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 Applicant: **ENBY PRODUCTS LTD.**
Stirling House Stirling Road
Chichester Sussex PO19 2EN (GB)

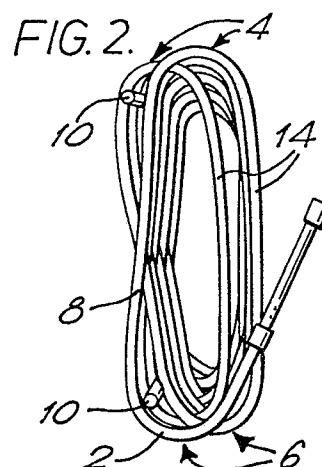
 Inventor: **Best, Norman**
20, North Pallant
Chichester, PO19 1TQ (GB)

Poole, Ronald R.
Haswell Farm
Avonwick, Devon (GB)

 Representative: **Hitchcock, Esmond Antony et al**
Lloyd Wise, Tregear & Co. Norman House 105-109 Strand
London WC2R 0AE (GB)

 Heat exchanger coils.

 An heat exchanger coil is disclosed, particularly but not exclusively for use in domestic apparatus such as dehumidifiers, coolers, and refrigerators. The coil comprises a plurality of turns of tubing (2) in which some are displaced from adjacent turns (2) in a direction substantially perpendicular to the overall axes of the coil. The displacement is defined by one or more spacer rods (10) which extends lengthwise in the coil to hold adjacent turns (2) apart. Typically, the coil is formed from a single length of tubing with the cross-section of the coil being made substantially elongate, and adjacent turns (2) of the coil mutually displaced at both ends of each turn (2).



Description

HEAT EXCHANGER COILS

This invention relates to heat exchanger coils, particularly but not exclusively for mechanical refrigeration systems, including dehumidifiers, air coolers and food and beverage coolers. Such heat exchangers serve the purpose of either cooling an airstream by transferring heat from the air to a fluid refrigerant passing through tubing, or cooling and condensing such refrigerant by transferring heat therefrom to an airstream. All mechanical refrigerating systems employ heat exchangers for both these functions.

The rate at which heat is transferred between a gaseous medium such as air, and a metal surface at a different temperature, is very much lower than that of the transfer between a metal surface and a liquid or vapour when the liquid or vapour is changing state; i.e., when the liquid is evaporating, or the vapour is condensing. Both of these actions necessarily occur in all mechanical refrigerating systems. The heat transfer rate between a volatile refrigerant such as dichloro-difluoro-methane (R-12) and a metal tube containing it, may be 50 times greater than the rate at the interface between a gaseous medium such as air, and the external surface of the tube.

A greater surface area or a greater temperature difference is required to transfer a given amount of heat from the airstream to the tube, rather than from the inside of the tube to the refrigerant. It has been the general practice therefore, to increase the external surface of the tubing by means of fins or wires bonded in thermal contact to the tubing, in order to improve the efficiency of the device. This expedient is costly, both in materials and labour, and involves specialised machinery for fabrication and assembly. Further, where a liquid is to be condensed by cooling a vapour-laden gaseous medium, for example, in the dehumidification of air, the temperature of the heat-absorbing surface frequently falls below the freezing point of the condensed liquid. The resultant frost formation tends to block the narrow passages between the fins, reducing the effective surface and restricting the flow of the circulating air or gas.

To overcome the above disadvantage, it has been the practice to add various automatic devices to melt and drain off any frozen liquid, by periodically interrupting the cooling process and heating the coil. A more economical and simple solution, particularly in the case of dehumidifiers, has been to make the heat exchanger of bare tube, usually of aluminium or copper, with no external fins or other extension, but with increased length of tube, sufficient to provide enough cooling surface for the required amount of heat transfer.

Such heat exchangers may be made in the form of a continuous length of plain tube, to carry the refrigerant, wound as an helical coil. The air or gas to be cooled passes across the coil in a direction substantially perpendicular to its axis. In order to permit free passage of air over the tubing, adjacent

turns must be spaced apart, the spacing allowing also for the occasional build-up of frost. Typically, adjacent turns have been spaced by at least half to three-quarters of the diameter of the tube. Such a coil is inevitably much larger than a finned coil of the same capacity, and may entail an unacceptable increase in the overall size of the device in which it is used.

The present invention is directed at a design of heat exchanger coil in which improved heat transfer performance can be achieved, with a more compact and rigid construction. According to the present invention, the coil comprises tubing for carrying heat exchange fluid, wound into a plurality of closely spaced turns, at least a portion of the plurality of turns being laterally displaced from adjacent turns to facilitate heat exchange between the external tube surface and another heat exchange medium passing thereover.

In most embodiments of the invention, alternate turns of the coil are displaced from their neighbours by an amount which leaves sufficient free space between adjacent turns to allow for substantially free passage of air for example in a lateral direction across the coil. The alternate turns are preferably displaced by a distance approximately twice the diameter of the tube, so that a clear space of little more than one diameter is left diagonally to each side of the displaced tube. This has the effect of deflecting the air flow so that it passes in a turbulent motion over the downstream sides of each of the turns, ensuring virtually complete contact between the airstream and all the tubes. The airstream encounters a second array of staggered tubes on reaching the downstream side of the coil.

In a simple embodiment, an heat exchanger coil according to the invention comprises a single tube which is wound helically; i.e., each turn completing substantially a circle, but we have found that rather better results are achieved when the cross-section of the coil is elongate. In preferred embodiments, the longer axis of this cross-section is 5 to 6 times the shorter. This elongate cross-section defines two ends of each turn, and the lateral displacement of the turns may be effected only at one end of the overall cross-section of the coil. However, the lateral displacement can be built into the coil design at both ends of the overall cross-section such that one side of the coil defines a concave surface, the lengths of tubing in alternate turns of the coil passing from one side of the displacement at one end of the turns to the other side of the displacement at the other end, and crossing in a region intermediate the two displacements. Different displacements can be established at both ends of course, but it should be remembered that the shape, proportion and dimensions of the turns are not critical to the invention, and may be varied to suit the configuration of the machine of which the coil is part. Generally, though, where the overall shape of each turn in the coil is elongate, it is preferred that at least one side thereof

is made substantially straight. Where both ends of this cross-section are to be displaced; either both ends of the same turn or alternate ends of alternate turns, the straight sides of alternate coils will be aligned respectively in two substantially parallel planes.

The displacement of alternate turns in the manufacture of a preferred coil according to the invention may be effected by placing the coil in a fixture which supports every second turn, while a movable bar, carrying a series of projections presses the intermediate turns crosswise to the axis of the coil, and in their own plane, to the required distance. On the side away from the movable bar, a pair of spacing rods is inserted parallel to the axis of the coil, between the row of displaced tubes and the undisplaced row, close to the upper and lower ends of the straight portions. On this side of the coil the two sets of turns cross each other obliquely in two intersecting planes, and it will be seen that the inclination of these planes tends to force the spacer bars towards the top and bottom bends, thereby forming a naturally rigid structure. The spacers are generally only needed on one side of the coil.

Spacer bars when used, can be made from tubing of the same metal as the coil, and of similar diameter thereto, and are preferably indented on alternate sides at a corresponding pitch to the turns of the coil, the indentations engaging therewith to locate the turns evenly and to prevent the spacer bars from slipping endwise. Projecting ends of the said bars serve to locate and secure the coil in the housing or frame of the device. The spacer bars might alternatively be made from rods or from metal strips, notched at intervals to engage with the coil turns.

A coil as described above will normally have approximately a full diameter of clearance between adjacent tubes in the front, or air-on side, while at the rear or air-off side alternate turns will be in contact for a short distance where they cross each other. This slight obstruction tends to drive some of the air upwards and downwards between the top and bottom ends, so that virtually all the surface of the tubing is exposed to the moving airstream.

The spacing between adjacent turns of the coil along its longitudinal axis will normally be less than half the external diameter of the tube, and in practice we have found that this spacing, in a direction substantially perpendicular to the plane of each turn can be reduced to substantially zero. With zero displacement, some contact between adjacent turns is of course inevitable, but by virtue of the lateral displacement of the turns such contact is minimal and does not adversely effect the performance of the heat exchanger in which the coil is used. In the initial winding of the coil, the turns may be, and are preferably wound very close together, or in actual contact, in order to minimise the overall axial length. By so doing, 50% more tubing can be fitted into a given space than would be possible in the case of a simple coil with only half a diameter of axial spacing between the turns. Where space is not an important consideration, or when exceptional frost formation is likely, the coil may be wound, or subsequently extended to a greater spacing.

A particular advantage of the invention, and its use of plain tubing, ie, without intervening fins, is that water or condensed liquid can more easily flow from the surface thereof. This is of special benefit in an unit that requires defrosting, such as a dehumidifier. With finned tubing, droplets can become attached to the fin and at contact points between the fins and tubing, which fail to drain during defrosting, and re-freeze when the unit is again used.

Another benefit of the invention is that relatively inexpensive tubing can be used. The permitted tolerances in the inner and outer diameters of the tubing, primarily because of the absence of the need for fins, are greater than have been required of tubing used in known comparable coils. This means that the manufacturing costs for the tubing can be greatly reduced. We have found that extruded tubes are quite satisfactory in coils of the invention, and extruded aluminium alloy tubing can cost as little as 20% of the cost of an equivalent tubing per unit length for use in a comparable coil in which fins are adopted.

As already mentioned, heat exchanger coils of the invention are useful in a number of applications, particularly in relatively small apparatus such as dehumidifiers, coolers, and refrigerators. In such equipment, the heat exchanger of the invention can occupy only a small amount of space which need normally be no greater in overall dimensions than 60 cms x 45 cms x 10 cms. In a typical application in a dehumidifier for domestic use, the overall dimensions of the coil are 25 cms x 22 cms x 5 cms. The tubing used in this case is 8 mm o.d. aluminium tubing with a 1 mm wall thickness, and with substantially zero axial spacing between adjacent turns of the coil. Greatly improved performance has been achieved with this embodiment of the invention, with improvements of the order of 30% in terms of water extraction being possible when compared to equivalent prior known units.

Normally, an heat exchanger coil according to the invention comprises a single tube wound into adjacent turns. However, comparable benefits can be achieved by the use of two or more lengths of wound tubing with the respective turns thereof interdigitated such that the turns of one tube are displaced from the turns of the others. Heat exchange fluid can be passed through the tubes in either parallel or series flow.

The invention will now be described by way of example and with reference to the accompanying drawings, wherein:

Figures 1 and 2 are opposite end views of an heat exchanger coil according to the invention; and

Figures 3 and 4 are end perspective views of the heat exchanger coil of Figures 1 and 2.

The heat exchanger coil shown in the drawings consists of a single length of continuous tube 2 wound in a plurality of turns. In the embodiment shown, the shape of each turn of the coil is elongate with ends 4 and 6 at opposite extremities of the general cross-section of the coil as a whole. In the formation of the coil, it is first wound around an appropriate elongate former, to form a substantially closed hollow body of elongate cross-section, with

the wall thereof defined by the contiguous turns of the coil. The coil is then distorted by the displacement laterally of alternate turns of the coil with respect to adjacent turns. This is accomplished by mounting the coil in a fixture in which a pair of bars with projections thereon are urged together with the projections engaging the alternate turns, and has been effected at both ends with the orientation of the projections on the bars reversed with respect to the turns of the coil with which they engage. This results in a distorted coil of the type illustrated where the left hand side as shown of the overall cross-section of the coil is generally concave, and defined by alternate substantially straight lengths 8 of tube which pass each other along a line extending the length of the coil substantially central of the respective side.

The distortion in the heat exchanger coil illustrated is preserved by means of spacer rods 10 disposed between adjacent turns of the coil. These define the extent of displacement, and will normally be gripped by the turns of the coil. They can also be secured to the tube 2 by means of for example, a welded or soldered joint with the end turns as indicated at 12. The projecting ends of the rods 10 can be used to support and secure the coil in the apparatus in which it is to be used.

The spacing rods may conveniently consist of straight tubes of diameter similar to that of the coil tubing, and they are preferably indented on alternate sides at the same pitch as the turns of the coil, so as to provide a positive location for each turn, giving a neat appearance. An alternative form of spacer may consist of a narrow rigid strip of metal having a series of notches on each side to engage and locate the tubes.

The above described distortion of the coil results in the lengths 14 of tube forming the right hand face as shown, of the undistorted coil also to be displaced from their respective neighbours. This displacement results in the respective sides 14 of the turns of the coil defining two spaced parallel planes, as is apparent from Figures 1 and 2.

In the use of the coil illustrated, a cooling fluid medium is passed through the tube 2, and the air to be cooled traverses the coil from right to left as indicated by the arrows in Figure 1. As it traverses the planes of tube lengths 14, at the right hand side, the air is deflected axially of the coil, creating turbulence and good heat exchange contact with the tube surface. After crossing the central region, engagement with the inclined lengths 8 creates further turbulence, and additionally directs the air to the upper and lower ends of the turns of the coil as indicated in Figure 2, further ensuring maximum heat exchange contact with the tubing in the coil.

For ease of understanding, the embodiment of the invention particularly described and illustrated is formed in such a manner that adjacent turns of the coil are spaced from each other to allow the free passage of a gaseous heat exchange medium over substantially the entire surface area thereof. While this arrangement certainly provides excellent heat exchange performance, we have found that the coil can be compressed in the axial direction to make

contact between adjacent turns of the coil at the crossover points. With the coils distorted in the manner illustrated, and so compressed, only three points of contact will be formed in each turn. There will be one point of contact between the slanted lengths 8, and one at each end 4 or 6. This contact is minimal and because the overall volume occupied by the coil is reduced, and the gaseous heat exchange medium must follow a more tortuous path across the coil, we have found the more closely coiled arrangement is at least as effective. Each turn of the coil occupies an axial length thereof equal to the diameter of the tube, and clearance for the airflow being provided by the lateral displacement of alternate turns. The overall length of the coil will thus be substantially less than that of a simple coil of spaced turns, normally by at least one-third. Put another way, 50% more heat exchange surface can be provided for the same frontal area.

An important advantage of creating a tortuous path for the gaseous medium to follow over the coil is that the displacement of the coil turns promotes turbulent movement of the gaseous medium, and increases its speed thus ensuring better contact with the heat transfer air current, and thereby appreciably increasing the overall heat transfer. Additionally, the distance between adjacent tubes over the predominant length thereof is almost equal to the tube diameter, thereby minimising the risk of the flow of gaseous medium being restricted by frost formation.

Heat exchanger coils with displaced turns according to the invention can take many forms to accommodate different configurations of air passages therein. For example, alternate turns of the coil may be displaced in opposite directions and/or slightly rotated, rotation achieving either the formation of an overall triangular cross-section of the coil or a figure of eight cross-section. However, these arrangements do run the risk of there being a larger area of continuous contact between adjacent turns of the coil and depending on the device in which it is to be installed, can result in slightly inferior performance compared to that described in detail above.

Heat exchanger coils of the type described above are equally useful as evaporators or condensers, and have particular application in dehumidifiers. In a dehumidifier, a condenser coil of the invention would be placed in the stream of cooled and dehumidified air which has just passed through the evaporator coil. It will thus be operating in a temperature considerably lower than ambient, and will accordingly need less surface area to dissipate heat than it would in a conventional condensing unit. We have found that identical coils can be used as both evaporator and condenser in a dehumidifier. Heat exchanger coils according to the invention are also suitable for use in refrigeration units of relatively low capacity, such as beverage coolers or small food display coolers, being considerably cheaper than the finned tube type for the reasons referred to above, and more compact than the plain tube units previously known. The unfinned tubes are also less prone to collect dust and other airborne matter, and are therefore more easily cleaned.

Coils made in accordance with the invention are also suitable for cooling or heating liquids, by passing cold or hot fluids through the tubing, and immersing the coil in a tank containing the liquid. Heat exchange may be assisted either by mechanical agitation of the liquid, or by natural circulation promoted by thermal convection currents, the very low resistance to movement of the liquid being advantageous to this application. For such purposes, among others, the coils may be made from stainless steel or other corrosion-resistant metals such as aluminium or aluminium alloys, as noted above.

Claims

1. An heat exchanger coil comprising tubing for carrying heat exchange fluid wound in a plurality of closely spaced turns, at least a portion of the plurality of the turns being laterally displaced from adjacent turns to facilitate heat exchange between the external tube surface and another heat exchange medium passing thereover.

2. An heat exchanger coil according to Claim 1 wherein the lateral spacing between each displaced turn and its adjacent turns is substantially equal to the external diameter of the tubing.

3. An heat exchanger coil according to Claim 1 or Claim 2 wherein the axial spacing between adjacent turns of the coil is substantially zero.

4. An heat exchanger coil according to any preceding Claim wherein said portion of the plurality of turns comprises alternate turns of the coil.

5. An heat exchanger coil according to any preceding Claim wherein the tubing is wound helically.

6. An heat exchanger coil according to any of Claims 1 to 4 wherein the form of each turn of the coil is elongate, and said displacement is in a direction substantially perpendicular to the longer axis of the turn.

7. An heat exchanger coil according to Claim 6 wherein one side of each turn of the coil is substantially straight.

8. An heat exchanger coil according to Claim 7 wherein each turn includes two lengths of tubing which are substantially straight and extend in the direction of said longer axis.

9. An heat exchanger coil according to Claim 8 wherein said straight lengths of tubing are substantially parallel.

10. An heat exchanger coil according to any of Claims 7 to 9 wherein substantially straight sides of alternate turns of the coil are in a substantially common plane.

11. An heat exchanger coil according to any preceding Claim wherein substantially the entirety of each of said portion of the plurality of turns is laterally displaced from adjacent turns.

12. An heat exchanger coil according to any preceding Claim wherein a spacing element is disposed between the turns of the coil at the points

of said displacement.

13. An heat exchanger coil according to Claim 12 wherein said spacing element comprises an elongate element having indentations for receiving and locating the turns of tubing thereon.

14. An heat exchanger coil according to Claim 7 and Claim 12 or Claim 13 wherein a spacing element is disposed to be proximate each end of each straight length of tubing.

15. An heat exchanger coil according to any of Claims 12 to 14 said spacing element is secured to the tube and extends beyond the coil to provide a structural support therefor.

16. An heat exchanger coil according to any preceding Claim wherein the tubing comprises a single length of tube.

17. An heat exchanger coil according to any of Claims 1 to 15 wherein the tubing comprises a plurality of lengths of tube, each length wound separately and with the turns of one length being interdigitated with those of the other length or lengths.

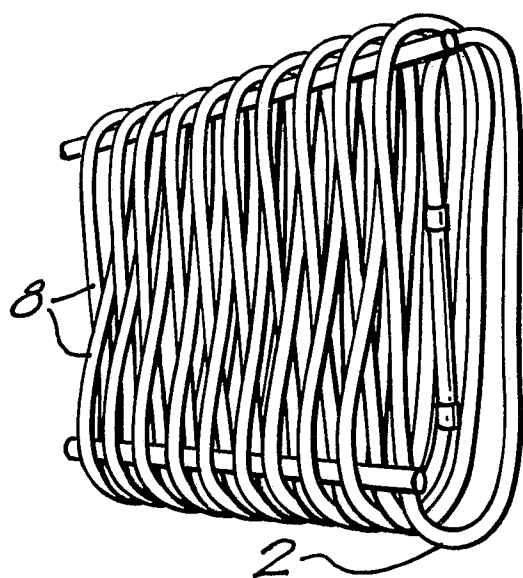
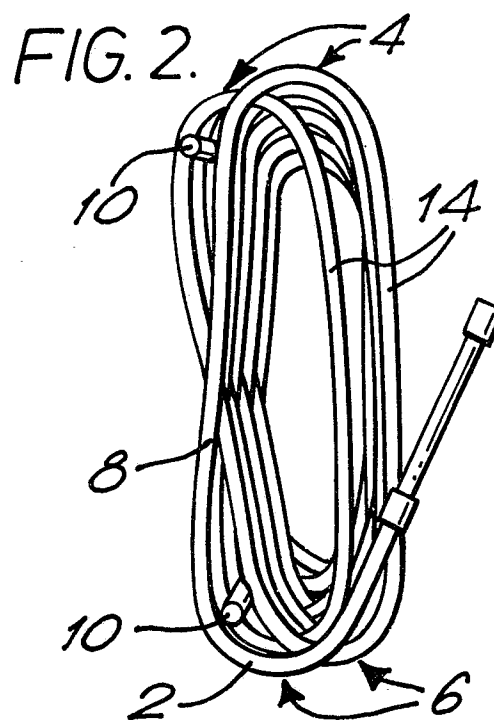
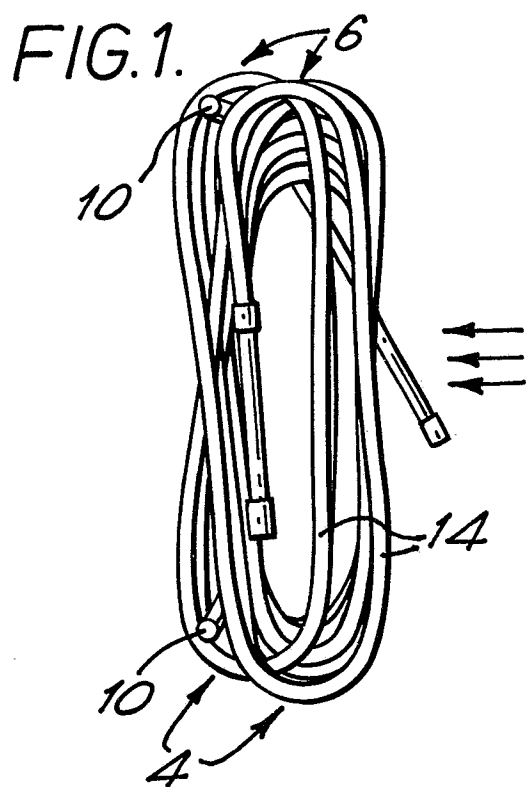
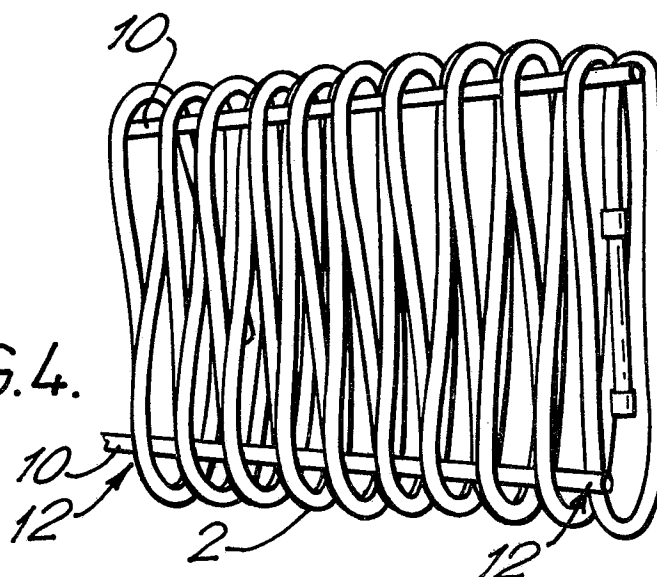


FIG. 3.

FIG. 4.





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
X	US-A-4 073 045 (P.H.E. MARGEN et al.) * Claims 1,7; figures 1,2,11,17,18 * ---	1,3,5- 15,16	F 28 D 7/08 F 28 D 1/047
X	US-A-1 818 762 (SETCHKIN) * Figures 5-10 * ---	1-4,6,7 ,16	
X	US-A-3 452 720 (LAWRENCE) * Figure 1 * ---	1,4,5, 16	
X	GB-A- 122 626 (SHAW) * Figures * ---	1-4,17	
A	FR-A-2 570 173 (ELM LEBLANC) -----		
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			F 28 D F 22 B F 25 D
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 15-11-1988	Examiner HOERNELL, L.H.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			