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2,415,243

REFRIGERATION APPARATUS AND METHOD OF MAKING SAME

Filed Oct. 20, 1943

2 Sheets-Sheet 1

Fig. 1.

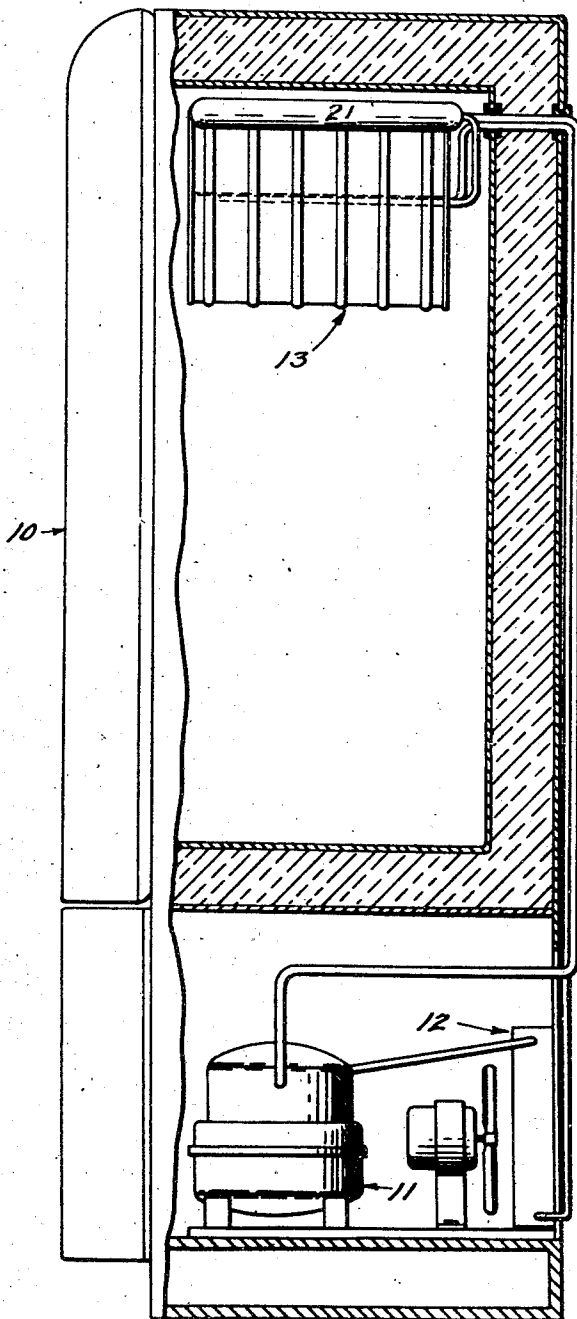


Fig. 3.

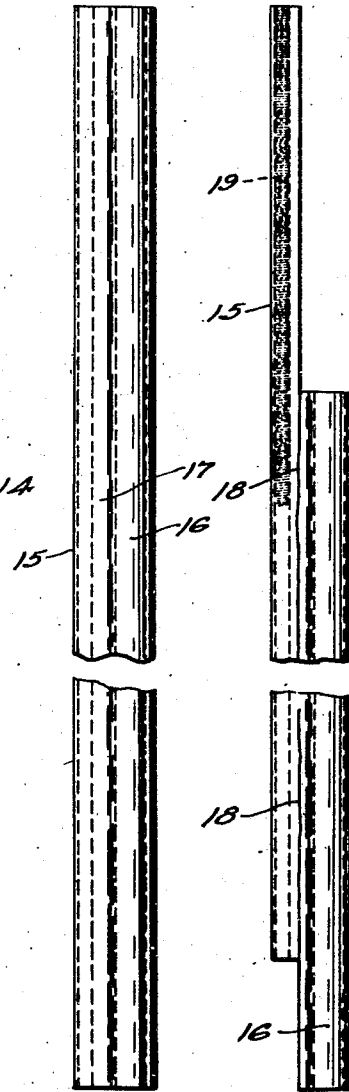


Fig. 2.

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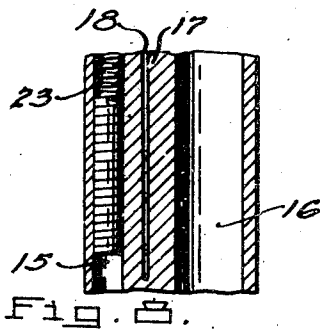
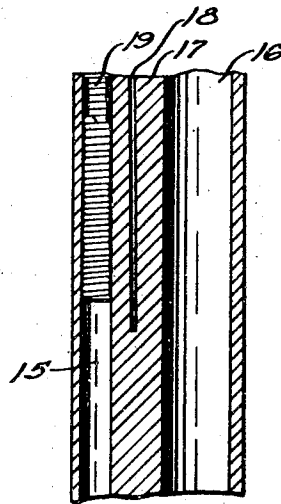
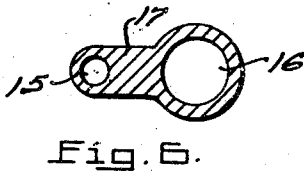
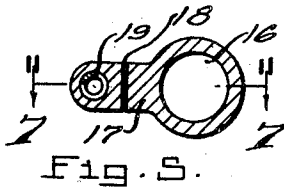
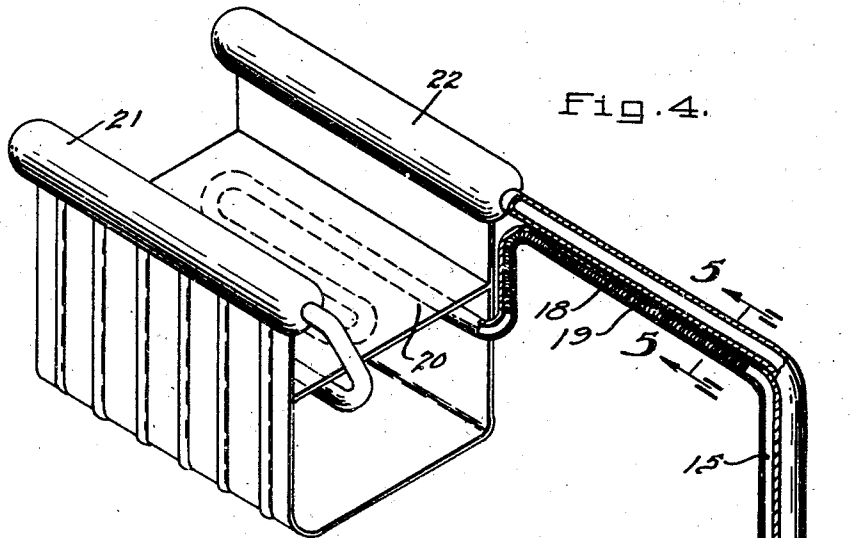
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2 Sheets-Sheet 2



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REFRIGERATION APPARATUS AND
METHOD OF MAKING SAME

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10 Claims. (Cl. 62—8)

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This invention relates to refrigerators, and more particularly to improvements in the lines used to feed liquid refrigerant to the evaporator and to draw the vaporized refrigerant from the evaporator.

A particular object of the invention is to provide an efficient arrangement for heat-exchange between the warm liquid line and the cold suction line, thus pre-cooling the liquid refrigerant before it reaches the device which controls its passage to the evaporator. This object is accomplished by forming the liquid and vapor lines as parallel bores in a single piece of material having good thermal conductivity, such as aluminum, so that these two lines may be kept in efficient heat-exchange for a major portion of their length. Preferably the piece of material in which the bores for these lines are formed is extruded, as this method of manufacture provides a part having the characteristics of wrought metal and entirely free from joints of any kind between the bores.

A further object is to provide an improved small-bore restrictor for controlling the flow of liquid refrigerant to the evaporator. An efficient and trouble-free restrictor is formed by inserting within the smooth bore of the line for liquid refrigerant, at a part near its connection to the evaporator, helically-coiled wire, the inner diameter and length of the coil being correlated so as to properly meter the flow of refrigerant in the same manner as done by small bore restrictors heretofore in use.

The two structures above mentioned unite to form a combined small-bore restrictor and heat-exchanger of simple and unique construction.

The invention also provides methods for manufacturing these structures.

These and other objects and advantages of the invention will become apparent as the description proceeds.

While preferred forms are illustrated herein for purposes of illustration, it should be understood that various changes may be made without departing from the spirit of the invention as herein set forth and claimed.

In the drawings:

Fig. 1 is a side elevation partly in section of a household refrigerator embodying the invention.

Fig. 2 is a plan view of a strip as extruded.

Fig. 3 is a view similar to Fig. 2 but showing the strip after it has been partly processed.

Fig. 4 is an enlarged isometric view of the evaporator and the upper end of the combined small-bore restrictor and heat-exchanger, parts of the latter being shown in section.

Fig. 5 is a cross section on line 5—5 of Fig. 4.

Fig. 6 is a cross section on line 6—6 of Fig. 4.

Fig. 7 is a longitudinal section on line 7—7 of Fig. 5.

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Fig. 8 is a view similar to Fig. 7 but showing a modification in the shape of the wire.

Referring in general to Fig. 1, the parts include the cabinet 10, motor-compressor unit 11, condenser 12 and evaporator 13, all of which may be of any preferred construction. The numeral 14 indicates the combined heat-exchanger and small-bore restrictor of the present invention.

The construction of part 14 can be explained most readily by following the steps by which it may be fabricated. The first step is to extrude a strip having the cross-sectional shape illustrated in Fig. 6, which consists essentially of a small bore 15 and a large bore 16, the walls of these bores being connected together by a solid web 17. A strip of this shape can readily be extruded by the apparatus shown in the patent to Schwerak, No. 2,031,008, and is preferably formed from a material having a high rate of thermal conductivity, such as aluminum or an alloy thereof. In the appended claims the term "aluminum material" is used to cover generically commercially pure aluminum and all alloys in which aluminum is the predominant element. This strip can be extruded in any economical mill length and is then cut into pieces of the size required for fabrication, one of which is shown in plan view in Fig. 2.

The next step in producing the combined heat-exchanger and small-bore restrictor illustrated in Figs. 1 and 4 is to saw a slot inwardly from each end of the strip as indicated at 18 in Fig. 3. Each of these slots cuts entirely through web 17, thus separating the small bore 15 from the large bore 16 and forming them into separate tubes. The small bore 15 is to form the line carrying liquid refrigerant from the condenser 12 to the evaporator 13, while the large bore 16 is to form the suction line carrying gaseous refrigerant from evaporator 13 to compressor 11. In order to make these connections in the particular installation shown it is convenient to cut off part of the tube carrying bore 16 at the upper end of Fig. 3 and to cut off part of the tube carrying bore 15 at the lower end of Fig. 3. The relative lengths of these tubes can thus readily be adjusted to meet the requirements of different refrigeration systems.

Prior to the present invention considerable use has been made of small-bore tubes to control the flow of liquid refrigerant to the evaporator. Such tubes have sometimes been called "capillary tubes," although it is believed that they operate, not by capillary action, but by retarding the flow of gas while permitting a metered flow of liquid on the vapor-lock principle, as indicated in the patent to Keyes, No. 1,293,469. Some variation was permissible in the inner diameter of the tube, but this diameter had to be correlated with the length of the tube in order to obtain proper metering of liquid refrigerant to the evaporator. Thus for a household refrigerator of 6 cu. ft. ca-

capacity, if the tube had an inner diameter of .032 in. the tube could be approximately 6 ft. in length whereas if the tube had an inner diameter of .040 in. the tube would have to be approximately 17 ft. in length. But it has been found very difficult to manufacture tubing of these small sizes and to assure that the bore is free from obstructions both when the system is assembled and during the life of the refrigerator.

A departure from the plain, smooth-bore restrictor tube was suggested in the patent to Karmazin, No. 2,166,109, which shows a restrictor tube made by brazing together the loops of a helically-wound metal wire.

The present applicant has discovered that an economical and efficient restrictor can be produced by the simple method of inserting a helically-coiled wire 19 in the small bore 15 of the double-bore strip 14 described above. The coiled wire is inserted in the upper end of bore 15, as in Fig. 3, and since it has merely a close sliding fit in the smooth bore, it can readily be pushed in to any required position, as indicated for example in Fig. 4.

An important advantage of this construction is that the bore 15 can be formed with a relatively large inner diameter, thus permitting economical extrusion.

It has been found that in an average household refrigerator of the type in which the compressor is in the base of the box, efficient operation is obtained when the inner diameter of the bore 15 is greater than .050 in. and less than .110 in.

In one example the bore 15 was formed with an inner diameter of .080 in., and the coiled wire had an outer diameter that permitted it to slide freely into the bore, while it had an inner diameter of .030 in. It was found that with these diameters the length of the coiled wire needed for a 6 cu. ft. refrigerator was about 18 inches. This represents a very considerable shortening from the 6 ft. of .032 in. smooth-bore tube used previously, as stated above, and hence provides for a neater and more economical installation.

The inner diameter of the coil can of course be varied within limits, but using a smaller diameter will increase the difficulties of manufacture and the possibility of clogging, while using a larger diameter will require using a greater length of coiled wire. In any case the inner diameter and length of the coil must be correlated so as to properly meter the flow of refrigerant.

In the example referred to, the large bore 16 had an inner diameter of .250 in., but this diameter is not critical as long as it is adapted to meet the needs of the particular system.

After the coiled wire has been inserted in bore 15 the end tubes carrying bores 15 and 16 may be separated and each one given a rounded external shape. The combined small-bore restrictor and heat-exchanger thus formed is then ready for assembly in the refrigeration system.

In the form illustrated in Fig. 1, which is a particular refrigerator of household size, the main body of the double-bore strip 14 is located outside of, and attached to the back of, the cabinet 10. The upper end of the tube carrying the small bore 15 is first secured in contact with the shelf 20 and then is connected to the inlet header 21 of the evaporator 13. The lower end of this tube is connected to the outlet of the condenser 12. The tube carrying the large bore 16 has its upper end connected to the outlet

header 22 of evaporator 13, and its lower end connected to the inlet of the motor-compressor unit.

In the operation of the refrigerator the gaseous refrigerant, which is relatively cold, is drawn from the evaporator to the compressor via the large bore 16. After being compressed and condensed the refrigerant, warm and mainly in the liquid state, passes from the condenser to the evaporator via the small bore 15. The restrictor formed by the coiled wire 19 permits a metered flow of liquid refrigerant while the refrigerant in bore 15 is under sufficient pressure. During idle periods of the compressor the restrictor remains open to permit substantial equalization of pressures throughout the system.

It should be noticed that in the main body of the part 14 the warm liquid refrigerant is moving upwardly through the bore 15 while the cold gaseous refrigerant is moving downwardly through bore 16, thus providing for a counter-flow heat exchange throughout the major length of these bores. The bore 15 is large enough to permit the liquid refrigerant to flow relatively slowly, thus permitting good heat exchange because of the relatively long time the warm and cold mediums are in heat exchange relation. This pre-cooling of the liquid refrigerant causes it to arrive at the evaporator at a temperature and pressure which permit it to evaporate without transmitting surplus heat to the evaporator. By forming bores 15 and 16 in a single piece of aluminum this heat-exchange takes place in a highly efficient manner, since there are no joints of any kind to impede heat flow through the solid, homogeneously integral mass.

The helically-coiled wire 19 is preferably formed of steel spring wire with adjacent convolutions in close contact with each other, but neither of these features is essential. It has been found that the coil functions properly if its convolutions are spaced apart as much as .015 in. The wire need not be of conventional round cross-section, but may have other appropriate cross-sectional shapes, such as the V shape of the wire 23 of Fig. 8. For convenience in manufacture several individual coils may be placed end-to-end to produce the desired overall length of coil.

By using a relatively large bore 15 and inserting therein coiled wire as described herein, it is possible to produce a small-bore restrictor of great accuracy and precision at low expense.

The double-bore strip 14 is of extruded metal which is quite malleable, and since the coiled wire is not anchored to the wall of its bore, the part of the tube which serves as the restrictor can be readily bent without reducing or obstructing the inner diameter of the coils of the wire.

It will be clear to those skilled in the art that the improved small-bore restrictor of this invention can be used separately from the heat-exchanger disclosed, but that maximum efficiency and economy can be gained by the use of the two devices in combination. An example of separate use of the restrictor would be its insertion in an ordinary liquid line of any type, in which case the restrictor would serve as an economical metering device. Conversely the double-bore heat-exchange tube can be used with any type of metering device such as an expansion valve or a low-side float valve.

In manufacturing, the particular sequence of steps set forth above need not be adhered to, but considerable latitude may be used in changing

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the sequence to arrive at the most economical process under particular circumstances.

The invention is, of course, not limited to refrigeration systems of household size, but can be used on systems of commercial size.

I claim:

1. For use in refrigeration systems, a tube having a bore with a smooth inner wall, the inner diameter of the tube being too large to serve as a small bore restrictor, and a coil of wire having a passageway of substantially capillary size, said coil being inserted in said bore, the length of said coil being so correlated to the inner diameter of the passageway as to provide for the delivery of the desired amount of refrigerant.

2. For use in refrigeration systems, a tube having a smooth inner bore of a diameter between .050 in. and .110 in., and helically-coiled wire inserted within said bore, the coil of wire having a passageway of substantially capillary size and having a sliding fit in the bore, the length of said coil being so correlated to the inner diameter of the passageway as to provide for the delivery of the desired amount of refrigerant.

3. For use in refrigeration systems, a tube having a smooth inner bore of a diameter of approximately .080 in., and helically-coiled wire having its convolutions arranged closely to each other inserted within said bore, the outer circumferential surface of the coil having a sliding fit in said bore, the inner diameter of the coil being approximately .030 in. and the length of the coil being approximately 18 inches.

4. A heat-exchanger for the gas and liquid lines of refrigeration systems having an evaporator, which comprises: a strip of aluminum material having a small bore for liquid refrigerant, the inner diameter of said bore being too large to serve as a small-bore restrictor, and a larger bore for gaseous refrigerant, the walls of the bores being connected over the major portion of their length by a web forming therewith a homogeneously integral body of such mass as to cool the liquid refrigerant so that it is delivered by the small bore to the evaporator at substantially the temperature of the gas entering the large bore from the evaporator, the web being severed for a distance inwardly from each end of the strip thus placing the bores in separate tubes at each end of the strip.

5. A combined small-bore restrictor and heat-exchanger for the lines of refrigeration systems which comprises: a strip of material of good heat conductivity, the strip having a small bore for liquid refrigerant and a larger bore for gaseous refrigerant, the walls of the bores being connected by a web over the major portion of their length to form a single, homogeneously integral mass, the small bore having a smooth wall and being of a size too large to serve as a small-bore restrictor; and coiled wire inserted in one end of the small bore, the inner diameter and length of said coil being correlated so as to meter the liquid refrigerant.

6. A combined small-bore restrictor and heat-exchanger as set forth in claim 5 in which the strip is formed of extruded aluminum material.

7. A combined small-bore restrictor and heat-exchanger for the lines of refrigeration systems which comprises: a strip of material of good thermal conductivity, the strip having a small bore for liquid refrigerant and a larger bore for gaseous refrigerant, the walls of the bores being connected by a web over the major portion of

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their length to form a single, homogeneously integral mass, the web being severed for a distance extending inwardly from each end of the strip, thus placing the bores in separated tubes at each end of the strip, the small bore having a smooth wall and being of a size too large to serve as a small-bore restrictor; and coiled wire inserted in one end of the small bore, the inner diameter and length of said coil being correlated so as to meter the liquid refrigerant.

8. A combined small-bore restrictor and heat-exchanger as set forth in claim 7 in which the strip is formed of extruded aluminum material and the coiled wire is formed of steel.

9. A combined small-bore restrictor and heat-exchanger for the lines of refrigeration systems which comprises: a strip of extruded aluminum, the strip having a small bore for liquid refrigerant and a larger bore for gaseous refrigerant, the walls of the bores being connected by a web over the major portion of their length to form a single, homogeneously integral mass, the small bore having a smooth inner wall and a diameter of approximately .080 in.; and helically-coiled steel wire having its convolutions arranged closely to each other inserted within the bore, the outer diameter of the coil having a close sliding fit in said bore, the inner diameter of the coil being approximately .030 in., and the length of the coil being approximately 18 inches.

10. The method of manufacturing a combined small-bore restrictor and heat-exchanger for the lines of refrigeration systems which comprises: extruding a strip of material, the strip having a small bore for a liquid refrigerant and a larger bore for gaseous refrigerant, the walls of the bores being connected by a web over the major portion of their length to form a single, homogeneously integral mass, the small bore having a smooth wall and being of a size too large to serve as a small-bore restrictor; cutting a slot completely through the web between the bores for a distance at each end of the strip, thus placing the bores in separated tubes at each end of the strip; winding wire into a close helical coil; and inserting the coil into the small bore of said strip, the inner diameter and length of said coil being correlated so as to meter liquid refrigerant and bending the tube containing the small bore at a place where the wire coil is present.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,063,745	Kucher	Dec. 8, 1936
2,146,823	Karmazin	Feb. 14, 1939
644,841	Allen	Mar. 6, 1940
2,281,207	Schoen	Apr. 28, 1942
1,823,919	Smith	Sept. 22, 1931
2,155,003	Benson	Apr. 18, 1939
2,329,139	Scullen	Sept. 7, 1943
2,166,109	Karmazin	July 18, 1939
2,210,031	Greene	Aug. 6, 1940
2,136,230	Berman	Nov. 8, 1938
97,448	Silsby	Nov. 30, 1869
166,294	Orum	Aug. 3, 1875
2,181,856	McCloy	Nov. 20, 1939
2,305,992	Quillen	Dec. 22, 1942
2,155,003	Benson	Apr. 18, 1939