Sept. 20, 1971 I. P. BIELEFELDT 3,606,287

HEAT TREATING APPARATUS FOR METAL WORKPIECES

Filed Nov. 24, 1969 2 Sheets-Sheet 1

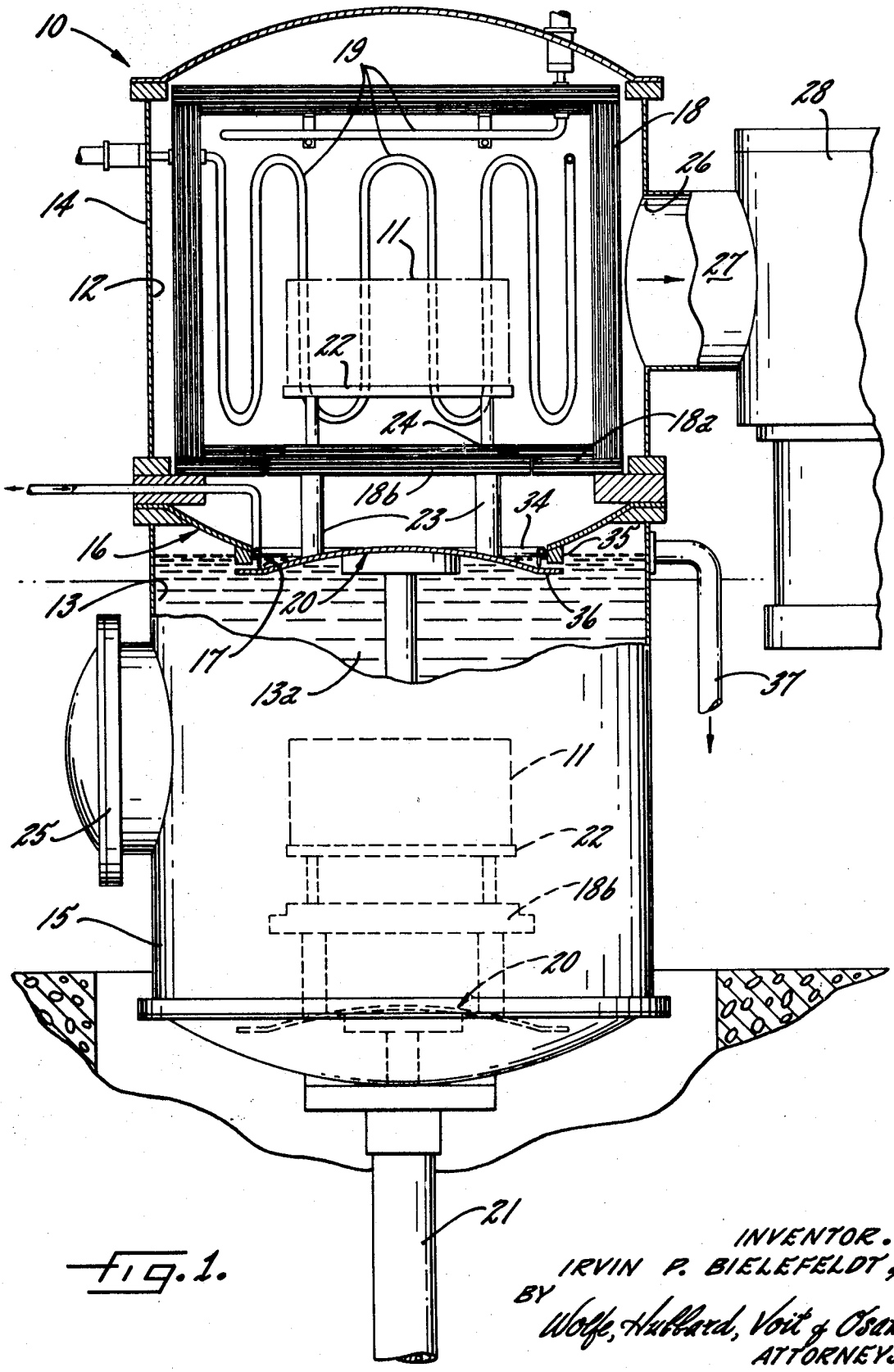


Fig. 1.

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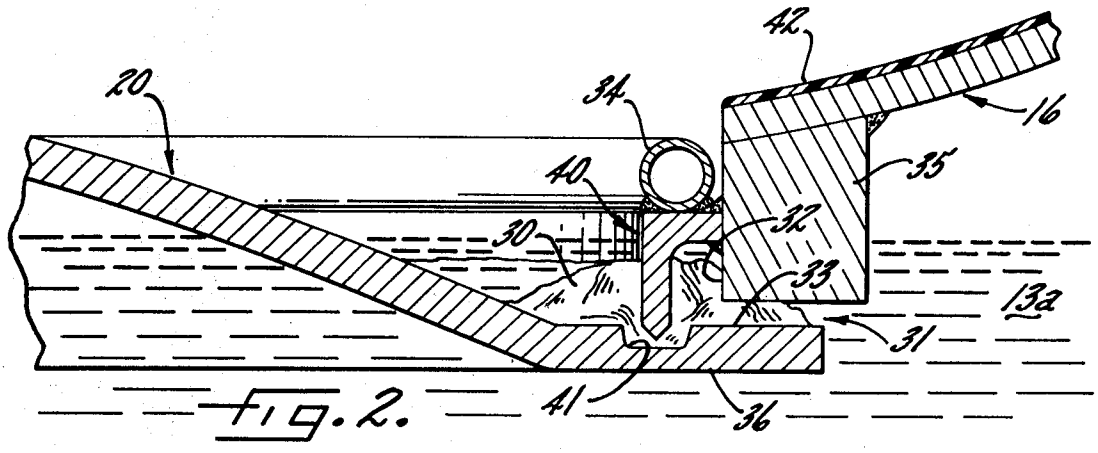


Fig. 2.

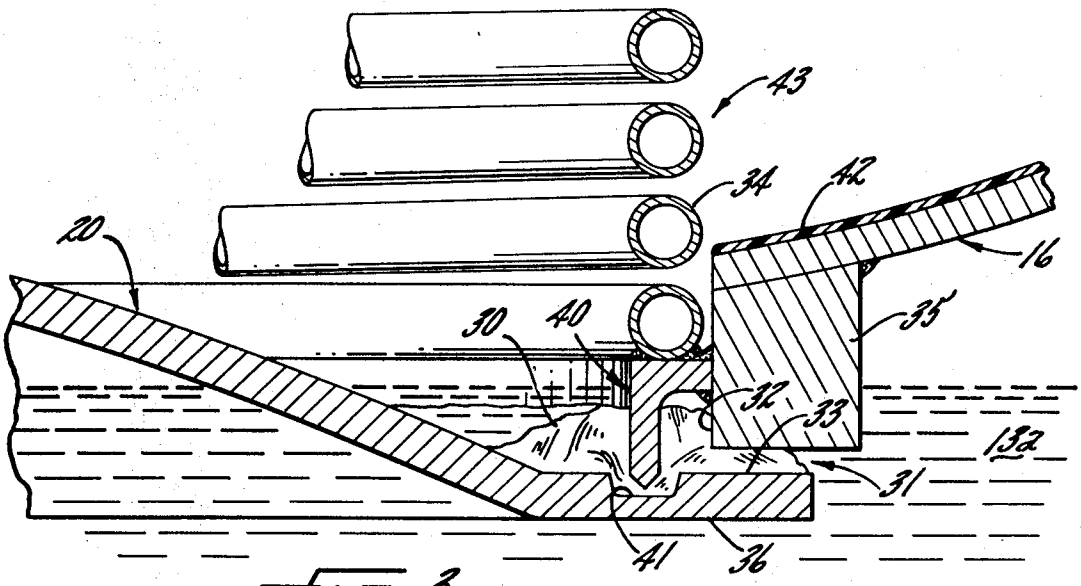


Fig. 3.

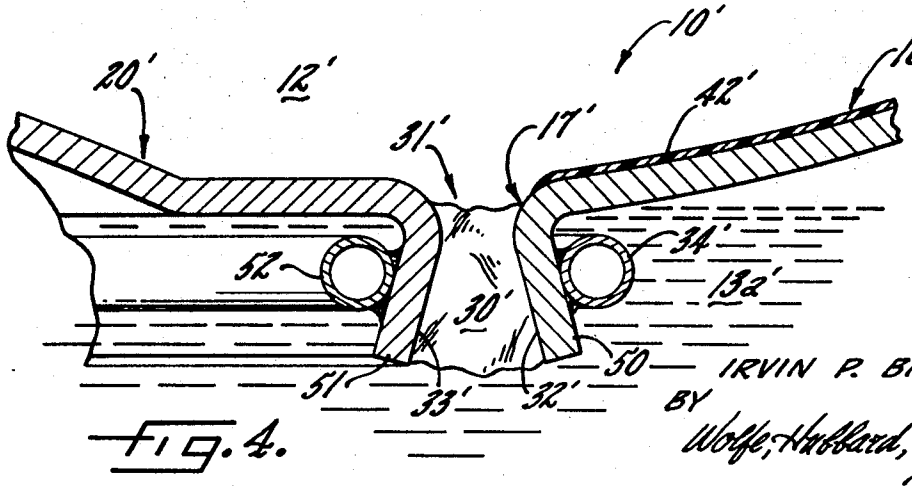


Fig. 4.

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HEAT TREATING APPARATUS FOR METAL WORKPIECES

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ABSTRACT OF THE DISCLOSURE

A seal of frozen quenching liquid is formed in a heat treating apparatus between the sealing surfaces of a flange defining an opening in a heating chamber and a closure member for blocking the opening, the seal being gastight so that the atmosphere within the chamber can be controlled.

BACKGROUND OF THE INVENTION

This invention relates to heat treating apparatus and, more particularly, to heat treating apparatus for treating a workpiece in a controlled atmosphere. A walled enclosure with an opening defines a heat treating chamber and, to close the opening for purposes of controlling the atmosphere within the chamber, a closure member is movable from an open position to a closed position in which the closure member blocks the opening. To completely close the opening and maintain the controlled atmosphere, a seal must be established between the sealing surfaces of the closure member and the enclosure.

SUMMARY OF THE INVENTION

It is the primary object of the present invention to provide a novel seal which can be broken quickly and without first changing the pressure of the controlled atmosphere to conform to the pressure of the atmosphere on the other side of the closure member, thus allowing earlier movement of the closure member from the closed position after treatment of the workpiece is completed.

It is a more detailed object to provide the seal by freezing a liquid between the sealing surfaces of the enclosure and the closure member, thus forming a seal of frozen liquid which can be shattered easily by initial movement of the closure member preparatory to opening thereby to allow the immediate passage of a gas through the opening.

It is a related object to accomplish the above by providing a chamber containing a quenching liquid adjacent the opening in the enclosure and by freezing a portion of the quenching liquid to form the seal.

Another object of the inventoin is to provide a seal of the above character in a vertical lift heat treating apparatus which is formed with a walled enclosure defining a heat treating chamber in the upper end portion and a quenching chamber filled with a quenching liquid in the lower end portion, the two chambers communicating through an opening defined by a flange extending inwardly from the walls between the two chambers. The closure member supports the workpiece and is movable vertically between the closed position in which the workpiece is positioned in the heat treating chamber and the lowered or open position in which the workpiece is disposed in the quenching liquid. In the preferred apparatus, the controlled atmosphere in the heat treating chamber is a vacuum.

It is a more detailed object to provide, in a vertical lift heat treating apparatus of the above type, a tube for circulating a coolant which freezes the quenching liquid, the tube being advantageously positioned not only to cause freezing of a portion of the quenching liquid to form the seal but also to cause freezing of moisture vapors in the heat treating chamber to assist in establishing a high order of vacuum in the heat treating chamber.

The invention also resides in the novel provision of a layer of nonwettable material on the upper surface of the flange to expedite the removal of liquid from the heat treating chamber by forcing any liquid on the flange to run off quickly toward the opening to be frozen by the coolant.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary elevational view partly in section of a heat treating apparatus embodying the novel features of the present invention.

FIG. 2 is an enlarged, fragmentary, cross-sectional view of a portion of the apparatus in FIG. 1 and showing ing the seal of frozen quenching liquid and the tube for circulating the coolant to freeze the liquid.

FIG. 3 is a fragmentary view similar to FIG. 2 but showing a modification of the tube for circulating the coolant.

FIG. 4 is a fragmentary view of a second embodiment of the heat treating apparatus.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in the drawings for purposes of illustration, the invention is embodied in an apparatus **10** (FIG. 1) for heat treating metal workpieces **11** (one shown in phantom in FIG. 1) in a heating chamber **12** in which the atmosphere is controlled and, preferably quenching the workpieces in a quenching chamber **13** filled with a quenching liquid **13***a*. In this instance, the heating chamber is defined by a vertically disposed, cylindrical enclosure or vessel **14**, and the quenching chamber is defined by a similar vessel **15**. The vessels are each open at one end, are positioned open end-to-open end and are sealed together with a gastight seal. A partition or flange **16** positioned between the open ends of the two vessels extends inwardly and defines a central opening **17** through which the two vessels commuicate.

To form and insulate a heating area within the heating chamber **12** in the upper vessel **14**, a hollow cylinder is formed of heat shield packs **18** made up of layers of metal foil. Inside the cylinder are heating elements **19** to heat the interior of the cylinder, and the packs reflect the heat inwardly so that upper vessel **14** remains relatively cool during heating of the workpiece within the cylinder formed by the packs.

To block and unblock the opening **17**, a closure member **20** is moved up and down by a hydraulic ram **21** and, in the upper position, the closure member blocks the opening to act as a barrier between the heating and quenching chambers **12** and **13**. The workpiece **11** is supported on a hearth **22** which is mounted by legs **23** on the upper side of the closure member. To enable access to the heating area within the cylinder formed by the packs, a hole **24** is formed in the bottom heat shield pack **18***a*, and a disc-shaped heat shield pack **18***b* is mounted on the legs for movement with the closure member to plug the hole when the closure member is in the upper position. When the closure member is in the upper position, the workpiece is disposed within the heating area and, when the closure member is in the lower position, the workpiece is disposed in the quenching chamber. The workpiece is placed on and removed from the hearth, when the closure member is in the lower position (shown in phantom in FIG. 1), through a door **25** in the side of the lower vessel **15**.

In this instance, the controlled atmosphere which is maintained in the heating chamber **12** is a vacuum, the heating chamber being evacauted through a port **26** in the

side of the upper vessel **14**. The port is connected by a pipe **27** to a vacuum pump **28**. To separate the heating chamber from the quenching chamber **13** when the vacuum is pulled on the heating chamber, the closure member **20** is shifted to the raised position, and a gastight seal **30** (FIG. 2) is formed in the gap **31** between the sealing surfaces **32** ad **33** of the flange **16** and the closure member, respectively.

In accordance with the present invention, the seal **30** is formed by freezing a portion of the quenching liquid **13***a* to form a continuous gastight seal of frozen quenching liquid between the closure member **20** and the flange **16**. For this purpose, a coolant is circulated through a tube **34** positioned adjacent the surfaces **32** and **33** to freeze the quenching liquid located between the two surfaces. With this arrangement, a dependable, gastight seal **30** can be easily formed, and the frozen seal can be easily shattered by slight initial movement of the hydraulic ram **21** preparatory to lowering of the closure member after heating of the workpiece **11** is completed. Such shattering allows a portion of the quenching liquid in the quenching chamber **13** to pass immediately through the gap **31** and to vaporize from the heat and low pressure in the heating chamber, thus destroying the vacuum in the heating chamber **12** and tending to equalize the pressure in the two chambers. This allows the closure member and the workpiece to be lowered into the quenching chamber sooner after heating is completed than has been possible heretofore.

In this instance, the flange **16** and the closure member **20** are formed to place the sealing surfaces **32** and **33** just under the upper surface of the quenching liquid **13***a* in the quenching chamber **13** so that ample quenching liquid is available to be frozen to form the seal while the largest portion of both the flange and the closure member are located above the upper surface of the quenching liquid. As best shown in FIG. 1, the flange extends downwardly as well as inwardly to form the opening **17** and, in the embodiment of FIG. 2, an annulus **35** with a generally rectangular cross section forms a part of the flange. The annulus encircles the opening and extends downwardly into the quenching liquid. The closure member curves outwardly and downwardly from its center and is formed at its peripheral edge with a flat horizontal rim **36** (FIG. 2). The outer edge portion of the rim extends under the annulus. An outlet pipe **37** (FIG. 1) in the wall of the lower vessel **15** keeps the level of the quenching fluid about one-third of the way up the annulus. With this arrangement, only a small amount of the quenching liquid is located above the upper surface of the closure member and inwardly of the outer vertical edge of the annulus so that only a small amount of the quenching liquid must be frozen to form the seal **30**.

To freeze a portion of the quenching liquid **13***a* to form the seal **30** between the sealing surfaces **32** and **33**, the tube **34** encircles the opening **17** and is supported by the flange **16**. The coolant, in this instance liquid nitrogen at —321 degrees F., is circulated through the tube when the closure member **20** is in the upper position to block the opening **17** thus placing the sealing surfaces in a sealing position. Normally, the liquid nitrogen is circulated only when the closure member blocks the opening.

So that a complete seal **30** can be formed and still be easily shattered, a thermal conducting member **40** (FIG. 2) with an L-shaped cross section is rigidly connected to the inside vertical wall of the annulus **35** and extends inwardly and then downwardly to concentrate the freezing effect of the tube **34** and to form a wedge in the seal **30**. The tube **34** is mounted on the upper surface of the horizontal leg of the thermal conducting member and is located generally over the vertical leg thereof, thus causing the freezing effect of the liquid nitrogen to be concentrated along the vertical leg of the thermal conducting member. As most clearly shown in FIG. 2, the lower end portion of the vertical leg is pointed and is fitted very

loosely into a groove **41** in the upper surface of the rim **36**, the groove extending entirely around the rim. With this arrangement, the seal of frozen quenching liquid completely seals the gap **31** between the flange and the closure member **20** while the vertical thickness of the seal is kept small for easy shattering. Additionally, there is no straight line path through the seal thus reducing the possibility of the seal popping out of the gap from the effect of the pressure differential between the heating chamber **12** and the quenching chamber **13**. Due to the circulation of the liquid nitrogen, any quenching liquid which might be pulled into the gap, should a crack appear in the seal, is quickly frozen thus keeping the seal gastight.

Before the closure member **20** can be lowered to place the workpiece **11** in the quenching liquid **13***a* after the heat treating of the workpiece, the pressure on both sides of the closure member must be nearly equal. In other words, the vacuum must be broken to permit movement of the closure member to its open position. To destroy the vacuum and raise the pressure in the heating chamber **12**, gas is admitted into the heating chamber through the opening **17**. When the heat treating is completed, the circulation of the liquid nitrogen is stopped, and the hydraulic ram **21** is activated to move slightly, thus shaking the closure member. As a result of the movement of the closure member, the seal **30** is shattered. As soon as the seal shatters, the quenching liquid is pulled into the heating chamber through the cracks in the seal by the reduced pressure in the heating chamber. Since the liquid nitrogen is not being circulated, there is little tendency of the quenching liquid to freeze, and it passes freely through the seal. Upon reaching the heating chamber, the quenching liquid is vaporized by the heat and low pressure and fills the heating chamber as a gas thus tending to equalize the pressure in the heating chamber with that in the quenching chamber **13**. As soon as the pressures in the two chambers are nearly equal, the hydraulic ram is activated to lower the closure member, thus quenching the workpiece. While the seal is broken in this instance by movement of the closure member, a heated liquid or gas may be circulated through the tube **34** to melt the seal after the circulation of the liquid nitrogen is stopped.

To pull a vacuum in the heating chamber **12** prior to heating the workpiece **11**, the closure member **20** must be raised and the seal **30** formed to make the heating chamber gastight. To pull the vacuum, most of the gases in the heating chamber must be removed, and these gases include those created by vaporization of the quenching liquid **13***a* during the quenching of the previous workpiece. The lower end portion of the heating chamber is formed in an advantageous manner to aid the vacuum pump **28** by assisting in removal of the vaporized quenching liquid. As the quenching liquid condenses due to the lowering temperature in the heating chamber caused by the coolant being circulated in the tube **34**, droplets of quenching liquid are formed on the upper surface of the flange **16**. The flange is covered with a layer **42** (FIG. 2) of nonwettable material, such as Teflon, thus causing the droplets to run down the flange immediately upon forming on the flange until reaching the seal to be frozen. The word "nonwettable" is used herein to refer to a material which, after having a liquid dumped thereon, will not hold a small film of the liquid on its surface as is normal with most materials due to intersurface attraction between the liquid and the material.

While the tube **34** is normally formed as a single loop around the opening **17** as shown in FIGS. 1 and 2, the tube may be formed as a coil **43** several loops high (FIG. 3) to extend upwardly into the heating chamber **12** to cool the heating chamber more quickly and thoroughly thus rapidly condensing a large portion of the vaporized quenching liquid and to reduce the load on the vacuum pump.

A modified heat treating apparatus **10′** embodying the novel features of the invention is shown in FIG. 4 in which

parts corresponding to those of the first embodiment are indicated by the same but primed reference numerals. Like the first embodiment, a closure member **20'** is raised to block an opening **17'** defined by a flange **16'**, and a seal **30'** of frozen quenching liquid **13***a'* is formed between the sealing surfaces **32'** and **33'** of the flange and the closure member, respectively. To freeze the quenching liquid, a tube **34'** for circulating liquid nitrogen is mounted on the flange and encircles the opening. The upper surface of the flange is covered with a layer **42'** of a nonwettable material to insure the quick run off of condensing vapors.

In this embodiment, the cross section of the seal **30'** is shaped generally like an inverted V. To form the seal in this shape, the inner edge portion of the flange **16'** is bent to form a leg **50** which extends downwardly and outwardly, and a second leg **51** extends downwardly and inwardly from the peripheral edge of the closure member **20'**. When the closure member is in the raised position, these two legs oppose each other, and their opposing surfaces **32'** and **33'** define a generally inverted V-shaped gap **31'**.

The tube **34'** extends around the outside of the flange leg **50**. To increase the cooling force directed toward the gap **31'**, a second tube **52** for circulating liquid nitrogen is mounted on the inside of the leg **51** of the closure member **20'**. The level of the quenching liquid **13***a'* is maintained at about the top of the leg **50**. After the closure member is moved to the raised position, the liquid nitrogen is circulated in the tubes **34'** and **52'** to freeze the quenching liquid in the gap **31'** thus forming the seal **30'**. Because a vacuum is pulled on the heating chamber **12'** all of the force on the seal is upwardly directed, and the inverted V-shape of the seal causes the seal to bear against the legs **50** and **51**. Thus, the seal is prevented from popping upwardly out of the gap. As in the first embodiment, movement of the closure member preliminary to lowering of the closure member breaks the seal. Thus, the quenching liquid in the quenching chamber **13'** is allowed to pass through the gap to vaporize and thereby equalize the pressure in the two chambers for quick lowering of the closure member and workpiece into the quenching chamber.

It will be observed that the freezing of a portion of the quenching liquid **13***a*, **13***a'* to form a seal **30**, **30'** between the sealing surfaces **32**, **32'** and **33**, **33'** of the flange **16**, **16'** and the closure member **20**, **20'** is a particularly advantageous arrangement. With this arrangement, the seal formed is gastight but can be broken quickly and easily without the necessity of generally equalizing the pressures in the heating chamber **12**, **12'** and the quenching chamber **13**, **13'** prior to breaking the seal. Further, the lower temperature generated to freeze the quenching liquid is utilized to aid the vacuum pump **28** in pulling a vacuum on the heating chamber by causing the vaporized quenching liquid in the heating chamber to condense and then by freezing the condensate thus removing a portion of the gas from the heating chamber. Advantageously, the flange is covered with the layer **42**, **42'** of nonwettable material to cause the condensed quenching liquid to run off the flange quickly. Additionally, it is beneficial to extend the tube **34** upwardly in a coil to condense the vaporized quenching liquid more rapidly.

I claim as my invention:

1. Heat treating apparatus comprising a hollow, vertically disposed enclosure having an upper portion defining a heating chamber, the lower portion of said enclosure defining a quenching chamber containing a quenching liquid, a flange projecting inwardly from and extending around the walls of said enclosure and separating the upper chamber from the lower chamber, said upper and lower chambers communicating with one another through an opening defined by said flange, a closure member, power operated mechanism selectively operable to move said closure member between an upper position in which said member closes said opening and a lower position in said quenching chamber, a hearth supported on the upper side of said closure member to receive a workpiece so that the workpiece moves between the heating chamber and the quenching chamber upon movement of said closure member between said positions, and means for drawing a vacuum in the heating chamber when said closure member is in said upper position, the improvement in said apparatus comprising, means for freezing a portion of the quenching liquid between the edge portion of said flange which defines said opening and said closure member when the latter is in said upper position thereby to form a gastight seal of frozen quenching liquid between said closure member and said flange to seal said heating chamber in a gastight condition.

2. The apparatus of claim **1** in which said freezing means comprises a tube mounted on said fiange and extending around said opening, and coolant circulating in said tube for freezing said liquid.

3. The apparatus of claim **2** in which said tube is formed in a plurality of coils extending upwardly from said flange into said heating chamber to condense and then to freeze vapors in said heating chamber thus assisting said vacuum drawing means in removing gases from said heating chamber.

4. The apparatus of claim **1** in which said flange includes an L-shaped member projecting into said opening with one leg horizontal and one leg extending downwardly, said tube being mounted on said horizontal leg, a groove formed in the upper surface of the closure member with the lower end of said downwardly extending leg being loosely fitted in said groove when said closure member is in said raised position, the quenching liquid being frozen in said groove and around said downwardly extending leg to form said seal so that said downwardly extending leg forms a wedge in said seal to shatter the latter on movement of said closure member.

5. The apparatus of claim **1** in which said flange includes a downwardly and outwardly projecting leg extending around the periphery of said opening, said closure member including a downwardly and inwardly projecting leg which extends around the periphery of said closure member and opposes said first leg thus forming a generally inverted V-shaped gap between said legs when said closure member is in said raised position, and said freezing means including a tube extending around one of said legs and coolant circulating in said tube whereby said seal is formed between said legs as a plug of inverted V-shaped cross-section.

6. The apparatus of claim **5** in which said tube is mounted on the outside of said outwardly extending leg, a second tube mounted on and extending around the inside of said inwardly extending leg, and coolant circulating in said second tube.

7. The apparatus of claim **1** in which the upper surface of said flange is covered with a layer of nonwettable material to help remove liquid from said heating chamber.

8. In a heat treating apparatus, the combination of, a walled enclosure with an opening at one end and defining a heat treating chamber, a closure member for closing said opening and movable between closed and open positions, a liquid located between the adjacent surfaces of the walls of said enclosure and said closure member when said closure member is in the closed position, and means for freezing said liquid to form a gastight seal of frozen liquid between said closure member and said walls to seal said enclosure gastight.

9. The apparatus of claim **8** in which said means comprises a tube mounted on said enclosure around said opening, and coolant circulating in said tube to freeze said liquid.

10. The apparatus of claim **9** in which said means further includes a second tube mounted on said closure member around the periphery of said closure member, and coolant circulating in said second tube.

11. The apparatus of claim 8 in which said means comprises a tube mounted on said closure member around the periphery of said closure member and coolant circulating in said tube to freeze said liquid.

12. Heat treating apparatus comprising, in combination, a walled enclosure defining a heating chamber in one portion and a quenching chamber in another portion, a partition separating said chambers, the two chambers communicating with one another through an opening in said partition, a closure member movable between open and closed positions with respect to said opening and having a surface adjacent to the surface of said partition when in said closed position, mechanism for varying the pressure of the atmosphere in said heating chamber when said closure member is in said closed position, a quenching liquid in said quenching chamber, and means for freezing a portion of the quenching liquid between adjacent surfaces of said partition and said closure member when the latter is in said closed position thereby to form a gastight seal of frozen quenching liquid between said closure member and said partition to seal said heating chamber gastight.

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