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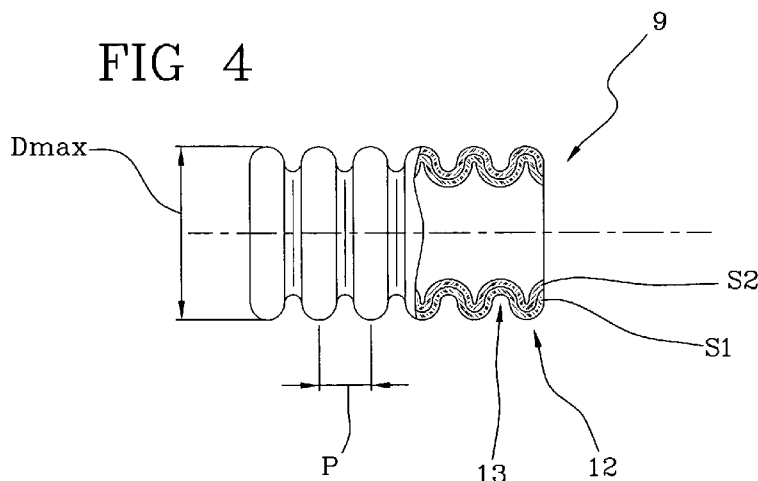
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(54) Title: REFRIGERATION CIRCUIT



(57) Abstract: A refrigeration circuit (3) for household appliances comprises a compressor (4) suitable for compressing a predetermined cooling fluid and for allowing the circulation thereof within said circuit (3), a first heat exchanger (5) or condenser in fluid communication with the compressor (4) for allowing the cooling and the consequent condensation of the cooling fluid going through, and a second heat exchanger (7) or evaporator in fluid communication with the first exchanger (5) through a circuit with a special device (6) suitable for decreasing the pressure of the cooling fluid at a space (2) to be cooled (normally inside the refrigerator). The second exchanger (7) allows the cooling fluid to evaporate, absorbing heat, thus cooling the space (2) and returning through the tubing (17) to the compressor (4). The cooling fluid circulates from the compressor (4) towards the first exchanger (5), from the latter towards the second exchanger (7) and then returns to the compressor (4) for a subsequent cycle. At least one of the heat exchangers (5, 7) comprises a plastic tubing (9), at least a portion whereof exhibits such corrugated profile as to impart flexibility thereof and/or increase the thermal exchange surface.

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**"REFRIGERATION CIRCUIT"**DESCRIPTION

The present invention relates to a refrigeration circuit.

5 More in particular, the present invention relates to a refrigerating apparatus, preferably of the type used in household appliances such as refrigerators, freezers, deep-freezers, iceboxes and the like. The invention is likewise and also applicable, in a  
10 totally similar manner, also to household appliances for conditioning.

It is known that refrigerators of the traditional type and similar refrigerating apparatus, comprise a refrigeration circuit wherein a refrigerating means  
15 is used suitable for subtracting heat from a closed space to be cooled to a predetermined temperature, such as the interior of the refrigerator or freezer, transferring it towards the outer warmer space. The above refrigeration circuit is a closed circuit  
20 wherein a compressor, a condenser, a lamination or capillary device and an evaporator operate in a sequence according to known operating modes. In particular, the refrigerating means is a low boiling point substance suitable for undergoing a passage of

state from liquid to vapour by expansion with the effect of subtracting heat to the ambient it is in contact with, and afterwards a reverse passage from vapour to liquid, during the circulation thereof  
5 within the refrigeration circuit. Focusing on the thermal exchanges of the refrigerating means with the air of the closed ambient to be refrigerated and of the outer ambient, such exchange takes place by means of metal coils wherein the refrigerating means is  
10 conveyed so as to increase the thermal exchange surface between the refrigerating means and the air itself.

The metal coils used for such function are generally obtained starting from a continuous metal tube  
15 (steel, aluminium or copper) which is suitably bent multiple times for following a profile of a useful surface intended for thermal exchange. Such useful surface is located at the back of the refrigerator in the case of the condenser, whereas in the case of the  
20 evaporator, the arrangement of the coils depends on the model of refrigerating apparatus or refrigerator, freezer or combined, and it concerns one or more walls inside the refrigerator itself. In particular, it is known to position the coil of the evaporator at

the inside bottom wall and/or at the inside side walls of the refrigerator, or even at one or more shelves provided inside the refrigerator. According to the arrangement inside the refrigerators and on  
5 the results to be achieved, the evaporators may be static (Wire On Tubes or Tubes On Plates) or dynamic (No Frost). In any case there is a pack consisting of steel or aluminium or copper tubes suitably bent and welded or otherwise connected to other metal bodies  
10 that increase the exchange surface thereof (metal wires in the case of WOT, metal sheets in the case of TOP and aluminium sheets in the case of NF).

The bending of the metal tube for making the evaporator coil is carried out according to different  
15 methods depending on the geometry of the surface whereon the coil itself is intended to be active. In fact, the bending of the metal tube is generally carried out by special tube bending machines prior to the final installation of the coil, and it must  
20 therefore be arranged in a differentiated manner according to the final geometry of the coil. The bending must be made so as to prevent chocking or section variations in such zones.

Disadvantageously, this implies poor operating

flexibility, related to the impossibility of providing for a standard process for obtaining the coil that will remain unchanged only for the refrigerators of the same model or same range. Such  
5 disadvantage causes the drawback of implying different production processes that strongly negatively affect the manufacturing times and as a direct consequence, imply high production costs.

Moreover, the storage processes are damaged as they  
10 must provide for the storage of different types of coils, each intended to be mounted only on predetermined thermal exchange surfaces having predetermined geometry.

Moreover, the manufacture of the above coils starting  
15 from metal tubes implies further production costs related to the procurement of raw materials (metal), to any processing of raw materials themselves, as well as to the complex operations for manufacturing the metal tube and the bending thereof for defining  
20 the end profile of the coil. In fact, the metal tube is obtained by welding a suitable formed flat sheet, and such process is very expensive and complex, as it must also be carried out in an accurate manner to prevent leaks of cooling fluid which would

irreparably damage the refrigerator in very short times, with serious economic consequences for the manufacturer and for the environment (such fluids are often polluting). Moreover, the metal tube is  
5 supplied in rolls to the manufacturers of evaporators and is thus unrolled, straightened, the diameter thereof is checked and then it is suitably bent multiple times at 180° in alternating direction to obtain the desired thermal exchange surface, and  
10 finally coupled to metal bodies shaped as fins or straight metal wires, suitable for facilitating the thermal exchange with the ambient to be cooled. The coupling with such metal wires is mostly made by spot welding (WOT) or by the introduction of the tube  
15 bundle into special slits obtained in the aluminium fins (NF). These are mainly manual operations that can be automated only to the disadvantage of the flexibility of the production line and moreover the need of making welding spots in the WOT and that of  
20 welding the inlet and outlet tubes of the evaporator to the remaining parts of the circuit, forces to chemically treating and then coating or galvanically treating all the surface of the part, so as to make it corrosion resistant. The complexity of the

production process of the metal coils of known type and described above is clear. Moreover, the presence of the metal coil and of the metal bodies greatly increases the overall mass and as a consequence, the weight of the household appliance.

Also the above further chemical treatments are expensive and very polluting (we may consider for example, nickel-plating): since after such treatments, sludge containing heavy metals is generated which must be disposed of to special collection centres for highly toxic waste.

A refrigerator is known from patent EP1479987, comprising an evaporator equipped with a flexible tube. The flexible tube, made of plastic material, is cylindrical and wound spiral-wise around respective supports and can be elongated or packed for varying its configuration based on a part of the refrigerator wherein a cooling action is desired.

The flexibility of the tube, however, is limited and the same may be deformed substantially along a single direction around which the coils are wound.

Moreover, a refrigerator is known from patent KR 20010094016 provided with an evaporator made of plastic material.

To prevent the known problems of frosting, such evaporator (with rigid structure and shaped as a flat surface defining the cooling tubes and the fins) exhibits a coating of electrically conductive paste to be connected to an external metal conductor and a further external insulating layer of plastic as well.

With reference to the European intellectual property mentioned above, disadvantageously, the adoption of a similar plastic tube having perfectly cylindrical shape, does not allow optimum thermal exchange by the cooling fluid circulating therein. Moreover, the above cylindrical tube wound spiral-wise is suitable for being elongated or packed along a predetermined direction, however it does not exhibit high properties of flexibility in any direction, and in particular in the case of very marked bending such as narrow radius bending generally required in making flat coils for refrigerators.

In detail, such intellectual property does not ensure high performance as regards the operating flexibility and adaptability of the heat exchanger geometry as is currently required on the market.

Also the Korean document makes no mention of the problems of adaptability and modularity of the heat



exchanger.

The above patent also refers to the making of a layer of conductive material comprised between an internal plastic material in contact with the cooling fluid  
5 and an external coating material the nature and application technology whereof are absolutely not described.

In the above patents in any case one of the most important problems was not solved: how to prevent gas  
10 leaks through the evaporator or condenser surfaces or through the connecting devices of such apparatus with the other components of the refrigerating circuit. The perfect seal to any gas leaks through the refrigeration circuit is a necessary condition for a  
15 refrigerator to work properly and for several years.

The making of a flexible tube is also known from patent EP 918182 for conveying a coolant in an air conditioning system.

The structure described by such intellectual property  
20 in any case appears very complex as it envisages a first inner layer and an outer layer of plastic material coupled by the adoption of an intermediate layer.

A cover is provided outside the tubes of plastic

material, consisting of synthetic fibres in turn protected by a further outer sheath.

Such a complex structure makes the tubing described in the European intellectual property substantially unsuitable for use within heat exchangers that must  
5 attain the passage of the heat itself between the cooling fluid and the external ambient.

On the other hand, the tube described in the above European patent exclusively serves for carrying such  
10 fluid and not for a thermal exchange with the ambient, which takes place in different and not described structures.

Hereinafter it is also noted that tubing of plastic material for heat exchangers is known for  
15 applications totally different from refrigeration circuits for household appliances.

In particular, such heat exchangers are designed for the most varied applications in the automotive field. For example, exchangers are known according to patent  
20 US2007/0289725 and US5706864.

However, it should be noted that the devices according to one or the other of the indicated patents cannot be used in refrigeration circuits according to the present invention since their field

of application makes them totally unsuitable for carrying the refrigerating gases commonly used in household appliances and also they are not suitable for allowing thermal exchange in conditions of liquid phase and gaseous phase of the fluid circulating therein. These applications typically use only a fluid that must work at operating temperatures and pressures totally different from those normally used in a refrigerating circuit for household appliances.

In this respect, using the one or the other of the devices described in the two patents mentioned above is unconceivable since the man skilled in the art would immediately recognise a plurality of difficulties of adaptation related to the leaks of refrigerating material, to the insufficient thermal exchange, to the impossibility of a correct velocity of the fluid inside the tubing, etc.

The technical task of the present invention is to provide a refrigeration circuit and household appliance which should be free from the drawback mentioned above.

Within such technical task, an object of the invention is to provide a household appliance for cooling whose production should imply a high

operating flexibility.

A further object of the invention is to provide a household appliance for cooling which should be made in a simple, inexpensive and more environment-  
5 friendly way.

A further object of the invention is to provide a household appliance for cooling which should be made in a more automated and thus reliable manner, with special reference to the above welding operations,  
10 eliminating manual welding that are presently carried out for connecting the various circuit devices to one another.

A further object of the invention is to combine, where possible, the materials used to make the  
15 various cooling system parts (presently copper, aluminium and steel), replacing them with plastic materials compatible and recyclable without separation, so as to simplify the storage processes of the parts themselves.

20 It is also an object of the invention to provide a household appliance for cooling which should have smaller mass and weight.

It further is an object of the invention to provide a household appliance for cooling which should exhibit

high flexibility in a plurality of directions, and in particular in the case of small bending radiuses.

These and yet other objects, as will appear hereinafter in the present description, are  
5 substantially achieved by a household appliance for cooling having the features respectively expressed in claim 1 and/or in one or more of the dependent claims.

The invention results from the observation that the  
10 slow step phase of the thermal exchange process on the current refrigerating circuits is not heat conduction through the thickness of the exchanger tube, but thermal exchange by natural or forced convection (no frost) between the air and the surface  
15 of the tube itself.

So far, the exchangers for household appliances have always been made of metal material (even very expensive like copper), to increase the thermal conductivity of the tube. The invention, on the  
20 contrary, uses a plastic material, less expensive, better processable, but with lower thermal conductivity, just because the exchange process is not generated by the thermal conductivity of the tube.

This applies to thickness of the plastic tube not larger than 1.5 mm; in order to improve the thermal exchange of the circuit it has been thought to intervene in the slow phase of the process (thermal  
5 exchange between tube and air), increasing the exchange surface with the use of corrugated tube surfaces that with the same diameter allow 30-50% increase of the exchange surface per unit of length of the tube.

10 A preferred but non-exclusive embodiment of a household appliance for cooling shall now be illustrate by way of a non-limiting example according to the present invention and to the annexed figures, wherein:

15 - figure 1 shows a schematic representation of a refrigeration circuit according to the present invention, and in particular of the type with evaporating tubes;

20 - figure 2 shows a perspective view of a portion of the refrigeration circuit of a household appliance according to the present invention;

- figure 3 shows a partly side and partly dissected representation of a tube usable in a refrigeration circuit according to the present

invention and according to a first embodiment;

- figure 3a shows a possible version of section of the tube of figure 3;

- figure 4 shows a partly side and partly  
5 dissected representation of the detail of figure 3 consisting of a double layer of plastic material suitable for making the tube wall totally gas-proof according to a different embodiment;

10 - figures 5 and 6 show two possible sections of a capillary tube used in the circuit according to the finding;

- figures 7 to 10a show a section of possible  
15 embodiments of the heating means used in the tubing according to the finding;

- figures 11-13 show different embodiments of connectors for connecting portions of tubing used in the circuit according to the invention;

- figures 14 and 15 show the coupling between a  
20 capillary tube and tubing according to the present invention;

- figures 14a, 14b and 14c show three possible embodiment versions of a coupling between capillary and corrugated tube for thermal

exchange and energy recovery;

- figure 16 shows the coupling between metal tubing and a plastic tubing according to the present invention;

5       - figures 17-19 show the coupling between two end portions of tubes of plastic material used in the circuit according to the present invention;

- figure 20 shows a possible configuration of coupling between a tubing and the compressor; and

10       - figures 21a and 21b show two possible configurations of engagement between tubing and capillary.

According to the schematic view of figure 1, reference numeral 1 globally indicates a  
15       refrigeration apparatus which may be, by way of an example, a refrigerator, a freezer, a deep-freezer, a conditioner or any other appliance mainly for household purpose suitable for cooling a closed ambient, in particular a space 2, particularly for  
20       storing food products or for conditioning a living room.

Apparatus 1 comprises a refrigeration circuit 3 object of the present invention, which is suitable for carrying out a thermo-dynamic refrigerating cycle



and is suitable for conveying a cooling fluid along a closed path according to an advance direction indicated with "A" in figure 1. The refrigeration circuit 3 works by a liquid-vapour phase change of the cooling fluid, and comprises a compressor 4, a condenser 5, a filter 18, a lamination device 6 and an evaporator 7, besides other optional devices suitable for improving the yield of the cooling cycle. The detailed operation of the refrigeration circuit 3 is beyond the contents of the present invention and therefore, it shall not be described hereinafter in detail.

Evaporator 7 defines a first heat exchanger which has the function of drawing energy in the form of heat from an inner portion of apparatus 1, and in particular from space 2, and transferring it to the cooling fluid circulating through evaporator 7. Space 2, which in the case of refrigerators is generally intended for storing food or in any case perishable food, is delimited by walls 8 and is accessible from the exterior of the apparatus, for example by one or more closing ports.

More in detail, evaporator 7 comprises a tubing 9 that extends from a first end 9a, connectable

(optionally through further tubing portions) to the lamination device 6, to a second end 9b which usually has the function of heat exchanger with the lamination device 6, connectable (optionally by  
5 further tubing segments as well) to compressor 4. Tubing 9 is intended for conveying the cooling fluid and allowing transfer of thermal energy (heat) from space 2 towards the cooling fluid circulating in tubing 9 itself.

10 Likewise, condenser 5 comprises a coil 10 which extends from a first end 10a, connectable to compressor 4, to a second end 10b, connectable to the lamination device 6 and that usually, contains a gas filtering element 18. Coil 10 is intended for  
15 conveying the cooling fluid and allowing transfer of thermal energy from the cooling fluid circulating in coil 10 itself towards an external ambient wherein the apparatus is placed or towards a hot source.

Unless otherwise stated in the following description,  
20 coil 10 may consist of a tubing similar to tubing 9 mentioned above but with a smaller diameter, due to the highest operating pressures or, as an alternative, it maybe made by a metal tubing as it commonly happens at present in the refrigerating

circuits on the market.

According to the regulations in force, the refrigerating fluid belongs to classes HFC (hydrofluorocarbons), HC (hydrocarbons) or mixtures thereof. Preferably, the cooling fluid used is an aliphatic hydrocarbon such as isobutane, R600a.

According to the configuration shown in figure 1, both tubing 9 and coil 10 are arranged according to respective winding paths (which by way of an example may form 180 degree deflections; however, other equivalent operating geometrical configurations may be taken, as better explained hereinafter), so as to substantially bend on themselves for taking a compact configuration suitable for obtaining an efficient thermal exchange. Figure 2 shows an example of embodiment of tubing 9 of evaporator 7, which is applied to a (bottom, or intermediate supporting) surface 11 of a refrigerator and is schematised with a thread-wise pattern to highlight the winding path of tubing 9 itself. More in detail, tubing 9 is built in a thickness of surface 11 so as to be steadily associated thereto but as an alternative, of course it may be positioned also inside a wall of the apparatus being buried into the same. Advantageously,

tubing 9 is made of synthetic and preferably plastic material, so as to simplify the production processes and reduce the overall weight of the circuit.

Tubing 9 shall exhibit at least two peculiarities: it shall be not permeable to the cooling fluid that flows therein to prevent contaminations of the environment and loss of refrigerating capability of the circuit, and it shall also ensure humidity/water impermeability to prevent infiltrations (and consequent freezing) of the latter into the refrigeration circuit; moreover, the tubing shall also ensure impermeability to O<sub>2</sub> and N<sub>2</sub> (incondensable gases).

Tubing 9 is at least partly, preferably entirely or at least at the curves, defined by a corrugated tube, exhibiting a profile of the type illustrated in figure 3. In detail externally, preferably also internally, tubing 9 exhibits an alternation of protrusions 12 and recesses 13, alternating with one another for defining a substantially undulated outer profile, according to what illustrated in figures 3 and 4.

This advantageously achieves an increase of the turbulence in the passage of the cooling fluid that

allows making the heat exchange more efficient.

Preferably, tubing 9 used for evaporator 7 has a maximum outer diameter "De-max" comprised between 6 mm and 14 mm and preferably within the optimum range 8-11 mm whereas the length of tube 9 for the evaporator will be comprised between 8 and 26 m based on the thermal exchange required and on load losses.

On the contrary, the optimum dimensions of the refrigeration circuit, in the condenser section (first heat exchanger 5), are as follows: maximum outer diameter De-max of the tube comprised within the range 5-10 mm and, preferably within the range 6-8 mm.

The above results from the fact that the cooling fluid going through the condenser is subject to higher pressures (condensing vapour) and thus this requires smaller cross dimensions of the tubing.

The tube length will be comprised within a range between 4-15 m based on the thermal exchange required and on load losses.

A fundamental feature of refrigeration circuits, besides ensuring the desired thermal exchange, is to constitute a barrier as much as possible impermeable to different agents.

Below are the agents and the typical limits application in question:

Agent	Maximum admissible permeation	Unit of measurement
Isobutane	0.5	g/year
Oxygen+Nitrogen	1%	Molar fraction, relative to the coolant, admitted for the entire life of the refrigerator (10 years)
Water	100 p.p.m	Fraction by weight, relative to the coolant, admitted for the entire life of the refrigerator (10 years)

5 It is known that the refrigeration circuits work in a range of temperatures from -30° to +70° C and in a range of pressure varying from 0.3 to 12 bar; of course, the impermeability specifications of the above table must be kept within all of these ranges.

10 Moreover, in the standard operation of a refrigeration circuit, the lubricating oil of the compressor is partly and uninterruptedly carried along with the coolant it is perfectly soluble with.

The oil does not exhibit the features of the coolant,  
 15 that is, those of evaporating at low temperature, and it is therefore carried by the suction current generated by the compressor along all the

refrigeration circuit, or in solution with the coolant or in the form of droplets if (evaporator) the coolant has already evaporated.

To allow this transport of the coolant, the velocity of the cooling fluid should in general preferably be higher than 4 m/sec. If not, there is the risk that the compressor may be deprived of the oil that gets trapped in the corrugations of the tube and may burn out.

Of course this phenomenon poses limitations to the maximum sections of the circuit itself which will also depend on the type of corrugation. Cost issues also pose limitations to the maximum usable sections. On the contrary, for reasons related to the thermal exchange and to load losses, it is important to have the higher sections of the refrigeration circuit within their maximum diameters, to the minimum values mentioned above.

It is therefore clear that the dimensional and geometrical ranges shown above are not simple design choices but they are the result of a compromise that allows ensuring and maintaining all the requirements of the refrigeration circuit.

Any variations outside the ranges mentioned above

imply the non observance of one or more operating requirements and the impossibility of the refrigeration circuit to be used in the commercial practice.

5 The tube diameter, its length and the shape of the profile corrugation are also involved in the generation of noise inside the tube by the effect of turbulence and of the frequencies of the vortices generated inside the tube itself.

10 The corrugation and the selection of the diameter must therefore take into account also this aspect and all the aspects related to the tubing shape.

Tubing 9, in a possible embodiment, has a step "p", that is, the distance between two consecutive protrusions 12, preferably equal to 2 mm. Moreover,  
15 the tubing may have a shape ratio, that is, the ratio between the outer side surface of a portion of tubing 9 and a corresponding longitudinal length of the portion itself, comprised between 20 mm<sup>2</sup>/mm and 60  
20 mm<sup>2</sup>/mm.

Advantageously, the corrugated shape of tubing 9 causes an increase in the outer surface of tubing 9 itself relative to a cylindrical tubing having a same length, and in this way the thermal exchange between



the cooling fluid circulating inside tubing 9 and the air outside the same is facilitated.

Advantageously, moreover, the corrugated profile of tubing 9 of plastic material makes the same more  
5 flexible compared to a similar cylindrical tubing, allowing bending radiuses and angles that otherwise would cause the squeezing thereof (with reduction of a passage section of the cooling fluid) and thus, adaptable to be arranged according to a plurality of  
10 different configurations by simply bending tubing 9 without intervening plastically and irreversibly deforming tubing 9 itself. According to an embodiment not shown, tubing 9 may exhibit only some corrugated portions, in particular only the portions intended  
15 for defining curved portions in the path of tubing 9 itself or those where thermal exchange is to be maximised. The remaining portions of tubing 9, in that case intended for defining rectilinear portions, may be smooth or in any case free from surface  
20 shaping. In the case of smooth portions, the inside diameter of the tubing will be comprised between 4 and 11 mm and preferably between 6-8 mm.

Tubing 9 may advantageously be produced by an extrusion process, wherewith a hollow cylindrical

extrusion is obtained which may be further modified by in line finishing processes, for obtaining a desired profile of tubing 9. In particular, the extrusion process may be followed by a shaping step  
5 that imparts the corrugated shape illustrated in figure 3 to the entire hollow cylindrical body or only to a portion thereof. This may be obtained by coupling a counter-shaped matrix to the corrugated profile to be obtained externally to the hollow  
10 cylinder body, and generating such pressure inside the body itself as to plastically deform it forcing it to take a shape counter-shaped to the matrix. Preferably, this step is carried out when the hollow cylindrical body is still at a high temperature,  
15 corresponding to a state suitable for a plastic deformation process. As an alternative, instead of an internal pressure it is possible to generate a depression between the hollow cylindrical body and the matrix, so as to force a reciprocal approach of  
20 the same and a deformation of the hollow body that takes the matrix shape. The shaping operation described above leads tubing 9 to take a corrugated profile both internally and externally, according to the view of figure 3, and this imparts the

flexibility properties mentioned above and of turbulence of the cooling fluid circulating therein.

Besides having circular shape as in figure 3, the geometry of the section of the corrugated tube can have also other shapes that aid the improvement of the thermal exchange. For example, on chest freezer, evaporator 7 is wound about a metal rack. The tube presently used, metal as well (mainly aluminium) generally has a circular shape and therefore it has a very small contact surface with the metal rack that may be indicated in a single line on all the tube length.

Using a corrugated tube, suitably acting on the extrusion section and on the corrugator shape, it is possible to obtain the D section of figure 3a which, while maintaining its flexibility required for winding the tube about the rack, allows increasing the exchange surface as well as considerably improving the performance of the freezer and decreases the cost.

According to the embodiment illustrated in figure 4, tubing 9 is obtained by a multilayer extrusion process (co-extrusion) suitable for improving the mechanical and impermeability properties of tubing 9.

In fact, with a multilayer extrusion process it is possible to obtain a tubing 9 having two or more layers, each suitably selected based on specific functions to be carried out such as, referring to  
5 what already said before, impermeability to the cooling fluid, impermeability to humidity and to incondensable gases, flexibility, thermal conductivity, as well as resistance to the pressure exerted by the cooling fluid.

10 According to a first requirement thereof, tubing 9 comprises a first layer "S1", typically outermost, made of a material provided with features adapted for imparting to tubing 9 the necessary resistance to mechanical and thermal strains and impermeable to the  
15 cooling fluids commonly used in cooling apparatus for household purpose (hydrocarbons), and in particular R600a. Preferably, such material is a polyamide 6; 6-6; 6-12; 11; 12 or one of the respective copolymers, preferably polyamide 6-6

20 According to a second requirements, tubing 9 comprises a second layer "S2", usually innermost, made of a material impermeable to water and resistant to hydrolysis (or also N<sub>2</sub> and O<sub>2</sub>) and characterised by good compatibility with the material of layer S1.

Preferably, such material is a copolymer, for example of the type Bynel® by the company DuPont like Bynel® 4206, low density polyethylene modified maleic anhydride or Bynel® 50E662, polypropylene modified maleic anhydride. The second layer "S2" is combined, that is, overlapped, to the first layer "S1" for making a protection of the cooling fluid to any introduction of humidity or water coming from the exterior, improving at the same time the chemical inertia of the tube against the above cooling fluids.

In general, the overall thickness S of the tube will be comprised between a minimum and maximum value of 0.4 - 1.5 mm and of a preferred range between 0.6 and 1.2 mm.

Thickness S1 of the material barrier to humidity and water is comprised between 20% and 40% of the total thickness and is about 30%.

On the contrary, thickness S2 of the material barrier to the cooling fluid and air is about 70% of the total thickness (in general comprised between 60% and 80%).

The thickness of the first layer S1 is comprised between 0.2 mm and 0.4 mm whereas the thickness of the second layer S2 is preferably comprised between

0.4 mm and 1 mm.

To alternatively reduce the molar fraction of water in the circuit, it may be necessary to search for balance conditions of the refrigeration circuit that provide for the use of different materials for balancing the permeability of water between condenser 10 and evaporator 7.

Since condenser 10 operates at a higher pressure (2.5-7 bar) than the evaporator (normally 0.5-2.5 bar - the pressure of 2.5 bar common to evaporator and condenser takes place at stationary circuit), it may be useful for the latter to consist of only the material PA6-6 or PA12 without the waterproof layer.

During the operation of the compressor, the condenser allows the water entered through the evaporator to go out again thus maintaining a balanced situation. This allows maintaining the water molar fraction inside the circuit below certain critical values that the current regulations set to 100 ppm.

Going back now to the exemplifying diagram of figure 1, the above filter 18 is noted, which is arranged between the first exchanger 5 and the lamination device 6 and is suitable for removing any humidity present in the circuit, for example by the use of a

gel capable of absorbing it.

The lamination unit 6, on the contrary, comprises a capillary tube 19 for reducing the pressure in the passage of the cooling fluid between the first  
5 exchanger 5 and the second exchanger 7. Moreover, in its path it also performs a function of energy recovery exchanging heat between the hot coolant at the liquid state that flows therein and the cold vapour present in the tube at the outlet of  
10 evaporator 7.

This thermal exchange operation is carried out in the so-called "exchanger tube" shown enlarged in figure 1.

In order to make the thermal exchange more efficient,  
15 with the same length of the tube and thus same load losses desired in the capillary, it is possible to make the capillary tube with a section different from the standard one illustrated in figure 5.

For example it will be possible for at least the  
20 portion of capillary tube 19 that performs the heat exchange exhibits an outer surface of larger area than that of the tube with circular section; in that case, the section of the capillary tube 19 may exhibit one or more lobes 22 for increasing the

thermal exchange.

The "lobed" section is illustrated in figure 6 and its primary purpose is to increase the outer surface of the tube that exchanges heat with the cooling gas outside.

In fact, always as visible in figure 1, at least a portion of the capillary tube 19 is placed inside a portion of tube 21 in output from evaporator 7 for allowing energy recovery.

Tubing 9 (figures 7, 8, 9, 10) then comprises heating means 23 steadily coupled for allowing a selective defrosting of evaporator 7 when required.

In dynamic or No Frost evaporators, the defrosting function of the evaporator circuit is carried out automatically by the intervention of electrical resistances external to the circuit.

This method of defrosting is not very efficient as it is based on the heat transmission from the electrical resistance of the ice formed on the tubes by radiation.

In the present finding the aim is to obtain the defrosting of the ice by the heating means 23 that are differently coupled in a steady manner to tubing 9.



The heating means 23 comprise, in a first embodiment, at least one metal conductor 24, preferably thread-like constrained to a layer S of tubing 9 (see figures 7, 8, 9, and 10).

5 In general, the metal conductor 24 is constrained to the second layer S2 inside tubing 9 as in particular it is coextruded with the same and is therefore at least partly buried.

10 Figures 7 and 8 show the presence of two electro-conductive wires arranged with prevailing pattern substantially parallel to the development direction of tubing 9.

On the contrary, figures 9 and 10 show the adoption of a thread-like metal conductor 24 wound spiral-wise  
15 around the axis of development of tubing 9.

In an alternative embodiment (or optionally in combination with the previous one), the heating means 23 comprise a layer of conductive material 25 obtained on a surface, preferably external, of tubing  
20 9 (see figure 10a).

The embodiment of such conductive layer 25 may be obtained according to different technologies, such as metallization of the tube surface to be made by metallization in high vacuum, by deposition of

conductive nanoelements on the tube surface, etc.

As an alternative it will be possible to coextrude a thin layer of conductive thermoplastic material that has the same function.

5 The coating of the tube with nanoelements may both constitute a further barrier to the inlet of water into the refrigeration circuit, and for the peculiarity of the surface thereof, a factor of increase of the thermal exchange with the air.

10 In general, at least one insulating surface coating 26 will be provided for protecting the heating means 23 from the ambient outside tubing 9 (fig. 10a).

In particular, such surface coating 26 may be obtained by deposition of an insulating polymeric  
15 film or by other surface coating treatments.

The heat required for defrosting the ice is thus transferred by the heating means 23 by direct conduction from the resistance buried in the tube to the ice, thus considerably increasing the efficiency  
20 of the defrosting system and reducing energy consumption.

It should be noted that the types of resistances mentioned above are flexible and thus they do not impair the typical possibility of bending of

corrugated tubes.

Advantageously, according to an embodiment illustrated in figures 17, 18 and 19, tubing 9 may be obtained both by direct extrusion and corrugation with elements of different sizes, and by the assembly of two or more tube portions, preferably corrugated (figure 18) but not necessarily so (figure 19), having dimensional modularity features. In other words, tubing 9 may be obtained from the reciprocal coupling of two, and preferably a plurality of, portions of corrugated tube preferably having same dimensions both in section and in length. This allows obtaining tubing 9 having different lengths starting in any case from portions having a same standard length, and thus suitable for facilitating respective storage processes. In this case in fact it is necessary to have stored only a reduced range of portions, or optionally only one type of tubes, which are then assembled in a sufficient number to make a tubing 9 having a desired length.

As mentioned before, a less expensive system that prevents junctions may be obtained by extrusion and continuous corrugation of the different parts of the refrigeration circuit using elements of the

corrugator made according to different geometries.

Some possible assembly solutions shall now be illustrated hereinafter with reference to the refrigeration circuit, of the various components thereof.

The details of the junctions illustrated may be made with alternative methods, such as vibration welding, laser etc; the purpose of the junctions is to provide a connection of mechanical and/or physical and/or chemical type, which should be impermeable to the cooling gas and to the other gases and humidity mentioned above.

In general, the circuit will exhibit a plurality of coupling terminals or connectors 15 for connecting to each other multiple portions of tube belonging to the refrigeration circuit or connecting the tube itself to the various components.

Figure 11 shows a possible embodiment of the connection between the capillary tube 19 and the corrugated tube 9 belonging to the evaporator.

In particular, connector 15 comprises a seat 27 suitable for receiving an end 28 of tubing 9; the seal between connector 15 and tubing 9 is ensured by a suitable welding.

Connector 15 further comprises a through cavity 29 for allowing the passage of the cooling fluid between the connected tubes and the connector itself. In particular, the capillary tube 19 entirely crosses  
5 the above through cavity bringing directly the cooling fluid at the inlet section of the corrugated tube 9.

In order to ensure the seal between the capillary tube 19 and connector 15, the latter comprises a  
10 shaped seating portion 31 suitable for being crossed by the end of the capillary tube 19 for defining in cooperation with the latter an irremovable constraint area 30. The constraint is preferably obtained using suitable glue.

15 Going to look at figure 12, it should be noted that the same shows a detail of the exchanger tube, that is, of the portion of tube wherein the capillary is within tubing 9 for making the above thermal exchange.

20 As it may be noted, the coupling in the left portion between the connector and the tubing portion 21 that contains the capillary may be obtained by welding, using the above seat 27 that receives end 28 of tubing 9 and the welding technology.

Connector 15 then comprises an inlet/outlet hole 37 for allowing the passage of the capillary tube 19 from inside tubing 9 to the outer ambient and vice versa (to this end it should be noted that the inlet zone of the capillary tube will be mirror or with different configurations compared to that shown in figure 12 where the outlet takes place).

It should then be noted that the connection between the exchanger tube with the return tube from the evaporator exhibits both a glued junction zone (exchanger tube+capillary tube with return tube), and a junction welded by rotation (exchanger tube to the connector).

Figure 13 shows an embodiment version of connection between the exchanger tube with the return tube to the evaporator: in fact, such junction is entirely made by gluing.

In particular, the shaped seating portion 31 and the tube end define means for first coupling 32 for allowing a first holding into position to the purpose of a subsequent irremovable constraint.

In particular, the first coupling means 32 of figure 19 comprise respective expansions 33 and recesses 34 respectively defined in one or in the other of the

shaped seating portions 31 and of the ends of the tube to ensure a first engagement by interference that maintains the reciprocal position during the subsequent permanent junction steps.

5 During assembly, such expansions 33 and recesses 34 are placed relative to each other so as to ensure the keeping of the position during the irremovable constraint steps (by glue, welding or the like).

The same type of first coupling means 32 may be used  
10 for connecting subsequent tubing portions directly to one another, as clearly shown in figure 19.

Finally, it should be noted that to avoid the use of connectors at the exchanger tube, it is possible to adopt the solutions shown in figure 14 and in figure  
15 15, that is, make in said tubing 9 an inlet/outlet hole 37 for allowing the passage of the capillary tube from the exterior inside tubing 9 and vice versa. The fluid seal may be ensured by glue or welding.

20 Figure 15 shown an embodiment version wherein the inlet/outlet hole 37, instead of being at the normal corrugations of the tubing, is defined in a pre-shaped zone 38 suitable for defining a flat inlet/outlet area of the capillary tube that is

substantially parallel to the axis of the tube itself.

In this way it is possible to define a reference surface and ensure better gluing and seal between the  
5 tubing.

In this way, only the seal of the capillary in input and output from the tube is required without further necessary processes.

Finally, figure 16 shows how to connect metal tubes  
10 belonging to the circuit (for example the inlets and the outlets from the compressor identified with reference 35) to tube 9 according to the invention.

In particular, an end of tubing 9 is overlapped to a corresponding end of a metal tube 35 and there is an  
15 over-pressing element 36 for irremovably constraining said ends.

In the preferred and illustrated embodiment, only evaporator 7 comprises a flexible tubing 9 made of plastic material, whereas condenser 5 comprises a  
20 conventional metal coil 10 which is welded to the remaining part of the refrigeration circuit 3. However, it is possible to make an apparatus 1 exhibiting both coil 10 of condenser 5 and tubing 9 of evaporator 10 of synthetic material, preferably



one or more plastic materials of the type described above.

The present invention attains the proposed objects, overcoming the disadvantages mentioned in the prior art.

The use of connectors that in any case are elements of discontinuity in the circuit and that have a certain cost, may be avoided using corrugators of higher length and provided with shaping elements shaped to obtain different sections in the same continuously extruded corrugated tube; the above sections with special shape, for example required for coupling to the copper tube (35), may be obtained by continuous extrusion and corrugation with shaped elements. In the same way, the exchanger tube 17 may be extruded continuously with tube 9 of evaporator 7, inserting in the corrugator, if required, shaped elements that allow obtaining section 38 for inserting capillary 19 and the final portion 36 for over-pressing. In this way it is possible to prevent some coupling joints, making the refrigeration circuit safer and less expensive.

The presence of a flexible tubing allows a very simple and elastic installation of the same on the

household appliance, since no advance definition of the tubing configuration is required but on the contrary, the latter is bent in optimised and diversified manner according to the requirements of space and shape of the thermal exchange surface to be covered.

The corrugated shape, at least in portions, of the tubing allows an increase of the thermal exchange surface since the corrugated shape of the tubing exhibits a greater outer surface than a corresponding smooth or in any case perfectly cylindrical tubing. Moreover, the corrugated shape also inside the tubing itself allows generating whirling motions in the cooling fluid that positively affect the thermal exchange made by the fluid itself.

The lamination device 6 and art of the exchanger tube 17 constitute a tubular exchanger having an inner tube a calibrated polyamide tube, wherein the liquid to be cooled flows, and an outer tube, optionally coextruded with the inner one (figures 14a, 14b) or rolled up or coextruded/rolled up (14c) externally or internally to tube 17, wherein the vapour to be heated to be then compressed by the compressor without droplets flows. The device described above

may be entirely made of plastic material and in the desired shapes, unlike what occurs presently using metals which, for obvious reasons, limit shapes and length thereof.

5 As said, tube 17 may also be obtained as simple extension of tube 9 of evaporator 7 thus eliminating a junction.

Both such device and the various components of the refrigeration circuit, are then suitable for being  
10 made by coextrusion of plastic material with inserted one or more thin metal wires, usable as resistances for the quick defrosting of the evaporator or any other part of the circuit, or for overheating the vapour to be sent to the compressor.

15 In other words, and if required it will thus be possible (even independently of the corrugation of the tubing or portions thereof) to bury such resistances (wires of metal or conductive material) in predetermined portions of the tubing for  
20 defrosting or heating one or more parts of the circuit.

As an alternative (or in combination) it will be possible to provide for the tube or portions thereof to be made by coextrusion of one or more layers of

plastic material covered by a special lake (further outer layer) containing conductive nanoelements; such lake will be applicable by spray during the extrusion or afterwards on the already assembled work or as an alternative even by immersion in a special bath and will have the characteristic of generating heat when crossed by an electrical current, so as to carry out the function of defrosting or heating device of specific zones of the refrigeration circuit.

Condensers 10 may be made similarly to what described for evaporators 9, making the plastic material tube shapes and sizes in the most suitable possible manner for the operating requirements of the refrigerating appliances.

Condensers 10 operating upstream of the compressor must higher pressures than those of evaporators 7. For this reason, they should meet more restrictive rules, in particular they should withstand a pressure of 36 bar.

For this reason, the thickness of corrugated tubes must be increased to no less than 0.7 mm (preferably 0.8-1.4 mm) and it is thus important to increase the thermal exchange surfaces making suitable geometries. All these components of the circuit may be coupled to

each other by the above connectors, allowing assembly saving (they are presently welded to one another) and assembly safety.

The connections between the components of the refrigeration circuit (evaporator, capillary, exchanger tube, compressor, condenser and filter) may be obtained by rotation welding operations or gluing by the use of quick connections with seals (o-rings or alternative ones) as sealing element.

It is also possible to make such shapes on the corrugated tube as to allow snap-wise coupling and creating the deposition seat of a sealing adhesive or a special sealing element such as for example an O ring of suitable material (figure 20) with the placement of glue 40 for sealing the space between the two sealing elements 42 and 43. The glue may be inserted through hole 41 (two symmetrical holes may be required for venting the air).

Moreover it should be noted that the particular shape of the capillary appears advantageous in se, irrespective of the presence of corrugated plastic tubes; also the connectors described above are per se usable and independent of the presence of corrugated plastic tubes.

The described invention thus eliminates the complex and expensive processes for making the metal tube and bending the same for obtaining the traditional metal coil of the evaporator, and the range of products on stock is reduced since it is necessary to store only the tubing that has not received the final winding and bent configuration yet. Also the need of storing the tubing may be easily eliminated having an extrusion and corrugation line for the plastic tube the cost whereof is at least 20 times less than a production line for metal tubes and for the operation whereof it is necessary to have a covered surface much smaller than that required for a production line of the metal tube.

The manufacture of the tubing of plastic material and in particular by extrusion or coextrusion processes drastically reduces the costs of the raw material required to make the various components of the refrigeration circuit and greatly simplifies the manufacturing processes of the tubing itself with consequent drastic decrease of the manufacturing costs of the household appliance. Moreover, this allows greatly reducing the mass of the household appliance, replacing the conventional metal coil with

a coil of plastic material.

The possibility of obtaining a tubing starting from modular portions of tube further facilitates storage as only few types of tube portions may be provided, having predetermined lengths and sections.

The coupling of the tubing to the remaining part of the refrigeration circuit does not require anymore the making of the traditional welding which besides requiring special apparatus and being mainly made manually, is also irreversible and thus it would not allow removing the tubing from the household appliance.

The availability of quick connectors, the possibility of having coextruded tubes that perform the function of heat exchangers and the possibility of alternating parts of straight and rigid tube to corrugated parts bending as desired, allows creating different shapes and sections in the refrigeration circuits such as to open new perspectives to design, to the functionality and to the performance of the circuits themselves.

Also in this case, having special corrugators it is possible to make different sections without discontinuities requiring the use of joints. For example, the condenser tube may be coextruded to

tube 10b and having special elements in the corrugator, the seat of filter 18 may be obtained in the same way without the use of connectors with the economic and safety advantages described above  
5 (figures 21a and 21b).

There are further advantages, such as corrosion resistance, less surface porosity that makes it more difficult for the ice to stick to the surfaces, the recyclability of the materials used for the  
10 refrigeration circuit without the need of expensive operations for separating the components, which contribute to making the proposed technology even more competitive and advantageous compared to the current one.



CLAIMS

1. Refrigeration circuit (3) for household appliances, in particular household appliances for cooling such as refrigerators, freezers and the like, comprising:

- at least a first heat exchanger (5), suitable for being placed in fluid communication with a compressor (4), for allowing the cooling of a cooling fluid substantially in liquid phase in crossing;

- at least a second heat exchanger (7) in fluid communication with said first exchanger (5) and active at a space (2) to be cooled, said second exchanger (7) allowing the cooling fluid at least partly in gaseous phase to absorb heat cooling said space (2), the cooling fluid circulating from the first exchanger (5), towards the second exchanger (5) and thus being directable to a compressor (4) for a subsequent cycle; and

- preferably a lamination device (6) arranged between said first (5) and second (7) heat exchanger for generating an expansion of said cooling fluid, at least one of said first (5) and

second (7) heat exchanger comprising at least one flexible tubing (9), characterised in that at least a portion of said tubing (9) exhibits such corrugated profile as to impart flexibility thereto.

2. Refrigeration circuit (3) according to claim 1, characterised in that said tubing (9) is a flexible corrugated tubing.

3. Refrigeration circuit (3) according to claim 1 or 2, characterised in that said tubing (9) is made of a material not permeable to said cooling fluid circulating in said tubing (9), preferably a material not permeable to cooling fluids selected from the group comprising HC, HFC or mixtures thereof.

4. Refrigeration circuit (3) according to one or more of the previous claims, characterised in that said tubing (9) comprises at least one layer (S1) of plastic material, preferably polyamide and even more preferably polyamide 6-6 or polyamide 6-12.

5. Refrigeration circuit (3) according to one or more of the previous claims, characterised in that said tubing (9) is made of a material not permeable to humidity to prevent external humidity from penetrating in said tubing (9) containing said

circulating cooling fluid.

6. Refrigeration circuit (3) according to one or more of the previous claims, characterised in that said tubing (9) comprises at least two superimposed layers (S1, S2) of different materials, preferably both plastic materials, a first layer (S1) of a material impermeable to the cooling fluid and/or to incondensable gases, a second layer (S2) impermeable to humidity.

7. Refrigeration circuit (3) according to claim 6, characterised in that said first layer (S1), preferably external, is made of a material selected from the group comprising polyamides 6; 6-6; 6-12; 11; 12 and the respective copolymers, preferably polyamide 6-6 or polyamide 6-12, and that said second layer (S2), preferably internal, is made of a material selected from the group comprising olephinic copolymers, low density polyethylene modified with maleic anhydride and polypropylene, preferably modified with maleic anhydride, type BYNEL 4206 by DuPont.

8. Refrigeration circuit (3) according to one or more of the previous claims, characterised in that said tubing (9) is defined by at least two, preferably a

plurality of, modular tube segments connected to each other by respective junction elements for obtaining a fluid-dynamic continuity between said tube segments.

9. Refrigeration circuit (3) according to one or more  
5 of the previous claims, characterised in that at least one of said heat exchangers (5, 7) is entirely defined by said tubing (9), said tubing (9) being in particular entirely provided with such corrugated profile as to impart flexibility thereto.

10 10. Refrigeration circuit (3) according to one or more of the previous claims, characterised in that at least one of said heat exchangers (5, 7) is entirely defined by said tubing (9), said tubing (9) consisting of portions of rectilinear tube spaced by  
15 portions of tube having corrugated profile so as to impart flexibility thereto for example in portions where it is necessary to make the bending zones, keeping the other zones stiff and self-supporting.

11. Circuit according to any one of the previous  
20 claims, characterised in that the tubing (9) exhibits a cross section not circular and comprises at least a portion (44), for example flat, suitable for coupling with a surface of a household appliance at least partly counter-shaped, for example flat, to said

portion (44).

12. Refrigeration circuit according to any one of the previous claims, characterised in that a wall thickness (S) of the tubing (9) is comprised within a  
5 range between 0.3 mm and 2 mm and preferably between 0.6 mm and 1.2 mm.

13. Circuit according to claim 6, characterised in that the thickness of the first layer (S1) of material impermeable to the cooling fluid is  
10 comprised between 60% and 80% and preferably it is about 70% of the total thickness (S) of the tubing (9), the thickness of the second layer (S2) of material impermeable to humidity is comprised between 20% and 40%, and preferably it is about 30% of the  
15 total thickness (S) of the tubing (9).

14. Refrigeration circuit according to the previous claim, characterised in that the thickness of the first layer (S1) is comprised between 0.2 mm and 0.4 mm, the thickness of the second layer (S2) being  
20 preferably comprised between 0.4 mm and 1 mm.

15. Circuit according to any one of the previous claims, characterised in that the tube thickness (10) of the first exchanger or condenser (5) is such as to allow a burst resistance of 36 bar, and it is

preferably comprised between 0.8 and 1.4 mm,  
preferably with maximum outer diameter of 7 mm.

16. Circuit according to any one of the previous  
claims, characterised in that said tubing (9)  
5 exhibits a maximum outer diameter (Dmax) comprised  
between 6 mm and 14 mm and preferably within the  
range of 8 mm - 11 mm.

17. Circuit according to any one of the previous  
claims, characterised in that said tubing (9) of the  
10 first exchanger or condenser (5) exhibits a maximum  
outer diameter (Dmax) comprised between 5 mm and 10  
mm and preferably within the range 6 mm - 7 mm.

18. Circuit according to any one of the previous  
claims, characterised in that said tubing (9) is  
15 sized for allowing, in standard operating conditions  
of the circuit, operating at a velocity of the  
cooling fluid of at least 4 m/sec.

19. Circuit according to any one of the previous  
claims, characterised in that said tubing (9) is  
20 sized for working with inside pressures within a  
range from 0.3 to 12 bar and preferably in a range of  
temperatures between -30° and +70°C.

20. Circuit according to any one of the previous  
claims, characterised in that it may comprise a

filter (18), in particular arranged between the first exchanger (5) and the lamination device (6), for removing any humidity present in the circuit, said removal being carried out for example by a gel  
5 capable of absorbing humidity.

21. Circuit according to claim 20, characterised in that the body of the filter 18 consists of the tube wall (10b) coming from the first exchanger or condenser (5), said wall being suitably enlarged, for  
10 example during corrugation, to contain the gel so as to create a filter integral with the tube (10b).

22. Circuit according to the previous claim, characterised in that the filter consists of a body obtained by corrugation from the tube (10b) closed by  
15 a connector, for example welded thereto by ultrasounds or glued, which couples to the capillary (21).

23. Circuit according to any one of the previous claims, characterised in that the lamination unit (6)  
20 comprises a capillary tube (19) for reducing pressure in the passage of the cooling fluid between the first exchanger (5) and the second exchanger (7).

24. Circuit according to any one of the previous claims, characterised in that the lamination unit (6)

exhibits at least one portion (20) suitable for carrying out a heat exchange between the cooling fluid circulating therein and the colder cooling fluid in output from the evaporator (7) and in that  
5 such tube is made of a plastic material.

25. Circuit according to claim 23, characterised in that at least a portion of the capillary tube (19) is placed inside a portion of tube (21) in output from the evaporator (7) for allowing energy recovery.

10 26. Circuit according to claim 23, characterised in that the portion of the capillary tube (19) exhibits an outer surface of larger area than that of a tube with circular section, preferably the section of the capillary tube (19) exhibiting one or more lobes (22)  
15 for increasing the thermal exchange surface.

27. Circuit according to claim 23, characterised in that the capillary tube (19) enters and exits from the exchanger tube (17) through special seats obtained by corrugation on the tube (17) and suitable  
20 for allowing easy introduction of the capillary (19) with relative sealing.

28. Circuit according to claim 23, characterised in that the capillary tube (19), at the inlet and outlet sections from the exchanger tube (17), has suitable



profiles that define the portion thereof inside the tube (17) and facilitate the coupling thereof to the sealing joint of the sections themselves.

29. Circuit according to any one of the previous  
5 claims, characterised in that said tubing (9) comprises heating means (23) steadily coupled for allowing a selective defrosting of the second exchanger (7).

30. Circuit according to the previous claim,  
10 characterised in that said heating means (23) comprise at least one metal conductor (24), preferably thread-like, constrained to a layer (S) of said tubing (9) and arranged so as to allow bending on the corrugated portions.

15 31. Circuit according to the previous claim, characterised in that said metal conductor (24), is constrained to a second layer (S2) inside the tubing (9), said conductor being at least partly buried in said second layer (S2).

20 32. Circuit according to claim 29, characterised in that said heating means (23) comprise a layer of conductive material (25) obtained on a surface, preferably external, of said tubing (9).

33. Circuit according to the previous claim,

characterised in that said layer of conductive material (25) is obtained by metallization of the surface of the tubing (9), for example by deposition of conductive nanopowders on the surface of the tubing (9) or with metallization in high vacuum of the surface of the tubing (9), the circuit then comprising at least one insulating surface coating (26) for protecting the heating means (23) from the ambient outside the tubing (9).

34. Circuit according to claim 32, characterised in that said layer of conductive material (25) constitutes a further barrier to the inlet of water into the tubing (9) and/or a factor of increase of the thermal exchange with the air.

35. Circuit according to any one of the previous claims, characterised in that it further comprises a plurality of connectors (15) for connecting to one another multiple portions of tube belonging to the refrigeration circuit.

36. Circuit according to the previous claim, characterised in that at least one of said connectors (15) comprises a seat (27) suitable for receiving an end (28) of the tubing (29), the seal between connectors (15) and tubing (9) being ensured for

example by welding.

37. Circuit according to claim 35, characterised in that said connector (15) comprises a through cavity (29) for allowing the passage of the cooling fluid  
5 between the tubes connectable to the connector.

38. Circuit according to claim 35, characterised in that the connector (15) comprises a shaped seating portion (31) suitable for being crossed by an end of tube to be connected and for defining in cooperation  
10 with the latter an irremovable constraint area (30), preferably by gluing.

39. Circuit according to the previous claim, characterised in that the shaped seating portion (31) and the tube end define means for first coupling (32)  
15 for allowing a first holding into position to the purpose of a subsequent irremovable constraint.

40. Circuit according to the previous claim, characterised in that first coupling means (32) comprise respective expansions (33) and recesses (34)  
20 defined on the shaped seating portion (31) and on the tube end for an engagement by interference.

41. Circuit according to any one of the previous claims, characterised in that an end zone of a tube comprises a shaped seating portion (31) that with the

end of the tubing (9) defines means for first coupling (32) for allowing a first holding into position to the purpose of a subsequent irremovable constraint.

5 42. Circuit according to the previous claim, characterised in that first coupling means (32) comprise respective expansions (33) and recesses (34) defined on the shaped seating portion (31) and in the tube end for an engagement by interference.

10 43. Circuit according to any one of the previous claims, characterised in that an end of the tubing (9) is overlapped to a corresponding end of a metal tube (35), the circuit comprising an over-pressing element (36) for irremovably constraining said ends.

15 44. Circuit according to claims 23 and 35, characterised in that said connector (15) comprises an inlet/outlet hole (37) for allowing the passage of the capillary tube (19) from inside the tubing (9) to the exterior or vice versa.

20 45. Circuit according to claim 23, characterised in that said tubing (9) exhibits an inlet/outlet hole (37) for allowing the passage of the capillary tube (19) from inside the tubing (9) to the exterior or vice versa.

46. Circuit according to the previous claim, characterised in that said tubing (9), at the inlet/outlet hole (37), exhibits a profile (38) suitable for defining a flat inlet/outlet area of the capillary tube (19) substantially orthogonal to the axis of the capillary tube, thus allowing the introduction and above all, the removal.

47. Circuit according to the previous claims, characterised in that with a single coextruded and corrugated tube, it is obtained the evaporator (7), the exchanger tube (17), the sections of inlet and outlet from the capillary (19), the end section suitable shaped so as to allow easy coupling to the compressor (4) and the other end section suitably shaped for coupling to the sealing joint of the capillary (19).

48. Circuit according to any one of the previous claims, characterised in that it comprises a single coextruded and corrugated tube which defines the condenser (5), the tube (10b), the filter body (18), the end section (3) shaped so as to allow easy coupling of the compressor (4) and the other end section suitably shaped for coupling to the sealing joint of the capillary (19).

49. Circuit according to claims 47 and 48, characterised in that it only comprises two or three elements defined by said single tube.

50. Circuit according to any one of the previous  
5 claims, characterised in that the evaporator (7) comprises a tubing (9) exhibiting at least two layers (S1, S2), at least a first layer (S1) of a material impermeable to the cooling fluid and at least a second layer (S2) of a material impermeable to  
10 humidity, the condenser (5) exhibiting at least a first layer (S1) of a material impermeable to the cooling fluid and not exhibiting any further layer of material specifically impermeable to humidity.

51. Circuit according to the previous claim,  
15 characterised in that the condenser (51) only comprises a layer impermeable to the cooling fluid such as a polyamide layer.

52. Use of a corrugated flexible tube as thermal exchange coil of an evaporator (7) or a condenser (5)  
20 of a refrigeration circuit (3) for a household appliance for cooling.

53. Use of a corrugated flexible tube, according to the previous claim, having:

- a first layer (S1) of a material impermeable to

at least one cooling fluid and to the air,  
preferably to hydrocarbons;

- a second layer (S2), of a material impermeable to humidity,

5 as thermal exchange coil of an evaporator (7) or  
a condenser (5) of a refrigeration circuit (3)  
for a household appliance for cooling, in  
particular the first layer (S1) being an outer  
layer, the second layer (S2) being an inner  
10 layer.

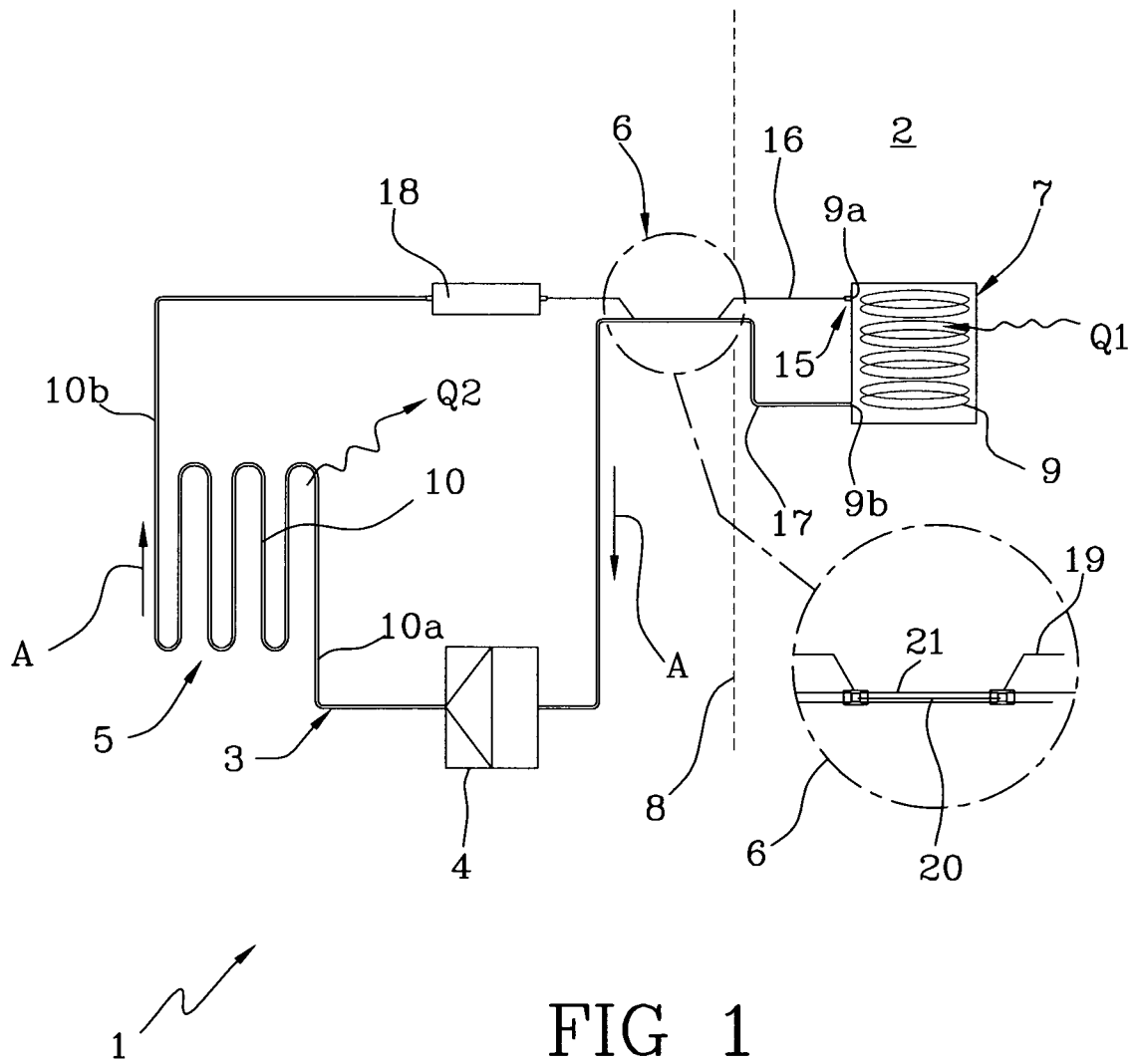


FIG 1



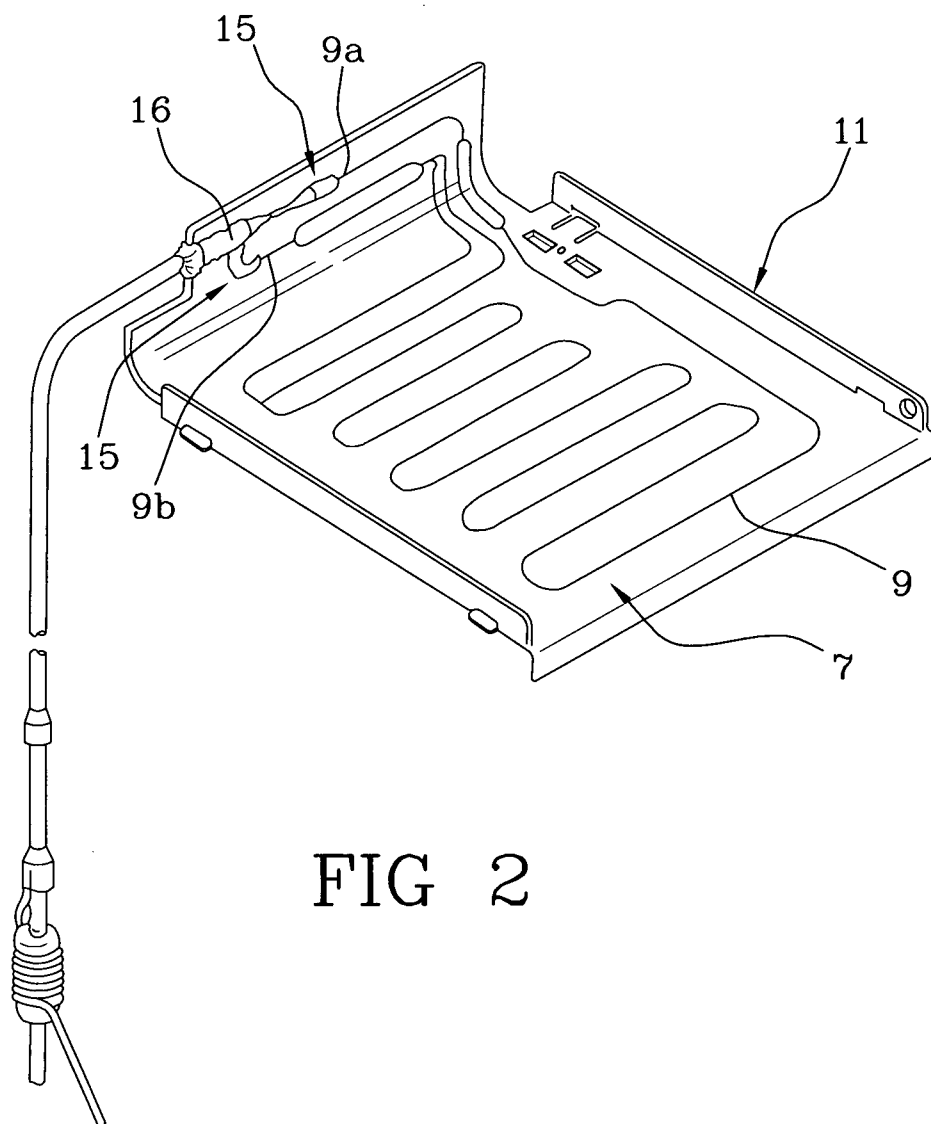


FIG 2

FIG 3

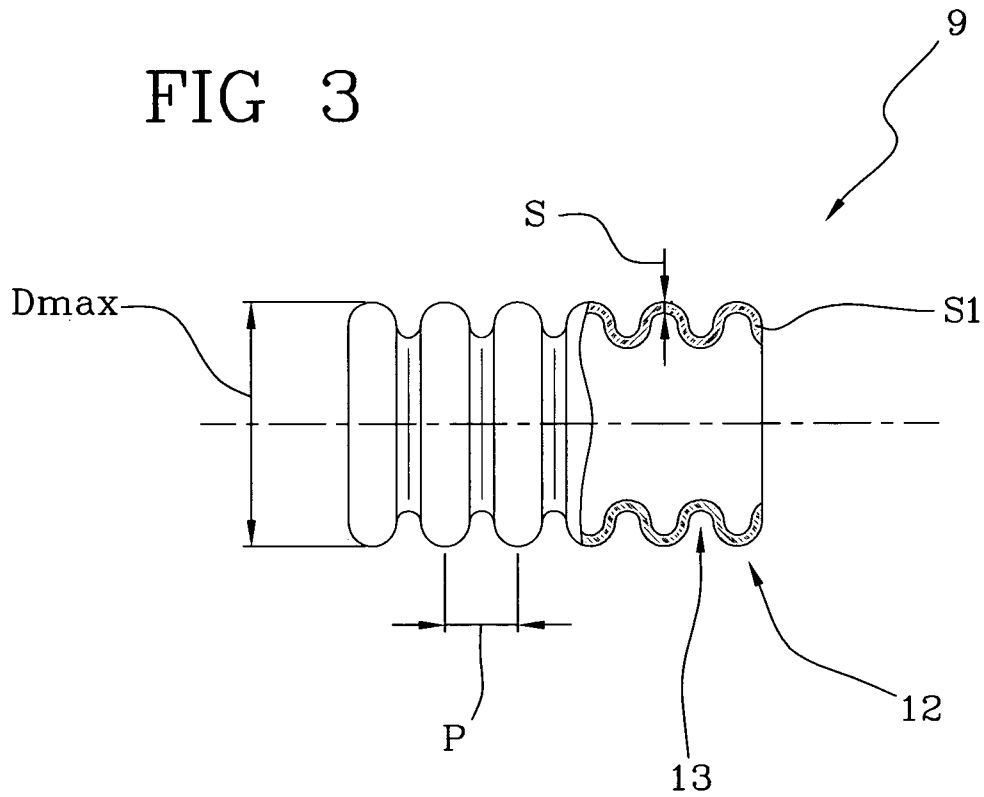


FIG 3a

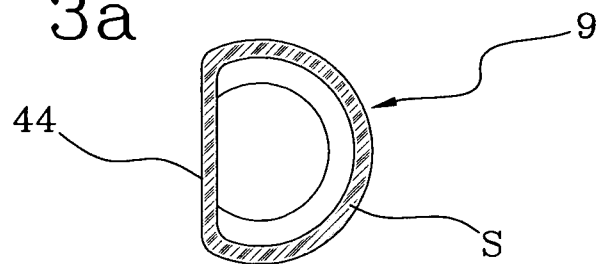


FIG 4

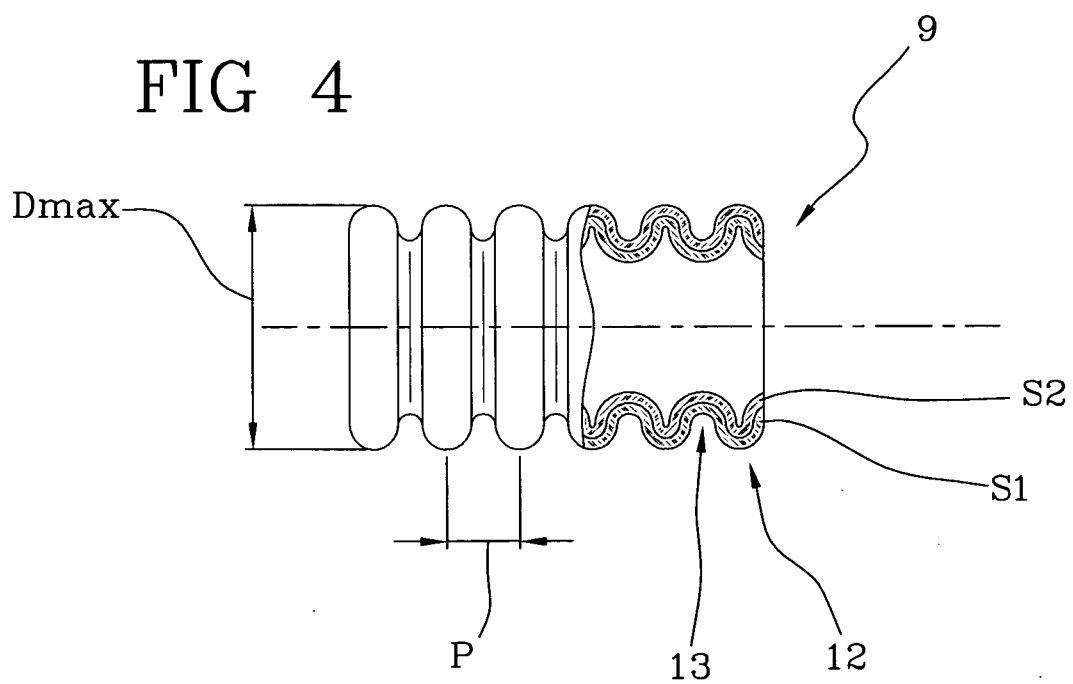


FIG 19

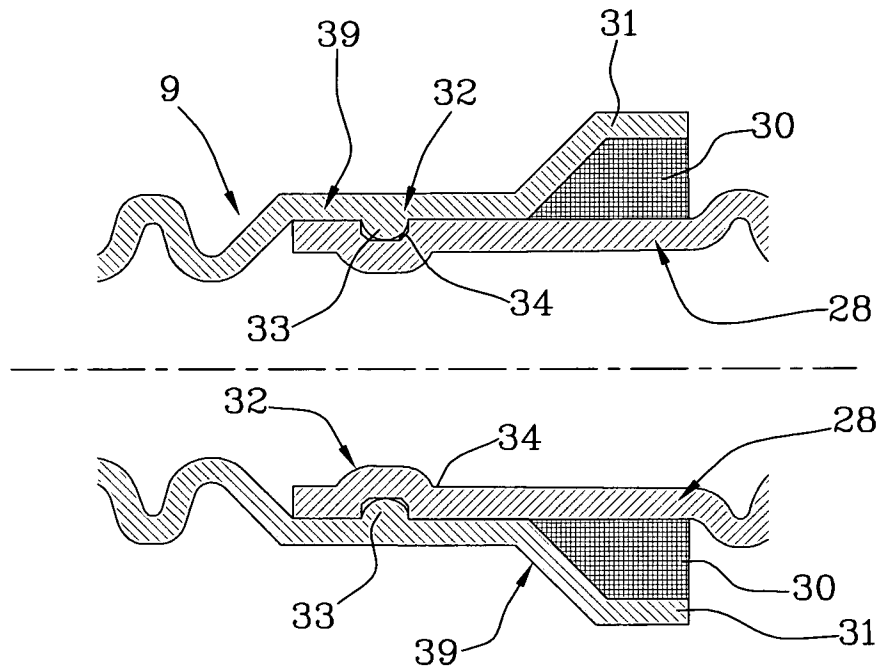


FIG 5

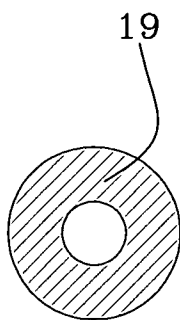


FIG 6

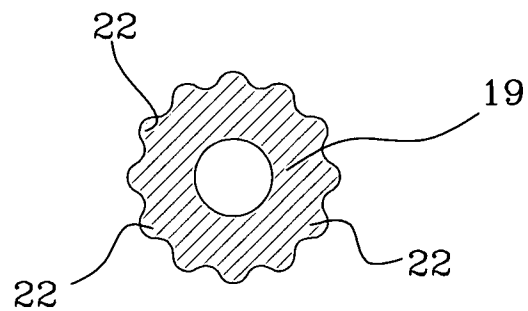


FIG 7

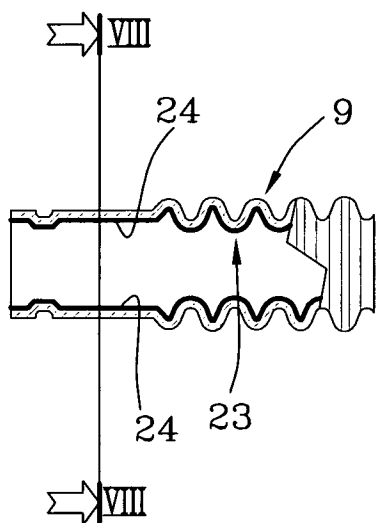


FIG 8

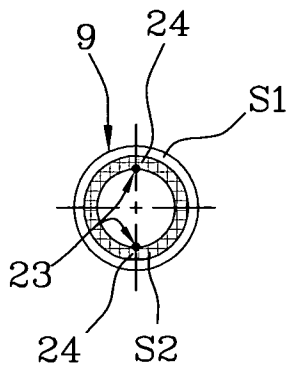


FIG 10a

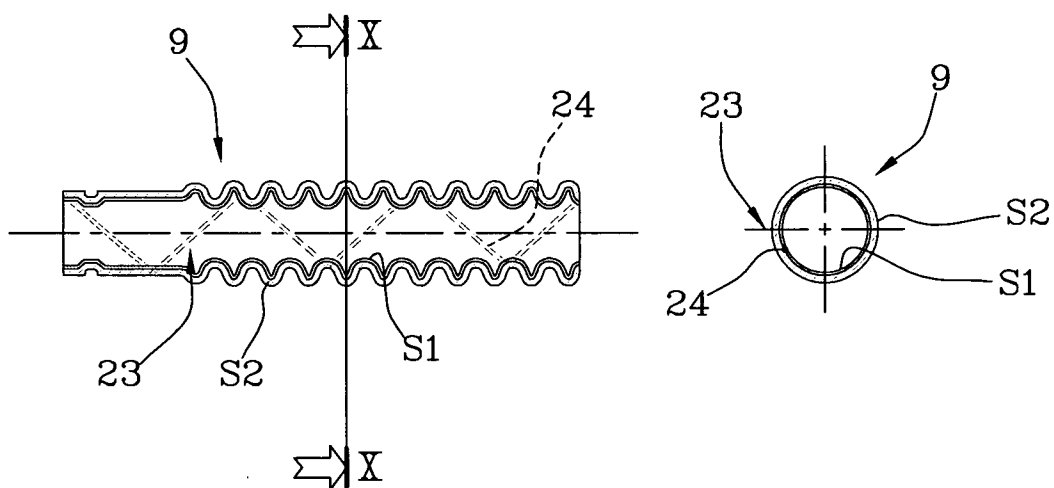
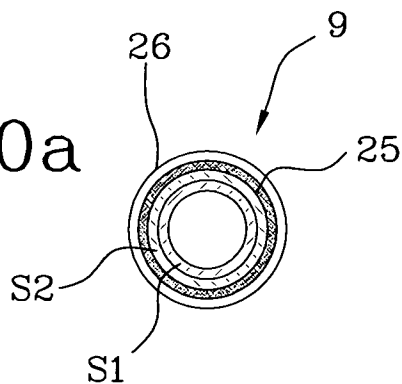


FIG 9

FIG 10

FIG 11

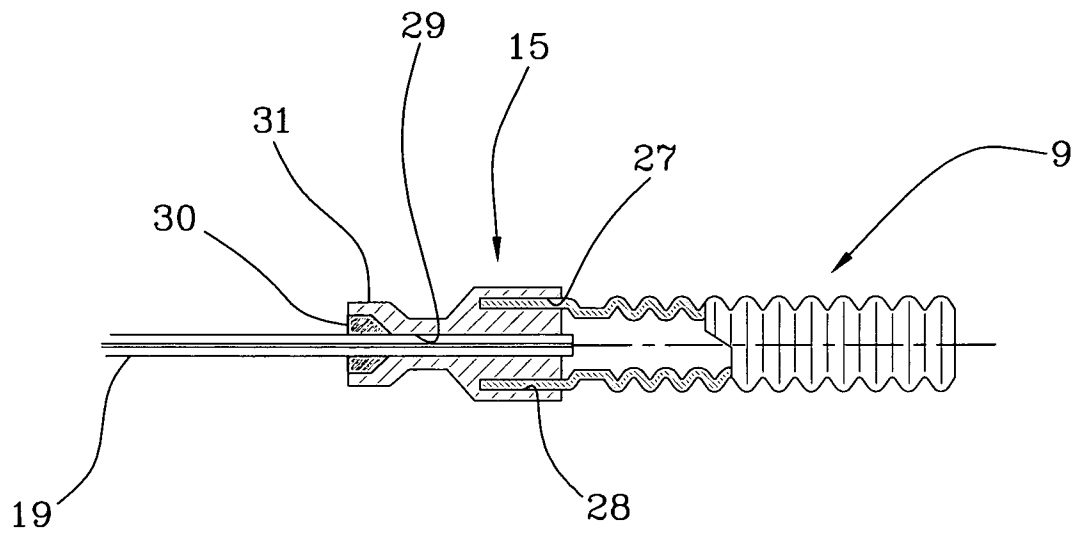
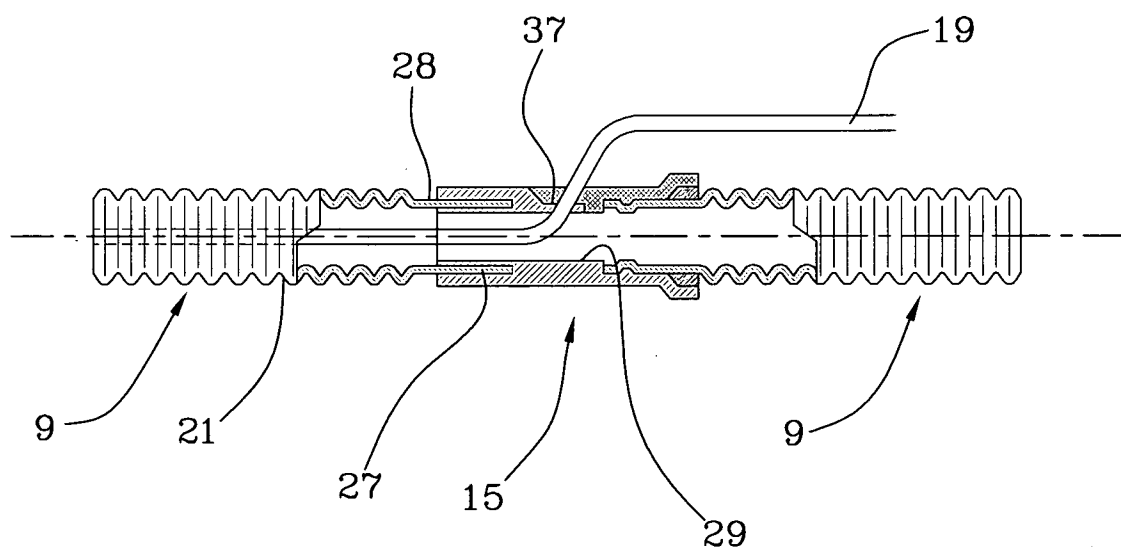
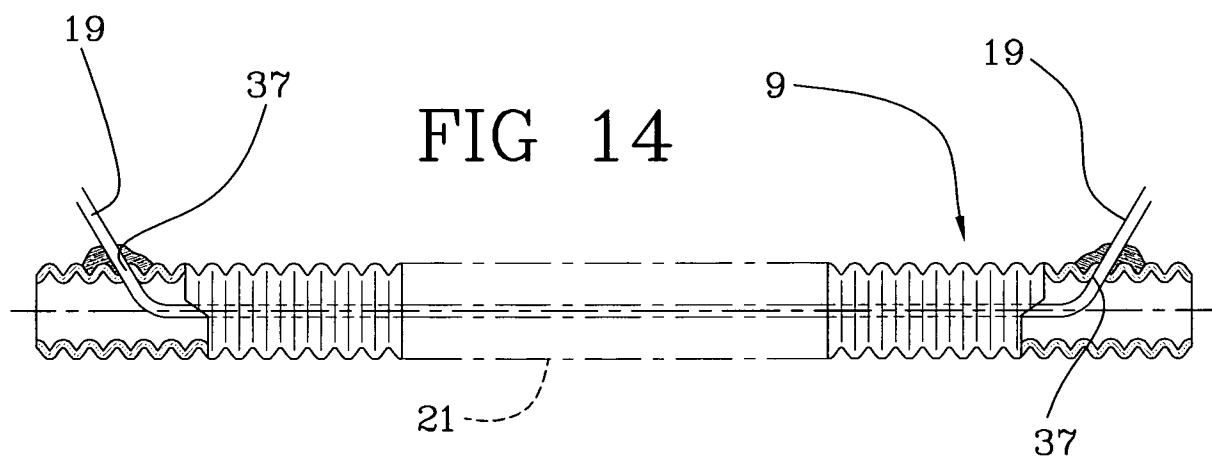
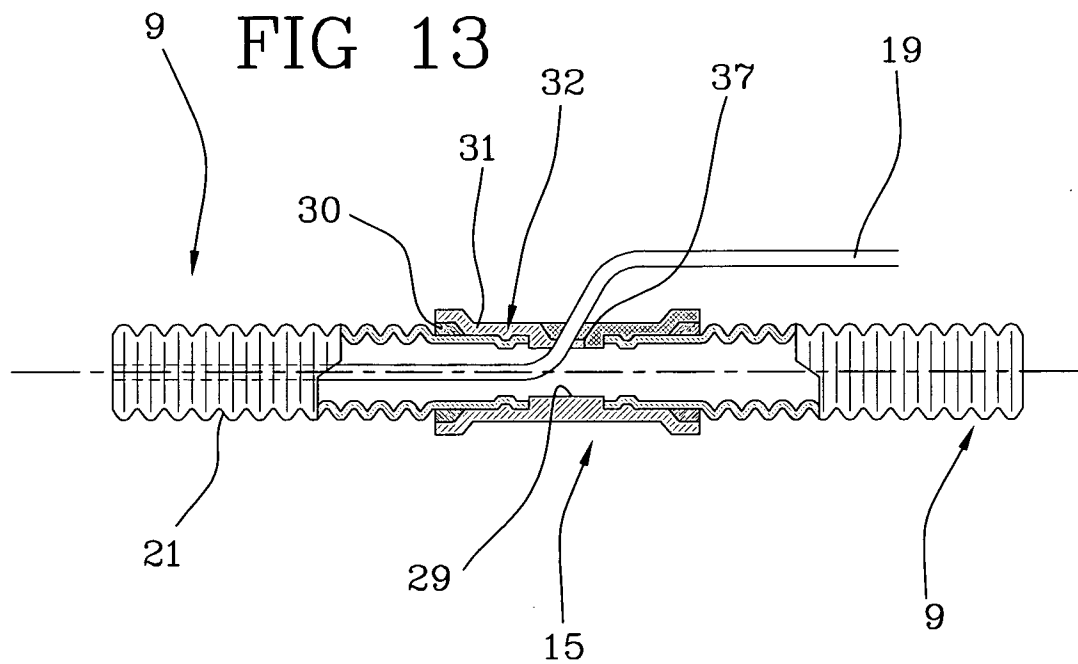
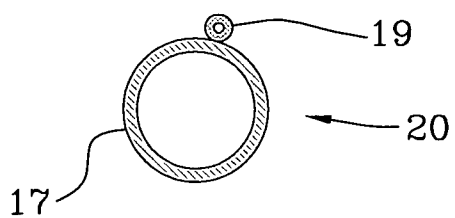


FIG 12





**FIG 14a**



**FIG 14b**

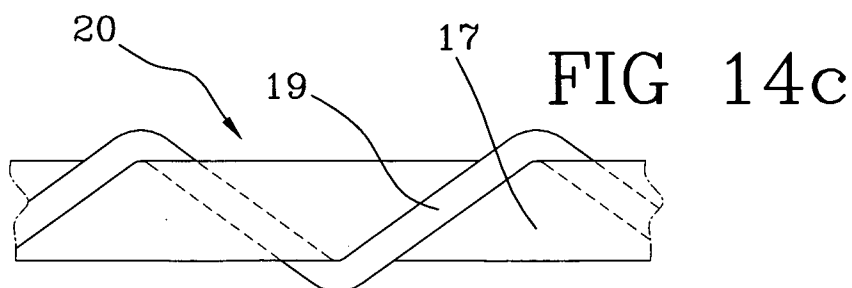
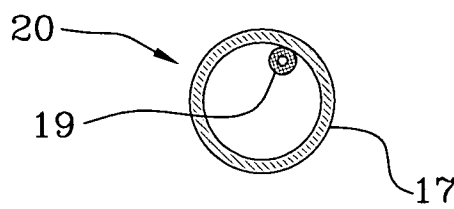


FIG 15

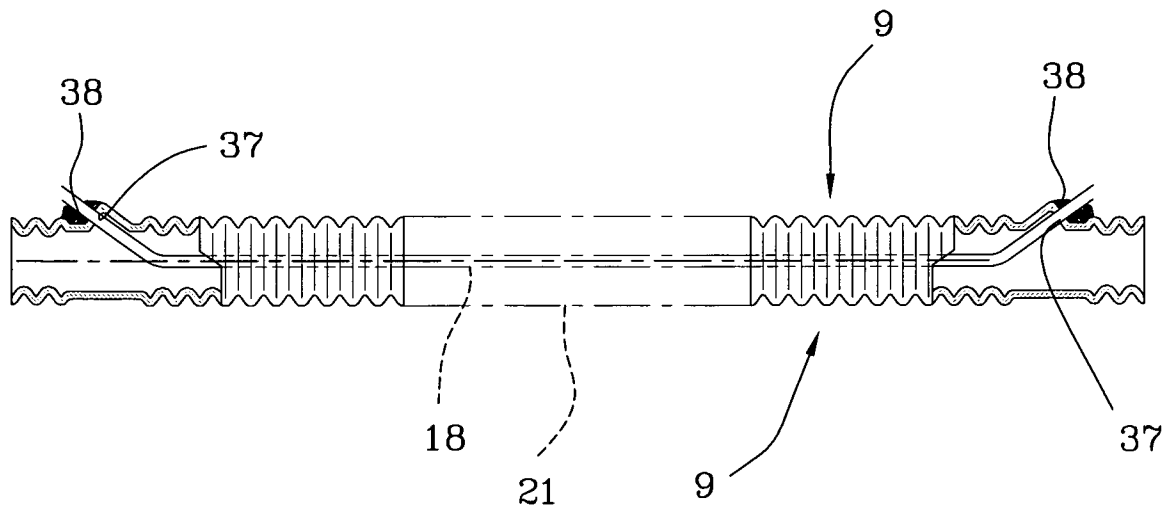


FIG 16

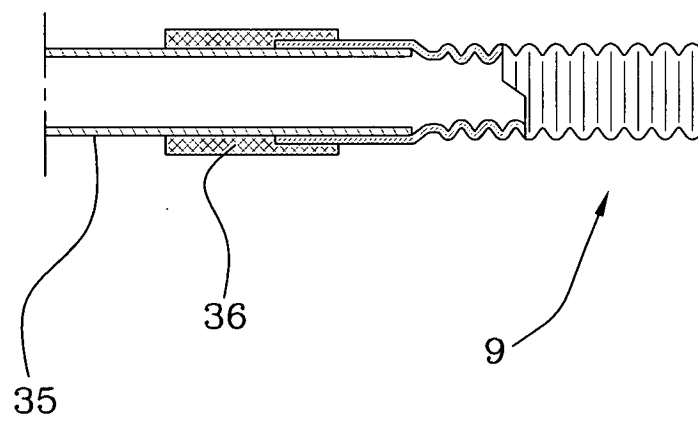


FIG 17

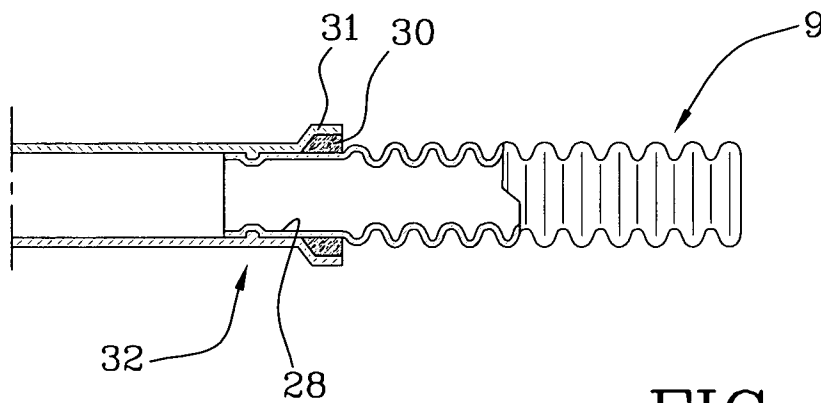


FIG 18

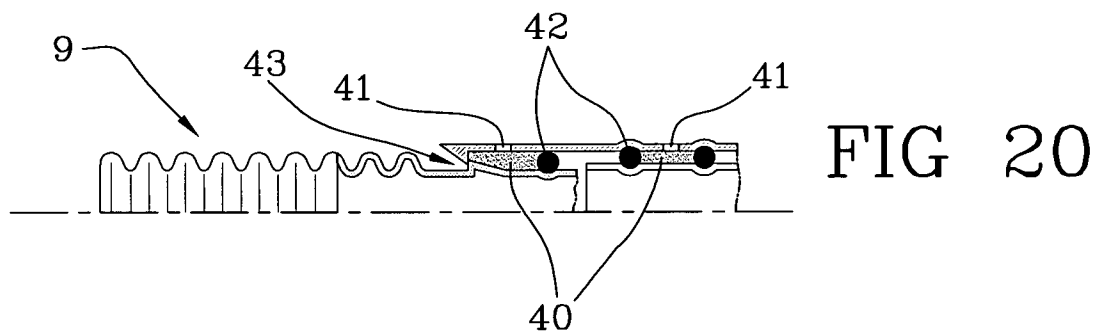
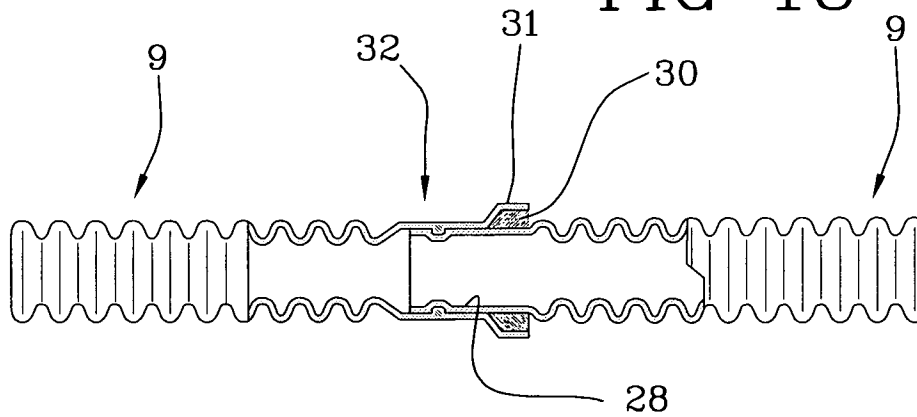


FIG 21a

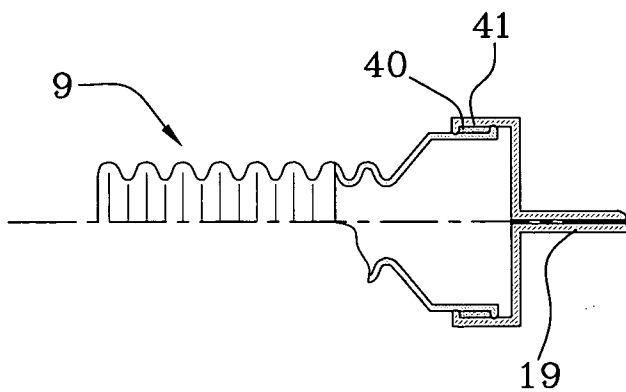


FIG 21b

