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(54) **FLAPPER GAS NOZZLE ASSEMBLY**

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C21B 7/16 (2006.01)
C21D 9/00 (2006.01)

(52) **U.S. Cl.** **266/250**; 266/270

(58) **Field of Classification Search** 266/249, 266/250, 270
See application file for complete search history.

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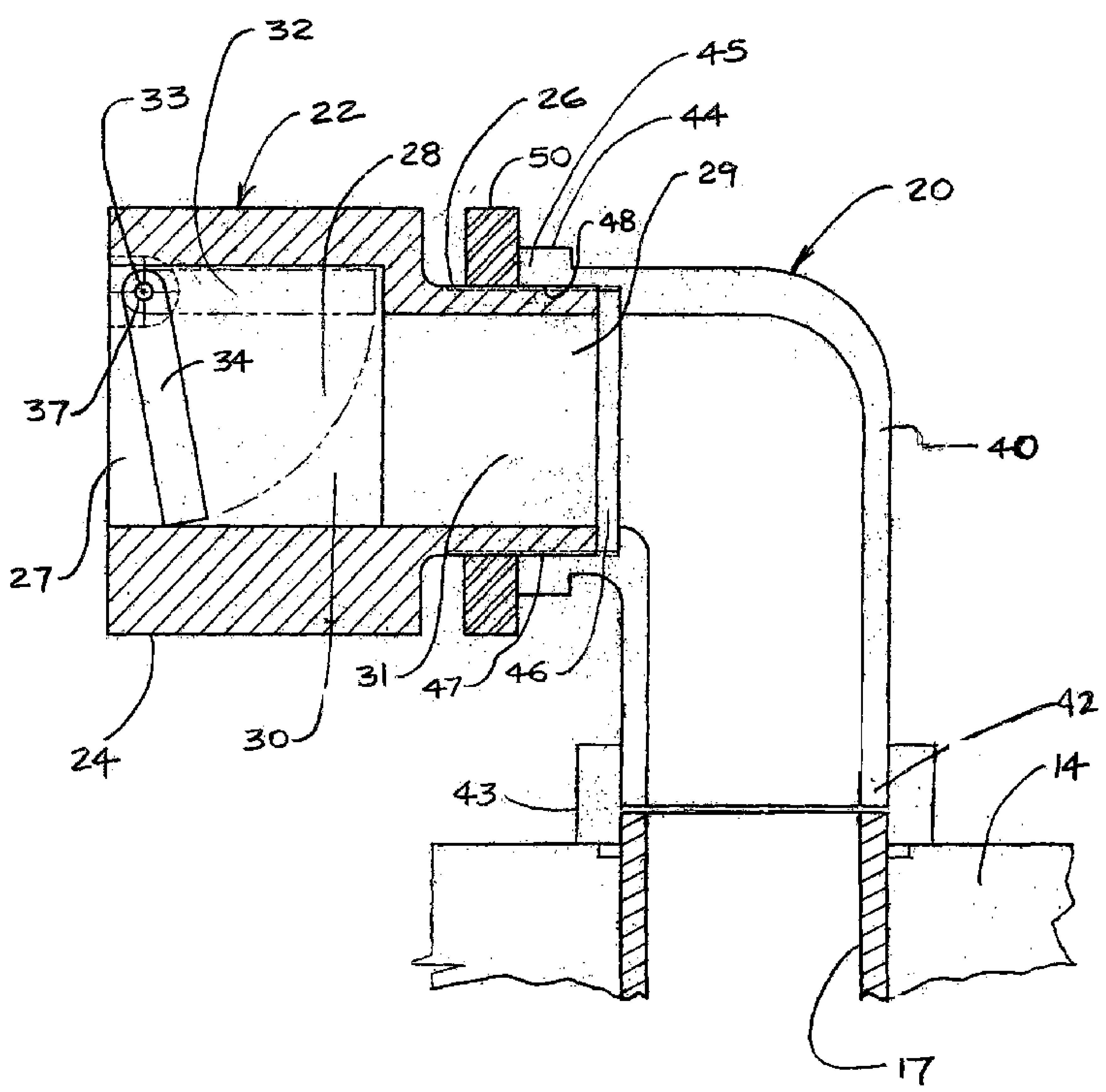
(57) **ABSTRACT**

A check valve assembly for the forced gas cooling system of a vacuum heat treating furnace is disclosed. The check valve assembly includes a check valve for installation on the exterior of a hot zone wall in a vacuum heat treating furnace. The check valve includes a valve body forming an inlet, an outlet, and a channel extending longitudinally through the valve body. The valve body has an inner wall that forms a recess near the inlet. The channel contains a flap pivotally supported on a shaft that extends through the recess. The flap pivots in and out of the channel to permit a cooling gas to flow through the valve body in one direction while substantially preventing the flow of gas through the valve body in the opposite direction. The flap is operable between a closed position in which the flap extends into the channel to obstruct the channel, and an open position in which the flap is pivoted out of the channel and into the recess. A vacuum heat treating furnace and a vacuum furnace hot zone utilizing the above-described check valve assembly are also described.

14 Claims, 3 Drawing Sheets



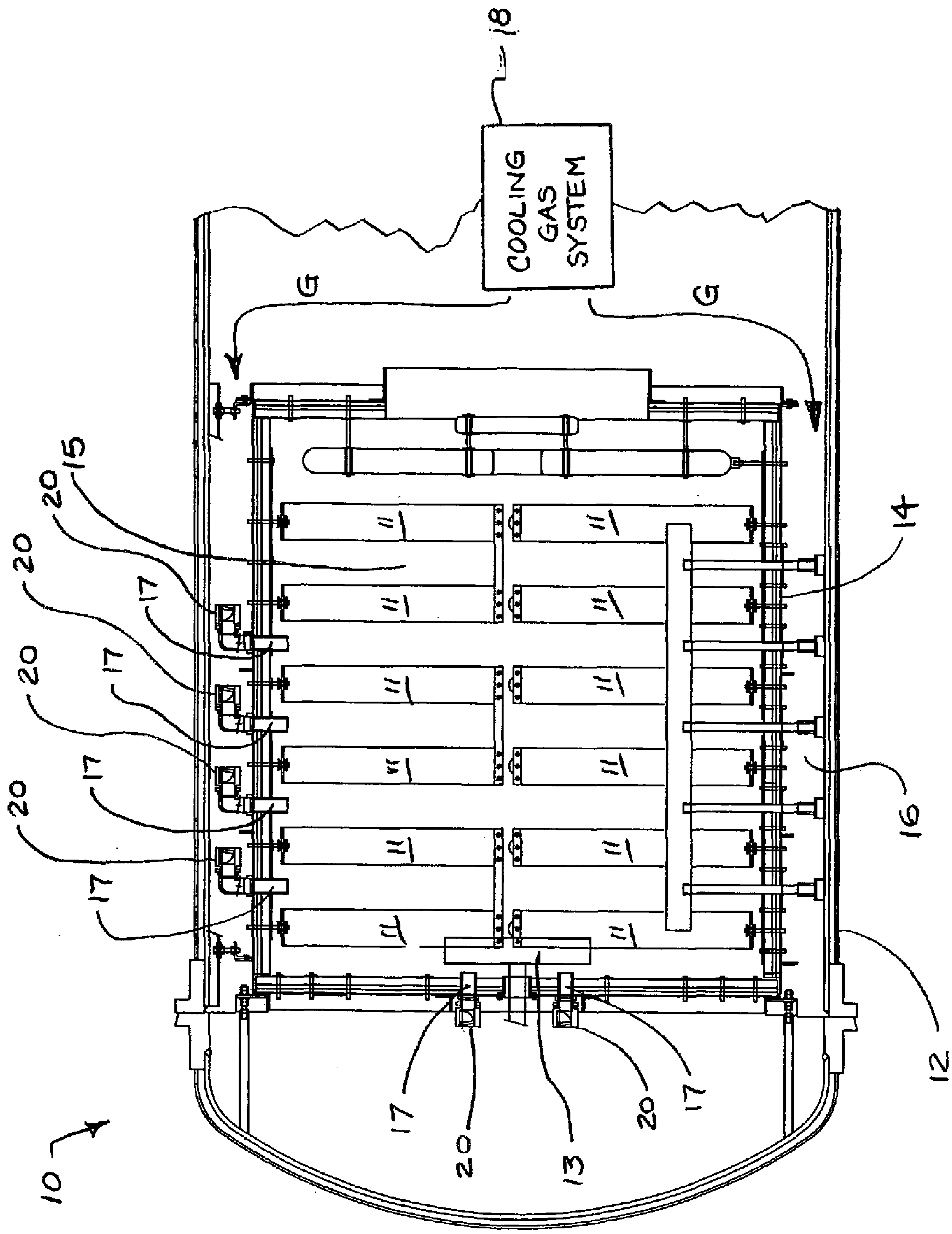


FIG. 1

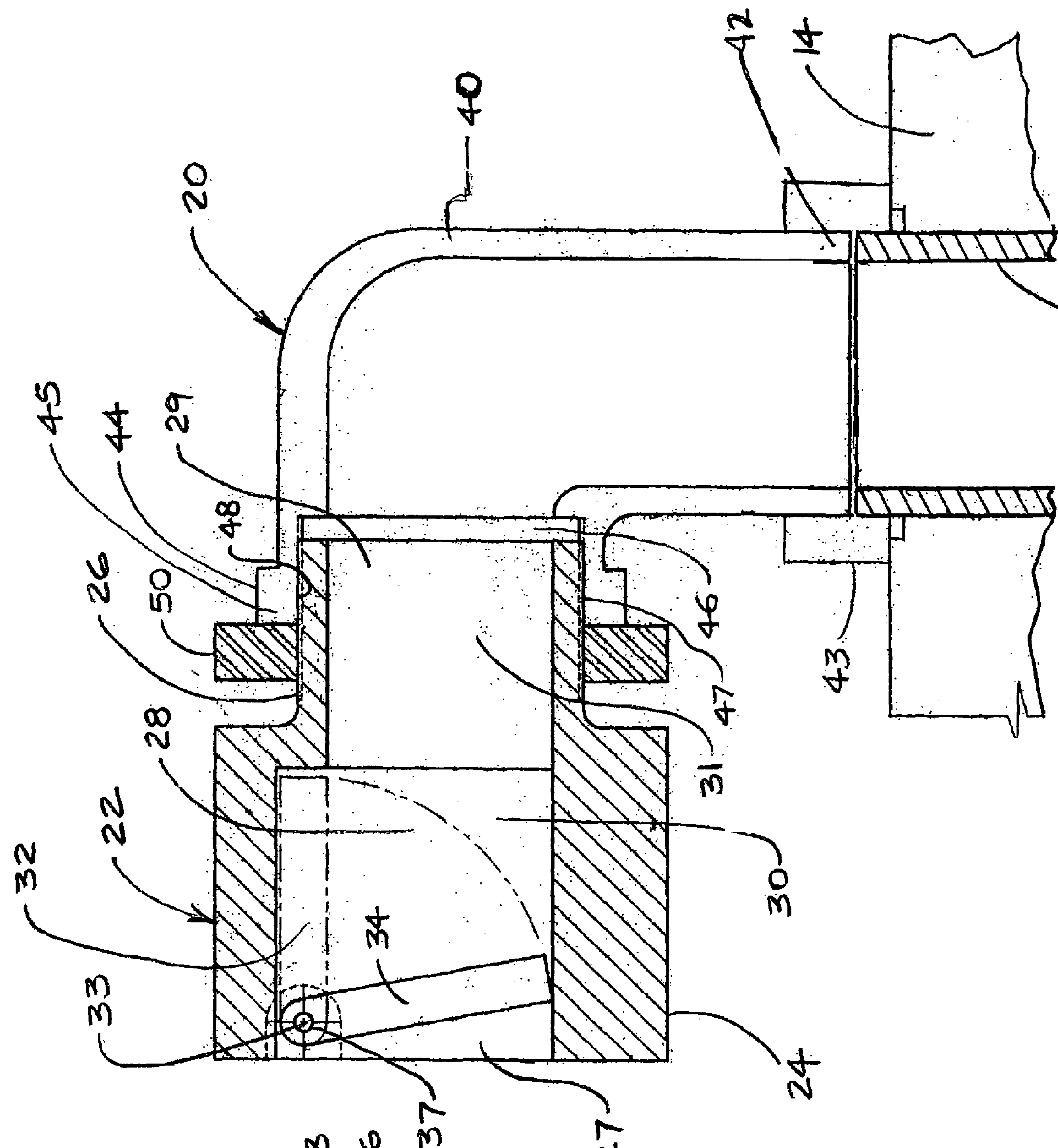

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FIG. 3

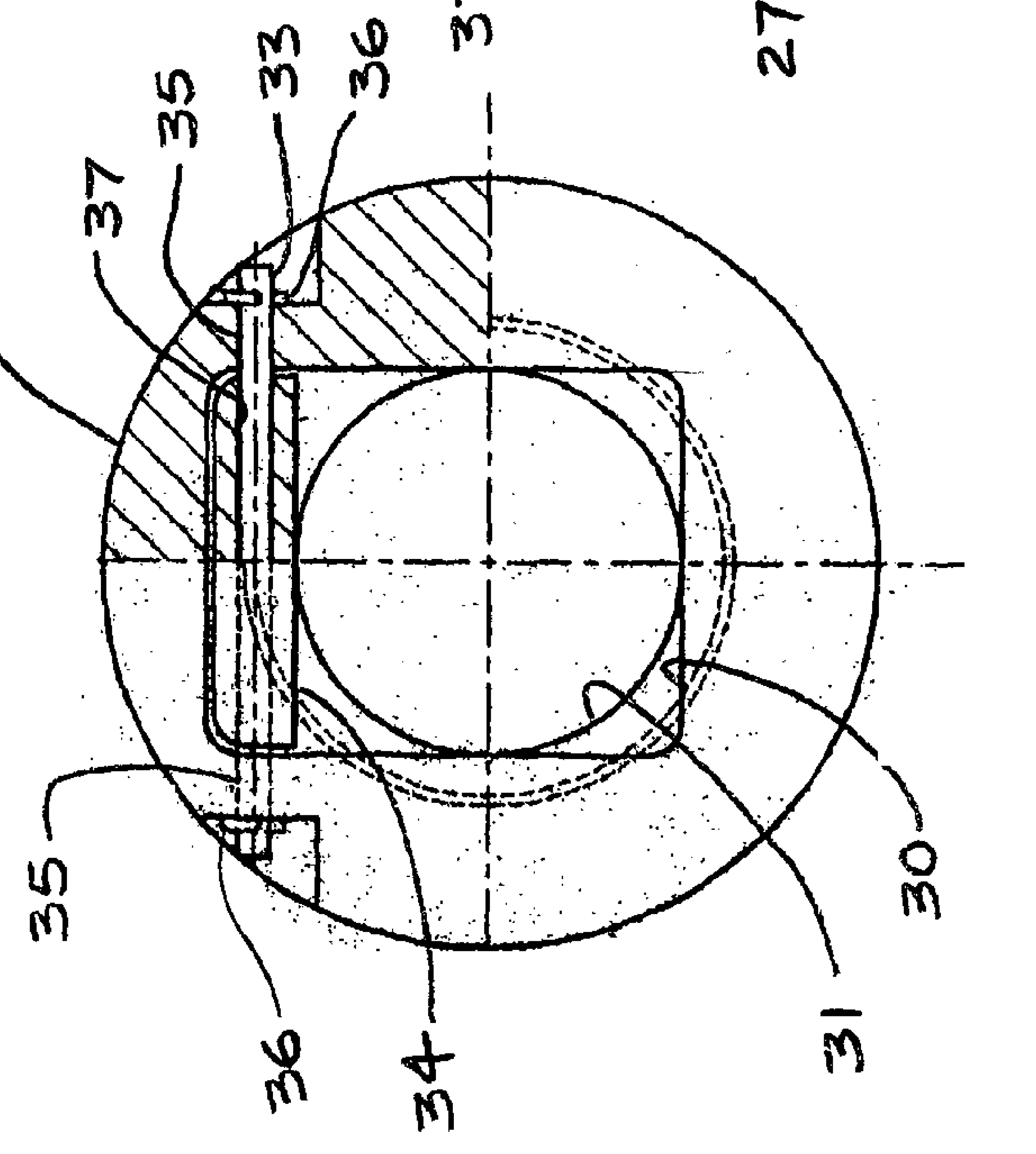
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FIG. 2

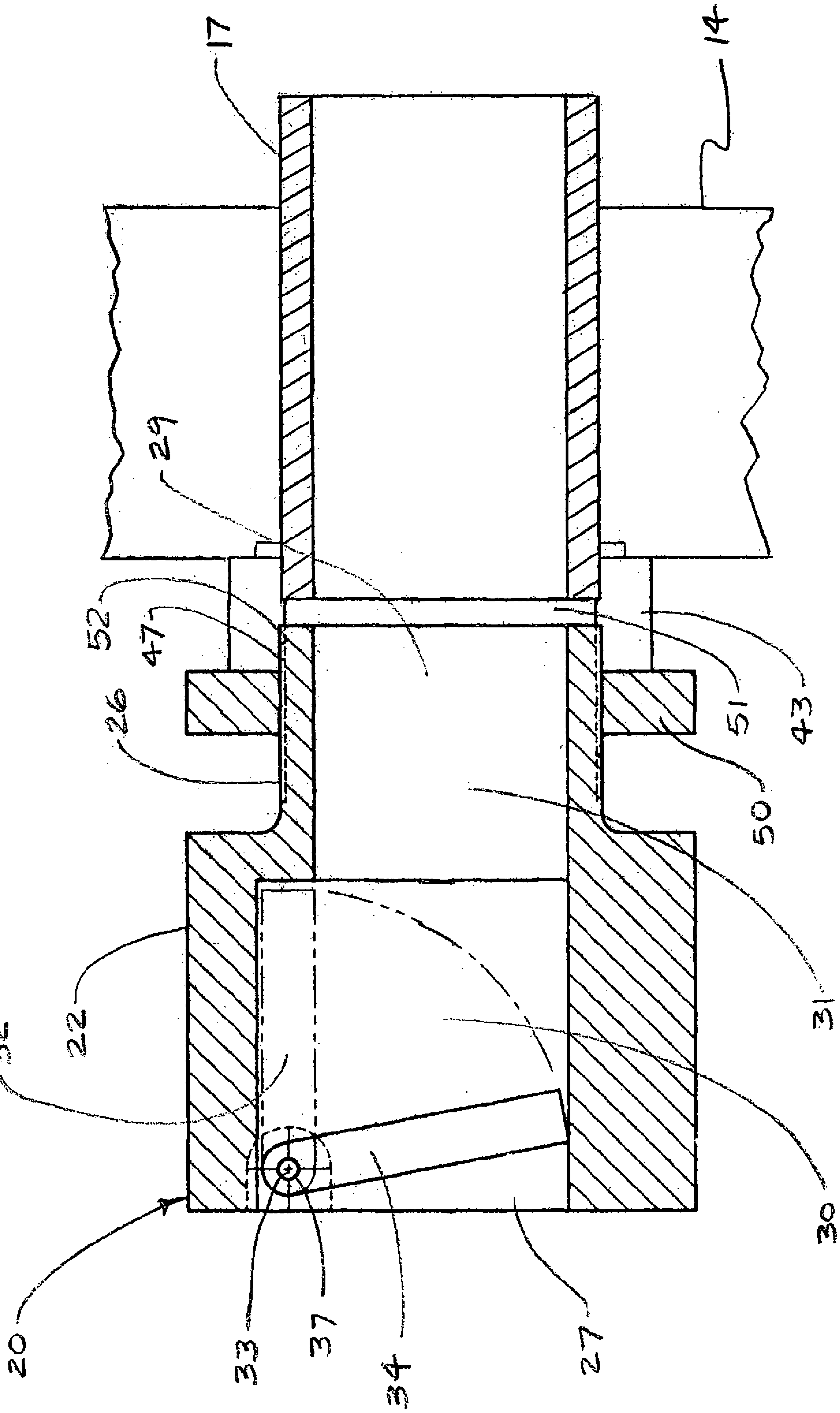

FIG. 4

FLAPPER GAS NOZZLE ASSEMBLY

FIELD OF THE INVENTION

The present invention relates to cooling gas systems for vacuum heat treating furnaces, and more specifically to a cooling gas valve assembly for use in such a cooling gas system.

BACKGROUND

In the known vacuum heat treating furnaces, the metallic workload is heat treated in a hot zone and subsequently cooled with a cooling gas. The cooling gas is injected into the hot zone through one or more nozzles that penetrate through the hot zone wall. The nozzles have unobstructed channels that reduce inert gas partial pressure and allow heat to escape from the hot zone during the heating portion of a heat treatment cycle. The gas pressure and heat loss result in poor temperature uniformity around the workpiece. In order to overcome this problem, some vacuum heat treating furnaces include valves or other hardware connected to the cooling gas nozzles on the inside of the hot zone. The valves allow cooling gas to enter into the hot zone through the nozzles, but limit the escape of gas partial pressure and heat through the gas injection nozzles during the heating cycle.

Valves installed in the interior of the hot zone are subject to breaking and wear in a short period of time, because many have moving parts that cannot withstand repeated exposure to the high temperatures in the hot zone. In addition, many of the known valves are formed from materials that cannot withstand such high temperatures. Failure of these devices can create significant down time, because the furnace and hot zone must be opened to access the broken or worn valve. Also, when the valves are arrayed radially about the interior of the hot zone, special measures must be implemented to maintain some of the valves in a closed position because the force of gravity tends to open them. It can be seen that the devices presently used to limit the loss of pressure and temperature from hot zones have limitations that cause them to fall short of the needs of those who operate such furnaces.

SUMMARY OF THE INVENTION

The limitations discussed above are resolved to a significant degree by a check valve assembly for a cooling gas nozzle in accordance with the present invention. The check valve assembly includes a valve body having an inlet, an outlet, and a channel that extends through the valve body between the inlet and the outlet. A chamber is formed in the valve body adjacent to the inlet and in fluid communication with the channel. The chamber has a recess formed therein. The check valve assembly further includes a flap that is pivotally supported in the chamber adjacent the inlet for moving inwardly into the recess of said chamber such that said flap pivots between a closed position where the inlet is closed and an open position in which the channel is not obstructed.

In accordance with another aspect of the present invention, there is provided a vacuum heat treating furnace. The vacuum heat treating furnace according to this invention includes a vacuum vessel having a vessel wall and a hot zone disposed in the vacuum vessel. The hot zone has a hot zone wall and a plenum is formed between the vessel wall and the hot zone wall. A plurality of nozzles extend through the hot zone wall to interconnect the plenum and the hot zone. The vacuum heat treating furnace also has a cooling gas system for providing a forced cooling gas into the plenum and a plurality of check valves, as described above, connected to the nozzles externally of the hot zone wall.

In accordance with a further aspect of the present invention, there is provided a hot zone for a vacuum heat treating furnace. The hot zone according to the present invention includes a closed wall defining an internal volume. Insulation is disposed over an interior surface of the closed wall and a plurality of nozzles are disposed in the closed wall for injecting a cooling gas into the hot zone. The hot zone further includes a plurality of check valves, as described above, each being connected to one of the nozzles and disposed external to the closed wall.

DESCRIPTION OF THE DRAWINGS

The foregoing summary as well as the following description will be better understood when read in conjunction with the drawings in which:

FIG. **1** is a side elevation view of the interior of a vacuum heat treating furnace in accordance with the present invention, with the furnace end wall broken away and the gas cooling system shown schematically;

FIG. **2** is a partial sectional end view of a cooling gas check valve used in the vacuum heat treating furnace of FIG. **1**.

FIG. **3** is a partial sectional side view of a first cooling gas valve assembly used in the vacuum heat treating furnace of FIG. **1**.

FIG. **4** is a partial sectional side view of a second cooling gas valve assembly used in the vacuum heat treating furnace of FIG. **1**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing figures, a vacuum heat treating furnace is shown and designated generally as **10**. The heat treating furnace **10** includes a vacuum vessel that has an outer vessel wall **12** and a hot zone wall **14** that forms a hot zone **15**. A plenum **16** is formed between the vessel wall **12** and the hot zone wall **14**. A plurality of electrical resistance heating elements **11** are positioned within the hot zone and are connectable to a source of electric current. When energized, the heating elements radiate heat within the hot zone **15**. The furnace **10** also has a cooling gas system **18** for injecting a cooling gas into the hot zone **15** to cool a work load after it is heat treated.

The hot zone wall **14** has a plurality of nozzles **17** that extend through the hot zone wall. Each nozzle **17** is connected to a check valve assembly **20** that is adapted to receive cooling gas from the cooling gas system **18**. The valve assemblies **20** are attached to the exterior of the hot zone wall **14**, where the valve assemblies are isolated and insulated from the intense heat generated inside the hot zone. The valve assemblies **20** have inlets that face in a direction for receiving cooling gas from the cooling gas system. Each assembly has an outlet end that is connected to a nozzle **17** for channeling the cooling gas into the nozzle.

Referring now to FIGS. **1**–**3**, the furnace **10** and cooling gas valve assemblies **20** will be described in greater detail. The valve assemblies **20** may be used with a variety of hot zone configurations. In FIG. **1**, the hot zone wall **14**, which is substantially closed, includes a generally cylindrical side wall and a pair of end walls. The hot zone wall **14** and vessel wall **12** are separated by the plenum space **16** that surrounds the exterior of the hot zone wall. The plenum **16** is in fluid communication with the cooling gas system **18**.

The cooling gas system **18** is operable to deliver cooling gas under positive pressure through the plenum **16** and into the hot zone **15** through the hot zone wall **14** via the nozzles **17**. The valve assemblies **20** are mounted on the cylindrical side wall and may be mounted on one or both end walls of the hot zone wall **14**. Each valve assembly **20** is connected with a nozzle **17** to form a fluid channel between the plenum **16** and the hot zone **15**. The valve assemblies **20** and nozzles **17** are adapted to receive the cooling gas under positive pressure and convey the cooling gas into the hot zone.

Each valve assembly **20** comprises a valve body **22** as shown in FIGS. **2** and **3**. The valve body **22** has a generally cylindrical shape, with a large diameter section **24** and a small diameter section **26** in coaxial alignment with the large diameter section. The valve body **22** is generally hollow and has an internal channel **28** that extends longitudinally through the body. The large diameter section **24** has a first chamber **30** that extends substantially the length of the large diameter section **24** and a second chamber **31** that extends from the chamber **30** through the small diameter section **26**. The valve body **22** has an inlet opening **27** formed on one end of the large diameter section **24**, and an outlet opening **29** at one end of the small diameter section **26**. The inlet opening **27** and outlet opening **29** are interconnected by the channel **28**.

Referring now to FIG. **3**, the first chamber **30** houses a panel or flap **34** that is pivotally supported on a shaft **33**. The shaft **33** is mounted adjacent to inlet **27** in the first chamber **30** and extends generally perpendicularly to the longitudinal axis of the channel **28**. The shaft **33** extends through a bore **37** formed in the flap **34** and pivotally supports the flap in the first chamber **30**. The flap **34** pivots on the shaft **33** between an open position and a closed position. In the open position, the flap **34** is pivoted into the chamber **30** and into a position generally parallel to the longitudinal axis of the channel. The open position of the flap **34** is illustrated by the dashed lines in FIG. **3**. In the closed position, the flap **34** is positioned such that it substantially closes the inlet opening. The closed position of the flap is shown by solid lines. The ends of the shaft **33** are supported in the first chamber **30** by a pair of bores **35** that extend through the body wall on opposite sides of the first chamber. Each bore **35** has a diameter that is slightly larger than the diameter of the shaft **33**. As such, the bores **35** permit the shaft **33** to slide axially through the slots. Preferably, the shaft **33** has a means for limiting axial displacement of the shaft in the bores **35** to prevent the shaft from slipping out of the bores. As shown in FIG. **2**, the ends of the shaft **33** each have wire or pin **36** that extends through a small diameter hole in the shaft. The lengths of the wires **36** are larger than the diameter of the bores **35** in the body **22**. As such, the wires **36** are configured to limit axial displacement of the shaft **20** through the bores **35** to minimize the potential for the shaft to slip out of the body **22**.

To optimize the flow rate of cooling gas through the valve assembly, it is desirable to minimize constrictions or abrupt transitions within the channel **28** when the flap **34** is pivoted to the open position. Preferably, the flap **34** is pivoted into chamber **30** when moved to the open position so that the profile of the flap does not obstruct the flow of cooling gas through the channel. Referring again to FIG. **3**, the first chamber **30** is formed with an additional space or recess **32** that is adapted to receive the flap when the flap is pivoted to the open position. The first chamber **30** has a generally rectangular cross section, and the second chamber **31** has a generally circular cross section. Three sides of the rectangular cross section of the first chamber **30** are more or less tangential to the circumference of the circular cross section of the second chamber **31**, as shown in FIG. **2**. In addition, three sides of the rectangular first chamber **30** are generally equidistant from the longitudinal axis of the valve body **22**. The fourth side of the first chamber **30** is offset and spaced further away from the longitudinal axis of the valve body **22**, forming the recess **32**. The recess **32** has dimensions that generally conform to the dimensions of the flap **34** so that the flap fits flush inside the recess when in the open position. In the open position, the front face of the flap **34** is more or less tangential with the circumference of the second chamber **31**, as shown in FIG. **2**. This provides a smooth transition between the first chamber and the second chamber to reduce turbulence in the cooling gas stream.

The valve assemblies **20** are mounted on the exterior of the hot zone wall **14** so that they are isolated from the heat generated within the hot zone during a heat treatment cycle. Although the valve assemblies **20** are located outside of the hot zone **14**, the valve assemblies may still be subject to high temperatures that can affect the performance and service life of the parts in the valve assemblies. Therefore, the components of the valve assembly **20** are preferably formed of durable refractory material that can withstand exposure to high temperatures. Preferably, the valve body **22** and flap **34** are formed of graphite, and the shaft **33** and wires **36** are formed of molybdenum. Alternatively, the components of the valve body **20** may also be formed of ceramic material.

Referring again to FIG. **1**, the cooling gas system **18** delivers cooling gas from one end of the furnace **10**. The cooling gas system **18** delivers a stream of cooling gas under positive pressure in the plenum space **16**, as shown by the arrows labeled "G". Each valve body **22** is mounted on the exterior of the hot zone wall **14** and in the plenum **16** with the inlet opening **27** generally facing into the cooling gas stream. In this way, the valve assemblies **20** can readily capture cooling gas as it passes through the plenum **16**. The valve assemblies **20** extending from nozzles **17** on the side wall of the hot zone **15** are fitted with an elbow transition to orient them substantially parallel to the cooling gas stream. In FIG. **1**, the valve assemblies **20** mounted on the side wall of the hot zone **15** are connected to the nozzles **17** by ninety degree elbows **40**.

The elbows **40** may be connected to the nozzles **17** using a variety of fittings or other connection means. In FIG. **3**, an elbow **40** has a first end **42** connected to a nozzle **17** in the hot zone wall **14**, and a second end **44** connected to a valve body **22**. The nozzle **17** has an inlet end that projects from the hot zone wall **14** to engage with the first end **42** of the elbow **40**. The inlet end of the nozzle **17** is coupled to the first end **42** of the elbow **40** with a weld nut **43**. The weld nut **43** secures the elbow **40** to the nozzle to hold the elbow in a fixed position relative to the hot zone wall **14**. The elbow **40** and weld nut **43** may be formed of steel or other high strength material. The first end **42** of elbow **40** may be secured to the weld nut **43** by tack welds

The second end **44** of the elbow **40** has a flanged section **45** configured to connect with the outlet end of the valve body **22**. The valve body **22** and elbow **40** may be connected in a variety of ways. In FIG. **3**, the flanged end **45** of elbow **40** forms a socket **46**. The socket **46** has an inner diameter adapted to receive the small diameter section **26** of the valve body **22**. The small diameter section **26** has an external male thread **47** configured to mate with a female thread **48** formed in the interior of the socket **46** when the small diameter section is inserted into the socket and rotated.

The flap **34** is operable in the closed position during a heat treatment cycle to minimize the escape of heat from the hot zone **15** into the plenum **16**. When the flap **34** is in the closed position, the flap engages the walls of the first chamber. The cross-sectional shape of the flap **34** is substantially commensurate with the cross sectional shape of the inlet **27**. As such, the flap **34** has a rectangular shape that substantially coincides with the sidewalls of the first chamber when the flap is in the closed position to effectively close the inlet opening **27**.

The rectangular flap **34** has a pair of long sides and a pair of short sides, as shown in FIG. **2**. Similarly, the cross-section of the first chamber **30** has a pair of long sides and a pair of short sides corresponding to the long and short sides of the flap **34**. The flap **34** is mounted over the shaft **33** with the shaft extending generally parallel to the short sides of the flap. The short sides of the flap **34** are slightly smaller in length than the short sides of the first channel section **30**, forming a small clearance space between the long sides of the flap **34** and long sides of the channel. The clearance space is dimensioned to permit the flap **34** to freely pivot on the shaft **33** between the open and closed positions, while minimizing frictional contact between the long sides of the flap and channel wall. Preferably, the amount of clearance space is minimized to limit the flow of gas around the flap **34** when the flap is in the closed position. The valve body **22** and locking ring **50** are preferably formed of graphite.

The valve body **22** is positioned so that the flap **34** is oriented with its short sides being generally horizontal and the long sides being generally vertical. In addition, the shaft **33** is preferably positioned horizontally at the upper end of the flap. In this orientation, referred hereinafter as the "upright position", the flap **34** is biased toward the closed position by the force of gravity. The long sides of the flap **34** are preferably commensurate in length with the long sides of the first chamber **30**. In this way, the bottom end of the flap **34** contacts the bottom wall of the first chamber **30** in frictional engagement. The frictional engagement between the bottom end of the flap **34** and the bottom wall of the first chamber **30** forms a partial seal along the bottom end of the flap **34** when the flap is in the closed position.

Partial pressures of inert gas may develop in the hot zone **15** during a convection heating cycle, causing the build up of pressure that pushes outwardly on each flap **34**. The frictional engagement between the bottom end of the flap **34** and the bottom wall in the first chamber **30** is sufficient to prevent the flap from pivoting outwardly past the closed position. This minimizes the loss of heat from the hot zone during the heating cycle, as discussed below in connection with the operation of the invention.

The valve body **22** is configured to mate with the flanged end **45** of the elbow **40**, as discussed earlier. The smaller diameter section **26** is rotatable in the flanged end **45** to connect the male thread **47** in the valve body with the female thread in the socket **46**. A locking ring **50** surrounds the smaller diameter section and is configured to securely lock the elbow and flap in the upright position when the valve body **22** is connected to the elbow. The locking ring **50** has a bore with female threading that mates with the male thread **47** on the smaller diameter section **26** of the valve body **22**. When the smaller diameter section **26** is inserted into the socket **46** of elbow **40**, the locking ring is rotatable on the smaller diameter section to displace the locking ring into abutting engagement with the flange **45**. The locking ring **50** is further rotatable as it abuts the flange **45** to tighten the engagement between the valve body and the elbow. In particular, the locking ring **50** is rotatable against the flange to tighten the engagement between the threads on the small diameter section **26** and in the socket. The tightened engagement between the threads limits rotational displacement of the valve body **22** relative to the elbow, securing the orientation of the valve body so that the flap is retained in the proper orientation for receiving the cooling gas flow.

Valve assemblies **20** that are disposed on one or both of the end walls of the hot zone **15** receive cooling gas flow from different directions in the plenum depending on their location. As shown in FIG. **1**, the valve assemblies on the end walls of the hot zone extend outwardly into the plenum. Referring now to FIG. **4**, the valve assemblies **20** located on an end wall of the hot zone **15** generally comprise the same components as valve assemblies on the side wall of the hot zone, but without the elbow fitting. The small diameter section **26** of the valve body **22** is connected directly to the nozzle **17** in the hot zone wall. The nozzle **17** has an inlet end that projects from the hot zone wall **14**. The inlet end of the nozzle **17** is coupled to the small diameter section **26** of the valve body **22** by a weld nut **43** having an interior bore **51**. The bore **51** is adapted to receive the small diameter section **26** of the valve body **22** and the inlet end of the nozzle **17**. As described above, the small diameter section **26** of the valve body **22** has an external male thread **47**. The male thread **47** is configured to mate with a female thread **52** that extends in the bore **51** of weld nut **43**. The inlet end of the nozzle **17** may be connected to the weld nut **43** using a variety of connection means, including but not limited to a threaded connection or welding.

A locking ring **50** surrounds the smaller diameter section **26** of the valve body **22**, similar to the valve assemblies on the side wall of the hot zone. The locking ring **50** is configured to securely lock the valve body **22** and flap **34** in the upright position when the valve body is connected to the weld nut **43**. The locking ring **50** has a bore with female threading that mates with the male thread **47** on the smaller diameter section **26** of valve body **22**. When the smaller diameter section **47** is inserted into the weld nut **43**, the locking ring is rotatable on the smaller diameter section to displace the locking ring into abutting engagement with the weld nut **43**. The locking ring **50** is further rotatable as it abuts the weld nut **43** to tighten the engagement between the threads on the valve body and the elbow. The locking ring **50** is operable to secure the orientation of the valve body **22** so that the flap **34** is retained in the upright position.

Referring back to FIG. **1**, the operation of the valve assembly **20** will now be described. During the heating cycle in the furnace **10**, the heating elements **11** in hot zone **15** are energized and generate heat to raise the temperature in the hot zone. An internal fan **13** is activated to circulate the atmosphere in the hot zone **15**, thereby providing convection heating of the workpieces. During this time, the flap **34** in each valve assembly **20** is biased in the closed position by gravity, thereby closing off channel **28** to substantially prevent the escape of heat through the nozzles **17** during the heating cycle.

After the heating cycle is completed, the heating elements **11** are de-energized, and the cooling gas system **18** is operated to fill the hot zone **15** with a quenching or cooling gas. The cooling gas system **18** forces the cooling gas into the plenum **16** and around the hot zone wall **14** under positive pressure. The positive pressure exerts inward force on the closed flaps **34** in the cooling valve assemblies **20**. The inward force on the flap **34** is significantly larger than the gravitational force that holds the flap in the closed position. As a result, the positive pressure pushes the flaps **34** inwardly, pivoting the flaps into the recesses in the respective first chambers of each valve. In the manner, the channels **28** are no longer obstructed by the flaps **34**, and cooling gas flows through the channels and through the nozzles **17** into the hot zone **15**.

As the stream of cooling gas passes through each valve assembly **22**, the pressure in the gas stream bears against the flap **34** and maintains the flap in the open position. Cooling gas is exhausted from the hot zone to maintain a pressure differential between the plenum **16** and the hot zone **15**. When the cooling cycle is completed, the cooling gas system **18** shuts off the flow of cooling gas. The pressures in the plenum **16** and hot zone **15** gradually drop until the two pressures approach equilibrium. As the net positive pressure in the plenum drops below a threshold value, the inward force on the flap **34** decreases until it no longer is sufficient to overcome the gravitational force that biases the flap toward the closed position. Thereafter, the flap **34** pivots or drops to the closed position.

The terms and expressions which have been employed are used as terms of description and not of limitation. There is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof. It is recognized, therefore, that various modifications are possible within the scope and spirit of the invention. Accordingly, the invention incorporates variations that fall within the scope of the following claims.

I claim:

1. A vacuum heat treating furnace comprising:

A. a vacuum vessel having a vessel wall;

B. a hot zone disposed in said vacuum vessel, said hot zone having a hot zone wall;

C. a plenum formed between the vessel wall and the hot zone wall;

D. a plurality of gas injection nozzles extending through the hot zone wall to interconnect the plenum and the hot zone;

D. a cooling gas system for providing a forced cooling gas into the plenum; and

E. a plurality of check valves connected to the gas injection nozzles externally of the hot zone wall, each of said plurality of check valves comprising:

i. a valve body having an inlet portion, an outlet portion, and a channel that extends through the valve body between the inlet portion and the outlet portion;

ii. a chamber formed in the inlet portion of said valve body, said chamber encompassing the channel and having a recess formed therein adjacent to said channel; and

iii. a flap that is pivotally supported in said chamber such that said flap is adapted to swing toward the outlet portion of said valve body, said flap having a closed position whereby the channel is closed to the flow of cooling gas and an open position whereby the channel is open to the flow of cooling gas and said flap is located substantially within the recess in said chamber.

2. The vacuum heat treating furnace of claim **1**, wherein the valve body and the flap are formed of graphite or a ceramic material.

3. The vacuum heat treating furnace of claim **2**, wherein the shaft is formed of molybdenum.

4. The vacuum heat treating furnace of claim **1**, wherein the flap has a shape that substantially conforms with the shape of the recess, said flap being configured to rest in the recess flush with a wall of the channel when the flap is in the open position.

5. A hot zone for use in a vacuum heat treating furnace comprising:

A. a closed wall defining an internal volume;

B. insulation means disposed over an interior surface of said closed wall;

C. a plurality of gas injection nozzles disposed in said closed wall for injecting a cooling gas into the hot zone; and

D. a plurality of check valves each being connected to one of the gas injection nozzles externally of the closed wall, each of said check valves comprising:

i. a valve body having an inlet portion, an outlet portion, and a channel that extends through the valve body between the inlet portion and the outlet portion;

ii. a chamber formed in.the inlet portion of said valve body, said chamber encompassing the channel and having a recess formed therein adjacent to said channel; and

iii. a flap that is pivotally supported in said chamber such that said flap is adapted to swing toward the outlet portion of said valve body, said flap having a closed position whereby the channel is closed to the flow of cooling gas and an open position whereby the channel is open to the flow of cooling gas and said flap is located substantially within the recess in said chamber.

6. The hot zone set forth in claim **5**, wherein each of the check valves comprises a shaft for supporting said flap, said shaft extending through an edge of said flap and having end portions supported by the valve body in said chamber.

7. The hot zone set forth in claim **5**, wherein the valve body and the flap are formed of a refractory material.

8. The hot zone set forth in claim **5**, wherein the valve body and the flap are formed of graphite or a ceramic material.

9. The hot zone set forth in claim **6**, wherein the shaft is formed of molybdenum.

10. The hot zone set forth in claim **5**, wherein the flap is dimensioned to fit entirety within the recess.

11. The vacuum heat treating furnace of claim **1** further comprising a coupling connected between the outlet portion of each of said plurality of check valves and to each of the plurality of gas injection nozzles.

12. The vacuum heat treating furnace of claim **11** wherein said coupling is an elbow coupling.

13. The vacuum heat treating furnace of claim **5** further comprising a coupling connected between the outlet portion of each of said plurality of check valves and to each of the plurality of gas injection nozzles.

14. The vacuum heat treating furnace of claim **13** wherein said coupling is an elbow coupling.

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