132** of the elevator frame. Thus, movement of the elevator will be substantially vertical as the followers **148** and **150** are guided within the tracks **144** and **146**.

In order to vertically move the elevator **74** with the work cart **72** mounted thereon, a hydraulic lift is employed and, as shown in FIG. **1**, includes a cylinder **152** that is mounted within the quench tank **110** on a support bracket **154**. A first ram **156** is telescopically received within the cylinder **152**, the first ram **156** receiving a second ram **158** in telescoping relation therein. Joined to the topmost ram **148** is a cross head **160** on which spaced sprocket wheels **162** and **164** are fixed. Chains **166** and **167** are secured at the lower end of the cylinder at **168** and **169** respectively, and extend around the sprocket wheels **162** and **164** and are joined to links **170** and **171** (FIG. **5**) fixed to the elevator **74** on the front frame member **122**. It is seen that upon actuation of the hydraulic lift, the rams **156** and **158** will be vertically moved to operate the chains **166** and **167** for moving the elevator **74** in a corresponding direction. Because the lift moves vertically as the pulleys are rotated on the cross head **160** at 2:1 mechanical advantage for movement of the elevator is obtained. Since the guide followers **148** and **150** are disposed for movement within the tracks **144** and **146**, the elevator **74** must move in a prescribed vertical direction between the transfer zone **28** and the quench zone **76** upon operation of the hydraulic lift. As will be described hereinafter in the operation of the furnace, the fluid medium for operating the hydraulic lift is the quench liquid as contained in the quench tank **110**. By utilizing the quench liquid for the lift cylinder, contamination of the quench zone by a hydraulic fluid as contained in an exterior system is avoided. It is for this reason that the lift cylinder **152** is mounted within the quench tank **110** as illustrated in FIG. **1**.

When the work cart **72** is introduced into the furnace at the transfer zone **28** and thereafter moved into the heating zone **30**, it is necessary to provide for automatically retracting the work cart onto the elevator **74** so that the elevator may then be lowered into the quench zone **76** for the quick quenching of the heat treated articles. As illustrated in FIGS. **5** and **8**, a tethering and locking device that is automatically operable externally of the furnace is provided and is adapted to be interconnected to the cart **72** for retracting it from the heating zone **30**. The tethering and retracting device includes an elongated metal tape **172** that is wound on a reel **174**, the reel **174** being mounted on a shaft **176** that is journalled for rotation in bearings **178** and **180** that are conveniently mounted on a bracket **181** located within the transfer zone **28**. As shown in FIG. **4**, the shaft **176** extends outwardly of the furnace housing through a seal **182** and has a pinion **183** mounted on the outermost end thereof that is engageable by a rack **184**. The rack **184** is connected to a piston rod **185** that is reciprocally moved by an automatic control device for effecting rotation of the shaft **176** and movement of the tape **172** as required.

The tape **172** as it extends from the reel **174** is received on a movable idler **182** and extends over a fixed idler **183** that is journalled between spaced plates **184** and **186** that are fixed to the frame **122** of the elevator. As shown in FIG. **4**, the idler **182** is interconnected to the cross head **160** through a bracket **187**, the idler **182** moving with the cross head **160** and relative to the elevator. Thus as the lift descends the elevator that is connected to the chains **166**, **167** is lowered at a more rapid rate. The tape **172** is maintained in tensioned relation during this movement since it will be taken up by the vertical position of the idler **182**. In order to tether and lock the work cart **72** on the elevator **74**, the end member **82** of the cart is formed with holes through which the legs **188** of a U-shaped rod **190** extend (FIG. **5**), the legs **188** also being received in suitable openings formed in brackets **192** and **194** that are secured to the end member **82**. The free end of the tape **172** is locked around a pin **196**, shown in FIG. **8**, and the pin **196** is located between the legs **188** of the rod **190** and the brackets **192**, **194**. It is seen that as the tape **172** is retracted onto the reel **174**, the pin **196** will engage the brackets **192** and **194** and will cause the cart **72** to follow the movement of the tape **172**. When the work cart reaches the fully retracted position in the transfer zone **28**, the pin **196** is received at stop points indicated at **198** and **200** on the plates **184** and **186** and the cart is then located in the locked position on the elevator **74** and will be retained therein by the fully wound tape on the reel **174**. It is seen that in the fully retracted position and with the elevator **74** located in the transfer zone **28**, the idler **182** is at its uppermost position. As the hydraulic lift lowers the work cart **72** within the quench zone **31**, the idler **182** will move downwardly with the cross head **160**, tensioning the tape **172** during the downward travel of the elevator, thereby retaining the work cart **72** in its fully locked and tethered position. Thus, when the work cart reaches the quench zone **31** on the elevator **74**, it will be locked in position by the tape **172** and the articles as contained thereon will be suitably positioned on the cart during the quenching operation. It is further seen that movement of the cart **72** over the elevator and through the door opening can be accomplished following the complete heat treating cycle by lifting the rod **190** from its position in the member **82**. Since the cart is then essentially released from the tape **172** it may be pulled over the elevator plates **184**, **186** and reel **174** and through the door opening.

During the quenching cycle and upon movement of the elevator **74** into the quench zone **31**, it is essential that the elevator and articles thereon be moved rapidly into the quench liquid. However, the elevator cannot fall too rapidly from the upper position in the transfer zone **28** or splashing will occur that will contaminate the furnace interior. As will be described in the operation of the apparatus, a special control system is provided for slowly dropping the elevator to just above the quench liquid and then rapidly moving the elevator into the quench liquid. This control system includes an actuating arm **202** that is mounted on the elevator **74** and extends thereabove, the actuating arm **202** being adapted to engage an operating element of a control valve for effecting the control of the system that provides the intended movement of the elevator.

Prior to the instant invention the housings of vacuum furnaces have usually been constructed of a stainless steel material, which, in large installations, is relatively costly. In the present invention the use of stainless steel in the furnace housing is avoided by forming the housing inner shell **16** of a mild steel and then applying a thin Teflon coating to the outer surface of the inner shell **16**. The Teflon coating not only prevents corrosion of the inner shell which is normally subjected to

water circulation therearound but effectively reduces the overall cost of the furnace construction. Protection of the vacuum vessel walls as represented by the inner shell **16** is also contemplated by chemically treating the circulating cooling liquid. This would effectively resist corrosion. Further, the use of a heat exchanger in the cooling system would reduce the corrosive activity of the cooling fluid on the inner shell. If desired, the outer jacket **14** may also be formed of a mild steel.

It has been the usual practice in cold wall vessels of the general type embodied in the present invention to enclose a cylindrical inner shell in a cylindrical outer shell and circulate a cooling medium therebetween. However, circulating the cooling medium between the cylindrical shells heretofore has been relatively inefficient, since the temperature of the inner shell could not be easily controlled because of the poor circulation of the cooling fluid. In order to adequately cool all of the surfaces of the furnace as embodied in the present invention, a large flow of cooling liquid is required. This is accomplished by enclosing the inner shell **16** with the outer shell **14** that has a substantially rectangular configuration in vertical cross section as illustrated in FIG. **10**. The outer shell **14** is open at the top to further provide for effective cooling of the circulating fluid, the fluid being directed in a circulating flow around the inner shell **16**. For this purpose, a plurality of jets **206** are located along the length of the outer shell **14** and introduce the cooling fluid under pressure into the cooling space between the inner and outer shells **14** and **16**. As shown in FIGS. **9** and **10**, the cooling system includes a pump **208** that supplies the jets **206** with the cooling fluid, such as water, and receives a continuous flow of the cooling fluid through a pipe **210** that communicates with the outer shell adjacent to the upper end thereof. As seen in FIG. **10**, the jets **206** are located substantially tangential to the inner shell **16**; and thus, upon injecting of the cooling fluid into the cooling space, a circulating action of the cooling fluid is produced, as indicated by the arrows in FIG. **10**. It is also seen that suction of the water through the pipe **210** by the pump **208** further induces the circulating action of the cooling fluid. In the event that the temperature of the cooling fluid in the cooling space exceeds a prescribed level, fluid such as water can be added through a supply pipe **212**, as indicated in FIG. **9**, and an inlet pipe **214** that communicates with the cooling space adjacent to the upper end thereof. In the event that excess cooling water is introduced into the cooling space, a drain **216** is provided for draining the excess as required.

As shown in FIG. **12**, the cooling system also provides for introducing the cooling fluid to the various areas of the furnace that require cooling. Thus, a pipe **218** supplies the cooling fluid to the cooling space between the quench tank **110** and the jacket **112**. Pipe **220** provides the necessary cooling fluid for the end wall **18**. The bus bars **48** are water cooled, and convenient flexible tubing **222** is connected to the bus bars **48** for conducting the cooling fluid thereto. Additional pipes **224** and **226** connected to the supply pipe **212** are also provided for conducting the cooling fluid to the jacketed space in the door **20**. A flexible hose **227** that is interconnected to the pipes **224** and **226** enables the door to be shifted laterally during loading or unloading of the furnace.

As mentioned above, the inner shell **16** is formed of mild steel and has a thin Teflon coating applied thereto. In order to visually inspect the inner shell **16**, the outer shell **14** has a plurality of inspection ports **219** located in the side walls thereof, as indicated in dotted lines in FIG. **1**. As shown in FIG. **3a**, an annular flange **221** surrounds each of the ports **219** and receives a cover plate **223** thereagainst in sealing relation. Sealing dogs **225** are bolted to the flange **221** and engage the cover plate **223** for locking it in sealing engagement against the flange **221**. It is seen that after the cooling fluid is removed from the cooling space between the shells, the cover plates **223** may be removed to uncover the ports **219**, whereupon the inner shell **16** may then be visually inspected.

OPERATION

In operation of the furnace **10** as embodied herein, a work load is first placed in a convenient basket or receptacle, and the work load as contained in the basket is placed on a transfer table (not shown) as it is located outside the furnace. With the door **20** open, the transfer table is rolled adjacent thereto, and the basket and work load thereon are moved therefrom onto the cart **72** as it is located on the elevator **74** in the transfer zone **28**. The work cart **72** is then moved into the heating zone **30**, wherein the work basket and the articles to be heat treated as contained therein are located within the heating chamber **32**. The door **20** is closed and sealed and the furnace evacuated for the heating cycle. Since the transfer zone **28**, heating zone **30** and quench zone **76** are all in open communication, all of these zones are evacuated by the vacuum pump equipment during the heat treating cycle. It is understood that when the work cart **72** is moved into the heating zone **30** as illustrated in FIG. **2**, the tape **172** has been interconnected therewith, and is unwound from the reel **174** as illustrated in FIG. **2**. The cycle of operation is then automatic as will now be described. After the heating cycle has been completed, the pump valve interconnecting the furnace and vacuum pump is closed. The furnace is then back-filled with nitrogen to a desired subatmospheric pressure, preferably about 12 in. hg and the oil circulating pumps **114**, **116** are started. When the transfer chamber **28** reaches the desired backfill pressure, the control cylinder for the door **60** is actuated to cause the door to be moved to the open position, as illustrated in FIG. **1**. The cylinder operating the rack **184** is next actuated and the reel **174** is rotated by the pinion **183** to retract the tape **172**, thereby withdrawing the work cart **72** and basket thereon into the transfer zone **28**. As the cart **72** is withdrawn from the heating zone, the side members **78** and **80** are received on the rollers **142** of the elevator **74**. When the tape **172** is fully retracted, the work cart **72** is disposed in tethered and locked position on the elevator **74**. The door **60** is now returned to the closed position and the apparatus is ready for the quenching cycle.

Referring now to FIG. **11**, a diagrammatic illustration of the system for controlling the operation of the hydraulic lift is illustrated, and movement of the elevator during the quenching cycle will now be described. When the work cart reaches the transfer zone and is located on the elevator, a solenoid operated three-way valve **228** is energized to locate the actuating portion of the lift cylinder **152** in communication with the interior

of the quench zone **31** by way of lines **230**, **232**, **234** and **236**. As the hydraulic fluid bleeds out of the cylinder **152** into the quench tank **110**, the elevator slowly descends. As previously mentioned, it is desirable to move the heat treated articles through the surface of the quench liquid very rapidly so as to effect a quick quenching thereof, and thereby prevent vaporization of the quenching medium. In order to accomplish this purpose, the operating arm **202** moves into engagement with the operating element of the control valve **238**. The control valve **238** is then placed in communication with the line **234** by way of line **240**. The operating fluid that is bleeding from the cylinder **152** into the quench tank **110** by way of line **236** is now further exhausted into the quench tank through the line **240**, valve **238** and a bleed valve **242**. The elevator then quickly descends through the surface of the quench medium and drops substantially into the quench tank. As the operating arm **202** passes over the actuating element of the valve **238**, this valve is then once more closed to prevent the operating fluid from exhausting into the quench tank **76**. The elevator then slowly descends to the bottom of the quench tank without undue shock as the elevator reaches the bottom of the tracks **144** and **146**.

After a predetermined period for quenching of the articles within the quench zone, the three-way solenoid valve **228** is automatically activated to place the exhaust of a pump **246**, mechanically interconnected to an air operated motor **244**, into communication with the line **232**. The operating fluid is now pumped from the quench tank into the cylinder **152** by way of line **236**, control valve **250**, line **252**, exhaust line **254**, and line **232**. Since the pump **246** draws the fluid through the lines **236** and **252**, and because the head pressure in the quench tank keeps the pump supplied, the fluid will not enter line **240** or valve **238** as the actuating arm **202** engages the valve element of valve **238** upon upward movement of the elevator. As the operating fluid enters line **232** and into the bottom of the cylinder **152**, the hydraulic lift is moved upwardly through the quench zone **76** and back into the transfer zone **28**. A bleed valve **256** to which a line **258** is connected and that communicates with the interior of the quench zone is provided for bleeding the hydraulic system as required.

As previously described, a cooling gas may be introduced into the transfer zone **28** and circulated therein, and for this purpose a cooling fan **260** is provided that circulates the cooling gas prior to the quenching of heat treated articles in the quench zone **76**.

It is seen that the system as described herein is completely automatic; and, once the heat treating cycle has begun with the work cart **72** located in the heating zone **30**, the operation thereafter is carried out at predetermined intervals, wherein the heat treated articles are moved into the transfer zone **28**, thereafter moved into the quench zone **76**, and, after the quenching operation, are moved upwardly and returned to the transfer zone **28** for removal from the furnace. By rapidly removing the articles from the heating zone and quenching in the manner as illustrated and described, the surfaces of the articles being heat treated are effectively protected and the desired metallurgical properties are attained with minimal distortion of the articles. Protection is further assured by heat treating the articles under vacuum and transferring the articles to the quench zone without removal of the article from the vacuum environment. This technique of heating under vacuum and rapidly quenching prevents contamination from occurring on the surfaces of the articles and further provides the articles with an unusually bright-appearing surface.

It is understood that the vacuum furnace as described herein is preferably operated to maintain the furnace interior and quench zone at a subatmospheric pressure even during quenching. However it is contemplated that after evacuating the furnace to remove the contaminants and impurities therefrom, the heating zone, transfer zone and the area above the quench liquid can be backfilled with a suitable atmosphere so that the heat treating and quenching operations are carried out at partial pressures or even at positive pressures. Thus even though the heat treating, cooling and quench cycles could be carried out in positive pressures with respect to atmosphere, the furnace interior must still be evacuated initially and the unit would still be designated as a "vacuum furnace."

While there is shown and described herein certain specific structure embodying the invention, it will be manifest to those skilled in the art that various modifications and rearrangements of the parts may be made without departing from the spirit and scope of the underlying inventive concept and that the same is not limited to the particular forms herein shown and described except insofar as indicated by the scope of the appended claims.

What is claimed is:

1. A vacuum furnace construction, comprising a housing having a heating zone and a transfer zone located in adjacent relation, a work cart mounted for movement in said housing to and from said heating and transfer zones, means located in said zones on which said work cart is moved, said heating zone including insulating side walls in which horizontal slots are formed through which a portion of said work cart extends when it is moved into said heating zone, and means secured to said cart for shielding the slots to prevent heat loss therethrough when the work cart is located in said heating zone.

2. A vacuum furnace construction as set forth in claim **1**, said work cart being defined by a u-shaped frame having parallel legs, said means on which work cart is moved including a plurality of rollers mounted in fixed position in said housing in horizontal spaced relation, each of the legs of the work cart having a channel configuration for receiving said rollers therein and for facilitating movement of said work cart.

3. A vacuum furnace construction as set forth in claim **2**, said work cart having a plurality of cross bars interconnected to said legs for receiving a work basket thereon, said cross bars defining the portion of the work cart that extends through said slots in the insulating side walls of said heating zone.

4. A vacuum furnace as set forth in claim **3**, said shielding means including a plurality of heat shields fixed to the legs of said work cart and being disposed in shielding position relative to the slots in the insulating side walls of said heating zone when said work cart is located therein.

5. A vacuum furnace as set forth in claim 4, said heat shields including outer elements spaced inwardly of said work cart legs and outwardly of said insulating side walls, and inner elements being spaced inwardly of said outer elements and being receivable in said slots when said work cart is located in said heating zone.

6. A vacuum furnace as set forth in claim 1, said work cart including side legs that are normally located exteriorly of the insulating side walls when the work cart is positioned in said heating zone, cross bars interconnecting said legs and extending through the slots in said side walls, said shielding means being interconnected to said side legs for shielding said slots.

7. A vacuum furnace as set forth in claim 6, said shielding means including a plurality of heat shields that are plate-like in conformation and that are positioned in spaced, parallel relation.

8. A vacuum furnace as set forth in claim 7, a first set of heat shields located exteriorly of the side walls of said heating zone in adjacent relation to said slots.

9. A vacuum furnace as set forth in claim 8, a second set of heat shields interconnected to said legs and being disposed inwardly of said first set of heat shields and being receivable in the slots in the side walls of said heating zone when the work cart is located therein, wherein radiation of heat through said slots is effectively prevented during a heat treating operation.

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