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Hansen et al.

[11] **3,741,242**

[45] **June 26, 1973**

[54] **REFRIGERANT FEED CONTROL AND SYSTEM**

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[73] Assignee: **Refrigerating Specialties Co.**, Broadview, Ill.

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[21] Appl. No.: **206,671**

[52] **U.S. Cl.** **137/504**, 137/269

[51] **Int. Cl.** **F16k 31/363**, F25b 43/00

[58] **Field of Search** 137/504, 503, 517, 137/269

[56] **References Cited**

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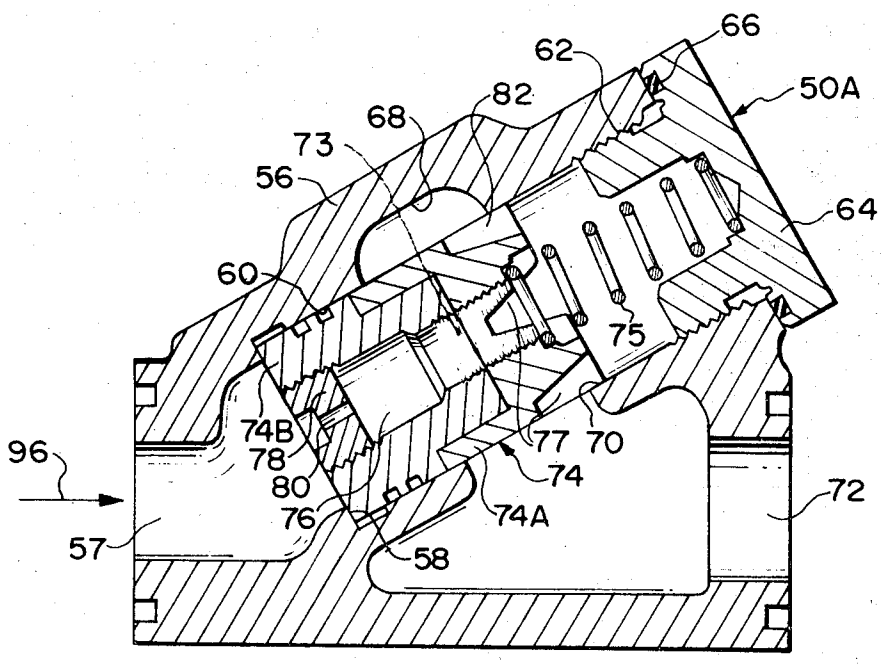
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Primary Examiner—Henry T. Klinksiek
Assistant Examiner—Robert J. Miller
Attorney—Watson D. Harbaugh et al.

[57] **ABSTRACT**

An automatic flow regulator for refrigeration systems in which a fixed flow control orifice in series with a spring-opened flow regulating valve are carried on the same member for access laterally from the refrigerant line for servicing and making changes in orifice sizes.

15 Claims, 9 Drawing Figures



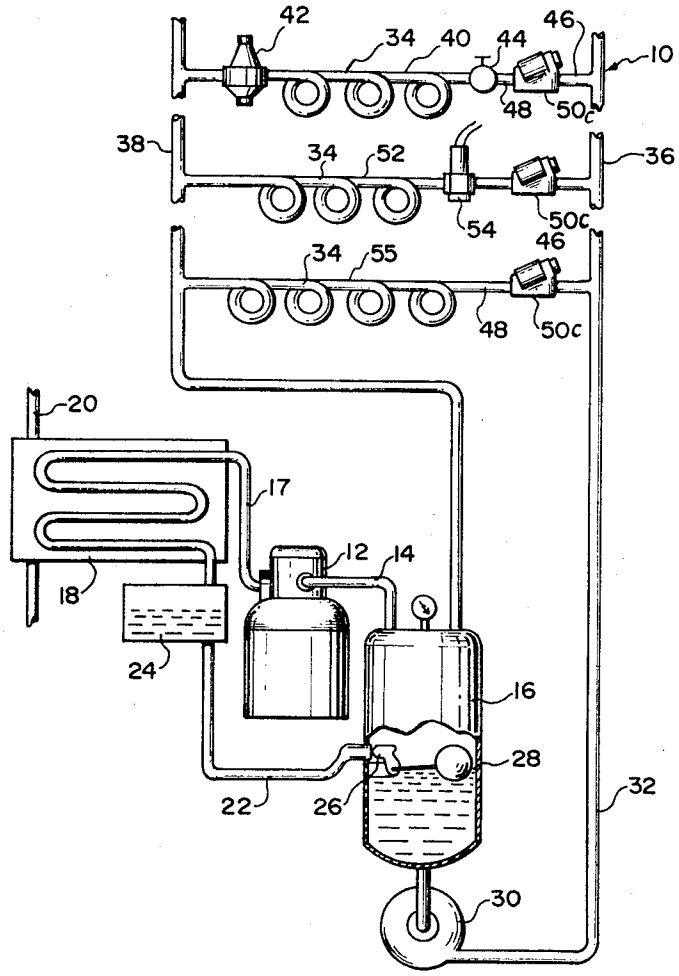


FIG. 1

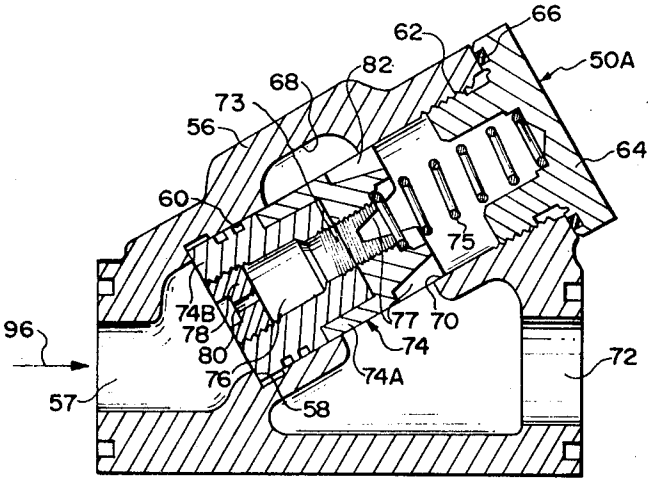


FIG. 2

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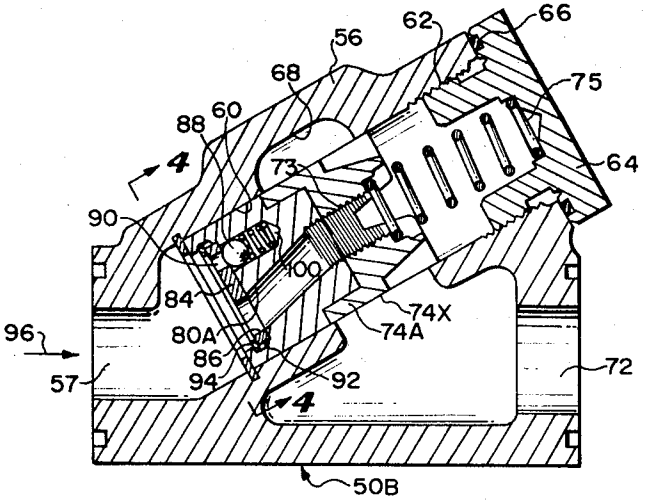


FIG. 3

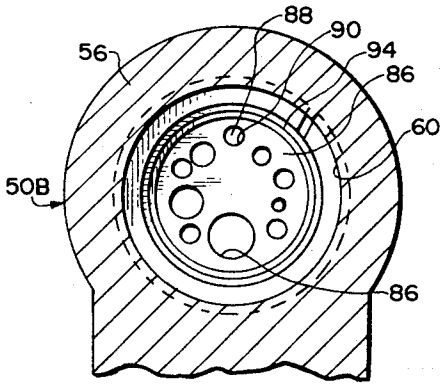


FIG. 4

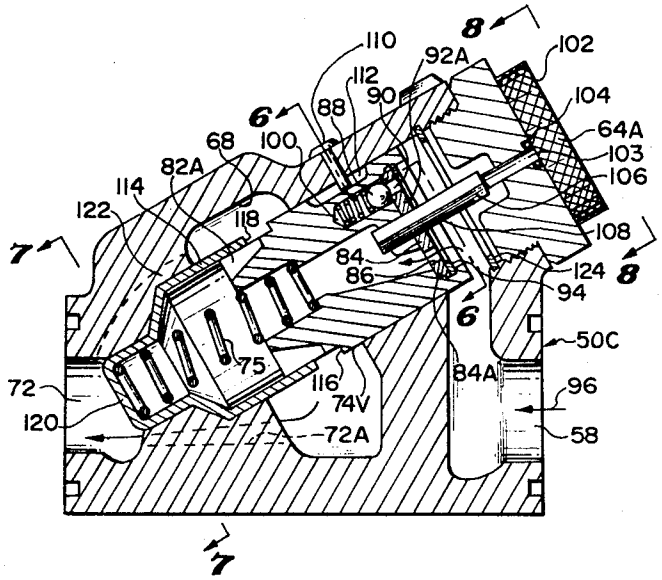


FIG. 5

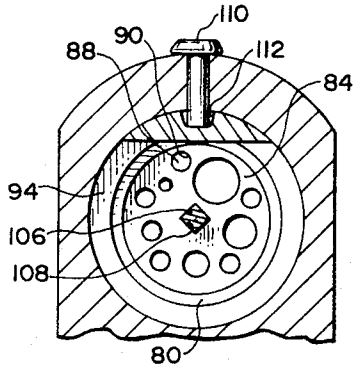


FIG. 6

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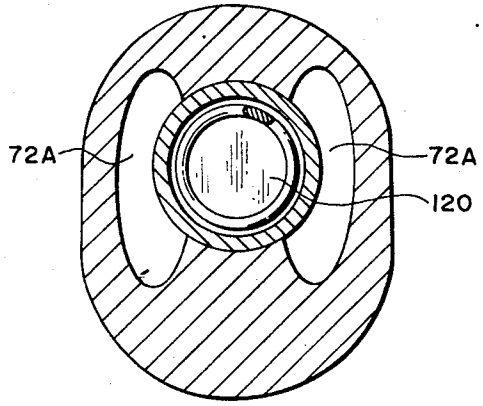


FIG. 7

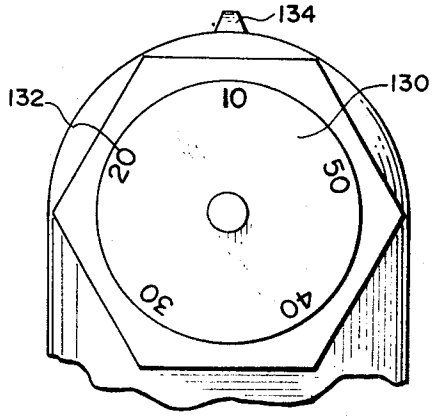


FIG. 8

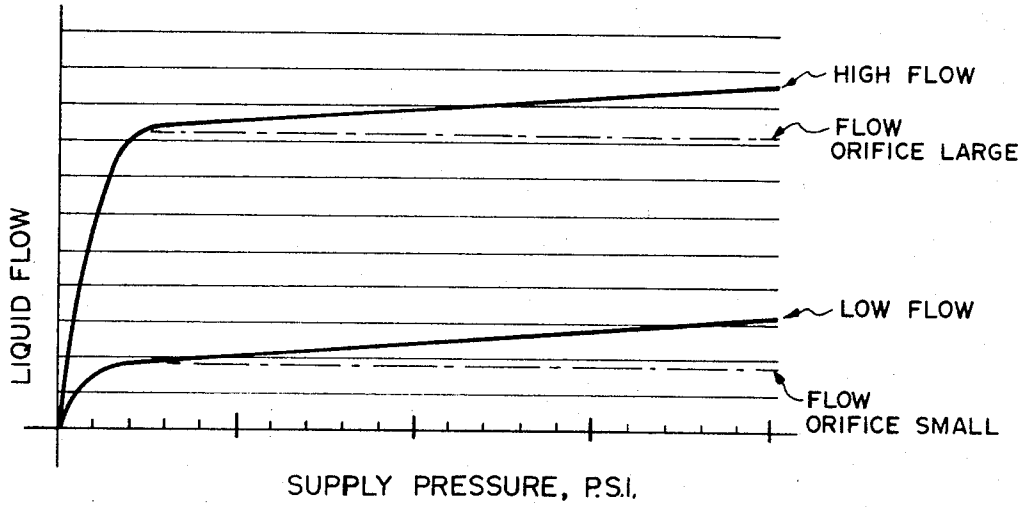


FIG. 9

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REFRIGERANT FEED CONTROL AND SYSTEM

BACKGROUND OF THE INVENTION

This is a simplification of the valve construction shown in Hansen et al., U.S. Pat. No. 3,449,923, reference to which is hereby made, and relates to a readily removable and changeable constant flow feed control valve in refrigerant recirculating systems which have one or more low pressure liquid circuits including dry expansion, flooded evaporators and surge tanks.

In such a system, as more particularly described in the patent, liquefied refrigerant is supplied from a surge tank to an evaporator coil under pressure where it is expanded and then returned to the surge tank. A compressor is connected to take vapor from the tank to establish in the tank a low return pressure, compress the vapor and pass it back to the surge tank through a condenser where it is returned to its liquid phase. The liquid level in the tank is conventionally controlled so that the expanded refrigerant is maintained at a low suction pressure by the compressor intake while a pump delivers the liquid refrigerant to the inlet of the evaporator coil under pressure to establish a pressure drop across the evaporator coil.

Evaporator coils may be located at various and widely spaced locations in a refrigerating plant, and have different flow distances, areas, elevations, and refrigeration loads whereby effective inlet pressures for the evaporators vary quite widely and individually from time to time during their work cycles.

Furthermore, evaporator circuits can be variously equipped, some with regulators at evaporator outlets with or without expansion valves at the inlet as well as other valves for different cycles. Accordingly, there will tend to be differences in the amount of recirculating liquid that can flow in the evaporators.

SUMMARY OF INVENTION:

The present invention is concerned with controlling the flow of liquid refrigerant to the evaporator at a predetermined flow at a variable pressure drop. It comprises an inexpensive constant flow regulator in which a fixed orifice and a movable member of a variable opening flow control valve are carried as a unit by a pressure responsive piston. The valve is generally characterized by plural triangularly shaped castellated openings that are variable and the piston at the inlet end is disposed to be responsive in a valve closing direction to the higher pressure of the liquid refrigerant. At its outlet end the piston is exposed to the lower pressure generally determined by spring and piston area. A spring urges the piston to open the valve in opposition to the effect of the higher liquid pressure to establish a pressure drop across the orifice. Thus a single movable unit which includes a movable valve member and an orifice; a spring; a housing; and a closure constitute the parts of the present simple constant flow regulator.

Preferably, the piston, and with it the movable valve member and orifice, are accessible for removal to exchange orifices upon the removal of the closure. Preferably this can be accomplished without disassembly of the housing from the refrigerant line. However, in one embodiment the fixed orifice can be changed to another without removal of the piston, thereby providing at low cost some versatility of fixed orifice sizes not only for reduced valve inventories, but some flexibility at low cost in refrigeration applications.

The evaporator side of the valve and the spring urge the valve to open while the liquid pressure in the refrigerant supply line urges the valve to close. The orifice permits liquid refrigerant to flow at a constant rate at any established pressure differential across the valve to oversupply the evaporator circuit in a predetermined constant ratio which safely includes maximum expected load conditions thereof.

This invention makes it possible to design and erect refrigeration systems with multi-evaporators using the recirculation method, which are considerably easier to put into operation, less costly to maintain, and provide improved performance results because of the elimination of both an evaporator starvation condition resulting in insufficient refrigeration and an evaporator overfeed situation with its problems of excessive refrigeration, excessive pumping cost, and excessive amounts of liquid return to the surge tank.

These being among the objects and accomplishments of the present invention other and further objects including simplicity of design, ease of manufacturing, the holding of tolerances, and rapidity of assembly and testing, including replacement of control spring or substitution of orifices, will become apparent from the following description and the drawings, in which:

FIG. **1** is a diagrammatical representation of a typical refrigeration system improved in its servicing and performance by and as a part of the present invention;

FIG. **2** is a longitudinal sectional view of the liquid feed control valve for a liquefied gas embodying the invention;

FIG. **3** is a sectional view similar to that shown in FIG. **2** illustrating a modification of the invention;

FIG. **4** is a sectional view taken on lines **4—4** of FIG. **3**;

FIG. **5** is a longitudinal sectional view of the liquid feed control showing another embodiment of the invention relating to the control element shown in FIGS. **2** and **3**;

FIG. **6** is a sectional view taken on line **6—6** of FIG. **5**;

FIG. **7** is a sectional view taken on line **7—7** of FIG. **5**;

FIG. **8** is an end view of the dial selector of an orifice size in the embodiment shown in FIG. **5**; and

FIG. **9** is a graphical presentation of the operation of the control shown in FIG. **2** in a typical refrigeration system such as shown in FIG. **1**.

Referring now to the drawings in which like numbers refer to like parts, and particularly FIG. **1**, a liquid recirculating refrigeration system **10** is shown in which a compressor **12** draws gas at suction pressure through line **14** from the top of a surge tank **16**, compresses it and discharges the high pressure refrigerant gas through a conduit **17** into a condensor **18** where the hot gas is cooled by means of a cooling fluid source **20** and is converted to a liquid refrigerant which flows into a high pressure reservoir **24** and liquid line **22**. From the high pressure liquid line **22**, the liquid passes through a float valve **26** whose operation is not responsive to pressure and enters the surge tank **16** where it is maintained at a pressure that is approximately equal to the suction pressure of gas entering the compressor **12** through line **14**. Normally, the liquid level in the surge tank is maintained by the float valve or by a float switch and solenoid valve (not shown) at a desired level **28** in the surge tank. This level is normally established suffi-

ciently below the suction gas exit line **14** from the surge tank to prevent carry-over of entrained liquid refrigerant into the compressor suction. Likewise, the liquid level **28** is maintained high enough to ensure an adequate supply of liquid and an adequate head of liquid for a liquid recirculating pump **30,** which is used to feed the liquid refrigerant out through the supply line **32** into the plant where it can be directed toward one or several of many evaporators **34.**

These evaporators may be of many different varieties and in many different locations in the plant. Some evaporators **34** may be on the first floor, others may be of a single pipe variety, a coiled type variety, a thin coil, a shell and tube pressure vessel, or any of the many different types of evaporators that are frequently used. Some of these evaporators may have very short refrigerant flow circuits with generous passage areas for the refrigerant gas resulting in a very low or even negligible pressure drop as a refrigerant gas passes through the evaporator. On the other hand, some evaporators may have very long and restrictive circuits which result in relatively high pressure drop as the refrigerant passes through the evaporator.

The representative system utilizing the invention as shown in FIG. **1** shows three different but representative types of evaporator circuits. The liquid refrigerant supply line is shown at **36** and the suction line is shown as **38.**

The upper circuit **40** includes the feed control valve **50** of the invention, the evaporator coil **34** and an evaporator pressure regulator **42** connected in series between the supply line and the suction line. A shut-off valve **44,** preferably controlled by a thermal responsive device such as a thermal bulb (not shown) actuating a solenoid which controls liquid to flow or not flow through the liquid valve **50** whether connected thereto at the inlet line **46** or outlet **48** of the valve **50.** In this circuit the pressure at the outlet **48** is substantially constant as controlled by the evaporator pressure outlet regulator **42,** and irrespective of supply line pressure the feed control **50** will deliver liquid refrigerant, at whatever flow rate desired, at a pressure that is in excess of the evaporator set pressure. This stabilized flow being constant such improves the performance and control effect of the pressure valve **42.**

In the next evaporator circuit **52** the feed control **50** is connected in series with an off-and-on solenoid valve **54** remotely controlled, and the evaporator **50,** between the liquid supply line **36** and the suction line **38.** Here the evaporator coil is at suction pressure and when the solenoid valve is open the feed control **50** operates to increase refrigerant flow with an evaporator pressure rise. In the lower circuit **55** the feed control **50** is shown connected directly between the supply line **32** and evaporator **34.**

Referring now to FIG. **2** the simplest embodiment of the invention is shown designated **50A** the feed control comprises a body member **56** having an inlet passage **57** terminating in a shoulder stop **58** that opens into a cylindrical bore **60** which outwardly terminates in a threaded opening **62** receiving a closure plug **64** sealed by an O-ring **66.** The bore **60** is centrally enlarged to provide a valve flow compartment **68** defined in part by a valve port **70** and leading to an outlet **72.**

A piston **74** preferably made in two telescoping elements **74A** and **74B** for freedom of movement with close tolerances in the bore **60,** is slidably mounted in the bore **60** to rest at one end of element **74B** against the shoulder **58** as urged by a compression spring **75** engaging the other end of element **74A** to function as a unit, and at said other end the piston enters and coacts with the port **70.** A conduit interconnects the inlet and port and preferably constitutes a longitudinal passage **76** provided through the piston to reduce interim space and at said one end the passage is threaded to receive a plug **78** having a fixed orifice **80.** At the other end the passage **76** terminates in a plurality of triangular castellated slots **77** providing a valve guide sleeve **82** for multiple lineal orifice flow control in coaction with the valve port **70.** The higher pressure of the liquid at the inlet **57** urges the piston to close the valve port **70.** The action of the spring **75** and the pressure downstream of the valve **70,** though reduced, urge the valve to its open position. Between them a pressure drop is provided across the valve that produces a constant flow through the orifice **80.** The relative flow characteristics are shown and legended in FIG. **8.**

The piston **74** is internally threaded at **73** and whenever it is desired to service the valve or change to a different sized orifice **80,** the plug **64** is unthreaded, the spring **75** is removed and piston **74** is tool engaged at the threads **73** and removed. The orifice plug **78** having a hex or square head or socket is then removed by a wrench and replaced with another orifice plug (not shown) having a different orifice size in it. The valve **50A** is easily reassembled and sealed with the plug **64** without having disturbed any connections between lines **46** and **48.**

Referring to FIG. **3** an embodiment **50B** of the valve is shown in which a selection of fixed orifices **80A** are provided in one member such as a rotatable disc **84** with the coincidence between a port **86** and the orifice **80A** offset radially of the piston whereby upon removal of the piston **74X** for orifice change, the replacement orifice is already there available for use by merely rotating the disc **84** to locate the chosen orifice at the port **86.**

In this embodiment a spring urged detent **88** is mounted in a well **100** off-center to and in the end of the piston **74X.** Appropriate indexing recesses **90** on the disc assure the correct positioning of any orifice chosen. Although a loosening and tightening of a screw (not shown) could be used to hold the disc in place and correctly positioned on the end of the piston, the disc otherwise is freely held in rotatable position in a recess **92** by a compressed C spring **94,** the liquid pressure as indicated by the arrow **96** pressing it in sealing relationship against the piston.

In FIG. **5** an embodiment **50C** is shown in which the changing of orifices can also be accomplished quite easily without opening the refrigerant line. The changing of the orifices **80A** and **80B** can be accomplished very easily merely by rotating a selector dial **102** when desired, it being desirable to have a ready selection of fixed size orifices of known flow characteristics in some installations rather than an infinitely variable adjustment.

In this valve embodiment **50C,** shown in FIG. **5,** the position of the piston **74Y** is reversed end for end in the housing **50C** and the orifice disc **84** rests in the recess **92A** on the end of the piston **74Y** adjacent to the plug **64A.** The dial **102** is journalled in the plug **64A** on a shaft **103** as sealed by an O-ring **104** and terminates inwardly in a cross-sectionally non-cylindrical shaft **106**

which is slidably received in a mating contour **108** in the disc **84** to rotate the disc yet permitting free axial reciprocation of the piston and the disc with respect thereto. A sealed drive pin **110** received through the side wall of the housing engages in a longitudinal channel section **112** in the surface of the piston **74Y** to prevent rotation of the piston and port **86** by the disc **84** when changing orifices.

At the castellated end **82A** of the piston a cup **114** is provided which slidably telescopes with the castellated end of the piston in mutually guided relationship and the outside diameter of the castellations **82** preferably is reduced to provide a circumferential shoulder **116** which serves as a value seat for the tim **118** of the cup **114.** At its closed end **120** the cup is of a reduced dimension to be received in guided relation in a space bounded by radial supports **122** that provide outlet passages **72A** (FIG. 7) between them. The reduced end **120** internally supports one end of the compression spring **75** that urges the piston **74Y** to its valve opening position.

A seal or C-spring **124** in the upstream compartment serves as an assembly stop limiting the valve opening urged by the spring **75** and a forward stop can be the engagement between the valve seat **116** and cup rim **118** in which position the valve castellations or valve seat **116,** or both, are closed. If a seal is used the spring **75** urges piston closure contact therewith under shutdown conditions as a positive check except for slight bore clearance leakage.

In event the pressure in the outlet opening **72** unexpectedly exceeds the inlet pressure to a dangerous degree, the cup **114** is urged away from its resting position shown in FIG. **5** and closes as a back flow check valve closing the castellation ports and resting, if desired, against the seat **116.**

Selection of a particular orifice to coincide with the port **86A** is made by rotation of the selector knob **102** upon whose face **130** (FIG. **8**) the positions of the respective orifices are maked by indicia **132** indicating refrigerant tonnage with reference to an indicator **130** on the housing. In making the selection the selector knob **102** is rotated to bring the selected orifice indicia in alignment with the arrow **134** by the square shaft rotating the disc **84A.**

In the operation of all three embodiments, despite variations in the inlet and outlet pressures and orifice sizes the pressure flow control valves **50,** once set, will maintain substantially constant liquid flow to the evaporator as illustrated in the chart FIG. **8.** Liquid refrigerant first entering the inlet passage **58** under supply line pressure is initially effective upon the piston **74** and it quickly responds tending to close the valve **82** since there is no initial counter pressure in the outlet conduit **72** that is counter effective on the piston. However, by the time the valve **82** approaches its closed position, liquid is flowing through the orifice **80** and counter pressure in the valve chamber begins to build up and open the castellated valve **82.** This tends to equal the inlet pressure due to substantially equal piston areas, but a pressure differential develops between the inlet and outlet.

The spring force determines this differential pressure and such is maintained by the spring **75** and the castellated valve yielding towards its closing position if the pressure differential increases and opening more if the differential decreases.

The size of the orifice desired remains to be selected in any particular application.

Assuming the spring provides a 2 p.s.i. pressure differential the size of the orifice can be calculated for the liquid flow desired at that differential to provide a desired circulation rate, for instance, a two to one rate which means twice as much liquid being supplied to the evaporator as is evaporated by the evaporator at full load. Other ratios may be selected if desired.

Thus with a constant pressure differential across the orifice established by the valve, the orifice and valve will maintain a substantially constant volume flow independent of the back pressure of the evaporator circuit at its outlet and this is irrespective of pressure variations in the inlet passage. It will be further observed that one overall benefit of this invention will be to permit systems to be designed at lower costs and feed rates than have been hitherto possible. In the past, high recirculation rates were invariably required in order to overcome the situation in which many evaporators in the field were being supplied with an excess amount of liquid under conditions that could not be corrected except at great expense because of the difficulty of determining which evaporators were over-feeding and the difficulty of readjusting these evaporators and the rest of the evaporators in the system for pumping economy after the problem was pinpointed.

It will be appreciated that different flow rate orifices can be computed for other ratios as mentioned, and, in the embodiments shown, given a spring **75** of known characteristics the orifices to be selected for particular evaporators can be rated in refrigeration tons **132** up to the capacity of a given valve size.

Moreover, the present invention eliminates the need of a separate check valve, to prevent "back-up" of the liquid from the evaporator into the liquid supply lines as an evaporator is washed down with hot water when it has the suction line closed or when the evaporator is supplied with hot gas and the suction line of the evaporator is closed during a hot gas defrost period.

Thus, it will be observed how in operation the invention delivers to the inlets of various evaporator circuits a flow that is constant, and how the stated objects and novel results are attained.

What is claimed is:

1. A liquid refrigerant feed control comprising:

a housing having an inlet for the feed line and an outlet to an evaporator for a liquid refrigerant and providing cylinder means therebetween having a lateral outlet opening defining a valve port facing the outlet;

piston means exposed at one end to inlet pressure slidably mounted in said cylinder means to extend beyond said outlet opening at its other end and having a conduit throughout its length centrally discharging essentially towards a wall of the housing through the center of said valve port;

fixed orifice means connected in series with and controlling flow through the conduit;

valve means carried by said piston means adjacent to said outlet including radial openings communicating with said conduit and movable by said piston means in a direction transversely to the plane of said port to coact with said valve port and vary the flow opening of the valve with movement of said piston means; and

means urging said piston means to establish a low pressure differential across the orifice including a resiliently operating element exerting a force upon the piston means in the valve opening direction.

2. The combination called for in claim **1** in which the axis of said cylinder means is at an acute angle to the common axis of said inlet and outlet and has an access opening at its remote end opening to atmosphere to receive and provide access to the piston means therethrough with said outlet opening in close proximity to said outlet; and

closure means for closing said access opening.

3. A liquid refrigerant feed control comprising:

a housing having an inlet for the feed line and an outlet to an evaporator for a liquid refrigerant and providing cylinder means therebetween having a lateral opening defining a valve port facing the outlet;

piston means slidably mounted in said cylinder means and having a conduit therethrough;

fixed orifice means in the conduit adjacent said inlet comprising a disc having angularly spaced orifices of different sizes for selective adjustment to coincide with said conduit;

valve means carried by said piston means adjacent to said outlet coacting with said valve port to vary the flow opening of the valve with movement of said piston means; and

means urging said piston means with a predetermined force in the valve opening direction to establish a low pressure differential across the orifice.

4. The combination called for in claim **1** in which said orifice means, piston means and valve means operate as a unit within the confines of said housing.

5. A liquid refrigerant feed control comprising:

a housing having inlet and outlet openings connected by a chamber having a wall defining a cylinder means in two spaced sections intermediate the openings and a valve chamber intermediate said sections with one section in communication with one of said openings;

a flow control means including a fixed orifice means, a valve means having a variable flow control valve element adjacent one end of the cylinder means and a porting valve element adjacent the other end of the cylinder means telescoping in sliding relation with said control valve member and coacting therewith for regulating flow between said openings;

piston means slidably mounted in said wall and having a conduit therethrough teminating in one of said valve elements adjacent to one of the openings and carrying adjacent to the other opening the orifice means in communication with said one valve member through said conduit;

said housing at said one opening carrying the other valve element; and

resilient means for urging said piston means to open said valve means in a direction counter to the direction of flow through said conduit to establish a low pressure differential across said orifice means.

6. A liquid refrigerant feed control comprising:

a housing having inlet and outlet openings connected by a chamber having a wall defining spaced cylinder sections intermediate the openings and a valve chamber intermediate said sections in communication with one of the openings;

plug means for closing said cylindrical chamber adjacent to one of said openings to confine flow communication to the other opening through said cylinder means and valve chamber;

a flow control means including a fixed orifice means and a valve means having a variable flow control sleeve valve element and a porting element telescoping therewith for regulating flow between said openings;

piston means slidably mounted in the cylindrical wall and having a conduit therethrough terminating in one of said valve elements adjacent to one of the openings and carrying adjacent to the other opening the orifice means in communication with said one valve member through said conduit;

said housing at said one opening carrying the other valve element; and

resilient means for urging said piston means to open said valve means in a direction counter to the direction of flow through said conduit.

7. The combination called for in claim **5** in which said flow control valve element is carried by said piston means; and

cup means axially in open communication with the lower pressure of said pressure differential on one side and the outlet pressure on the other side reciprocably supporting said piston means and mounted in said housing to carry both said flow control valve element and said resilient means for coaction with said piston to actuate said valve means.

8. A liquid refrigerant feed control comprising;

a housing having inlet and outlet openings connected by a chamber having wall defining a cylinder intermediate the openings;

a flow control means including a fixed orifice means and a valve means carried by said piston means having a variable flow control sleeve valve element and a porting element telescoping therewith for regulating flow between said openings;

piston means slidably mounted in the cylindrical wall and having a conduit therethrough terminating in one of said valve elements adjacent to one of the openings and carrying adjacent to the other opening the orifice means in communication with said one valve member through said conduit;

said housing at said one opening carrying the other valve element;

resilient means for urging said piston means to open said valve means in a direction counter to the direction of flow through said conduit;

cup means reciprocably supporting said piston means and mounted in said housing to carry both said sleeve valve element and said resilient means for coaction with said piston to open said valve means;

said cup means being reciprocably mounted in said housing adjacent said outlet opening to respond as a back flow check valve in coaction with said resilient means and flow control valve element when the pressure differential between said outlet opening and the inlet opening is substantially reversed.

9. The combination called for in claim **6** in which the orifice means includes a disc rotatably mounted on said piston means carrying a selection of fixed orifices of different sizes of which flow control means has at least one fixed orifice;

shaft means journaled in said plug means and rotatably driving said disc to dispose any fixed orifice selected in sole communication with said conduit at a time;

means for holding said piston against rotation; and
manually rotated indicator means carrying said shaft for selective orifice rotation of said disc.

10. The combination called for in claim **6** in which said plug means is of a size greater than the cylinder size for removal of said piston from the cylinder; and said orifice being releasably mounted on said piston for removal and replacement.

11. A liquid refrigerant feed control comprising:
a housing having inlet and outlet openings connected by a chamber having a wall defining a cylinder intermediate the openings;
a flow control means including a fixed orifice means and a valve means having a variable flow control sleeve valve element and a porting element telescoping therewith for regulating flow between said openings;
piston means slidably mounted in the cylindrical wall and having a conduit therethrough terminating in one of said valve elements adjacent to one of the openings and carrying adjacent to the other opening the orifice means in communication with said one valve member through said conduit;
said housing at said one opening carrying the other valve element;
resilient means for urging said piston means to open said valve means in a direction counter to the direction of flow through said conduit;
said orifice member comprising a disc element carrying a plurality of selective fixed orifices; and
detent means for holding said disc means with any selected fixed orifice in communication with said conduit.

12. The combination called for in claim **5** in which said piston means is in two sections bridging said valve chamber and define between them a second valve chamber and said porting element.

13. The combination called for in claim **5** in which the piston means is supported at opposite ends in said cylinder sections and comprises two sections held together at an engagement with each other located essentially between said cylinder sections by said spring to operate as a unit.

14. The combination called for in claim **6** in which said sleeve valve element continuously engages said porting element and includes a plurality of triangular castellated slots for multiple lineal orifice flow control in coaction with the porting element.

15. A liquid refrigerant feed control comprising a housing having coaxial inlet and outlet openings and with a cross wall between them and defining on the outlet side of the wall a valve compartment whose major space is disposed to one side of said axis;
said wall and the housing adjacent one of said coaxial openings defining a cylinder whose axis is disposed at an acute angle to said coaxial openings with an external access opening spaced laterally from one of said coaxial openings;
piston means reciprocably mounted in the cylinder to bridge said valve compartment;
valve port means carried by said housing opening into said compartment adjacent to one of said openings;
flow control valve means carried by said piston having triangular castellated lineal slots coacting with said valve port means;
conduit means through said wall interconnecting said flow control valve means and said inlet opening including an orifice member;
resilient means urging said piston means to open said flow control valve means;
means for applying inlet pressure to said piston to urge the piston means to close said flow control valve means; and
closure means for said access opening.

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