United States Patent [19]

Wreen, Jr. et al.

[11] **3,754,409**

[45] **Aug. 28, 1973**

[54] **LIQUID TRAPPING SUCTION ACCUMULATOR**

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[22] Filed: **Mar. 6, 1972**

[21] Appl. No.: **232,110**

[52] **U.S. Cl.** **62/503**

[51] **Int. Cl.** **F25b 43/00**

[58] **Field of Search** 62/503

[56] **References Cited**

UNITED STATES PATENTS

3,643,465 2/1972 Bottum 62/503

3,483,714 12/1969 Krause 62/503

Primary Examiner—Meyer Perlin

Attorney—David H. Semmes

[57] **ABSTRACT**

A liquid trapping suction accumulator of the type used intermediate the compressor and evaporator in a vapor-compression refrigeration system as a protective device for the compressor. The device provides for minimal pressure drop in the system while still performing the function of compressor protection, and provides for safe removal of accumulated oil and/or liquid refrigerant from the accumulator chamber.

5 Claims, 5 Drawing Figures

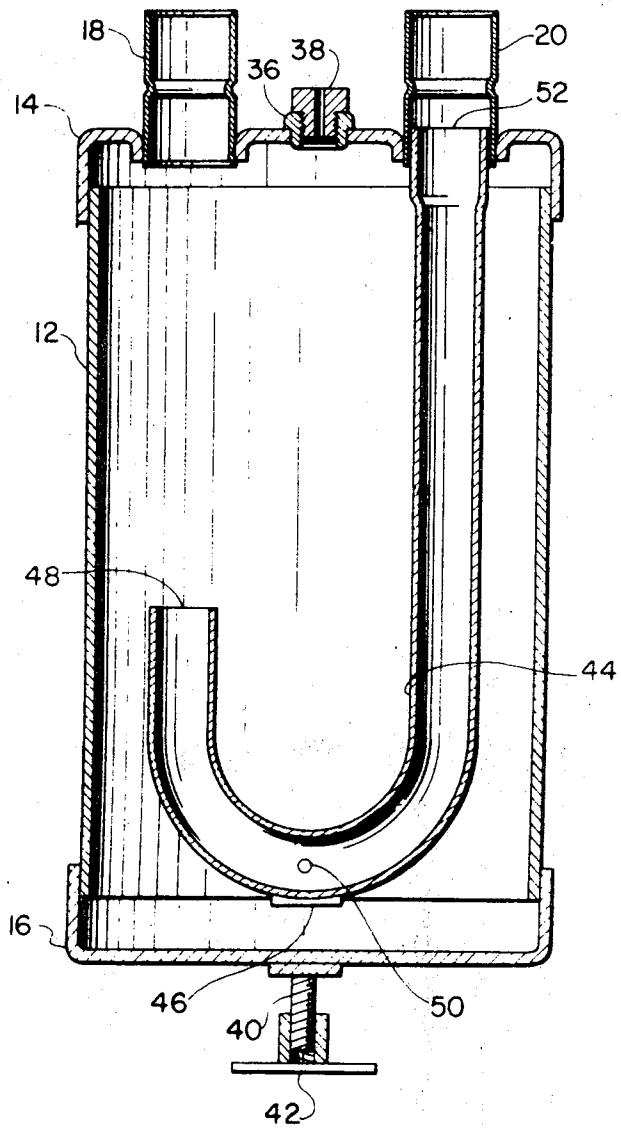


FIG. 1

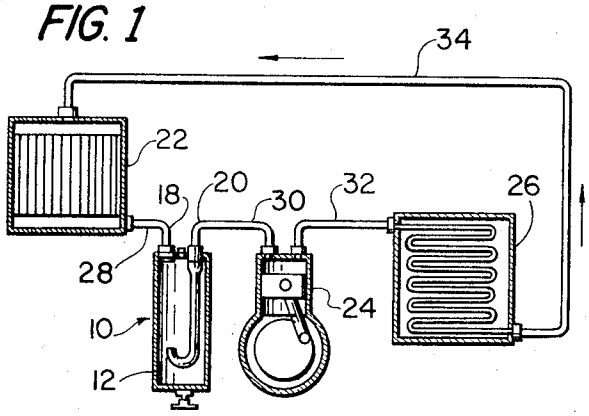


FIG. 2

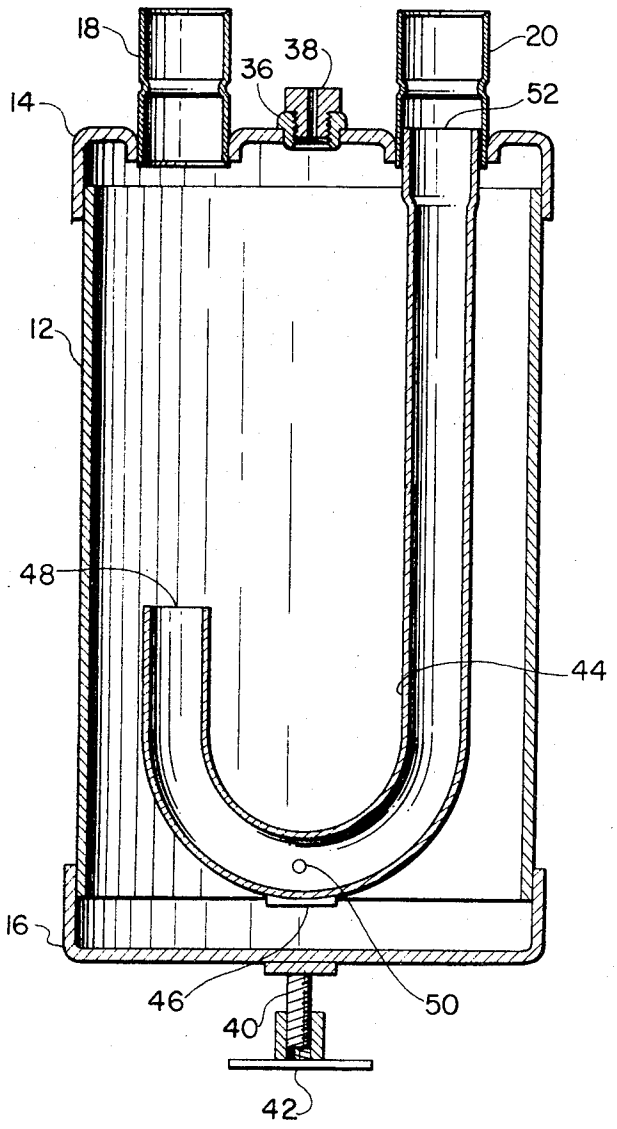


FIG. 3

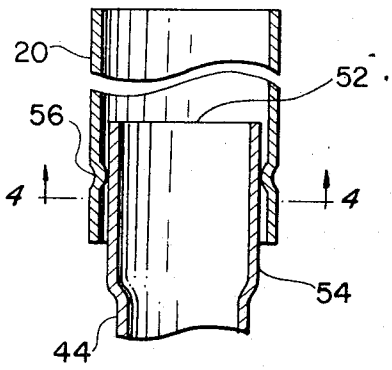
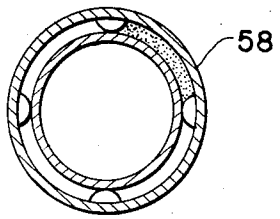


FIG. 4



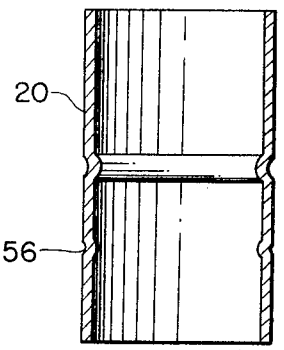


FIG. 5

LIQUID TRAPPING SUCTION ACCUMULATOR

BACKGROUND OF THE INVENTION

A suction accumulator is an enclosed chamber, located between the evaporator and the compressor in a vapor-compression refrigeration system, used as a protective device for the compressor. However, quite often liquid refrigerant and oil is entrained in the return gas, and the presence of large enough quantities of such returning to the compressor could result in severe damage to this vital system component. Also, after such conditions as defrost or long-duration shutdown, condensed liquid refrigerant can often suddenly surge towards the compressor on startup. Large volumes of liquid refrigerant or oil, if introduced into the compression chamber of positive displacement type compressors, due to its relative incompressibility, can result in so-called compressor "slugging" which can lead to severe damage to reeds or valves, pistons, and connecting rods. If the liquid is primarily condensed refrigerant, dilution of the lubricating oil can result, due to the high solubility of oil in the liquid refrigerant, which can severely reduce the lubrication of the bearings and moving surfaces and also cause compressor failure. Suction accumulators have been designed to prevent, or at least minimize, compressor failures such as these.

Previous accumulator designs have provided for elaborate means of baffling or directing the inlet gas/-liquid flow away from the outlet gas flow stream in order to prevent the liquid that is entrapped in the gas stream from proceeding directly downstream to the compressor with the return gas. This has resulted in accumulator designs that had an inherent low efficiency with respect to the pressure drop across the device. Since pressure drop across any component in the suction line of a refrigeration system has such an adverse effect on the total system capacity, the total pressure loss must be minimized.

SUMMARY OF THE INVENTION

The present invention discloses a liquid trapping suction accumulator for disposition in a compression refrigeration system intermediate the compressor and evaporator and which functions as a protective device for the compressor. The arrangement of parts is such that there is a minimal pressure drop in the system while still insuring compressor protection. The invention also provides for safe removal of accumulated oil and/or liquid refrigerant from the accumulator chamber which otherwise could cause compressor failure. An additional function of the invention is that the compressor oil that circulates with the refrigerant is returned on a metered basis and compressor "slugging" is substantially eliminated.

Additional objects and advantages of the invention will be more readily apparent from the following detailed description of an embodiment thereof when taken together with the accompanying drawings in which:

FIG. 1 is a schematic view of a liquid refrigeration system;

FIG. 2 is an enlarged vertical sectional view of the liquid trapping suction accumulator of the invention;

FIG. 3 is a fragmentary enlarged sectional view showing joinder of a J-tube outlet used in the invention with an outlet connector from the accumulator;

FIG. 4 is a sectional view taken on line 4—4 of FIG. 3; and

FIG. 5 is an enlarged sectional view showing details of an outlet connector.

Referring now in more detail to the drawings, FIG. 1 schematically shows a liquid refrigeration system of a type incorporating the liquid trapping suction accumulator of the invention. The accumulator **10** includes a cylindrical housing **12** having a top closure **14** and a bottom closure **16.** An inlet generally designated **18** and an outlet generally designated **20** are provided for appropriate connection into the system shown in FIG. **1.** The system, as is usual in this type includes an evaporator **22** and a compressor **24** with the accumulator **10** being positioned intermediate therebetween. The system also includes condenser **26.** Inlet **18** is fed by conduit **28** extending from evaporator **22.** Conduit **30** extends between accumulator **10** and compressor **24** and conduit **32** extends between compressor **24** and condenser **26.** A further conduit **34** interconnects condenser **26** and evaporator **22.** Flow directions are indicated by arrows in FIG. **1.**

The new accumulator design, as shown in FIG. **2,** consists of the top closure **14** into which is incorporated inlet **18** and outlet **20** connections, and a mounting stud **36** for the insertion of an optional fusible plug device **38** for pressure release in the event of fire. The cylindrical housing **12** and bottom closure **16** make up the accumulator chamber. A threaded stud **40** for use with possible brackets and a removable thread protector **42** make up the external configuration of the accumulator. Internally there is a J-shaped tube **44** mounted by means of a bottom bracket **46** and located centrally within the outlet connector **20,** an important feature. Of equal importance is the alignment of the J-tube inlet **48** directly on center with the inlet connector **18.** Located near the lowest point on the J-tube is a small bleed hole **50** provided for controlling the return of small amounts of oil and/or liquid refrigerant. The alignment of the J-tube inlet with the inlet fitting provides minimal pressure drop while still performing the function of compressor protection.

Consider the action of this accumulator as refrigerant vapor carrying some liquid refrigerant and oil with it proceeds down the suction line and enters the accumulator through the inlet fitting **18.** As the gas suddenly enters the large inner chamber of the accumulator, it is allowed to expand rapdily. This immediately causes the gas and liquid to disperse across the entire cross section of the accumulator diameter, with some of the expanding liquid changing phase to the gaseous state. Observations of this phenomenon with completely flooded evaporator operation showed the gas and liquid "spraying" into accumulator much like a nearly closed garden hose nozzle. The relatively large separation distance between the accumulator inlet connector **18** and the J-tube inlet **48** allows the incoming gas and any liquid to spread over a much larger cross section; therefore, any entering liquid will occupy a far lesser portion of the cross-sectional area. Since the cross-sectional area of the accumulator chamber is much greater than that of the inlet cross section of the J-tube, an extremely small percentage of liquid refrigerant can impinge on this tube inlet and be returned to the compressor. It is possible that some droplets can go directly downward and be returned via the passage offered by the J-tube itself, but there can aways be a small per-

centage of liquid returning to a compressor, regardless of accumulator design. Total restriction of liquid feedback to a compressor is not possible with any accumulator known today, and indeed is not even desired since compressor equipment manufacturers have designed their equipment to handle modest amounts of returning liquid refrigerant often present.

Like the entering liquid, the gas itself also expands upon entering the accumulator chamber. However, since there is no baffling or misdirecting of the gas flow, the gas can quite easily proceed toward the J-tube inlet **48** where it must make a single directional change along the path of the J-tube conduit before exiting. Previous accumulator designs, with the elaborate baffling and often numerous directional changes necessary have resulted in high pressure drops due to the kinetic energy losses associated with the changing of direction of a fluid. The present design has minimized the kinetic energy loss of the returning refrigerant vapor and consequently has minimized the total pressure loss across the accumulator, which in turn has minimized the system capacity losses.

The invention also concerns itself with the safe removal of the accumulated oil and/or liquid refrigerant from the chamber. FIGS. **2** and **3** show the typical detail of the J-tube **44** with the liquid feedback port **50** and its outlet end **52** flared out at **54** to a controlled diameter. Also, as shown in FIGS. **3** and **4**, the outlet connector **20** is staked with **4** "dimples" **56, 4** are shown in this case, a minimum of three being necessary to centrally locate the J-tube outlet O.D. within the I.D. of the fitting. As can be seen, the diameter as given by the height of the dimples **56** creates an interference fit with the diameter of the J-tube outlet end **54** when the two are mated as in FIG. **3.** This method lends a rigid support to the upper end of the J-tube when mounted within the accumulator. Further, the cross-sectional areas between the O.D. of the tube **54** and the I.D. of the outlet connector **20** and between the dimples **56,** the region shown typically by stippling area **58,** permit a predetermined open area for exiting gas as will be explained later.

Once any liquid refrigerant or oil is "sprayed" into the accumulator chamber, the overwhelming majority of the droplets either impinge on the accumulator inner walls and run down the sides, or fall harmlessly to the bottom where the liquid is allowed to build up. If this situation were to continue over a period of time the liquid level would build up to a point just below the liquid feedback port **50.** Then, the returning vapor passing through the J-tube causes a low pressure area at the port, due to the relatively high velocity of the returning vapor inside, and liquid is drawn up and through the port and is carried back with the gas. The small opening of the port acts as a metering orifice to limit the flow of liquid into the J-tube and on to the compressor.

While this port can be designed to safely prevent excess liquid from entering the J-tube while the system is running, it cannot prevent the influx of oil and liquid refrigerant into the J-tube when the system is shut down and no vapor is flowing through the J-tube. If the liquid within the accumulator were to rise above the J-tube bend, then sufficient liquid could enter the tube via the port to completely fill the bottom of the J-tube. This situation happens quite often in practice and must be coped with. If the tube were the only means of exit of the gas returning to the compressor, then the full bottom portion of the tube would cause the slug of liquid trapped therein to be returned in one large volume, causing possible damage to the compressor.

Previous accumulator designs have incorporated small vent holes near the top of the oil return tubes to allow bypassing of the gas when the oil return tube was blocked off or sealed by the liquid level as explained above. The reason for this is that during a prolonged shutdown, during which time the refrigerant is susceptible to condensing and collecting in the accumulator chamber, pressure equalization occurs throughout the system, which causes the relatively high saturation pressure of the refrigerant to build up on the suction side, including within the accumulator. Immediately upon restart of the compressor the suction lines begin to be pumped down to a pressure considerably lower than before restart. With liquid entrapped within the oil return tube, the pressure upstream of the accumulator remains essentially the same (high) while downstream pressure becomes quite reduced. With no internally communicating vent hole between the inlet and outlet connections, the high pressure behind the liquid slug can force this fluid out in one large volume toward the compressor. A vent hole provides communication between the high pressure upstream side and the low pressure downstream piping and permits the high pressure gas to temporarily bypass the oil return tube until the upstream pressure is also reduced by the pumping action of the compressor. Some previous designs do not allow sufficient quantities of gas to vent under some conditions to equalize the upstream and downstream pressures. This results in a portion of the liquid within the tube being forced downstream in order to provide temporary escape for more of the high pressure gas.

The method of attaching the J-tube to the outlet connector, as shown in FIG. **3,** allows a unique arrangement for controlling the size of the vent, depending on the design parameters. To insure proper venting the bypass cross-section area should be within 5 to 50 percent of the total cross-sectional area of the suction line piping, the actual area dependent on many variable operating conditions. It should be noted here that a number of methods of construction of a suitable "vent" cross-sectional area can be employed, but one of the unique features is that this design can provide the proper vent with minimal obstruction to gas flow, both during venting and, more important, during normal operation to minimize pressure drop. The area can, of course, be controlled to the desired optimum condition by proper sizing of the J-tube outlet diameter **54,** with respect to the connector **20** inside cross-sectional area, and the height of the dimples, or staking, used.

Still another feature of this outlet connector arrangement is that it provides a streamlined section that creates a venturi action as mentioned for example in W. O. Krause U.S. Pat. No. 3,483,714, at the outlet connection. This venturi action is created as the refrigerant vapor flowing through the accumulator accelerates through the region of reduced cross section, shown at stippled area **58.** This high velocity exiting gas creates an area of low pressure at the J-tube outlet **52** which helps to vaporize any refrigerant liquid within the tube, as well as tends to help remove the oil/liquid refrigerant by a "pumping" action forcing the liquid up the tube. The streamlining of this venturi creates a more efficient "pump", with inherent reduced kinetic energy loss, and therefore less system capacity loss. The proper venturi

action is likewise dependent on the cross-sectional area through which the exiting vapour must pass. Therefore, proper sizing of the venturi throat is also necessary. Again, this can be controlled by the method of construction of the outlet connector and J-tube sizing. Therefore, it can be seen that optimization is necessary, and with this construction method optimization between the venturi throat sizing and high pressure bypass vent can be achieved very easily for any given condition.

The herein described accumulator has been extensively tested under many and severe conditions. The testing revealed that the design results in a pressure drop loss of less than half that of the best accumulator currently available on the market. Oil return tests under all conditions were good. Liquid fill tests, where liquid refrigerant is allowed to build up inside the chamber to various levels prior to restarting the accumulator, have been conducted with the vessels as much as **80%** full of liquid refrigerant, the J-tube inlet **48** being more than **8** inches below the liquid level, and restarting the compressor caused no sluggin at all.

Manifestly minor changes in details of construction can be effected within the scope and purview of the invention without departing from the spirit and scope of the invention as defined in and limited soley by the appended claims.

We claim:

1. A liquid trapping suction accumulator adapted for insertion in a vapor-compression refrigeration system between the evaporator and the compressor, comprising:

A. an accumulator chamber defined by a casing having a top closure and a bottom closure;

B. inlet and outlet ports in said top closure opening into said chamber and respectively adapted for operative connection to said evaporator and said compressor;

C. an outlet connector in said outlet port;

D. a J-shaped tube mounted within said casing; and

i. the long leg thereof extending into and terminating in said outlet connector centrally positioned within and in peripherally spaced relationship from the internal surface of said outlet port;

ii. inwardly extending dimples spacedly positioned about the inner periphery of said outlet connector and providing an interference fit with the outer diameter of said J-tube outlet end for rigid support thereof in said connector, the spacing between the dimples creating a predetermined open area therebetween for exiting gas;

iii. the outlet end of said J-tube being outwardly flared to a controlled diameter for coacting with said dimples in an interference fit therewith; and

iv. the short leg thereof terminating in an inlet opening directly centrally aligned with said inlet port and in spaced relation therefrom.

2. A liquid trapping suction accumulator as claimed in claim **1,** and including a liquid feedback port centrally positioned in a side of the bend in said J-tube.

3. A liquid trapping suction accumulator as claimed in claim **2,** including a J-shaped tube support bracket mounted within said accumulator chamber proximate the bottom thereof.

4. A liquid trapping suction accumulator as claimed in claim **3,** including a fusible plug in said top closure adpated for pressure release in the event of fire.

5. A liquid trapping suction accumulator as claimed in claim **4,** including an inlet connection in said inlet port in said top closure and centrally internally aligned with the inlet opening of the short leg of said J-shaped tube.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,754,409 Dated August 28, 1973

Inventor(s) George T. Wenn, Jr., et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the cover sheet, inventor's name "George T. Wreen, Jr." should read -- George T. Wrenn, Jr. --.

Signed and sealed this 12th day of February 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.