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(54) Apparatus and method for the application of evaporators on already formed refrigerator liners

(57) In a household-type refrigerator appliance, a method for the application of a roll-bond evaporator onto the outer surface of a liner (1) delimitating internally a food storage compartment of the refrigerator appliance; the method comprises a phase in which adhesive means are interposed between the liner (1) and the evaporator, this phase consisting in applying a layer of adhesive substance on the outer surface (8) of the liner (1), in view of then applying the evaporator thereupon.

The process of deposition of the adhesive layer consists in producing and casting a jet of said adhesive substance towards the surface (8) of application, and converting said jet, as soon as it leaves the emitting nozzle, into a continuous filament which is then almost atomized and distributed all over the surface by means of one or more flows of gas, e.g. air, issued by respective nozzles arranged and oriented towards said filament of adhesive substance in such a manner as to intercept the flowpath thereof and convert it into an open spray.

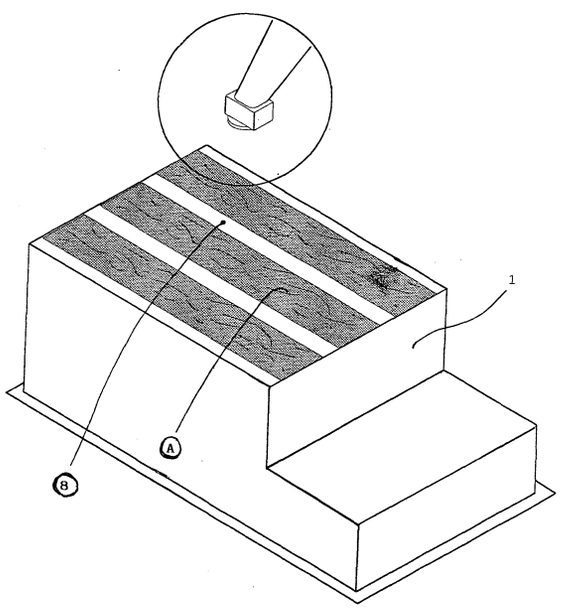

Fig.1

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Description

[0001] The present invention refers to an apparatus and a method concerning a production technology used in manufacturing household-type refrigerators provided with a so-called "concealed"-type evaporator, i.e. an evaporator that is not arranged inside the storage or refrigerating compartment of the refrigerator, but is rather provided on the outside of the same compartment and, therefore, generally embedded in the thermally insulating material surrounding the compartment itself.

[0002] Household-type refrigerators provided with a refrigerating or cold storage compartment and a concealed-type evaporator are largely known in the art. In the large majority of the cases, the liner that delimitates this cold storage compartment in these appliances is made of thermoformed plastic material, typically a sheet of polystyrene, and is thermally insulated from the outside by means of a layer of thermally insulating material, usually polyurethane, that is applied on the outside of the same liner by means of a largely known foaming process.

[0003] In view of improving the manufacturing technique and removing from the interior of the storage compartment the encumbering presence of the evaporator, the latter is made out of a roll-bond plate that is applied onto the outer surface of said liner prior to foaming, in such a manner that, after foaming, said roll-bond plate is practically embedded in said layer of foamed insulating material and is held captive, i.e. trapped between said same layer and the liner, so as to ensure the desired heat-exchange relation.

[0004] However, in order to ensure the accurate positioning and stability of the roll-bond plate during the various handling phases preceding the foaming one, and above all in view of ensuring the required firmness and continuity to the way in which the roll-bond plate adheres to the surface of the liner, a generally used technique calls for a very thin layer of a bi-adhesive material to be applied thereupon, by interposing it between the liner and the roll-bond plate so that the latter is practically "glued" on to the surface of the same liner.

[0005] The nature of said bi-adhesive material, and the thickness thereof, are of course selected so as to by all means avoid impairing the close heat-exchange relation being required in this particular application.

[0006] This practice, on the other hand, is well-known in the art, where it is widely used without any particular drawback or problem of either technical or functional nature.

[0007] However, owing to household-type refrigerators being very popular and widespread consumer durables that are generally mass-produced on a very large scale, the provision of an additional manufacturing step that must usually be performed outside of an automated production line (in order to be able to carry out certain necessarily manual operations), and which further requires the use of an additional material, i.e. the layer of bi-adhesive material, gives rise to additional manufacturing costs that are increasingly penalizing and less and less accepted by both manufacturers and the market.

[0008] It would therefore be desirable, and is actually an object of the present invention, to provide a method for applying an evaporator plate onto the outer surface of a liner of a household refrigerator prior to foaming, which enables significant savings on production costs to be obtained and is capable of being put into effect, i.e. carried out in a fully automated manner.

[0009] In addition, this method shall be capable of being easily implemented and carried out with the use of existing techniques and must ensure the required constancy of the heat-exchange condition between the evaporator plate and the liner.

[0010] According to the present invention, all these aims are reached in a particular method for carrying out a manufacturing step included in the production of a refrigerator appliance, which is suitably improved to include the characteristics and features as recited in the appended claims and as described in greater detail below by way of non-limiting example with reference to the accompanying drawings, in which:

- Figure 1 is a symbolical view of the coverage pattern of strips of adhesive substance on an outer surface of the liner of a refrigerator appliance, according to the method of the present invention;
- Figure 2 is a perspective view of the layout schematics of an apparatus according to the present invention;
- Figure 3 is a symbolical top view of an apparatus according to the present invention;
- Figure 4 is a perspective view of a sub-assembly of the apparatus shown in the preceding Figures;
- Figure 5 is a symbolical view of the functional schematics of the sub-assembly of Figure 4;
- Figure 6 is a symbolical, see-through view of the functional schematics of a second sub-assembly of an apparatus according to the present invention;

- Figure 7 is a bottom view of a detail of the nozzle comprised in the sub-assembly of Figure 4;

- Figure 8 is a schematical view of the phase in which the jet of adhesive substance issuing from the nozzle of Figure 7 is cast and dispersed (atomised);

- Figure 9 is a view of a liner treated with an adhesive deposition method according to the present invention, immediately prior to and after the application of a related evaporator.

[0011] The top-priority targets, i.e. the targets that had imperatively to be reached by starting a research work dedicated to such an object, were as follows:

- possibility for a method to be found which was capable of being fully automated,
- possibility for such a method to be integrated in a continuous cycle of sequential production,
- reduction of production costs,
- absence of any permanent deformation or distortion of the liner during the evaporator assembly phase,
- high reliability and simplicity of the method,
- highest safety and low environmental impact,
- uniform coverage or, anyway, coverage capable of satisfactorily meeting the given requirements.

[0012] On the basis of these pre-requisites, a large number of comparative experiments and application-related test runs have therefore been carried out, by also having resort to statistical research and analysis techniques based on fractional factorial design of experiments, in view of identifying the basic parameters of the method.

[0013] A method has therefore been eventually found and selected on this basis, which substantially enables the afore cited aims and targets to be reached, and whose basic feature, distinguishing it at least partly from prior-art techniques, lies substantially in the fact that the adhesive is not applied with the aid of a support means that is subsequently removed (by way of example, much in the same manner of an adhesive plate or label), but is rather deposited directly onto the surface to be treated by spraying it thereupon by means of one or more appropriate spray heads, in which there are arranged both a nozzle issuing a thin jet of previously prepared liquid adhesive, and a plurality of nozzles issuing respective jets of air, said nozzles being situated in close vicinity of said adhesive jet and oriented so as to hit, and therefore atomise, said adhesive jet, thereby substantially converting it into an emission which is very similar to a very fine and, for the matter, practically atomised open spray.

[0014] It has therefore been ascertained that, in order to attain the above-cited purpose, use could advantageously be made of the so-called "SPIRO" method, which essentially consists in arranging one or more nozzles in close vicinity of the nozzle from which the adhesive substance issues in the form of a continuous filament, which is in this way substantially atomised.

[0015] The effect brought about by the various air jets is therefore twofold: in fact, further to the first and actually more important effect of producing a broad and elongated strip of adhesive sprayed to a very reduced thickness, which is distributed on the application surface not only in an uniform manner, but also intercalating said strip with limited areas of non-treated surface, as this is symbolically illustrated in Figures 1 and 9, the effect is also obtained of keeping said adhesive substance at the desired temperature throughout the very short, but critical time elapsing from the emission of the adhesive from the nozzle to the deposition of the same adhesive onto the surface of the liner.

[0016] With reference to Figure 2, a preferred example of application of the above method is now illustrated. Prior to foaming for thermal insulation, the liners 1 are arranged orderly, with their backside facing upwards, on a continuously moving conveyance means 2, usually consisting of a sliding slat or apron conveyer, which carries said liners 1 under a spray head 3 in an orderly sequence.

[0017] This spray head is provided and arranged so as to be able to displace along three orthogonal axes Y, Y and Z, in which on the axis X there are represented the vertical displacements made in relation to said conveyance means 2 (as a result, in the case of liners of the same type, i.e. having similar dimensions, there will be no displacement of said head along the axis X).

[0018] Said spray head 3 is then driven so as to move on a horizontal plane along two axes Y and Z by means of an arm 4 connecting said head 3 to a first member 5 that enables it to slide horizontally along a direction Z extending orthogonally to the direction of displacement of the apron conveyor, said first member being in turn connected to a second member 6 enabling again the head to slide horizontally, however in a direction Y that is parallel to the direction of displacement of the apron conveyor 1.

[0019] There are further provided means (not shown) for driving said two displacement mechanisms, which are adapted, under suitable control, to move said spray head 3 into each spatial position, namely into each position lying on a horizontal plane parallel to the surface 8 to be treated of said liner and, therefore, at a constant distance therefrom.

[0020] As far as this spray head 3 is specifically concerned, the same is represented schematically in Figures 3, 4

and 5, and substantially comprises:

- a central body 11,
- a conduit 12 to deliver the adhesive substance,
- a conduit 13 to deliver a flow of air to atomising purposes,
- a terminal emission plate 14,
- an electromagnetic valve 15 to control said conduit 12,
- two independent heating elements 16, 16 to selectively heat up said flow of adhesive substance and said flow of atomising air, duly provided with related power-supply cables 16A and 17A,
- a control cable 18 associated to said electromagnetic valve 15.

[0021] Said terminal emission plate 14 is in turn provided with at least a preferably central nozzle 19, adapted to issue said adhesive substance, as well as a plurality of nozzles 23 for issuing air under pressure with such a flow orientation as to be able to cause the jet of adhesive substance to be atomised.

[0022] As far as the apparatus in general is concerned, and with reference to Figure 3, this comprises also a machine 20 for preparing, heating up, liquefying, putting under pressure and pumping the adhesive substance; it further includes a control unit 21 for generating and transmitting appropriate sequences of synchronized control signals adapted to at least control the operation of the driving means of said first member 5 and said second member 6 which determine the position of the arm 4, which in turn supports said spray head 3.

[0023] Said machine 20 and said control unit 21 are already available on the market or, anyway, readily implementable by those skilled in the art, so that - owing to them not being inherently a part of the present invention - they shall not be described here any further.

[0024] The operation of the invention, which is described below by intentionally omitting all those details which are either inherently obvious or fully within the capabilities of those skilled in the art, will now become fully apparent.

[0025] On the slat or apron conveyor 2, which displaces in the direction indicated by the arrow, there is arranged a sequence of regularly spaced liners 1 following each other in an orderly row, in which the surface 8 to be treated of said liners 1 is so oriented as to face upwards. Above said surfaces, at a certain distance therefrom, there is arranged the spray head 3, the latter being fitted out as described above. This spray head is driven to displace along the two axes X and Z by means of corresponding movements imparted, with the aid of generally known means (not shown), to said second member 6 and said first member 5.

[0026] It will also be readily appreciated that, in order to be able to control the motion and the position of the arm 4 carrying said spray head 3, said arm 4 is slidably connected to said first sliding member 5 with the aid of appropriate means (not shown, but generally identified at H in the Figure), said first member being in turn slidably linked to said second sliding member 6, again with the aid of means that are not shown, but generally situated at K in the Figure.

[0027] At the same time, the machine 20 for the preparation of the adhesive substance lets a flow of said adhesive substance into the conduit 12, through which it then reaches the nozzle 19 of the plate 14, which however keeps in its closed state owing to the electromagnetic valve 15 on the spray head 3 being closed, so that said adhesive substance is put under pressure upstream of said electromagnetic valve.

[0028] At pre-set moments during the movement of said arm 4, the electromagnetic valve 15 on the spray head 3 is opened, so that a thin continuous jet of adhesive substance is able to issue, directed downwards, from the nozzle 19 of the terminal plate 14.

[0029] Since said terminal plate is also provided with the compressed-air conduits 23 arranged in the close vicinity of the adhesive-emitting nozzle 19, and owing to these conduits being oriented obliquely downwards, the effect thereof is to cause the filament of adhesive substance issuing from said nozzle 19 to practically atomise and, ultimately, to produce an atomised jet of adhesive substance onto the surface 8 of the liners.

[0030] For the treatment to be such as to ensure an adequate coverage of the surface 8 of the liner, the spray head 3 is displaced in a controlled manner so as to move along the axes Y and Z repeatedly, i.e. to perform more passages along said axes, as long as each surface 8 dwells therebelow, so that the atomised jet of adhesive is capable of spreading over the surface with the desired evenness and according to the desired distribution pattern, so as this is for instance illustrated symbolically in Figure 1.

[0031] In this manner, said jet of atomised adhesive substance tends to affect a pre-determined portion A of the surface of the liner, as well as to settle according to a pre-established geometry, i.e. pattern, on said surface to be treated, so that it is actually the pre-established areas of said surface that are substantially covered by said adhesive substance to a pre-determined, fully controllable extent.

[0032] Advantageously, both the flow of adhesive substance and the jets of air issuing from said emission plate 14 are heated up immediately prior to being emitted from said plate and, to this purpose, the afore cited respective heating elements 16, 17 are appropriately energized with means and in manners that are largely known in the art.

[0033] In the course of the exhaustive programme of systematic experiments and comparative evaluation of the

related results, it has been possible to also identify ways and means enabling optimum and preferred results to be obtained in the process, these ways and means being schematically set forth in due detail below:

- the adhesive substance used in the method has general properties similar to those of the product normally available on the market under the type designation PRESSEN 1510, the main properties of which are indicated in Table A;

- this adhesive substance is pre-heated to a temperature situated anywhere between 140°C and 170°C, and is ejected from the spray head at such a temperature;

- this adhesive substance is then distributed over and deposited onto the surface to be treated through the ejection from a related nozzle of a continuous filament that is atomised soon upon leaving said nozzle;

- the jet of atomised adhesive substance must be deposited onto the surface to be treated in an amount ranging from 130 to 220 g/m^2;

- the rate at which said filament is ejected from the nozzle shall be comprised between 100 and 200 mm/sec;

- the distance from said terminal emission plate 14 to the underlying surface to be covered must be comprised between 5 and 8 cm.

[0034] Quite obviously, the actual size of the jet of adhesive is a critical factor. It has been found that the ejection of the adhesive should ideally occur from a nozzle, the outlet port of which must have a diameter comprised between 0.35 and 0.50 mm.

[0035] It has been furthermore found that the optimum size of the jet, when the latter hits and deposits onto the surface to be treated, corresponds to a width that should not lie below 3 mm.

[0036] Be it briefly pointed out here that this construction is completely different from prior-art solutions of this kind, in which it is in all cases the entire surface, without any discontinuity, that is affected by the application of the adhesive layer, actually.

[0037] It has also been found that an optimum adhesion can be obtained when the surface area that is actually treated with adhesive is not lower than 95% of the surface 8 that must undergo such an application in view of ensuring the adherence thereof. It will be readily appreciated that different patterns of deposition of said adhesive strips may be selected. It is however obvious that the best possible application pattern can be easily and most effectively identified on the basis of existing constraints and experimental verifications, as this on the other hand is well within the capabilities of all those skilled in the art.

[0038] In particular, it has been found, and verified experimentally, that optimum characteristics can be achieved, further to using the afore indicated optimum amount of adhesive, by also providing a dwelling time in open air of said treated surface that should not exceed 45 seconds until the evaporator plate is applied to said surface. The adhesive is actually of the so-called open-time type, so that it preserves its adhesiveness for a theoretically unlimited length of time. The practice however suggests that the evaporator plate be best applied onto the adhesive-sprayed surface within a 24-hour term.

[0039] During the experiments that have been carried out in this connection, it has been noticed that fully satisfactory results are obtained when the cycle time is kept below 30 seconds with a treated surface of 25 to 30 dm^2.

[0040] It can be readily appreciated that all of the main parameters of the method according to the present invention, such as the distance between the nozzles, the pressure values, the angle between the axes of the same nozzles, and so on, may be easily inferred through simple observations of the apparatus and by performing orderly and systematic cycles of experiments with sequentially varied set of parameters, as anyone skilled in the art is fully capable of doing.

[0041] As far as the application means themselves are concerned, these may be constituted by an adhesive application machine of the type NORDSON 3830V, capable of ensuring the above-indicated process parameters or adapted to be controlled, set or programmed so as to ensure them.

[0042] In view of more clearly defining the characteristics of the two evaporator application methods by means of adhesive, i.e. according to the prior-art and the present invention, on a comparative basis, laboratory test runs have been carried out, the results of which may be summarized here as follows:

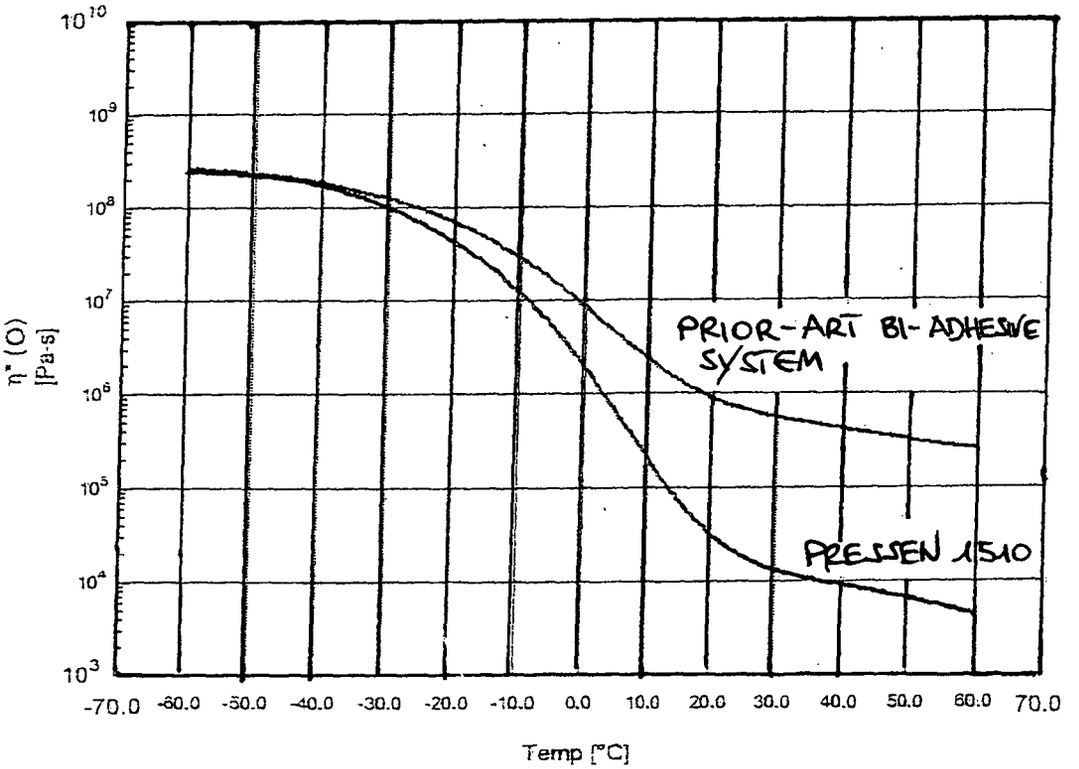
[0043] A basic aim was to measure the adhesiveness, under peel (90x) and shear stress, of the two bonding methods, both directly on the involved items and, in view of a better and more comprehensive assessment, on appropriately prepared specimens.

[0044] As a first investigation, the viscosity of the two systems has been measured as a function of temperature. As it can be noticed in the graph appearing below, the afore-cited hot-melt adhesive Pressen shows a lower viscosity than the prior-art bi-adhesive system starting already from as low a temperature as -40°C. Such a difference then tends to

become larger and larger, until it reaches a really significant extent at temperatures above 0°C. This fact, while proving favourable at low temperatures, makes the hot-melt adhesive far less resistant at high ambient temperatures.

[0045] The effect of an increased amount of hot-melt adhesive is of little consequence on the highest load that can be sustained; it is on the contrary of import in terms of total energy due to an increased amount of work connected with the flow of the adhesive mass.

[0046] It is therefore largely demonstrated that the hot-melt adhesive does not give rise to any evaporator-liner detachment problem at the low temperatures. What on the contrary must be most carefully considered is the compromise between the low viscosity at high temperature - which allows for working with lower pressures on the bonding machine - and the relative adhesiveness - with the afore cited poor adhesiveness at the higher temperatures - especially in view of the stresses which the assembly may be subject to prior to foaming.



[0047] This description is concluded by pointing out a circumstance which is potentially important, although quite obvious to those skilled in the art: the preferred embodiment of the above-described method is in fact the one that is carried out by means of the automatic apparatus described above. However, due to strictly production-related reasons, circumstances may sometimes arise, owing to which it does not prove suitable or even feasible for an industrial apparatus of the above-described kind to be used, actually. In such a case, it will be readily appreciated that the adhesive application method according to the present invention is capable of being implemented and carried out in a fully manual manner, as well, provided that this occurs in compliance with at least one of the appended method-related claims. This is the reason why claim 1 explicitly relates to a method that may be "carried out also manually".

TABLE A

PRESSEN 1510 - Hot-Melt Adhesive

1. MANUFACTURER AND MATERIAL IDENTIFICATION

Trade name of product: PRESSEN 1510
Chemical description: Hot-melt adhesive
Manufacturer: Beardow & Adams (Adhesives) Limited

2. INFORMATION ON INGREDIENTS

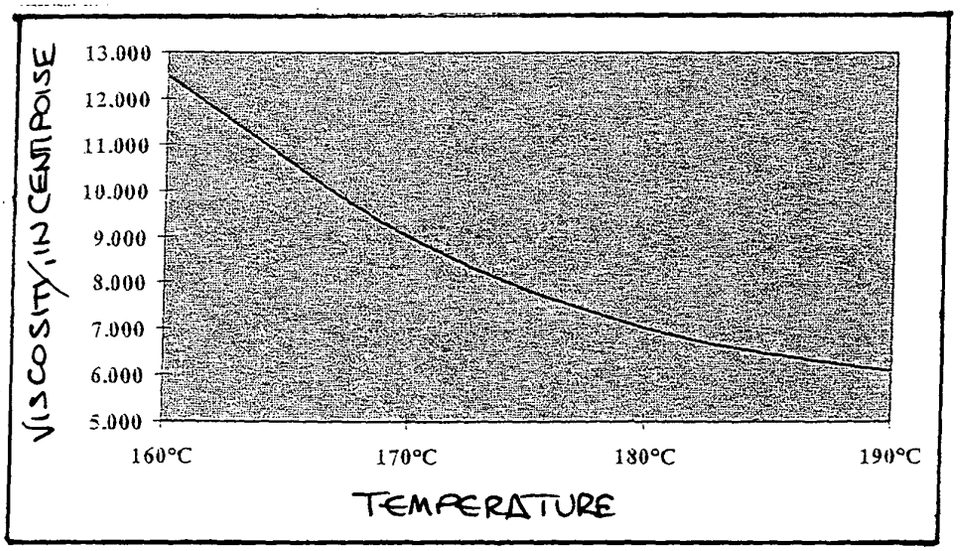
Chemical description: Hot-melt adhesive containing thermoplastic polymers, adhesive resins, waxes and antioxidant agents.

DESCRIPTION

***PRESSEN 1510* is a versatile adhesive based on synthetic polymers, of the pressure-sensitive type, for assembly applications, where it enables high-strength bonds to be obtained. It bonds plastics (EPDM, polypropylene, PVC, polyethylene, nylon), rubbers (natural, synthetic, neoprene), porous materials (leather, fabrics, paper and paperboard), metals (aluminium, steel, painted steel). It has an excellent adhesive power, even on difficult materials. It is characterized by an excellent heat stability, an excellent strength at both high and low temperatures and to both aging and peeling.**

TECHNICAL SPECIFICATIONS		**Test Method**
Softening point	80°C	BA QA102
Viscosity at 180°C (S.27 / 20 rpm)	7000 cP	BA QA101
Hue	Slightly amber-coloured	
Open time	Permanent	
Adhesive power in the molten state	Very high	

Recommended application temperature: from 160°C to 180°C depending on substrates to be bonded



Claims

1. Method, adapted to be carried out also manually, for the application of an evaporator, in particular with a side thereof lying on a plane, onto the outer surface (8) of a liner (1) delimitating internally the food storage compartment of a refrigerator appliance, comprising a phase in which adhesive means are interposed between said outer surface (8) and the evaporator, **characterized in that** said interposition of adhesive means includes:

   - the ejection of a jet of semi-liquid adhesive substance from a proper nozzle comprised in a spray head, facing said surface (8), but lying at a distance therefrom, and the conversion of said semi-liquid jet into an atomised spray prior to hitting said surface, so that the latter is invested by said atomised ejection and is covered in a selective manner with a substantially uniform layer of said adhesive substance.

2. Method according to claim 1, **characterized in that** said conversion of a jet of adhesive substance into an atomised spray is carried out by investing said jet with at least a proper forced flow of gas, preferably ambient air, immediately downstream of said ejection nozzle, so that said jet is broken up into an atomised spray directed against said outer surface (8).

3. Method according to claim 1 or 2, **characterized in that** said adhesive substance is distributed on said surface to an amount by weight situated anywhere between 130 and 220 g/m^2.

4. Method according to any of the preceding claims, **characterized in that** said nozzle issuing said jet of adhesive substance is kept at a distance of 5 to 8 cm from said outer surface.

5. Method according to any of the preceding claims, **characterized in that** the temperature at which said semi-liquid adhesive substance leaves the ejection nozzle is situated anywhere between 140°C and 170°C.

6. Method according to any of the preceding claims, **characterized in that** the time needed by said atomised spray to cover said surface is less than 30 seconds when the surface being treated has an area of 30 dm^2.

7. Apparatus for the emission and deposition of a flow of adhesive substance onto a preferably planar surface, in particular onto a surface of a liner of a refrigerator appliance, **characterized in that** it comprises at least one of following elements or a combination thereof:

   - a spray head (3),
   - a machine (20) for preparing the adhesive substance and delivering it under pressure to said spray head (3).

8. Apparatus according to claim 7, **characterized in that** said spray head (3) comprises:

   - a conduit (12) delivering said adhesive substance,
   - a second conduit (13) delivering a flow of gas under pressure,
   - an electromagnetic valve (15) controlling said adhesive-substance delivering conduit (12) terminating in a first nozzle (19),
   - one or more other nozzles (23) arranged in close proximity of said first nozzle (19) and adapted to convey said flow of gas towards the ejection zone of said first nozzle so as to intercept the jet of adhesive substance issuing therefrom, in which said first nozzle (19) and said further nozzles (23) are possibly provided in the form of through-holes in an emission plate (14) arranged on the lower side of said head (3).

9. Apparatus according to claim 8, **characterized in that** it further comprises:

   - means (2) to orderly conveying said liners below said spray head,
   - further means (4, 5, 6) that are at least partly capable of being selectively positioned and displaced above said conveyance means (2), and are slidably connected also to said spray head (3),
   - a control unit (21) adapted to control the position and the displacements of said further means (4, 5, 6).

10. Apparatus according to any of the preceding claims 7 to 9, **characterized in that** said spray head (3) also comprises two independent heating elements (16, 17) adapted to selectively heat up said flow of adhesive substance and said flow of gas.

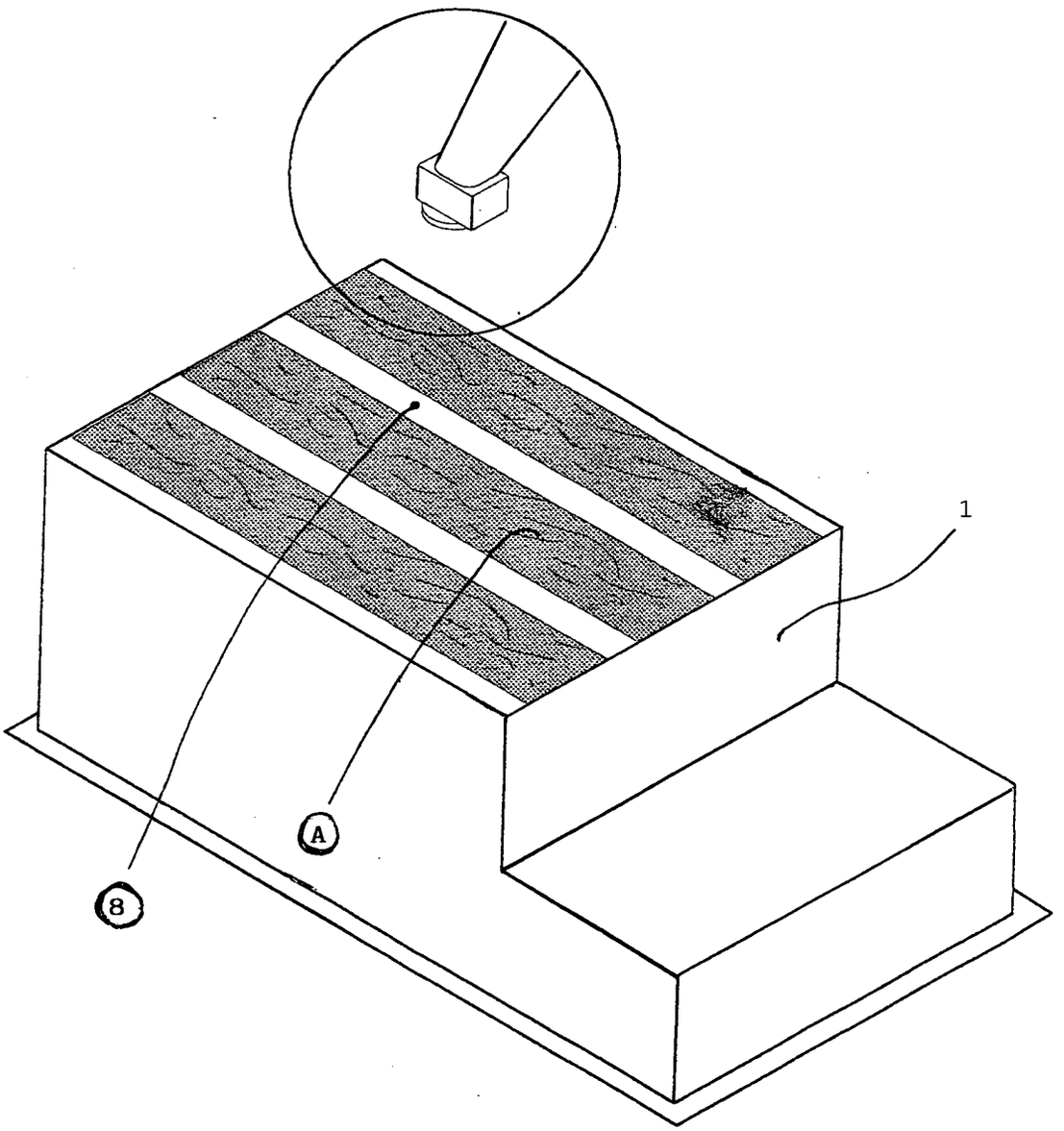


Fig.1

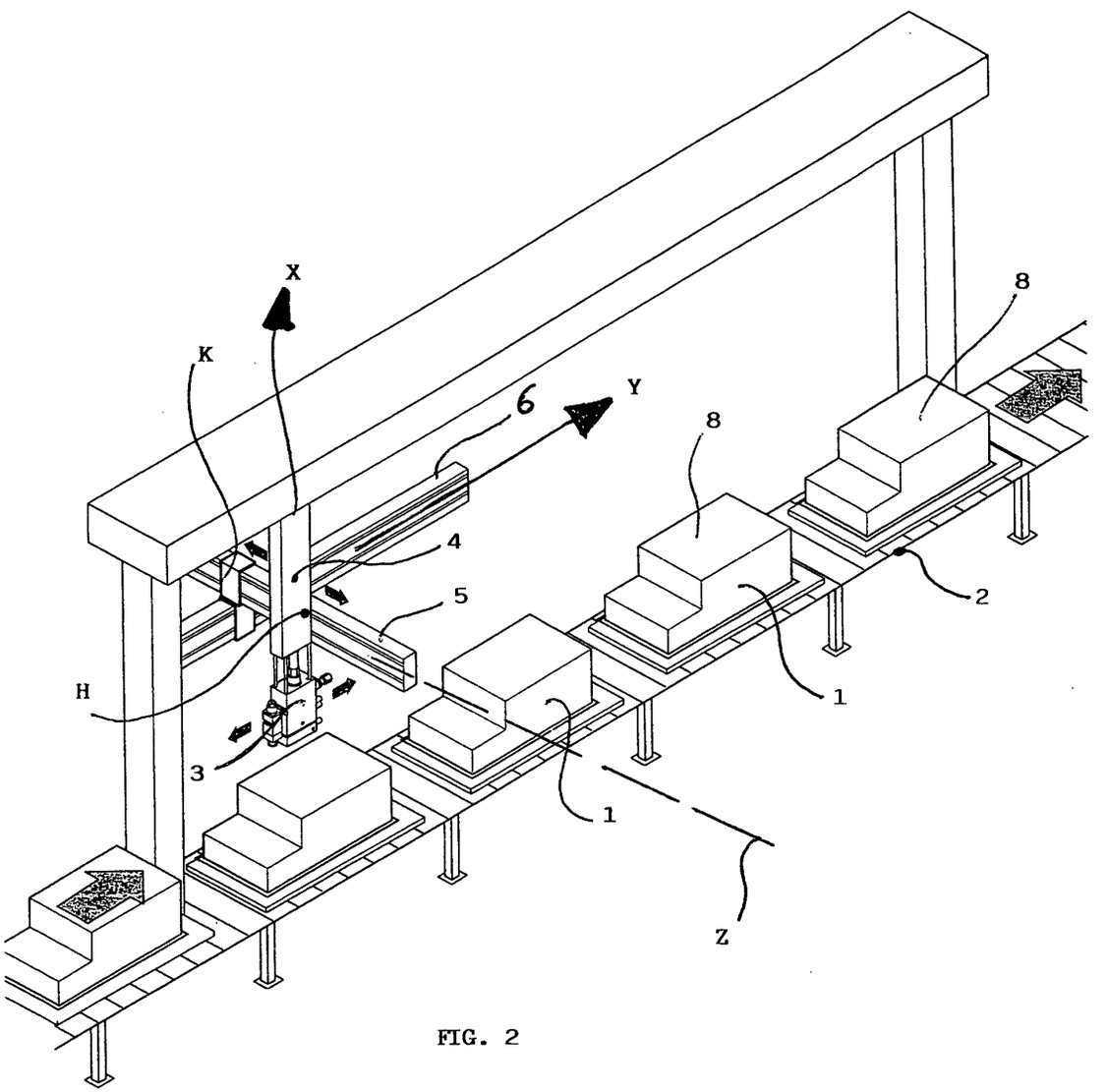


FIG. 2

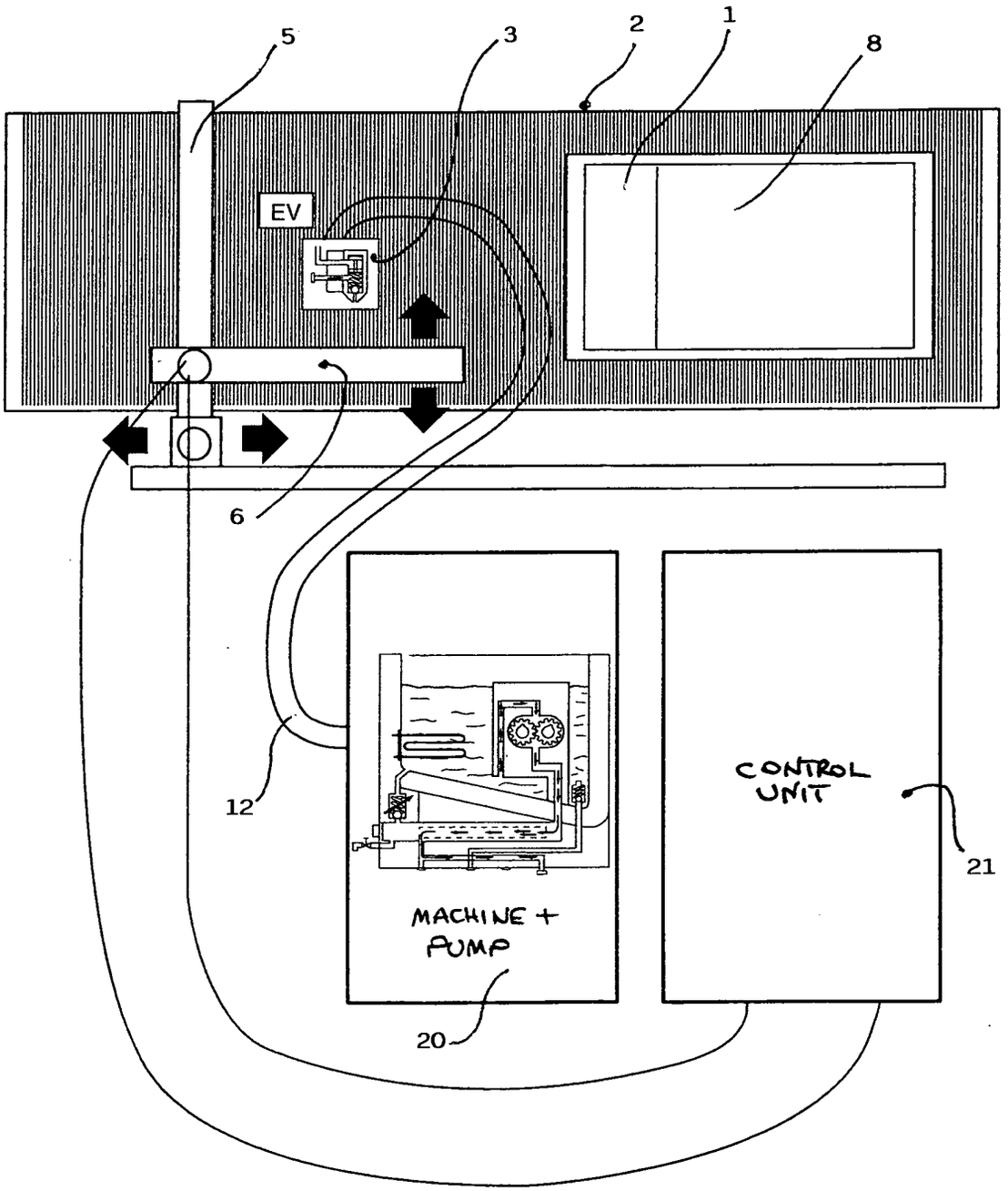


FIG. 3

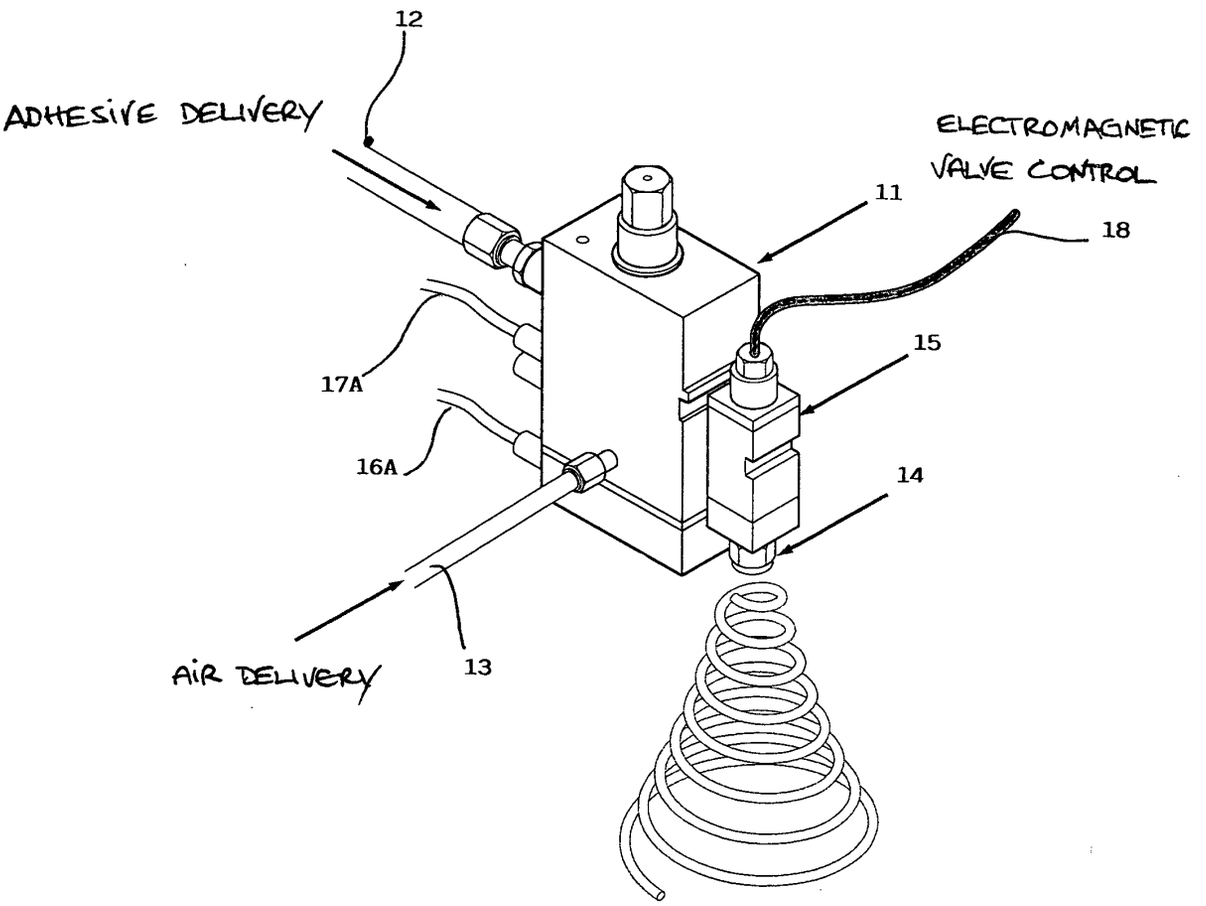

12
ADHESIVE DELIVERY
ELECTROMAGNETIC
VALVE CONTROL
11
18
15
17A
16A
14
AIR DELIVERY
13

FIG. 4

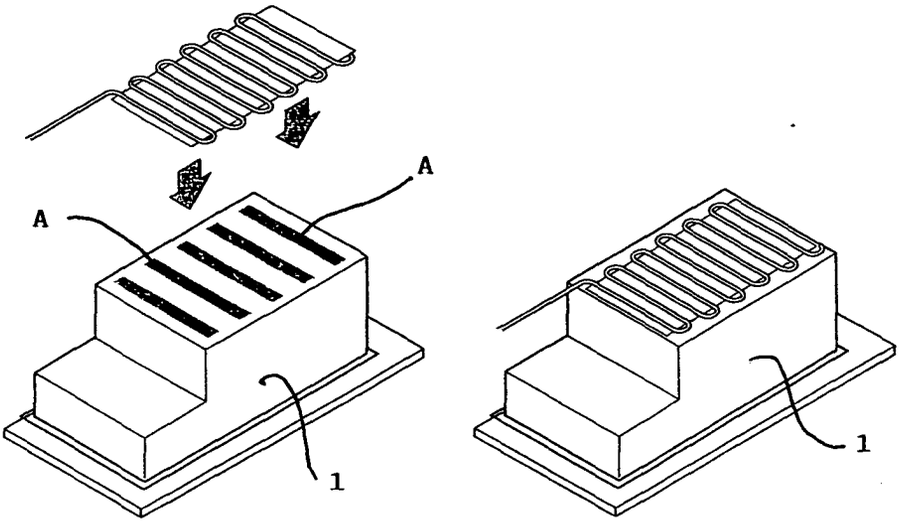


FIG. 9

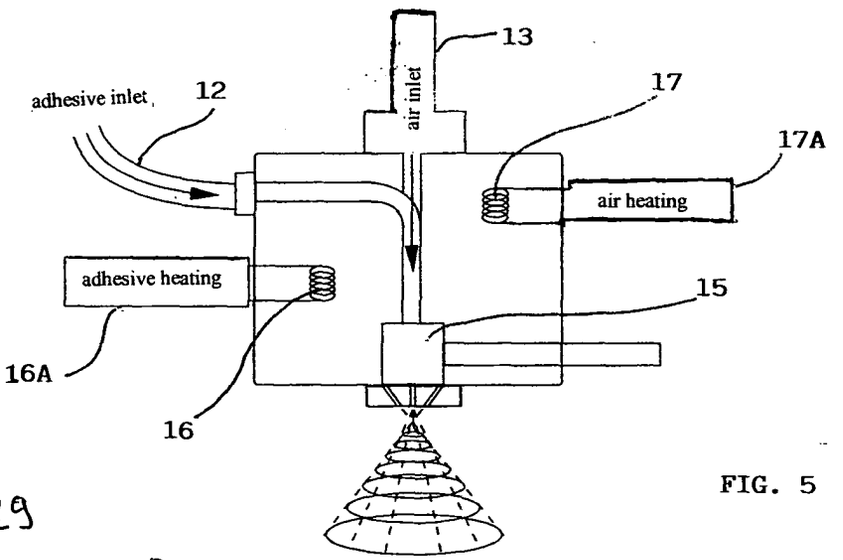


FIG. 5

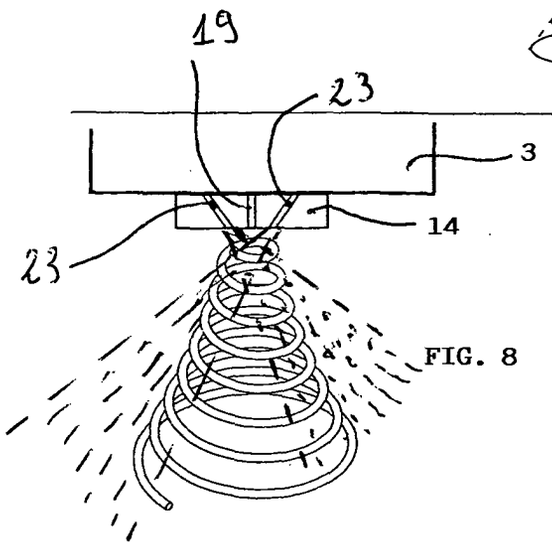


FIG. 8

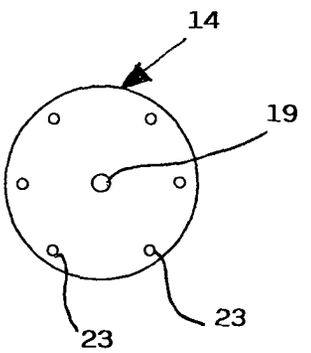


FIG.7

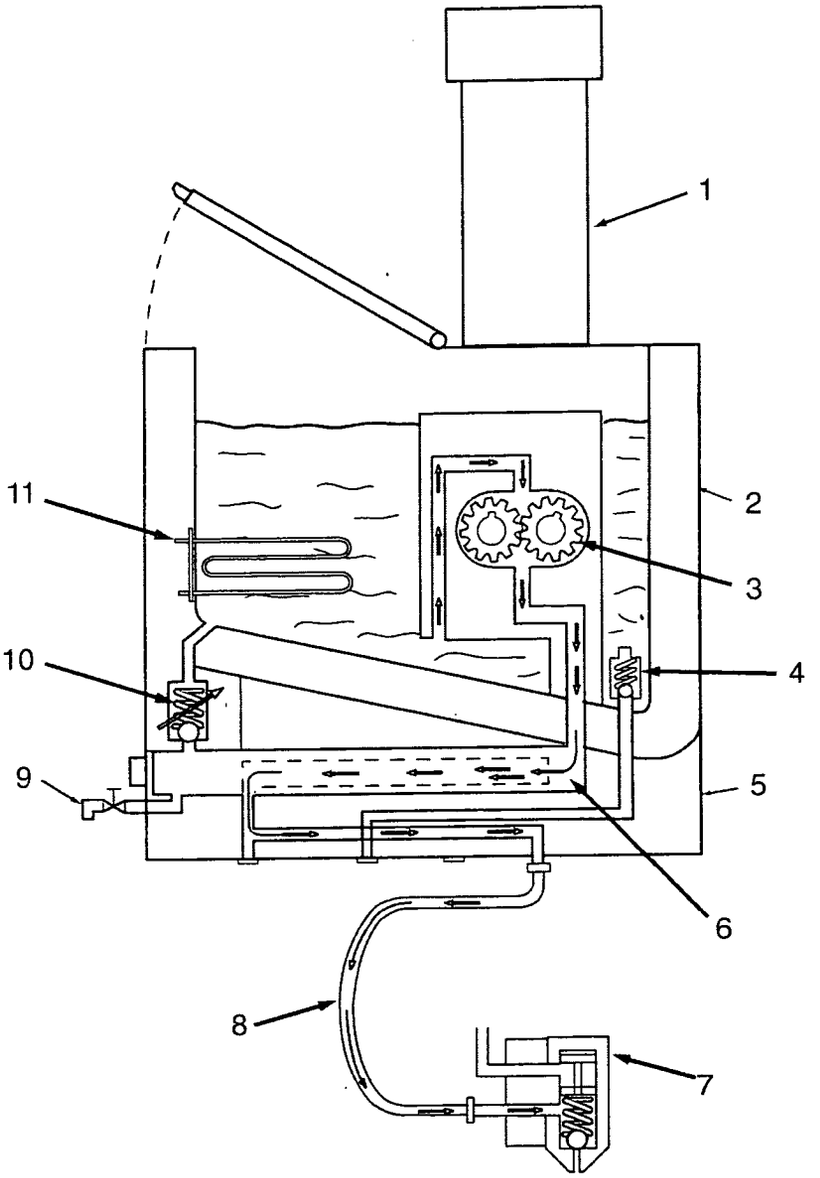


FIG. 6