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(54) **Method and installation for producing heat-exchanger tubes.**

(57) A method and installation for the completely automatized production of heat-exchanger tubes, particularly for household refrigerators.

The heat-exchanger tubes are composed of two coaxial pipes: the outer pipe (1) connects the outlet of the evaporator to the refrigerant intake port of the compressor; the inner pipe (2), normally comprising a capillary tube (5), connects the outlet of the cooling condenser to the inlet of the expansion chamber of the evaporator.

The installation comprises a plurality of stations (11,13-20,22-25) for the execution of the various

processing phases of which the operating cycle is composed, interconnected by means for the automatic and continuous transfer (12,21) of the heat-exchanger tube from one working station to the next.

The installation is designed for the production of a plurality of heat-exchanger tubes of selected dimensions in a completely automatized manner and with the employ of endless components which are in the first instance cut to measure and prepared for their interconnection.

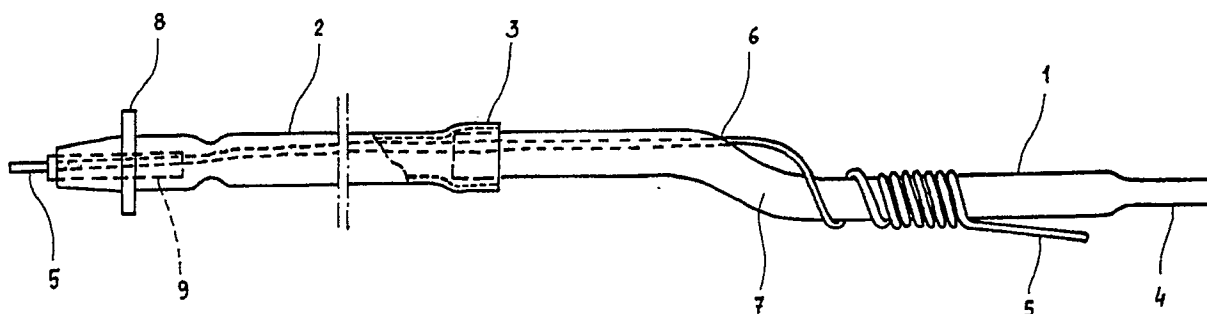


FIG. 1

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METHOD AND INSTALLATION FOR PRODUCING HEAT-EXCHANGER TUBES

The invention relates to a method an installation for the automatized production of heat-exchanger tubes of different dimensions for evaporators of refrigerating apparatus and the like.

In the following description, reference is had to evaporators for refrigerating apparatus for domestic use, but those skilled in the art will not meet with any difficulty in applying the teachings of the present invention to other branches of the industry.

It is helpful to call to mind the operating principles of refrigerating apparatus: the refrigerant circuit is composed of four main components, namely, the compressor, the condenser, the capillary and the evaporator with its associated expansion chamber.

The functions of these four main components are as follows: An electric motor operates the compressor, which acts to pressurize a gaseous fluid of particular characteristics and to direct it towards the condenser.

In the condenser, which is disposed outside of the refrigerating apparatus, the fluid supplied therein in a pressurized and heated state assumes the so-called "ambient temperature", or is cooled by releasing its heat to the environment.

The cooling causes the gaseous fluid to condense, i.e. to assume the liquid state (as will any gas when its temperature drops below a determined level).

The fluid is then directed through the capillary which acts to regulate the flow of the fluid and promotes its compression in the so-called "high pressure phase".

On reaching the expansion chamber, the liquified fluid is sprayed into the evaporator in the form of diminutive droplets.

In the evaporator the fluid encounters an expansion chamber and passes from the liquid to the gaseous state in response to the augmentation of the available volume.

This results in a well-known physical phenomenon, inverse to the one explained above, according to which the fluid returns to the gaseous state by absorbing heat.

From the evaporator the fluid returns (by aspiration) to the compressor, to resume its circulation as described above.

From the designer's point of view it is common practice to pass the capillary issuing from the condenser in a number of windings around the return pipe from the evaporator to thereby ensure that the fluid in the capillary is still further cooled by using the low temperature still prevailing in the return pipe, and to finally guide the capillary into the return pipe, resulting in only a single connection

between the evaporator and the remainder of the circuit, since the inlet connection of the capillary is disposed coaxially within the outlet connection of the return pipe.

5 The production of this section (the so-called heat-exchanger tube) of the circuit, with a coaxial and a non-coaxial portion, between the evaporator and the intake port of the compressor, is thereby rendered rather difficult and cumbersome from the viewpoint of manufacturing technology.

10 In this connection it is to be remembered that the intake pipe leading to the compressor is usually made of copper or copper-plated steel, whereas the evaporator is normally made of aluminum. To enable the ends of the heat-exchanger tube to be welded to both of these components, it is therefore preferably made of copper, i.e. of a metal capable of being welded or electrically bonded both to the compressor and to the evaporator (aluminum).

15 20 On the other hand, however, copper is a metal which is considerably more costly than aluminum. In order to avoid having to bear the high expense for a heat-exchanger tube made completely of copper, it is common practice to make the heat-exchanger tube in two sections, a copper section extending from the compressor to beyond the point whereat the capillary enters the return pipe, and the remaining section made of a less costly material, for instance aluminum.

25 30 This results in the additional complication that the heat-exchanger tube has to be made of aluminum towards its connection to the evaporator, and of copper towards its connection to the compressor, i.e. that the heat-exchanger tube has to be assembled of two sections made of the two different metals, which have to be connected to one another in a hermetically sealed manner.

35 40 This results in an evident complication of the production process, particularly in view of the fact that the welding operations have to be carried out with a high degree of precision and accuracy to ensure the required hermetic sealing.

45 50 It is therefore an object of the present invention to overcome the described difficulties and to provide a method and an automatically, reliably and flexibly operable installation advantageously combining the techniques of industrial automatization with a technique of joining pipes made of different metals for producing a heat-exchanger tube having the desired characteristics in a completely automatized process.

This object is attained according to the invention by the method and installation to be described by way of example with reference to the accompanying drawings, wherein:

fig. 1 diagrammatically illustrates the structure of a heat-exchanger tube made in accordance with the invention, and

fig. 2 represents a diagram of a preferred embodiment of an installation according to the invention.

Shown in fig. 1 are the following elements:

- 1) Heat-exchanger tube, copper section,
- 2) Heat-exchanger tube, aluminum section,
- 3) Juncture of the two sections,
- 4) Restricted end portion of the tube for connection to the intake pipe of the compressor,
- 5) Capillary
- 6) Entry point of the capillary into the heat-exchanger tube,
- 7) Double-bent portion of the heat-exchanger tube at the capillary entry point,
- 8) Press-formed aluminum collar on the end portion of the heat-exchanger tube adjacent its connection to the evaporator,
- 9) Strengthening rib.

With reference to fig. 2, the illustrated installation includes the following components:

- 11) Aluminum pipe cutting station,
- 12) Shuttle step transfer,
- 13) Copper pipe cutting station,
- 14) Copper pipe transfer station,
- 15) Copper pipe press-forming station,
- 16) Flash welding station
- 17) Tube calibrating station,
- 18) Tube cleaning station,
- 19) Strengthening rib application station,
- 20) Copper pipe restriction-forming station,
- 21) Chain conveyor with grippers,
- 22) Copper pipe bending and drilling station,
- 23) Capillary cutting station,
- 24) Capillary brazing station,
- 25) Capillary winding station.

For a better understanding of the invention, reference will be made to an example in which the working stations are substantially aligned in two files along the end portions of the heat-exchanger tubes, and the joining of the components is accomplished by welding the surfaces to be joined, although the invention is not limited to this arrangement and this technique, respectively, inasmuch as those skilled in the art will be readily able to employ the teaching of the invention in combination with other joining techniques and different conveying and processing arrangements.

The illustrated installation operates in accordance with the following procedure:

In the first place, cutting stations 11 and 13 operate to unwind the respective pipes from supply reels and to cut them to predetermined lengths for obtaining pipe sections 1 and 2, respectively.

Copper pipe section 1 is then press-formed at press-forming station 15 to provide it with a re-

stricted end portion for insertion into aluminum pipe section 2 as at 3 in fig. 1.

Subsequently transfer station 14 operates to transfer pipe section 1 to welding station 16, whereat it is joined to aluminum pipe section 2 and welded thereto.

Shuttle step transfer mechanism 12 comprises a plurality of substantially hollow supports for carrying respective assemblies each composed of a copper pipe section and an aluminum pipe section. These supports are synchronously and incrementally displaced transversely of their longitudinal direction for carrying the respective heat-exchanger tubes to successive positions corresponding to the various working stations for the performance of the various processing steps thereat.

At the succeeding station 17, copper pipe section 1 is recalibrated to re-establish its inner and outer diameters which may have been altered by the welding operation.

At the following station 18 the tubes are internally cleaned of welding and calibration residues by means of a powerful jet of compressed air directed into the end of the aluminum pipe section, whereupon station 19 operates to implant an elastic member 9 into the end of the tube's bore to be connected to the evaporator.

This elastic member serves the purpose of reinforcing the end portion of the heat-exchanger tube so as to prevent the tube from being bent at the location whereat it is welded to the evaporator; as a matter of fact, the heat-exchanger tube is welded to the evaporator at 8, and subsequently bent by about 90° relative thereto.

In view of the fact that aluminum is a highly malleable metal, bending of the pipe section adjacent the welding location would otherwise frequently result in the formation of cracks in the weld seam or in buckling of the pipe section's walls, whereby the passage of the gaseous fluid could be unacceptably restricted.

These disadvantageous possibilities are eliminated by the insertion of elastic member 9 into the end of the tube.

In continuation of the operation cycle the pre-assembled heat exchanger tube is carried to station 20, whereat a suitable apparatus forms the tube with a restricted end portion 4 for insertion into the intake pipe of the compressor.

The conveyance of the tubes by means of the shuttle transfer conveyor 12 is then terminated, the tubes being transferred in the same alignment as before onto a chain conveyor 21 provided with grippers and operating in the same manner as conveyor 12. The reason for this transfer is that from this point onwards the tubes are to be bent, drilled and welded with a high degree of precision. To this purpose the tubes have to be immobilized

in accurately defined positions, which can only be ensured by clamping them in suitable gripper devices.

The tubes are subsequently bent and drilled at station 22. This station plays a determinant role in the performance of the present invention. This is because in order to completely finish the heat exchanger tube in a fully automatized process, it is necessary that the insertion of the capillary 5 into the tube is also accomplished automatically. This would not be possible, or would only be possible with considerable difficulties, if the heat exchanger tube were of rectilinear configuration as in the conventional construction, because the capillary would then have to be inserted in an oblique direction, and the insertion hole to be closed by welding would have to be asymmetric.

If to the contrary the tube is provided with a double bend in the shape of a cranked portion as indicated at 7 in fig. 1, the hole 6 for the insertion of the capillary can be drilled in the longitudinal direction in the thus formed oblique wall portion, so that the insertion, of the capillary and the closing of the insertion hole by welding can be accomplished without any difficulty thanks to the parallel and coaxial configuration of these elements.

At the succeeding station 23 the capillary is automatically unwound from its supply reel, cut to the required length and readily inserted through the hole 6 in the oblique wall of the heat exchanger tube. The insertion hole 6 is then closed at the next station 24 by a generally known automatic welding operation. At this point the assembly of the heat-exchanger tube is substantially finished; the sole remaining step of winding the capillary about the return pipe is carried out at station 25 at the downstream end of the automatic processing installation.

The characteristics of the invention will thus be readily evident to one skilled in the art: Whereas the conventional technique for the production of heat-exchanger tubes involves the manual or semiautomatic execution of the various operations due to the difficulties opposing the automatized insertion and weld-sealing of the capillary in a pipe section having strictly cylindrical walls, the present invention provides the formation of a double bend in a portion of the heat-exchanger tube, resulting in a pronouncedly oblique wall portion which is accessible to a high-precision processing operation in the longitudinal direction without the need for any special auxiliary devices or particular provisions at the respective station in relation to the other stations which are all designed and arranged for "endwise" processing operations.

Those skilled in the art will not fail to notice another substantial advantage of the present invention: In view of the fact that all of the processing

steps are carried out in a fully automatized manner, it is readily possible to use one and the same installation for manufacturing heat-exchanger tubes of different dimensions. All that is required to this purpose is that the various working stations with their respective tools are displaceable or adjustable lengthwise of the heat-exchanger tubes, and controlled by a unitary control system, with the possible assistance of suitable servo systems.

Claims

1. A method and installation for producing heat-exchanger tubes, particularly for refrigerating apparatus for domestic use, wherein a number of components (1, 2, 5, 6) made of suitable materials, preferably aluminum and/or copper, are prepared and joined to one another by successive operations in a predetermined sequence, characterized in that one of said operations (22) involves the formation of a crank-shaped double bend (7) in a portion of the heat-exchanger tube, that a hole (6) aligned in the axial direction of the tube is formed in a wall portion of said double-bend portion facing towards the compressor connection end (4) of the tube, and that a capillary (5) is inserted through said hole (6), the latter being subsequently closed, preferably by welding.
2. A method and installation according to claim 1, characterized in that said successive operations are carried out at a plurality of processing stations (11, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25) connected to one another by automatic transfer means (12, 21).
3. A method and installation according to claim 2, characterized in that said transfer means (12, 21) comprise shuttle step transfer mechanisms and/or gripper-equipped chain conveyor means.
4. A method and installation according to any of the preceding claims, characterized in that said processing stations are adjustable to correspond to different lengths of the heat-exchanger tubes, and that the sequence of the various operations as well as the variable adjustment of the processing stations are controlled by a unitary control system.

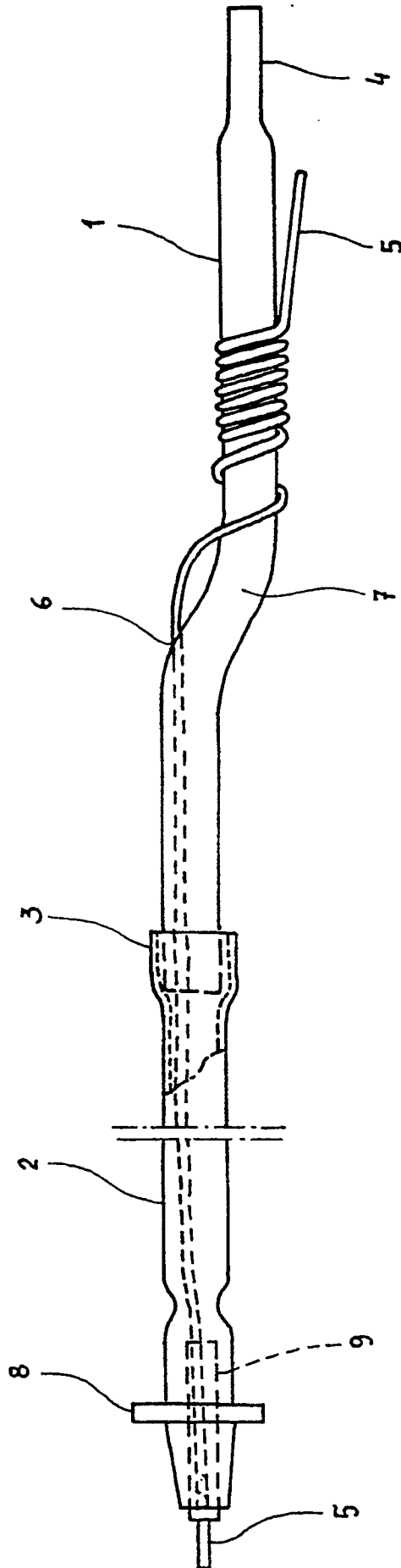


FIG. 1

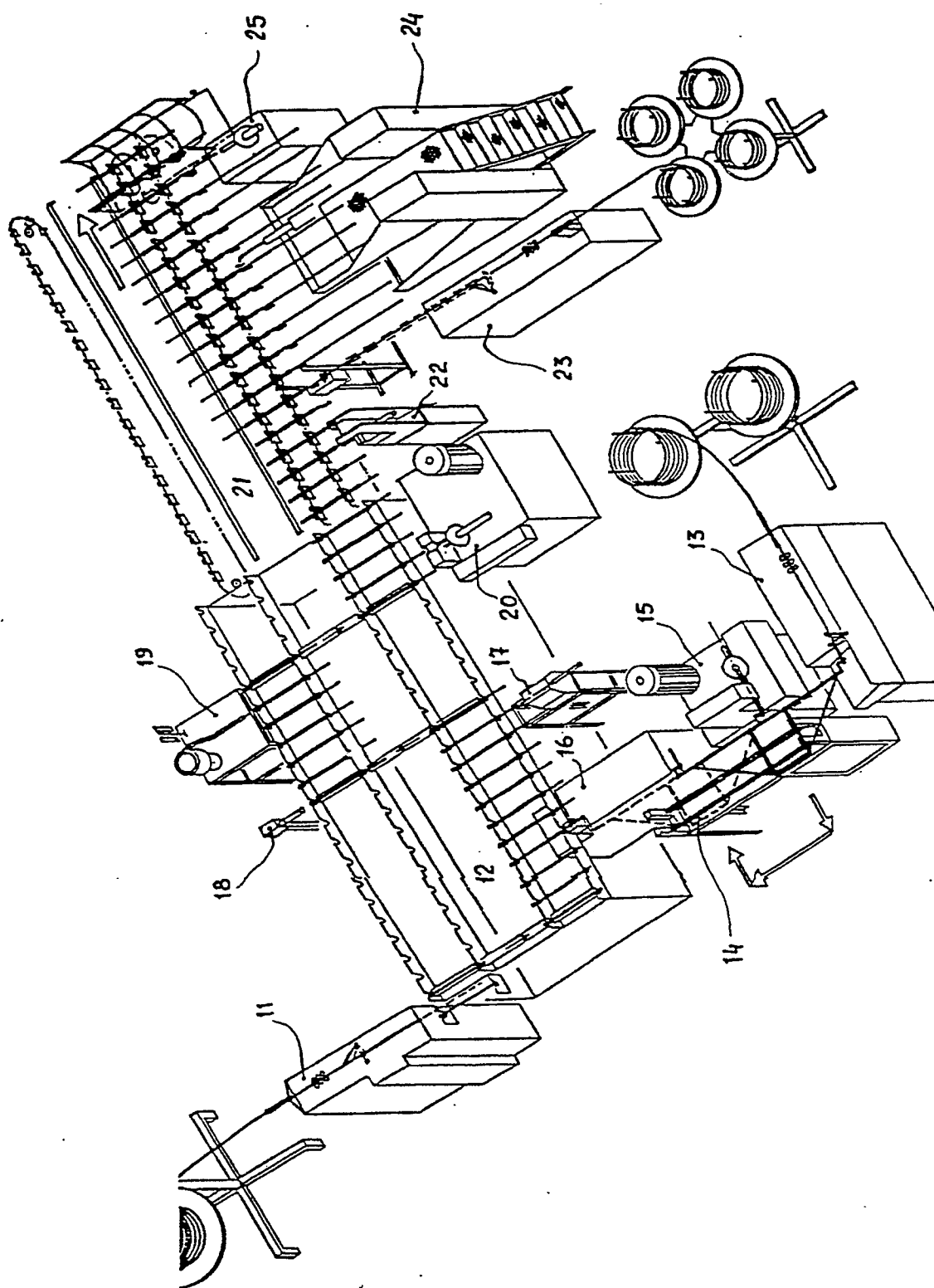


FIG. 2



EUROPEAN SEARCH REPORT

EP 90 12 0685

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	EP-A-0 209 418 (SOCIETE D'ELECTROMENAGER DU NORD SELNOR) * column 1, line 1 - column 3, line 11; figures 1, 2 *	1	F 25 B 41/06
Y	DE-C-3 613 395 (BOSCH-SIEMENS) * the whole document *	1	
A	US-A-2 956 421 (STEVENS) * the whole document *	1	
A	US-A-4 300 672 (MILLAR ET AL.) * the whole document *	1,2,4	
A	US-A-4 581 912 (IRITANI ET AL.) * the whole document *	2,4	
A	EP-A-0 022 095 (ITALTRACTORI.T.M.) * the whole document *	3	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			F 25 B B 23 P
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of search 04 February 91	Examiner BROMAN B.T.
CATEGORY OF CITED DOCUMENTS X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons &: member of the same patent family, corresponding document			