US 20050081559A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2005/0081559 A1**

McGregor et al. (43) **Pub. Date: Apr. 21, 2005**

(54) **ACCUMULATOR WITH PICKUP TUBE**

(76) Inventors: **Ian Alexander Neil McGregor**, Belleville (CA); **Timothy Russell Dickson**, Kingston (CA); **Scott Murray Finlayson**, Belleville (CA)

Correspondence Address:
BAKER & DANIELS
300 NORTH MERIDIAN STREET
SUITE 2700
INDIANAPOLIS, IN 46204-1782 (US)

(21) Appl. No.: **10/964,196**

(22) Filed: **Oct. 13, 2004**

Related U.S. Application Data

(60) Provisional application No. 60/512,102, filed on Oct. 20, 2003.

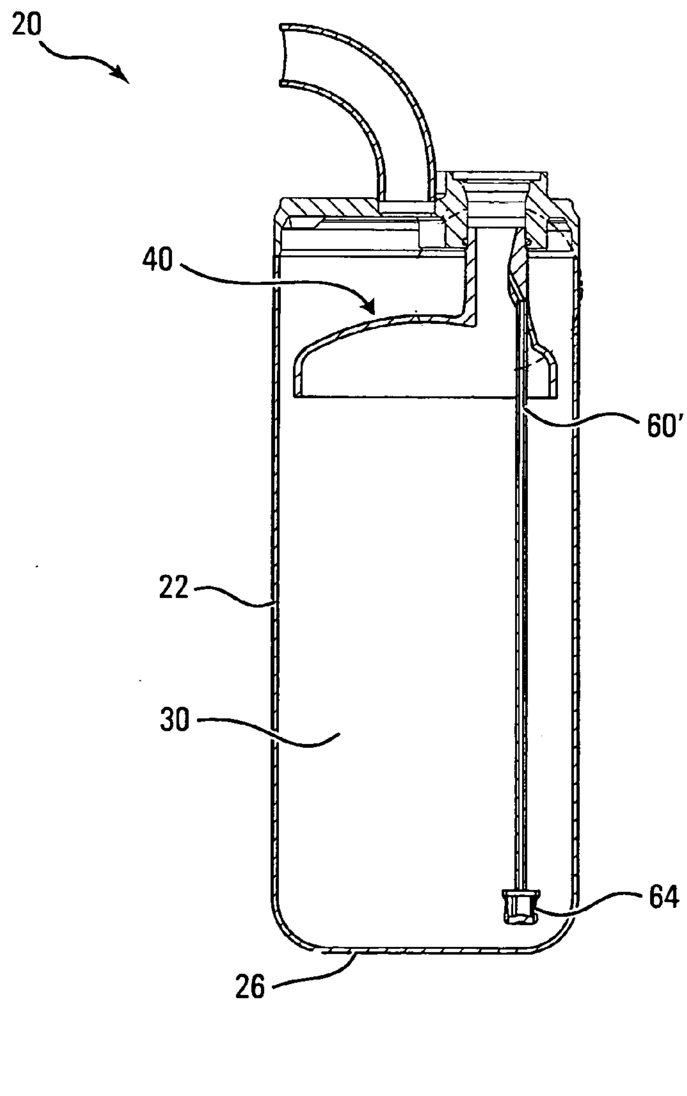
Publication Classification

(51) **Int. Cl.**[7] **F25B 43/00**

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

(57) **ABSTRACT**

A suction accumulator for refrigeration or air-conditioning system use, especially for automotive air conditioning system use, which comprises a "pickup tube" to withdraw liquid from a reservoir of the accumulator to return oil to the compressor. The accumulator has a deflector with an outlet tube, to help ensure that fluid does not flow directly from the inlet opening to the outlet opening of the accumulator. The relatively narrow second portion of the outlet tube is closer to the outlet opening than the first portion. The pickup tube is secured in communication with the relatively narrow second portion and optimises the oil return function, minimises restriction to refrigerant flow, maximises effective and actual reservoir volume, and minimises the amount of liquid delivered to the compressor at switch-off. Incorporating an electric heating element or a heat exchanger for engine coolant or exhaust allows the accumulator of the present invention to function as the evaporator when the refrigeration system is used in heat pump mode for heating applications.



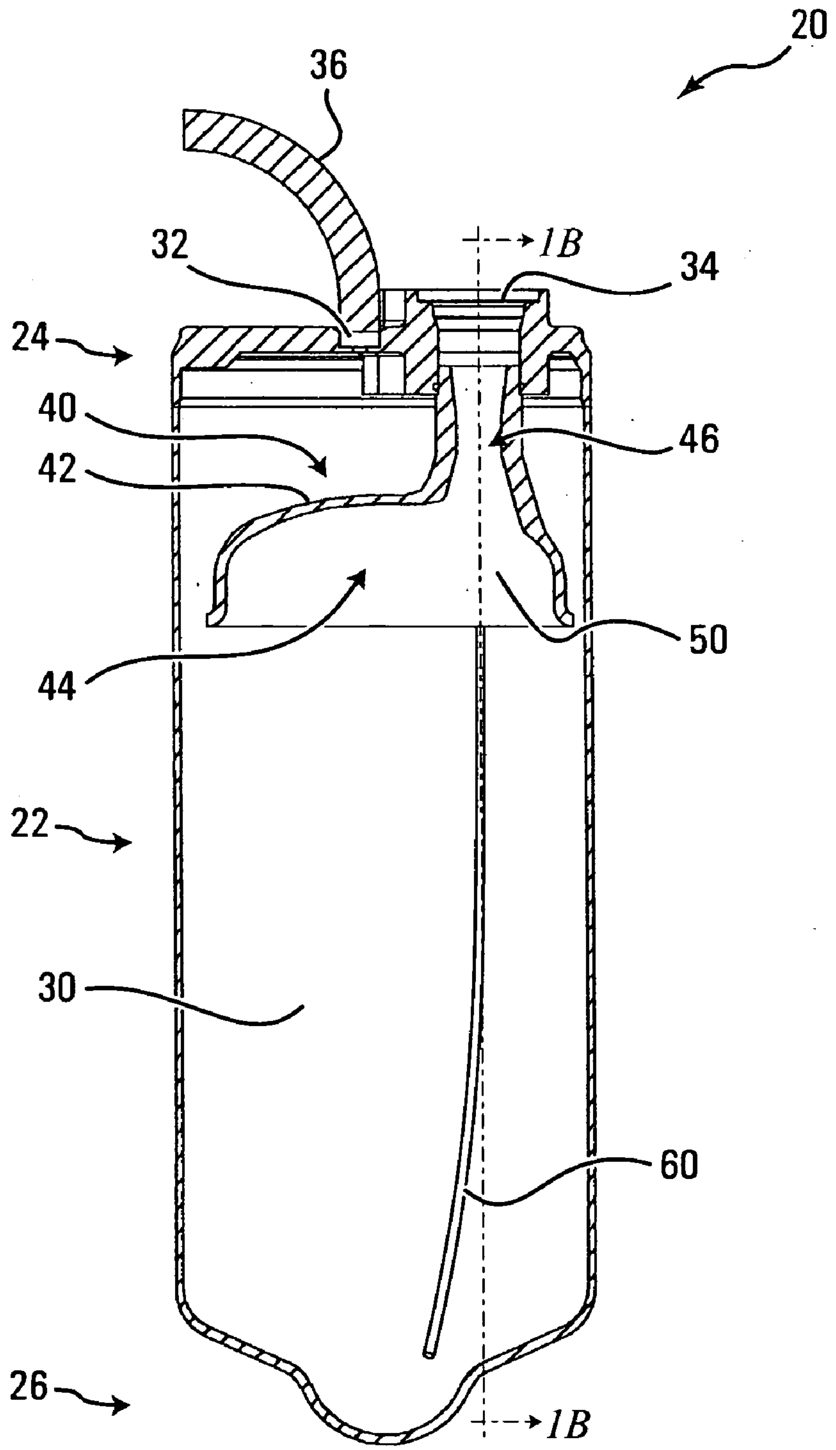
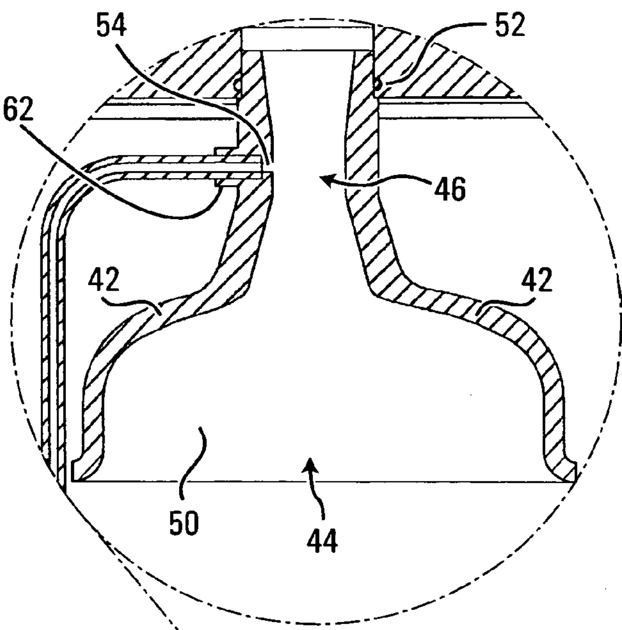


FIG. 1a

FIG. 1c



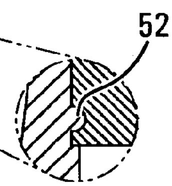


FIG. 1d

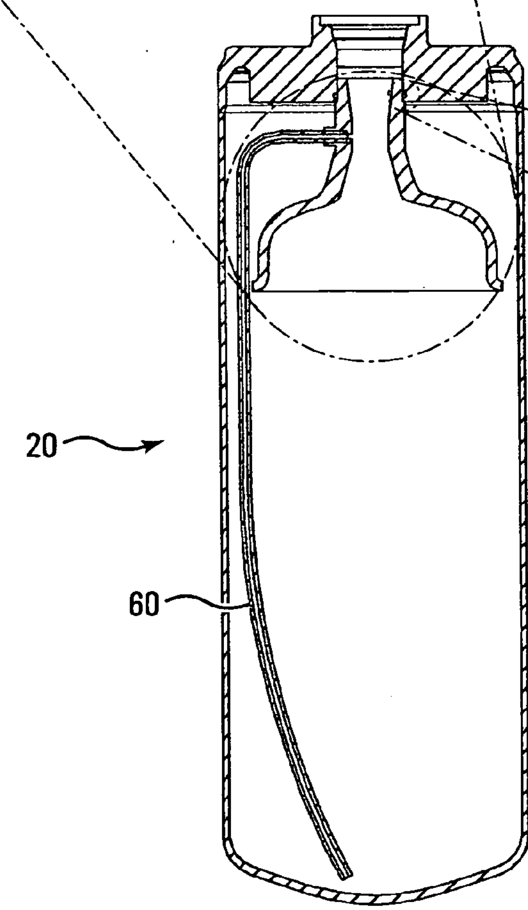


FIG. 1b

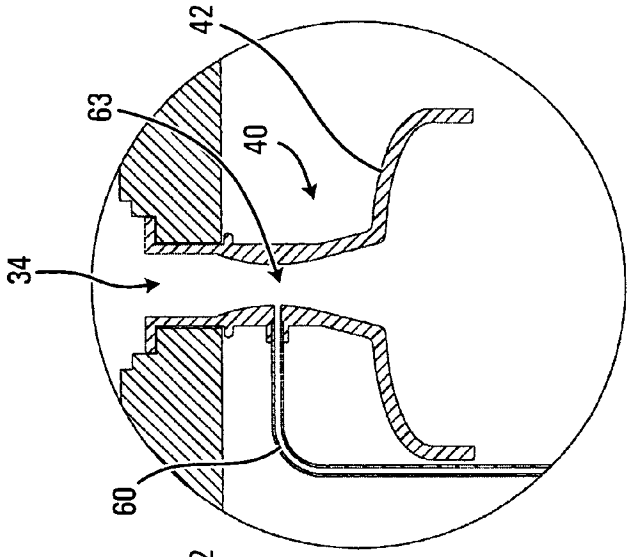


FIG. 1g

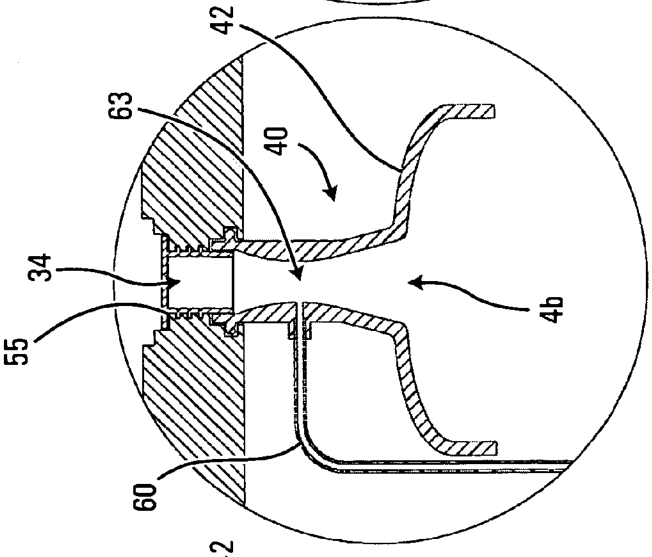


FIG. 1f

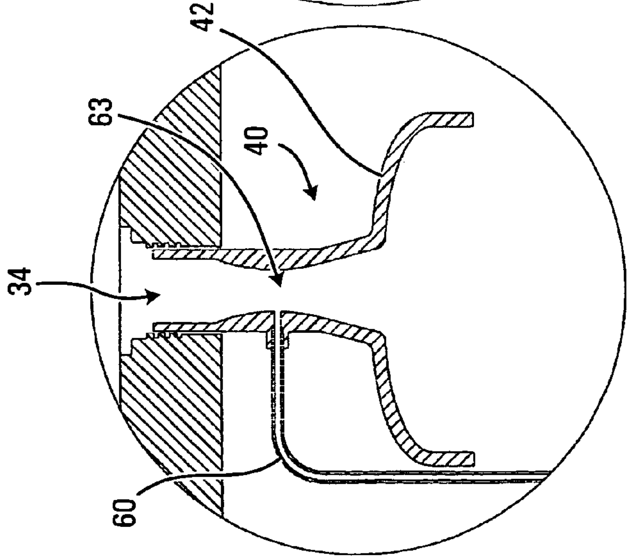


FIG. 1e

FIG. 2b

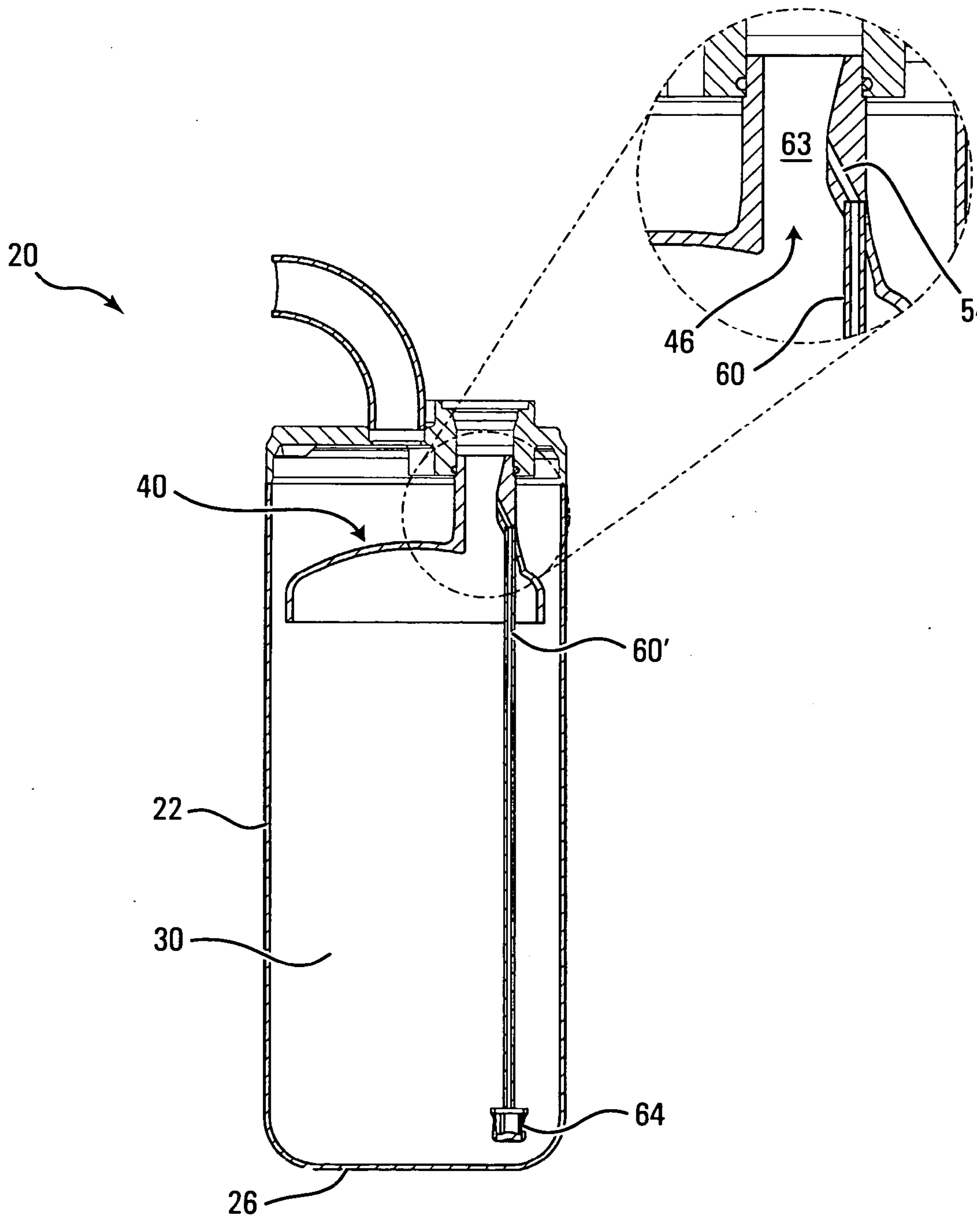


FIG. 2a

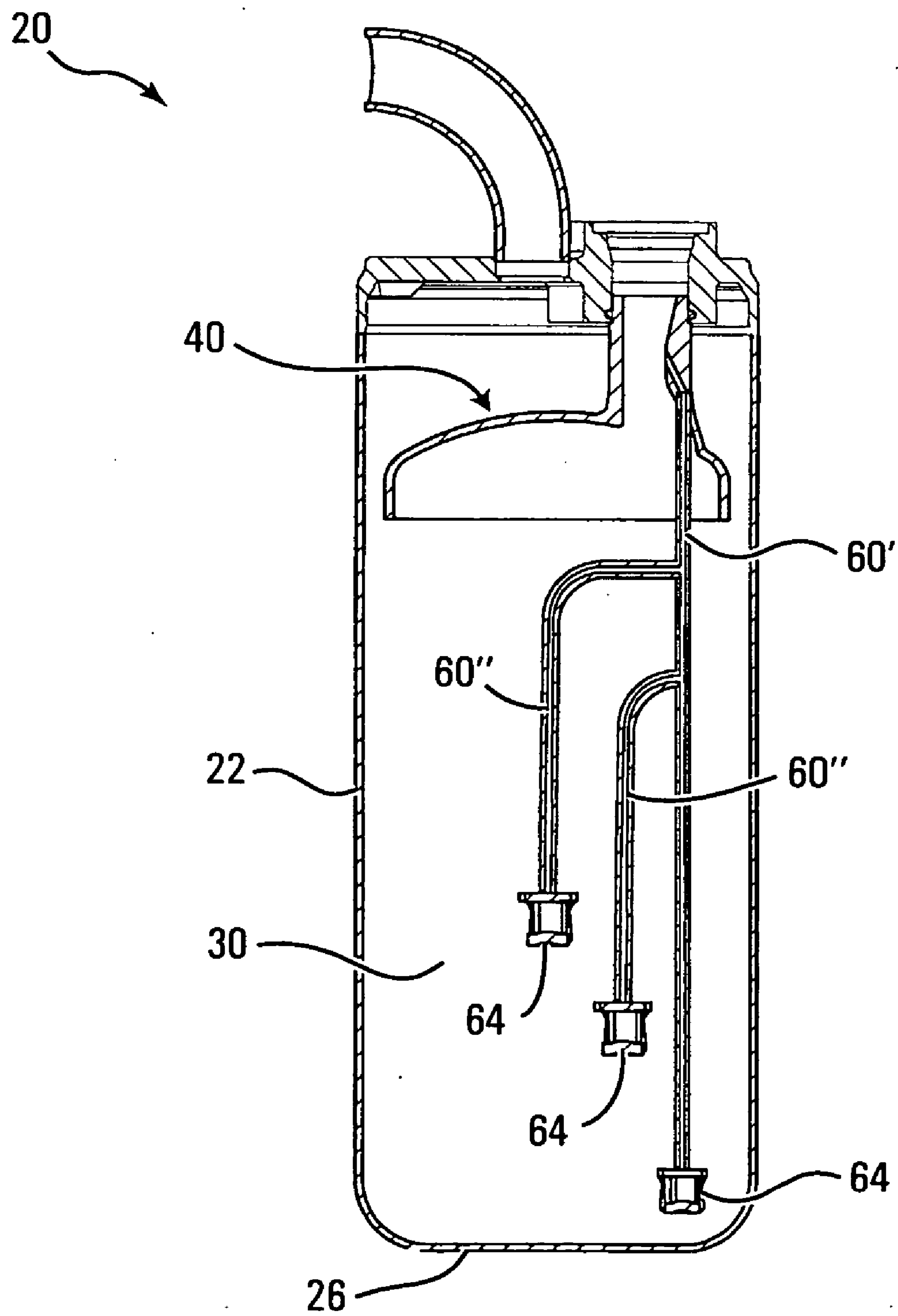


FIG. 2c

FIG. 3b

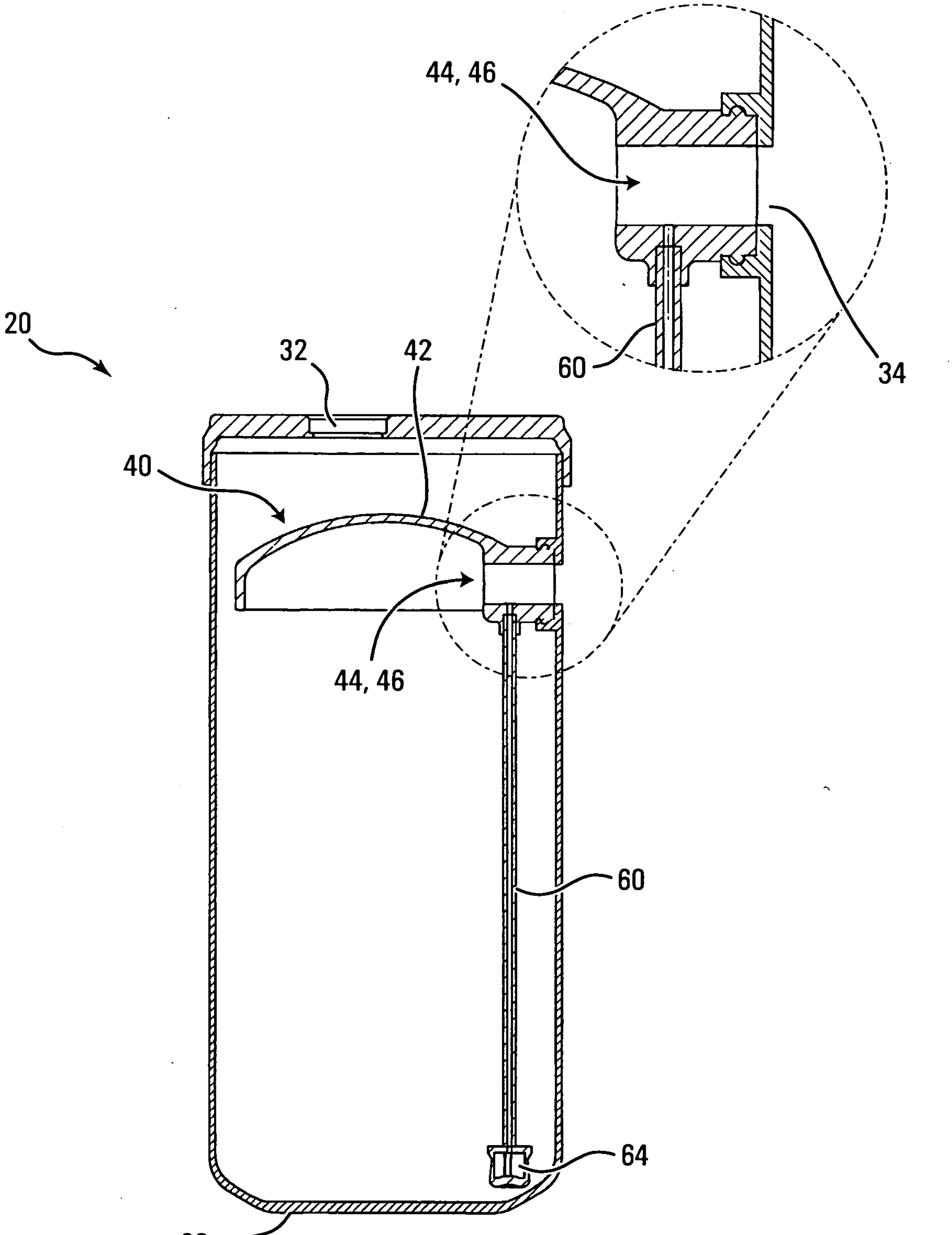
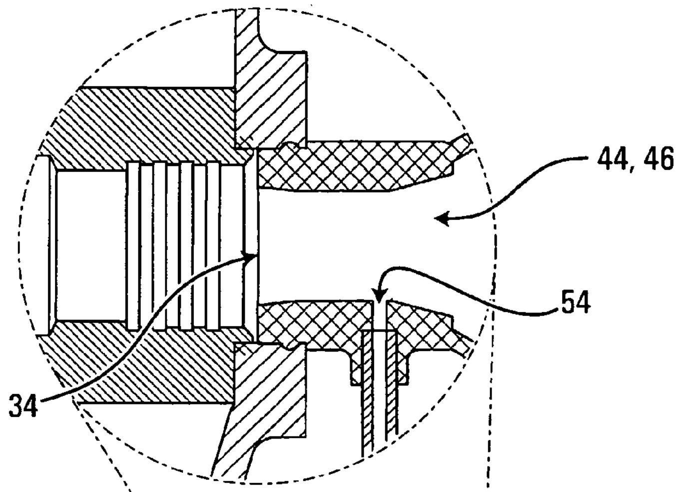


FIG. 3a

FIG. 4b



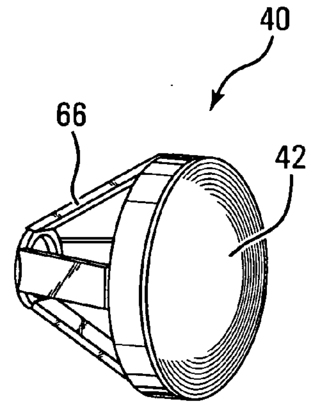


FIG. 4c

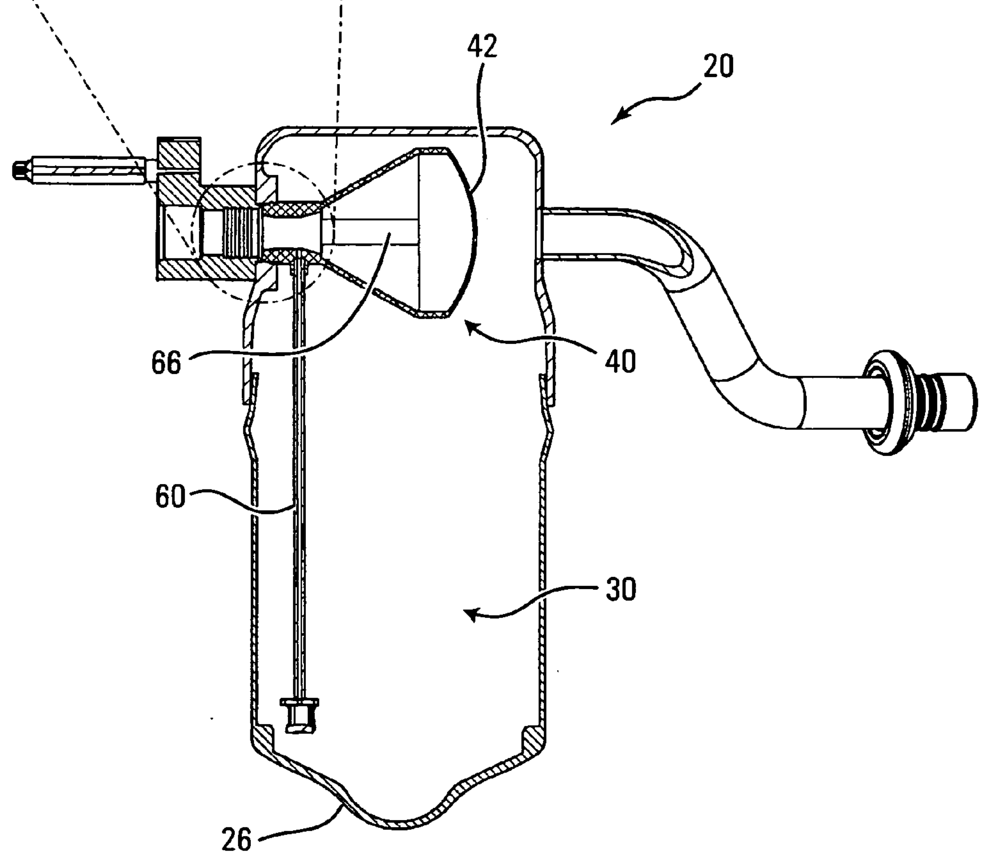


FIG. 4a

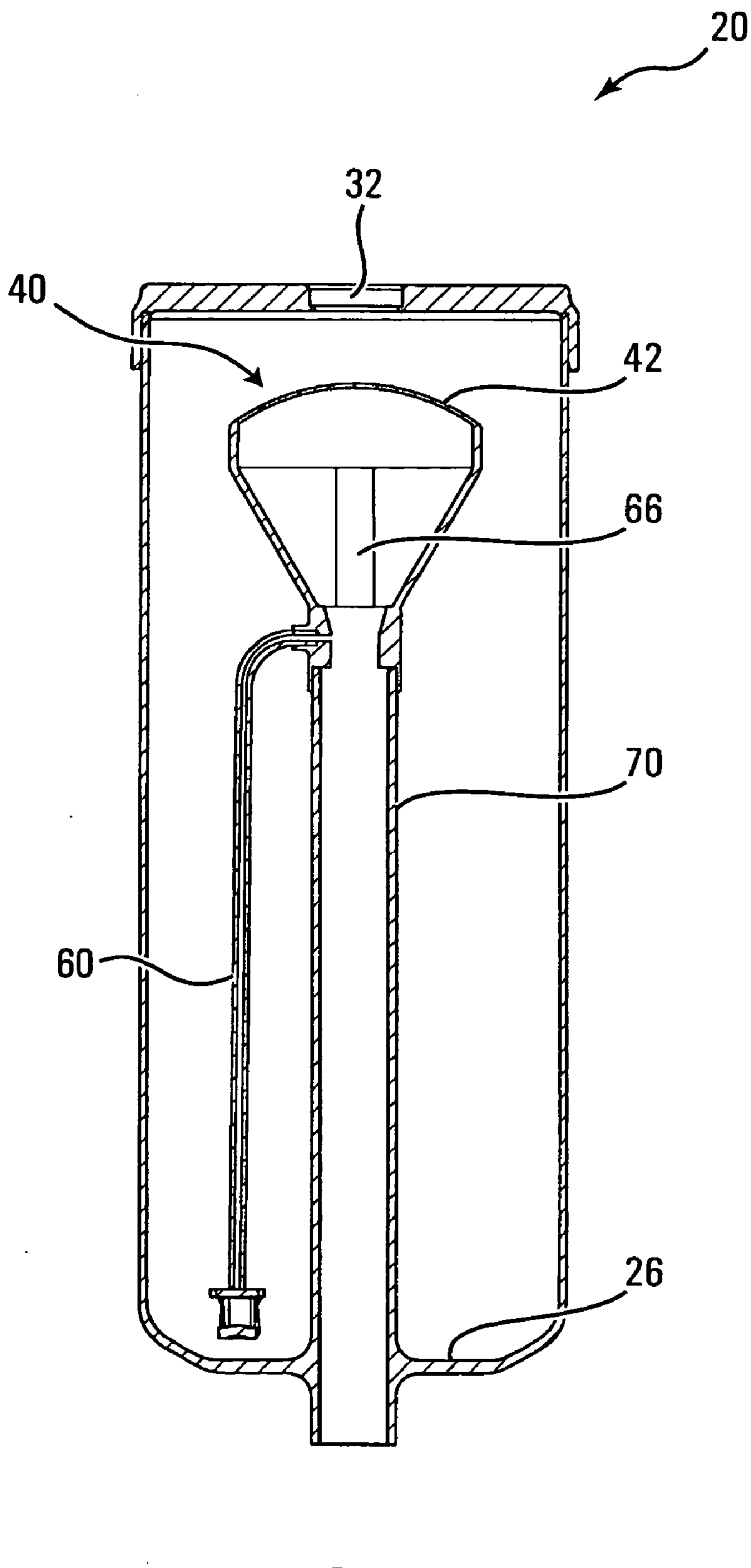


FIG. 5

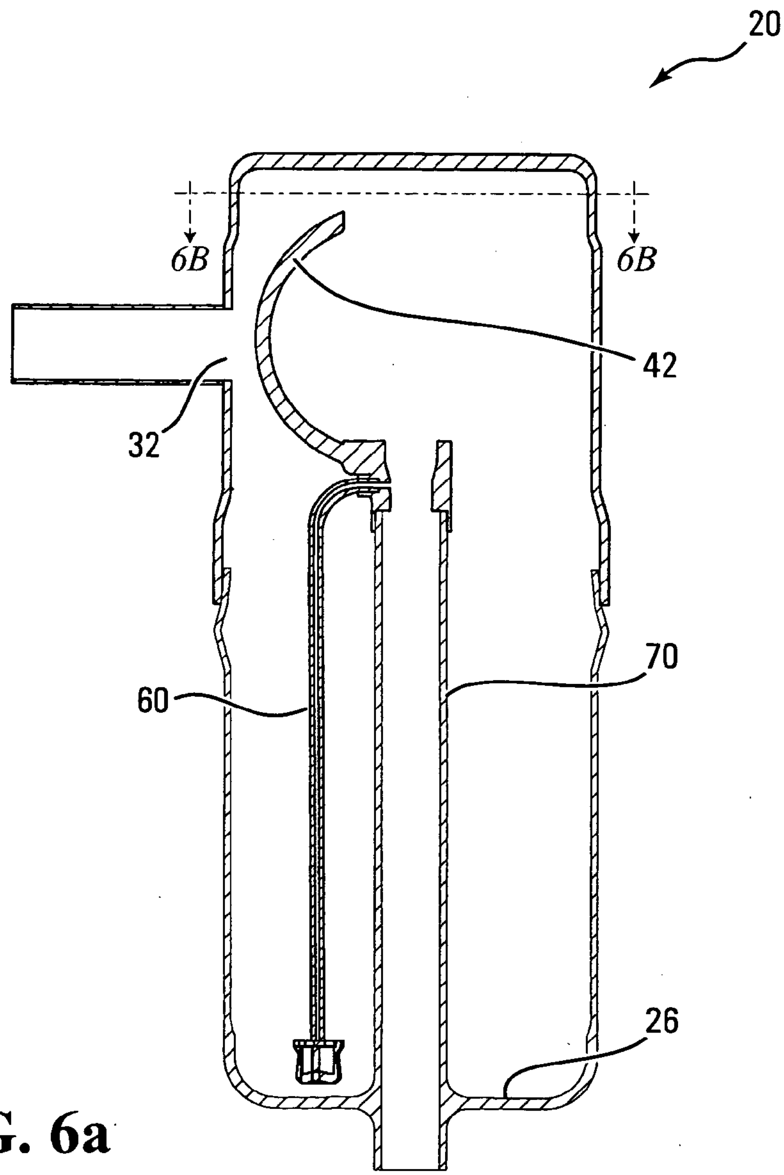


FIG. 6a

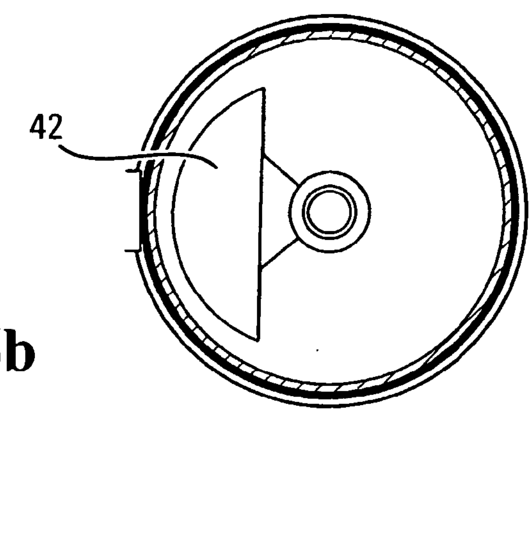


FIG. 6b

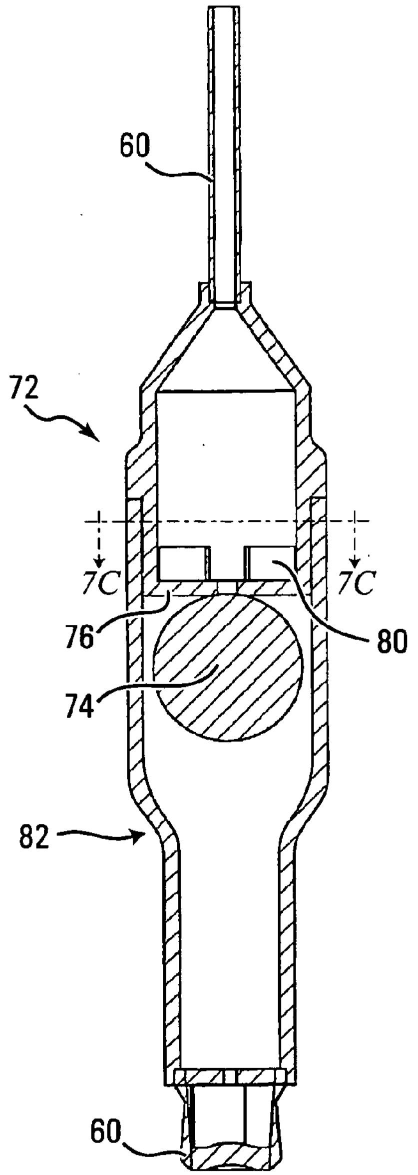


FIG. 7a

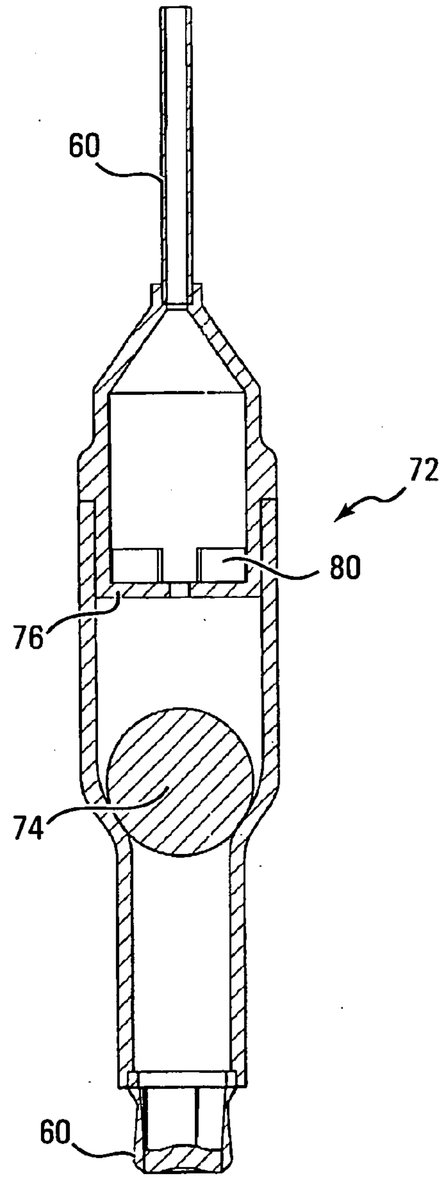


FIG. 7b

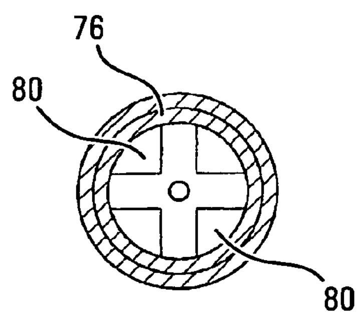


FIG. 7c

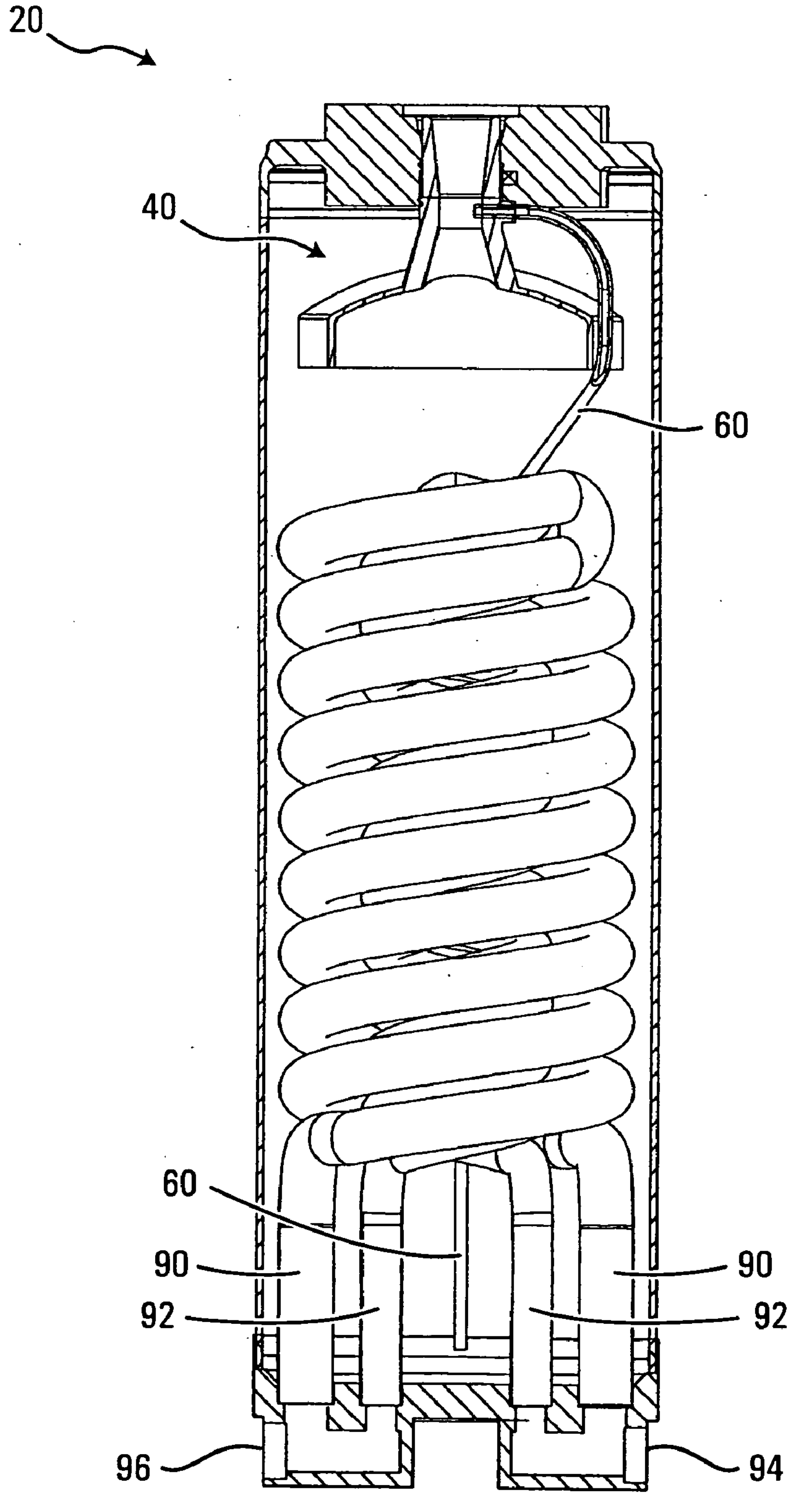


FIG. 8

ACCUMULATOR WITH PICKUP TUBE

[0001] This application is a conversion from U.S. Provisional application No. 60/512,102.

FIELD OF THE INVENTION

[0002] The present invention relates to a new and improved suction accumulator for use in a refrigeration system, including air-conditioning (A/C) or heat pump systems, and may be used in an air-conditioning or heat pump system of a motor vehicle.

BACKGROUND OF THE INVENTION

[0003] Closed-loop refrigeration systems conventionally employ a compressor that is meant to draw in gaseous refrigerant at relatively low pressure and discharge hot refrigerant at relatively high pressure. The hot refrigerant condenses into liquid as it is cooled in a condenser. A small orifice or valve divides the system into high and low-pressure sides. The liquid on the high-pressure side passes through the orifice or valve and turns into a gas in the evaporator as it picks up heat. (Some systems operate in "transcritical" mode, where the hot refrigerant is merely cooled in the high side heat exchanger, now termed a "gas cooler", and turns to gas plus liquid as it passes through the expansion device.) At low heat loads, it is not desirable or possible to evaporate all the liquid in the evaporator. However, excess liquid may cause problems. Excess liquid refrigerant entering the compressor (known as "slugging") causes system efficiency loss and can cause damage to the compressor. For that reason, it is standard practice to include a reservoir between the evaporator and the compressor to separate and store the excess liquid. The reservoir is also used to store excess refrigerant. (Extra refrigerant is typically added to the system during manufacture to compensate for unavoidable leakage during the working life of the system.) This reservoir is called a suction line accumulator, or simply an accumulator.

[0004] An accumulator is typically a metal can, welded together, and often has fittings attached for a switch, transducer and/or charge port. One or more inlet-tubes and an outlet tube pierce the top, sides, or occasionally the bottom, or attach to fittings provided for that purpose. The refrigerant flowing into a typical accumulator will impinge upon a deflector or baffle intended to reduce the likelihood of liquid flowing out the exit, generally by removing kinetic energy from the liquid so it settles quietly into the reservoir area without churning or splashing. There are several known baffles and deflectors, designed to reduce liquid carryover.

[0005] Promoters of certain accumulators claim not to need deflectors. These can be satisfactory for designs that have an inlet that enters the accumulator from one side, horizontally. In those cases, the opposite side of the accumulator can act as an energy-reducing deflector. However, for other configurations, such as those having an inlet in the top, the lack of a deflector may reduce effective reservoir volume and system efficiency by allowing churning and splashing that allows liquid to exit the accumulator and flow to the compressor, that is, by allowing liquid carryover.

[0006] Some known devices are concerned with reducing the turbulence of the inlet flow as a way to reduce liquid carryover. Other designs are more concerned with the coupling between the reservoir and an outlet passage, mainly to reduce the pressure drop across the accumulator (an important system performance parameter).

[0007] A consequence of using a suction line accumulator is that compressor oil can become trapped within it. Compressor oil is circulated with the refrigerant in some systems in current usage. Even if a separator is used, some oil escapes into the system. This oil will find its way into the accumulator.

[0008] While liquid refrigerant may be expected to evaporate and return to circulation as needed, the oil does not evaporate. Some means must be provided to return this oil to circulation.

[0009] A common current practice is to use a J-shaped outlet tube (a "J-tube") to carry the exiting gaseous refrigerant from the top of the accumulator down to the bottom and then back up to the outlet from the accumulator. An orifice at the bottom of the "J-tube" is used to entrain the oil from the bottom of the liquid area into the stream of exiting gas. Often, the orifice has a filter around (or in) it, and the filter may extend into a sump formed in the bottom of the accumulator to collect the oil-rich liquid.

[0010] Some J-tubes have a hole near the top, which prevents the liquid from siphoning or flowing out of the accumulator reservoir when the system is switched off. The size of the hole is a balance between breaking any siphon and reducing the effectiveness of oil pickup.

[0011] Another feature of known designs is the inclusion of desiccant in the accumulator. Some refrigerant systems are more susceptible to moisture ingression and damage than others. In some systems, it is necessary to remove any moisture. The accumulator is a convenient spot to house a desiccating element. Many early designs featured desiccant cartridges (or other desiccant containers), but the typical modern usage is a porous fabric bag of some suitable shape, containing beads of desiccating material like alumino-silicate zeolite, and secured to some inner feature of the accumulator, such as the J-tube, at a position where the beads will contact the liquid refrigerant.

[0012] Certain known devices are concerned with transferring heat from the warm refrigerant flowing to the expansion device on the high pressure side of the refrigerant loop to the cold refrigerant on the low pressure side. The purpose is typically to cool the high pressure refrigerant to get more capacity from the evaporator, or to evaporate any excess liquid that would otherwise flow to the compressor and damage it. It has been taught to have heat exchange with automobile exhaust gases to evaporate the excess liquid refrigerant. There are several reasons why heat exchange with the accumulator fluid may be desirable. However the desire to put heat exchangers into an accumulator is typically hampered by the requirement of many accumulator designs to have the gaseous refrigerant routed near the bottom of the reservoir volume as it exits the accumulator so that oil may be entrained. A large, open, and accessible reservoir volume would be more convenient for including a heat exchanger.

[0013] In view of volume restrictions in a J-tube style accumulator, it is difficult to fit heat exchanger coils into an accumulator that utilizes a j-tube for oil return. It would therefore be advantageous to have an accumulator with a large, unobstructed reservoir for incorporating features in an accumulator, such as heat-exchange coils.

[0014] While it is possible to put heat exchange coils in an accumulator, it is typically not recommended have a heat source in the reservoir. The heat source may vaporize liquid refrigerant, causing more refrigerant to circulate in the system than would otherwise be the case, which may defeat the purpose of having a reservoir. One example where heat in the reservoir may be advantageous is where the A/C system is operated in heat pump mode—that is, when the object is to supply warm air, not cool. Typically in such systems, the condenser is located in the area to be warmed, for instance the cabin of an automobile, and the evaporator is in the ambient air. Under very cold ambient conditions, it is difficult for the evaporator to extract heat from the air, and performance suffers.

[0015] In motor vehicle applications, it is possible to extract heat from the engine exhaust gases or coolant. The engine coolant warms rapidly. However, in some case, it takes a significant amount of time before the coolant is warm enough to transfer sufficient heat to the cabin, such as, for instance, when it is necessary to defrost the windscreen. With some high-efficiency motors, especially diesels, the coolant may never get warm enough to provide comfortable cabin temperatures in very cold weather. However the coolant is warm enough to provide sufficient heat to evaporate the refrigerant, if connected to the refrigerant through a suitable heat exchanger. Accordingly, in some cases it would be desirable to be able to put heat exchange coils in an accumulator.

[0016] As another issue, often the compressor oil and the refrigerant are selected to be miscible so that the oil does not deposit thickly on heat exchanger walls, or collect in pools in the A/C system plumbing or separate in the accumulator. However, in some instances the required refrigerant and the required oil are not miscible. The separation of the oil and refrigerant in the accumulator does not affect the return of oil to the compressor provided the oil is more dense than the refrigerant, because the extraction point is typically fixed near the bottom of the reservoir. However if the oil is less dense than the refrigerant it is problematic to extract the oil as the volume of refrigerant changes in the reservoir. The problem is particularly acute if the oil is more dense than the refrigerant at high temperatures but less dense at low temperatures such that the location of the oil switches from under to over the refrigerant when the operating conditions change. A similar problem could exist (where the location of the oil within the accumulator changes) when the accumulator is tilted when climbing steep hills, for example. It would be desirable to overcome this problem.

[0017] It would be desirable to design an accumulator for an air-conditioning system where one or more of the following are achieved: restrictions to refrigerant flow are minimized or reduced; the effective and actual reservoir volume is increased by minimizing or reducing the volume occupied by internal components and by minimizing or reducing liquid splashing and churning; oil is returned to the compressor in optimal (or improved) fashion; the amount of liquid delivered to the compressor at switch-off is minimized or reduced; and the accumulator cost is minimized by improving the ease of assembly and minimizing the size and number of components.

[0018] As noted above, there are several challenges and goals for designers of suction line accumulators. Any restriction in flow between the evaporator and the compressor decreases system performance as it increases evaporator pressure (increasing the temperature) and increases compressor specific work. Hence one challenge is to minimize the pressure drop caused by the accumulator. Second, it is desirable to minimize liquid carryover during operation. Third, the oil required by the compressor should be returned to circulation. Fourth, it is desirable to minimize or reduce the flow of liquid to the compressor when the system is switched off, either by siphoning or migration. Fifth, it would be desirable to make the accumulator small, inexpensive, and easy to assemble. Existing literature in this field typically considers these challenges or goals as being largely separate, where one design seeks to achieve one goal, at the expense of the others. It would be desirable for an accumulator to achieve as many of these goals as possible.

SUMMARY OF THE INVENTION

[0019] An improved accumulator may be achieved through the realization that although pressure drop between the evaporator and the compressor caused by the accumulator can be minimized or reduced by eliminating unnecessary restrictions, pressure drop cannot be eliminated entirely due to the requirement to return oil to the compressor. Although apparently not previously recognized, a careful study of the mechanism for collecting oil from the reservoir in the accumulator and delivering it out of the accumulator shows that some pressure difference is required to draw the oil out. That is primarily because of the design of many accumulators where the oil and liquid refrigerant settle into the bottom of the reservoir section while the outlet is located at or near the top of the accumulator. However even when the outlet is at or near the bottom of the accumulator, a riser tube is typically required to prevent the reservoir from being emptied at switch-off (to avoid filling the lines or the compressor with liquid and causing undesirable compressor slug at start up).

[0020] An embodiment of the present invention minimizes or reduces the pressure drop by using a deflector to manage the flow of fluid and by using a pressure reduction at a restriction within a conduit through the deflector. The pressure reduction helps lift liquid (oil or mostly oil) up a small tube or passage (a "pickup tube") where the liquid is be entrained into the outlet flow of gaseous refrigerant. The pickup tube is relatively small in diameter (occupying much less internal volume than a conventional J-tube) which therefore increases the effective internal volume of the accumulator when combined with a deflector (where the deflector helps to minimize or reduce reservoir churning and splashing).

[0021] As noted in the previous paragraph, reduced pressure is used to lift oil up the pickup tube. Less pressure is needed in view of the use of the restriction in the conduit. The pickup tube is secured in communication with the restriction in the conduit. Fluid is accelerated through the restriction. In other words, pressure is decreased locally in the area of the restriction according to Bernoulli's law and does not contribute to overall pressure drop.

[0022] In practice some pressure drop is introduced in the accumulator because the flow is not incompressible. There is a minimum required pressure differential that must be incurred to return the oil to the compressor. The simplicity of certain embodiments of the present invention eliminates (or reduces) the existence of incidental elements that contribute to pressure drop. Oil is thus returned to the compressor in a more efficient fashion.

[0023] The pickup tube also minimizes the return of liquid to the compressor at switch-off, because the pickup tube is open at the top and hence cannot function as a siphon. As well, because the gas flow after switch-off is due primarily to migration (refrigerant evaporating from warm areas of the system and condensing at cooler places), and the velocity of migrating refrigerant is quite small, the pressure drop generated at the restriction will be quite small as well, and hence only minimal liquid, if any, will be withdrawn from the reservoir at switch-off.

[0024] In accordance with a further embodiment of the present invention, there is provided an accumulator which is relatively small, has few components, and is relatively easy to manufacture, all of which results in decreased cost. The relatively small size also makes embodiments of the present invention easier to package into systems. Further, the relatively large unobstructed reservoir in the accumulator allows for the possibility of other features to be incorporated into the accumulator, such as, for example, desiccant and/or coils for heat exchange, if desired.

[0025] In accordance with a further aspect of the present invention, there is provided an accumulator especially for automotive use embodying an outer housing consisting of sides and ends which are welded, crimped, or otherwise hermetically joined together, with one or more inlets, one or more outlets, and ports piercing or connecting through the ends and sides as required, and a deflector and an outlet tube or passage, with a restriction in the outlet passage to increase the flow velocity therein. A pickup tube, or other passage, is connected in communication with the restriction. The pickup tube extends to the bottom (or near the bottom) of the reservoir to facilitate liquid pickup. The restriction effect is used to meter liquid from the reservoir into the flow of gas through the outlet tube. There may also be a container, either of rigid or flexible material, which holds desiccant for drying the refrigerant as it flows through the accumulator, and filters as required. There may also be coils or other components in the accumulator reservoir for heat exchange.

[0026] In accordance with another aspect of the present invention, refrigerant and oil entering an accumulator through an inlet hits against a deflector surface and possibly other inner surfaces to dissipate kinetic energy. Oil and liquid refrigerant then flow downward along the inside surface of the accumulator and settle on the bottom of the accumulator due to gravity, while the gaseous refrigerant rises toward an inlet of the outlet passage. The inlet of the outlet passage is protected from splashing liquid. The inlet of the outlet passage is shielded by the deflector. Gaseous refrigerant is drawn up through the outlet passage and out of the accumulator, and then flows to the compressor. The path through the outlet passage has a restriction which causes the gaseous refrigerant passing through it to increase in velocity and thus have reduced static pressure. Advantageously, to minimize or reduce turbulence and unnecessary pressure drop, the outlet tube may include a gradual taper into the restriction. A pickup tube or passage extends from the reduced pressure area of the restriction to the liquid reservoir at or near the bottom of the accumulator. The reduction in static pressure at the restriction can be calculated to draw the required amount of liquid from the reservoir through the pickup tube and into the outlet flow of gaseous refrigerant.

[0027] In accordance with a further aspect of the present invention, there is provided a pickup tube having a flow check device that only allows liquid to flow up the tube, and not downward. This device helps keep the pickup tube filled with liquid even when there is no (or insufficient) refrigerant flow through the outlet tube. A filled pickup tube reduces the time required to return oil to the compressor at system switch-on. The pickup tube could also be provided with a screen or filter to help prevent debris from clogging it or passing to the compressor. The pickup tube could also have more than one orifice in the reservoir of the accumulator, allowing hydraulic connection to the reservoir at more than one point, particularly at different heights. Such a feature could be important should the oil be lighter than the liquid refrigerant.

[0028] If the oil is less dense than the refrigerant, it is problematic to extract the oil as the volume of refrigerant changes in the reservoir. The problem is particularly acute if the oil is more dense than the refrigerant at high temperatures but less dense at low temperatures such that the location of the oil switches from under to over the refrigerant when the operating conditions change. The pickup tube concept can be employed to resolve this problem by utilizing multiple tubes at various heights in the reservoir.

[0029] In accordance with another aspect of the present invention there is provided an accumulator with a largely unobstructed reservoir volume that could be used for ancillary purposes such as containing a heat exchanger, for instance, for heat exchange with other available fluids such as engine exhaust or coolant.

[0030] While many different heat exchangers have been used in motor vehicles, implementing one as a separate unit requires finding a space to put it and entails additional cost, both problems in modern vehicles. It would be advantageous to have such space. Putting the heat exchange coils in the accumulator would resolve much of the space and cost issues. While operating as an A/C unit the heat exchange coils could be rendered inactive with a suitable valve to shut off the coolant or exhaust gas. In heat pump mode the valve could be opened and the accumulator would function as the evaporator. In other words, the refrigerant would be routed into the accumulator directly from the expansion device, and the heat exchange coils would evaporate the liquid to gas in the reservoir volume, from whence the gas would return to the compressor. In this embodiment, the reservoir function would be largely lost and hence system efficiency would suffer. However, that is not serious in heat pump mode for two reasons. First, the actual energy delivered for supplementary heating is typically not as great as the energy that must be extracted for cooling. Second, the amount of heat extracted from the refrigerant by the condenser is the sum of the heat input mechanically by the compressor plus the heat put in by the evaporator, so the system does not need to work as efficiently to deliver as much energy in heating mode as it does to extract the same amount of energy in A/C mode.

[0031] Electric heaters may be used to provide supplementary heat. A cost effective option is to install an electric heater in the accumulator reservoir to supply heat for evaporation. Since the heat delivered by the heat pump is the sum of the heat put in by the compressor plus the heat put in by the evaporator, the heat put in to evaporate the refrigerant is less than the heat evolved by the heat pump, and therefore less electricity would be required to get sufficient supplementary heat with this method. By using such a heat pump, a smaller alternator, less wiring, and fewer controls would be required than to provide direct electric supplementary heating. Hence in one embodiment, it is advantageous to have an accumulator with a large open reservoir volume that can effectively house heat exchanger coils or an electric heater to provide the evaporator function in heat pump mode.

[0032] In accordance with a further aspect of the present invention, there is provided an accumulator comprising an inlet opening, an outlet opening, a deflector to help ensure that liquid does not flow directly from the inlet opening to the outlet opening, a conduit inside the accumulator in communication with the outlet opening, the conduit comprising a conduit wall surrounding an open interior, the open interior having a first portion and a second portion, the second portion having a cross-sectional area less than a cross-sectional area of the first portion and the second portion being closer to the outlet opening than the first portion, and a pickup tube having a first end and a second end, the second end being in communication with the second portion of the open interior.

[0033] In accordance with another aspect of the present invention, there is provided an accumulator comprising an inlet opening, an outlet opening, a means to help ensure that liquid does not flow directly from the inlet opening to the outlet opening, an outlet conduit means inside the accumulator in communication with the outlet opening, the outlet conduit means comprising an open interior, the open interior having a first portion and a second portion, the second portion having a cross-sectional area less than a cross-sectional area of the first portion and the second portion being closer to the outlet opening than the first portion, and a pickup conduit means in communication with the second portion of the open interior.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] **FIG. 1***a* is a sectional side view of a top in, top out accumulator, in accordance with an embodiment of the present invention;

[0035] **FIG. 1***b* is a sectional view of the accumulator of **FIG. 1***a* taken along line B-B of **FIG. 1***a;*

[0036] **FIG. 1***c* is a magnified view of a circled portion of **FIG. 1***b;*

[0037] **FIG. 1***d* is a magnified view of another circled portion of **FIG. 1***b;*

[0038] **FIGS. 1***e*, **1***f* and **1***g* are three views, similar to **FIG. 1***c*, showing three different techniques for securing a deflector to an outlet port;

[0039] **FIG. 2***a* is a sectional side view of a top in, top out accumulator in accordance with another embodiment of the present invention;

[0040] **FIG. 2***b* is a magnified view of the circled portion of **FIG. 2***a;*

[0041] **FIG. 2***c* is an alternate embodiment of a pickup tube having a number of offshoot tubes ending at different heights;

[0042] **FIG. 3***a* is a sectional side view of a top in, side out accumulator in accordance with another embodiment of the present invention;

[0043] **FIG. 3***b* is a magnified view of the circled portion of **FIG. 3***a;*

[0044] **FIG. 4***a* is a sectional side view of a side in, side out accumulator in accordance with another embodiment of the present invention;

[0045] **FIG. 4***b* is a magnified view of the circled portion of **FIG. 4***a;*

[0046] **FIG. 4***c* is a perspective view of a portion of the deflector of **FIG. 4***a;*

[0047] **FIG. 5** is a sectional side view of a top in, bottom out accumulator in accordance with another embodiment of the present invention;

[0048] **FIG. 6***a* is a sectional side view of a side in, bottom out accumulator in accordance with another embodiment of the present invention;

[0049] **FIG. 6***b* is a cross-sectional view of the accumulator of **FIG. 6***a*, taken along line B-B of **FIG. 6***a*.

[0050] **FIG. 7***a* is a side sectional view of a ball valve (or a check valve), in accordance with an embodiment of the present invention, where the ball is in a raised position;

[0051] **FIG. 7***b* is a side sectional view of the ball valve of **FIG. 7***a* where the ball is in a lowered or closed position;

[0052] **FIG. 7***c* is a cross-sectional view of the ball valve of **FIG. 7***a* taken along line C-C of **FIG. 7***a;*

[0053] **FIG. 8** is a partial, sectional side view of an accumulator having heat exchange coils, in accordance with another embodiment of the present invention.

DETAILED DESCRIPTION

[0054] A sectional side view of an accumulator **20** is shown in **FIG. 1***a*. The accumulator has a body **22** and a cap **24**.

[0055] The body **22** is generally cylindrical, with an open top end, and a closed bottom end or floor **26**. The bottom end **26**, in this embodiment, is sloped inwards, with a depression or sump around and near the center. The volume within the accumulator **20** may be referred to as a reservoir **30**.

[0056] The cap **24** is formed to fit securely over the top end of the body **22**. The cap **24** has in inlet hole (or inlet port or inlet opening) **32** and an outlet hole (or outlet port or outlet opening) **34** formed therein. An inlet line **36** is secured to the inlet hole **32**. The cap **24** is formed of a suitable material, such as aluminum, for example.

[0057] The cap **24** is secured to the body **22** by welding, swaging, heat or ultrasonic staking, gluing or some other suitable technique.

[0058] A deflector **40** is secured to (or in communication with) the outlet port **34**. The deflector **40** has an exterior deflecting surface **42**. As shown in the views of **FIGS. 1***a*, **1***b* and **1***c*, the deflector **40** in this embodiment is of a generally inverted funnel shape, having an open interior **44**, with a relatively narrow portion or restriction **46** and a portion of greater diameter **50**. The open interior **44** may also be referred to as a conduit, an outlet conduit, an outlet conduit means or an outlet tube. The deflector **40** is formed of a suitable material such as polyamide or polypropylene plastic.

[0059] The deflector **40** is secured to or in communication with the outlet port **34** through one of any number of techniques known to those skilled in the art, such as a snap detail, as shown in the magnified views of **FIGS. 1***c* and **1***d*. In this embodiment, one or more beads **52** protrude from the exterior of the deflector **40**, near an upper end of the deflector **40**. There are one or more corresponding indentations formed within the outlet port **34** to securely accommodate the one or more beads **52**. Alternatively, the one or more beads could extend from the outlet port (not shown) and fit within corresponding indentations within the exterior of the deflector (not shown).

[0060] Different embodiments for securing the deflector **40** to the outlet port **34** include ultrasonic staking (using ultrasonic sound to locally melt and push plastic into grooves or other features machined into an aluminum port), swaging (deforming outwards) a metal (or plastic) deflector into the outlet port **34**, which typically has grooves for better grip, swaging a short aluminum tube insert inside the outlet tube **44** to hold plastic more firmly against the outlet port **34**, and heat staking (deforming plastic to lock it into position). **FIG. 1***e* shows a plastic deflector **40** ultrasonically staked to the outlet port **34**. **FIG. 1***f* shows a swaged aluminum tube insert **55** used in conjunction with the snap detail (for ease of fixturing during swaging). **FIG. 1***g* shows a deflector **40** staked into the outlet port **34**, a procedure that could be performed mechanically on a metal deflector or with heat on a plastic deflector. For the staking technique, it is necessary to have a bead or stop formed on the underside of the deflector to lock it in place with the top **1***e* staked downwards to form the outward projections that complete the lock.

[0061] The inlet line **36** and an outlet line (not shown) are secured to the inlet hole **32** and the outlet port **34**, respectively.

[0062] A passageway **54** is formed within a wall of the deflector **40** adjacent the restriction **46**, extending from the restriction **46** of the deflector **40** to the exterior of the deflector **40**. A tube (hereinafter referred to as a "pickup" tube) **60** is secured to or in communication with the passageway **54**. The pickup tube **60** extends outside the deflector **40** and down the reservoir **30** near the floor **26** of the accumulator **20**. The pickup tube **60** may be secured directly to the passageway **54** or may be secured in communication with the passageway **54** otherwise, such as, for example, through a port **62** shown in **FIGS. 1***b* and **1***c*.

[0063] The restriction **46** is that portion of the outlet tube **44** where the cross section is reduced. For ease of reference, the portion of restriction **46** having a minimum cross-sectional area may be referred to as a throat **63**. The cross-sectional area of the restriction **46** may increase downstream from the throat **63**. For instance, in **FIG. 1***f*, the diameter of the restriction **46** reduces smoothly to a minimum at the throat **63** and then increases again.

[0064] For maximum suction, the pickup tube may be connected (directly or indirectly) to the restriction **46** at the throat **63**.

[0065] In **FIG. 3***a* and **FIG. 3***b*, the entire outlet tube **44** functions as a restriction **46** and there is no separate throat **63** since no one point has a minimum cross-section. In **FIGS. 3***a* and **3***b*, the pressure will be reduced in the entire outlet tube **44** because the gas velocity in the outlet tube **44** is higher than in the reservoir, creating the required lower pressure in the outlet tube **44** to pull liquid up the pickup tube **60**. However, because the outlet tube **44** in **FIGS. 3***a* and **3***b* is not tapered, there may be undesirable turbulence and pressure drop. Accordingly, the outlet tube **44** in the embodiment of **FIG. 3***a* could be modified to include a tapered restriction (not shown). The cross-sectional area of throat **63** of the restriction **46** may be determined according to the parameters discussed below. However, it is first helpful to discuss the operation of the accumulator **20**.

[0066] In operation, fluid (not shown), namely refrigerant mixed with oil, enters the accumulator **20** through the inlet line **36**. The fluid encounters the deflecting surface **42** of the deflector **40**, and is therefore directed down and towards the perimeter of the accumulator **20**. Gaseous refrigerant flows into the open interior **44** of the deflector **40** and then flows up the open interior **44** and out the outlet port **34**.

[0067] Liquid refrigerant and oil flow to the floor **26** of the accumulator **20**. In cases where the oil is denser than the liquid refrigerant, the oil will settle on the floor **26** of the accumulator **20** below the liquid refrigerant. Advantageously, the end of the pickup tube **60** extends below the liquid refrigerant (assuming the oil is denser than the liquid refrigerant) and into the oil.

[0068] Gaseous refrigerant flowing up the interior **44** of the deflector **40**, past the restriction **46**, causes a pressure reduction, thereby drawing oil up the pickup tube **60**, and into the throat **63**, where the oil becomes entrained with the gaseous refrigerant and therefore flows out the accumulator **20** with the gaseous refrigerant.

[0069] The size of the restriction **46** is determined empirically and/or through a calculation as discussed below.

[0070] The restriction **46** is similar to a venturi, which is used to entrain fluids into other fluids.

[0071] The size of the throat **63** is determined so that the pressure at that point (which, advantageously, is the location in the restriction **46** where the pickup tube **60** connects) is low enough to draw the liquid up out of the reservoir **30**. The main principle is the Bernoulli principle, and it is the same principle that causes lift on an airplane wing: faster flowing fluid exerts less pressure. For the airplane wing, air moves faster to get around the curved surface of the top of the wing compared to the flatter lower surface, so the air on top exerts less pressure than the air on the bottom (ergo lift).

[0072] In accordance with an aspect of the present invention, the gas at the throat **63** must move faster to get the same amount of fluid through because the cross-sectional area for flow is reduced. Therefore, the pressure at the throat **63** is reduced and this reduced pressure can be used to suck liquid out of the reservoir **30**. If friction and other losses are ignored, the calculation may be described as follows. The pressure reduction at the throat **63** of the restriction **46** is calculated by Bernoulli's equation:

$$\Delta P = P_{tube} - P_{throat} = \frac{1}{2}\rho_{gas}(v_{tube}^2 - v_{throat}^2)$$

[**0073**] where v_{tube} is the velocity of the gas in the portion of the outlet tube of greater diameter **50** and V_{throat} is the velocity of the gas at the throat **63** where the pickup tube **60** enters. The velocity of the gas is related to the diameter of a tube by the mass flow rate, ṁ:

$$\dot{m} = \frac{\pi}{4}\rho_{gas} \cdot v_{gas} \cdot d^2$$

[**0074**] The difference in pressure (ΔP) required to lift the liquid is the density of the liquid (ρ_{liquid}) times gravity (g) times the height of the lift (h):

$$\Delta P = \rho_{liquid} \cdot g \cdot h$$

[**0075**] By equating the two pressure drops it is possible to solve for the diameter of the throat **63**. So to calculate the diameter of the throat **63** the following factors are considered:

[**0076**] $d_{outlet\ tube}$=diameter of the portion of the outlet tube of greater diameter **50**.

[**0077**] ṁ=mass flow rate of refrigerant.

[**0078**] $h = h_{reservoir} - h_{liquid}$ where

[**0079**] $h_{reservoir}$=the height of the reservoir section of the accumulator (measured from the floor to where the pickup tube joins the throat), and

[**0080**] h_{liquid}=the height of the liquid in the reservoir

[**0081**] ρ_{gas}=the density of the gas in the accumulator

[**0082**] ρ_{liquid}=the density of the liquid in the accumulator

[**0083**] Unfortunately the calculated diameter is only a good starting approximation. Several "secondary" factors have, so far, been neglected in the calculation. For instance, the pressure difference required to lift the liquid up the pickup tube **60** is not exactly the same as the pressure difference between the throat pressure and the pressure in the portion of the outlet tube of greater diameter **50**. Actually it is the difference between the pressure inside the accumulator **20** and the pressure at the throat **63**. There will be some pressure drop caused by the gas in the accumulator **20** squeezing into the outlet tube **44**, so the pressure in the portion of the outlet tube of greater diameter **50** will be less than the pressure in the accumulator interior. To help reduce these pressure losses, changes in cross-sectional area along the path followed by the gas may advantageously be made gradually, with smooth transitions rather than sharp edges. It may also be advantageous to have a flare on the entrance to the outlet tube **44**, such as, for example, like the end of a trumpet, as shown at the entrance to the outlet tube **44** in **FIG. 1***c*.

[**0084**] The pressure loss due to an expansion or contraction in a tube is governed by an equation of the form:

$$\Delta P = C \cdot \frac{\rho}{2} \cdot v^2$$

[**0085**] where ρ is the density of the fluid, v is the velocity of the fluid in the portion of the outlet tube greater diameter **50**, and Cis a "loss coefficient". Loss coefficients may be calculated by various correlation equations and relations, but it is typically more accurate to measure them. A neglected secondary factor here is the loss coefficient for the entry of gas into the outlet tube **44**. Advantageously, as discussed above, the entrance to the outlet tube **46** may be flared.

[**0086**] Not all of the pressure across the pickup tube **60** will be applied to lifting the liquid. Some of the pressure will be consumed in frictional losses through a filter **64** on the end of the pickup tube **60** (if there is one, such as that shown in **FIG. 2***a* discussed below) and frictional losses incurred moving the liquid up the pickup tube **60**. The pressure loss related to the filter **64** is another relation like the one used at the entrance to the outlet tube **44**, but now the density is of the liquid and the velocity is of the liquid moving up the pickup tube **60** of diameter D. Putting the relation in terms of the mass flow of liquid instead of the pressure drop results in the following equation:

$$\Delta P_{filter} = C_{filter}\frac{8 \cdot \dot{m}_{liquid\ up\ tube}^2}{\pi^2 \cdot \rho_{liquid} \cdot D_{pickup\ tube}^4}$$

[**0087**] Other secondary factors to consider include the loss coefficient of the filter **64**, the diameter of the pickup tube **60**, and the flow rate of the liquid. The liquid is typically a mixture of refrigerant and oil, so the flow of liquid is related to the percentage of oil in circulation.

[**0088**] The pressure loss required to overcome friction when moving fluid through a pipe (or tube) of length L and diameter D is governed by:

$$\Delta P_{flow} = f\frac{L}{D} \cdot \frac{\rho}{2} \cdot v^2$$

[**0089**] where f is the "friction factor". Over quite a wide range of flow conditions, the friction factor is described quite well by the Blasius equation:

$$f = 0.3164 \cdot Re^{-1/4}$$

[**0090**] where Re is the "Reynold's number" of the flow, given by:

$$\mathrm{Re} = \rho \cdot \frac{v}{\mu} \cdot D$$

[**0091**] The following secondary factors that affect the calculation of the diameter of the restriction have been considered:

[0092] C_{flare}=Loss coefficient of the entrance to the outlet tube, which may be flared.

[0093] C_{filter}=Loss coefficient of the filter (if any) on the pickup tube.

[0094] $\dot{m}_{liquid\ up\ tube}$=Mass flow of liquid up the pickup tube, which is related to:

[0095] % OIC=Percentage of oil in circulation in the A/C system.

[0096] $D_{pickup\ tube}$=The diameter (or cross-sectional area) of the pickup tube.

[0097] $L_{pickup\ tube}$=The length of the pickup tube.

[0098] f=The friction factor of the flow up the pickup tube, which is related to:

$$\mathrm{Re} = \rho \cdot \frac{v}{\mu} \cdot D$$

[0099] =The Reynold's number of the flow up the pickup tube, which involves the density ρ of the liquid and the diameter D of the pickup tube, which have already been mentioned as factors, and to the velocity v of the liquid up the pickup tube, which is proportional to the mass flow rate of liquid up the tube and is related to the % OIC, as above, and also to:

[0100] μ=The viscosity of the liquid

[0101] Accordingly, there are several factors involved in sizing the throat diameter. All of these can be calculated. It may also be effective to calculate once to get a good starting range, and then make prototypes and test experimentally to optimise.

[0102] Embodiments of the present invention provide improved control of the oil entrainment while allowing minimized (or less) overall pressure drop without harming the oil pickup function. The pressure drop across the present accumulator **20** is given by the sum of pressure drops due to expansion into the accumulator **20**, dissipation of energy (to separate the liquid and prevent liquid carry over), the gas squeezing into the outlet tube **46** (using the flare) and contracting and expanding through the restriction **56**. (The Bernoulli principle predicts that the pressure will return to the same pressure as it had upstream before the restriction **46**, but in practice there is always some pressure drop across the restriction **46**.) The pressure drop across the accumulator **20** may be represented as follows:

$$\Delta P_{accumulator} = C_{expansion} \cdot \frac{\rho}{2} \cdot v^2 + C_{dissiption} \cdot \frac{\rho}{2} \cdot v^2 + C_{flare} \cdot \frac{\rho}{2} \cdot v^2 + C_{restriction} \cdot \frac{\rho}{2} \cdot v^2$$

[0103] This equation would appear to represent the smallest value of ΔP for a functional accumulator **20**, which, it will be noted, does not have terms that are required to ensure oil pick up.

[0104] Commonly used accumulators may be referred to as "dome deflector" (U.S. Pat. No. 4,474,035), "dixie cup deflector" (U.S. Pat. No. 4,111,005), or "trumpet tube" (U.S. Pat. No. 5,179,844) (no deflector) types (not shown). These all share the same form of expression for the pressure drop, although the magnitude of the terms will vary depending on the details of construction:

$$\Delta P_{dome} = C_{expansion} \cdot \frac{\rho}{2} \cdot v^2 + C_{dissiption} \cdot \frac{\rho}{2} \cdot v^2 + C_{contraction} \cdot \frac{\rho}{2} \cdot v^2 + f_{j\text{-}tube} \frac{L_{j\text{-}tube}}{D_{j\text{-}tube}} \cdot \frac{\rho}{2} \cdot v^2 + C_{restriction} \cdot \frac{\rho}{2} \cdot v^2$$

[0105] Here the friction of the j-tube is included as well as a term due to the restriction caused by punching the oil pickup hole in the j-tube. The word "contraction" is used instead of "flare" in the third term because many of these accumulators do not use a flare at the entrance to the j-tube, but it is understood to mean "flare" if one is present.

[0106] All these other types of accumulators noted in the preceding paragraph (but not shown) generate a pressure drop across an oil pick-up hole to pump liquid into a gas stream. That pressure drop is the sum of the pressure due to the column of liquid in the reservoir above the pick-up hole, plus the pressure drops caused by contraction plus the friction in the portion of the j-tube (or liner, in a liner-type accumulator) between the reservoir and oil pick-up point. For the common types this would be:

$$\Delta P_{oil\ pickup} = \rho_{liquid} g h_{liquid} + C_{contraction} \cdot \frac{\rho}{2} \cdot v^2 + \frac{1}{2} f_{j\text{-}tube} \frac{L_{j\text{-}tube}}{D_{j\text{-}tube}} \cdot \frac{\rho}{2} \cdot v^2 + C_{restriction} \cdot \frac{\rho}{2} \cdot v^2$$

[0107] It may be that the term due to the column of liquid is not too important. A test was conducted with plastic blocks inside an accumulator to displace the liquid refrigerant and create a higher column of liquid. The system performance for this test was the same (or similar) as a test without the blocks, which suggested that the liquid exiting the accumulator was the same at identical charge levels, regardless of the liquid height. Since the column of liquid is likely not as significant as the other terms, the other terms are likely more important to ensure oil pick-up. Those other terms are also included in the expression for pressure drop across the accumulator, so the pressure drop across the accumulator cannot be eliminated or made as small as might otherwise be desired without harming the oil pick up function. In contrast, the expression for oil pick up for certain embodiments of the present invention is:

$$\Delta P_{oil\ pickup} = C_{flare} \cdot \frac{\rho}{2} \cdot v^2 + \frac{1}{2} \rho_{gas} (v_{tube}^2 - v_{throat}^2)$$

[0108] This expression relies upon the velocity difference within the outlet tube **44** and the throat **63** of the restriction **46**. This difference does not appear in the expression for pressure drop across this accumulator. Hence with embodiments of the present invention, pressure drop across an accumulator can be minimized or reduced without compromising the oil pick up function. Although the restriction **46** in embodiments of the present invention actually does add some pressure drop (as discussed above), the situation is improved from other accumulators. Therefore, embodiments of the present invention provide an improved accumulator having the minimum or reduced pressure drop and good oil pick up.

[**0109**] In the embodiment described above, the pickup tube **60** is described as being separate from the deflector **40**. In another embodiment (not shown), the pickup tube **60** could be integral with the deflector **40** or the outlet tube **44**.

[**0110**] In the embodiment shown in **FIG.** **1***a*, a pickup tube **60** is secured in communication with the restriction **46**.

[**0111**] **FIGS.** **2***a* and **2***b* show a different embodiment. In this embodiment, the floor **26** of the accumulator **20** is essentially flat as shown. However, a sump or depression could be provided within the floor **26** (such as that shown in **FIG.** **1***a*, for example), if desired. A filter **64** is attached to a lower end of the pickup tube **60** to help prevent fouling or blockage of the pickup tube **60** or downstream by detritus that might otherwise flow from the reservoir **30** up the pickup tube **60**.

[**0112**] In this embodiment, the pickup tube **60** is relatively straight, and is secured to the inside of the deflector **40**, unlike in the embodiment of **FIG.** **1***a*, for example. A passageway **54** extends from the throat **63** through, or part-way through the wall or boundary of the deflector **40**. One end of the pickup tube **60** is secured to (or in communication with) the passageway **54**, as shown in the magnified view of **FIG.** **2***b*. The pickup tube **60** may be formed integrally with the passageway **54**, for example, or welded or otherwise secured in communication with the passageway **54**.

[**0113**] Top and side surfaces of the accumulator body **22** may be formed by welding or otherwise joining separate pieces, or by forming as one piece, for instance by impact-extruding. The floor **26** of the accumulator **20** may be formed by spin-closing, to create a hermetic body. The accumulator body **22** may also be formed, for example, by welding and/or forming.

[**0114**] In the embodiments shown in **FIGS.** **1***a* and **2***a*, the pickup tube **60** is secured in communication with the passageway **54**. However, according to another embodiment (not shown), the pickup tube **60** extends inside the outlet tube **44**. In this embodiment, there is no passageway **54**. For example, the pickup tube **60** may extend up the outlet tube **44** so that one end of the pickup tube **60** terminates at the restriction **46**. For maximizing or improving suction, with minimum or reduced turbulence, it may be advantageous to secure one end of the pickup tube **60** so that its opening is at approximately 90° to the flow of gaseous refrigerant through the restriction **46**.

[**0115**] Various different configurations of inlet and outlet positions may be used, as required by the geometry of the surrounding components. **FIGS. 1 and 2** show top-in, top-out configurations.

[**0116**] **FIG.** **3***a* shows an embodiment with a top-in, side-out configuration. **FIG.** **3***b* shows a magnified view around the outlet port **34**. In this embodiment, fluid enters the accumulator **20** through an inlet port **32**. The fluid is deflected by the deflecting surface **42** of the deflector **40** towards the sides of the accumulator **20** and then flows downward. Gaseous refrigerant flows up the interior of the deflector **40**, and then out the outlet port **34**. Oil and liquid refrigerant flow to the floor **26** of the accumulator **20**. Oil (and perhaps some liquid refrigerant) then flows through the filter **64** at the bottom of the pickup tube **60** and up the pickup tube **60**, and then into the restriction **46**, where it is entrained within the gaseous refrigerant.

[**0117**] **FIG.** **4***a* shows an embodiment with a side-in, side-out configuration. **FIG.** **4***b* is a magnified view of the circled portion of **FIG.** **4***a*. In this embodiment, fluid flows into the side of the accumulator **20** through an inlet port. Typically, the velocity of the fluid through the inlet port **36** is such that all the fluid will impinge on the deflecting surface **42** of the deflector. The deflecting surface **42** should advantageously be shaped to ensure (or reduce the likelihood) that fluid will not be deflected directly into the outlet tube. Gaseous refrigerant flows into the interior of the deflector, through the openings created between support arms **66**, as perhaps best seen in the perspective view of **FIG.** **4***c*. The gaseous refrigerant then flows out of the accumulator **20** through the outlet port. Oil and liquid refrigerant will flow to the floor **26** of the accumulator **20**, where the oil (and perhaps some liquid refrigerant) will be drawn up the outlet tube **60** and then out through the outlet port **34**. The outlet tube **46** in **FIG.** **4***b* could be modified to have a flared entrance (not shown) and/or a more tapered restriction (not shown).

[**0118**] **FIG.** **5** shows an embodiment with a top-in, bottom-out configuration. In this embodiment, fluid flows into the accumulator **20** through the inlet port **32**. Fluid is deflected toward the inside surfaces of the accumulator **20** by the deflecting surface **42** of the deflector **40**. Fluid then flows down. Gaseous refrigerant flows into the interior of the deflector **40**, through the openings created between support arms **66**. The gaseous refrigerant then flows out of the accumulator **20** through outlet tube **70**. Oil and liquid refrigerant flow to the floor **26** of the accumulator **20**, where oil (and perhaps some liquid refrigerant) is drawn up pickup tube **60** and then out through the outlet tube **70**.

[**0119**] The outlet tube **70** in **FIG.** **5** could be modified to have a flared entrance (not shown) and/or a tapered (or more tapered) restriction (not shown).

[**0120**] **FIGS.** **6***a* and **6***b* show an embodiment with a side-in, bottom-out configuration. In this embodiment, fluid enters accumulator **20** through inlet port **32**. Some fluid (without much velocity) may flow down, inside the accumulator **20**. However, typically most will deflect against the deflecting surface **42** of deflector **40**. As noted above, advantageously, the defecting surface **42** will be shaped to ensure (or reduce the likelihood) that fluid will not be deflected directly into the outlet tube **70**. Gaseous refrigerant will flow into and down the outlet tube **70**, and then exit the accumulator **20**. Oil and liquid refrigerant will flow to the floor **26** of the accumulator **20**, where suction will draw oil (and perhaps some liquid refrigerant) up the pickup tube **60** and then into and down the outlet tube **70**.

[**0121**] Under certain conditions of rapid cycling, for instance due to a low amount of charge in the air conditioning system, the pickup tube **60** may not deliver sufficient oil to prevent the compressor (not shown) from overheating. When the compressor is first turned on, there is a short time when no oil is entrained with the gaseous refrigerant exiting the accumulator **20**, namely when oil is being drawn up to fill the pickup tube **60**. If that time is a significantly large fraction of the cycle time, the amount of oil flowing to the compressor may be significantly reduced. This potentially harmful situation can be remedied by maintaining liquid in the pickup tube **60**. One such technique or means to trap liquid in the pickup tube **60**, according to an embodiment of the present invention, involves the use a check valve (or "ball valve") **72** in (or in communication with) the pickup tube **60**, for instance as shown in **FIGS.** 7*a*-7*c*.

[**0122**] **FIG.** 7*a* depicts the check valve **72** when fluid is flowing up through the pickup tube **60**. The upward flow of fluid causes a ball **74** to move upward against a ball barrier **76**. A cross-sectional view of the ball barrier **76** is shown in **FIG.** 7*c*. In this position, fluid flows around the ball **74** and continues up through openings **80** in the ball barrier **76**.

[**0123**] When the flow of fluid stops (or is sufficiently reduced), the ball **74** is pulled by gravity (and/or pushed by the weight of fluid above it) to a narrowed section **82** of the valve **72**, where the diameter of the narrowed section **82** is less than the diameter of the ball **74**. The ball **74** fits snugly, and preferably sealingly, within the narrowed section **82** of the valve **72**, thereby preventing fluid above the ball **74** from flowing down below the ball **74**.

[**0124**] Another embodiment (not shown) includes a desiccant. The desiccant may be placed in the reservoir of the accumulator in a location through which all liquid refrigerant must pass. The desiccant could be housed in a canister, a fabric bag, or any other appropriate container. The desiccant and/or its container could be combined with a filter.

[**0125**] If the oil is less dense than the refrigerant, it is problematic to extract the oil when the volume of refrigerant changes in the reservoir. The problem is particularly acute if the oil is more dense than the refrigerant at high temperatures but less dense at low temperatures, such that the location of the oil switches from under to over the refrigerant when operating conditions change. One or more pickup tubes can be employed to resolve this problem by utilizing multiple tubes at various heights in the reservoir. An example is shown in **FIG.** 2*c*, which shows an alternate embodiment of the pickup tube **60** of **FIG.** 2*a*. In **FIG.** 2*c*, pickup tube **60'** has two offshoot pickup tubes **60"**, each of which has a filter **64** on a lower end. Each of the offshoot pickup tubes **60"** is positioned at a different height above the floor **26**. Similarly, another embodiment may include a single pickup tube having two or more openings at different heights (not shown).

[**0126**] An embodiment of the present invention, such as that shown in **FIG. 1** can provide a large reservoir for incorporating features in an accumulator, such as heat-exchange coils. **FIG. 8** shows an example where two coils **90**, **92** have been inserted in the reservoir section of the accumulator of **FIG. 1**, especially to enable engine coolant to provide heat exchange with the refrigerant in heat pump mode. In this example, fluid flows in and up the coils **90**, **92** from coil flow inlet **94** and flows out the accumulator **20** through coil flow outlet **96**. As discussed above, these coils **90**, **92** could be replaced with an electric heating element for heat pump function. If, instead, warm refrigerant from the condenser was routed through the coils in air conditioning mode then heat exchange with the cold refrigerant in the accumulator would provide the "internal heat exchange" function for enhanced air conditioning effect. However the internal heat exchange would probably be too large, and baffles may be required to limit the exposure of reservoir fluid to the coils.

[**0127**] Numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practised otherwise than as specifically described herein. The present invention allows for significant changes in shapes, sizes, dimensions, materials, and aspects as required by the overall air-conditioning and/or heating system. The external structure such as the tubes and fittings can be modified without departing from the invention as disclosed herein, as can adding brackets, insulation, service ports, inlets from auxiliary evaporators, etc.

[**0128**] As an example, all of the embodiments described above incorporate a deflector. While the accumulator **20** should have a means to help ensure that liquid does not flow directly from the inlet opening **32** to the outlet opening **34**, that means need not be a deflector, per se. In other words, provided that an accumulator can be designed so that liquid refrigerant is substantially prevented from flowing from the inlet port **32** directly to the outlet port **34**, it may be possible to avoid the use of a deflector. In such a case, the accumulator will have a particular geometry or other means (such as the shape of the accumulator combined with the location of the inlet port **32** with respect to the outlet port **34**) to help ensure that liquid does not flow directly from the inlet port **32** to the outlet port **34** (or outlet tube **44**).

[**0129**] The outlet tube **44** as described above may be cylindrical or tubular. The outlet tube **44** could also be any other shape that allows fluid to flow through. The outlet tube **44** could comprise one or more parts. For example, the portion of the outlet tube **44** containing the restriction **46** need not be integral with the portion of greater diameter **50**.

[**0130**] It should also be noted that the pickup tube **60** need not be a tube, per se. It need only be a passage (not shown) adapted to extend from liquid in the reservoir **30** of the accumulator **20** and be in communication with the restriction **46**. Such a passage may be referred to as a pickup conduit means.

[**0131**] While the above description refers to a single inlet port **32** and a single outlet port **34**, alternate embodiments could incorporate one or more inlet ports and one or more outlet ports (not shown).

1. An accumulator comprising

an inlet opening,

an outlet opening,

a deflector to help ensure that liquid does not flow directly from the inlet opening to the outlet opening,

a conduit inside the accumulator in communication with the outlet opening, the conduit comprising a conduit wall surrounding an open interior, the open interior having a first portion and a second portion, the second portion having a cross-sectional area less than a cross-sectional area of the first portion and the second portion being closer to the outlet opening than the first portion,

a pickup tube having a first end and a second end, the second end being in communication with the second portion of the open interior.

2. The accumulator of claim 1 wherein the first end of the pickup tube is adapted to extend into liquid accumulated within the accumulator.

3. The accumulator of claim 2 wherein the conduit wall has a passageway formed therein extending from the second portion of the open interior through at least part of the conduit wall and the second end of the pickup tube being secured in communication with the second portion of the open interior via the passageway.

4. The accumulator of claim 2 wherein the conduit forms part of the deflector.

5. The accumulator of claim 2 wherein the conduit comprises one or more parts.

6. The accumulator of claim 3 wherein the passageway extends from the open interior of the conduit to an exterior of the conduit wall.

7. The accumulator of claim 4 wherein the deflector is secured to the outlet opening.

8. The accumulator of claim 2 wherein the inlet opening and the outlet opening are both located in a top of the accumulator.

9. The accumulator of claim 2 wherein the inlet opening is located in a top of the accumulator and the outlet opening is located in a side of the accumulator.

10. The accumulator of claim 2 wherein the inlet opening and the outlet opening are both located in one or more sides of the accumulator.

11. The accumulator of claim 2 wherein the pickup tube comprises a means to trap liquid in the pickup tube if suction within the pickup tube is stopped or if suction is insufficient to draw liquid up the pickup tube.

12. The accumulator of claim 11 wherein the means to trap liquid comprises a ball valve.

13. The accumulator of claim 2 wherein the pickup tube comprises a filter located at a lower end of the pickup tube.

14. The accumulator of claim 2 wherein the pickup tube has several openings at different heights above the floor of the accumulator.

15. The accumulator of claim 2 further comprising heat exchanger coils.

16. The accumulator of claim 2 wherein the open interior tapers smoothly from the first portion to the second portion.

17. The accumulator of claim 2 wherein an entrance to the open interior of the first portion is gently flared.

18. An accumulator comprising

an inlet opening,

an outlet opening,

a means to help ensure that liquid does not flow directly from the inlet opening to the outlet opening,

an outlet conduit means inside the accumulator in communication with the outlet opening, the outlet conduit means comprising an open interior, the open interior having a first portion and a second portion, the second portion having a cross-sectional area less than a cross-sectional area of the first portion and the second portion being closer to the outlet opening than the first portion,

a pickup conduit means in communication with the second portion of the open interior.

19. The accumulator of claim 18 wherein one end of the pickup conduit means is adapted to extend into liquid accumulated within the accumulator.

20. The accumulator of claim 18 wherein the means to help ensure that liquid does not flow directly from the inlet opening to the outlet opening is a deflector.

21. The accumulator of claim 2 further comprising one of engine coolant coils and electric heating coils.

22. The accumulator of claim 21 for use as an evaporator.

* * * * *