Sept. 19, 1967 H. W. WESTEREN 3,342,469

SEALING DEVICE FOR HIGH VACUUM FURNACE

Filed Feb. 8, 1965 2 Sheets-Sheet 1

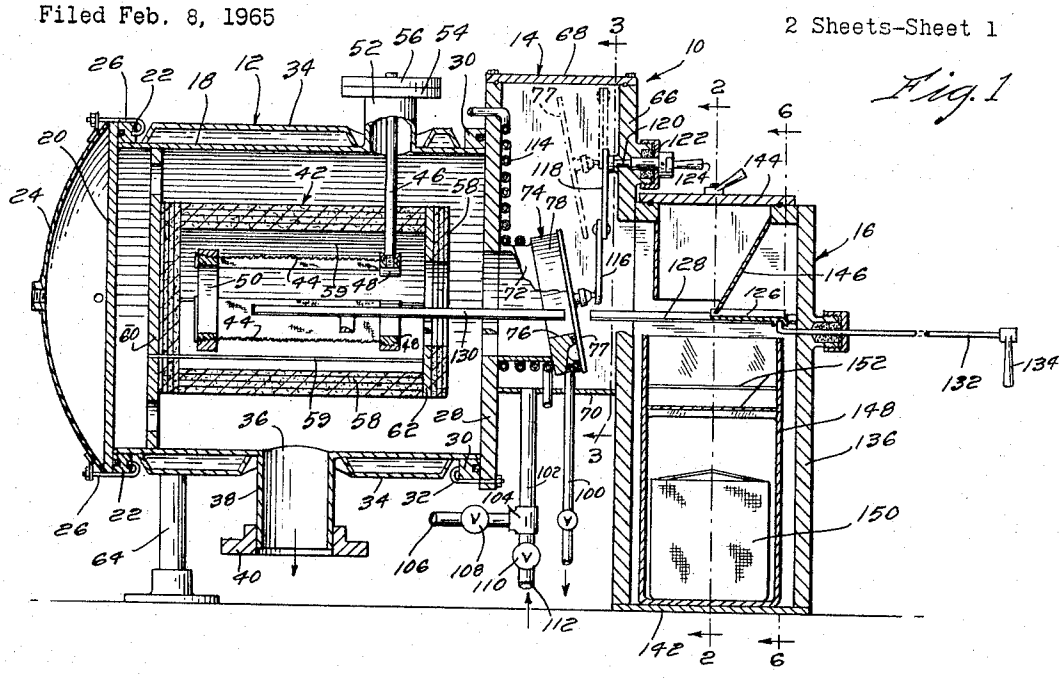

Fig. 1

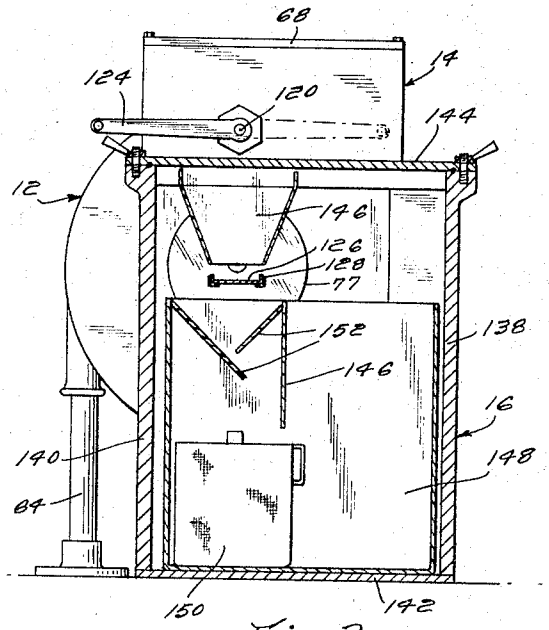

Fig. 2

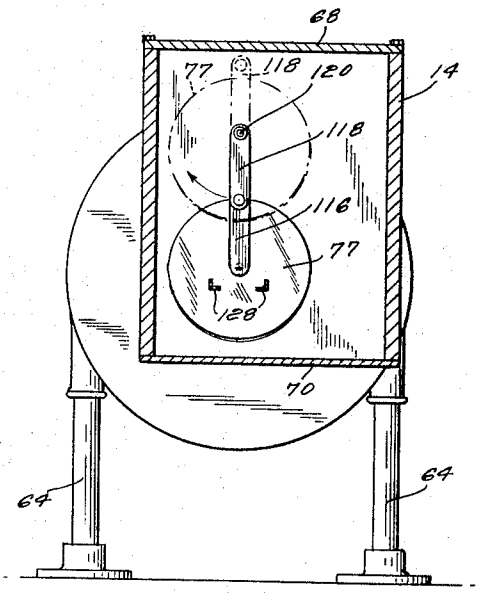

Fig. 3

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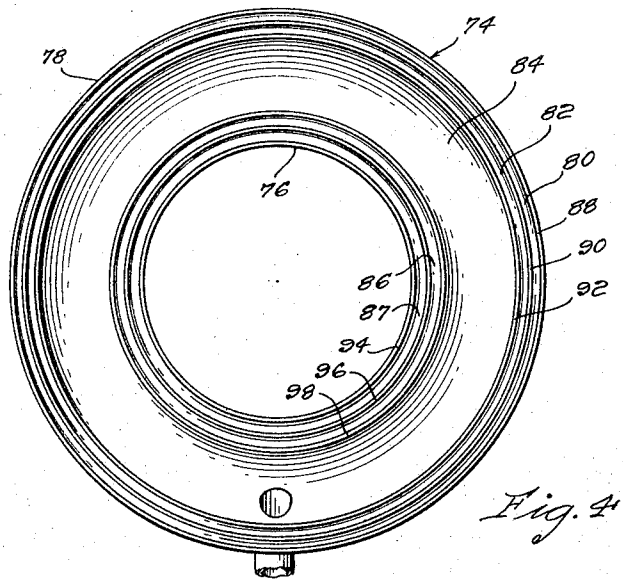

Fig. 4

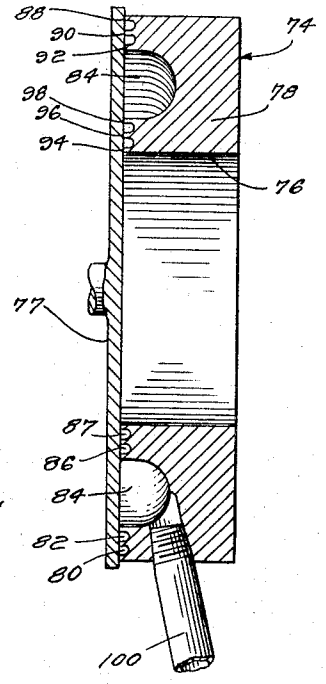

Fig. 5

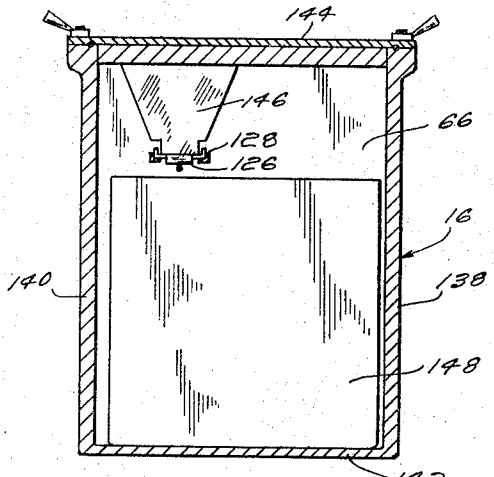

Fig. 6

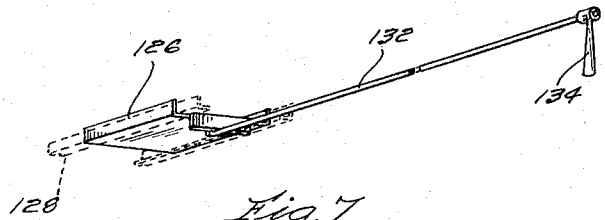

Fig. 7

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SEALING DEVICE FOR HIGH VACUUM FURNACE

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Filed Feb. 8, 1965, Ser. No. 430,989
3 Claims. (Cl. 263—36)

The present invention relates to a high vacuum electric furnace. More particularly, the present invention relates to a sealing device for use in a high vacuum electric furnace, wherein the heating chamber located within the furnace is effectively sealed during loading of work pieces in the furnace and unloading of work pieces therefrom after the heat treatment cycle.

In the prior known vacuum furnaces, it was the usual practice to place a batch of the articles to be heat treated within the furnace heating chamber, after which the heating chamber was evacuated and then heated to a prescribed temperature for heat treating the articles therein for a predetermined period of time. After the heating cycle was completed, the articles were effectively cooled and then the vacuum within the furnace was broken for the purpose of removing the heat treated work pieces therefrom.

Since it is desirable to maintain the heating chamber of the furnace under vacuum and at the heating temperature at all times, thereby providing for greater capacity of articles being heat treated, the present invention provides for continuously maintaining the heating chamber of the furnace under vacuum and at a prescribed temperature after removal of the heat treated articles therefrom and during loading and unloading of the articles to and from the furnace. Because of the high temperatures generated in the heating chamber, the usual sealing elements such as silicone, rubber, etc., are not practical for use with the door of the heating chamber for the sealing thereof.

In order to accomplish the purpose of maintaining the heating chamber of the furnace under continuous vacuum and high level temperatures, the present invention employs a unique metal-to-metal seal that provides for sealing the door of the heating chamber from an outer compartment into which the work pieces are loaded or unloaded therefrom. Since it is not practical to employ an insulation type seal for the door of the heating chamber of the furnace embodied herein, the metal-to-metal seal incorporated herein includes an annular sealing flange through which a bore extends for communication with the interior of the chamber of the furnace. The outer face of the annular sealing flange is formed with a series of concentric grooves, the centermost of which is substantially greater in depth and cross-sectional dimension than that of the remaining grooves. The spaces between the grooves define annular lands that are co-extensive with the face of the flange and are adapted to cooperate with a circular sealing plate for making metal-to-metal surface contact therewith. The annular grooves located adjacent to the larger grooves form labyrinth-type seals that cooperate with the larger groove to effectively seal the interior of the heating chamber. Since the heating chamber is under vacuum, the normal tendency of atmosphere contained in the outer compartment of the furnace would be to leak through the seal and into the bore formed in the annular sealing flange that communicates with the interior of the heating chamber. In order to prevent such leakage, the larger groove formed in the outer face of the annular sealing flange is placed in communication with a source of vacuum, such as a vacuum pump. The larger groove is thus evacuated to a vacuum pressure that corresponds generally to the vacuum conditions of the heating chamber. Any atmosphere that tends to leak through

the labyrinth seal formed by the sealing plate and the annular sealing flange will then be trapped in the larger groove and will be evacuated before it can leak into the bore of the sealing flange and then into the interior of the heating chamber.

Accordingly it is an object of the present invention to provide a furnace in which the heating chamber thereof may be maintained continuously under vacuum and at a prescribed temperature level while work pieces are loaded into the furnace or removed therefrom.

Another object of the invention is to provide an effective, yet inexpensive metal-to-metal vacuum seal for sealing the heating chamber of a high vacuum furnace.

Still another object is to provide a seal for use in a high vacuum furnace that includes a plurality of annular grooves that define a labyrinth-type seal, one of the annular grooves having communication with a vacuum source for evacuating the groove and thereby preventing ingress of atmosphere through the labyrinth seal.

Still another object is to provide a metal-to-metal seal for use in a high vacuum furnace, wherein a metallic sealing plate is remotely controlled for movement into sealing engagement with an annular sealing flange that defines a door for the heating chamber located in the high vacuum furnace.

Still another object is to provide a high vacuum furnace having externally controlled transfer apparatus for moving a load support member and articles carried thereby to and from a heating zone and for further moving the support member in a manner to transfer the articles to a quench tank after the heat treatment thereof.

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.

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

FIG. 1 is a vertical sectional view with parts shown in elevation of the furnace construction embodied in the present invention;

FIG. 2 is a sectional view taken along lines **2—2** in FIG. 1;

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

FIG. 4 is a front elevational view of the annular sealing flange embodied in the present invention;

FIG. 5 is a sectional view of the sealing flange illustrated in FIG. 4 and showing the coaction of the sealing plate therewith;

FIG. 6 is a sectional view taken along lines **6—6** in FIG. 1; and

FIG. 7 is a perspective view showing the control means and trough joined thereto on which the articles to be heat treated are mounted, the control means being actuated externally of the furnace for movement of the trough into the heating chamber of the furnace.

Referring now to the drawings and more particularly to FIG. 1, a high vacuum heat treatment furnace of the coldwall type is illustrated and is generally indicated at **10**. The heat treatment furnace **10** is electrically heated, as will be described hereinafter, and may be evacuated to 100 microns and less, being normally operated at approximately 10^{-3}–10^{-4} mm. Hg. As illustrated in FIG. 1, the furnace **10** includes a heating chamber generally indicated at **12**, an outer compartment generally indicated at **14** and communicating with the heating chamber **12**, and an outer housing generally indicated at **16** that communicates with the compartment **14** and that defines the area in which load pieces to be heat treated are inserted and withdrawn therefrom and further includes means for quickly quenching the heat treated articles that are removed from the heating chamber **12**.

The heating chamber **12** is defined by a cylindrical section **18** to which an end wall **20** is secured. The end wall **20** sealingly engages a flange **22** and has joined thereto a dome **24** the interior of which may be water cooled if it is so required. A plurality of fastening elements **26** are employed for securing the end wall **20** and dome **24** to the sealing flange **22**. Mounted in sealing engagement at the other end of the cylindrical section **18** is an end wall **28** that is secured to an end flange **30** by a plurality of fastening elements **32**. An annular jacket **34** envelops the cylindrical section **18** and is adapted to receive a cooling liquid therein for maintaining the walls of the cylindrical section at a temperature level that is safe for handling of the apparatus. The jacket **34** further provides for rapid cooling of the heating chamber when required.

As mentioned hereinabove the interior of the furnace construction is adapted to be evacuated during the heat treatment cycle, and for this purpose the cylindrical section **18** is provided with an enlarged exhaust port **36** with which a pipe **38** communicates. The pipe **38** is secured directly to the cylindrical section **18** and is provided with an outer flange **40** for securement to a corresponding flange that is, in turn, connected to suitable evacuating equipment.

Located interiorly of the heating chamber **12** is a heating unit generally indicated at **42** that includes a plurality of woven graphite flexible heating elements **44** that are secured to terminals one of which is indicated at **46** by segments **48**. The opposite end of the heating elements **44** are interconnected by a conducting ring **50**. Suitable openings are formed in the cylindrical section **18** with which mounting sleeves **52** communicate for receiving the terminals therethrough.

As described above, the woven graphite heating elements **44** define a heating zone therebetween. In order to insulate this heating zone so as to obtain the maximum benefit for the work being heat treated within the heating zone, an insulating material indicated at **58** is also provided and is located in surrounding relation with respect to the heating elements **44**. The insulating material is defined by a plurality of layers of graphite felt material, the layers being formed in annular relation to define walls as illustrated in FIG. 1. A plurality of rods **59** extend through the side layers of the insulating material **58** and are secured to a plate **60** at one end of the heating zone and to another plate **62** located at the other end of the heating zone. In connection with the specific construction of the heating chamber **12**, reference is made to the copending application Serial No. 262,686 filed March 4, 1963.

The furnace **10** is supported in position by spaced pedestals **64** that are secured to the exterior surfaces of the heating chamber **12** and by the lower end of the outer housing **16**. Disposed intermediate the outer housing **16** and the heating chamber **12** is the outer compartment **14** that is defined by the end wall **28**, an opposing wall **66**, a top wall **68** and a bottom wall **70**, the top wall **68** and bottom wall **70** being secured to the end walls **28** and **66**. Extending into the interior of the outer compartment **14** and formed as part of the end wall **28** is a pipe **72** to which an annular flange **74** is joined. The annular flange **74** is inclined with respect to the vertical and is provided with a bore **76** therein that communicates with the interior of the pipe **72** and the cylindical section **18** of the heating chamber **12**.

The annular flange **74** defines a port through which the articles to be heat treated are inserted and is adapted to be sealed after the heat treatment cycle and removal of the articles from the interior of the heating chamber **12**. For this purpose the annular flange **74** is formed in such a manner so as to cooperate with a sealing plate **77** for effectively sealing the interior of the heating chamber **12**. Referring now to FIGS. 4 and 5, the annular flange **74** is illustrated in detail and includes a body portion **78** in which the bore **76** is formed. The outer surface of the

body **78** is formed with a plurality of concentric annular grooves that are formed in pairs around an enlarged central groove. Thus as shown in FIGS. 4 and 5 outer annular grooves **80** and **82** surround an enlarged annular groove **84** as opposed to the interior annular grooves **86** and **88**. The annular grooves **80** and **82** cooperate with the enlarged annular groove **84** to define annular lands **88**, **90** and **92**, while the interior annular grooves **86** and **87** cooperate with the enlarged annular groove **84** to define lands **94**, **96** and **98**. As will be described hereinafter, the sealing plate **77** is adapted to be placed in metal-to-metal engagement with the lands defined by the annular grooves and thus form a seal therewith. The annular grooves **80**, **82**, **84**, **86** and **87** define a labyrinth seal with the sealing plate **77** and eliminate the requirement of the usual flexible sealing construction such as silicone or rubber normally associated with seals in high vacuum apparatus. It is understood that the use of the heretofore known flexible seals is not practical in the present invention because of the high temperatures that are associated with the apparatus described herein.

In the operation of the furnace **10**, after removal of the heat treated articles from the heating chamber **12**, the sealing plate **77** is moved into engagement with the face of the sealing flange **74** and thereafter the vacuum that is present in the outer compartment **14** and the housing **16** is broken so that the heat treated articles may be removed from the furnace and additional articles inserted therein without breaking the vacuum within the heating chamber **12**. Since the areas surrounding the annular sealing flange **74** are subjected to atmosphere or pressures above atmosphere, a tendency for the atmosphere to leak through the labyrinth seal of the annular flange and into the bore **76** for entry into the interior of the heating chamber **12** is present. In order to eliminate any tendency of leakage through the annular flange **74**, the enlarged annular groove **84** is placed into communication with a source of vacuum such as a vacuum pump by means of a pipe **100**. With the space defined by the annular groove **84** under vacuum, any tendency of atmosphere to leak through the annular grooves **86** and **87** and then through the grooves **80** and **82**, will be prevented, since the atmosphere that may have leaked through the grooves **86**, **87** will be quickly pumped out through pipe **100** by the vacuum pump communicating therewith. The annular groove **84** is formed sufficiently large enough to provide an enlarged vacuum area that will trap leaking atmosphere therein for evacuation through the pipe **100**. The leak rate across the annular grooves **86** and **87** and the corresponding lands **94**, **96** and **98** is thereby effectively reduced for preserving the vacuum that is maintained within the interior of the heating chamber **12**.

In order to evacuate the outer compartment **14** and the interior of the outer housing **16** and to further supply an atmosphere under pressure therein where required, the pipe **102** is provided and extends through the bottom wall **70** of the outer compartment. Connected to the pipe **102** by a coupling **104** is a pipe **106** that communicates with a source of vacuum such as a vacuum pump. A valve **108** is adapted to control communication of the pipe **106** with the pipe **102** and is operated concurrently with a valve **110** that controls communication of a pipe **112** with the pipe **102**. An atmosphere under pressure may be introduced through the pipe **112** and valve **110** for entry into the compartment **14** and housing **16** when the vacuum is broken therein.

Since the extension **72** of the wall **28** is located in communication with the heating chamber **12**, together with the wall **28**, cooling coils **114** through which a cooling liquid is circulated are placed into contact with extension **72** and the wall **28**.

As hereinabove, stated, movement of the sealing plate **77** is adapted to be remotely controlled for placing the plate in contact with the sealing flange **74**. For this purpose the sealing plate **77** is connected to a lever **116** that is

in turn joined to a bar **118** through which a shaft **120** extends. The shaft **120** projects through the sealing gland **122** in the wall **66** and is provided with a handle **124** on the outer end thereof. It is seen that manipulation of the handle **124** will move the bar **118** and lever **116** for positioning the plate **77** in proper sealing relation on the face of the sealing flange **74**.

It is seen that there is no requirement for utilizing clamps, bolts, or other positive locking elements for sealing the plate **77** to the sealing flange **74**. Thus, after the handle **124** has been operated to locate the plate in proper sealing position on the sealing flange **74** and the pressure in the compartment **14** is brought to atmospheric, the pressure differential produced between the heating chamber **12** and the compartment **14** will be sufficient to lock the plate **77** in place. The seal across the sealing flange **74** is then effectively maintained by means of the labyrinth seal defined by the grooves **80**, **82**, **86** and **87**, the lands **88**, **90**, **82**, **84** and **86**, the large annular groove **84**, and the plate **77**.

Although various techniques may be employed for inserting the work pieces to be heat treated into the heating chamber **12**, as shown in FIGS. 1, 2 and 7 a track assembly is utilized on which the work support defined by a trough **126** is mounted. The track assembly includes a first track **128** that extends through the housing **16** and into the compartment **14**. Disconnected from the first track section **128** and extending from the interior of the bore **76** into the heating zone of the heating chamber **12** is a second track section **130**. Since the heating chamber **12** must be completely enclosed after withdrawal of the work pieces therefrom the track section **128** and **130** are disconnected as indicated. Although not shown in detail, it is understood that the track sections **128** and **130** are suitably supported in position within the furnace **10**. The trough **126** is mounted for movement on the track sections **128** and **130** and in order to accomplish movement of the trough from a position exteriorly of the chamber **12** an actuating rod **132** is connected to the rear end of the trough and includes a handle **134** that is joined to the outermost end thereof. The first track section **128** is located at a load and unload station in the housing **16** and as seen in FIGS. 1 and 2 the housing **16** is defined by the wall **66**, a forward wall **136**, side walls **138** and **140**, a bottom wall **142** and a removable loading door **144**. A directing chute **146** is located within the upper part of the housing **16** below the door **144** and provides for directing work pieces into the trough **126**. A quench tank **148** is located within the housing **16** below the track section **128** and includes a quench basket **150** therein into which the heat treated articles are directed after the heat treatment thereof. A baffle construction indicated at **152** is also formed as part of the quench tank **148** and prevents vaporized quenching medium from escaping from the quench tank **148**. It is seen that after the articles to be heat treated are loaded into the trough **126**, the trough is moved on the track section **128** and then onto the track section **130** for placement within the heating zone of the heating chamber **12**. During movement of the trough **126** to the heating zone, it is understood of course that the sealing plate **77** is located in the open position thereof as seen in dotted lines in FIG. 1.

In operation after the articles to be heat treated are placed on the trough **126** and before movement into the heating zone within the heating chamber **12** the compartment **14** and housing **16** are evacuated. The interior of the heating chamber **12** is maintained at the prescribed temperature level and the area therein is continuously evacuated by the vacuum pump that is interconnected to the heating chamber **12** through the pipe **38** and port **36**. In order to evacuate the compartment **14** and housing **16**, the valve **112** connected to the atmosphere source is closed and the valve **108** is opened so that the pipe **102** is placed into communication with the vacuum pump for the evacuation of the compartment **14** together with the interior of the housing **16**. It is understood, of course, that the door **144** is located in closed position after loading of the articles on the trough **126**. The sealing plate **77** is then opened after the compartment **14** and housing **16** are evacuated to receive the trough and articles thereon for entry into the heating chamber **12**. After completion of the heating cycle, the trough **126** and the articles thereon are withdrawn from the heating chamber into the housing **16**, at which point the articles in the trough **126** are engaged by the chute **146**, which knocks the articles off the trough and into the quench tank **148** for quick quenching thereof. As described in copending application Ser. No. 422,617, filed Dec. 31, 1964, the quick quenching of the heat treated articles while the articles are continuously exposed to a vacuum prevents the contamination of the surfaces thereof and provides a bright appearing surface.

After the articles have been dumped into the quench tank **148**, and the basket **150** therein removed, the sealing plate **77** is once again moved into contact with the sealing flange **74** to effectively seal the interior of the heating chamber **12**. It is at this time that the valve **108** is closed and the valve **110** opened to admit atmosphere into the compartment **14** and the housing **16**. This breaks the vacuum in the compartment **14** and housing **16** and the door **144** may then be opened for placement of additional articles to be heat treated into the trough **126**. After placement of the articles to be heat treated in the trough **126**, the valve **110** is again closed and the valve **108** opened to effectively evacuate the interior of the compartment **14** and the housing **16**. During the interim period that the compartment **14** and housing **16** was exposed to atmosphere, the annular groove **84** in the sealing flange **74** was being evacuated through the pipe **100**. Evacuation of this groove effectively prevented leakage of the atmosphere through the labyrinth seal in the sealing flange defined by the grooves **80** and **82**. After the compartment **14** and the housing **16** are evacuated through the pipe **102**, the plate **77** is withdrawn from the sealed position thereof by manipulation of the handle **124** and the trough **126** with the articles thereon, may then be moved on the track sections **128** and **130** to place the trough **126** and the articles thereon within the heating zone in the heating chamber **12**.

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. In a furnace for use in heat treating metallic articles, a heating chamber in which said articles are heat treated at relatively high temperatures, a compartment communicating with said heating chamber and receiving said articles prior to introduction into said heating chamber and after the heat treating operation, a metal sealing member located between said heating chamber and compartment and having a bore formed therein that provides communication between said heating chamber and compartment when said articles are moved to and from said heating chamber, said metal sealing member being subjected to the high temperatures generated in said heating chamber, means for controlling the pressure in said heating chamber and compartment during the heating cycle of said articles wherein the pressure in said heating chamber is the same as that maintained in said compartment, a metal sealing plate that is movable into engaging relation with said sealing member when said bore is to be sealed for maintaining the temperature and pressure in said heating chamber, the face of said sealing member with which said sealing plate engages having a cavity formed therein, a vacuum source communicating with said cavity for imposing a negative pressure therein when

said plate is in engagement with said sealing member, wherein a vacuum seal is formed across the engaging portions of said sealing member and plate, said sealing member being free of sealing materials so that there is only metal-to-metal contact between said plate and sealing member and the heat to which the sealing member is subjected is transferred to said sealing plate, means for introducing a gaseous medium into said compartment after said plate has been placed in contact with said sealing member for increasing the pressure in said compartment, said sealing plate being sealed to said sealing member by the differential pressure between the heating chamber and compartment when said sealing plate is engaged with said sealing member, and means for moving said plate into and out of contact with said sealing member.

2. In a furnace as set forth in claim 1, a plurality of grooves formed in the face of said sealing member, said grooves cooperating with said cavity to define lands therebetween, the grooves and lands forming a labyrinth seal with said cavity between said sealing member and plate.

3. In a furnace as set forth in claim 2, said cavity that communicates with a vacuum source being greater in cross-sectional dimension than that of the other grooves and being located substantially coaxial in the face of said sealing member and in surrounding relation with respect to said bore.

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