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(19) **United States**(12) **Patent Application Publication**  
**Griffin et al.**(10) **Pub. No.: US 2006/0236716 A1**(43) **Pub. Date: Oct. 26, 2006**(54) **REFRIGERANT ACCUMULATOR**(52) **U.S. Cl.** ..... **62/503; 62/513**(76) Inventors: **Gary E. Griffin**, Penn Yan, NY (US);  
**Daniel R. Rice**, Marion, NY (US);  
**Michael L. Ford**, Baldwin, MS (US)(57) **ABSTRACT**

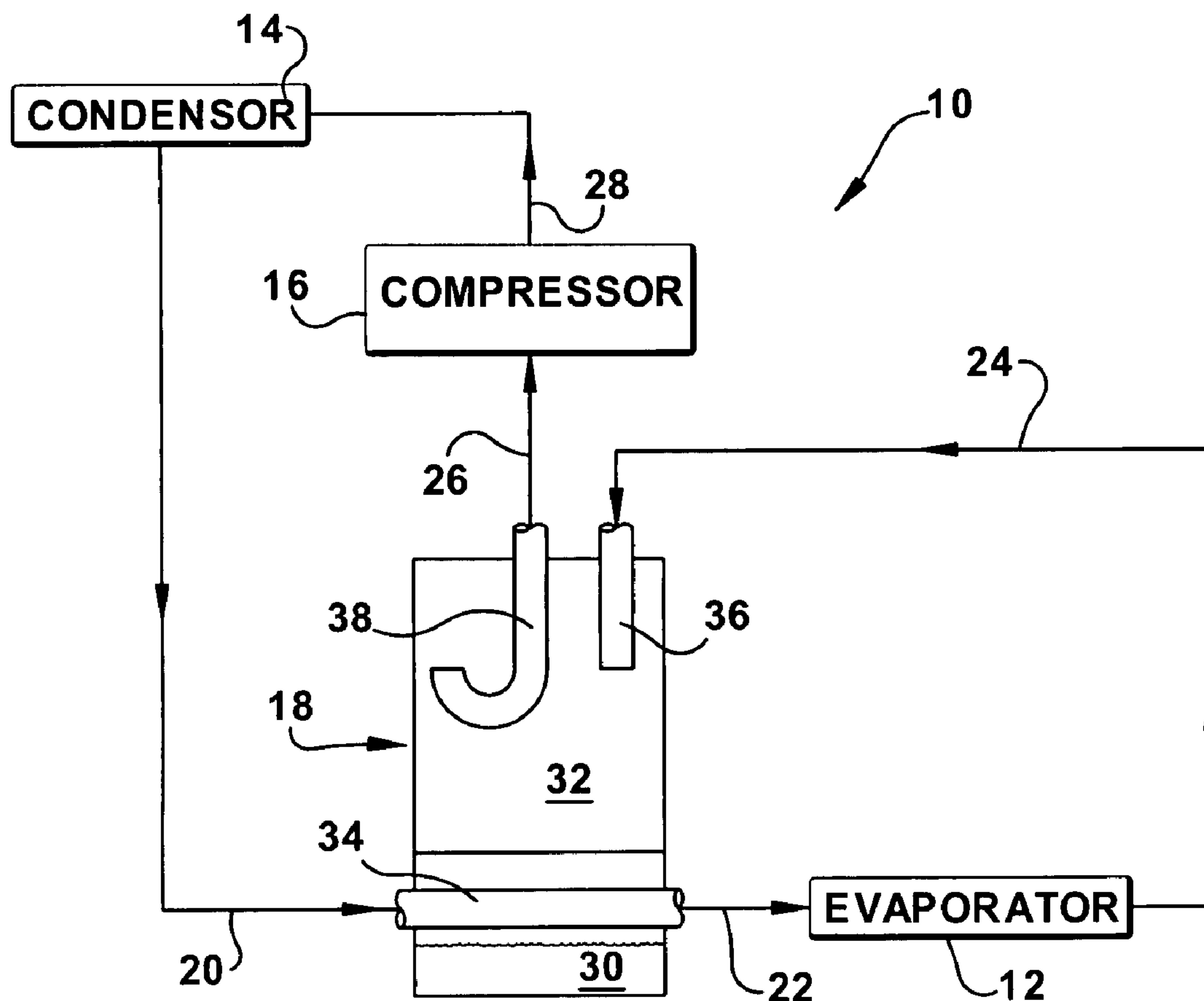
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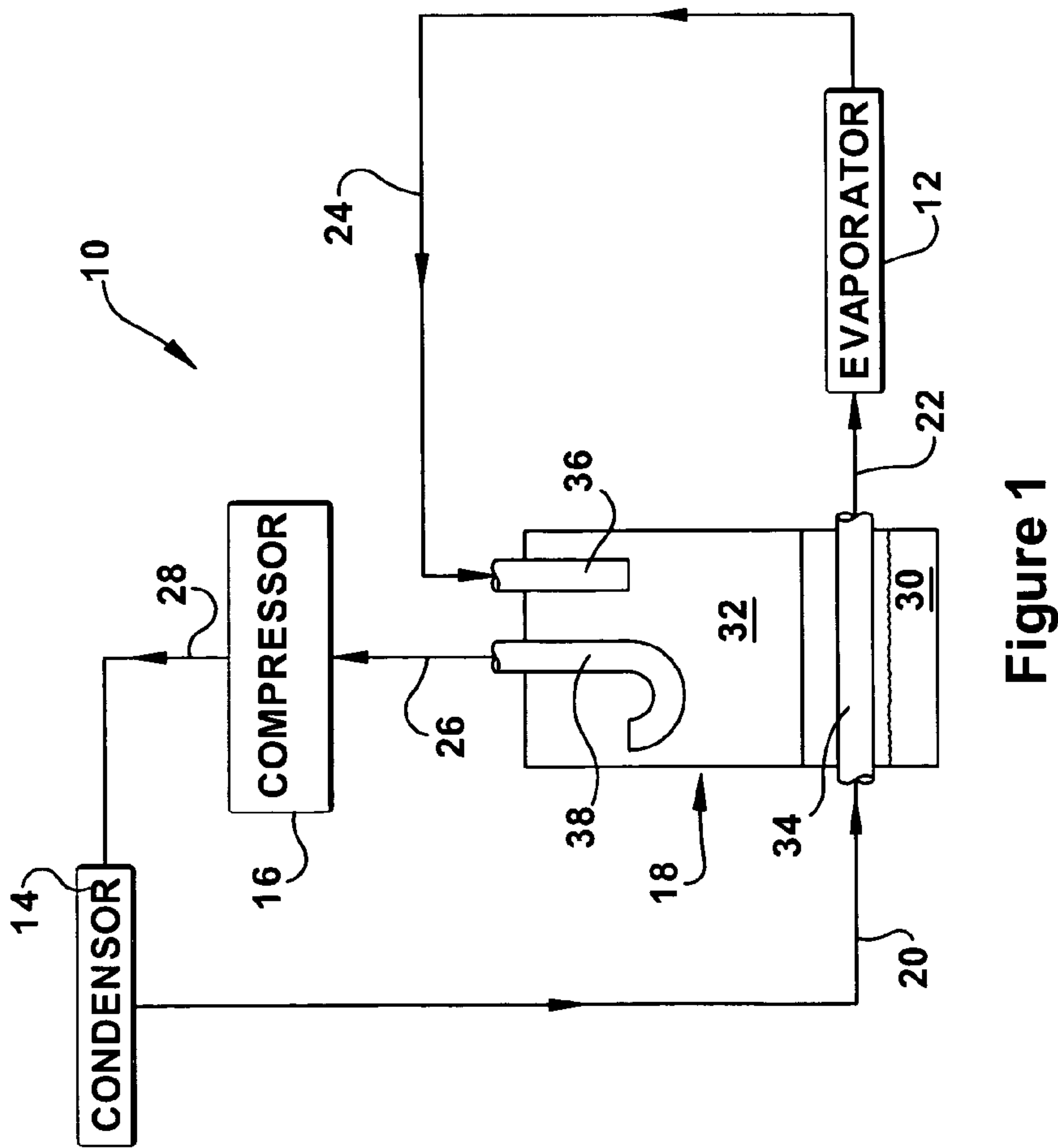
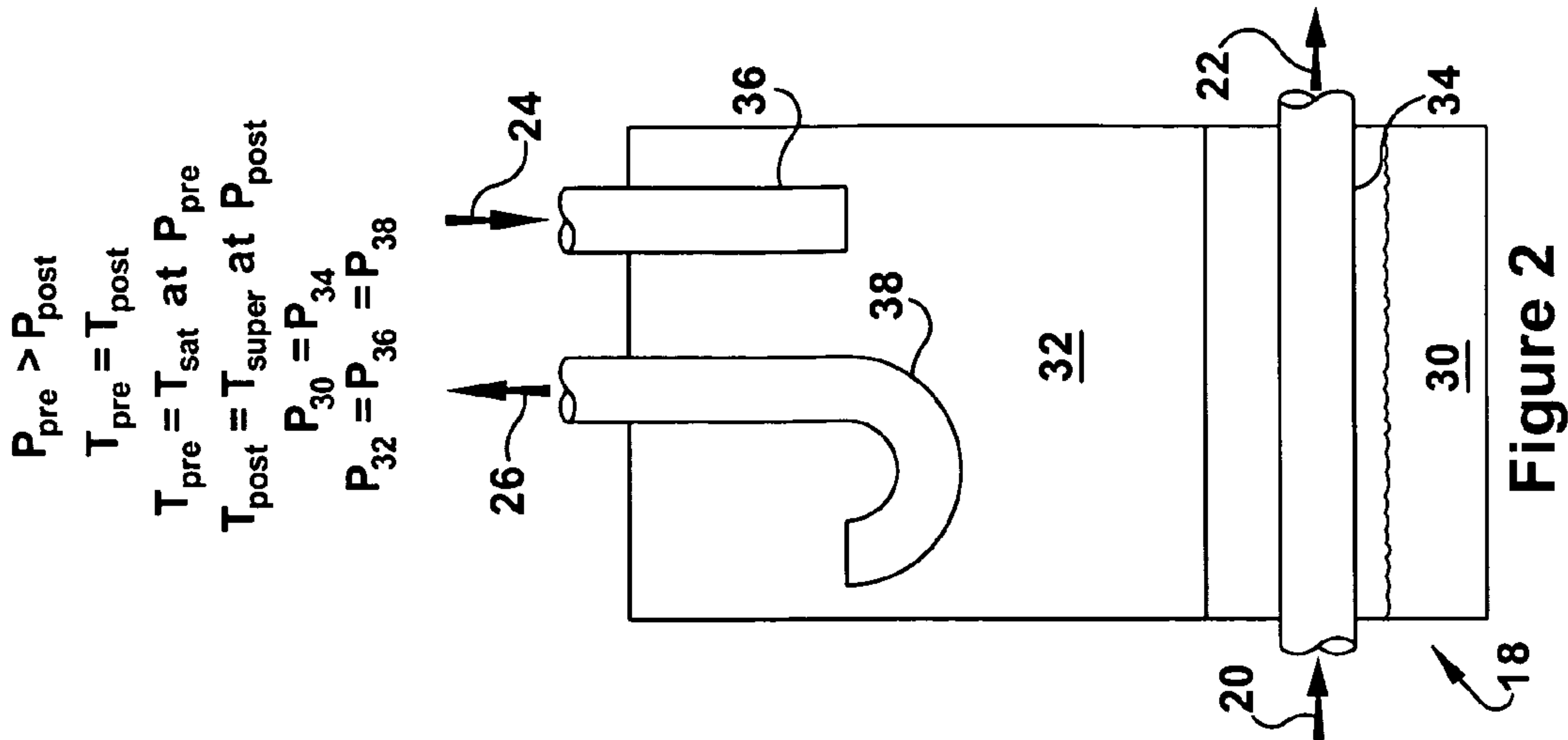
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An refrigerant accumulator (18) comprises a first chamber (30), a second chamber (32), a pre-evaporator line (34), a post-evaporator-inlet line (36), and a post-evaporator-outlet line (38). The chambers (30, 32) are in a pressure-isolated arrangement and a heat-transfer relationship. The pre-evaporator line (34) passes through and communicates with the first chamber (30). In a steady state, the pressure of fluid in the first chamber (30) is greater than the pressure of fluid in the second chamber (32), but their temperatures are the same, and the pressure of fluid within the first chamber is balanced with the pressure of fluid within the pre-evaporator line. In a starved or flooded state, temperature differentials between the chamber (30) and chamber (32), and pressure imbalances between the chamber (30) and the pre-evaporator line (34), adjust the charge of refrigerant fluid to return the system to a steady state.

(21) Appl. No.: **11/407,832**(22) Filed: **Apr. 20, 2006****Related U.S. Application Data**

(60) Provisional application No. 60/673,455, filed on Apr. 21, 2005.

**Publication Classification**(51) **Int. Cl.**  
**F25B 43/00** (2006.01)  
**F25B 41/00** (2006.01)



$$\begin{aligned} P_{pre} &> P_{post} \\ T_{pre} &< T_{post} \\ T_{pre} &= T_{sat} \text{ at } P_{pre} \\ T_{post} &> T_{super} \text{ at } P_{post} \\ P_{30} &= P_{34} \\ P_{32} = P_{36} &= P_{38} \end{aligned}$$

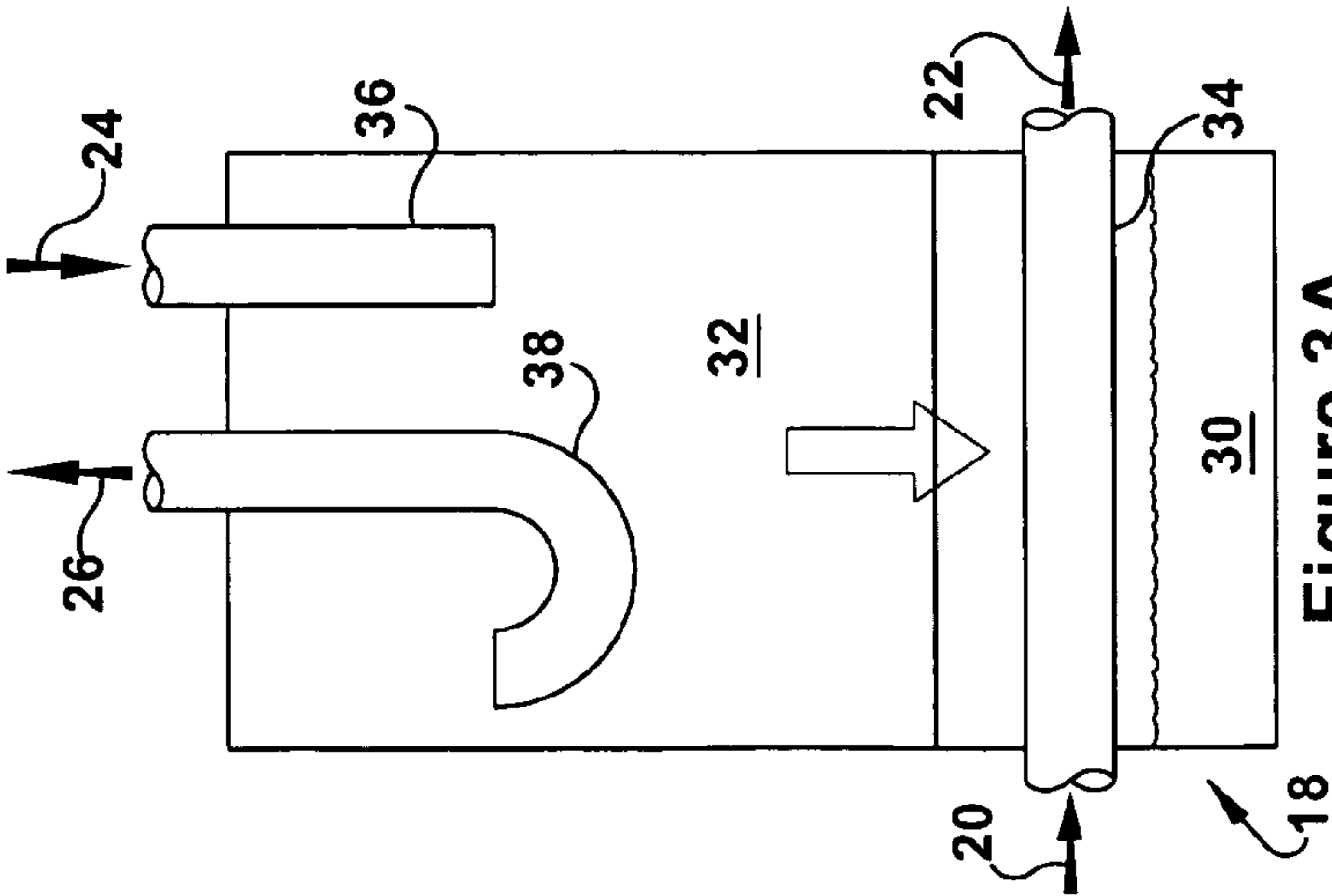


Figure 3A

$$\begin{aligned} P_{pre} &> P_{post} \\ T_{pre} &= T_{post} \\ T_{pre} &= T_{sat} \text{ at } P_{pre} \\ T_{post} &= T_{super} \text{ at } P_{post} \\ P_{30} &> P_{34} \\ P_{32} = P_{36} &= P_{38} \end{aligned}$$

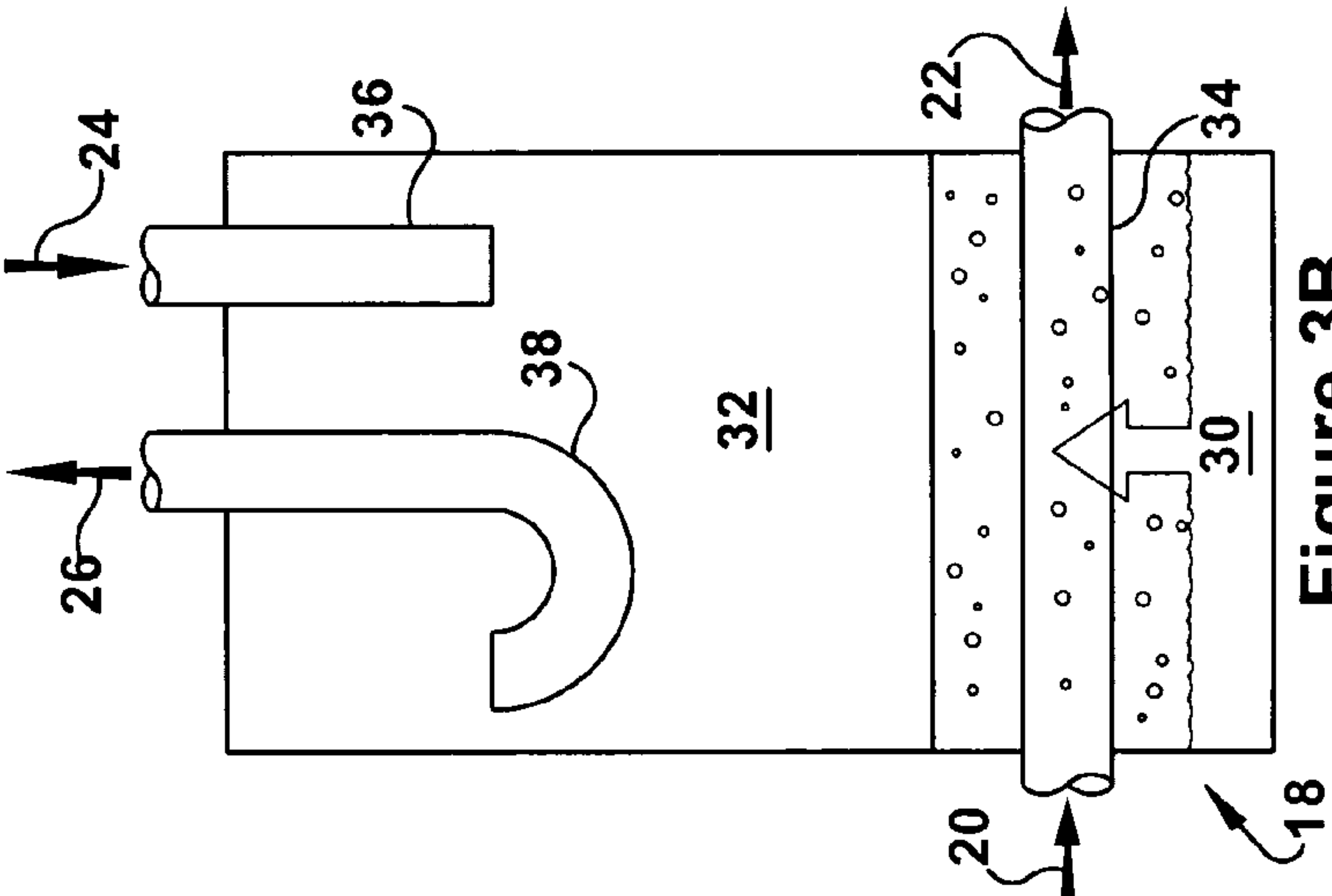


Figure 3B

$$\begin{aligned} P_{pre} &> P_{post} \\ T_{pre} &= T_{post} \\ T_{pre} &= T_{sat} \text{ at } P_{pre} \\ T_{post} &= T_{sat} \text{ at } P_{post} \\ P_{30} &= P_{34} \\ P_{32} = P_{36} &= P_{38} \end{aligned}$$

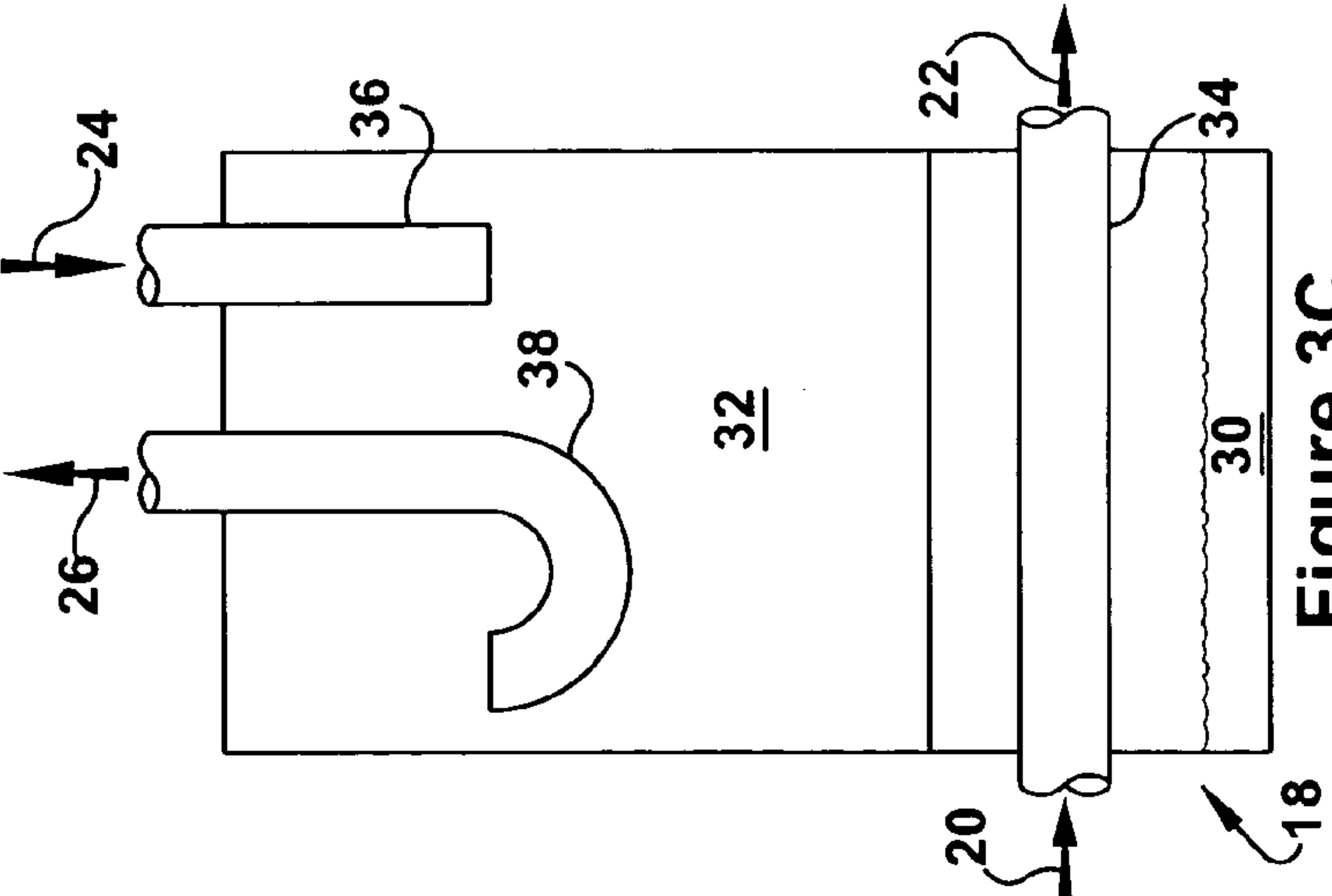


Figure 3C

$$\begin{aligned} P_{pre} &> P_{post} \\ T_{pre} &> T_{post} \\ T_{pre} &= T_{sat} \text{ at } P_{pre} \\ T_{post} &< T_{super} \text{ at } P_{post} \\ P_{30} &= P_{34} \\ P_{32} &= P_{36} = P_{38} \end{aligned}$$

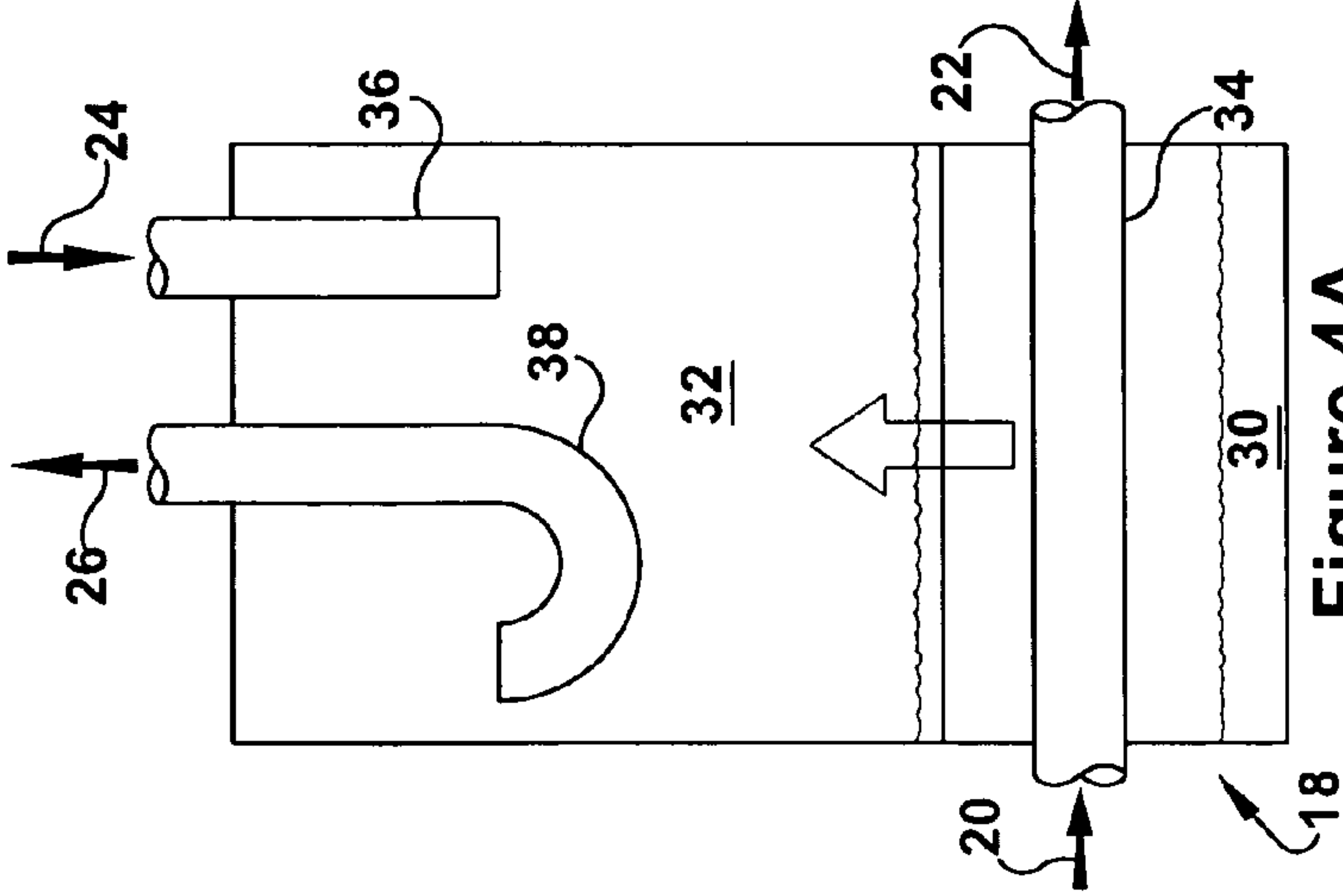


Figure 4A

$$\begin{aligned} P_{pre} &> P_{post} \\ T_{pre} &= T_{post} \\ T_{pre} &= T_{sat} \text{ at } P_{pre} \\ T_{post} &= T_{super} \text{ at } P_{post} \\ P_{30} &< P_{34} \\ P_{32} &= P_{36} = P_{38} \end{aligned}$$

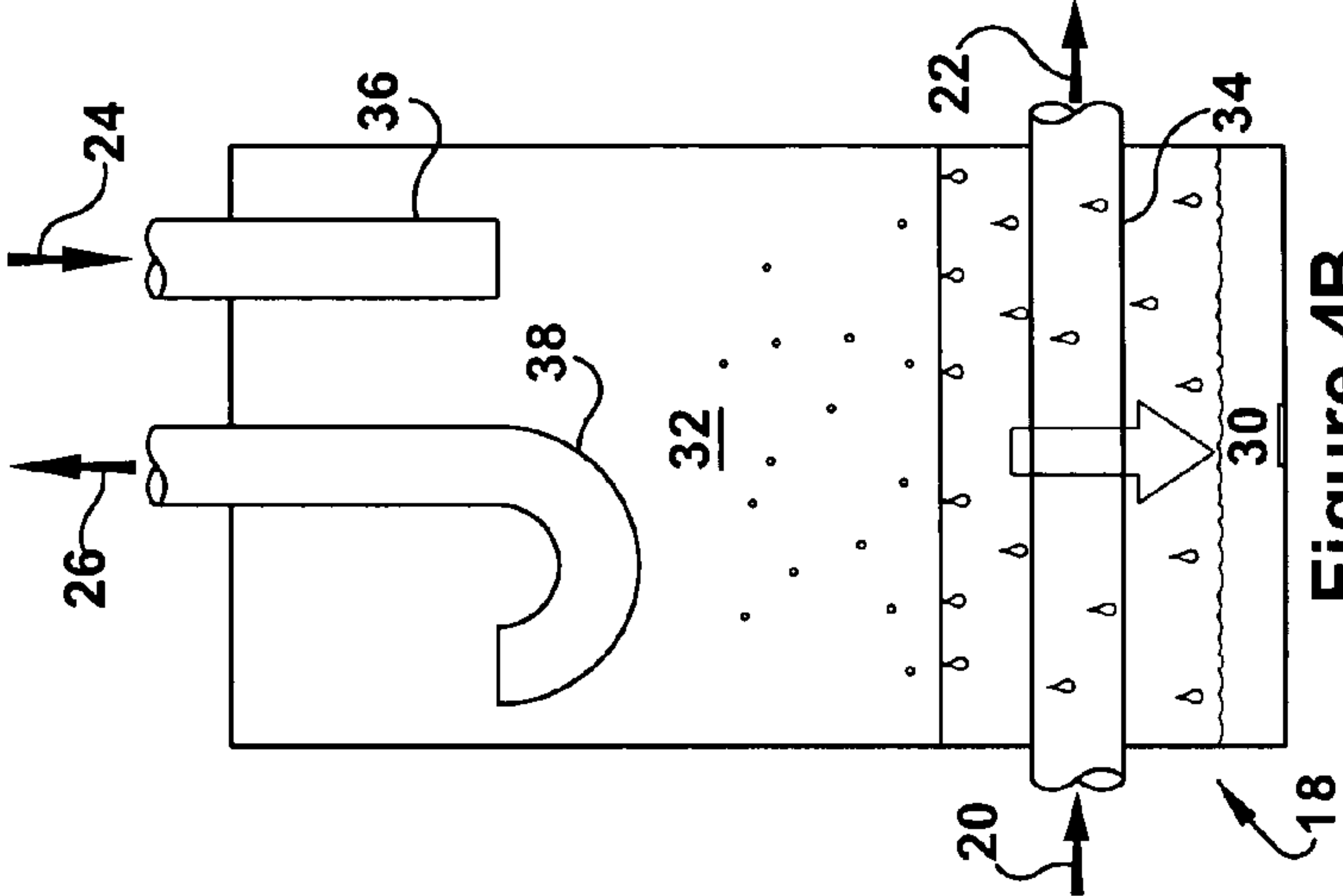


Figure 4B

$$\begin{aligned} P_{pre} &> P_{post} \\ T_{pre} &= T_{post} \\ T_{pre} &= T_{sat} \text{ at } P_{pre} \\ T_{post} &= T_{super} \text{ at } P_{post} \\ P_{30} &= P_{34} \\ P_{32} &= P_{36} = P_{38} \end{aligned}$$

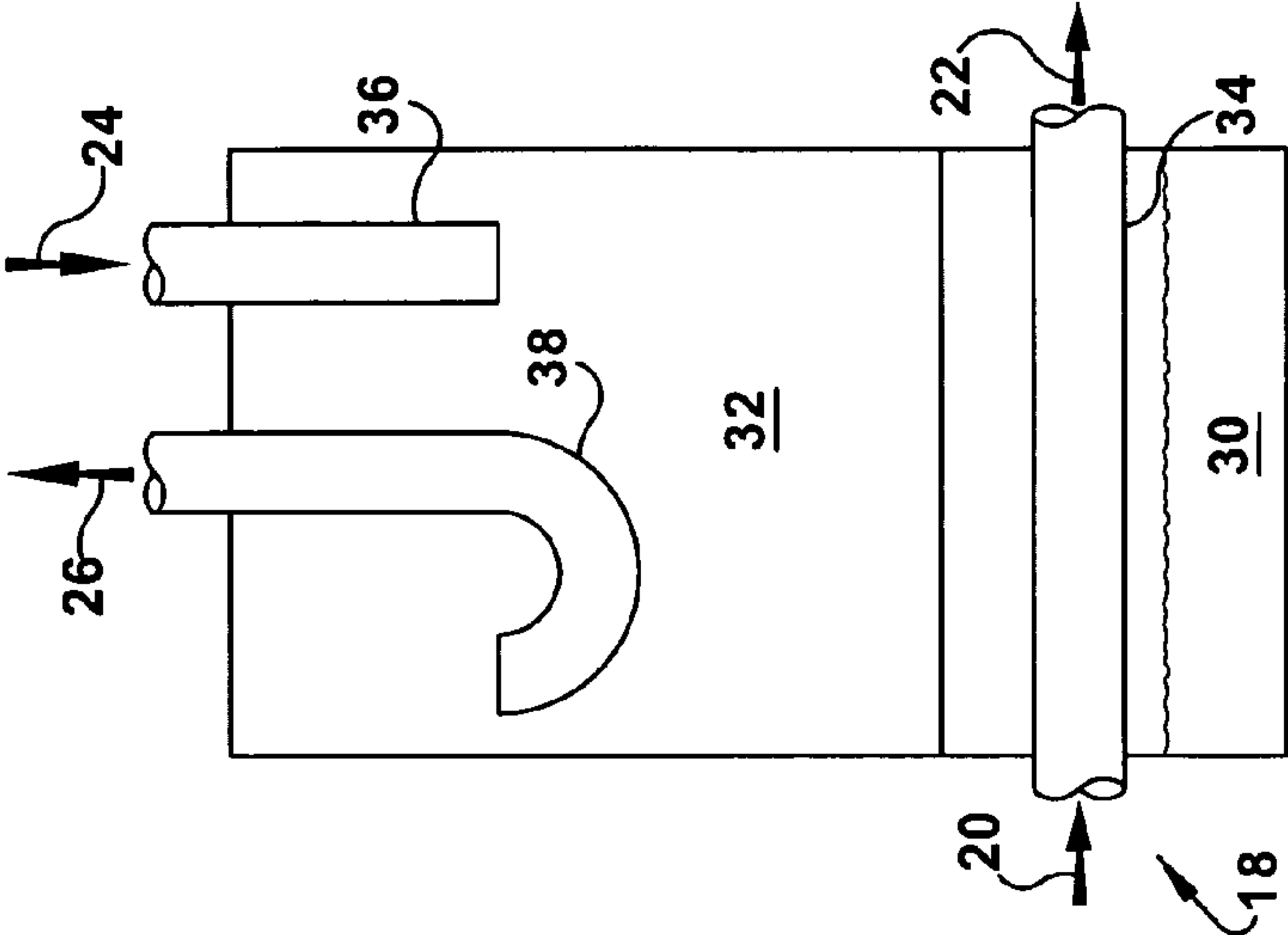
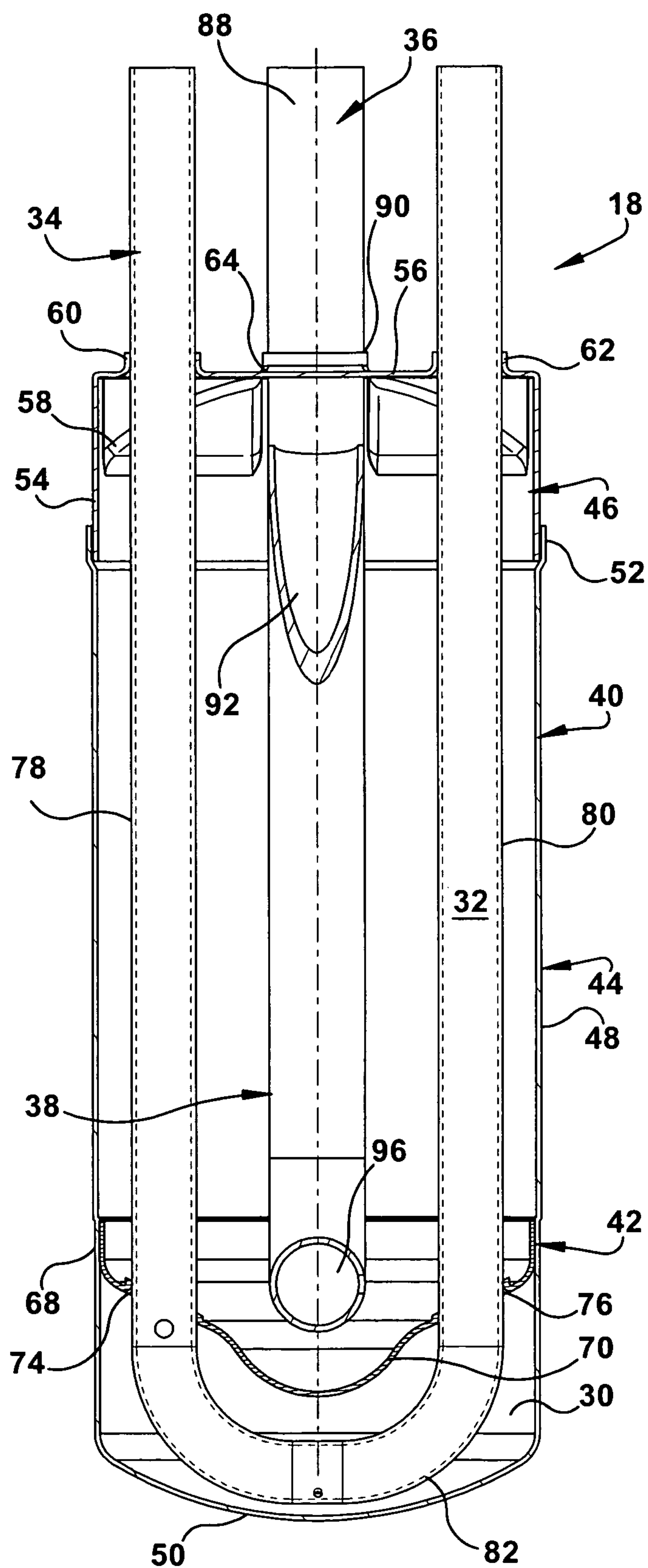


Figure 4C









### Figure 5D

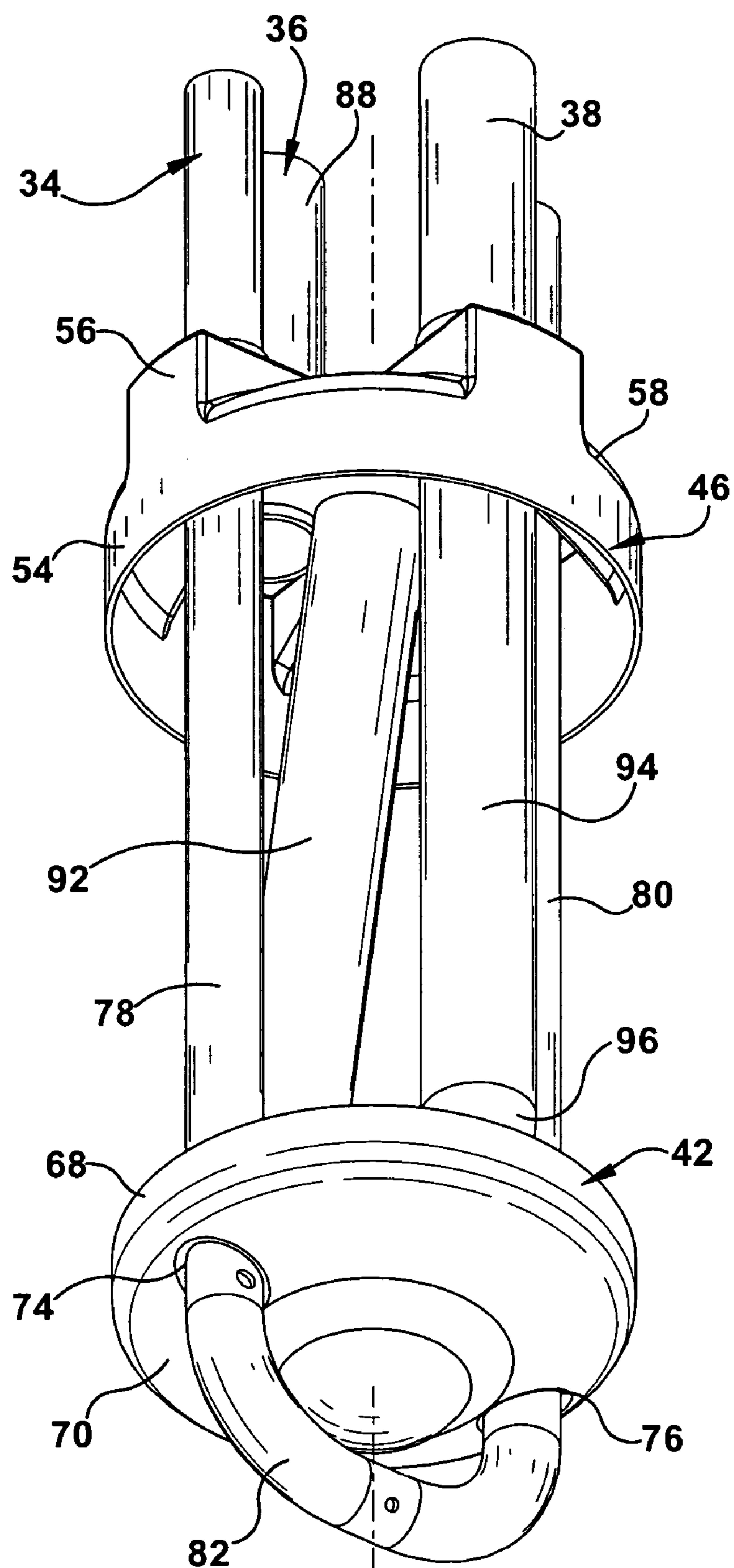


Figure 6



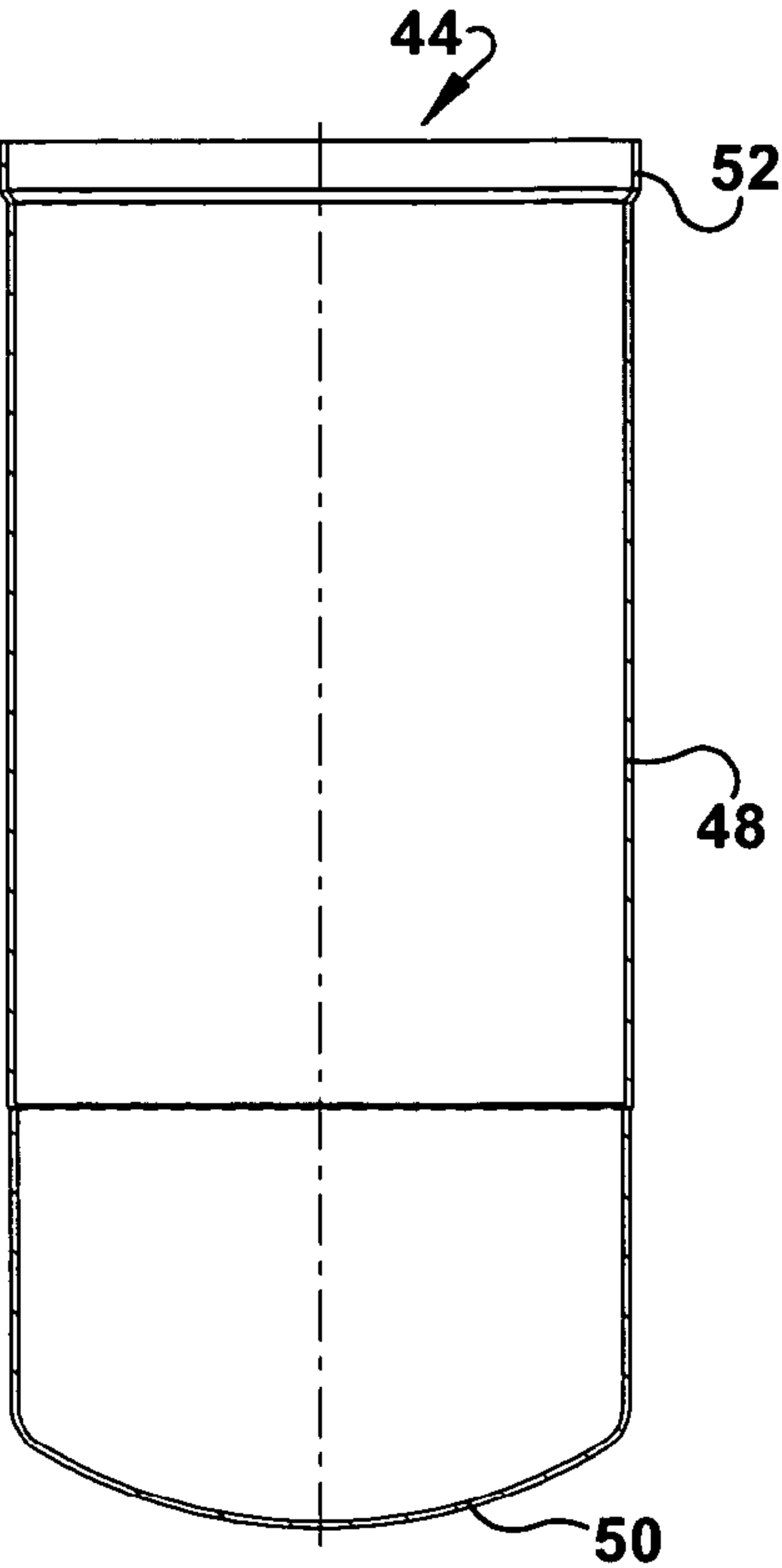


Figure 7

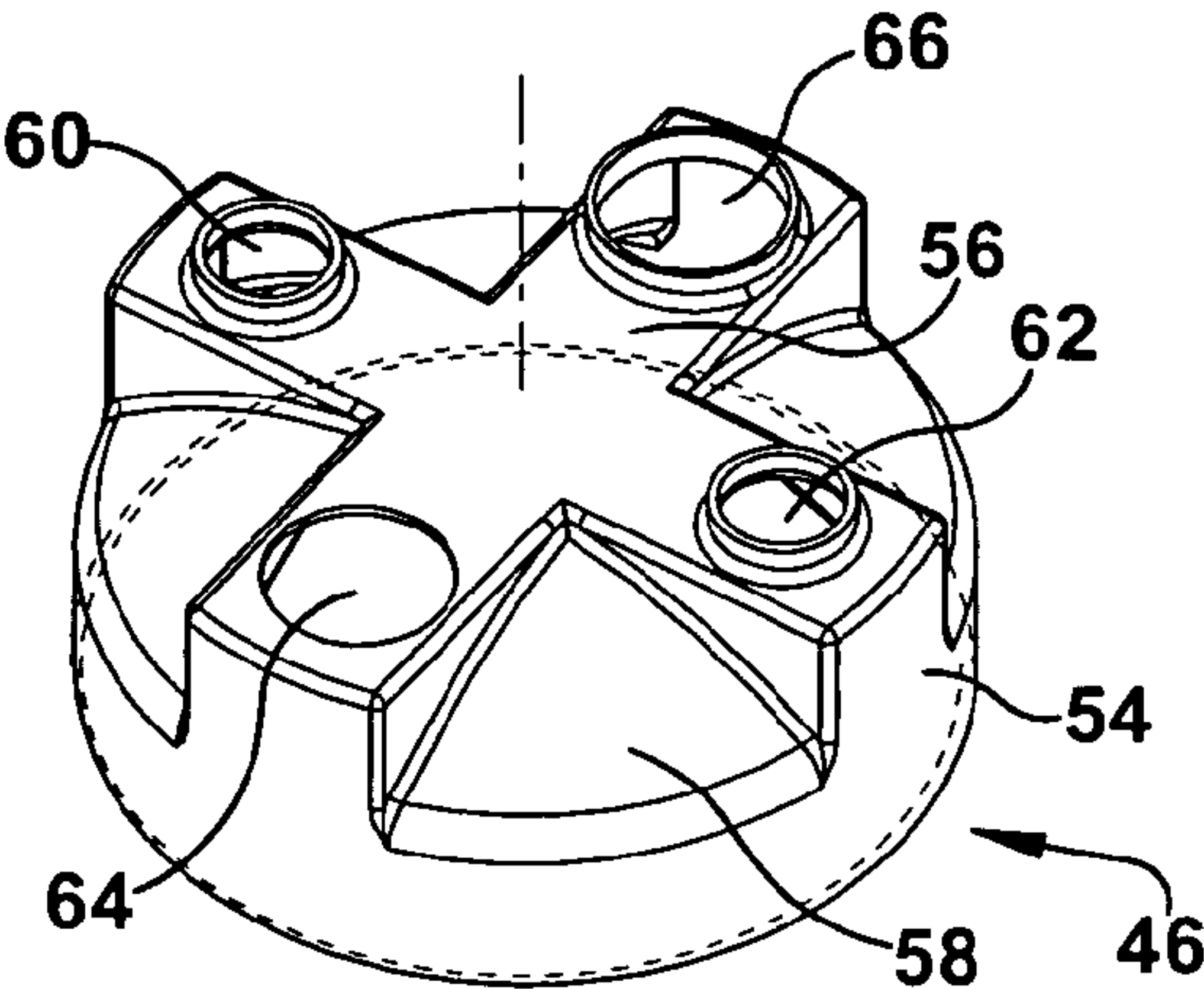


Figure 8A

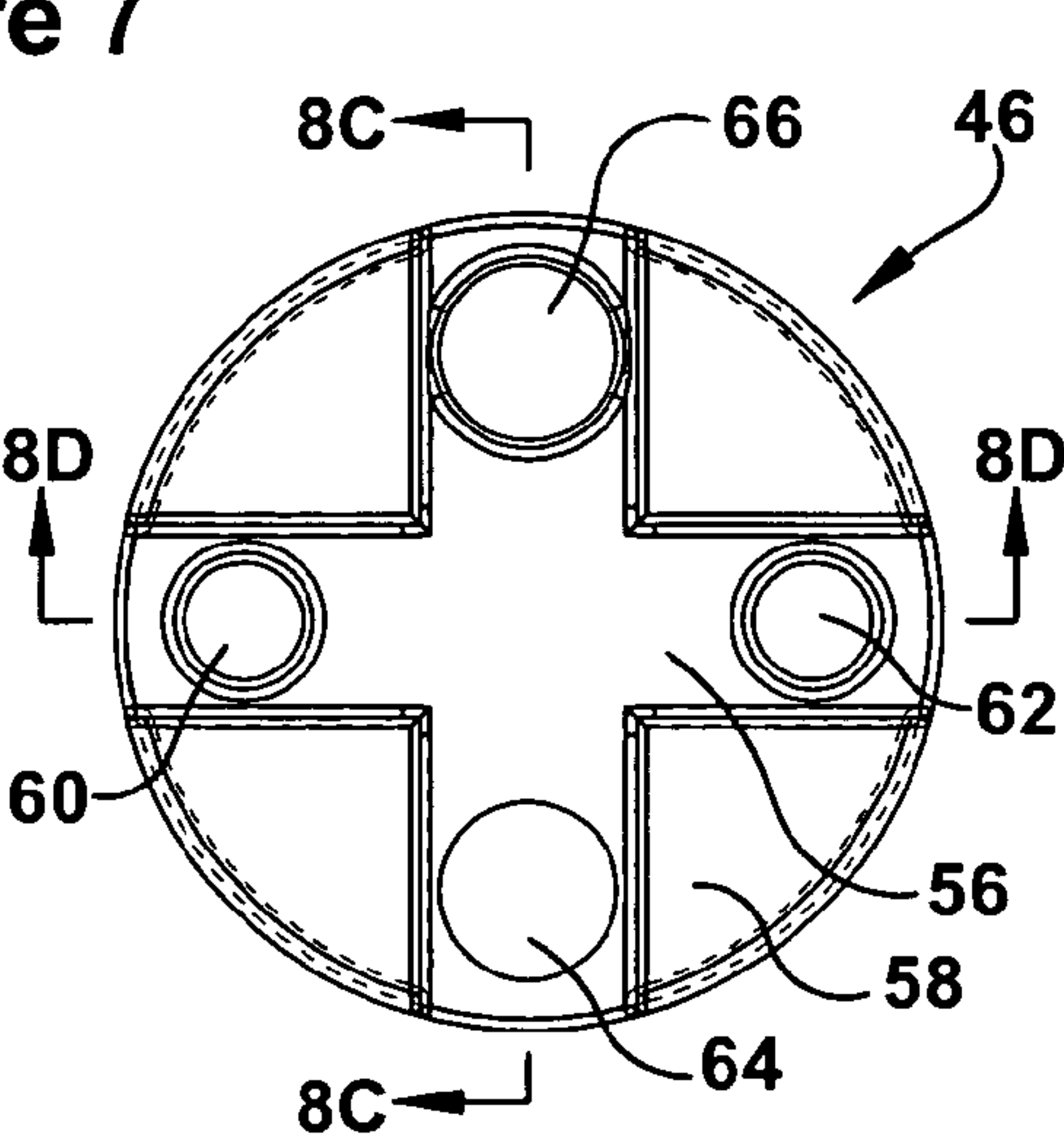


Figure 8B

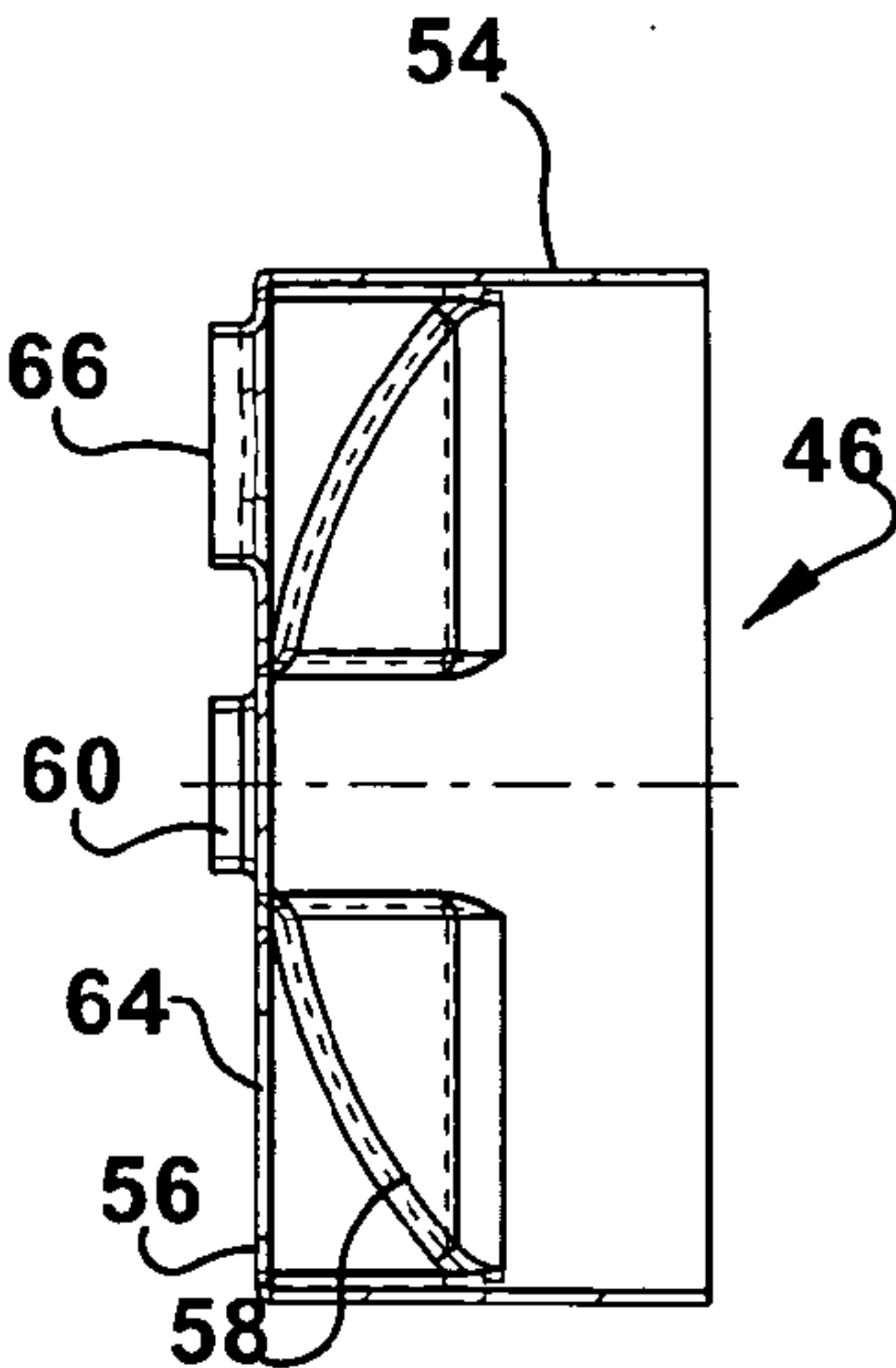


Figure 8C

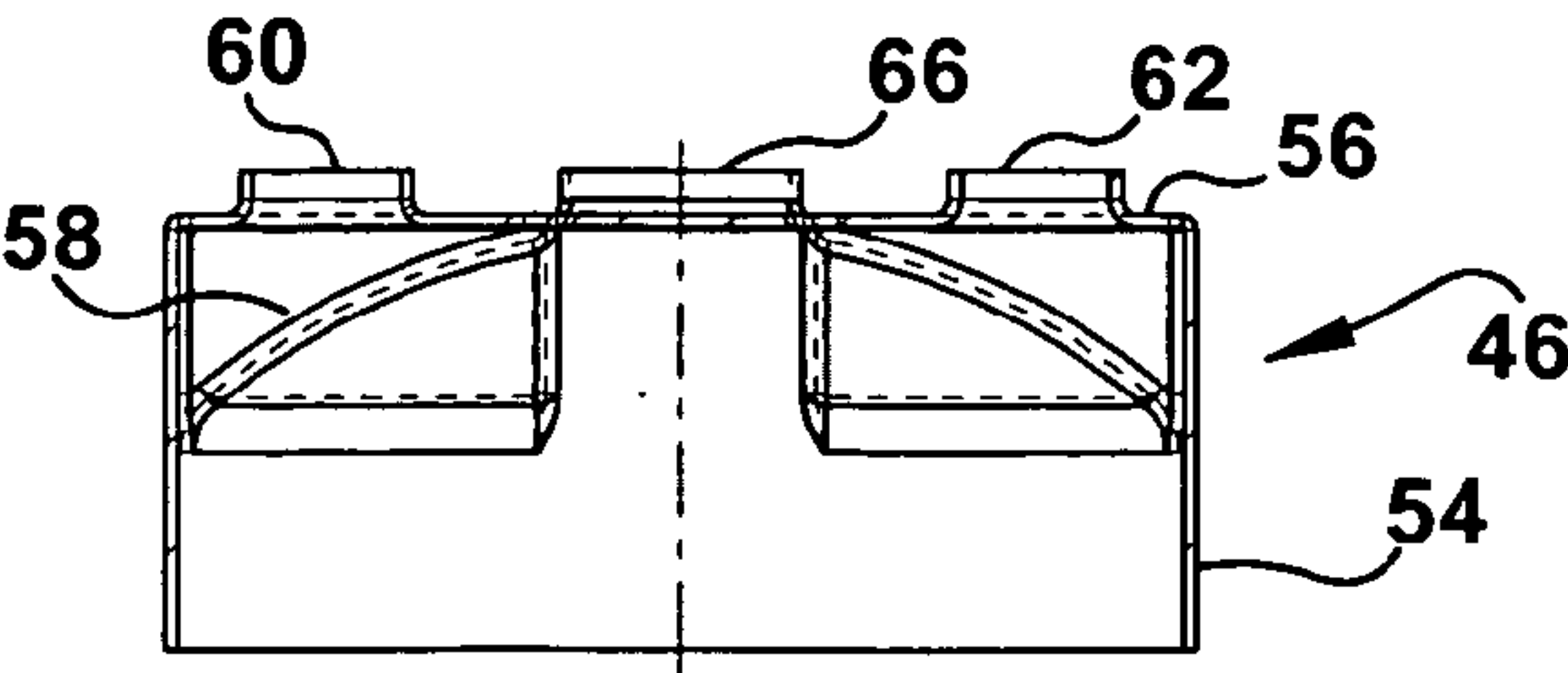


Figure 8D

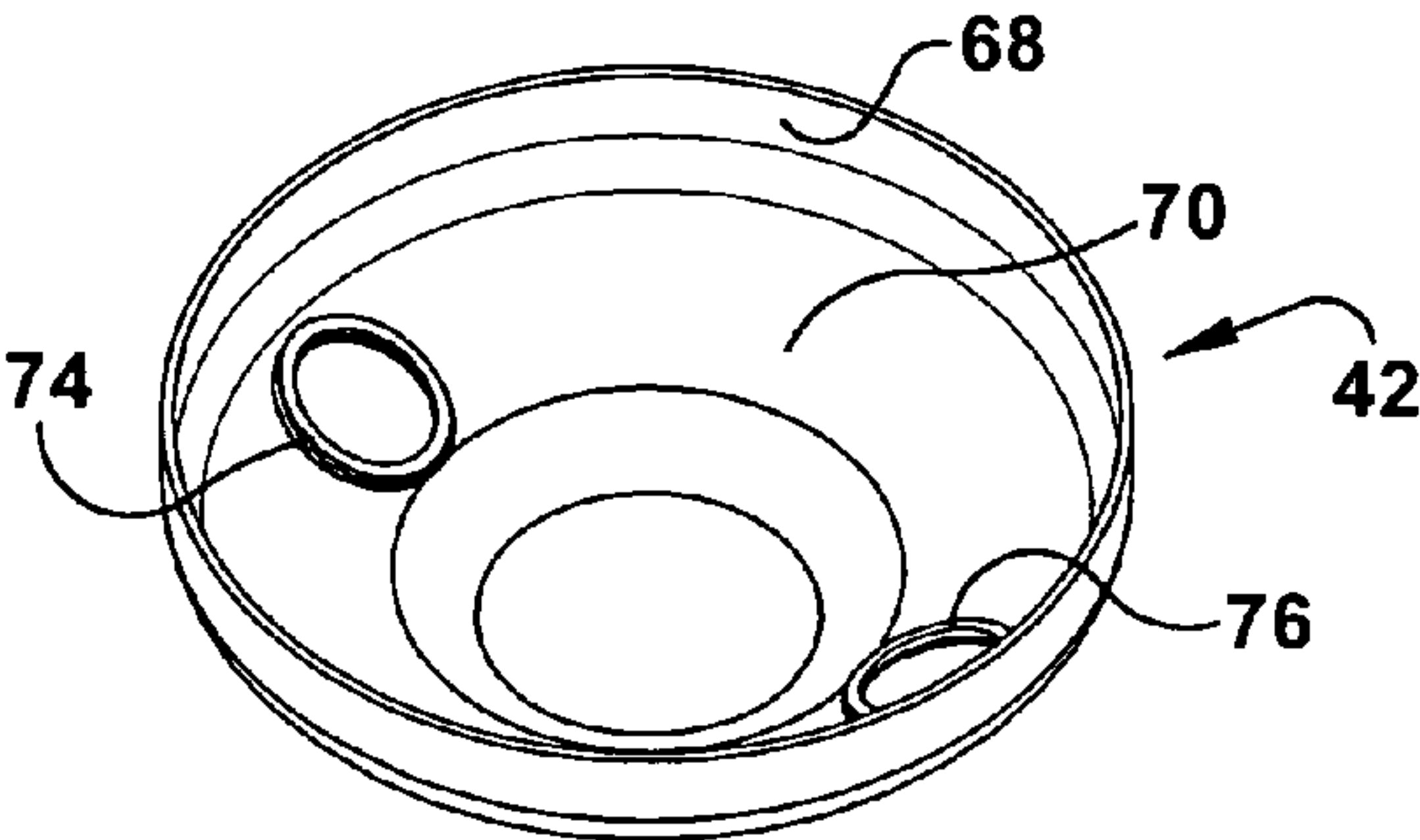


Figure 9A

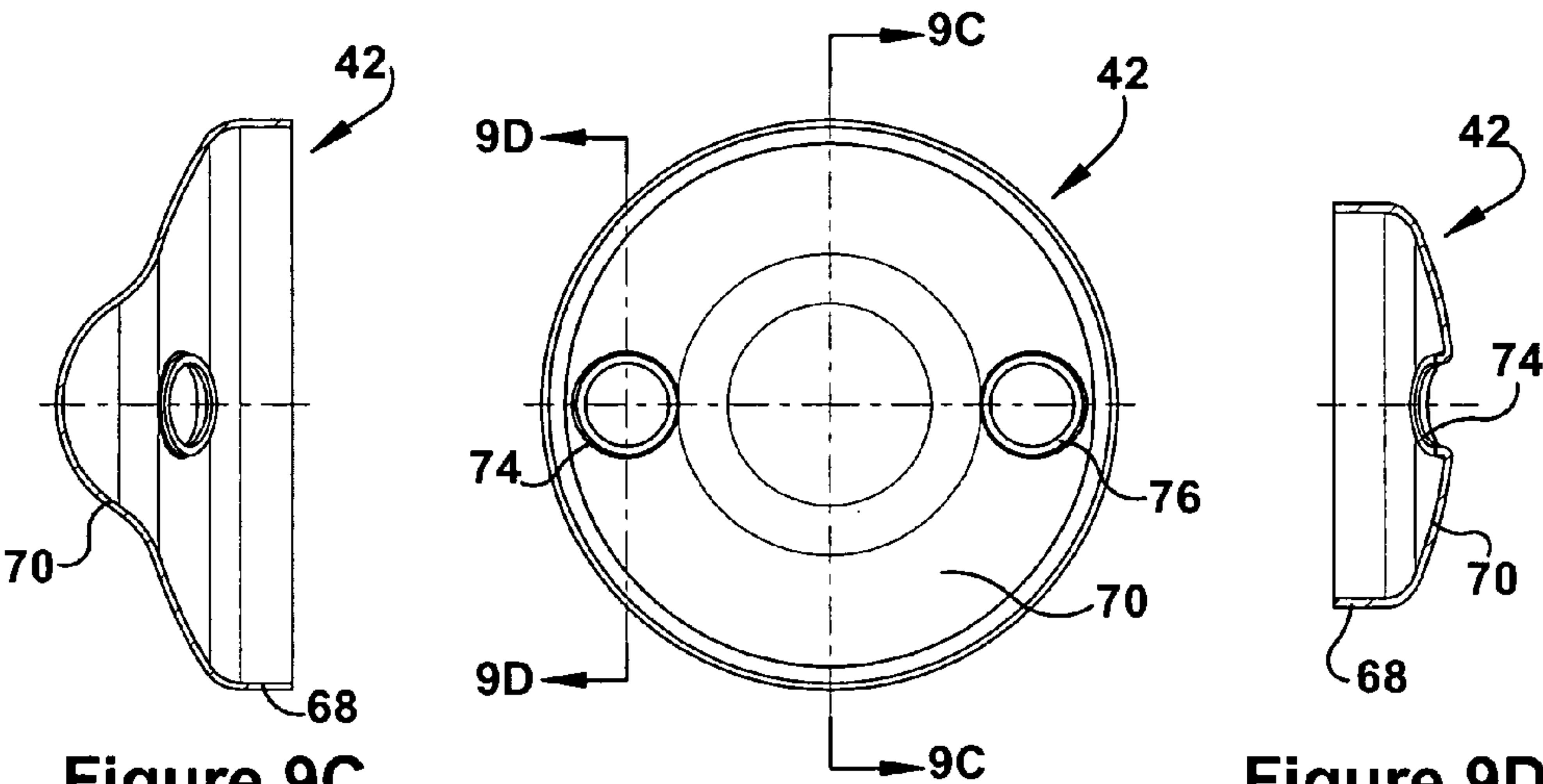


Figure 9C

Figure 9B

Figure 9D

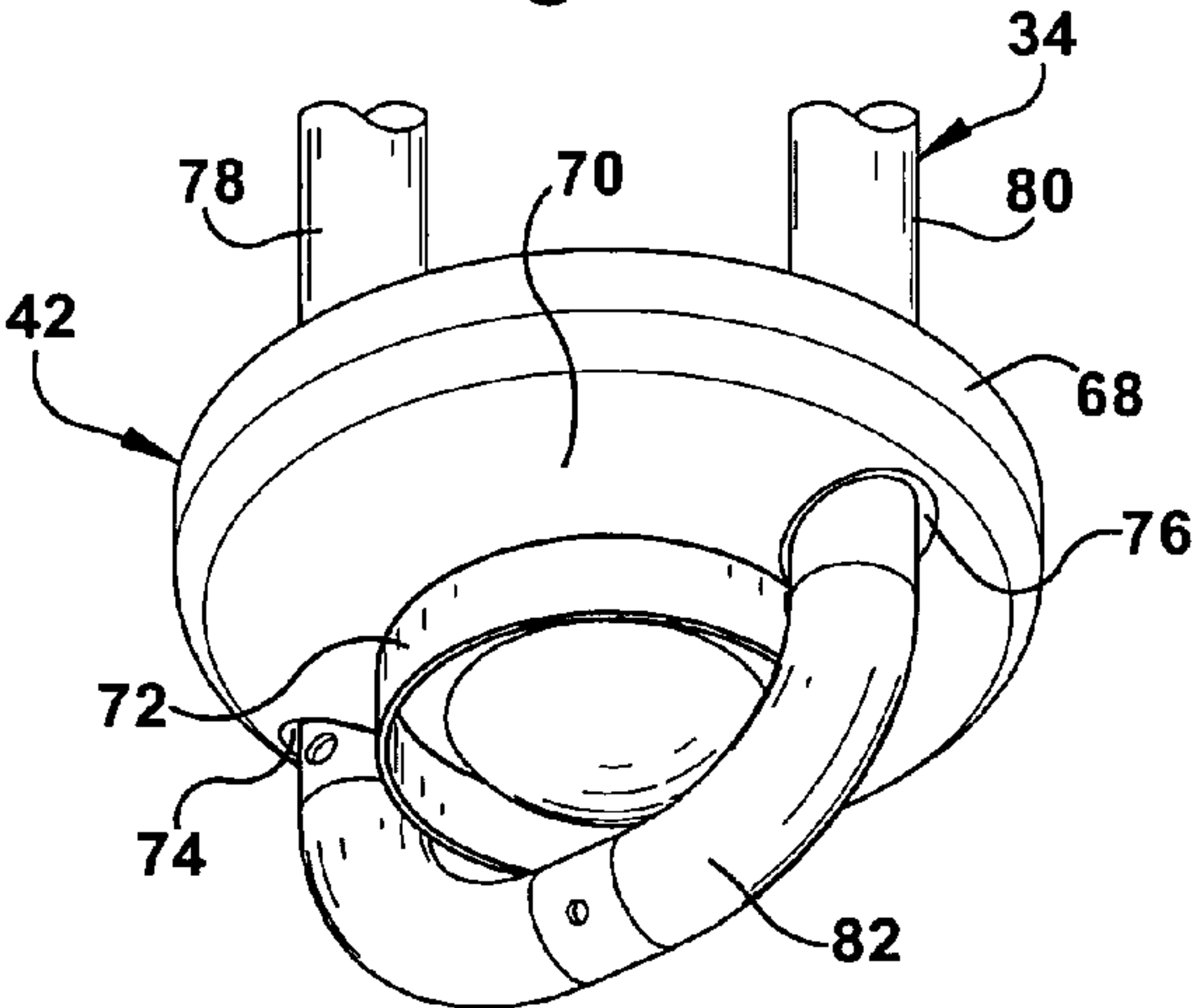


Figure 9E



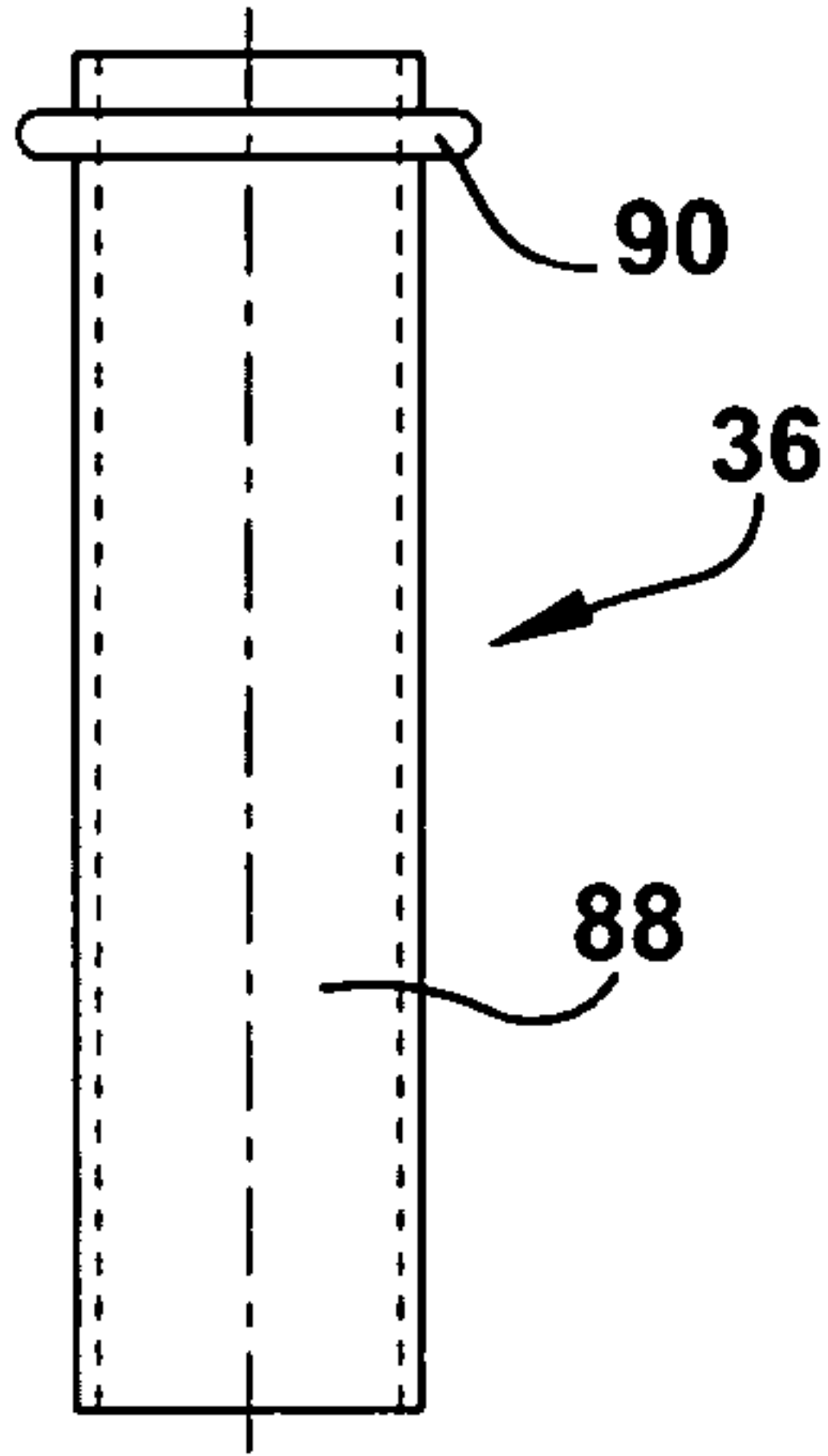


Figure 11A

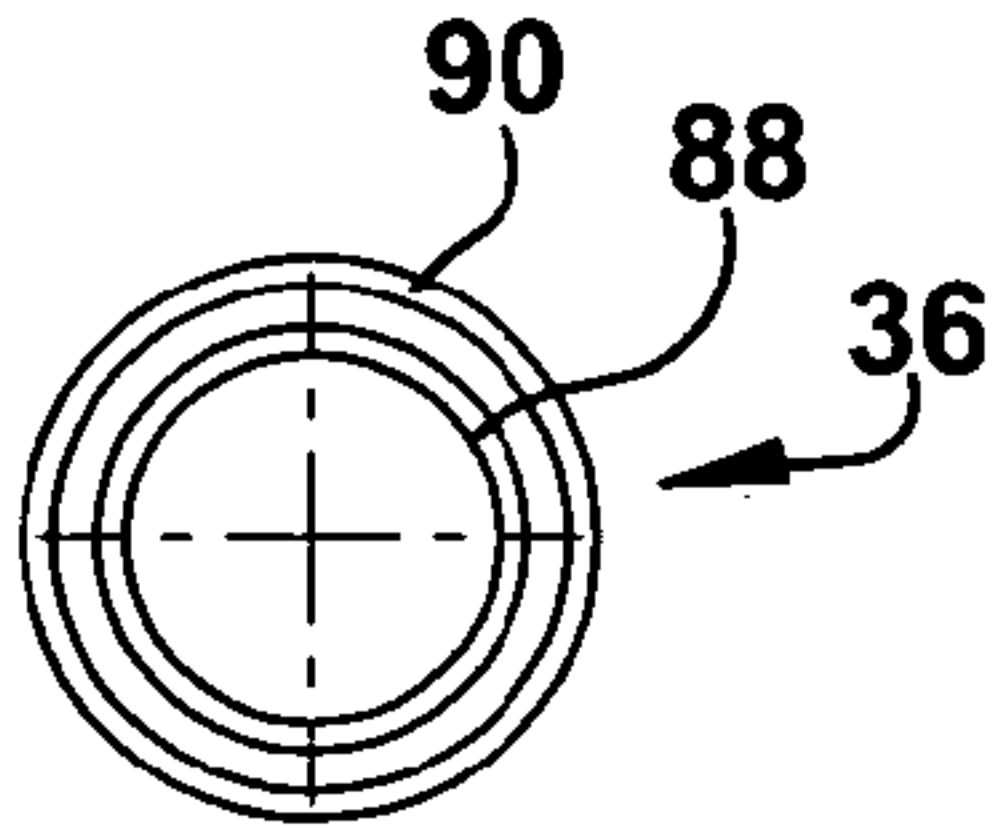


Figure 11B

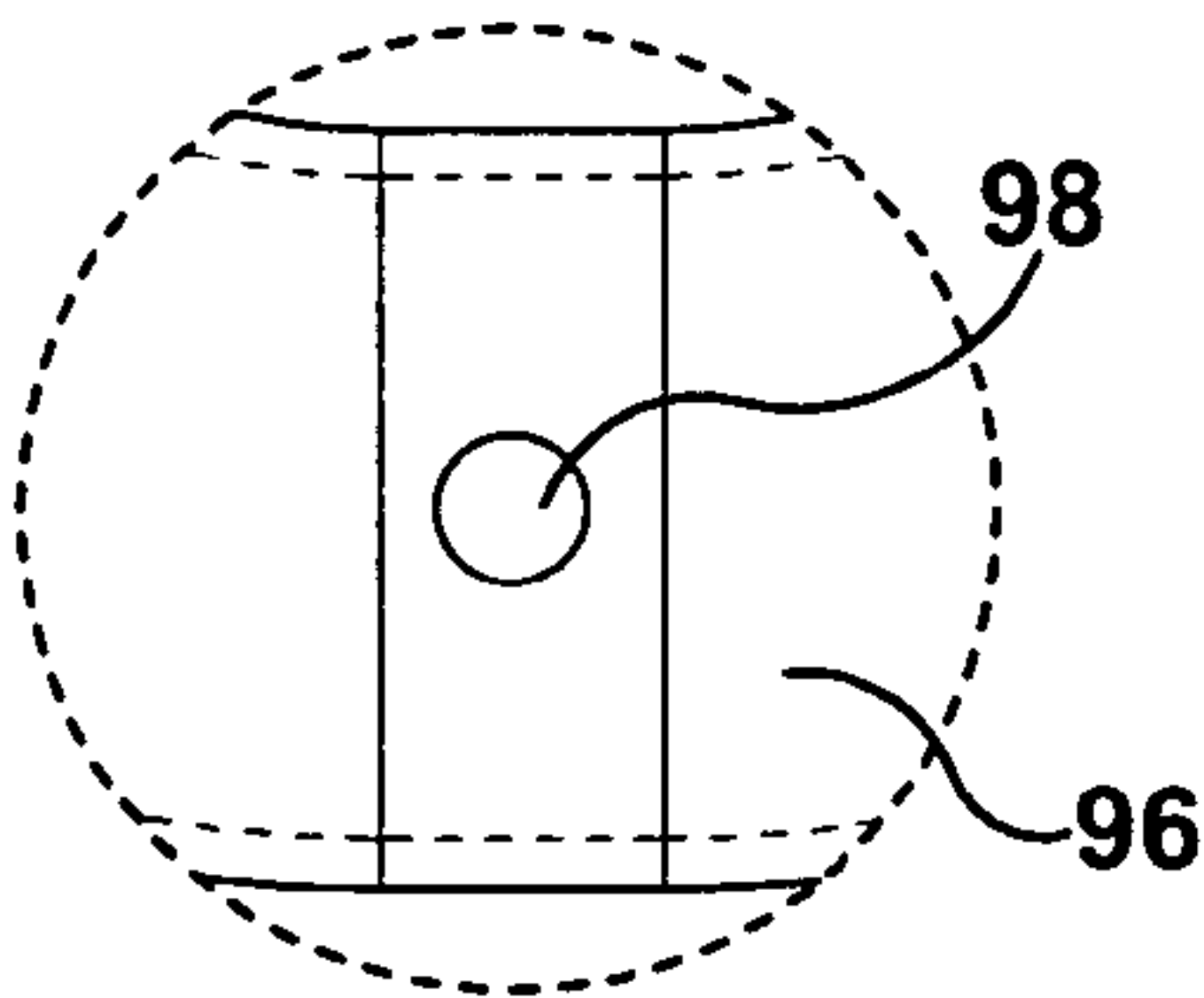


Figure 12C

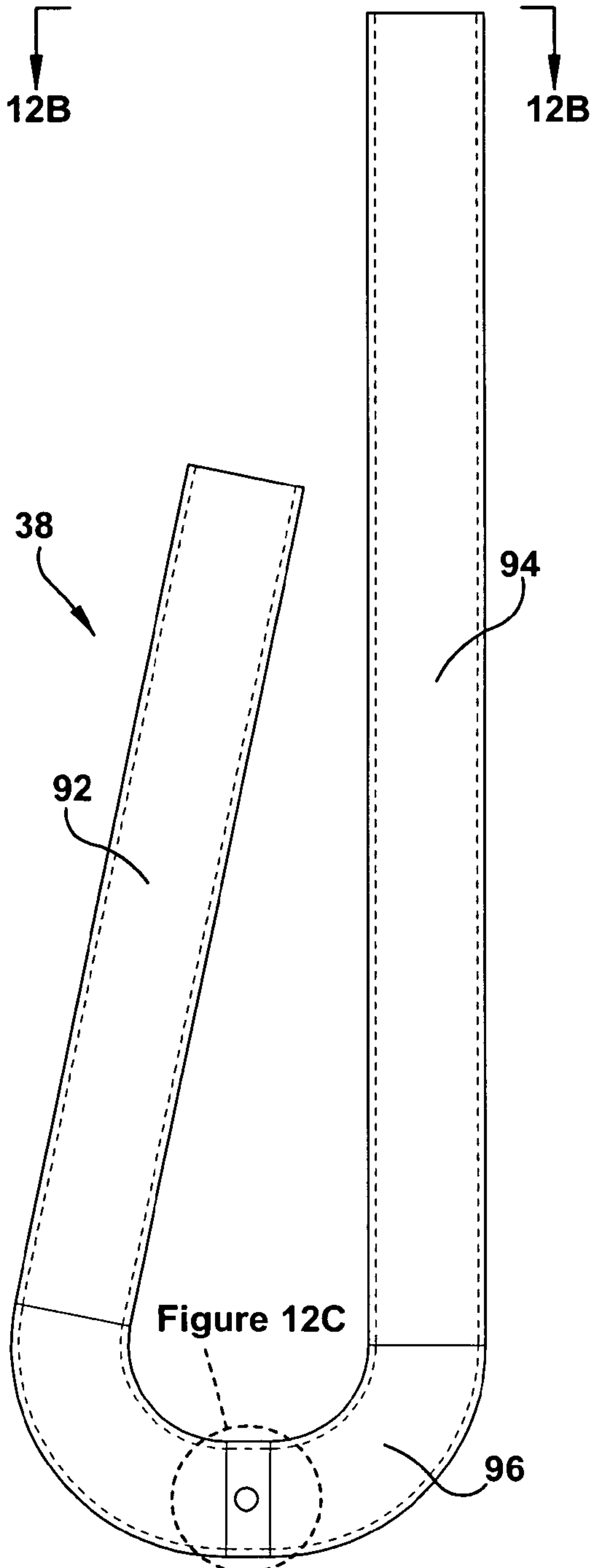


Figure 12A

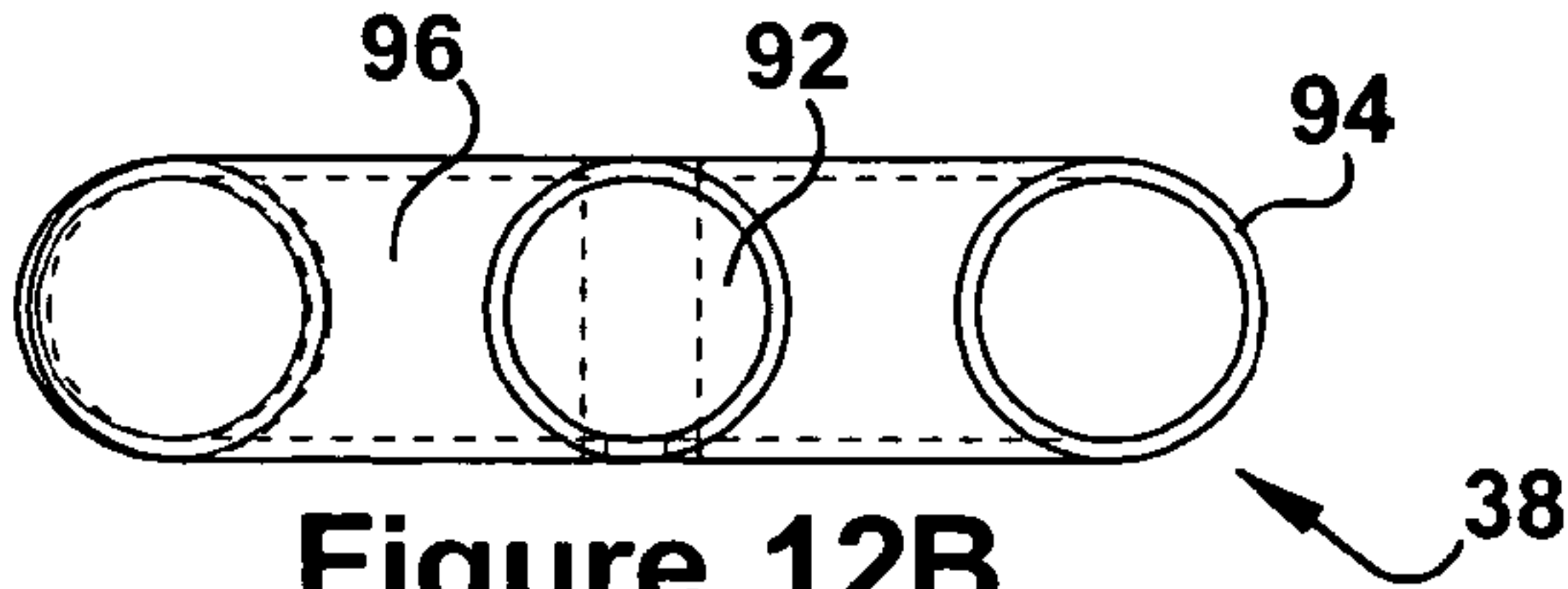


Figure 12B



**REFRIGERANT ACCUMULATOR****RELATED APPLICATION**

[0001] This application claims priority under 35 U.S.C. §119 (e) to U.S. Provisional Patent Application No. 60/673,455 filed on Apr. 21, 2005. The entire disclosure of this provisional application is hereby incorporated by reference.

**BACKGROUND**

[0002] A refrigeration system is used to control the temperature of a certain medium such as, for example, the air inside of a car, truck, or other vehicle. The system generally comprises an evaporator, a condenser, a compressor and a series of lines (e.g., pipes, tubes, ducts, etc.) connecting these components together so that refrigerant fluid can circulate therethrough. To maintain efficiency and effectiveness, the circulating mass of refrigerant fluid can be adjusted to accommodate changing heat loads. Additionally or alternatively, a system will usually carry an excess of refrigerant fluid to compensate for any escape or leakage. In either or any event, some type of an accumulator is usually provided to store excess (e.g., non-circulating) refrigerant fluid.

**SUMMARY**

[0003] An accumulator for a refrigerant system is provided that not only stores excess refrigerant fluid, but automatically controls/adjusts the charge of the system without the use of moving parts. The accumulator can be constructed to capitalize on the almost unavoidable pressure drop which occurs when refrigerant fluid passes through an evaporator. This pressure drop, in combination with the impulsion of the fluid to seek thermodynamic equilibrium conditions, can be used to insure superheated refrigerant fluid will exit the evaporator.

[0004] The accumulator comprises a first chamber and a second chamber, these chambers being in a pressure-isolated arrangement and a heat-transfer relationship. In other words, the pressure of fluid in one chamber does not equalize to the pressure of fluid in the other chamber, but the temperature of fluid in one chamber equalizes with the temperature of the fluid in the other chamber. Thus, if the pressure of fluid in the first chamber is greater than the pressure of fluid in the second chamber, and fluid in the first chamber is saturated, fluid in the second chamber will be superheated.

[0005] A pre-evaporator line passes through the first chamber, a post-evaporator-inlet line passes into the second chamber, and a post-evaporator-outlet line passes out of the second chamber. The pre-evaporator line communicates with the first chamber whereby the pressure of fluid within the first chamber equalizes with the pressure of fluid within the pre-evaporator line. Thus, if the pressure of fluid in the first chamber is greater than the pressure of fluid within the pre-evaporator line, fluid will be pushed from the first chamber to pre-evaporator line. Likewise, if the pressure of fluid in the pre-evaporator line is greater than the pressure of fluid within the first chamber, fluid will be pushed from the pre-evaporator line to the first chamber.

[0006] A temperature differential between the first chamber and the second chamber is indicative that an incorrect charge (i.e., too much or too little) of refrigerant fluid is circulating in the system. An inter-chamber temperature

differential will result in heat being transferred to or from the first chamber. This heat transfer will in turn cause a change in the pressure of fluid in the first chamber thereby precipitating a pressure imbalance between the pre-evaporator line and the first chamber. This pressure imbalance will result in fluid being pushed from the first chamber into the pre-evaporator line (to compensate for a light charge) or fluid being pushed from the pre-evaporator line to the first chamber (to compensate for a heavy charge).

[0007] The accumulator allows the first chamber to serve as the holding cell for excess refrigerant fluid during, for example, light loads. If and when this excess fluid admitted for circulation, this admittance occurs upstream of the evaporator thereby allowing immediate reintroduction of refrigerant upon restarts to avoid cooling lags. Additionally or alternatively, such a pre-evaporator (as opposed to post-evaporator) entry minimizes the risk of compressor slugging because the reintroduced fluid must pass through the evaporator on route to the compressor.

[0008] These and other features of the invention are fully described and particularly pointed out in the claims. The following description and annexed drawings set forth in detail certain illustrative embodiments of the invention, these embodiments being indicative of but a few of the various ways in which the principles of the invention may be employed.

**DRAWINGS**

[0009] **FIG. 1** is a schematic illustration of a refrigeration system which includes an accumulator.

[0010] **FIG. 2** is a schematic illustration of the accumulator when the refrigeration system is in a steady state.

[0011] **FIGS. 3A-3C** are schematic illustrations of the accumulator as the system adjusts from a starved state to a steady state.

[0012] **FIGS. 4A-4C** are schematic illustrations of the accumulator as the system adjusts from a flooded state to a steady state.

[0013] **FIGS. 5A-5D** are front, top and sectional views of the accumulator.

[0014] **FIG. 6** is a perspective view of the accumulator without its shell.

[0015] **FIG. 7** is a sectional view of the shell of the accumulator.

[0016] **FIGS. 8A-8D** are perspective, top, and sectional views of the end cap of the accumulator.

[0017] **FIGS. 9A-9D** are perspective, top, and sectional views of the dividing baffle of the accumulator.

[0018] **FIG. 9E** is a perspective view of the dividing baffle modified to include a fin.

[0019] **FIGS. 10A-10B** are side and top views of a pre-evaporator line of the accumulator.

[0020] **FIGS. 10C-10D** are closeup views of certain regions of the pre-evaporator line.

[0021] **FIGS. 11A-11B** are side and top views of a post-evaporator-inlet line.



[0022] **FIGS. 12A-12B** are side and top views of a post-evaporator-outlet line.

[0023] **FIG. 12C** is a closeup view of a certain region of the post-evaporator-outlet line.

#### DETAILED DESCRIPTION

[0024] Referring now to the drawings, and initially to **FIG. 1**, a refrigeration system **10** is schematically shown. The refrigeration system **10** can be used to control the temperature of a certain medium (e.g., air in the cabin of a vehicle) and generally comprises an evaporator **12**, a condenser **14**, a compressor **16**, and an accumulator **18**. A plurality of lines connect the components **12**, **14**, **16** and **18** so that refrigerant fluid can cycle therethrough. In the illustrated embodiment, line **20** connects the outlet of the condenser **14** to the accumulator **18**, line **22** connects the accumulator **18** to the inlet of the evaporator **12**, line **24** connects the outlet of the evaporator **12** to the accumulator **18**, line **26** connects the accumulator **18** to the suction of the compressor **16**, and line **28** connects the discharge of the compressor **16** to the inlet of the condenser **14**. For the purposes of the present description, the term "line" means any pipe, tube, duct or other device(s), in tandem, series, parallel or otherwise, through which fluid is circulated through the refrigeration system **10**.

[0025] Refrigerant fluid enters the evaporator **12** (via lines **20** and **22**) as low pressure and low-temperature vapor-liquid. As the vapor-liquid passes through the evaporator **12**, it is boiled into low pressure gas, and drawn by suction to the compressor **16** (via lines **24** and **26**). The compressor **16** increases the pressure and temperature of gaseous refrigerant for conveyance to the condenser **14** (via line **28**). In the condenser **14**, the refrigerant is condensed to a high pressure and low temperature liquid. On route back to the evaporator **12** (via line **20**), the high pressure liquid is passed through a metering device to reduce its pressure. The refrigerant fluid then again enters the evaporator **12** as a low pressure and low temperature vapor-liquid to complete the cycle. As is explained in more detail below, pre-evaporator refrigerant passes through the accumulator **18** on its way to the evaporator **12** (via lines **20** and **22**) and post-evaporator refrigerant passes through the accumulator **18** on its way to the compressor **16** (via lines **24** and **26**).

[0026] The system **10** is intended to operate so that refrigerant fluid exits the evaporator **12** as superheated vapor (e.g., about 5° F. to about 15° F. above saturation). This superheated exit, as opposed to a classic just-saturated exit, is believed to improve the performance of the system **10**. Specifically, for example, it allows the compressor **16** to maintain lower evaporating pressure/temperature.

[0027] Referring now to **FIGS. 2-4**, the accumulator **18** and its operation are schematically shown. The accumulator **18** comprises a first chamber **30**, a second chamber **32**, a pre-evaporator line **34**, a post-evaporator-inlet line **36**, and a post-evaporator-outlet line **38**. The chambers **30** and **32** are in a heat-transfer relationship so that the temperature in one chamber **30/32** equalizes to the temperature of the other chamber **32/30**. The chambers **30** and **32** are not in fluid communication with each other, except to the extent that circulating fluid exiting the chamber **30** will re-enter the chamber **32** after passing through the evaporator **12**. As such, the chambers **30** and **32** can be considered pressure-

isolated, in that a change in pressure in one chamber **30/32** will not substantially and/or directly effect the pressure in the other chamber **32/30**.

[0028] The pre-evaporator line **34** forms a liquid-vapor flow passage which passes through and communicates with the first chamber **30**. The pressure  $P_{30}$  within the first chamber **30** and the pressure  $P_{34}$  within the pre-evaporator line **34** will equalize to the pressure  $P_{pre}$  of the pre-evaporator refrigerant fluid. The post-evaporator-inlet line **36** forms a flow passage into the second chamber **32**, and the post-evaporator-outlet line **38** forms a gas-only flow passage out of the second chamber **32**. The pressure  $P_{32}$  within the second chamber **32**, the pressure  $P_{36}$  within the inlet line **36**, and the pressure  $P_{38}$  within the outlet line **38**, will equalize to the pressure  $P_{post}$  of the post-evaporator refrigerant fluid.

[0029] As refrigerant fluid passes through the evaporator **12**, there is invariably a pressure drop (e.g., due to pipe resistance of the serpentine coils). As such, the pressure  $P_{pre}$  of the pre-evaporator fluid is greater than the pressure  $P_{post}$  of the post-evaporator fluid. This pressure drop is usually in the range of about 2 psi to about 15 psi in an automotive air conditioner, but will, of course, vary depending upon the refrigeration system **10** in which the accumulator **18** is incorporated. In any event, the temperature  $T_{pre}$  of the pre-evaporator fluid is substantially the same as the temperature  $T_{post}$  of the post-evaporator fluid whereby when pre-evaporator fluid is saturated, post-evaporator fluid is superheated.

[0030] In **FIG. 2**, the pressure/temperature conditions of the accumulator **18** are schematically shown when the system **10** is in a steady state (e.g., the correct charge of refrigerant fluid is circulating in lines **20-28**). The pressure  $P_{30}$  of the fluid within the first chamber **30**, and the pressure  $P_{34}$  of fluid within the pre-evaporator line **34** are equal (i.e., they are equal to  $P_{pre}$ ). The pressure  $P_{32}$  of the fluid within the second chamber **32**, the pressure  $P_{36}$  of the fluid within the post-evaporator-inlet line **36**, and the pressure  $P_{38}$  of the fluid within the post-evaporator-outlet line **38** are equal (i.e., they are equal to  $P_{post}$ ). Thus the pressures  $P_{30}$  and  $P_{34}$  are greater than the pressures  $P_{32}$ ,  $P_{36}$  and  $P_{38}$ .

[0031] The temperature  $T_{30}$  within the first chamber **30** is equal to the temperature  $T_{32}$  within the second chamber **32**. The temperature  $T_{pre}$  of the pre-evaporator fluid is at saturation temperature  $T_{sat}$  for the pre-evaporator pressure  $P_{pre}$  and the temperature  $T_{post}$  of the post-evaporator fluid is at a superheated temperature  $T_{super}$  for the post-evaporator pressure  $P_{post}$ . The post-evaporation temperature  $T_{post}$ , which is equal to  $T_{super}$ , will be a desired number of degrees temperature above the saturation temperature at the post-evaporation pressure  $P_{post}$ . For example, the desired superheated temperature  $T_{super}$  can be about 5° F. to about 15° F. above saturation temperature at the post-evaporator pressure  $P_{post}$ .

[0032] Referring now to **FIGS. 3A-3B**, the pressure/temperature conditions of the accumulator **18** are schematically shown as the system **10** adjusts from a starved state (i.e., not enough refrigerant fluid circulating in the lines **20-28**) to a steady state. As in the steady state, the pressure  $P_{pre}$  of the pre-evaporator fluid is greater than the pressure  $P_{post}$  of the post-evaporator fluid, and the pressure  $P_{30}$  of the fluid within the first chamber **30**, and the pressure  $P_{34}$  of fluid within the pre-evaporator line **34** are equal (i.e., they are equal to  $P_{pre}$ ). However, when the system **10** is in a starved state, the post-evaporator fluid will be overly-superheated resulting in



a temperature  $T_{\text{post}}$  greater than the desired superheated temperature  $T_{\text{super}}$ . Consequently, the pre-evaporator temperature  $T_{\text{pre}}$  is less than the post-evaporator temperature  $T_{\text{post}}$  (FIG. 3A.)

[0033] The temperature differential (i.e.,  $T_{32}-T_{30}$ ) causes heat-transfer from the second chamber 32 to the first chamber 30 to equalize the temperatures  $T_{30}$  and  $T_{32}$ . As the temperature  $T_{30}$  of the fluid within the chamber 30 increases, liquid within this chamber 30 evaporates thereby increasing the chamber pressure  $P_{30}$  so that it is greater than the pressure  $P_{34}$  of fluid within the pre-evaporator line 34. (FIG. 3B.) This pressure differential (i.e.,  $P_{30}-P_{34}$ ) pushes fluid within the chamber 30 into the pre-evaporator line 34 thereby increasing the mass of refrigerant fluid circulating in the system 10. The injection of refrigerant fluid into the line 34 will continue until the pressure  $P_{30}$  within the chamber 30 equals the pressure  $P_{34}$  within the pre-evaporation line 34. (FIG. 3C.)

[0034] Referring now to FIGS. 4A-4B, the pressure/temperature conditions of the accumulator 18 are schematically shown as the system 10 adjusts from a flooded state (i.e., too much refrigerant fluid circulating through the lines 20-28) to a steady state. As in the steady state and the starved state, the pressure  $P_{\text{pre}}$  of the pre-evaporator fluid is greater than the pressure  $P_{\text{post}}$  of the post-evaporator fluid, and the pressure  $P_{30}$  of the fluid within the first chamber 30 and the pressure  $P_{34}$  of fluid within the pre-evaporator line 34 are equal. However, as an aftereffect of the evaporator 12 having to handle too much fluid, the temperature  $T_{\text{post}}$  of the fluid exiting the evaporator 12 will be under-superheated (e.g., saturated or superheated to less than the desired superheated temperature  $T_{\text{super}}$ ). The temperature  $T_{\text{pre}}$  of the pre-evaporator fluid equals the saturation temperature  $T_{\text{sat}}$  at the pressure  $P_{\text{pre}}$ , whereby the pre-evaporation temperature  $T_{\text{pre}}$  is greater than the post-evaporation temperature  $T_{\text{post}}$ . (FIG. 4A.)

[0035] As a result of the temperature differential ( $T_{\text{pre}}-T_{\text{post}}$ ), heat is transferred from the first chamber 30 to the second chamber 32. This heat transfer causes vapor within the first chamber 30 to condense into liquid and this condensation lowers the chamber pressure  $P_{30}$ . (FIG. 4B.) The pressure imbalance ( $P_{34}-P_{30}$ ) between the chamber 30 and the pre-evaporator line 34 pushes fluid from the pre-evaporator line 34 into the first chamber 30, thereby decreasing the mass of refrigerant fluid flowing through the system 10. The ejection of refrigerant fluid from the line 34 continues until the chamber pressure  $P_{30}$  equals the line pressure  $P_{34}$  and the system 10 is once again at a steady state. (FIG. 4C.)

[0036] With the accumulator 18, some hunting may occur during adaption to transient heat loads. However, the accumulator 18 can be constructed so that the system 10 very quickly reaches a steady state condition. Response time can be, for example, in the range of about ten seconds to about two minutes, depending upon the parameters of the system 10 and the design of the accumulator 18.

[0037] Turning now to FIGS. 5-12, one possible construction for the accumulator 18 is shown. In the illustrated construction, the accumulator 18 comprises a capsule 40 and a baffle 42 within the capsule 40. (FIGS. 5A and 5C-5D.) The baffle 42, or any appropriate divider for that matter, separates the space defined by the capsule 40 into the first chamber 30 and the second chamber 32. (FIGS. 5C-5D.) In

the illustrated embodiment, the heat-exchange between the chambers 30 and 32 will occur primarily, if not exclusively, through the baffle 42. It may be advantageous for the first chamber 30 to be positioned below the second chamber 32.

[0038] The illustrated capsule 40 comprises a shell 44 and an end cap 46 which closes the upper open end of the shell 44. (FIGS. 5A and 5C-5D.) The shell 44 can be formed from a cylindrical wall 48 and a bottom end wall 50. (FIGS. 5A and 5C-5D, and FIG. 7.) The cylindrical wall 48 can have a flanged upper edge (adjacent its open end) for receipt of a portion (namely a rim 54, introduced below) of the end cap 46. The capsule 40 and/or shell 44 are sized so that the first chamber 30 can accommodate the expected maximum mass of excess refrigerant fluid. The height of the capsule 40 and/or the shell 44 can be, for example, about one to three inches more than a conventional one-chamber accumulator.

[0039] The end cap 46 can comprise a rim 54, a cross-shape platform 56 extending upward from the rim 54, and dome-sections 58 spanning the spaces between the four annexes of the platform 56. (FIGS. 5A-5D, FIG. 6, and FIGS. 8A-8D.) The rim 54 is sized/shaped for receipt within the flanged upper edge of the cylindrical wall 48 of the shell 44. The illustrated end cap 46 includes a pre-evaporator entrance opening 60, a pre-evaporator exit opening 62, a post-evaporator-inlet entrance opening 64, and a post-evaporator-outlet exit opening 66. The entrance/exit openings 60 and 62 can be positioned on aligned annexes of the platform 56 and the entrance/exit openings 64 and 66 can be positioned on the platform's other two aligned annexes. In the illustrated embodiment, the openings 60, 62, and 66 have flanges surrounding them, the opening 64 does not.

[0040] In the assembled accumulator 18, inlet/outlet portions (namely leg portions 78/80, introduced below) of the pre-evaporator line 34, the post-evaporator-inlet line 36, and the post-evaporator-outlet line 38 pass through the entrance/exit openings 60/62, 64 and 66, respectively, in the end cap 46. (FIGS. 5A-5D and FIG. 6.) This entrance/exit arrangement allows the lines 34, 36 and 38 to share a common block-type fitting, thereby minimizing the number of connections and simplifying incorporation of the accumulator 18 into the refrigeration system 10. However, other inlet/outlet arrangements are certainly possible and contemplated. For example, the post-evaporator-outlet line 38 could instead exit the second chamber 32 through an opening in the side cylindrical wall 48 of the shell 44. The end cap 46 can include only one entrance/exit opening, two entrance/exit openings, three entrance/exit openings, and/or, as shown, all four of the entrance/exit openings. In other words, any or all of lines 34, 36, and 38 could enter/exit their relevant chambers 30 and 32 without passing through the end cap 46.

[0041] The baffle 42 can comprise a rim portion 68 for fluid-tight connection to an interior surface of the capsule 40 and a heat-transferring central portion 70. (FIGS. 5C-5D, FIG. 6, and FIGS. 9A-9D.) The central portion 70 can have a non-flat profile (e.g., curved, indented, etc.) to increase its heat-transfer surface area and/or to form a collection pond. Additionally or alternatively, a fin 72 or other heat-transfer-increasing means could be incorporated into the baffle 42. (FIG. 9E.) Usually, the baffle material will be metal and/or have a thermal conductivity in the range of about 50 BTU/(h\* $ft^{\circ}$  F.) to about 300 BTU/(h\* $ft^{\circ}$  F.) at the expected



temperature range for the chambers 30 and 32. If the first chamber 30 is positioned below the second chamber 32, as illustrated, the heat-transferring portion 70 of the baffle 42 will form the ceiling of the first chamber 30 and the floor of the second chamber 32.

[0042] The illustrated baffle 42 includes a pre-evaporator inlet opening 74 and a pre-evaporator outlet opening 76 for accommodating inlet/outlet portions (namely leg portions 78/80, introduced below) of the pre-evaporator line 34. (FIGS. 5C-5D, FIG. 6, and FIGS. 9A-9D.) These openings 74/76 may be necessary when, for example, the end cap 46 serves as the fitting for the pre-evaporator line 34 and/or when this line 34 passes through the second chamber 32 on route to/from the first chamber 30. However, if the pre-evaporator line 34 enters/exits the first chamber 30 in another manner, the baffle 42 could be made without the opening 74 and/or the opening 76.

[0043] The pre-evaporator line 34 can comprise a U-shape tube having an inlet leg portion 78, an outlet leg portion 80, and a curved portion 82 therebetween. (FIGS. 5C-5D, FIG. 6, and FIGS. 10A-10B.) In the system 10, the inlet leg portion 78 would be connected to line 20 from the condenser 14 and the outlet leg portion 78 would be connected to line 22 to the evaporator 12. The curved portion 82 is positioned within the first chamber 30, with its lowermost region being positioned close to the chamber's floor. The inlet leg portion 78 extends through the opening 60 in the end cap 46, through the second chamber 32, through the baffle opening 74, and into the first chamber 30 whereat it translates into the curved portion 82. The outlet leg portion 80 extends from the curved portion 82 in the first chamber 30 through the baffle opening 76, through the second chamber 32, and through the opening 62 in the end cap 46.

[0044] The pre-evaporator line 34 can include at least one fluid-interchange opening situated within the first chamber 30 so that there will be fluid communication between the chamber 30 and the line 34. In the illustrated embodiment, an interchange port 84 is located on the lower end of the inlet leg portion 78 (near its junction with the curved portion 82) and another interchange port 86 is located on a lower region of the curved portion 82. (FIGS. 10C-10D.) It is through the port 84 and/or the port 86 that refrigerant fluid is pushed from the chamber 30 into the line 34 (when the system 10 is starved) and pushed from the line 34 into the chamber 30 (when the system 10 is flooded). No separate fill line is necessary to introduce refrigerant fluid to the pre-evaporator line 34 and/or no separate drain line is necessary to remove fluid from this line 34.

[0045] Generally, but not necessarily, the upper port 84 will interchange vapor while the lower port 86 will interchange liquid. The lower port 86 can also serve as an interchange port for oil which has separated from the refrigerant fluid and accumulated in the first chamber 30. Specifically, the oil can pass through the port 86 for reunion with refrigerant fluid and travel therewith to the compressor 16.

[0046] The dimensions of the interchange port 84 and/or the interchange port 86 can be selected to provided a desired charge-adjusting response time to a change in heat load. This will typically result in the interchange port 84/86 having a flow area substantially less than the flow area of the pre-evaporator line 34. Specifically, for example, the port 84/86

can have a flow area that is about 30% or less, about 25% or less, about 20% or less, about 15% or less, and/or about 10% or less than the flow area of the pre-evaporator line 34. In some cases, it may be beneficial to make the upper interchange port 84 larger than the lower interchange port 86. For example, if the pre-evaporator line 34 has a diameter of about 0.5 inch, the upper opening 84 could have a diameter (if it is circular) of between about 0.100 inch and about 0.200 and the lower opening 86 could have a diameter (if it is circular) of between about 0.040 inch and about 0.05 inch. That being said, the pre-evaporator line 34 can have any number, size, and/or arrangement of fluid-interchanging openings which accomplish the desired adjustment of refrigerant charge.

[0047] In the illustrated embodiment, the inlet/outlet portions 78/80 of the pre-evaporator line 34 travel through the second chamber 32 on route to/from the first chamber 30. (FIGS. 5C-5D and FIG. 6.) As was alluded to above, this travel path allows these inlet/outlet portions 78/80 to be connected with the same fitting (e.g., the end cap 46) as the post-evaporator lines 36/38. However, other travel paths for the pre-evaporator line 34 are certainly possible and contemplated. For example, the line 34 could enter/exit the chamber 30 through the cylindrical wall 48 and/or the bottom wall 50 of the shell 44. In either or any case, it may be advantageous for the line 34 to include a convex bend (e.g., similar to portion 82).

[0048] Significantly, the first chamber 30 functions as the primary (and usually only) accumulation area for excess refrigerant fluid. Thus, excess fluid is stored upstream of the inlet to the evaporator 12 (rather than downstream of its outlet) whereby it is readily available upon start-up. Also, this upstream-storage arrangement minimizes the chance of excess liquid refrigerant being suctioned into the compressor 16 and causing slugging thereof.

[0049] A fixed orifice metering, or other pressure-dropping device (not shown) can be incorporated into the inlet leg portion 78 of the pre-evaporator line 34 thereby eliminating the need for a separate section and/or fitting in the line 20 from the condenser 14. In this regard, the bend in the line 34 (e.g., the curved portion 82) could also help quiet any flow noise associated with the orifice tube. Additionally or alternatively, a metering device (fixed orifice or otherwise) can be installed upstream of the accumulator 18 in line 20 from the condenser 14. In either or any event, the accumulator 18 eliminates the need for an orifice-adjusting device (e.g., a thermostatic expansion valve) upstream of the evaporator 12 and the problems associated therewith. That being said, the accumulator 18 could certainly be used in conjunction with another flow-adjusting device if necessary or desired in certain circumstances.

[0050] The post-evaporator-inlet line 36 can comprise a relatively straight tube 88 which extends through the entrance opening 64 in the end cap 46 and into the second chamber 32. (FIGS. 5A-5D, FIG. 6, and FIGS. 11A-11B.) A rim or flange 90 can be provided on the upper end of the tube 88 for seating against the platform surface around its flange-less opening 64 in the end cap 46. In the system 10, the upstream end of the tube 88 would be connected to the line 24 from the evaporator 12. As post-evaporator fluid passes into the second chamber 32 through the inlet line 36, entrained liquid will fall to the floor of the chamber 32. A



deflector (not shown) may be included in the second chamber 32 to encourage this liquid-vapor separation.

[0051] The post-evaporator-outlet line 38 can comprise a J-shape tube having a tail portion 92, a stem portion 94, and a curved portion 96 therebetween. (FIGS. 5C-5D, FIG. 6, and FIGS. 12A-12B.) The curved portion 96 is positioned in a lower region of the second chamber 32 and has an opening 98 therein. The tail portion 92 extends upwardly from one end of the curved portion 96, slants towards the stem portion 94, and has an open end positioned in an upper region of the second chamber 32.

[0052] The stem portion 94 extends upwardly from the other end of the curved portion 96 and through the exit opening 66 in the end cap 46. (FIGS. 5A-5D and FIG. 6.) In the system 10, the downstream end (e.g., the upper end) of the stem portion 94 would be connected to line 26 to the suction side of the compressor 16. The J-shape insures that only vapor can enter the open end of the tail portion 92 and the opening 98 in the curved portion 96 drains any condensation which may occur within the portions 92/94. (FIG. 12C.) Thus, only vapor will exit the second chamber 32 and make its way to the compressor 16. The drain opening 98 is positioned enough above the floor of the chamber 32 so that a liquid puddling thereon will not be suctioned into the outlet line 38 by the compressor 16.

[0053] As was indicated above, any entrained liquid entering through the inlet line 36 and/or condensation within the outlet line 38 will fall/drain to the floor of the second chamber 32. Thus, the second chamber 32 may intermittently and/or temporarily serve as a collection zone for a minimal amount of excess liquid refrigerant. However, this liquid is quickly vaporized when the second chamber 32 is at, or returning to superheated conditions.

[0054] One may now appreciate that the accumulator 18 can automatically adjust (without moving parts) refrigerant charge in the system 10 to ensure superheated evaporator outlet conditions. Although the invention has been shown and described with respect to certain preferred embodiments, it is apparent that equivalent and obvious alterations and modifications will occur to others skilled in the art upon the reading and understanding of this specification. The present invention includes all such alterations and modifications and is limited only by the scope of the following claims.

1. An accumulator for a refrigeration system, comprising:

a first chamber and a second chamber, the chambers being in a pressure-isolated arrangement, whereby the pressure of fluid in one chamber does not equalize to the pressure of fluid in the other chamber, and being in a heat-transfer relationship, whereby the temperature of fluid in one chamber equalizes with the temperature of the fluid in the other chamber;

a pre-evaporator line forming a flow passage which passes through and communicates with the first chamber, whereby the pressure of fluid within the first chamber equalizes with the pressure of fluid within the pre-evaporator line;

a post-evaporator-inlet line forming a flow passage into the second chamber; and

a post-evaporator-outlet line forming a flow passage out of the second chamber.

2. An accumulator as set forth in claim 1, wherein the pre-evaporator line includes at least one interchange opening for communication between fluid within the first chamber and fluid within the pre-evaporator line.

3. An accumulator as set forth in claim 2, wherein the interchange opening(s) each have a flow area substantially less than the flow area of the pre-evaporator inlet line.

4. An accumulator as set forth in claim 1, wherein the pre-evaporator line includes at two interchange openings for communication between fluid within the first chamber and fluid within the pre-evaporator line, and wherein one of the interchange openings is positioned above the other of the interchange openings.

5. An accumulator as set forth in claim 1, wherein the flow passage formed by the post-evaporator-outlet line is a gas-only flow passage.

6. An accumulator as set forth in claim 5, wherein the post-evaporator-outlet line includes an open end positioned in an upper region of the second chamber and a drain opening in a lower region of the second chamber.

7. An accumulator as set forth in claim 1, wherein the first chamber is positioned below the second chamber.

8. An accumulator as set forth in claim 1, wherein the pre-evaporator line passes through, but does not communicate with, the second chamber.

9. An accumulator as set forth in claim 1, wherein the pre-evaporator line includes a fixed orifice metering device upstream of the first chamber.

10. An accumulator as set forth in claim 1, wherein the first chamber and the second chamber are formed by a capsule and a heat-transferring divider and wherein the divider separates space defined by the capsule into the first chamber and the second chamber.

11. An accumulator as set forth in claim 10, wherein the capsule has an entrance for the pre-evaporator line, an exit for the pre-evaporator line, an entrance for the post-evaporator-inlet line, and an exit for the post-evaporator-outlet line.

12. An accumulator as set forth in claim 11, wherein the capsule includes a fitting and wherein at least three of the entrance(s) and exit(s) are situated on the fitting.

13. An accumulator as set forth in claim 12, wherein the pre-evaporator line passes through, but does not communicate with, the second chamber.

14. An accumulator as set forth in claim 13, wherein the heat-transferring divider includes at least one opening through which the pre-evaporator line can pass to/from the first chamber.

15. An accumulator as set forth in claim 13, wherein the heat-transferring divider includes an opening through which the pre-evaporator line can pass to the first chamber and an opening through which the pre-evaporator line can pass from the first chamber.

16. An accumulator as set forth in claim 12, wherein the two entrances and the two exits are situated on the fitting.

17. An accumulator as set forth in claim 1, wherein:

the first chamber and the second chamber are formed by a capsule and a heat-transferring divider;

the first chamber is positioned below the second chamber;

the pre-evaporator line includes at least one opening for communication between fluid within the first chamber

and fluid within the pre-evaporator line, and each opening has a flow area substantially less than the flow area of the pre-evaporator line; and

the flow passage formed by the post-evaporator-outlet line is a gas-only flow passage.

**18.** An accumulator as set forth in claim 17, wherein the pre-evaporator line includes at least two openings for communication between fluid within the first chamber and fluid within the pre-evaporator line, one opening being positioned in an upper region of the first chamber and the other opening being positioned within a lower region the first chamber.

**19.** A refrigeration system comprising an evaporator, a condenser, a compressor, the accumulator set forth in claim 1, and refrigerant fluid flowing through lines between the evaporator, the condenser, the compressor and the accumulator; wherein said lines comprise:

a line from the condenser outlet to the accumulator's pre-evaporator line,

a line from the accumulator's pre-evaporator line to the evaporator inlet,

a line from the evaporator outlet to the accumulator's post-evaporator-inlet line, and

a line from the accumulator's post-evaporator-outlet line to the compressor.

**20.** A refrigeration system as set forth in claim 19, wherein, in a steady state, refrigerant fluid within the first chamber is saturated and refrigerant fluid within the second chamber is superheated.

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