United States Patent [19]

Kramer

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[45] **Dec. 18, 1973**

[54] **SUCTION ACCUMULATORS FOR REFRIGERATION SYSTEMS**

[76] Inventor: **Daniel E. Kramer,** 2009 Woodland Dr., Yardley, Pa. 19067

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

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

[58] **Field of Search** 62/278, 472, 503

[56] **References Cited**

UNITED STATES PATENTS

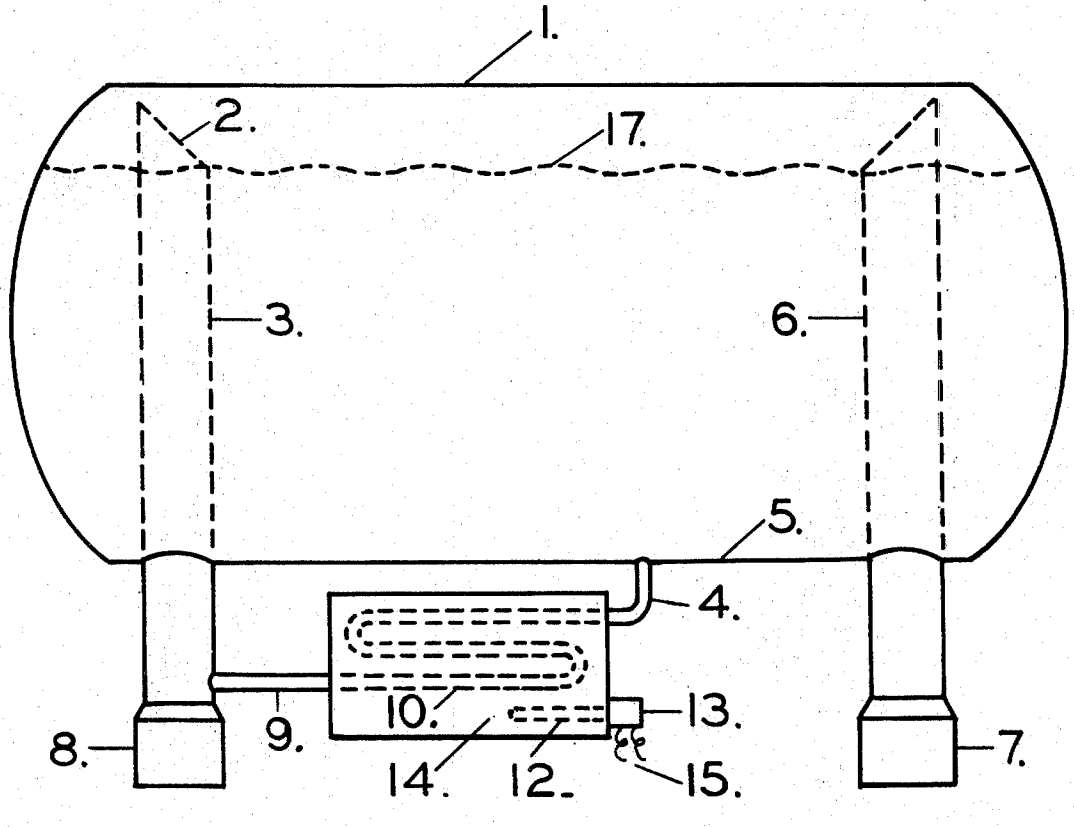
2,614,402	10/1952	Swart	62/503
2,698,522	1/1955	La Porte	62/503
3,012,414	12/1961	La Porte	62/503
3,060,704	10/1962	Miller	62/503
3,071,935	1/1963	Kapeker	62/503
3,276,215	10/1966	McDonell	62/472
3,636,723	1/1972	Kramer	62/503

Primary Examiner—Meyer Perlin

[57] **ABSTRACT**

In a suction accumulator for refrigeration systems, the improvement which comprises an external conduit for the flow of oil and of trapped liquid refrigerant which conduit passes in heat exchange relation with a heat storage means allowing the stored heat to be transferred to the liquid refrigerant and oil as it flows through the conduit.

8 Claims, 8 Drawing Figures



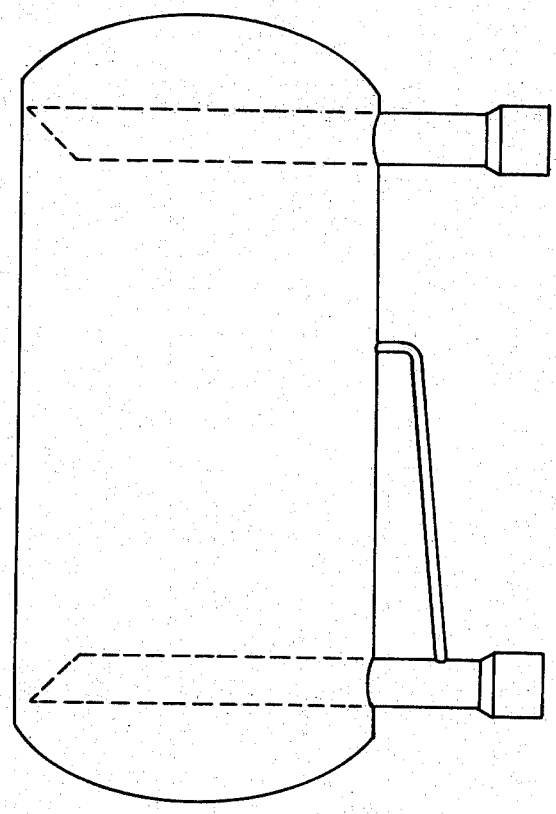


FIG. 2.

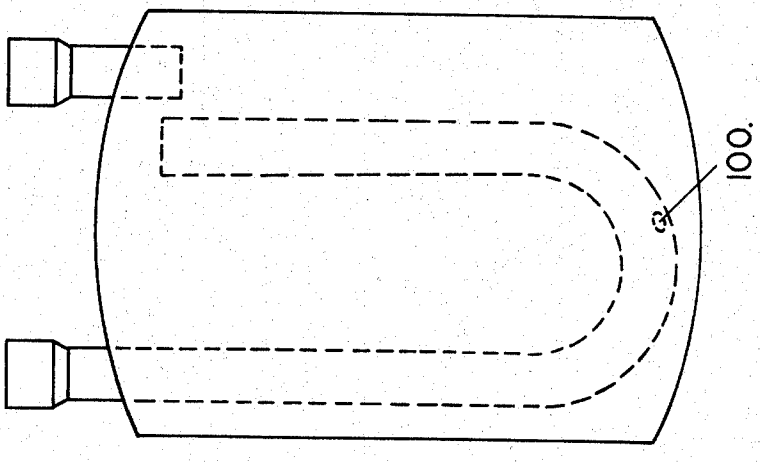


FIG. 1.

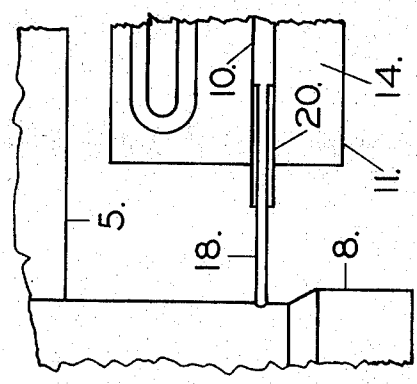


FIG. 5.

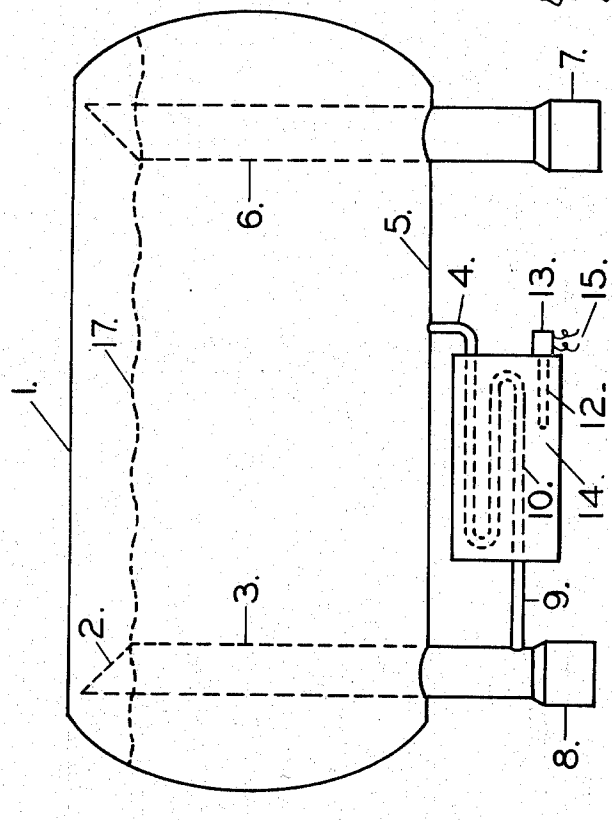


FIG. 3.

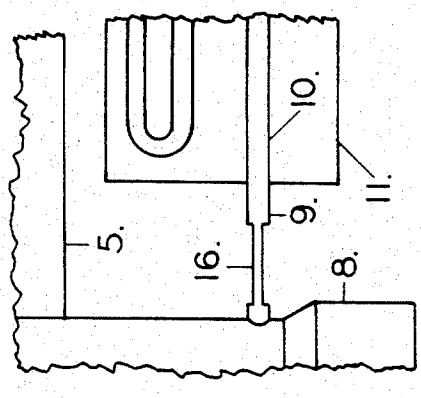


FIG. 4.

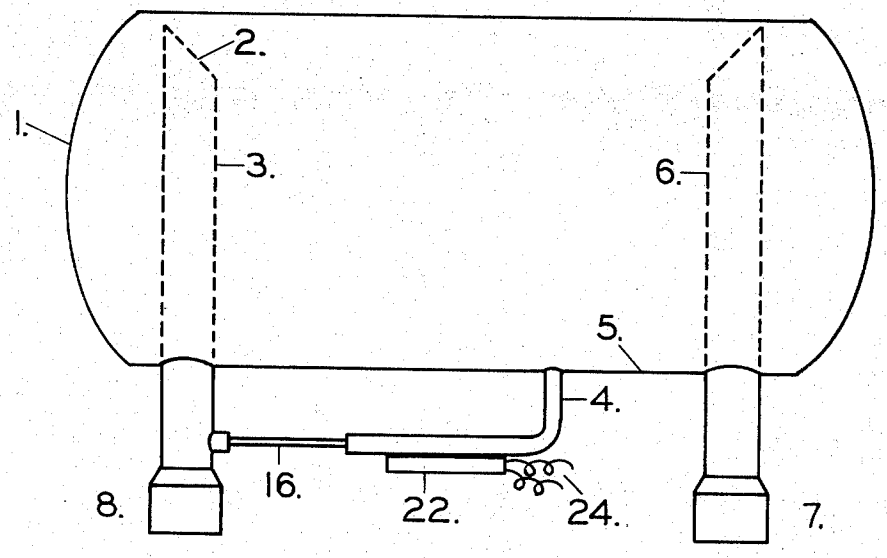


FIG. 6.

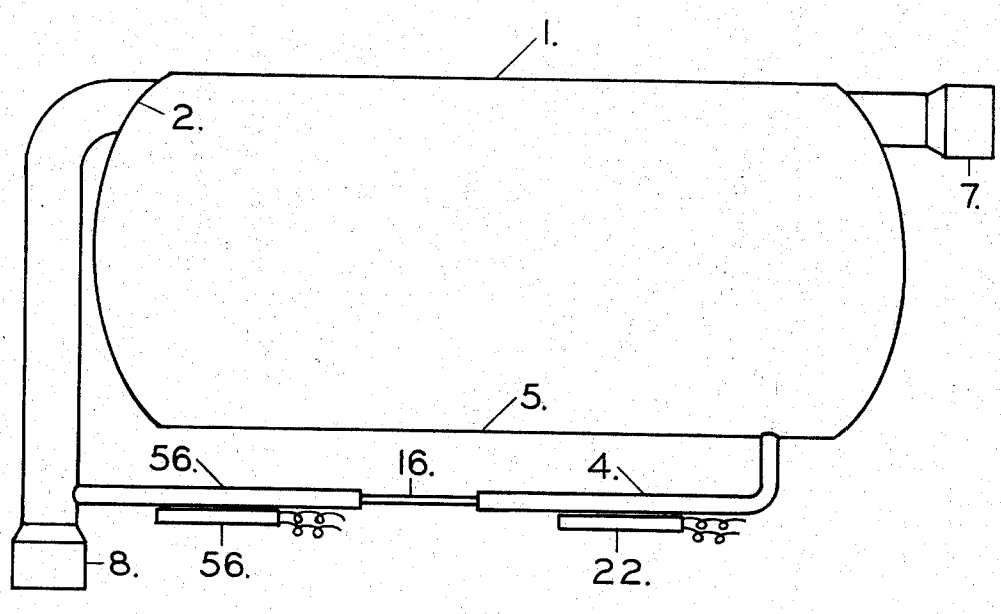


FIG. 7.

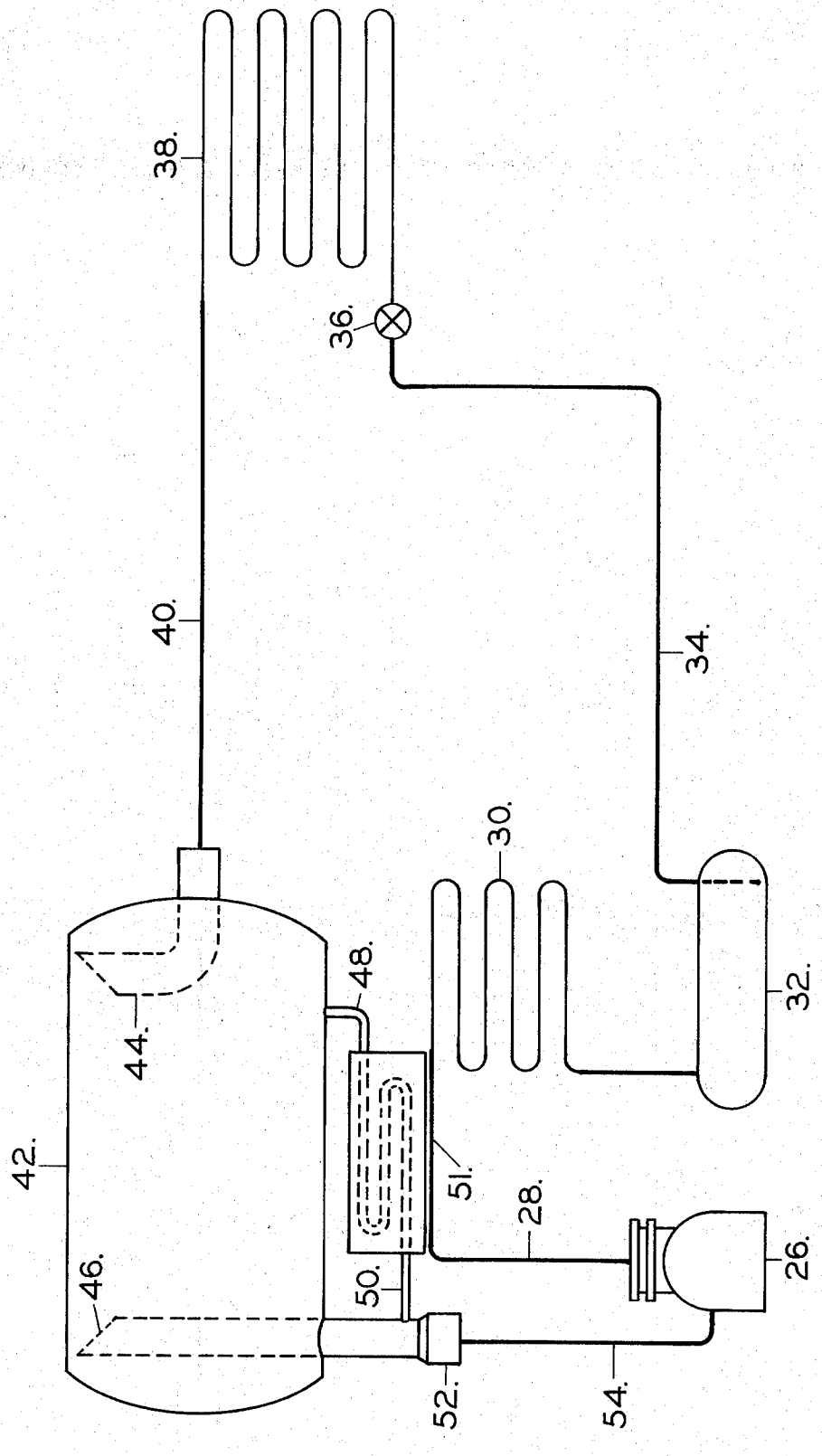


FIG. 8.

SUCTION ACCUMULATORS FOR REFRIGERATION SYSTEMS

BACKGROUND OF THE INVENTION

Modern positive displacement refrigerant compressor technology has generated designs which provide the maximum in capacity per unit, weight, cost and power. In order to achieve these features, the compressors are generally designed for relatively high rotative speeds and high bearing loads. Standard rotative speeds for compressors are approximately 1,725 and 3,400 revolutions per minute. At these speeds, ingestion of liquids of any sort into the compression chamber can cause instantaneous mechanical failure.

Liquid entering the cylinders can stem from two sources: 1) Liquid oil entering the cylinders from foaming of the oil in the compressor crankcase on startup, especially under conditions where liquid refrigerant has condensed or dissolved in the oil during the off cycle. 2) Liquid refrigerant in relatively pure form accidently returning through the suction line from the evaporator.

If large quantities of liquid oil or refrigerant enter the compressor, much of the liquid will be entrained into the cylinders with the vapor and will cause a condition known as slugging which is accompanied by pounding and knocking sounds and frequently will cause instantaneous compressor damage.

If liquid regrigerant returns to the compressor in small quantites, but over a long period of time, the liquid refrigerant tends to dilute the oil reducing its lubricity and generating a condition of rapid bearing wear under those design conditions of high rotative speeds and high bearing loads to which the compressor is ordinarily exposed.

To help guard compressors against either immediate or long-range damage, more and more compressor manufacturers presently recommend the use of so-called surge drums or suction accumulators whose purpose is to catch the liquid refrigerant returning in large or small quantities and prevent this potentially harmful liquid refrigerant from reaching the compressor.

Because of the recently increased requirements for suction line protection against liquid return to the compressor, many manufacturers have begun listing for sale suction accumulators with various inlet and outlet line sizes supposedly designed to fit a wide range of systems and refrigerant charges.

Manufacturers of accumulators are faced with the problem of providing positive means for the oil, which normally circulates with the refrigerant in refrigeration systems, to be returned to the compressor. If this oil is not returned, but is caught or trapped in the suction accumulator, the compressor not only may run out of oil but the accumulator's potential for holding liquid refrigerant may be diminished. A means that manufacturers have in the past used to achieve this oil return, is the provision of a metering hole (**100**) in FIG. **1** large enough to allow the return of oil to the compressor without accumulation in the accumulator. Since the metering hole is built-in, it must be made large enough to return the maximum flow of oil that might ever be expected.

Unfortunately, experience has shown that if the metering means is made large enough to return oil at the highest rate at which it might be delivered to the discharge stream by any compressor, the metering means is then so unrestrictive that excessive amounts of refrigerant are allowed to return to the compressor when the accumulator is partially filled with liquid refrigerant.

An improved accumulator design is shown in FIG. **2**. This design has the advantage of having an external metering tube which is so designed and constructed that it can be removed and exchanged for a tube of a different diameter. Either solder or mechanical connections at the ends of the metering tube can be used, but mechanical connections are preferred for improved ease of inspecting, cleaning or replacing the metering tube.

In addition, this design permits the metering tube to be made with its internal diameter as small as necessary without any concern that dirt might plug the metering tube and permanently destroy the usefulness of the accumulator, since the tube can be removed readily for inspection and cleaning.

Instead of the metering means having to be made sufficiently large for the highest predictable oil return rate, the metering tube can be made with an internal bore which closely matches the system requirements. Even if an error is made in initially sizing the metering tube, its accessability makes substitution of a different size easy.

Though the development of the suction accumulator with an external and replaceable metering tube constituted an important advancement over the best previously available accumulators, all these accumulators had an inherent defect, namely that liquid refrigerant caught and retained had to be returned, however slowly, to the suction line. Therefore, accumulators were best installed so that a relatively long run of suction line existed between the outlet of the accumulator and the compressor inlet. In addition, the suction line was preferably exposed to an ambient significantly higher than the saturated suction temperature. The purpose of requiring this length of suction line maintained in a relatively high ambient was to ensure that the liquid refrigerant that flowed through the metering tube into the suction line, under conditions when flood-back into the accumulator occurred, was completely evaporated to dryness so that no liquid refrigerant at all entered the compressor.

Under the conditions where the accumulator is placed very close to the compressor and/or where a very short suction line is employed or the suction line is exposed to relatively cold winter ambients, for example, +20 for air conditioning systems or −10 for freezer systems, complete reevaporation of the liquid refrigerant flowing through the metering tube may not occur. The residual liquid refrigerant entering the compressor can cause oil dilution and excessive bearing wear leading to early compressor failure.

The low ambient problem is aggravated by the increased viscosity of oil when cold. Although the oil pumping rate of the compressor is constant, regardless of its surrounding ambient, the ability of the oil metering tube to return oil depends on the viscosity of the oil.

Therefore, accumulators which must function in cold ambients must have metering tubes which are much less restrictive, i.e., larger in diameter, than have accumulators designed to work in warm ambients.

While the viscosity of oil increases sharply as its temperature drops, the viscosity of liquid refrigerant increases only slightly for the same temperature drop. Consequently, the increased metering tube diameter required to satisfactorily return oil when the accumulator is in a low ambient can and does pass quantities of

liquid refrigerant which are excessive when liquid refrigerant collects in the accumulator.

In order to make sure that no liquid returns to the compressor, even where the suction line is short and cold as, for instance, where the accumulator is mounted directly on the compressor chassis, several solutions are possible. One is the provision of a heater or heat exchanger in the suction line between the accumulator outlet and the compressor using, for instance, the heat available from the hot gas leaving the compressor to evaporate the liquid mixed with suction vapor. This system has the drawback that the normally cold suction vapor is heated, not only when the ambient surrounding the system is low, as in the winter, but also when the weather is very hot. Then the suction heat exchanger aggravates potential compressor overheating and reduces compressor capacity by warming the suction vapor entering the compressor which makes the vapor less dense and allows the compressor to pump less refrigerant with each rotation of its crank shaft.

A second method for achieving the desired result is to evaporate the liquid while it is in the metering assembly. A basic principle of this improvement involves the application of a heater to the external metering tube assembly so selected that liquid refrigerant flowing through the assembly is essentially completely reevaporated before it reaches the suction line. This construction has the advantage that even vigorous heating of the assembly will have essentially no effect on the temperature of the vapor leaving the accumulator. The heater therefore becomes discriminating in that it only heats liquid refrigerant or oil leaving the accumulator via the assembly but does not exert any significant heating effect on the suction vapor traversing the accumulator itself.

Unfortunately, when the accumulator is exposed to cold ambients, the metering tube must be very large, ie 5/16 in. inside diameter (id) or larger compared to 0.090 id or smaller needed when the accumulator is in a warm ambient.

The rate of liquid refrigerant flow which can traverse the large metering tube is so great that a very high rate of heat input is needed to completely evaporate all the refrigerant flowing through the metering tube.

SUMMARY OF THE INVENTION

The application of a large wattage electric heater to the heat exchange portion of the metering tube is feasible but costly. This invention is the improvement where a small wattage electric heater is used to store heat in a heat-hold of the sensible or latent type where the heat-hold is in heat exchange relation to the metering tube. The heat storage means may be a tank which contains a liquid such as water.

If the liquid is cooled but not frozen, the heat is the sensible type. If some of the water is frozen, the heat storage is the latent type. The heat storage means may be solid as a block of copper or aluminum and it may be insulated to prevent heat loss to the atmosphere. Suction accumulators utilizing the improvement of this invention can be used in very low ambients and will freely return oil as it enters the accumulator, yet will completely reevaporate refrigerant liquid which enters the metering tube, so that no liquid refrigerant enters the compressor.

For purposes of utilizing a small heat storage means, it may be desirable to restrict the metering tube. Another facet of the invention lies in providing a restriction in the metering tube. The restriction must be so located that the heating means can warm the oil leaving the accumulator via the metering tube before the oil encounters the restriction.

Although the described accumulator can be applied in the suction line of any refrigerant system, it is a further intent to apply this accumulator to a hot gas defrost system. A hot gas defrost system utilizing this accumulator can be applied even when the compressor, the accumulator and other high side components are located in low winter ambients. Accumulators not utilizing the improvement described herein allow, under these conditions substantial floodback to the compressor. Defrost under these conditions could not occur without damaging floodback.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross section of a common commercial Suction Accumulator with an internal metering hole.

FIG. **2** is a cross section of an improved suction accumulator with an external metering tube.

FIG. **3** is an accumulator with an external metering tube which passes in heat exchange relation with a heat storage.

FIG. **4** is an inset showing an alternate construction of an accumulator like that of FIG. **3** where a section of the metering tube at the outlet of the heat storage is restricted.

FIG. **5** is an inset showing an alternate construction of an accumulator like that of FIG. **4** where the restricted portion of the metering tube extends into the heat storage.

FIG. **6** shows an accumulator where the inlet portion of the metering tube has a large diameter and is heated and the outlet portion of the metering tube is restricted.

FIG **7** shows an accumulator similar to that of FIG. **6** except only the mid-portion of the metering tube is restricted and the inlet and outlet portions are heated.

FIG. **8** shows a complete refrigeration system utilizing an accumulator installed in the suction line.

DETAILED DESCRITPION OF THE PREFERRED EMBODIMENT

In the accumulator of FIG. **3** there is a tank **1** which is constructed to be sufficiently strong to safely withstand the internal refrigerant pressures to which it may be exposed. The tank has an inlet fitting **7** connected to an inlet tube **6** which extends into the accumulator to a point close to the top of the tank. This is to ensure that the entering vapor does not bubble through a body of liquid **17** collected in the accumulator since this would cause agitation of the liquid and entrainment of some of the liquid into the vapor stream. The outlet tube **3** also extends into the tank as high as possible to allow the maximum quantity of liquid to be accumulated in the accumulator before overflow of pure liquid into the outlet tube occurs. Such overflow would indicate that the tank was not selected large enough and that a larger one should be employed.

The bottom **5** of the tank has a port into which a metering tube **4** is sealed. The metering tube connects to tubes **10** in a heat storage **11** which may be solid, as aluminum or cast iron, or may be a container filled with a heat storage liquid, such as water or glycol-water mixture. Whether the heat storage is solid or liquid, a heater **12** is employed to keep the heat storage warm.

The tubes 10 in the heat storage have an outlet in tube 9 which completes the flow circuit of the metering tube to allow metered flow from the bottom of the accumulators to the outlet tube 3.

In the event the diameter of the metering tube 10 is so large that the heat storage cannot completely evaporate all the liquid refrigerant which can flow through it, it may be necessary to constrict the metering tube circuit. The most desirable location for the constriction is at the outlet connection 9 of the heat storage. This ensures that cold viscous oil which moves with great reluctance through small tubes can enter the warm heat storage 11 via the larger tube 4. The cold viscous oil warms sufficiently in the heat storage 11 to cause its viscosity to reduce (make the flowability greater) to the point where the oil can flow freely through the restricted portion 16. In FIG. 5 the restricted portion 18 of the metering tube circuit extends partly into the heat storage. This technique allows a greater length of restrictive tube to be employed because the space available between the outlet of heat storage 11 and the tank outlet 3 may be limited.

FIG. 6 shows an accumulator with a shell 1, an inlet tube penetrating the shell with an exterior part 7 and an interior part 6 extending to the top of the accumulator shell 1, an outlet with an interior part 3 and an exterior part 8 and an oil metering tube 4 penetrating the bottom of shell 1. The metering tube has a reduced diameter outlet portion 16. The large inlet portion of the metering tube 4 is heated by electric heater 22 or by thermal contact with a portion of hot gas tube equivalent to conduit 51 in FIG. 8.

When suction vapor containing admixed liquid refrigerant enters the accumulator through inlet 6 & 7, the liquid separates from the vapor and falls to the bottom 5. The vapor, free of entrained liquid, flows direct to the inlet part 2 of outlet tube 3 and flows on to the compressor via outlet tube 8.

The collected liquid, it it be refrigerant, flows to the outlet 8 through metering tube 4 but its rate of egress is sufficiently sharply reduced by restricted portion 16 that the relatively low wattage heater 22 can essentially completely evaporate the liquid to a vapor so that essentially only vapor enters the suction line on the outlet side of the accumulator.

If the liquid be oil, it will, though very viscous, readily flow into the large metering tube 4 where it will be heated by heater 22. The warmed and much less viscous oil will now readily flow through the restricted portion 16 of the metering tube and enter the suction stream on the outlet side of the accumulator without excessive quantities collecting in the accumulator shell.

The accumulator of FIG. 7 is essentially identical to that of FIG. 6 except the inlet 7 is at the top of the tank 1 and does not extend into it. The inlet portion 2 of outlet lead 8 is at the top of the tank and the outlet lead 8 extends downward to a point below the bottom of tank 5 for connection thereto of the outlet portion of metering conduit 4. The heaters 22 and 58 shown may be either electric or a portion of a hot gas conduit or a heat storage means. Heater 58, in heating contact with the outlet portion 56 of the metering conduit, is for the purpose of evaporating even the small amount of liquid refrigerant which restricted portion 16 allows to flow.

The refrigeration system of FIG. 8 shows an accumulator 42 installed in the suction line 40 of a compression type refrigeration system utilizing compressor 26, discharge ine 28, condenser 30, receiver 32, liquid line 34, expansion valve 36 and evaporator 38.

The accumulator has side inlet 44 bent to impinge the entering fluid against the top of the accumulator shell 42. The metering tube 48 traverses a heat storage 50 which is heated by a portion of discharge line 28 passing in heat exchange relation to it.

During extended off cycles of the compressor 26, much or all the refrigerant in the system may migrate to the evapoartor 38 and condense there. On starting the compressor 26, most of the liquid which has condensed in the evaporator during the off cycle will surge toward the compressor.

In the absence of the accumulator 42, the liquid would enter the compressor and damage it. With the accumulator installed as shown, the liquid refrigerant will be trapped in the accumulator and metered back into the suction line at the outlet of the accumulator in vaporous form having been distilled to vapor by the heat storage 50.

I claim:

1. An improvement in an accumulator for installation in the suction line of a refrigerating system, said accumulator having a tank with a top and bottom for separating liquid from vapor, an inlet to the tank for connection to the suction line for receiving suction vapor and liquid, a vapor outlet tube, having an inlet and an outlet for receiving vapor from the tank and discharging it to the suction line, whose inlet is near the top of the tank and whose outlet is below the bottom of the tank, a port in the bottom of the tank and an oil metering tube with an inlet and an outlet whose inlet is connected to the port and whose outlet is connected to the vapor outlet tube at a point outside the tank wherein the improvement comprises a restriction in the metering tube and means for heating an unrestricted portion of the metering tube.

2. An accumulator as in claim 1 where the restriction is near the outlet of the metering tube.

3. An improvement in an accumulator for installation in the suction line of a refrigerating system, said accumulator comprising a tank with a top and bottom for separating liquid from vapor, an inlet to the tank for connection to the suction line for receiving suction vapor and liquid, a vapor outlet tube, having an inlet and an outlet for receiving vapor from the tank and discharging it to the suction line, whose inlet is near the top of the tank and whose outlet is below the bottom of the tank, a port in the bottom of the tank and an oil metering tube with an inlet and an outlet whose inlet is connected to the port and whose outlet is connected to the vapor outlet tube at a point outside the tank wherein the improvement comprises a heat storage in heat exchange relation to the oil metering tube for storing heat and transferring it to the metering tube and where the heat storage is a container of liquid and the metering tube only is immersed in the liquid.

4. An accumulator as in claim 3 where the heat storage includes heating means.

5. An accumulator as in claim 3 where the tube has a portion of reduced diameter.

6. An accumulator as in claim 5 where the portion is adjacent the vapor outlet tube.

7. An improved refrigerating system comprising, in combination, conduit-connected compressor, condenser, receiver, expansion valve, evaporator and suc-

tion accumulator where the accumulator comprises a tank with a top and bottom for separating liquid from vapor, an inlet to the tank for connection to the suction line for receiving suction vapor and liquid, a vapor outlet tube having an inlet and an outlet for receiving vapor from the tank and discharging it to the suction line whose inlet is near the top of the tank and whose outlet is below the bottom of the tank, a port in the bottom of the tank and an oil metering tube with an inlet and an outlet where the inlet of the metering tube is connected to the port and the outlet of the metering tube is connected to the vapor outlet tube at a point outside the tank wherein the improvement comprises a restriction in the metering tube and means for heating an unrestricted portion of the metering tube.

8. An improved refrigeration system which comprises, in combination, conduit-connected compressor, condenser, reciever, expansion valve, evaporator and a suction accumulator where the accumulator comprises a tank with a top and a bottom for separating liquid from vapor, an inlet to the tank for connection to the suction line for receiving suction vapor and liquid, a vapor outlet tube having an inlet and an outlet for receiving vapor from the tank and discharging it to the suction line, whose inlet is near the top of the tank and whose outlet is below the bottom of the tank, a port in the bottom of the tank and an oil metering tube with an inlet and an outlet whose inlet is connected to the port and whose outlet is connected to the vapor outlet tube at a point outside the tank wherein the improvement comprises a heat storage means containing liquid where the metering tube only is immersed in the liquid.

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