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CAPILLARY REFRIGERATING SYSTEMS

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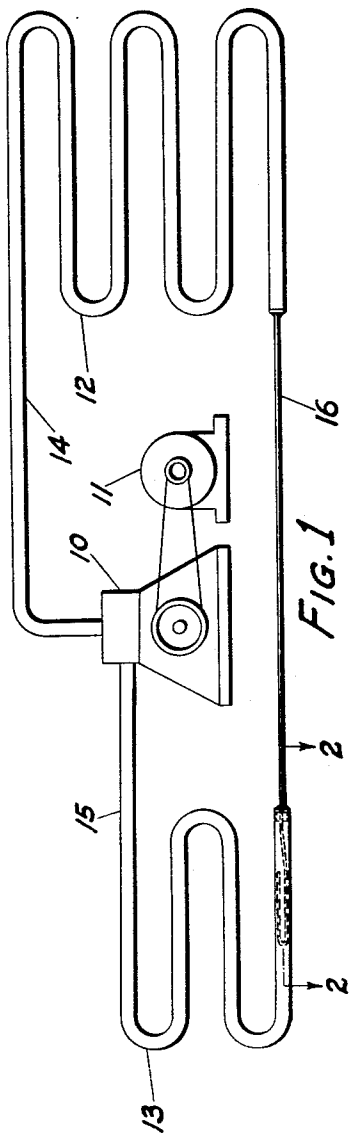


FIG. 1

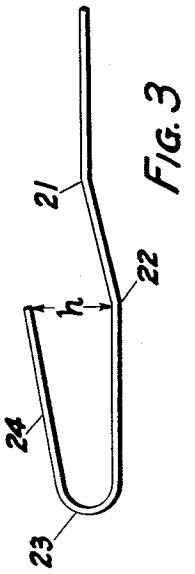


FIG. 3

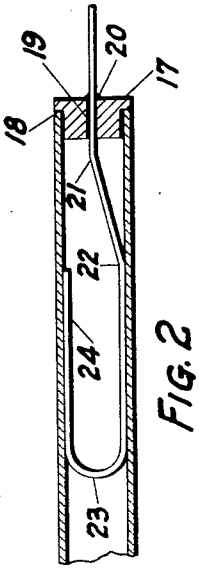


FIG. 2

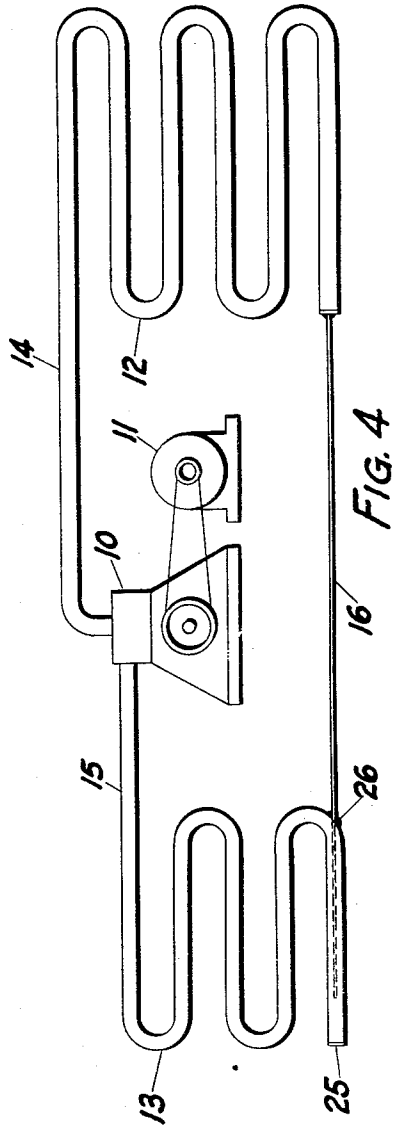


FIG. 4

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CAPILLARY REFRIGERATING SYSTEMS

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This invention relates to refrigerating systems and more particularly to such systems having a capillary fed evaporator.

In a refrigerating system some means must be provided for maintaining the differential in pressure between the evaporator and the condenser of the system, and also for metering the flow of refrigerant from the condenser to the evaporator. This can conveniently take the form of a capillary or restrictor tube. Such a capillary tube has the advantages of low cost and trouble-free operation.

However, in such a capillary, the refrigerant leaving the capillary and discharging into the evaporator comprises a mixture of liquid and gas. This has the effect of producing undesirable noises both due to the higher velocity of the mixture flow through the capillary due to the gas therein and the fact that gaseous globules or pockets of refrigerant form within the evaporator and then collapse.

It is an object of the invention, therefore, to provide a refrigerating system including a capillary fed evaporator wherein refrigerant noises are considerably reduced.

It is a further object to provide a refrigerating system including a capillary fed evaporator wherein refrigerant is discharged into the evaporator in such a manner as to create a turbulent effect thereon.

It is yet another object to provide a refrigerating system including a capillary fed evaporator wherein the refrigerant discharging from the capillary into the evaporator is subcooled prior to such discharge recondensing gaseous refrigerant therein, the capillary being so arranged that an area of turbulence is created within the evaporator into which area the discharging refrigerant is directed.

Yet another object of the invention is to provide a refrigerating system including a capillary fed evaporator, the evaporator including a closed end, and means for discharging refrigerant from the capillary against said closed end.

In carrying out the invention, the capillary is inserted into the evaporator for some portion of its length. The refrigerant mixture flowing through this portion of the capillary is then sub-cooled prior to its discharge to recondense a portion of the gaseous refrigerant. In addition, the capillary is so arranged that it discharges against an end wall of the evaporator. This effects a further noise reduction due to the creation of a turbulent effect on the discharging refrigerant.

The invention consists of the novel constructions, arrangements, devices and methods to be hereinafter described and claimed for carrying out the above-stated objects and such other objects as will appear from the following description of preferred embodiments of the invention illustrated with reference to the accompanying drawings, in which:

Fig. 1 is a diagrammatic view of a refrigerating system embodying the invention;

Fig. 2 is a sectional view on an enlarged scale taken on line 2—2 of Fig. 1, showing a preferred form of a capillary discharging into an evaporator, according to the invention;

Fig. 3 is a side view of the capillary prior to its insertion in the evaporator; and

Fig. 4 is a diagrammatic view of a refrigerating system embodying an alternate embodiment of the invention.

Referring now to Fig. 1, a refrigerating system embodying the invention comprises a compressor **10** driven by a motor **11**. A condenser **12** and an evaporator **13** are provided to complete the basic components of the refrigerating system. The discharge of the compressor **10** is connected to the condenser **12** by way of a hot gas line **14**. The evaporator **13** is connected to the inlet of compressor **10** by way of a cold gas line **15**. Condenser **12** and evaporator **13** are connected together by means of a restrictor or capillary tube **16**.

The end of evaporator **13** connected to the capillary **16** is closed by a connector **17** brazed thereto, as indicated at **18**. A passageway **19** is provided in connector **17** for receiving the capillary tube **16**. The capillary tube **16** extends through the passageway **19**, as can be clearly seen in Fig. 2, and is brazed to the connector **17** at **20**.

Immediately adjacent the connector **17**, the end of the capillary tube is bent, as shown at **21**. A second reversed bend **22** is provided so that the capillary lies adjacent the inner wall of the evaporator **13**. The end of the capillary is turned on itself, as at **23**, and terminates in a free end portion **24**, so that refrigerant leaving the end portion **24** of the capillary discharges against connector **17**.

The capillary, prior to its insertion within the evaporator **13**, takes the form shown in Fig. 3. The distance *h* is greater than the inside diameter of the evaporator **13** so that when the capillary is pressed into its position in the evaporator the free end portion **24** is placed under a compressive force so that the capillary fits snugly within the evaporator adjacent the walls thereof and does not vibrate therein. This has the further effect of consistently locating the free end of the capillary.

In operation, liquid refrigerant evaporated within evaporator **13** flows through cold gas line **15** to the inlet of compressor **10**. After being compressed within the compressor, the now high pressure gas flows through hot gas line **14** and into condenser **12** where it is condensed to a liquid. The liquid then flows through capillary **16** and into evaporator **13** to complete the cycle.

Capillary **16** serves two primary functions: (1) it serves to maintain the differential in pressure between the condenser and evaporator of the refrigerating system and (2) it serves as a metering device to meter the refrigerant from the condenser to the evaporator. It is apparent that the flow rate through the capillary may be varied by varying the length thereof and also the inside diameter. However, once this flow rate has been established for a particular system by fixing the inside diameter and length of the tube, it obviously remains a constant for a given set of ambient conditions. In designing the capillary, a condenser and evaporator temperature are selected as being representative of the average conditions under which the equipment must operate.

In a refrigerating system as set out above, properly charged with a sufficient amount of refrigerant, and operating at the average conditions for which the capillary was designed, liquid refrigerant free of gas enters the capillary from the condenser. In its passage through the capillary from condenser pressure to evaporator pressure, however, a certain portion of the refrigerant flashes into gas, so that a mixture of gaseous and liquid refrigerant is usually emitted from the discharge end of the

capillary. The velocity of the refrigerant mixture leaving the capillary varies as the proportion of gas therein varies; the greater the amount of gas therein, the greater the velocity. A hissing noise is generally produced by the mixture discharging from the capillary. The intensity of the noise varies as the discharging velocity of the mixture varies; the greater the discharging velocity, the greater the noise intensity. It will be apparent, therefore, that the hissing noise produced by the discharging refrigerant will increase as the discharge velocity of the refrigerant increases.

The system will operate with fairly good efficiency over a range of conditions both more and less severe than the design conditions. Quite often, however, the condensing ambient temperature is such that a mixture of gas and liquid refrigerant enters the capillary from the condenser. This will greatly increase the proportion of gas-to-liquid of the refrigerant as it issues from the discharge end of the capillary. As pointed out above, this has the effect of intermittently increasing the velocity of flow through the capillary, increasing the intensity of the hissing noise produced by the higher velocity mixture discharging from the capillary **16** into the evaporator.

In addition to the above hissing noise, there is a further noise effect due particularly, I believe, to globules of gas forming within the evaporator, when the refrigerant mixture discharges from the capillary into the considerably larger evaporator passage, and then collapsing with the attendant noises. This noise is quite apart from the hissing noise produced by the high velocity mixture discharging from the capillary and is quite independent of velocity.

It is well known, of course, that considerable noise can be eliminated by sub-cooling the refrigerant within the capillary before it emerges into the evaporator **13**. This sub-cooling has the effect of recondensing the gas mixed in with the liquid refrigerant. I have provided for this sub-cooling of the refrigerant by inserting a relatively large portion of the capillary into the evaporator so that refrigerant passing there through is subjected to a refrigerating effect once it passes bend **21** and until the time it discharges from the end of the capillary, all as is well known in the art. It will be appreciated that the amount of sub-cooling varies with the amount of capillary lying within the evaporator. An optimum length can be determined empirically beyond which length no appreciable improvement in the noise level will be observed.

In addition to the above, I have discovered that the general noise level can be considerably reduced by discharging the refrigerant into the pocket formed between the evaporator walls and connector **17** and against connector **17**. I believe that the reason this reduces the noise level is that it sets up a turbulent region slowing the velocity of discharge of the mixture of liquid and gas and also either preventing the formation of globules of gas within the evaporator or else collapsing such globules before they have a chance to enlarge to a size sufficient to create an appreciable noise.

In any event, I have discovered that the closer the end of the capillary is to the connector **17**, the greater is the reduction in the noise level. The only limiting factor is, of course, that the end of the capillary must not be so close to the connector **17** as to restrict the flow through the evaporator.

In addition, I believe that the creation of turbulence is aided by the fact that the refrigerant flow must be reversed before it can flow through the evaporator.

In Fig. 4 I show an alternative embodiment in which the same results of sub-cooling the refrigerant and creating a turbulent area within the evaporator are achieved. This is done, however, without the necessity of reversing the capillary on itself. In this embodiment, the end of the evaporator **13** is closed by a plug **25**. The evaporator is, in effect, reversed with respect to the capillary **16**. The capillary **16** then passes through an aperture **26** provided in the wall of the evaporator **13** and terminates at the desired distance from end plug **25**. Aperture **26** is then closed around the capillary by some method, such as brazing, soldering, etc.

It will be appreciated that the refrigerant flowing within the capillary is sub-cooled in its passage through the capillary once it has passed the aperture **26**. The mixture leaving the capillary discharges against end plug **25** producing a turbulent area with the desired effect of slowing the velocity of the mixture and collapsing gaseous globules formed within the evaporator.

It will be apparent that I have provided, in a simple, expeditious and extremely low cost manner, a device which functions efficiently and reliably to reduce the noise level in a refrigerating system. This problem of noise reduction in refrigerating systems, particularly in their use within the home, is one that has always plagued industry. Yet, for but a minute increase in cost, I have devised a method for substantially reducing refrigerant noises within an evaporator, contributing greatly to an overall noise reduction in the operation of such a system.

I wish it to be understood that my invention is not to be limited to the specific constructions and arrangements shown and described, except only insofar as the claims may be so limited, as it will be apparent to those skilled in the art that changes may be made without departing from the principles of the invention.

What is claimed is:

1. In a refrigerating system, an evaporator having a closed end, a restrictor tube extending through said closed end into said evaporator and connected thereto, said restrictor tube being turned back on itself to form a U-shaped portion discharging refrigerant against said closed end.

2. In a refrigerating system, an evaporator having a closed end, a restrictor tube extending through said closed end into said evaporator and connected thereto, said restrictor tube being turned back on itself to form a U-shaped portion discharging refrigerant against said closed end, the width of said U-shaped portion in an unstressed condition being greater than the inside diameter of said evaporator.

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