US 20060236716A1

(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**

(76) Inventors: **Gary E. Griffin**, Penn Yan, NY (US); **Daniel R. Rice**, Marion, NY (US); **Michael L. Ford**, Baldwyn, MS (US)

Correspondence Address:
DON W. BULSON (PARKER HANNIFIN)
RENNER, OTTO, BOISSELLE & SKLAR, LLP
1621 EUCLID AVENUE / 19TH FLOOR
CLEVELAND, OH 44115 (US)

(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.

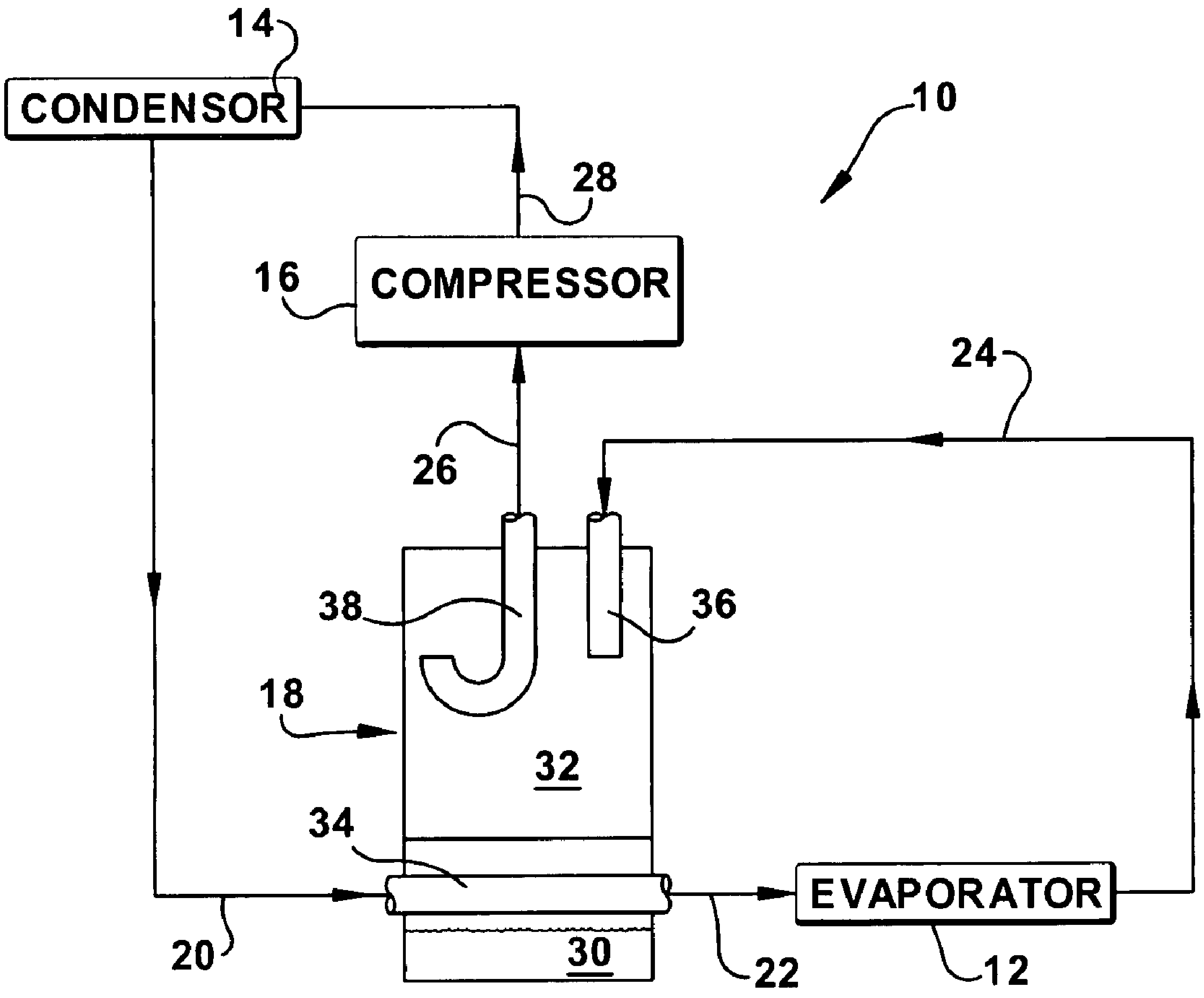
Publication Classification

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

(52) **U.S. Cl.** **62/503**; 62/513

(57) **ABSTRACT**

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.



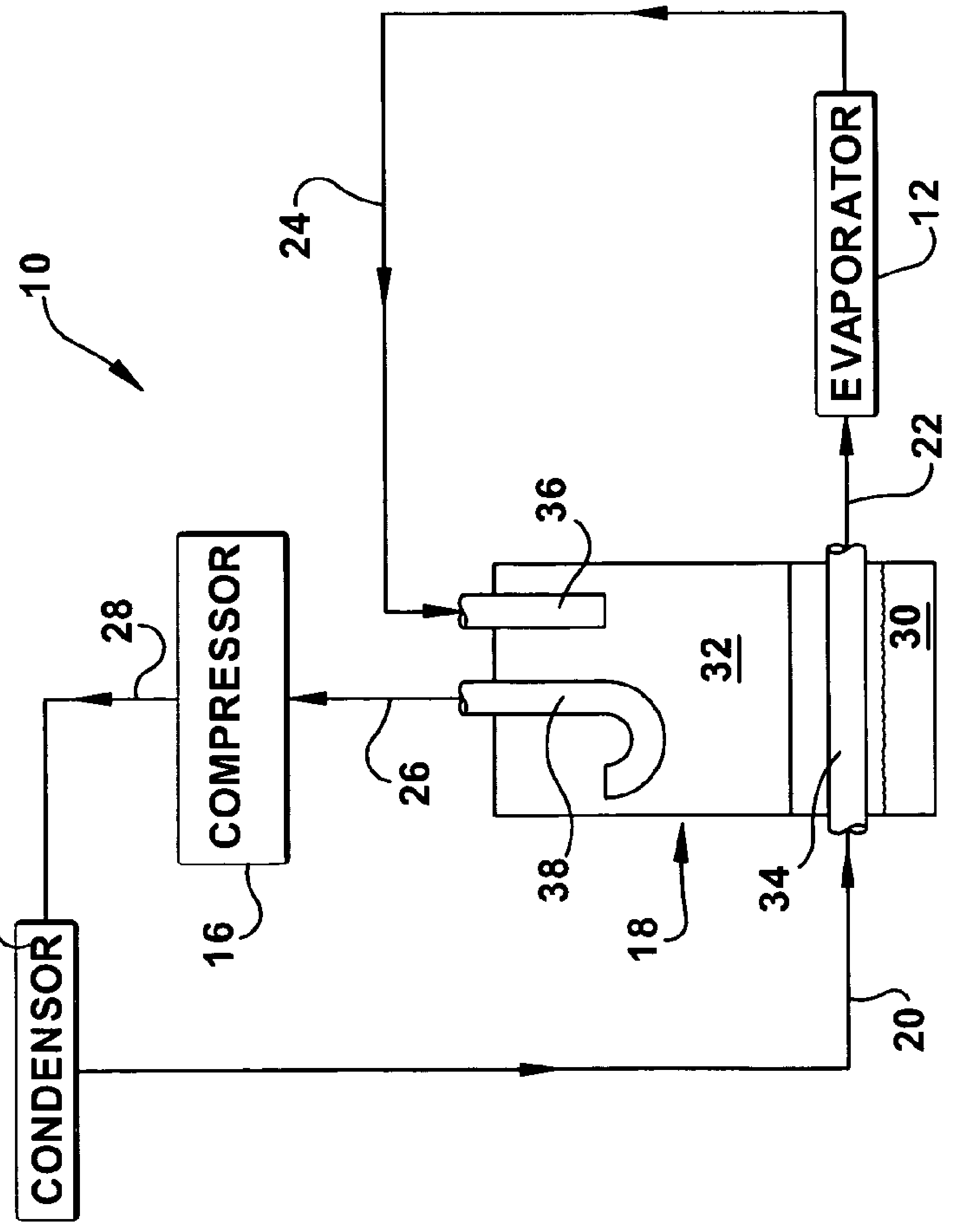
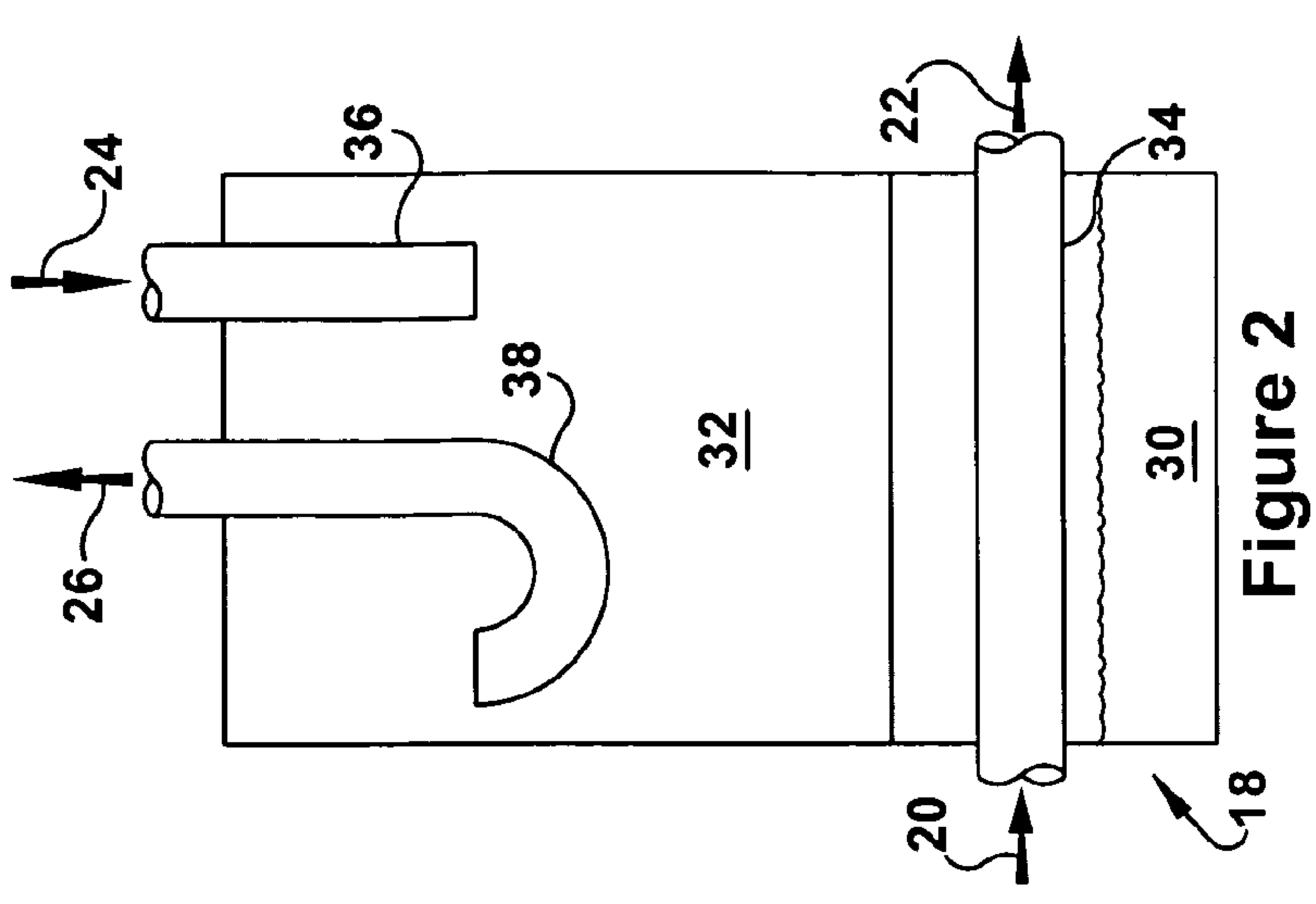


Figure 1



$P_{pre} > P_{post}$

$T_{pre} = T_{post}$

$T_{pre} = T_{sat}$ at P_{pre}

$T_{post} = T_{super}$ at P_{post}

$P_{30} = P_{34}$

$P_{32} = P_{36} = P_{38}$

Figure 2

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

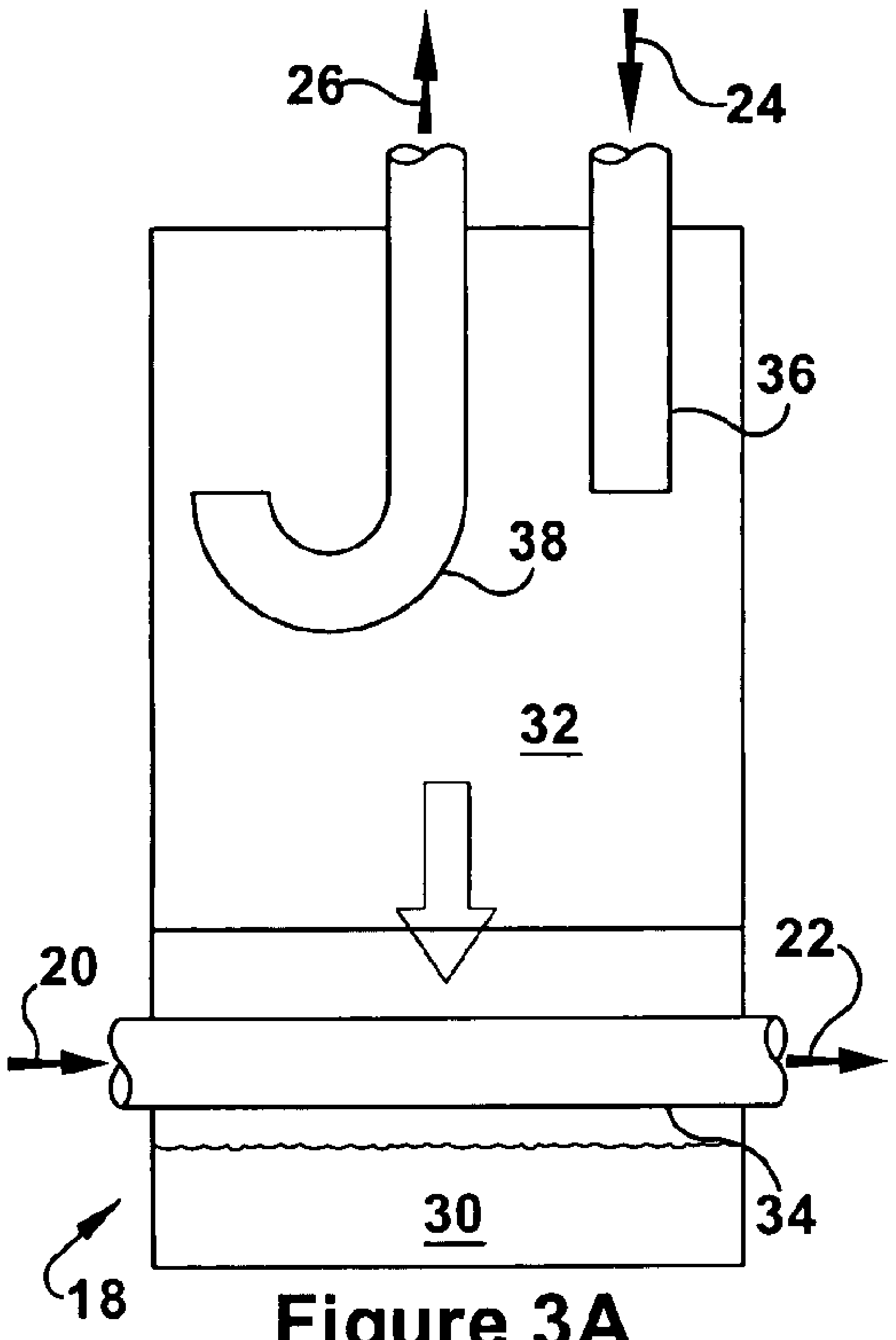


Figure 3A

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

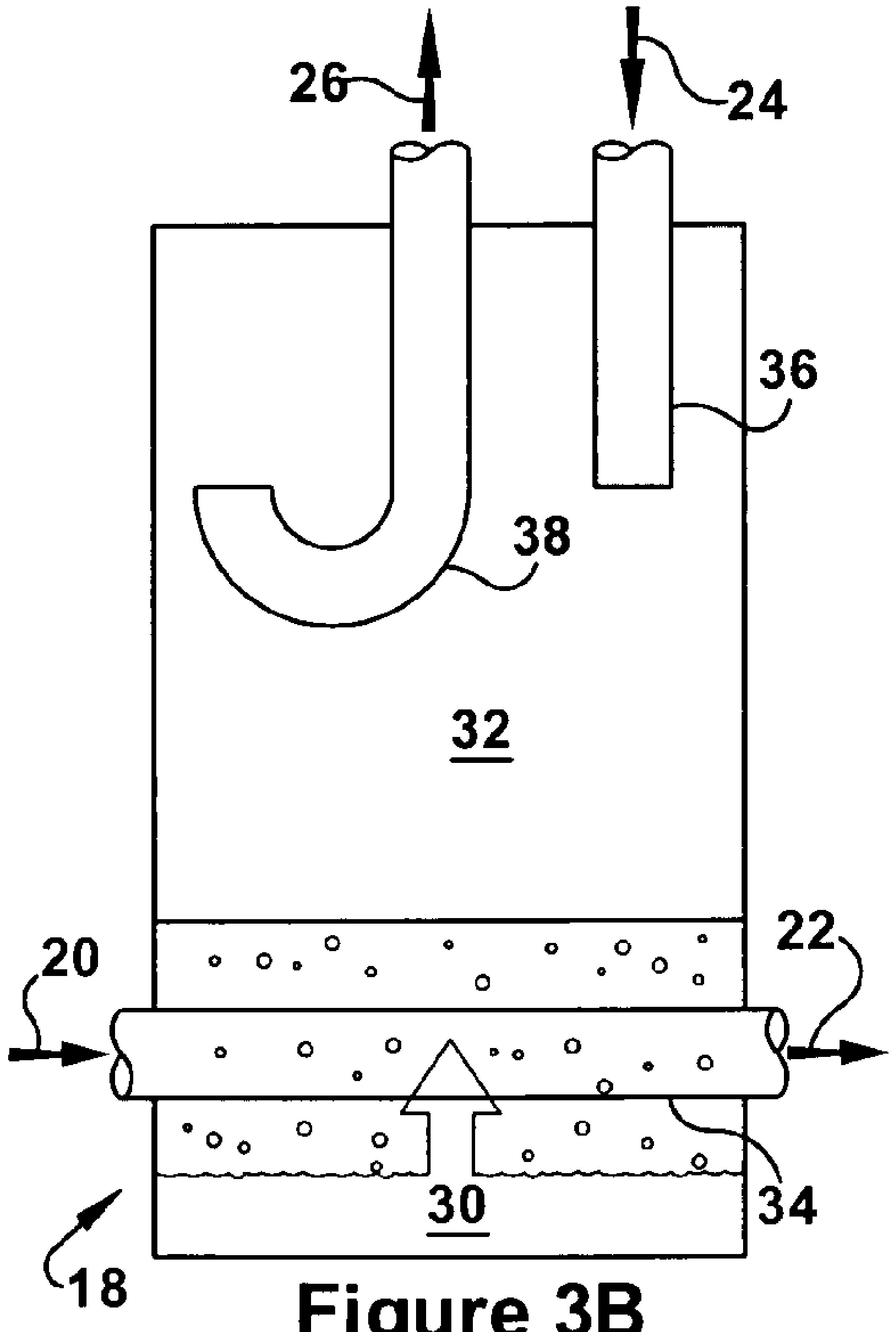


Figure 3B

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

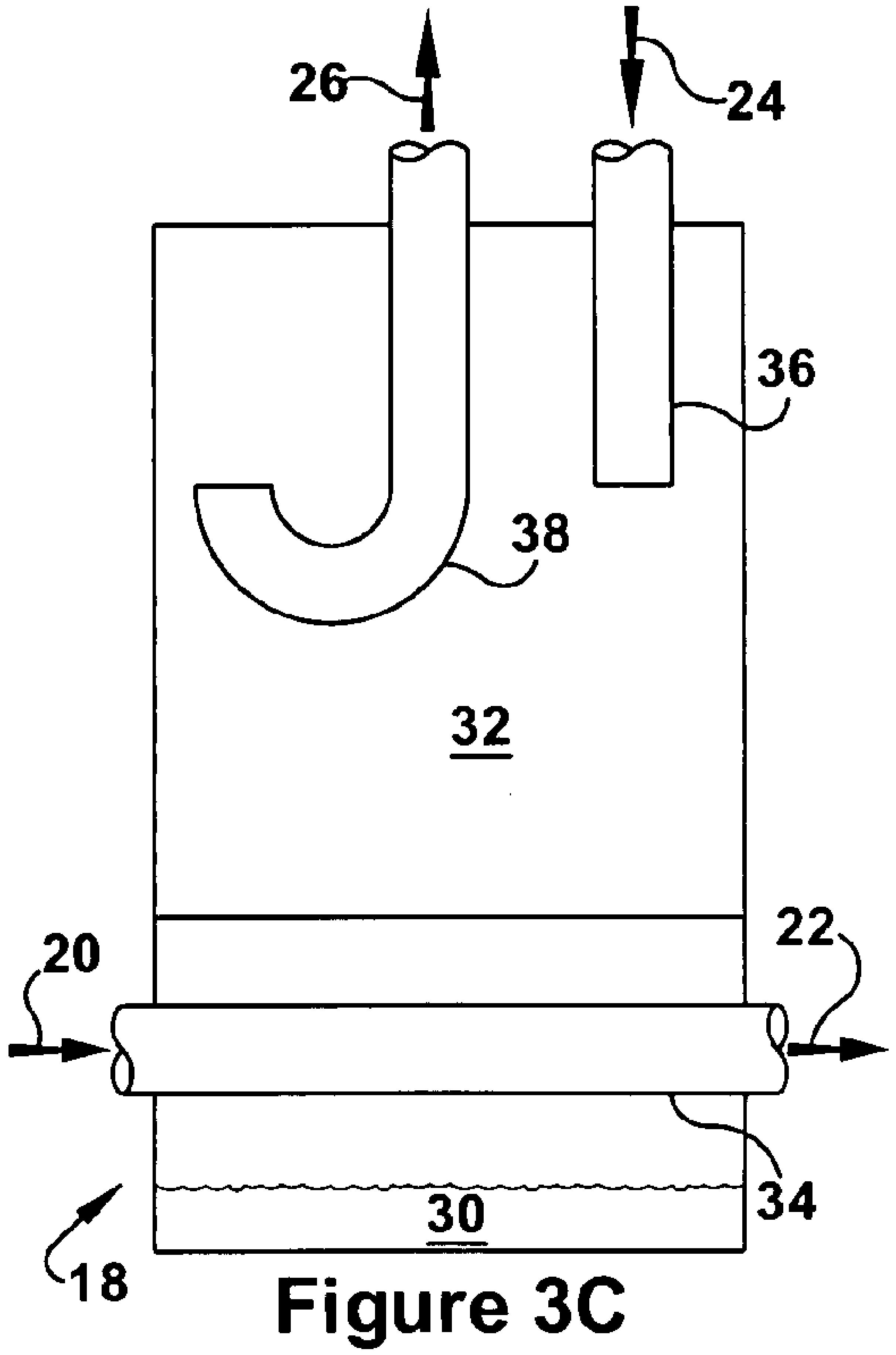


Figure 3C

$P_{pre} > P_{post}$
$T_{pre} > T_{post}$
$T_{pre} = T_{sat}$ at P_{pre}
$T_{post} < T_{super}$ at P_{post}
$P_{30} = P_{34}$
$P_{32} = P_{36} = P_{38}$

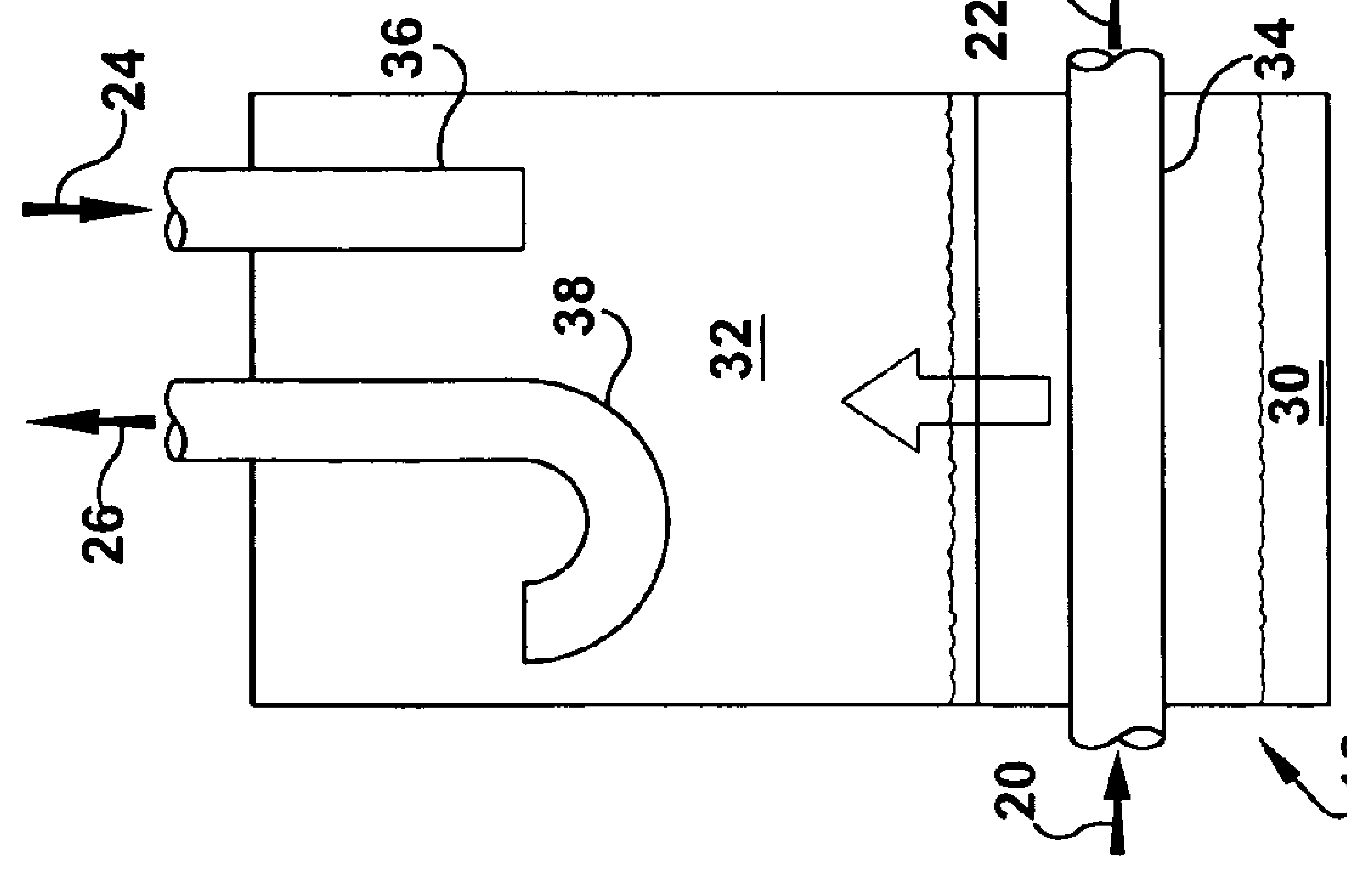


Figure 4A

$P_{pre} > P_{post}$
$T_{pre} = T_{post}$
$T_{pre} = T_{sat}$ at P_{pre}
$T_{post} = T_{super}$ at P_{post}
$P_{30} < P_{34}$
$P_{32} = P_{36} = P_{38}$

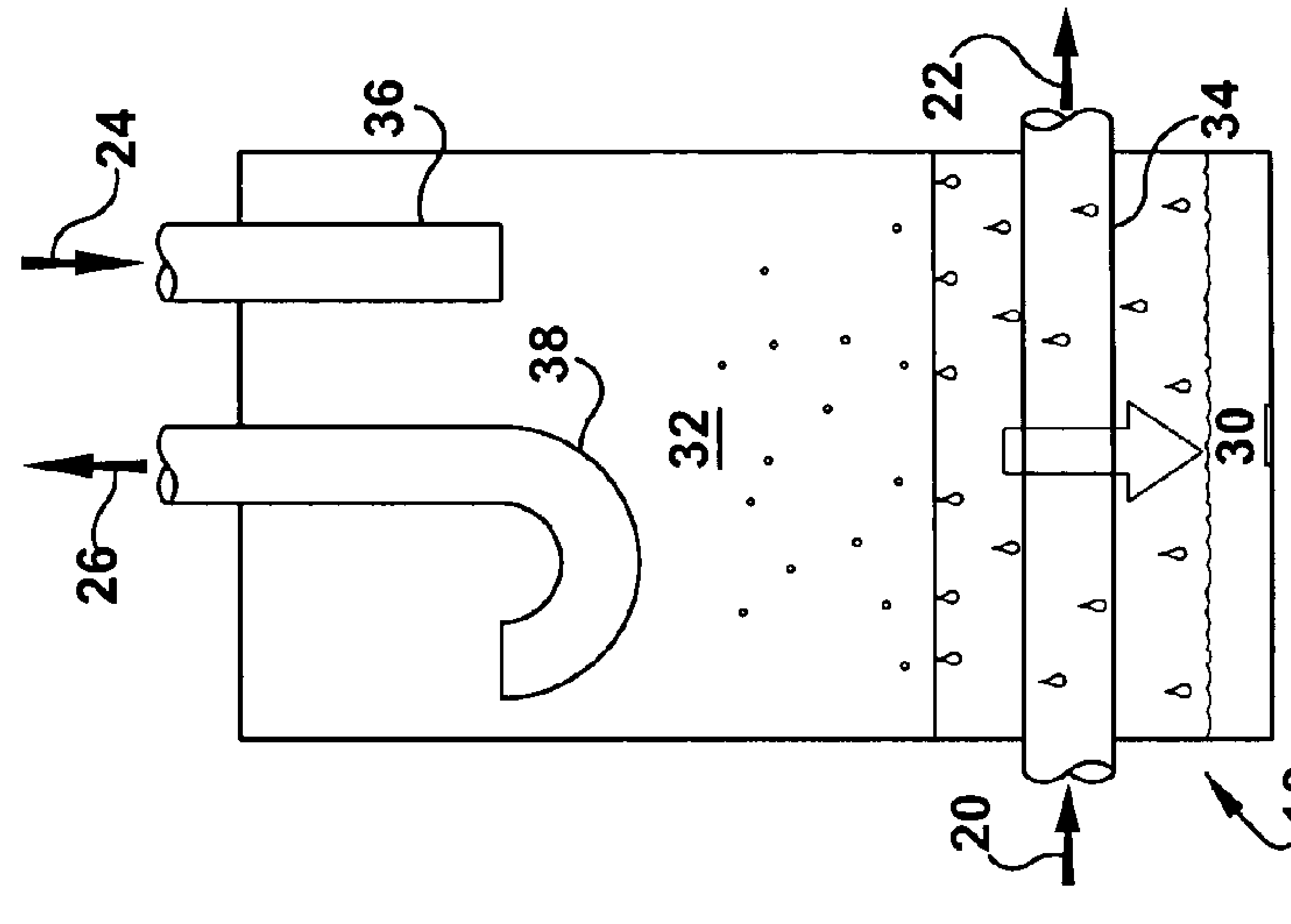


Figure 4B

$P_{pre} > P_{post}$
$T_{pre} = T_{post}$
$T_{pre} = T_{sat}$ at P_{pre}
$T_{post} = T_{super}$ at P_{post}
$P_{30} = P_{34}$
$P_{32} = P_{36} = P_{38}$

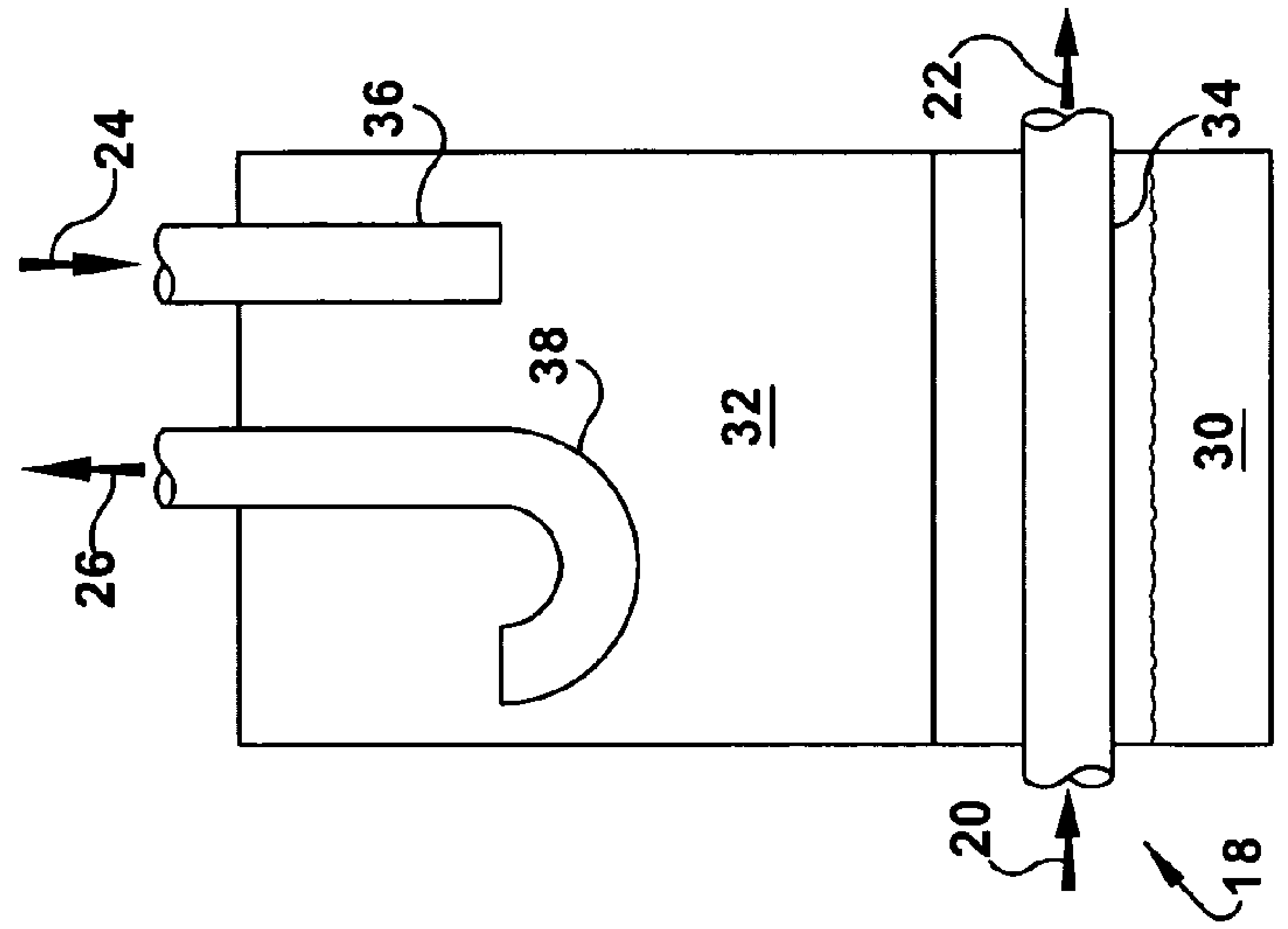


Figure 4C

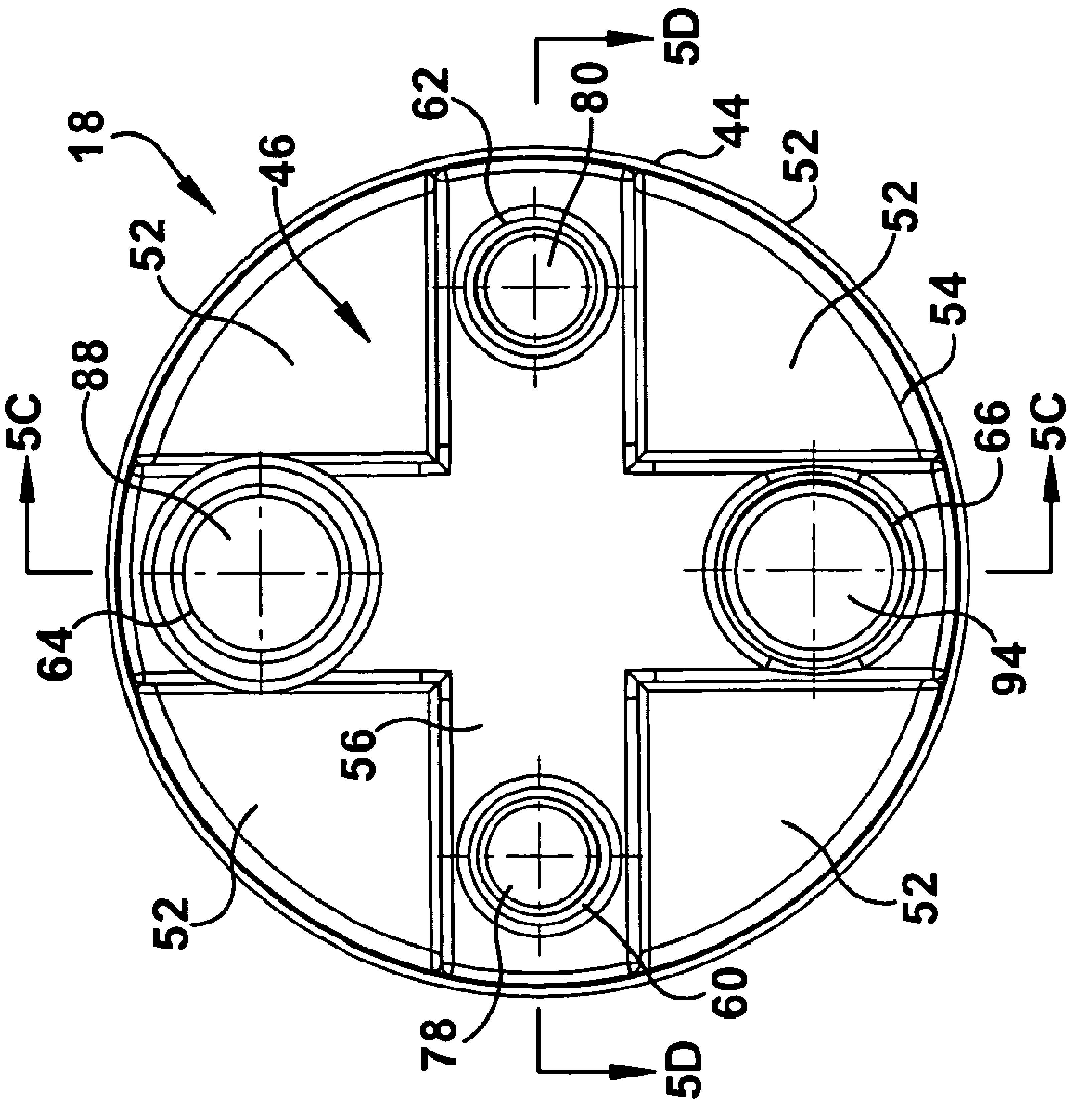


Figure 5B

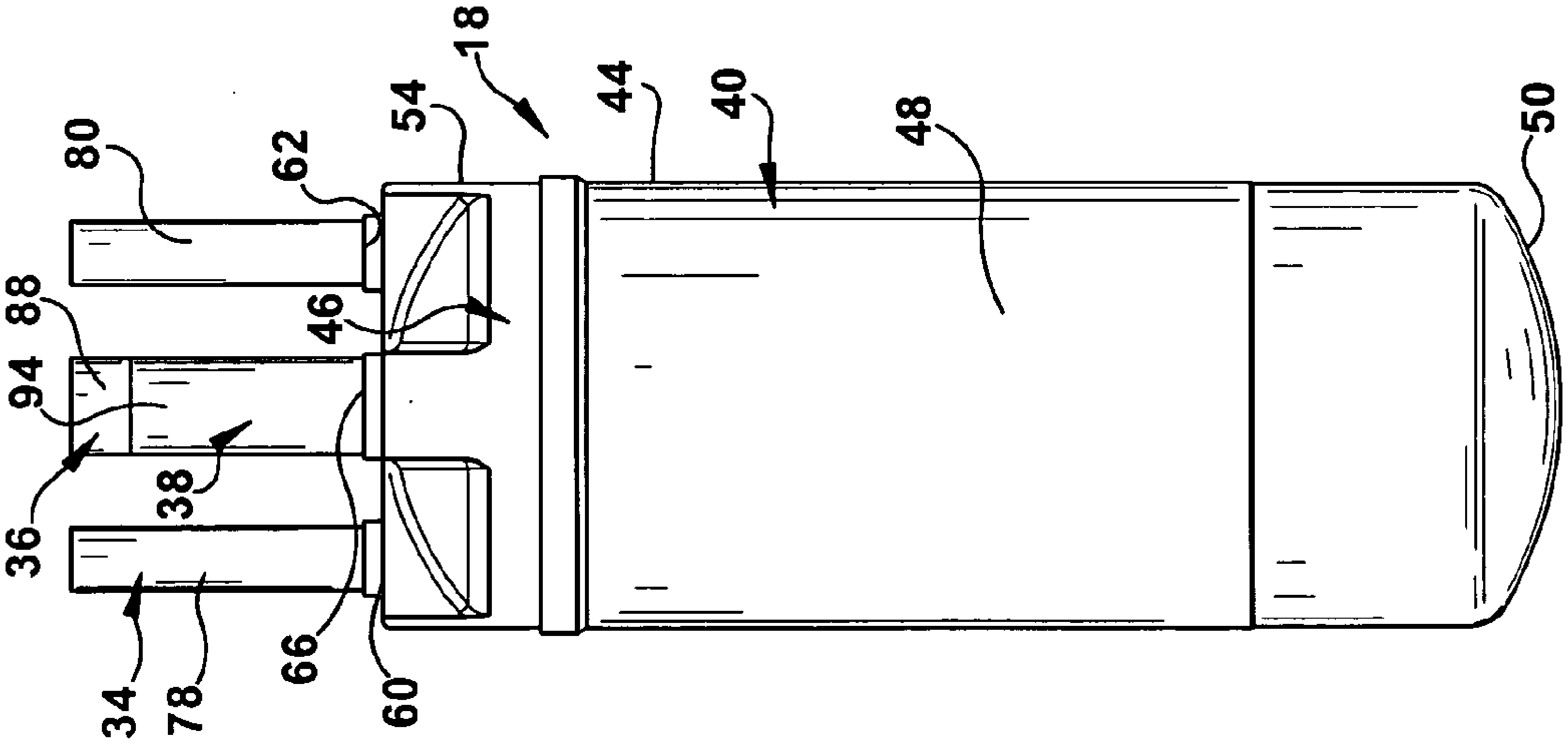


Figure 5A

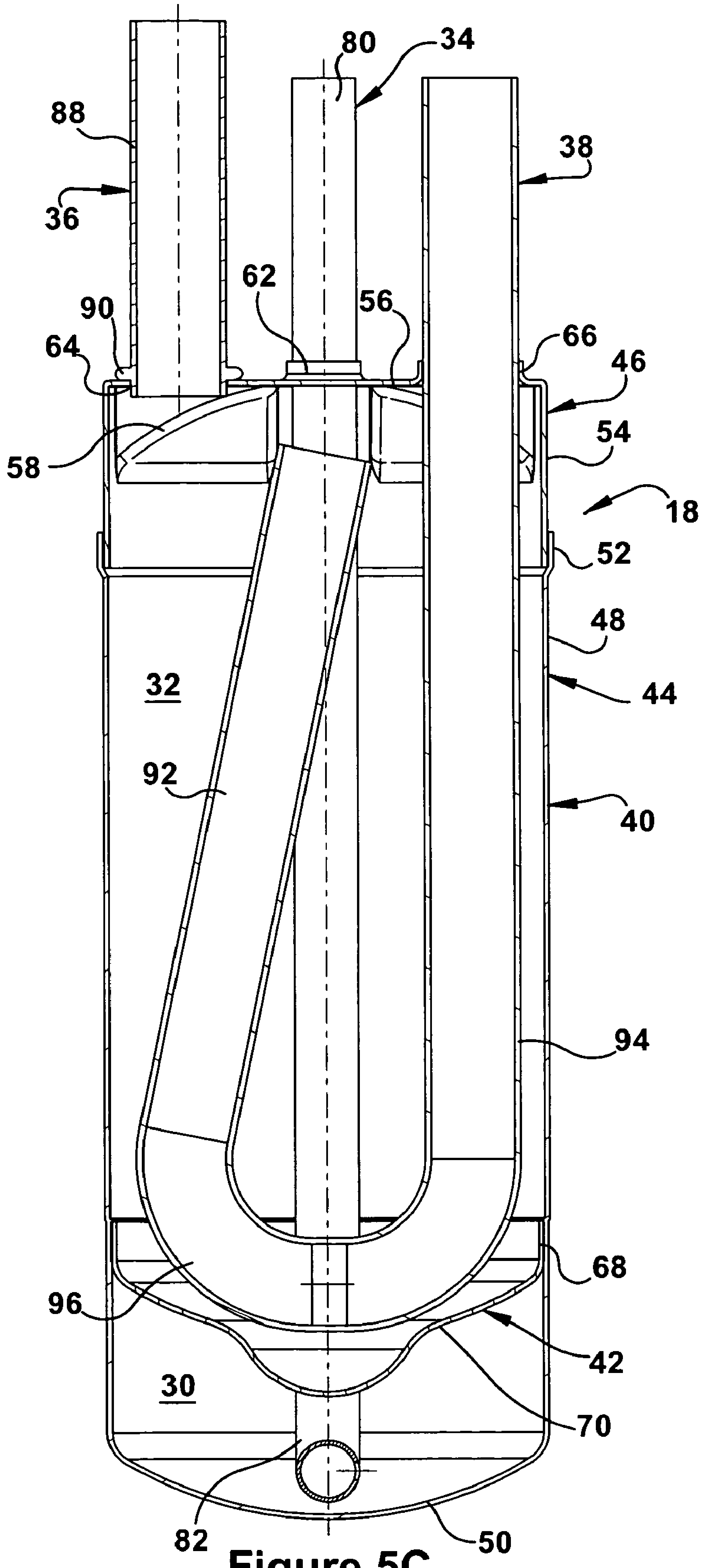

80
34
88
38
36
62
56
90
64
66
46
58
54
18
52
48
44
32
92
40
94
68
96
42
30
70
82
50

Figure 5C

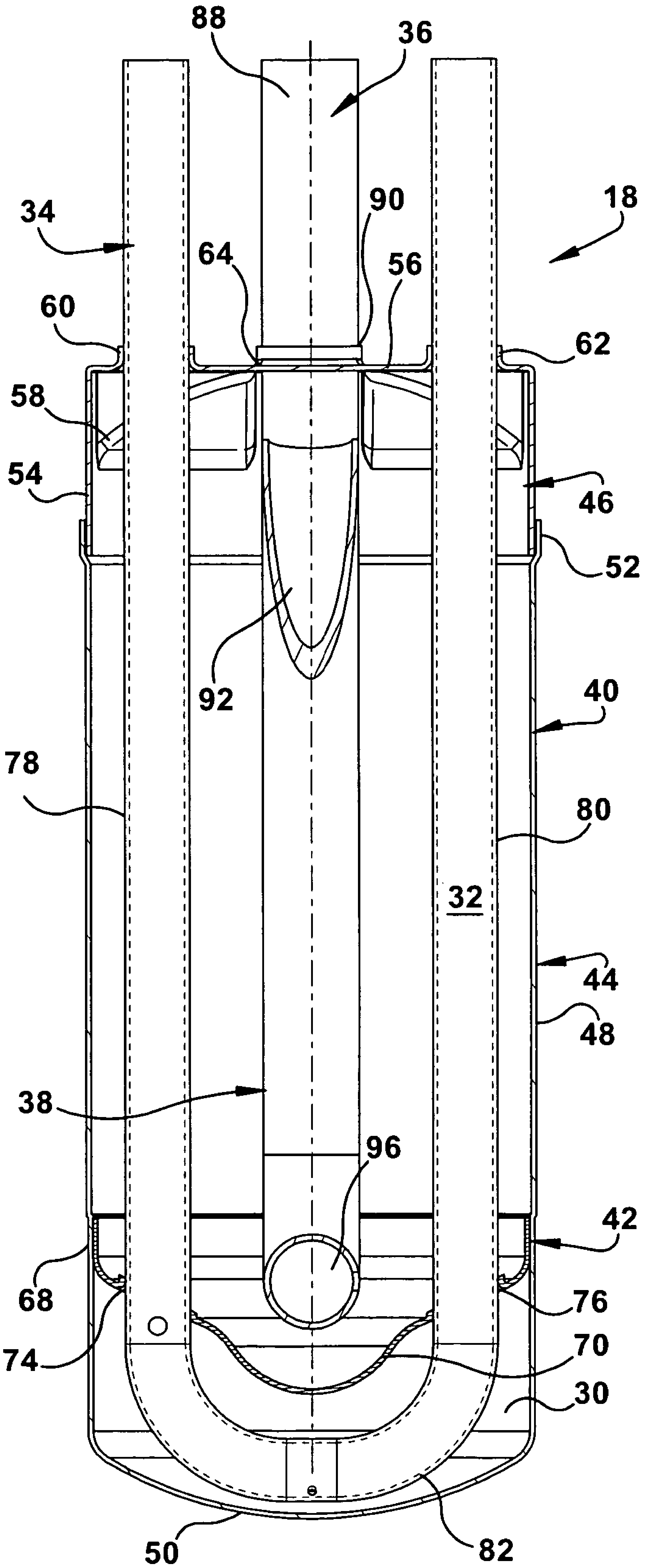

88
36
34
90
18
64
56
60
62
58
54
46
52
92
40
78
80
32
44
48
38
96
42
68
76
74
70
30
50
82

Figure 5D

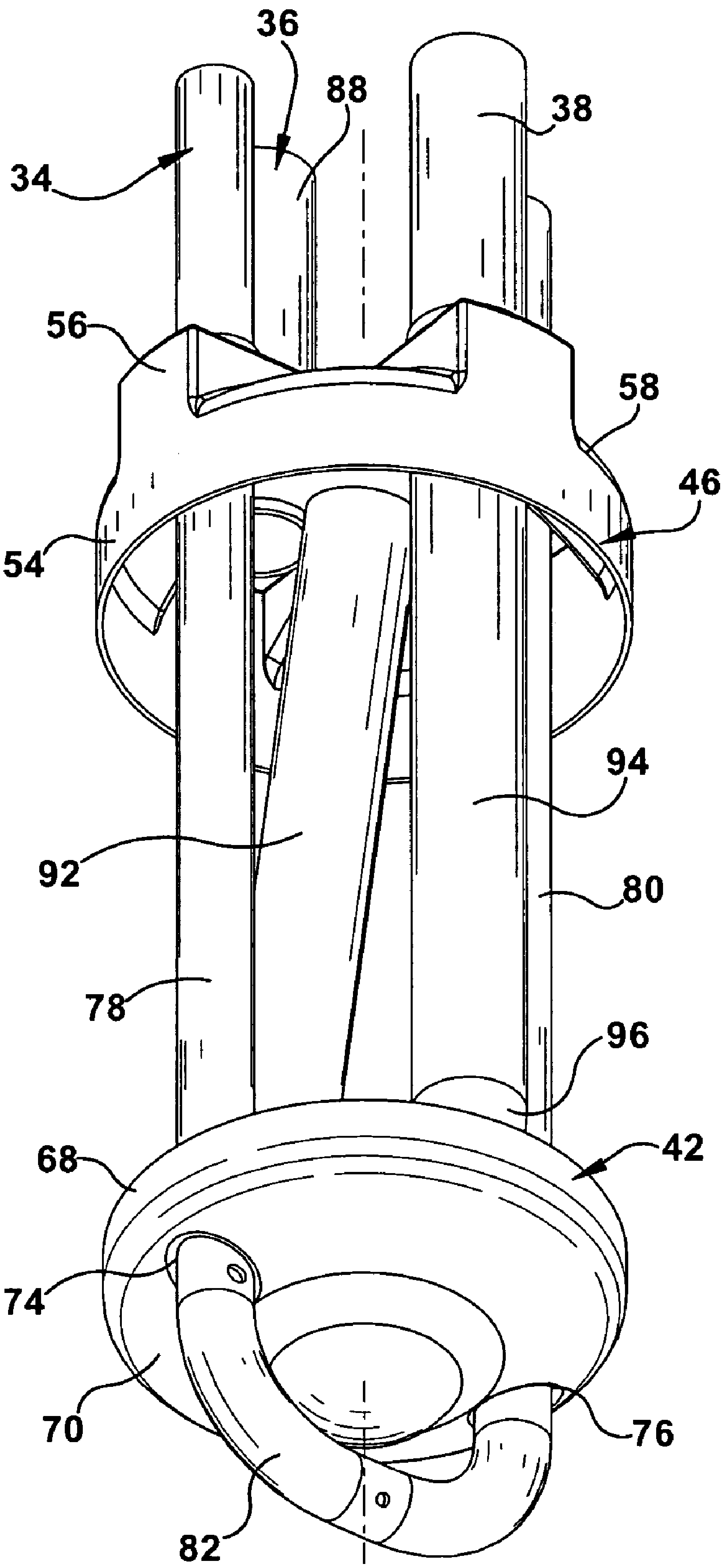


Figure 6

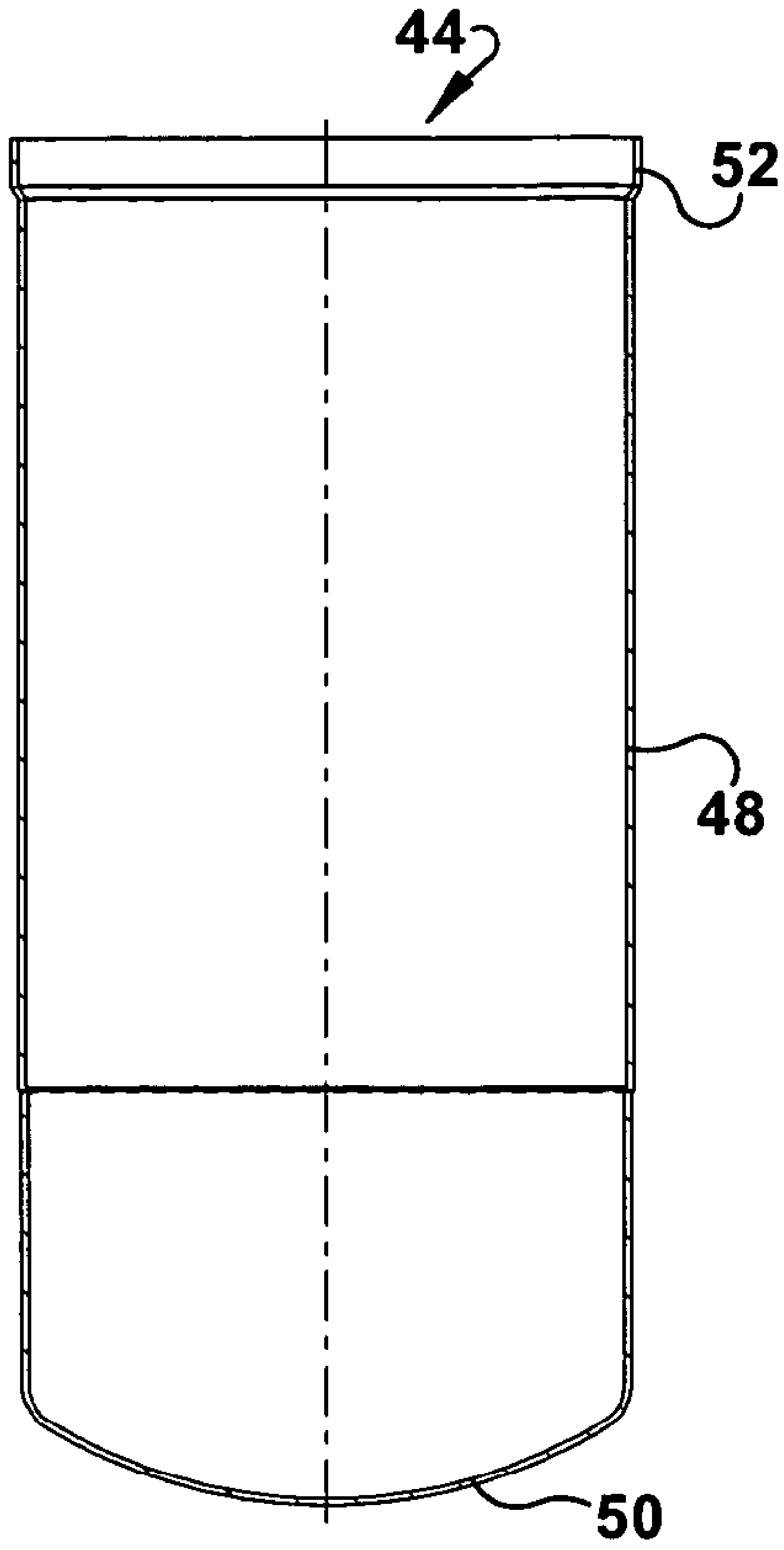


Figure 7

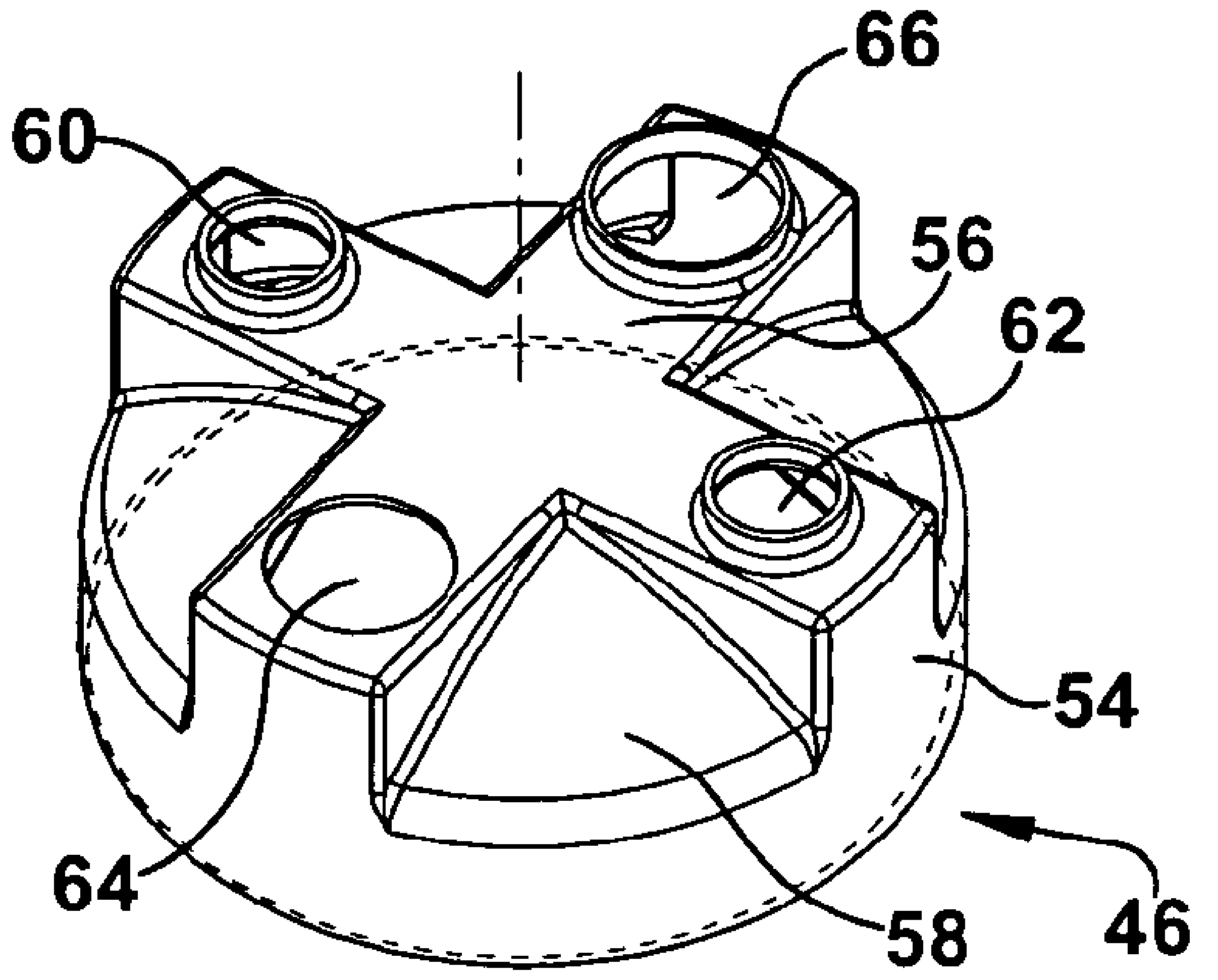


Figure 8A

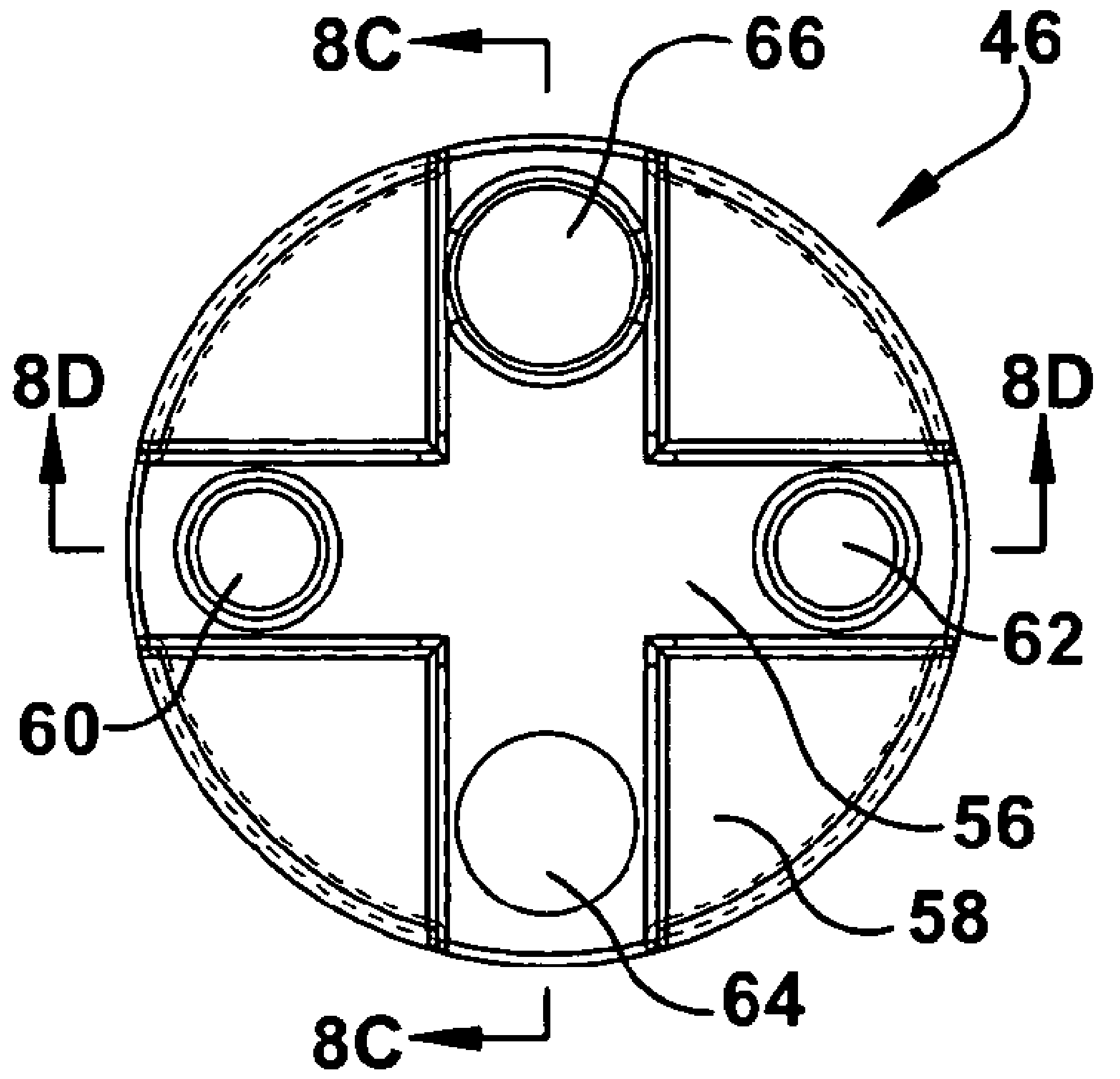


Figure 8B

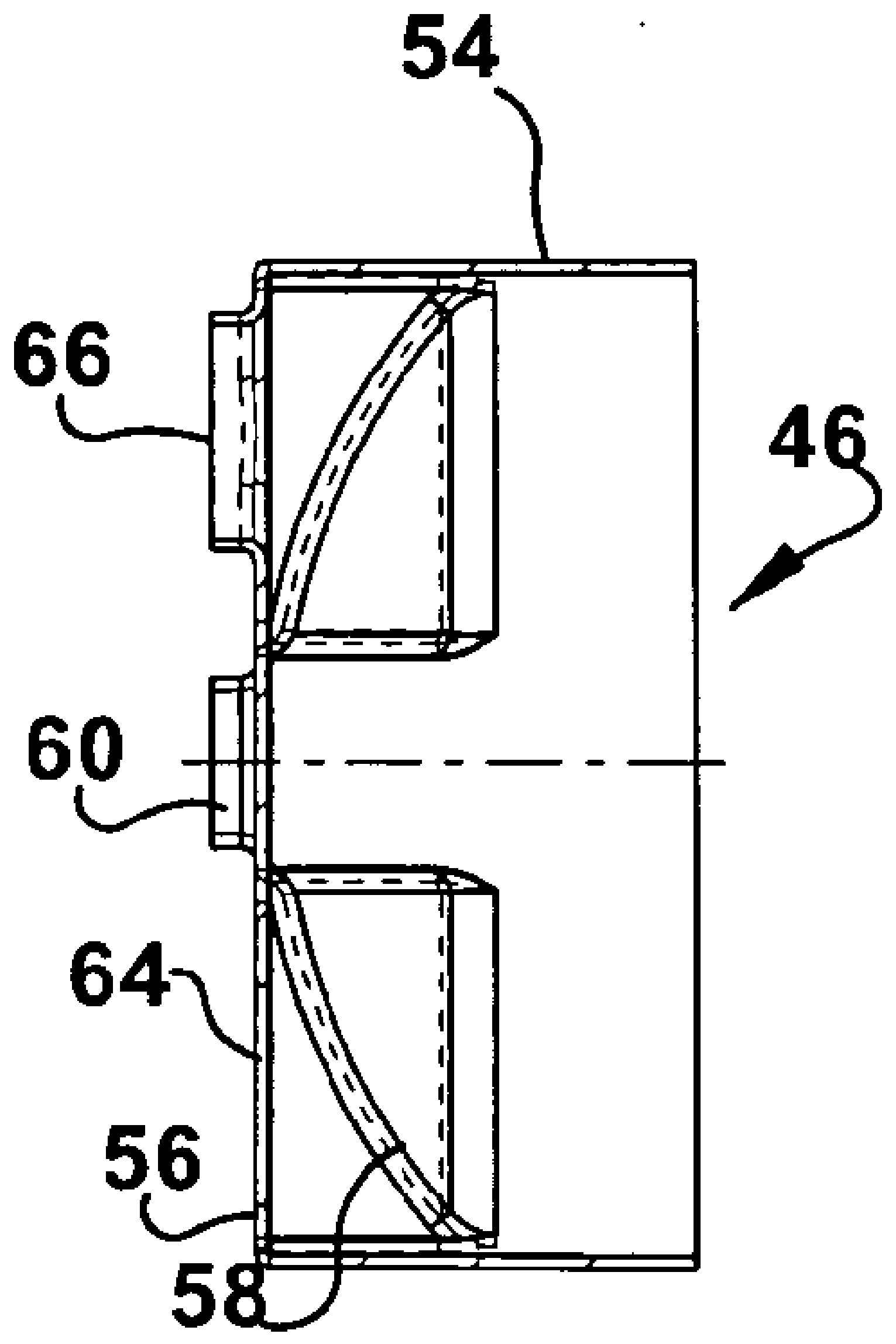


Figure 8C

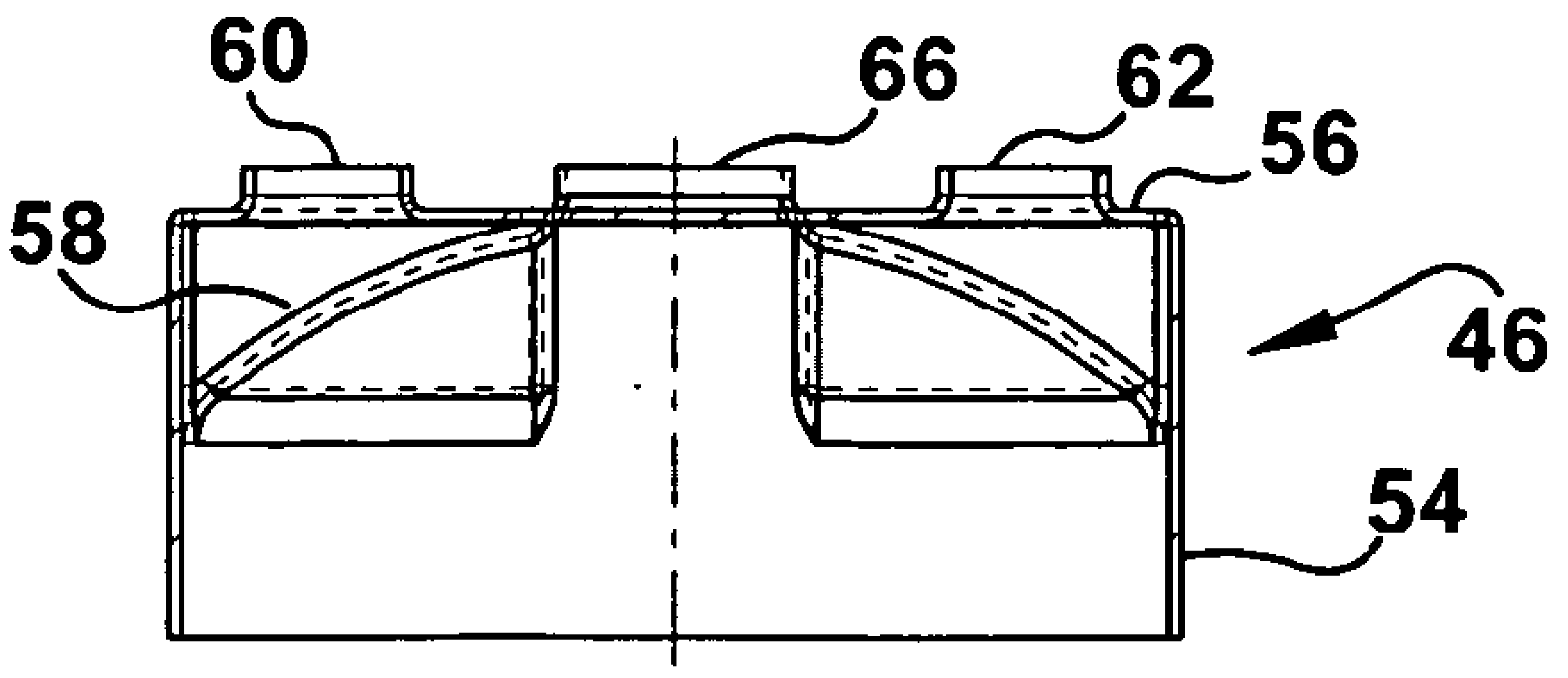


Figure 8D

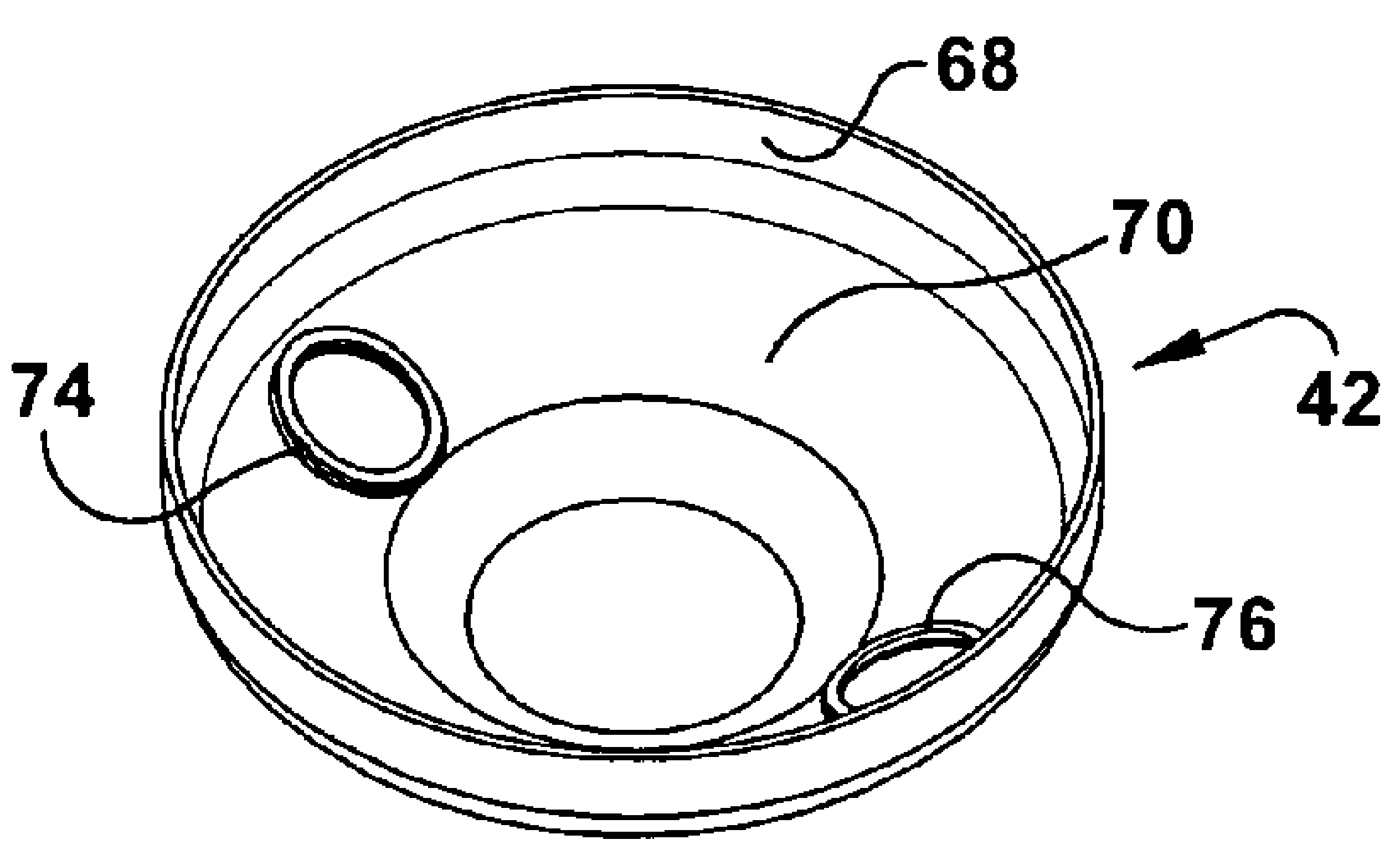


Figure 9A

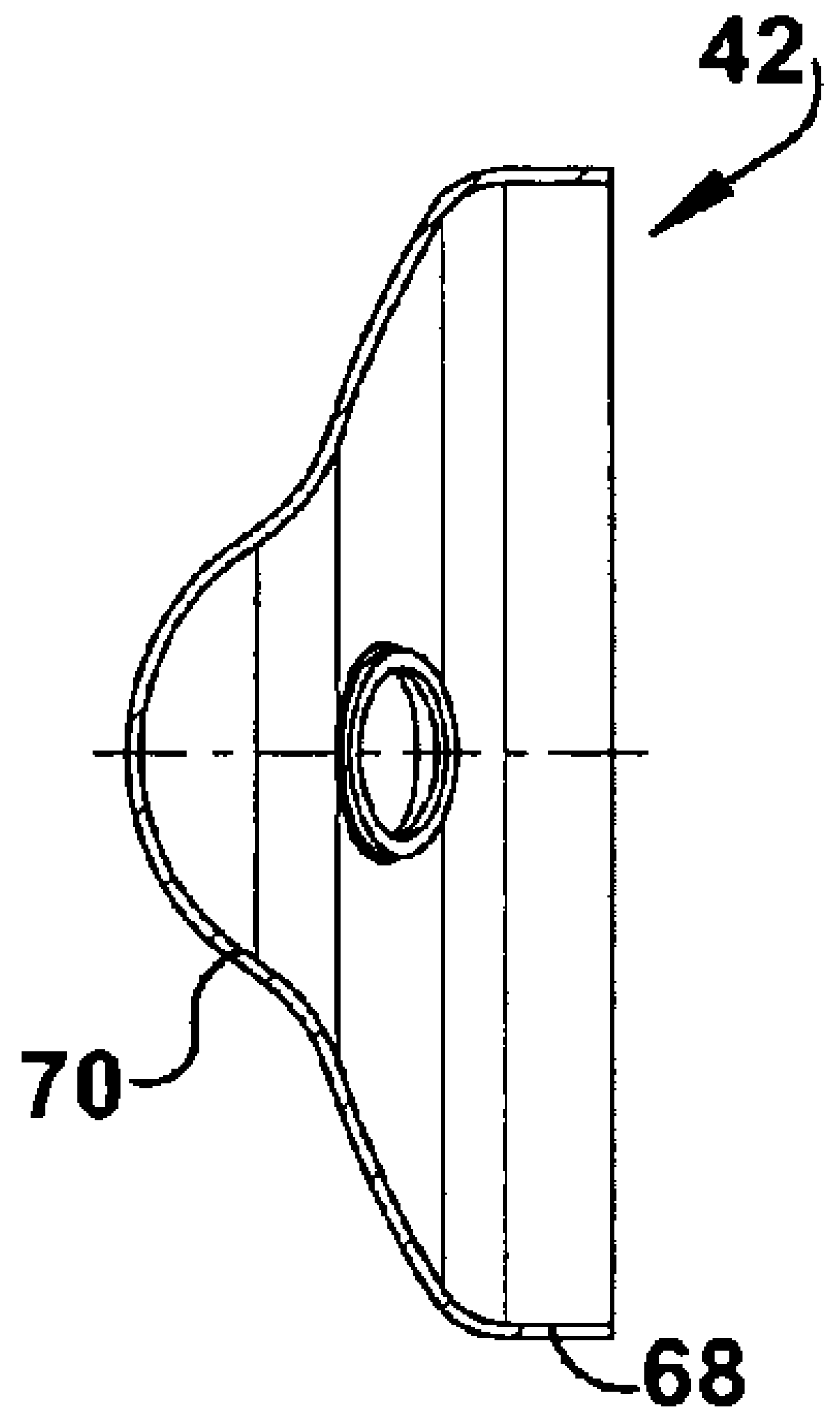


Figure 9C

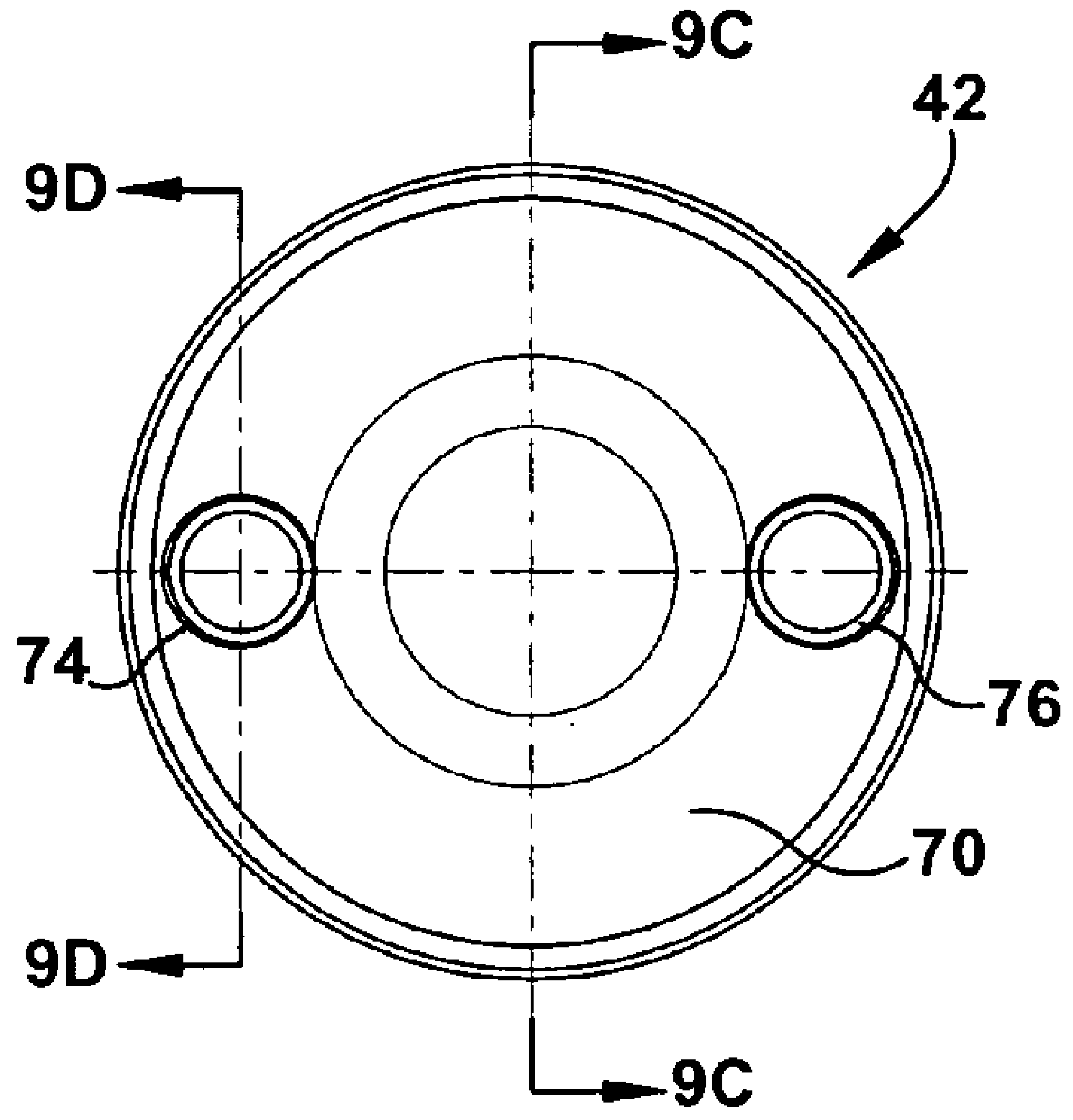


Figure 9B

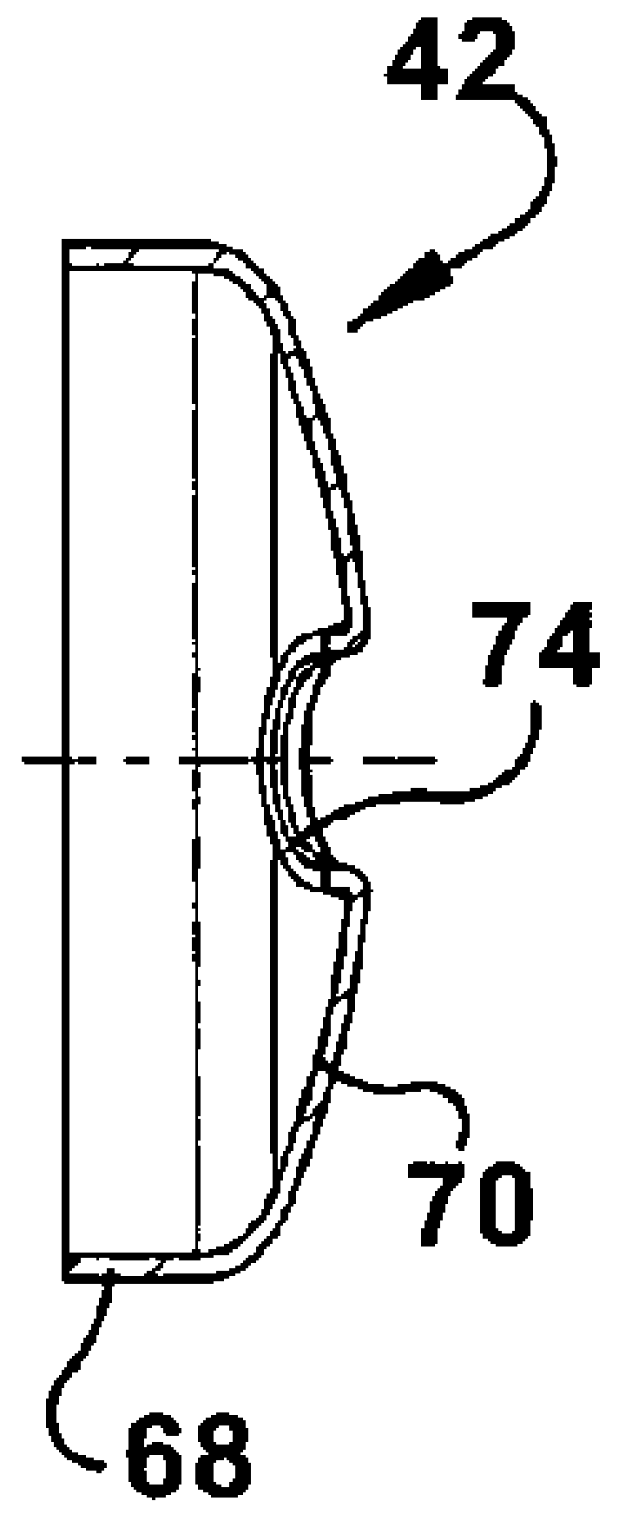


Figure 9D

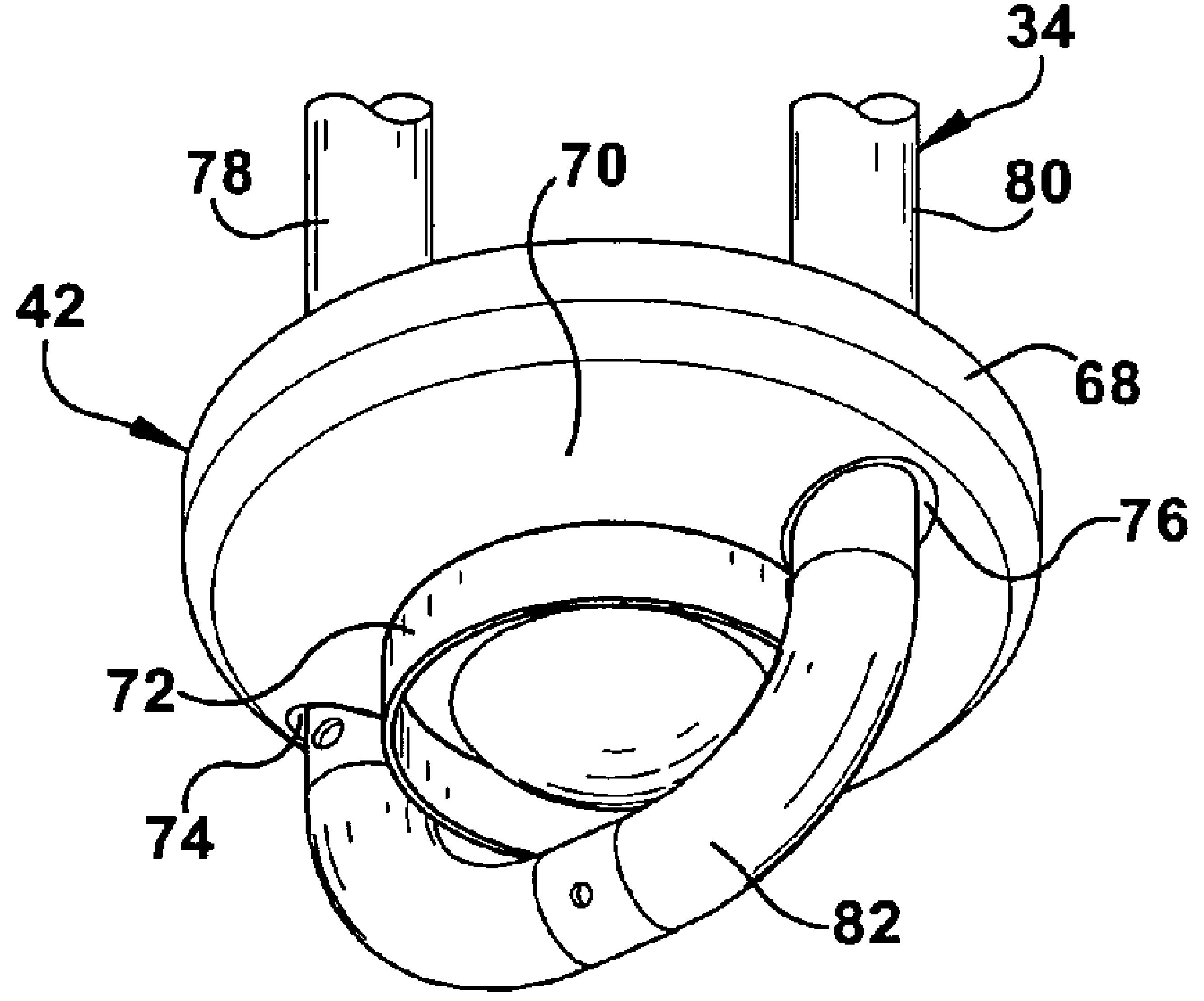


Figure 9E

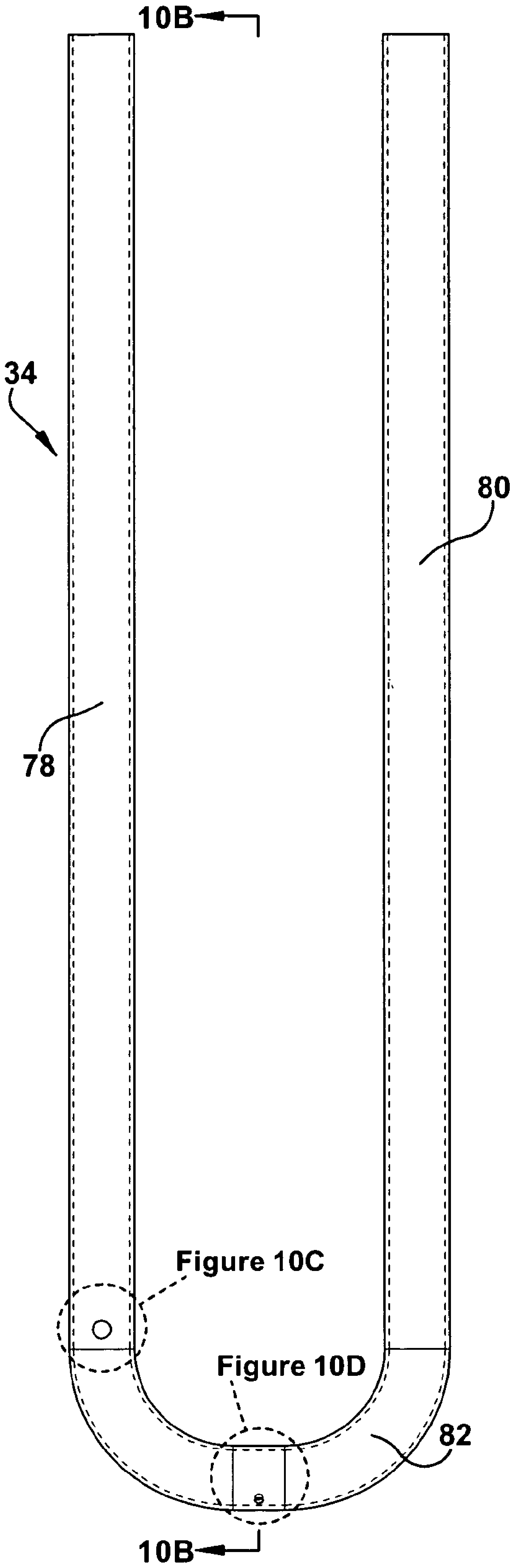


Figure 10A

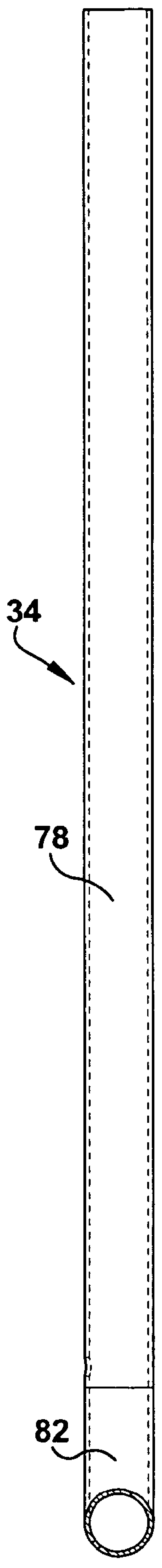


Figure 10B

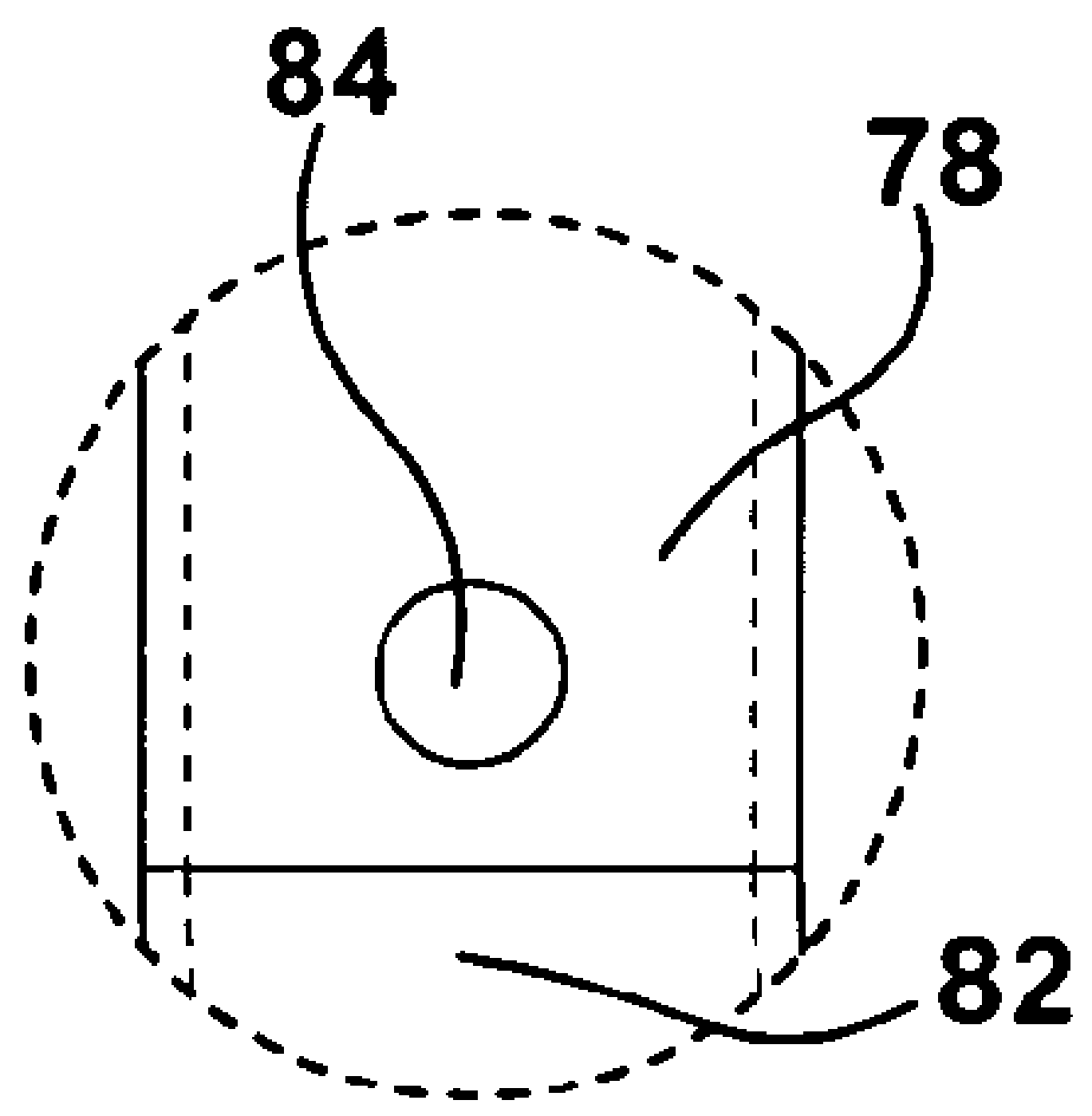


Figure 10C

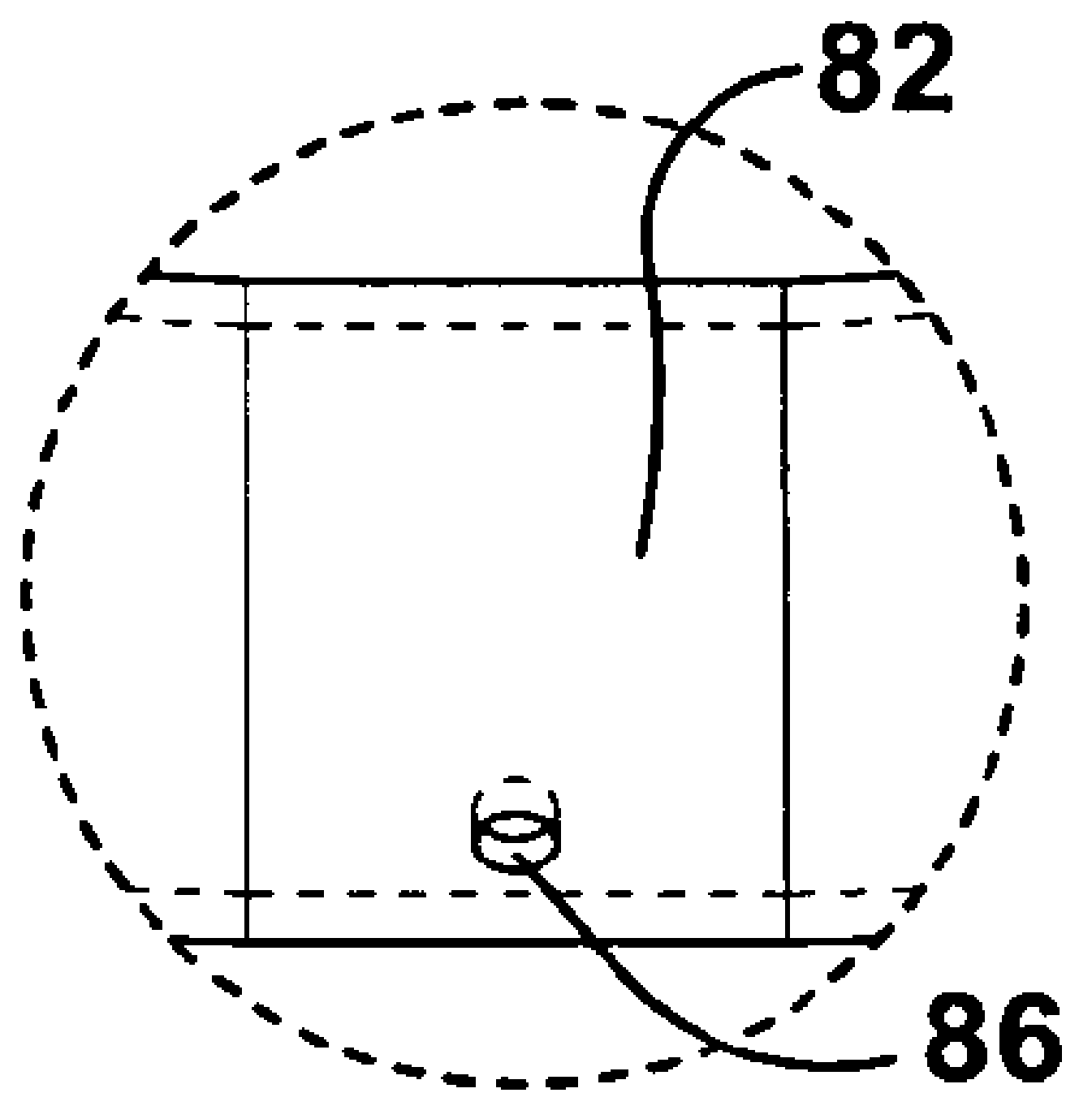


Figure 10D

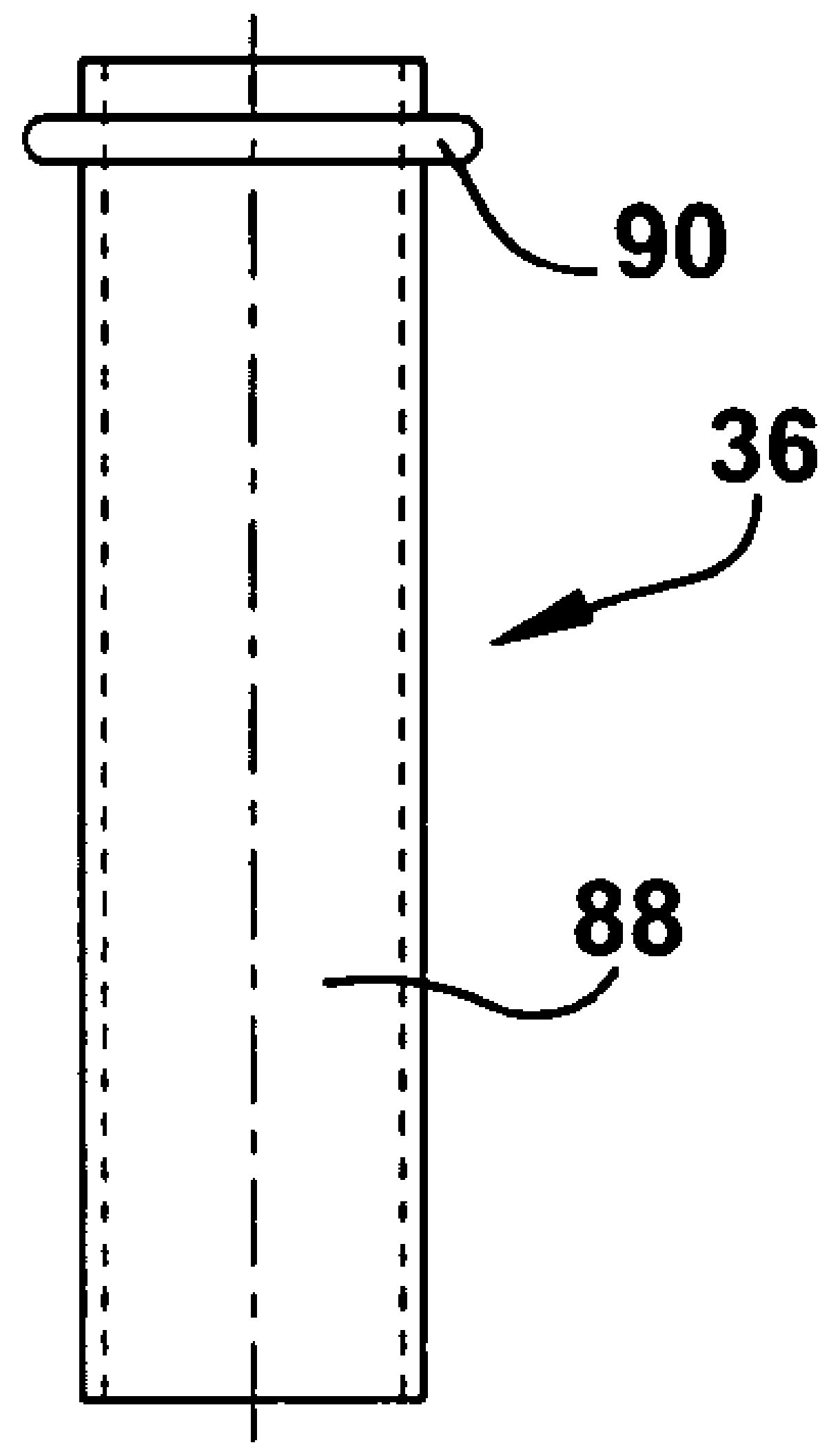


Figure 11A

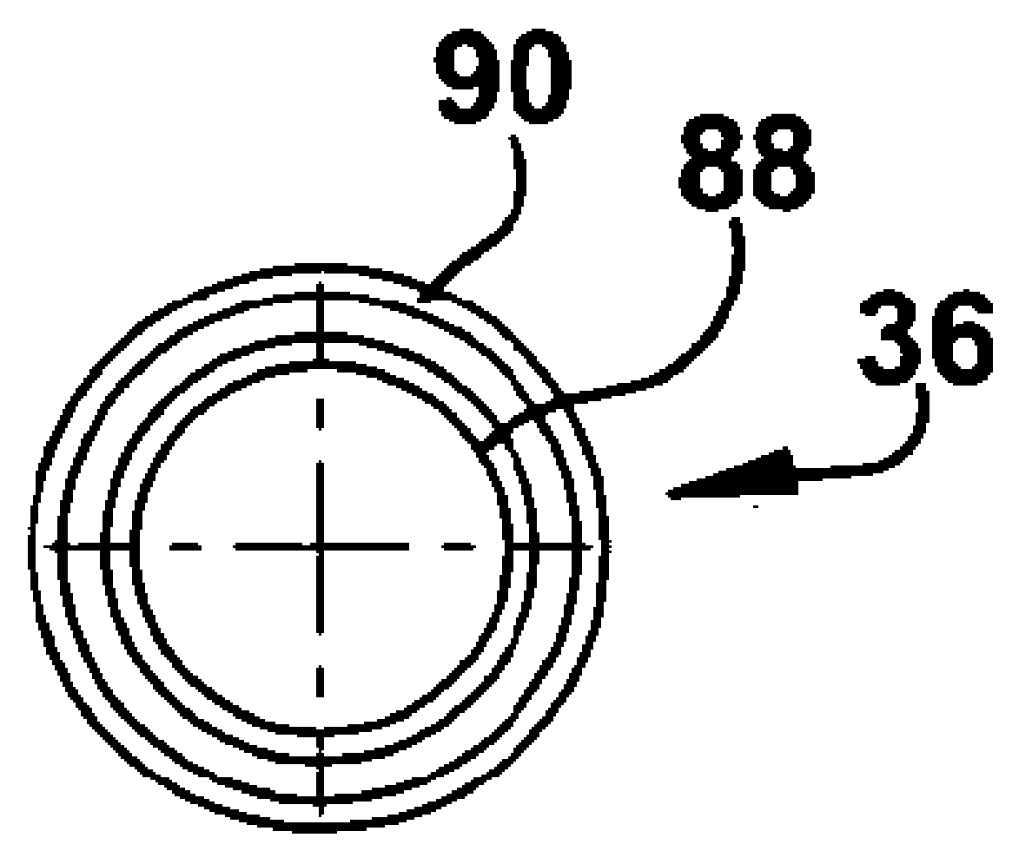


Figure 11B

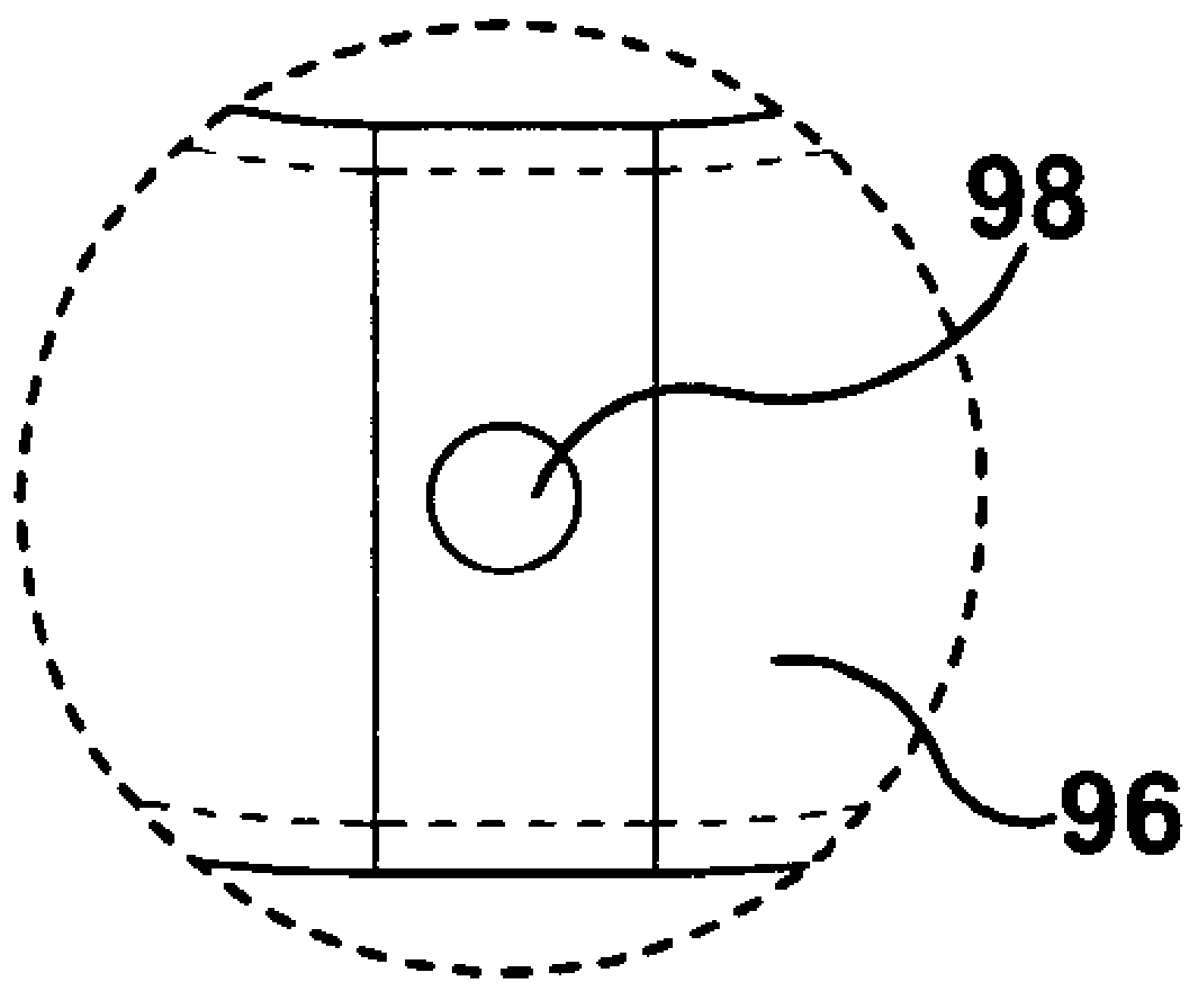


Figure 12C

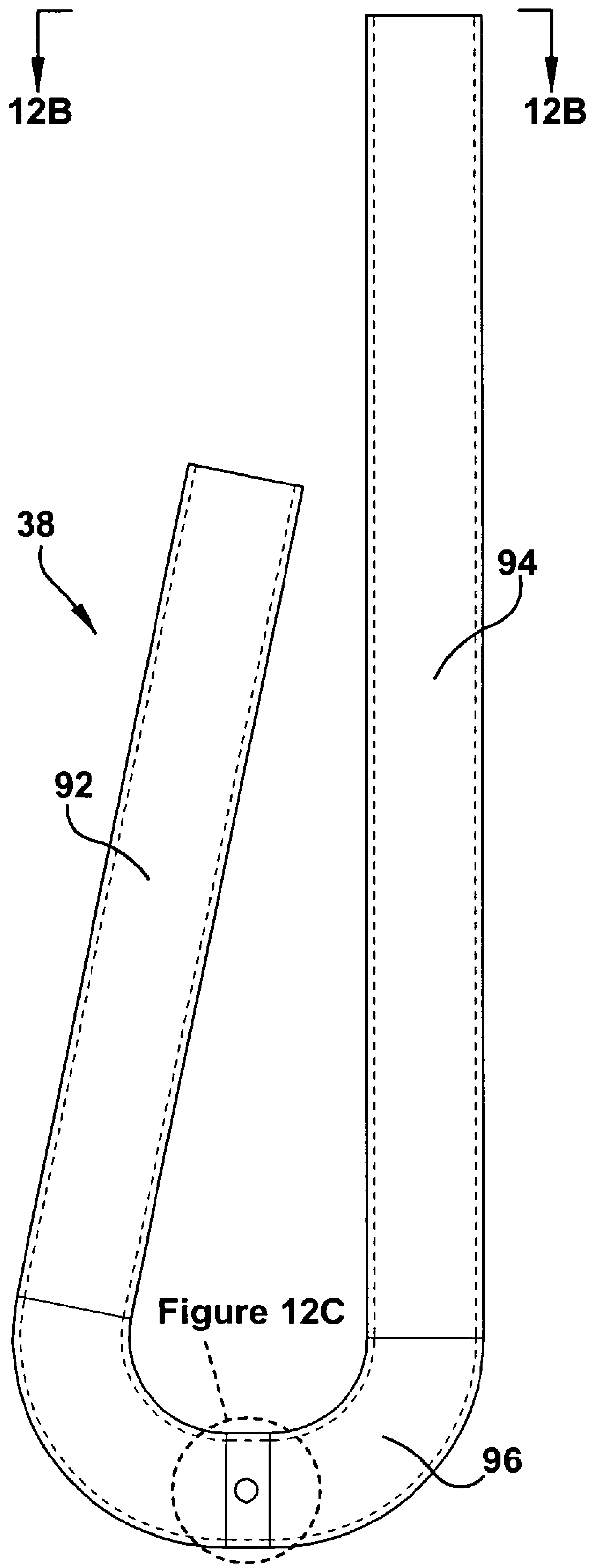


Figure 12A

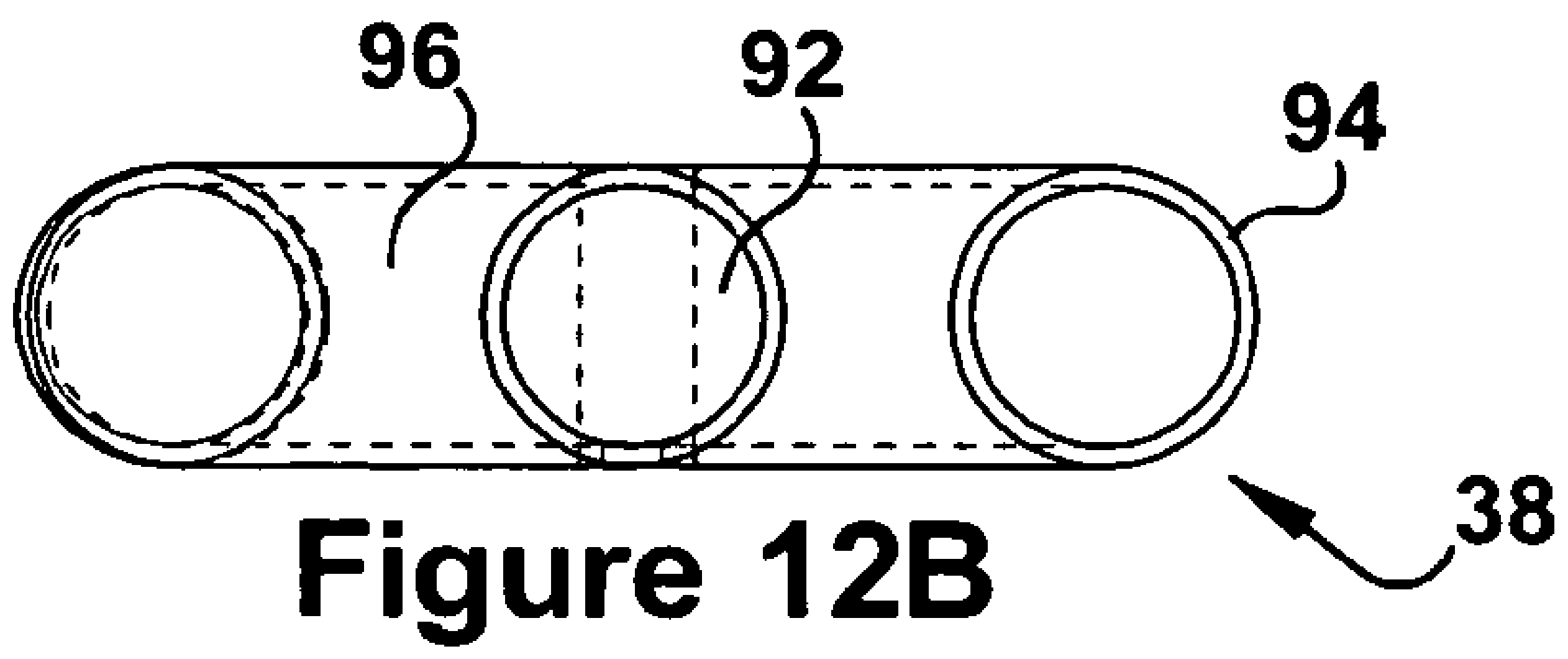


Figure 12B

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 pre-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 refrigerant 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_{post} greater than the desired superheated temperature T_{super}. Consequently, the pre-evaporator temperature T_{pre} is less than the post-evaporator temperature T_{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_{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. However, as an aftereffect of the evaporator **12** having to handle too much fluid, the temperature T_{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_{super}). The temperature T_{pre} of the pre-evaporator fluid equals the saturation temperature T_{sat} at the pressure P_{pre}, whereby the pre-evaporation temperature T_{pre} is greater than the post-evaporation temperature T_{post}. (**FIG. 4A**.)

[**0035**] As a result of the temperature differential (T_{pre}-T_{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. **5**A and **5**C-**5**D.) 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. **5**A and **5**C-**5**D.) The shell **44** can be formed from a cylindrical wall **48** and a bottom end wall **50**. (FIGS. **5**A and **5**C-**5**D, 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° F.) to about 300 BTU/(h*ft° 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 tp 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.

* * * * *