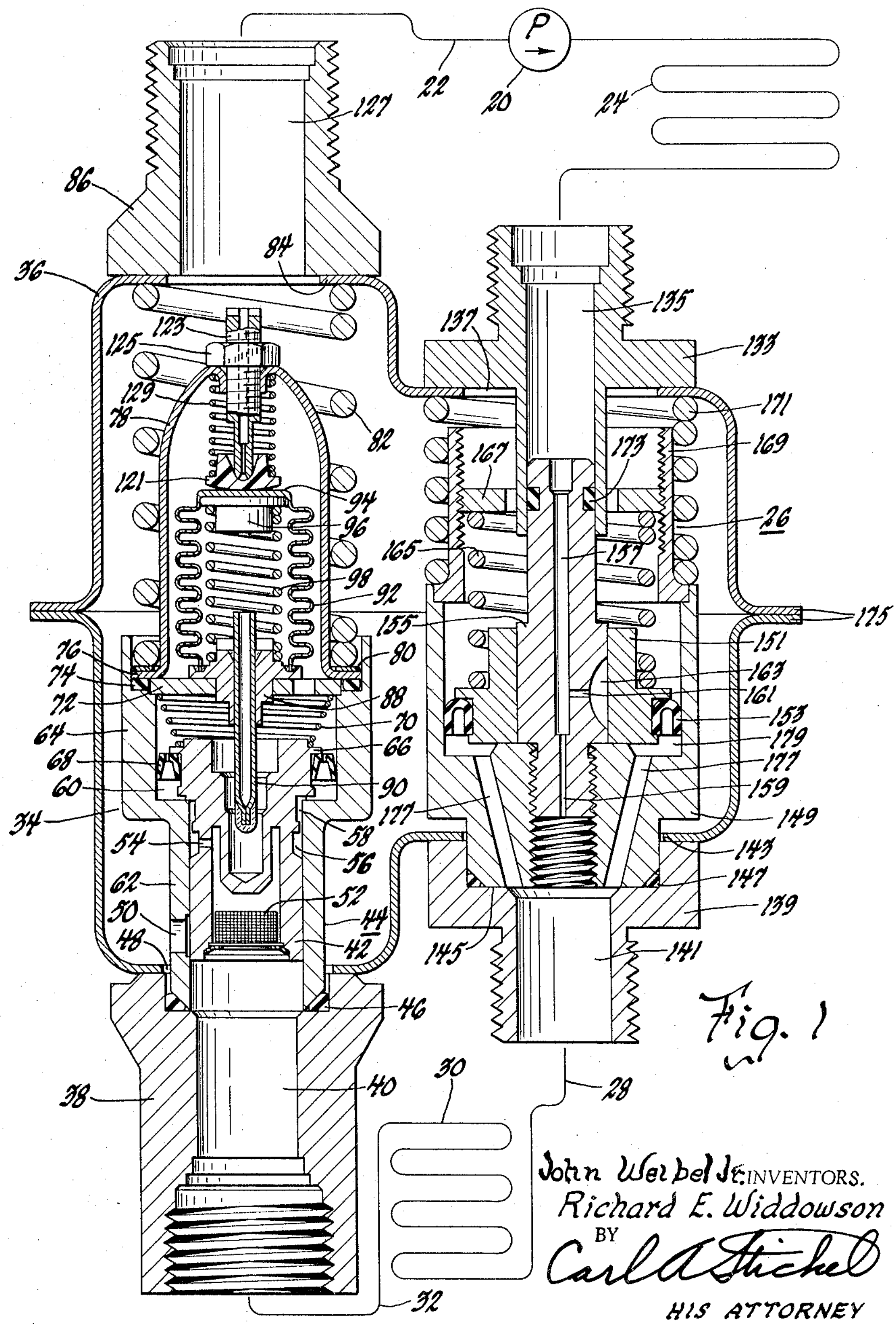
Jan. 10, 1967 J. WEIBEL, JR., ETAL 3,296,816

FLOW CONTROL DEVICE FOR REFRIGERATING APPARATUS

Filed April 10, 1964 2 Sheets-Sheet 1



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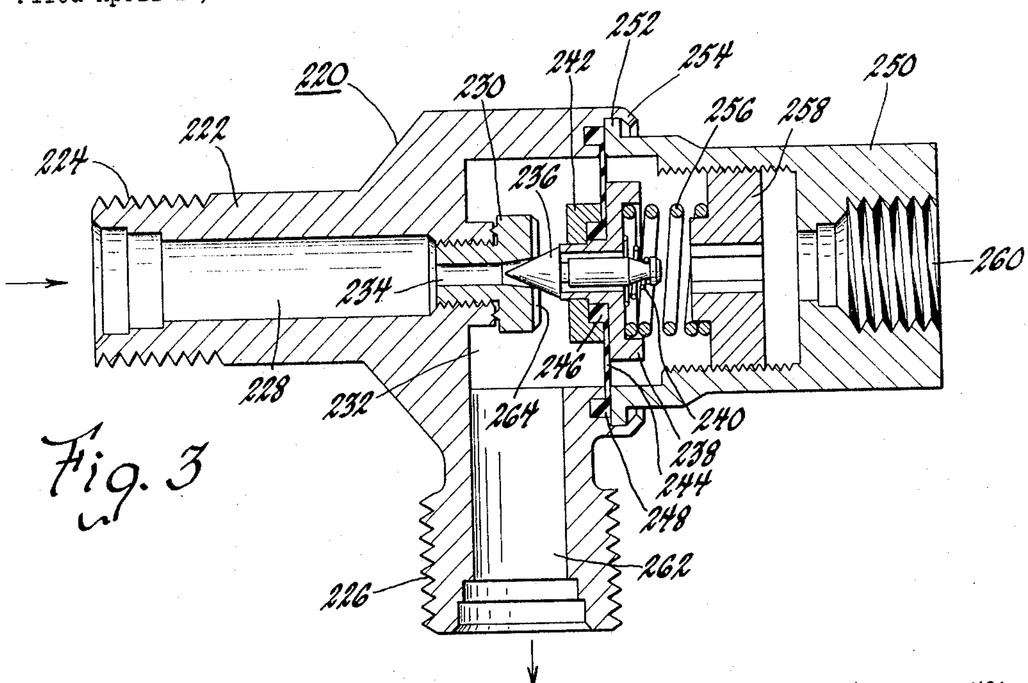

Fig. 3

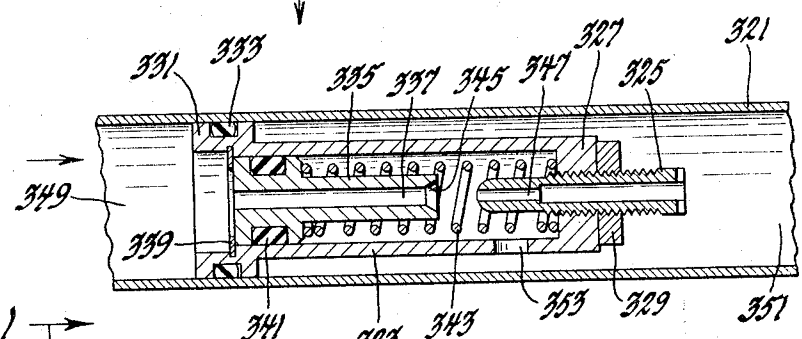

Fig. 4

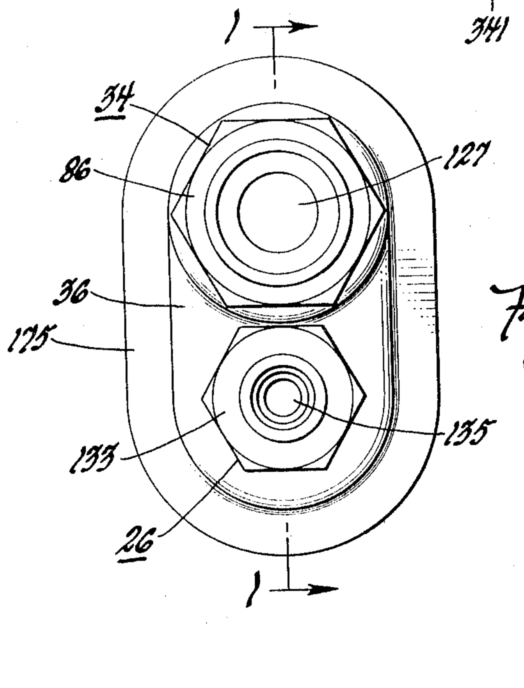

Fig. 2

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FLOW CONTROL DEVICE FOR REFRIGERATING APPARATUS

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8 Claims. (Cl. 62—210)

This invention pertains to refrigerating apparatus and more particularly to controlling automobile air conditioners.

Controlling automobile air conditioners is difficult. The controls must be inexpensive, compact and readily fit into cramped unoccupied space remaining in the engine compartment. The controls must feed adequate amounts of liquid refrigerant to the evaporator at all temperatures and at all car speeds and all speeds of the compressor. The temperature and the car speed will affect the need for cooling and the rate of evaporation of refrigerant in the evaporator. Provision must also be made for sufficient refrigerant flow into and out of the evaporator during idling of the engine. The flow must be controlled in such a way that the evaporator will not frost and yet maintain a temperature as low as possible therein in order to obtain maximum capacity.

It is an object of this invention to provide an efficient, compact, inexpensive flow control device which will at all times supply all the refrigerant that the evaporator can beneficially use without discharging liquid refrigerant to the compressor.

It is another object of this invention to provide a compact, inexpensive flow control device which is controlled in response to the pressure between the suction line control valve and the compressor inlet.

It is another object of this invention to provide an efficient, compact, inexpensive flow control device which is controlled in response to the difference in the pressure between the suction line control valve and the compressor inlet and the pressure in the evaporator.

It is another object of this invention to provide an efficient, compact, inexpensive flow control device which will provide minimum flow of refrigerant during idling conditions and the maximum flow which can be beneficalIy used at all other times.

These and other objects are attained in the forms shown in the drawings in which a restrictor is used to provide a minimum liquid flow from the condenser to the evaporator at all times. A by-pass for this restrictor is provided which is controlled by a slide valve or a needle valve operated by a fluid motor which is responsive on one face to the pressure prevailing between the suction line control valve and the inlet of the compressor. The opposite face of the fluid motor is exposed to the pressure of the refrigerant within the evaporator. With this arrangement, either a rise in pressure in the evaporator or a fall in pressure between the suction line control valve and the compressor inlet or both will open the by-pass to provide increased refrigerant flow so that maximum capacity of the compressor is used as well as maximum capacity of the evaporator. The suction line control valve at the outlet of the evaporator assures that the pressure and the temperature within the evaporator are kept sufficiently high to prevent frosting thereof.

In a third type of liquid flow control device there is provided a piston valve including a restricted passage which under a high pressure differential connects in series with a second restricted passage to provide minimal flow. When the pressure differential is less, the piston valve will move away from the second restricted passage to permit additional liquid to by-pass the second restricted passage to provide increased flow.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred embodiment of the present invention is clearly shown.

In the drawings:

FIGURE 1 is a vertical sectional view through a combined liquid flow control device and suction line control valve embodying one form of my invention taken along the line 1—1 of FIGURE 2 together with the remaining elements shown diagrammatically of the automobile air conditioning system;

FIGURE 2 is a top view of the combined structure shown in FIGURE 1;

FIGURE 3 is a simplified form of liquid flow control device incorporating a needle valve and diaphragm and

FIGURE 4 is another modified form of liquid flow control device.

Referring now more particularly to FIGURE 1, there is shown diagrammatically a compressor **20** which is customarily driven by the engine of the automobile through a belt and an electromagnetic clutch. This compressor has its inlet connected to the suction line **22** and its outlet connected to the inlet of the condenser **24**. The outlet of the condenser **24** is connected to the inlet of the liquid control device **26** which has its outlet connected to the liquid supply conduit **28** connecting with the inlet of the evaporator **30**. The outlet of the evaporator **30** is connected by the suction conduit **32** to the inlet of the suction line control valve **34** which is housed in the same housing **36** as the liquid flow control device **26**. The outlet of the suction line control valve **34** is connected to the suction line **22** connecting with the inlet of the compressor **20**.

The suction line control valve **34** includes an inlet fitting **38** containing an inlet passage **40** leading to a piston valve **42** slidably mounted within the double cylinder housing **44**. The lower end of the double cylinder housing **44** has a beveled rim resting upon a gasket **46** mounted on a shoulder of the inlet fitting **38** for sealing the cylinder member **44** to the inlet fitting **38**. The cylinder member **44** extends through an opening **48** in the housing **36** and the inlet fitting **38** is sealed to the housing **36** surrounding the opening **48**. The double cylinder member **44** is provided with a plurality of slots **50** in its sides above the lowermost position of the piston valve **42** which are progressively uncovered as the piston valve **42** rises under pressure in the inlet passage **40**.

The piston valve **42** is provided with a central strainer **52** at the entrance of its hollow central portion which connects through a leakage path which includes the radial passage **54** and annular passages **56** and **58** which connect with the dash pot chamber **60** formed by the junction between the smaller cylinder portion **62** of the member **44** and the larger portion **64** thereof. The piston valve **42** has an enlarged upper portion **66** provided with a flexible plastic seal ring **68** which is U-shaped in cross-section and contains several tiny apertures. This seal ring **68** cooperates with the chamber **60** to form a dash pot which prevents hunting of the piston valve **42** and assures smooth operation.

The upward movement of the piston valve **42** is opposed by a light conical coil spring **70** having its lower end seated on top of the piston valve **42** and its upper end seated upon the plate **72** fitting on a shoulder in the upper portion of the enlarged cylinder portion **64** inside a seal ring **74**. Resting upon top of the seal ring **74** and the perforated disk **72** is the out-turned flange **76** of an inverted cup-shaped member **78**. A clamping ring **80** rests on top of the out-turned flange **76** to hold the out-turned flange **76** in sealing engagement with the seal ring **74** and in engagement with the adjacent edge of the disk **72**. On top of the clamping ring **80** rests the lower end of a stiff compression type coil spring **82** which surrounds the inverted cup-shaped member **78** and has its upper end bearing against the in-turned flange **84** of the housing **36**. The in-turned flange **84** connects directly to the outlet fitting **86** connecting with the suction line **22**. The coil spring **82** holds the inverted cup member **78** and the double cylinder member **44** in place with its beveled rim sealed upon the gasket **46** surrounding the inlet passage **40**.

The perforated disk **72** carries a bellows mounting member **88** and a bellows evacuating tube **90**. The bellows evacuating tube **90** extends to the interior of a metal bellows **92** having its lower edge sealed to the bellows mounting member 88 and having an upper closed end **94** containing a spring retainer **96** supporting the upper end of a compression type coil spring **98**, the lower end of which is seated on the bellows supporting member **88**. This bellows **92** is evacuated so that it will be collapsed by a high pressure and expanded by the spring **98** at a lower pressure. It is exposed to the pressure prevailing within the inverted cup-shaped member **78** which through leakage is responsive to the pressure in the inlet passage **40**.

Resting on top of the closed end **94** of the bellows **92**, is a plastic valve member **121** having a frusto-spherical bottom surface and a cup-shaped inner valve seat which is adapted to cooperate with the rounded end of the hollow screw **123** having a restricted passage extending down to its rounded lower end. This screw **123** is threaded through the top of the inverted cup-shaped member **78** and is locked in place by the lock nut **125**. This screw **123** is accessible from the outlet passage **127** in the outlet fitting **86** for adjustment. The screw **123** is surrounded by a light compression type coil spring **129** having its upper end held by the top of the inverted cup-shaped member **78** and its bottom supported on the flange of the plastic valve member **121**. The bellows **92** is shown holding the valve member **121** tightly against the bottom of the screw **123** so as to close the restricted passage in the screw **123** to prevent the escape of gas from the interior of the inverted cup-shaped member **78** surrounding the bellows **92**.

The leakage past the piston valve **42** will tend to keep the pressure within the inverted cup-shaped member **78** substantially at the same pressure as the inlet passage **40**. When this pressure rises to the desired minimum pressure to be maintained in the evaporator **30**, the bellows **92** will be compressed to allow the valve member **121** to move away from the bottom of the screw **123** to allow a flow out of the inverted cup-shaped member **78** through the hollow screw **123** to reduce the pressure above the piston valve **42** to allow the piston valve **42** to open wider to reduce the pressure in the evaporator **30** to maintain the selected pressure and temperature. The selected pressure and temperature is adjusted by the adjustment of the screw **123**.

The housing **36** is also provided with an inlet fitting **133** containing an inlet passage **135** connected to the outlet of the condenser **24**. This inlet fitting **133** is sealed to an opening **137** in the housing **36**. The housing **36** is also provided with an outlet fitting **139** containing an outlet passage **141** connecting with the liquid line **28**. This outlet fitting **139** is sealed to the housing **36** surrounding the opening **143**. The outlet fitting **139** is provided with a shoulder **145** containing a seal ring **147** on which rests the bottom of a cylinder member **149**. This cylinder member **149** contains a piston valve or slide valve **151** surrounded by a plastic seal ring **153** which is U-shaped in cross-section and cooperates with the inner cylindrical wall of the cylinder member **149** to form a fluid motor.

Threaded into the bottom of the cylinder member **149** is a hollow stem **155** containing a long passage **157** connecting with the inlet passage **135** and a restricted passage **159** connecting with the outlet passage **141**. The passage **157** is provided with a branch passage **161** connecting with a vertical slot **163** on the outer face of the stem **155**. The piston valve **151** slides on the outer surface of the stem **155** over the slot **163**. The piston valve **151** is urged downwardly to a position covering the slot **163** against the bottom of the cylinder member **149** by a compression type coil spring **165** which at its lower end is seated on an outwardly extending flange of the piston valve **151** and at its upper end, is supported by the disk **167** which is threaded into an upper cylindrical member **169** which rests on top of the lower cylinder member **149**. Both cylinder members are held in place by the heavy coil spring **171** which rests on the outer flange of the upper cylinder member **169** and at its upper end bears against the inner wall of the housing **36** surrounding the opening **137**. The inlet fitting **133** has a cylindrical portion extending downwardly telescoping the upper end of the hollow stem **155** and extending over the seal ring **173**. The housing **36** is made of sheet metal with an upper half and a lower half connected together at the outwardly turned flanges **175**.

The bottom of the cylinder member **149** is provided with a plurality of drilled diagonal passages **177** extending from the annular chamber **179** formed between the piston valve **151** and the bottom of the cylinder member **149** to the outlet passage **141**. The piston valve **151** is therefore subject to the difference in pressure between the chamber **179** and the pressure of the gas above it which has direct communication through the interior of the upper cylinder member **169** and the housing **36** with the pressure prevailing in the outlet passage **127** connecting with the suction line **22**. When the suction line control valve **34** is throttling to such an extent that the compressor **20** is lowering the pressure in the suction line **22**, there will be a correspondingly low pressure on top of the piston valve **151** to cause it to open because of the greater pressure in the chamber **179**. That is, the piston valve **151** will open wider upon lowering of the pressure in the suction line **22**. When the pressure within the evaporator is high, this will raise the pressure in the chamber **179** to assist in the opening of the piston valve **151** and the uncovering of the slot **163**. The uncovering of the slot **163** will allow augmented flow of liquid refrigerant from the passage **151** through the passage **161** and the slot **163** to the chamber **179** and through the passages **177** to the outlet passage **141**. This will augment the flow of liquid refrigerant through the restricted passage **159** by providing additional flow through this by-pass arrangement. Under normal operating conditions the piston valve **151** will uncover the slot **163** to a greater or lesser extent to provide sufficient flow to keep the evaporator **30** supplied with as much liquid refrigerant as it can beneficially use. The piston valve **151** will normally move to close the slot **163** when the automobile engine is idling and driving the compressor **20** at a very low speed. Under such circumstances a minimum flow of refrigerant is provided through the restricted passage **159**. Through this simple arrangement the flow of liquid refrigerant is controlled.

In FIGURE 3 there is shown a modified liquid flow control device **220** similar in its system of control. It includes a valve body **222** having an inlet connection **224** adapted to be connected to the outlet of the condenser **24** and an outlet connection **226** adapted to be connected to the liquid line **28**. The inlet connection **224** connects through an inlet passage **228** to the valve seat bushing **230** which is threaded into the valve body **222** between the inlet passage **228** and the diaphragm chamber **232**. This valve seat bushing **230** includes a passage **234**, the outlet of which is provided with a valve seat cooperating with the needle valve **236**. The needle valve **236** is provided with a stem passing through the diaphragm follower **238** and held thereto by a light conical coil spring **240** located on the other side of the follower **238**. This arrangement enables the needle valve **236** to align itself with the passage **234**. The follower **238** is clamped by a clamping ring **242** to a diaphragm **244** of flexible synthetic rubber or plastic having an inner bead **246** clamped between the clamping member **242** and the diaphragm follower **238**. The periphery of the diaphragm **244** is provided with an outer bead **248** which is lodged in a recess in the valve body **222** surrounding the diaphragm chamber **232**.

The bead **248** is locked in place by the fitting **250** having an outwardly turned flange **252** pressing against the diaphragm **244** held in place by the turned in rim **254** upon the valve body **222**. The diaphragm follower **238** also serves as a spring retainer for one end of the coil spring **256**, the other end of which is held by the adjustable spring retainer **258** which is threaded in the fitting **250**. This spring retainer **258** is provided with a hexagonal aperture which can be adjusted through the threaded pressure connection **260** at the outer end of the fitting **250**. This threaded section **260** is adapted to be connected by a flare connection with tubing which will connect with the suction line **22** so that it is responsive to the pressure between the suction line control valve **34** and the inlet of the compressor **20**.

The diaphragm **244** constitutes a fluid motor subject on its right face to suction pressure as prevails between the suction line control valve **34** and the inlet to the compressor **20** and to evaporator pressure on the left face. It is the equivalent of the piston valve **151** in FIGURE 1 which likewise constitutes a fluid motor subject to the same pressures. The diaphragm chamber **232** connects with the passage **262** to the outlet connection **226** connecting with the liquid line **28**. To prevent the flow from being completely closed during idle conditions of the automobile engine and correspondingly slow compressor speeds, the valve **236** is provided with a constantly open restricted passage corresponding to the passage **159** by providing a transverse groove **264** across the face of the bushing **230** which will permit restricted flow even when the needle valve **236** is seated. The opening of the needle valve **236** will in effect provide a by-pass for the groove **264**. The valve shown in FIGURE 3 is a full equivalent of the liquid flow device **26** shown in FIGURE 1 and operates to control the liquid flow in substantially the same way.

In FIGURE 4 is a simplified form of liquid flow control device adapted to be housed within a straight tube **321**. It includes a sleeve **323** having a hollow screw **325** threaded into its closed end **327** and locked by a lock nut **329**. The sleeve **323** has an outwardly extending flange **331** fitting the interior of the tube **321** provided with an annular groove containing a seal ring **333** providing a seal between the interior surface of the tube **321** and the sleeve **323**. Within the sleeve **323** is a piston valve **335** containing a central passage **337** which is held in the sleeve **323** by a C-type retainer **339**. The piston valve **335** is provided with a groove containing a seal ring **341** providing a seal between the piston valve **335** and the sleeve **323**. The piston valve **335** is urged to the left by a compression type coil spring **343** which engages the enlarged portion of the piston valve **335** at one end and the closed end **327** of the sleeve **323** at the opposite end.

The piston valve **335** is provided with a valve seat **345** at its small end which is adapted to seat upon the rounded end of the hollow screw **325**. The passage **337** in the piston valve **335** is larger than the restricted passage **347** provided in the rounded end of the hollow screw **325**. When the piston valve **335** has its seat **345** separated from the rounded end of the hollow screw **325** liquid refrigerant coming through the inlet end **349** of the tube **321** passes through the passage **337** into the interior of the sleeve **323** and some can also flow through the restricted passage **347** in the hollow screw **325** to the outlet end **351** of the tube **321**. Whenever the valve seat **345** is separated from the screw **325** the restrictor **347** is by-passed by flow out of the sleeve **323** through an aperture **353** in the wall thereof to the outlet **351**. This provides the condition for normal flow. However, to prevent flooding of the evaporator during idling conditions of the automobile engine, when the pressure differential on the piston valve **335** is high, the piston valve **335** will be moved to the right against the force of the spring **343** until the seat **345** engages the rounded end of the hollow screw **325**. This will prevent any flow by-passing the restrictor **347** and require all the flow to pass from the passage **337** through the restricted passage **347** to the outlet **351**. The inlet of the tube **321** connects to the outlet of the condenser **24** while the outlet **351** connects to the liquid line tube **28**. The piston valve **335** constitutes a fluid motor responsive to the difference in pressures on its opposite sides controlling the by-passing of the restrictor passage **347**.

While the embodiment of the present invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. Refrigerating apparatus including a compressor having an inlet and an outlet, a condenser having an inlet connected to said outlet and having an outlet, evaporating means having an inlet and an outlet, a suction line control valve connected between the outlet of said evaporating means and the inlet of said compressor, a flow control device having an inlet connected to the outlet of said condenser and having an outlet connected to the inlet of said evaporating means, said flow control device comprising valve means provided with pressure responsive operating means substantially responsive to the difference between the pressure in the evaporating means and the pressure between the suction line control valve and the inlet of said compressor, said pressure responsive operating means being oriented and connected to provide increased opening of the valve means in response to reduced pressure between said suction line control valve and the inlet of said compressor.

2. Refrigerating apparatus including a compressor having an inlet and an outlet, a condenser having an inlet connected to said outlet and having an outlet, evaporating means having an inlet and an outlet, a suction line control valve connected between the outlet of said evaporating means and the inlet of said compressor, a flow control device having an inlet connected to the outlet of said condenser and having an outlet connected to the inlet of said evaporating means, said flow control device comprising valve means substantially responsive to the difference between the pressure in the evaporating means and the pressure between the suction line control valve and the inlet of said compressor, said flow control device also having a restricted orifice bypassing said valve means to assure a minimal flow.

3. Refrigerating apparatus including a compressor having an inlet and an outlet, a condenser having an inlet connected to said outlet and having an outlet, evaporating means having an inlet and an outlet, a suction line control valve connected between the outlet of said evaporating means and the inlet of said compressor, a flow control device having an inlet connected to the outlet of said condenser and having an outlet connected to the inlet of said evaporating means, said flow control device comprising a valve means for controlling flow through its inlet and a fluid motor having opposite faces for operating said valve means, said fluid motor having one face exposed to and responsive substantially to the pressure between the suction line control valve and the inlet of said compressor and having an opposite face exposed to and responsive substantially to the pressure within the evaporating means, said valve means being connected to said fluid motor in an orientation to open wider in response to lowering of pressure between the suction line control valve and the inlet of said compressor.

4. Refrigerating apparatus including a compressor having an inlet and an outlet, a condenser having an inlet connected to said outlet and having an outlet, evaporating means having an inlet and an outlet, a suction line control valve connected between the outlet of said evaporating means and the inlet of said compressor, a flow control device having an inlet connected to the outlet of said condenser and having an outlet connected to the inlet of said evaporating means, said flow control device comprising a valve means for controlling flow through its inlet and a fluid motor for operating said valve means, said fluid motor having opposed surfaces with one of the opposed surfaces being exposed to and responsive substantially to the pressure between the suction line control valve and the inlet of said compressor and another of the opposed surfaces being exposed to and responsive to the pressure in said evaporating means.

5. Refrigerating apparatus including a compressor having an inlet and an outlet, a condenser having an inlet connected to said outlet and having an outlet, evaporating means having an inlet and an outlet, a suction line control valve connected between the outlet of said evaporating means and the inlet of said compressor, a flow control device having an inlet connected to the outlet of said condenser and having an outlet connected to the inlet of said evaporating means, said flow control device comprising a valve means for controlling flow through its inlet and a fluid motor for operating said valve means, said suction line control valve having an outlet connected to said flow control device, said fluid motor being located in said device exposed to and located between and separating the connection with said suction line control valve and the outlet of said device.

6. Refrigerating apparatus including a compressor having an inlet and an outlet, a condenser having an inlet connected to said outlet and having an outlet, evaporating means having an inlet and an outlet, a suction line control valve connected between the outlet of said evaporating means and the inlet of said compressor, a flow control device having an inlet connected to the outlet of said condenser and having an outlet connected to the inlet of said evaporating means, said flow control device comprising means forming a constantly open restricted passage and a bypass for said restricted passage provided with valve means and a pressure differential fluid motor device for operating said valve means.

7. A flow control device including a body having an inlet and an outlet, means within said body containing a restricted passage between said inlet and outlet, valve means cooperating with said passage for controlling fluid flow through said passage, a fluid motor within said body responsive to the pressure in said body between said passage and said outlet, said valve means being operatively connected to said fluid motor, one of said means being provided with a substantially smaller passage to provide a minimum flow when said valve means is in closed position.

8. A flow control device including a body having an inlet and an outlet, means within said body containing a restricted passage between said inlet and outlet, valve means cooperating with said passage for controlling fluid flow through said passage, a fluid motor within said body responsive to the pressure in said body between said passage and said outlet, said valve means being operatively connected to said fluid motor, one of said means being provided with a substantially smaller passage to provide a minimum flow when said valve means is in closed position, said body having an additional chamber associated with said fluid motor for varying the operation of said fluid motor to vary the operation of said valve means.

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MEYER PERLIN, *Primary Examiner.*