(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 844 447 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
**27.05.1998 Bulletin 1998/22**

(51) Int. Cl.$^6$: **F25B 39/02**, F28F 1/22, B23P 15/26

(21) Application number: **97118032.8**

(22) Date of filing: **17.10.1997**

(84) Designated Contracting States:
**AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE**
Designated Extension States:
**AL LT LV RO SI**

(30) Priority: **26.11.1996 IT PN960065**

(71) Applicant:
**Electrolux Zanussi S.p.A.**
**33170 Pordenone (IT)**

(72) Inventor: **Biasoni, Gianfranco**
**33085 Maniago, Pordenone (FR)**

(74) Representative:
**Agostini, Agostino et al**
**PROPRIA,**
**Protezione Proprietà Industriale srl,**
**Via Mazzini 13**
**33170 Pordenone (IT)**

# (54) Method for producing a heat exchanger for a refrigeration apparatus and heat exchanger produced therewith

(57) The invention relates to a method for producing a heat exchanger for household-type and similar refrigeration appliances, said heat exchanger being manufactured starting from a coil-like bent pipe (10) and at least a plate (51), wherein said pipe and said plate are preferably made of an iron alloy. Along at least one (15) of the substantially rectilinear sections (21) of the coil, the pipe (10) is torsionally deformed beyond the limit of elasticity of the material of which it is made. The therewith associated plate (51) is at the same time bent at right angle. The invention also relates to a heat exchanger produced according to such a method.

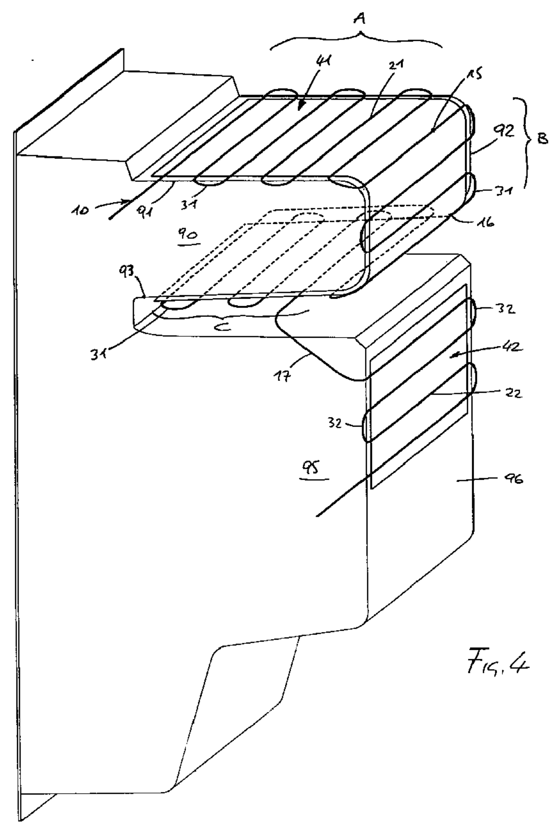


Fig. 4

EP 0 844 447 A2

## Description

The present invention refers to a method for producing a heat exchanger adapted to be used in a refrigeration apparatus, in particular household-type or similar refrigerating equipment, as well as a heat exchanger produced with such a method. An advantageous, but not sole application of this heat exchanger is as a so-called static evaporator, ie.an evaporator operating by natural convection, that is adhesive-bonded to inner walls of the refrigeration apparatus.

In the almost totality of the cases, an evaporator of the above and is currently produced according to two different technological methods, wherein the first one of such methods is the one that is generally known as the "Roll Bond"™ technique, which calls for the use of two metal plates, which are joined to each other by rolling, ie. roll-bonding, and between which a meandering flowpath is created for the refrigerant medium by a silkscreen process. The second technological method calls on the contrary for the use of a pipe having a circular or a D-shaped cross-section and curved in the form of a flat coil with substantially rectilinear sections and related connecting or union bends (180°-elbows), said coil being subsequently adhesive-bonded on one or more walls of the inner compartments of the refrigeration apparatus.

Aluminium alloys are generally used in the evaporators produced with such technologies, so that, owing to well-known soldering or brazing difficulties, a certain criticality is always present at the points in which the evaporators are joined to the remaining parts of the refrigerating circuit of the apparatus. Furthermore, the costs of the above mentioned raw material, ie. aluminium, are subject to quite frequent price fluctuations, which may be even of a quite considerable extent and clearly affect in a negative manner both production costs and the overall manufacturing economics.

A method of producing heat exchangers is also known in which the pipe being bent into a coil is made of an iron alloy, which undoubtedly features technological and economic uncertainties to a much smaller extent than aluminium alloys. To the purpose of compensating for the smaller heat conductivity of the material, the heat-exchange surface of the pipe must however be increased. A commonly known technique consists in caulking the substantially rectilinear sections of the flat coil on a plate, which is also made of an iron alloy and is coplanar with, ie. lies in the same plane as said coil. However, when the heat exchanger must be given a three-dimensional shape, as for instance in the case of a static evaporator of a refrigerator which must subsequently be adhesive-bonded on to the concealed surface of at least two adjacent and substantially perpendicular walls of an inner compartment of the same refrigerator, the toughness of iron alloys makes it difficult for the evaporator to be compliantly adapted to the above cited walls.

It therefore is a main purpose of the present invention to provide a manufacturing method which is particularly, although not exclusively suited to produce, even on a large scale, static evaporators for household-type refrigeration appliances, which, while allowing for the use of such materials as iron alloys for the production of said evaporators, does not involve any of the above cited drawback.

The subject covered by the present invention therefore relates to a manufacturing method and a heat exchanger produced with such a method, both having the characteristics as substantially recited in the appended claims.

Anyway, the invention will be more readily and clearly understood in its features and advantages from the description of a preferred, but not exclusive embodiment thereof that is given below by way of non-limiting example with reference to the accompanying drawings, in which

- Figure 1 is a schematic, top view of a length of coiled pipe attached to a coplanar plate so as to provide a static evaporator;
- Figure 2 is an enlarged-scale view along the II-II section of Figure 1;
- Figure 3 is an expanded view of the illustration appearing in Figure 1, since it relates to the two evaporator arrangements of a household refrigeration appliance provided with a freezing compartment and a cold storage compartment; the same view also includes a schematic illustration of the tools used to carry out the method according to the present invention;
- Figure 4 is a perspective view of the two compartments of the refrigeration appliance which are mentioned with reference to Figure 3, after the two evaporators have been assembled by adhesive-bonding.

With reference to Figures 1 and 2, it can be noticed that a static evaporator for the freezing compartment of a household refrigeration appliance is made starting from a pipe 10, which is made of an iron alloy material and has a circular cross-section, wherein such a pipe is bent so as to obtain a desired flat-coil configuration that is formed by a plurality of substantially rectilinear and parallel sections 20 and union elbows 30 provided between each one of said sections and the next one. The coiled pipe 1 is arranged on a quadrilateral plate 50 that is also made of an iron alloy material, is substantially coplanar with the pipe 10 and is provided with a plurality of parallel grooves 60 extending between two mutually opposing side edges 70 and 80 thereof. More exactly, the rectilinear sections 20 of the pipe 10 are inserted in the grooves 60, whereas the union elbows

30 protrude from the side edges 70 and 80 of the plate 50 (see Figure 1). At this point the assembly is consolidated with a caulking operation, the result of which is a semi-finished part in which the pipe 10 is integral with the plate 50 (see Figure 2) along the whole length of the rectilinear sections 20. All hitherto described manufacturing steps are carried out with conventional operative methods and means which are well-known to all those skilled in the art, so that no further explanation is actually needed here.

It is the subsequent phase of the manufacturing method that actually forms the main feature of the present invention and will be described in greater detail hereinafter with reference to the two above mentioned evaporators, generally indicated at 41 and 42, each one of which is made starting from semi-finished products with the above described materials and manufacturing operations. The evaporators 41 and 42 (hereinafter called simply freezer evaporator and cold storage evaporator, respectively) are made starting from and consist of a single pipe 10 and comprise two plates that are generally indicated at 51 and 52, respectively.

The freezer evaporator 41 comprises three zones A, B, C that are made up by substantially rectilinear and parallel sections 21 of the pipe 10, with the related union elbows 31, and the therewith associated portions of the plate 51. For the reasons that will be better explained further on, it is the substantially rectilinear of the pipe 10 which are indicated with the reference numerals 15 and 16, and whose longitudinal axes are indicated with X-X and Y-Y, respectively, that are particularly highlighted in the drawings.

The cold storage evaporator 42 is on the contrary formed by a single group of substantially rectilinear, parallel sections 22 and related union elbows 32 of the pipe 10, as well as by the therewith associated plate 52. The hydraulic connection of the two evaporators 41 and 42 with each other is brought about by a pipe union 17 arranged outside the outer contour of the plates 51 and 52, for instance perpendicularly to the above mentioned rectilinear sections 21 and 22 of the pipe 10.

The method according to the present inventions provides for (see Figure 3):

- a first end portion of the afore mentioned substantially rectilinear section 15 of the pipe 10 to be clamped in a stationary vice 11, and the other end portion of the same section 15 of the pipe 10 to be clamped in a vice 12 that is capable of being rotated about the axis X-X;

- a first end portion of the afore mentioned substantially rectilinear section 16 of the pipe 10 to be clamped in a stationary vice 13, and the other end portion of the same section 16 of the pipe 10 to be clamped in a vice 14 that is capable of being rotated about the axis Y-Y;

- the vice 12 to be rotated by approx. 90° about the axis X-X in a direction (eg. clockwise) and the vice 14 to be rotate about the axis Y-Y in the opposite direction (eg. anti-clockwise);

- the vices 11, 12, 13, 14 to be eventually removed.

In the above illustrated manner, following is obtained simultaneously:

- a deformation of the substantiallyrectilinear sections 15 and 16 of the pipe 10 beyond the limit of torsional elasticity of the alloy of which said pipe is made;

- two right-angle bends (with respect to the portion belonging to the zone B) of the portions of the plate 51 that belong to the zones A and C, respectively, of the freezer evaporator 41, said two bends being such as to confer a three-dimensional or, more precisely, a C-shaped configuration to the evaporator 41.

To state it more precisely, as better illustrated in Figure 4, the zones A, B and C of the freezer evaporator 41 are therefore so shaped as to be able to more fittingly conform to the outer surface (not exposed to view) of the walls 91, 92 and 93 of the freezing compartment 90 of a household combined freezer-fridge refrigeration appliance. In particular, the above mentioned substantially rectilinear, parallel sections 15 and 16 of the pipe 10 are so arranged as to be eventually positioned along the corners of the compartment 90 that are formed by the walls 91, 92 and 92, 93, respectively. In this connection, it should be noticed that the torques used to clamp the pipe end portions in the vices 12 and 14 are of course so selected as to prevent the pipe 10 from being damaged, ie. so as to prevent the surface thereof from cracking or suffering similar damages which, albeit microscopic in their nature, might well give rise to refrigerant gas leaks during the useful life of the refrigeration appliance concerned. Furthermore, the mechanical properties of the iron alloys and the wall thicknesses of both the pipe 10 and the plate 50 are so selected as to prevent the freezer evaporator 41 from showing any tendency to lose its C-shaped configuration, ie. to resume its original flat shape, alter the above mentioned operations of torsional deformation and right-angle bending.

At this point (or, in the case that adequate manufacturing tools and equipment are available, even simultaneously with the above illustrated operations)the operation can be started to bend in the required manner the sections of the pipe 10 that are not associated with the plates 51 and 52, and in particular the pipe union 17, so as to conform them to the particular requirements placed by the other parts that make up the refrigeration apparatus. Anyway, this phase of the manufacturing process is a substantially conventional one, so that no further explanation is felt to be necessary here.

Subsequently to the above described manufacturing steps, the zones A, B, C of the freezer evaporator 41 are attached by adhesive-bonding to the unexposed (ie. not in view) surface of the afore mentioned walls 91, 92 and 93 of the freezing compartment 90, while the cold storage evaporator 42 is attached by adhesive-bonding to the rear wall 96 of the cold storage compartment 95 (see Figure 4), wherein also these adhesive-bonding operations are carried out in accordance with techniques that are well-known to those skilled in the art.

It clearly emerges from the above description that the main advantages of the above described method basically derive from the possibility of using iron alloys to manufacture heat exchanger that may also be given a three-dimensional shape, as well as the method itself being fully suited for use in large-scale or volume production applications, thanks to the simple, quick manner in which the various operations provided for by the method according to the present invention are actually capable of being carried out.

It will be appreciated that, although the above description and illustrations have been given with reference to a preferred embodiment of the present invention, the latter may be developed in a number of different manners by those skilled in the art without departing from the scope of the present invention.

## Claims

1. Method for producing a heat exchanger adapted to be mounted in a refrigeration apparatus, particularly a household-type refrigeration appliance, comprising the phases of: bending a metal pipe (10) so as to form a flat coil configuration having substantially rectilinear sections (21, 22) and union elbows (31, 32); bonding of said substantially rectilinear sections (21, 22) of the coil on to at least a metal plate (51) that is substantially coplanar with said coil, **characterized in that** it also comprises a further phase that consists in bending the plate (51) along at least one (15) of said substantially rectilinear sections (21) of the pipe (10) amd comprises at least a simultaneous deformation of the same section (21) of the pipe (10) beyond the limit of torsional elasticity of the material of which the pipe itself is made, so as to confer a three-dimensional shape to the heat exchanger (41).

2. Method according to claim 1, **characterized in that** said further phase is carried out by clamping a first end portion of the desired substantially rectilinear section (15) of said pipe (10) and rotating by substantially 90° the second end portion of the same longitudinal pipe section about the axis thereof.

3. Method according to claim 1 or 2, **characterized in that** said further phase concerns two parallel and substantially rectilinear sections (15, 16) of said pipe (10), as well as two end portions of said plate (51).

4. Heat exchanger, adapted to be mounted in a refrigeration apparatus, particularly a household-type refrigeration appliance, of the type substantially made of a metal pipe (10) that is bent in such a manner as to form a flat coil having substantially rectilinear sections (21, 22) and union elbows (31, 32), and at least a metal plate (51) which is substantially coplanar with said coiled pipe and onto which said substantially rectilinear sections (21) of said coil are attached, **characterized in that**, along at least one (15) of said substantially rectilinear sections (21) of the coil, the pipe (10) is torsionally deformed beyond the limit of torsional elasticity of the material of which it is made, whereas the therewith associated metal plate (51) is bent at substantially right angle.

5. Heat exchanger according to claim 4, **characterized in that** both said plate (51) and said pipe (10) are at least prevailingly made of an iron alloy.

6. Heat exchanger according to claim 4 or 5 and adapted to form the evaporator (41) adhesive-bonded onto the unexposed surface of at least two adjacent and substantially perpendicular walls (91, 92, 93) of an inner compartment (90) of the refrigeration apparatus, **characterized in that** said torsionally deformed pipe section (15, 16) is so arranged as to eventually be situated in correspondence of the corner formed by two adjacent walls (31, 32; 32, 33) of said inner compartment (90).

7. Heat exchanger according to claim 6 and adapted to form the evaporators (41, 42) of the freezing compartment (90) and the cold storage compartment (95) of the refrigeration apparatus, **characterized in that** it is manufactured out of a single length of pipe (10) and two metal plates (51, 52) separated from each other, and that it further comprises two substantially rectilinear, torsionally deformed sections (15, 16) of the pipe (10) which are so arranged as to be eventually situated in correspondence of the corners formed by three mutually adjacent walls (91, 92; 92, 93) of the freezer compartment.

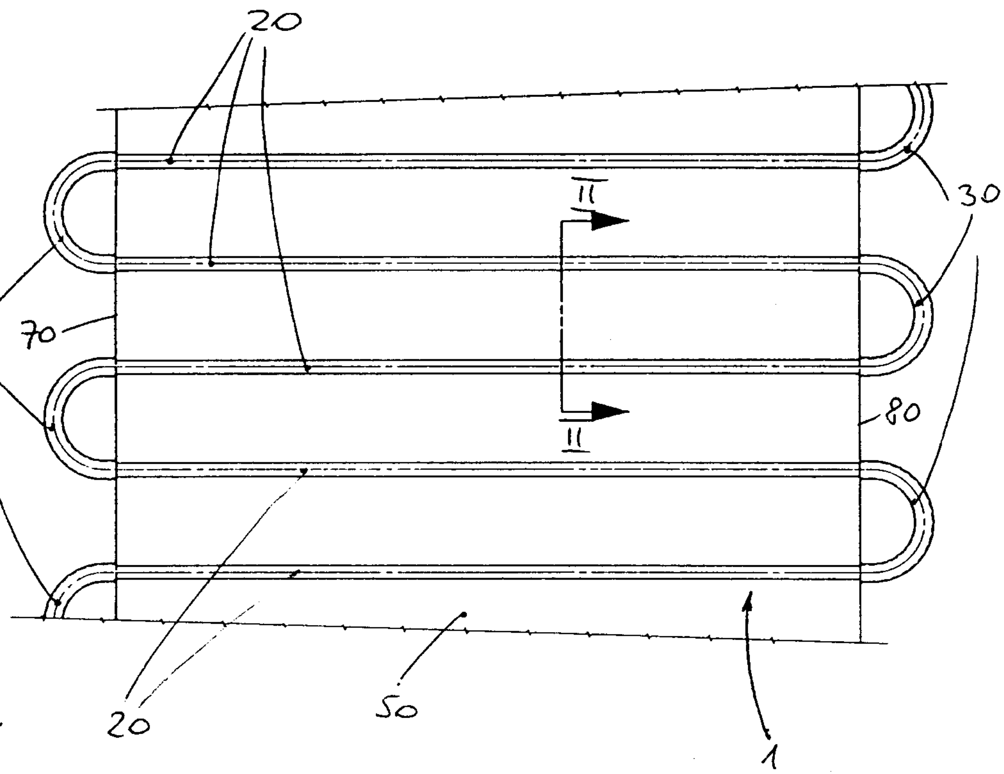


Fig. 1

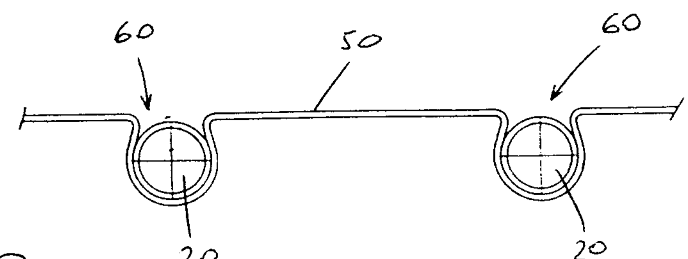


Fig. 2

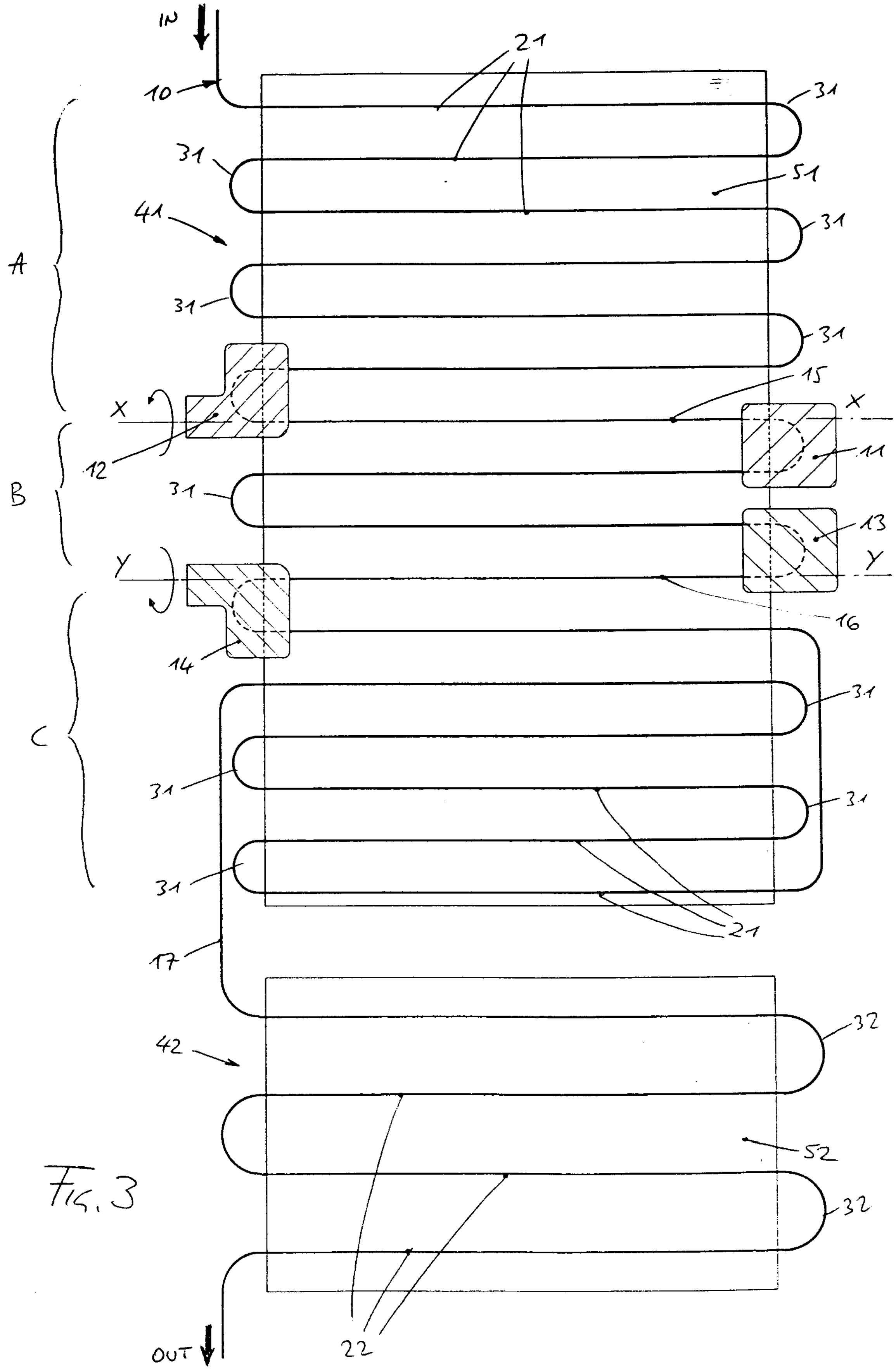


Fig. 3

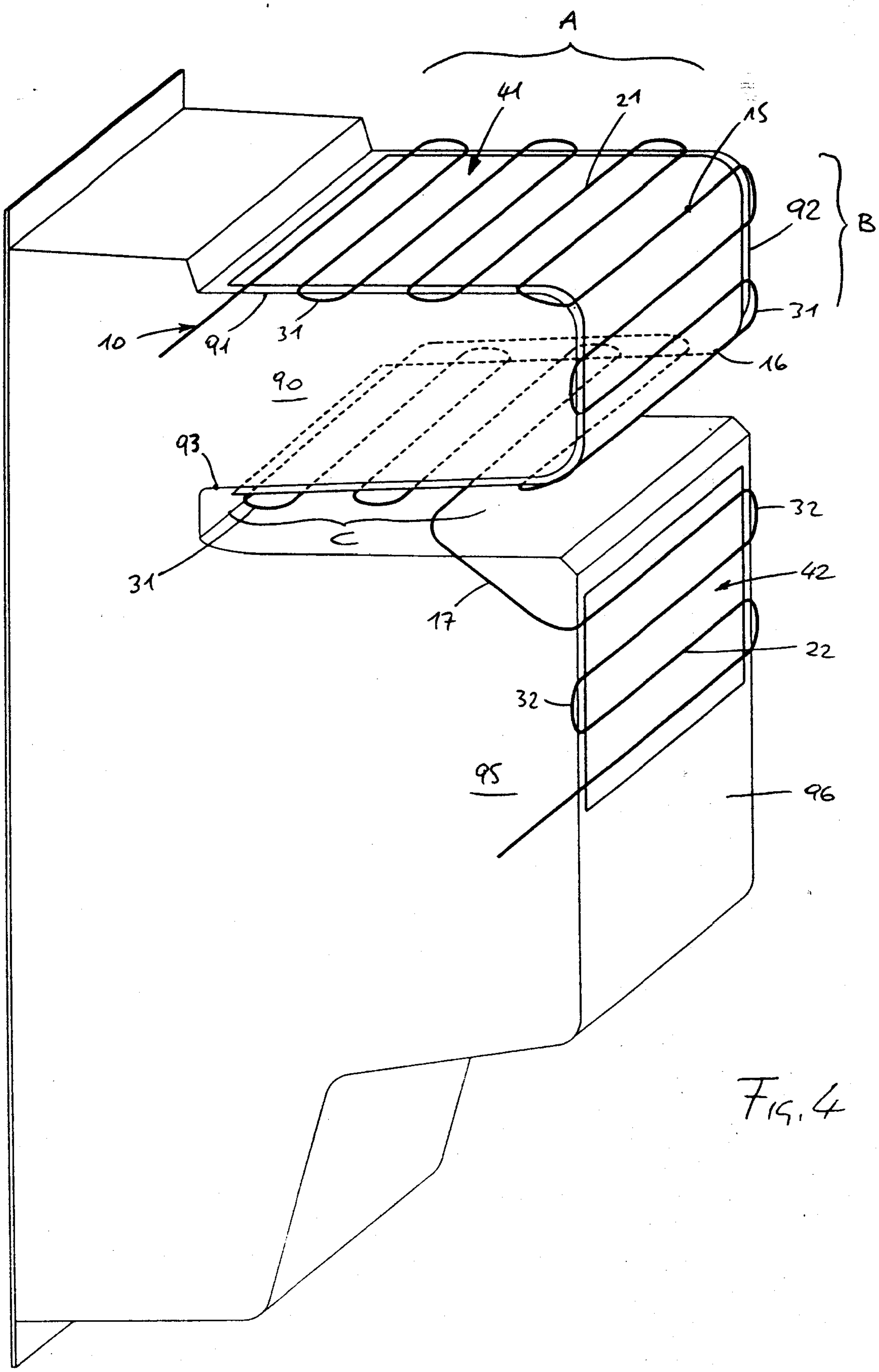


Fig. 4