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(71) Applicant: **MITSUBISHI ELECTRIC CORPORATION**
Chiyoda-ku
Tokyo 100-8310 (JP)

(72) Inventors:
• **Oya, Ryo,**
Mitsubishi Electric Corporation
Chiyoda-ku,
Tokyo 100-8310 (JP)

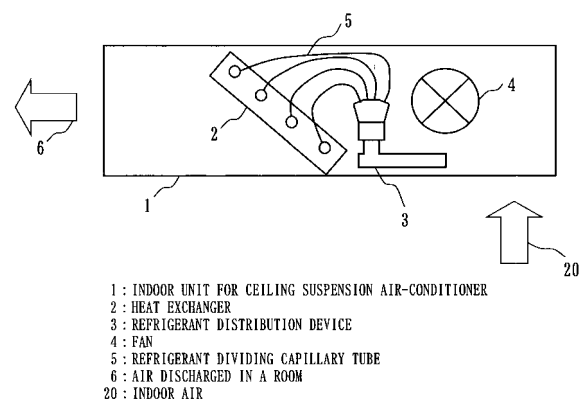
- **Sekiguchi, Kazunobu,**
Mitsubishi Electric Corporation
Chiyoda-ku,
Tokyo 100-8310 (JP)
- **Takagi, Masahiko,**
Mitsubishi Electric Corporation
Chiyoda-ku,
Tokyo 100-8310 (JP)
- **Abe, Ryoji,**
Mitsubishi Electric Corporation
Chiyoda-ku,
Tokyo 100-8310 (JP)
- **Kuwahara, Yoshiaki,**
Mitsubishi Electric Engineering Co., Ltd.
Chiyoda-ku,
Tokyo 102-0073 (JP)

(74) Representative: **Nicholls, Michael John**
J.A. Kemp & Co.
14, South Square
Gray's Inn
London WC1R 5JJ (GB)

(54) **Refrigerant distribution device**

(57) The present invention aims to provide a refrigerant distribution device which eliminates a need for maintaining a certain length of a straight portion at an inflow tube to a distributor, and for adjusting lengths of capillary tubes to send a refrigerant to each flow path of the refrigerant of a heat exchanger, and which resolves an unevenness of a liquid refrigerant at a bend of the inflow tube due to a centrifugal force. A refrigerant distribution device according to the present invention including an inflow tube, which is connected to a distributor for distributing and providing a refrigerant in a gas-liquid two-phase state to a heat exchanger, wherein an upstream side of the inflow tube is in an approximately horizontal position and a downstream side of the inflow tube is bent to stand approximately at a right angle, includes a bend of the inflow tube, a longitudinal form of which is made of a combination of straight lines and is bent approximately at a right angle.

Fig. 1



Description

[0001] The present invention relates to a gas-liquid two-phase refrigerant distribution device (hereinafter referred to as a refrigerant distribution device in this specification) established in a refrigerant flow path of an air-conditioner and the like. The air-conditioner to be applied the refrigerant distribution device is a large-sized one, such as a ceiling suspension type, a ceiling cassette type, a wall mounted type, a floor standing type, and a ceiling embedded type. In this specification, an application to a ceiling suspension type is explained as an example.

[0002] In a conventional refrigerant distribution device, at an R bend of an inflow tube wherein a gas-liquid two-phase refrigerant flows just ahead of a distributor whereto a plurality of capillary tubes or copper tubes toward each refrigerant flow path of a heat exchanger are connected, a liquid phase refrigerant with a higher specific gravity is subject to a centrifugal force higher than a gas phase refrigerant, so that the liquid refrigerant unevenly concentrates in an periphery direction of the R bend. Therefore, to prevent the unevenness of the liquid refrigerant, there is a need to maintain a certain length of a straight portion at the inflow tube from the R bend to the distributor.

When it is impossible to maintain a certain length of the straight portion at the inflow tube, it is necessary to eliminate the unevenness in the distributor. Therefore, there is a need to lengthen the lengths of the capillary tubes to each of the refrigerant flow paths coming out of the distributor, or to establish a plurality of capillary tubes for each refrigerant flow paths (for example, refer to JP 01-159571).

[0003] A conventional refrigerant distribution device has a problem to be a factor in preventing miniaturization of a main body of an air-conditioner, since there is a need to maintain a certain length of a straight portion at an inflow tube on a downstream side of an R bend to eliminate an unevenness of a liquid refrigerant occurred at the R bend due to a centrifugal force.

[0004] The present invention aims to solve the aforementioned problem. It is one of the purposes of the present invention to provide a refrigerant distribution device wherein it is unnecessary to maintain a certain length of a straight portion at an inflow tube toward the distributor, and to adjust lengths of capillary tubes for sending a refrigerant to each of the refrigerant flow paths of the heat exchanger, and it is possible to eliminate an unevenness of the liquid refrigerant at a bend of the inflow tube due to a centrifugal force.

[0005] This is achieved according to the present invention by forming the inflow tube with an upstream and a downstream portion, the downstream portion connecting to the distributor, and the upstream and downstream portions being joined in such a way that the refrigerant does not follow a single smoothly curved flow path around the join. Thus the flow does not subject the refrigerant to centrifugal force. Instead the flow from upstream to down-

stream portions may be comprise local flows from different directions or non-smooth, or turbulent, or non-laminar flows. This may be achieved by the join providing flow paths in the upstream and downstream portions which join in sharp angles as formed by a combination of straight lines.

[0006] The refrigerant distribution device according to the present invention includes an inflow tube which is connected to a distributor for distributing and providing a refrigerant in a gas-liquid two-phase state to a heat exchanger, wherein an upstream side of the inflow tube is in an approximately horizontal position and a downstream side of the inflow tube is bent to stand approximately at a right angle, includes a bend of the inflow tube, a longitudinal form of which is made of a combination of straight lines and is bent approximately at a right angle.

[0007] The invention will be further described by way of example with reference to the accompanying drawings, wherein:

Fig. 1 is a diagram illustrating a first embodiment, and is a cross-sectional view of an indoor unit 1 of a ceiling suspension air-conditioner whereto a refrigerant distribution device 3 is applied;

Fig. 2 is a diagram illustrating the first embodiment, and is a Mollier chart for a refrigerant;

Fig. 3 is a diagram illustrating the first embodiment, and is a diagram showing flow patterns of an unheated upward two-phase flow in a vertical tube;

Fig. 4 is a diagram illustrating the first embodiment, and is a diagram showing flow patterns of an unheated two-phase flow in a horizontal tube;

Fig. 5 is a diagram illustrating the first embodiment, and is a schematic diagram of an overall structure of the refrigerant distribution device 3;

Fig. 6 is a diagram illustrating the first embodiment, and is a longitudinal sectional view of a bend of an inflow tube 8 in the refrigerant distribution device 3;

Fig. 7 is a diagram illustrating a second embodiment, and is a longitudinal sectional view of the bend of the inflow tube 8 in the refrigerant distribution device 3;

Fig. 8 is a diagram illustrating the second embodiment, and is a perspective view of the refrigerant distribution device 3;

Fig. 9 is a diagram illustrating the second embodiment, and is an exploded perspective view of the refrigerant distribution device 3;

Fig. 10A is a diagram illustrating a third embodiment, and is a diagram of the refrigerant distribution device 3 viewed from an opposing wall 9 side;

Fig. 10B is a diagram illustrating a third embodiment, and is a schematic diagram of an overall structure of the refrigerant distribution device 3;

Fig. 11 is a reference diagram and is a block diagram of an overall structure of the refrigerant distribution device 3 wherein the bend of the inflow tube 8 is formed to be an R bend; and

Fig. 12 is a reference diagram and is a cross-sectional view of the bend of the inflow tube 8 in Fig. 11.

Embodiment 1.

[0008] Fig. 1 through Fig. 6 are diagrams illustrating the first embodiment: Fig. 1 is the cross-sectional view of the indoor unit 1 of a ceiling suspension air-conditioner where the refrigerant distribution device 3 is applied; Fig. 2 is the Mollier chart for a refrigerant; Fig. 3 is the diagram showing flow patterns of an unheated upward two-phase flow in a vertical tube; Fig. 4 is the diagram showing flow patterns of an unheated two-phase flow in a horizontal tube; Fig. 5 is the schematic diagram of the overall structure of the refrigerant distribution device 3; and Fig. 6 is the longitudinal sectional view of the bend of the inflow tube 8 in the refrigerant distribution device 3.

[0009] Fig. 11 and Fig. 12 are reference diagrams: Fig. 11 is the block diagram of the overall structure of the refrigerant distribution device 3 wherein the bend of the inflow tube 8 is formed smoothly curved/radiused, or as an R bend; and Fig. 12 is the cross-sectional view of the bend of the inflow tube 8 in Fig. 11.

[0010] As mentioned above, there are a ceiling suspension type, a ceiling cassette type, a wall mounted type, a floor standing type, and a ceiling-embedded type, and the like in large-sized air-conditioners. It is here explained an application to the ceiling suspension type as an example.

[0011] As a heat exchanger of an indoor unit for a large-sized air-conditioner such as a ceiling suspension type, one having a multi-path structure in which refrigerant circuits are generally divided into several circuits is used.

[0012] In a refrigerant circuit (unshown) of a large-sized air-conditioner such as a ceiling suspension type, as is generally known, a compressor for compressing a refrigerant, a four way valve, an outdoor heat exchanger and a decompression device are mainly installed in an outdoor unit, and an indoor heat exchanger and a refrigerant distribution device are mainly installed in an indoor unit.

[0013] During cooling operation of an air-conditioner, a refrigerant compressed by the compressor to be at a high temperature and pressure is condensed by the outdoor heat exchanger to be a liquid refrigerant, then is decompressed by the decompression device to become a gas-liquid two-phase refrigerant, and flows into the indoor unit wherein the gas-liquid two-phase refrigerant first flows into the refrigerant distribution device. The gas-liquid two-phase refrigerant distributed in the refrigerant distribution device is evenly provided to the multi-path indoor heat exchanger.

[0014] In the refrigerant distribution device 3 wherein the bent is formed to be an R bend as shown in the reference diagram Fig. 11, a centrifugal force acts on a liquid refrigerant of the gas-liquid two-phase refrigerant flows in the inflow tube 8 during cooling operation of the air-conditioner at the R bend in the bend part, and the liquid

refrigerant unevenly concentrates in an outer periphery direction. Therefore, in the vertical part (rise part) located behind the bend, big bubbles concentrates on the inner side as shown in Fig. 12. If the length of the vertical portion is short, the refrigerant flows into the indoor heat exchanger in its state. Therefore, there is a problem that the refrigerant is not evenly distributed to the indoor heat exchanger.

[0015] In the present embodiment, the bend of the inflow tube of the refrigerant distribution device is configured to be bent approximately at a right angle without forming R shape, whereof the longitudinal form is made of the combination of the straight lines, so that a centrifugal force does not act on the liquid refrigerant of the gas-liquid two-phase refrigerant and the liquid refrigerant does not spread unevenly.

[0016] It is hereinafter explained with reference to the diagrams of Fig. 1 through Fig. 6. In Fig. 1, the indoor unit 1 of the ceiling suspension air-conditioner has an approximately rectangular casing with an external form short in height. An indoor air 20 is sucked in a fan 4 from a bottom surface of the casing, and sent to the heat exchanger 2 to be heat-exchanged with a refrigerant, then a secondary air heat-exchanged is blown off into a room from a front surface of the casing as an air discharged in a room 6. As for the refrigerant circuit, the refrigerant distribution device 3 for distributing and supplying the gas-liquid two-phase refrigerant to the heat exchanger 2 is installed at a portion to be an upper side of the heat exchanger 2 during cooling operation of the air-conditioner.

[0017] Operations in the refrigerant circuit during cooling operation of the air-conditioner are explained with reference to the Mollier chart in Fig. 2. A refrigerant sucked into a compressor of an outdoor unit (unshown) is in a gaseous state, which is designated by a point a in Fig. 2 when illustrated in the Mollier chart. The refrigerant sucked in the compressor is compressed to be a high temperature and pressure gaseous refrigerant, and is discharged from the compressor. When illustrated in the Mollier chart, the refrigerant at the time is under a state designated by a point b in Fig. 2. Further, the high temperature and pressure gaseous refrigerant is condensed by an outdoor unit heat exchanger to be a high pressure liquid refrigerant, then slightly supercooled and introduced to the decompression device. When illustrated in the Mollier chart, the refrigerant at the time is under a state designated by a point c in Fig. 2. In the decompression device, the liquid refrigerant is expanded to be a gas-liquid two-phase refrigerant. When illustrated in the Mollier chart, the refrigerant at the time is under a state designated by a point d in Fig. 2. The gas-liquid two-phase refrigerant is flown into the refrigerant distribution device 3 of the indoor unit 1 for the ceiling suspension air-conditioner. The gas-liquid two-phase refrigerant distributed by the refrigerant distribution device 3 is evaporated in the heat exchanger 2, to be subject to gradual increase in dryness and slight rise in degree of superheat,

and then returned to a suction inlet of the compressor (point a in Fig. 2).

[0018] The following is a brief description of flow patterns of a gas-liquid two-phase refrigerant, namely, flow patterns of a gas-liquid two-phase flow (adapted from "KIEKI-NISOURYU" (or "Gas-liquid two-phase flow"), Kouji Akagawa, Corona Publishing Co., LTD., Published on May 20, 1974).

[0019] There are five kinds of flow patterns of an unheated upward two-phase flow in a vertical tube as shown in Fig. 3. They represent the flow patterns in the vertical portion located behind the bend of the inflow tube 8 (described below) in the refrigerant distribution device 3. The features of each flow pattern are described as follows:

- (a) Bubble flow - A flow wherein small air bubbles are dispersed in a liquid phase;
- (b) Slug flow - A flow consists of alternating portions of those which includes bullet-shaped large bubbles surrounded by liquid films occupying almost the whole of a cross-section of a pipe line, and those which includes small bubbles in the liquid (liquid slug portion);
- (c) Froth flow - A flow including short liquid slug portions with a high gas content in which a liquid is reticulate;
- (d) Annular-mist flow - A flow wherein a liquid film is formed on a tube wall while liquid droplets are included in a core of a gas phase; and
- (e) Mist flow - A flow wherein a continuous liquid film is not formed on a tube wall while liquid droplets are included in a gas phase.

The change in the flow patterns from (a) through (e) as mentioned above virtually corresponds to a case in which a gas flow rate is gradually increased under a constant liquid flow rate.

[0020] On the other hand, there are eight kinds of flow patterns of an unheated two-phase flow in a horizontal tube, as shown in Fig. 4. Main features of each flow pattern which are different from those in the vertical tube are only described as follows:

- (a) Stratified flow - A flow wherein a gas and a liquid are separated in upper and lower two layers with approximately a flat and smooth interfacial boundary therebetween;
- (b) Wavy flow - A flow wherein an interfacial boundary between a gas and a liquid is wavy;
- (c) Plug flow - A flow wherein long large bubbles exist in an upper part of a flow path; and
- (e) Slug flow - A flow including a number of small bubbles at a liquid slug portion between large bubbles.

The flow patterns (a) through (h) in Fig. 4 virtually correspond to flow patterns according to an increase in a gas flow rate under a constant liquid flow rate.

[0021] As illustrated in the Mollier chart for a refrigerant in Fig. 2, a dryness fraction of the gas-liquid two-phase refrigerant flows in the refrigerant distribution device 3 is generally about 0.2. The gas-liquid two-phase refrigerant with a dryness fraction of about 0.2 becomes a bubble flow in a horizontal tube (at a horizontal portion located ahead of the bend of the inflow tube 8 in the refrigerant distribution device 3), and an annular-mist flow or a froth flow in a vertical tube (at a vertical portion located behind the bend of the inflow tube 8 in the refrigerant distribution device 3).

[0022] With reference to Fig. 5 and Fig. 6, the structure and the operations of the refrigerant distribution device 3 are described. The refrigerant distribution device 3 includes an L-shaped inflow tube 8 wherein a gas-liquid two-phase refrigerant flows, and the distributor 7 connecting to the vertical portion located behind the bend of the inflow tube 8. The refrigerant distribution device 3 is characterized in that the longitudinal form of the bend of the inflow tube 8 is made of a combination of straight lines and bent approximately at a right angle. Therefore, there is no R bend in the bend part of the inflow tube 8.

[0023] A gas-liquid two-phase refrigerant decompressed and generated at the decompression device of the outdoor unit during cooling operation of the air-conditioner flows in the horizontal portion (upstream portion) of the inflow tube 8 in the refrigerant distribution device 3 configured as above. Since a dryness fraction of the gas-liquid two-phase refrigerant flows in the inflow tube 8 is about 0.2, the gas-liquid two-phase refrigerant becomes a bubble flow in the horizontal portion. The gas-liquid two-phase refrigerant flows through the horizontal portion as the bubble flow reaches the bend in due course. In this case, the longitudinal form of the bend is made of a combination of straight lines and bent approximately at a right angle; therefore, a centrifugal force does not act on the refrigerant, and the refrigerant collides with an opposing wall 9 of the bend. Since the centrifugal force does not act, a liquid phase and a gas phase having different specific gravities are not acted upon by different external forces. Therefore, a biased distribution of large bubbles in an annular-mist flow or a froth flow is prevented in the vertical portion of the inflow tube 8 connected to the distributor 7.

[0024] As shown above, since the longitudinal form of the bend of the inflow tube 8 in the refrigerant distribution device 3 is made of a combination of straight lines and is bent approximately at a right angle, a centrifugal force does not act on the gas-liquid two-phase refrigerant in the bend of the inflow tube 8. Therefore, it is possible to prevent a biased distribution of the large bubbles in the vertical portion of the inflow tube 8 connected to the distributor 7, and to eliminate an unevenness of refrigerant distribution to each path of the heat exchanger 2.

Embodiment 2.

[0025] Fig. 7 through Fig. 9 are diagrams illustrating

the second embodiment: Fig. 7 is the longitudinal sectional view of the bend of the inflow tube 8 in the refrigerant distribution device 3; Fig. 8 is the perspective view of the refrigerant distribution device 3; and Fig. 9 is the exploded perspective view of the refrigerant distribution device 3.

[0026] In the second embodiment, the longitudinal form of the bend of the inflow tube 8 in the refrigerant distribution device 3 is made of a combination of straight lines and is bent approximately at a right angle as in the first embodiment, and additionally as shown in Fig. 7, a depression 10 is established at a part where the opposing wall 9 facing a gas-liquid two-phase refrigerant flows in horizontally is formed. The depression 10 is formed by allowing the horizontal portion of the inflow tube 8 to bulge to an opposite side of a side from which the gas-liquid two-phase refrigerant flows in.

[0027] By establishing the depression 10 at the part where the opposing wall 9 of the bend of the inflow tube 8 is formed, it is possible to restrain a rise velocity of a refrigerant at an outer periphery near the bend. Therefore, it is possible to prevent production of a turbulence of a refrigerant flow near the bend. The turbulence of the refrigerant flow leads to production of a pressure loss or a refrigerant noise in the refrigerant tube. Thus, by preventing the turbulence of the refrigerant flow, it is possible to suppress production of a pressure loss or a refrigerant noise in the refrigerant tube.

[0028] Fig. 8 is the perspective view of the refrigerant distribution device 3. Fig. 9 is the exploded perspective view of the refrigerant distribution device 3. A connecting copper tube 12 is connected to one connection port at a head of a T-tube 11, while the other connection port at the head of the T-tube 11 is sealed to form the opposing wall 9 and the depression 10. The distributor 7 is connected to a connection port at a foot of the T-tube 11. In this way the refrigerant distribution device 3 is produced.

[0029] As mentioned above, by using the T-tube 11 having connection ports (openings) in three directions, it is possible to produce easily the refrigerant distribution device 3 having a generally L-shaped overall configuration and including the depression 10 at the part of the opposing wall 9 of the bend, without the need of bending the tube.

[0030] By including the depression at the part of the opposing wall 9 of the bend, it is possible to restrain a rise velocity of a refrigerant at the outer periphery near the bend, and prevent production of a turbulence of a refrigerant flow near the bend. By preventing the turbulence of the refrigerant flow, it is possible to suppress production of a pressure loss or a refrigerant noise in the refrigerant tube.

Embodiment 3.

[0031] Fig. 10A and Fig. 10B are diagrams illustrating the third embodiment: Fig. 10A is the diagram of the refrigerant distribution device 3 viewed from the opposing

wall 9 side; and 10B is the schematic diagram of the overall structure of the refrigerant distribution device 3.

[0032] According to "KIEKI-NISOURYU" (or "Gas-liquid two-phase flow") by Kouji Akagawa (as mentioned above), an upward flow in an inclined pipe also flows in virtually the same manner as the flow patterns in a vertical tube, if the inclined pipe has an inclination angle of 30 or more degrees relative to a horizontal plane. Therefore, when the distributor 7 is inclined at an angle of 30 through 150 degrees with respect to a horizontal direction, the biased distribution of bubbles at an inlet to the distributor 7 are prevented, as in a case of a vertical tube. By allowing the distributor 7 to incline, it is possible to reduce the height of the refrigerant distribution device 3, and to limit the height (thickness) of the indoor unit of the ceiling suspension air-conditioner to a low level.

[0033] The refrigerant distribution device according to the present invention with the aforementioned structure enables eliminating an unevenness of a liquid refrigerant at the bend of the inflow tube due to a centrifugal force.

[0034] Having thus described several particular embodiments of the present invention, various alterations, modifications, and improvements will readily occur to those skilled in the art within the scope of the present invention as defined in the following claims.

Claims

1. A refrigerant distribution device, including an inflow tube connected to a distributor for distributing and providing a refrigerant in a gas-liquid two-phase state to a heat exchanger, the inflow tube having an upstream portion and a downstream portion, the downstream portion of the inflow tube being approximately at a right angle to the upstream portion, and wherein:

viewed in cross-section longitudinally of the inflow tube the walls of the upstream and downstream portions join in a combination of straight lines to achieve a bend approximately at a right angle.

2. The refrigerant distribution device according to claim 1, further comprising:

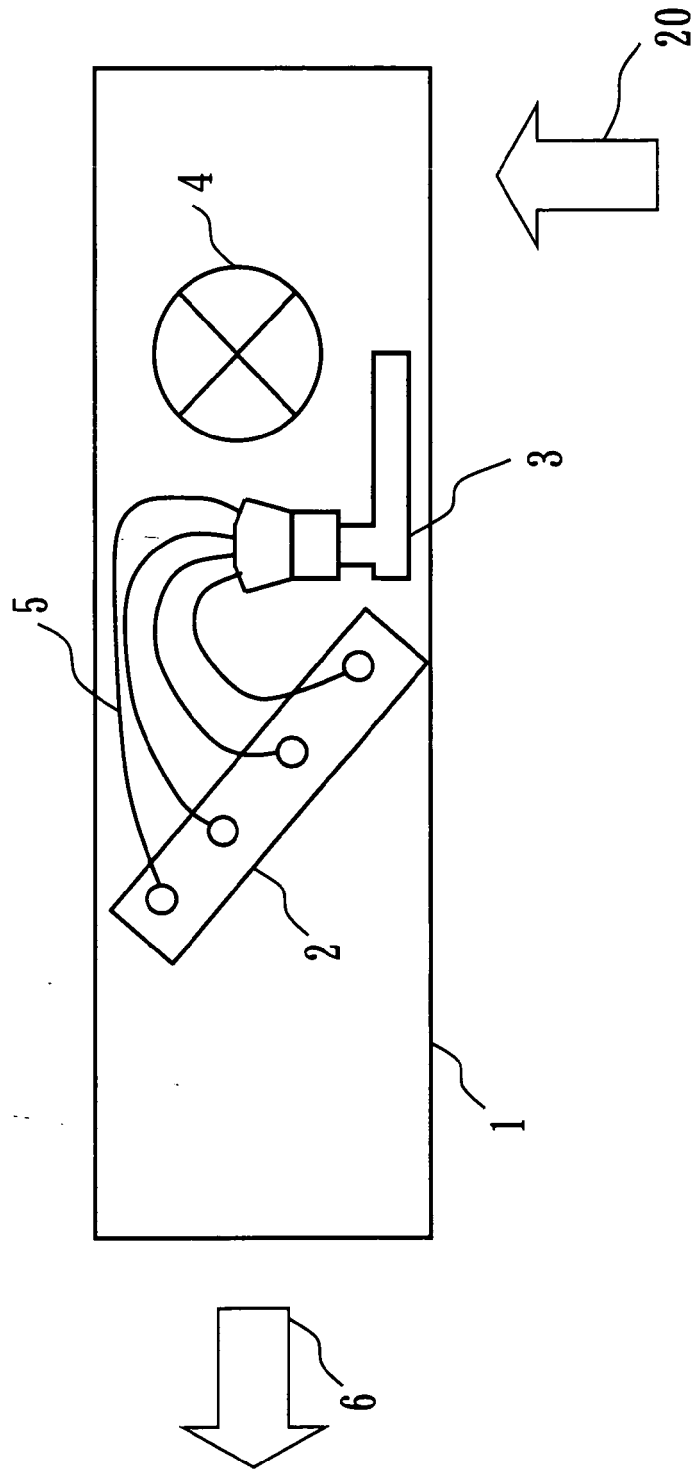
a depression formed near a wall which faces an inflow direction of a refrigerant to the bend.

3. The refrigerant distribution device according to claim 2, further comprising a T-tube including connection ports in three directions, wherein a connection port at a foot of the T-tube is connected to the distributor, and wherein one connection port at a head of the T-tube is connected to a connecting copper tube forming an upstream side of the inflow tube, and the other connection port is sealed to form the depression near

the bend.

4. The refrigerant distribution device according to claim 1, 2 or 3, wherein the distributor is at an angle ranging from 30 through 150 degrees to the horizontal around a longitudinal axis of the upstream portion of the inflow tube 5
5. A refrigerant distribution device, including an inflow tube connected to a distributor for distributing and providing a refrigerant in a gas-liquid two-phase state to a heat exchanger, the inflow tube having an upstream portion and a downstream portion, the downstream portion of the inflow tube being approximately at a right angle to the upstream portion, and wherein the upstream and downstream portions join so as to define a non-progressive change in flow direction of the refrigerant. 10 15 20 25 30 35 40 45 50 55

Fig. 1



- 1 : INDOOR UNIT FOR CEILING SUSPENSION AIR-CONDITIONER
- 2 : HEAT EXCHANGER
- 3 : REFRIGERANT DISTRIBUTION DEVICE
- 4 : FAN
- 5 : REFRIGERANT DIVIDING CAPILLARY TUBE
- 6 : AIR DISCHARGED IN A ROOM
- 20 : INDOOR AIR

Fig. 2

MOLLIER CHART FOR REFRIGERANT

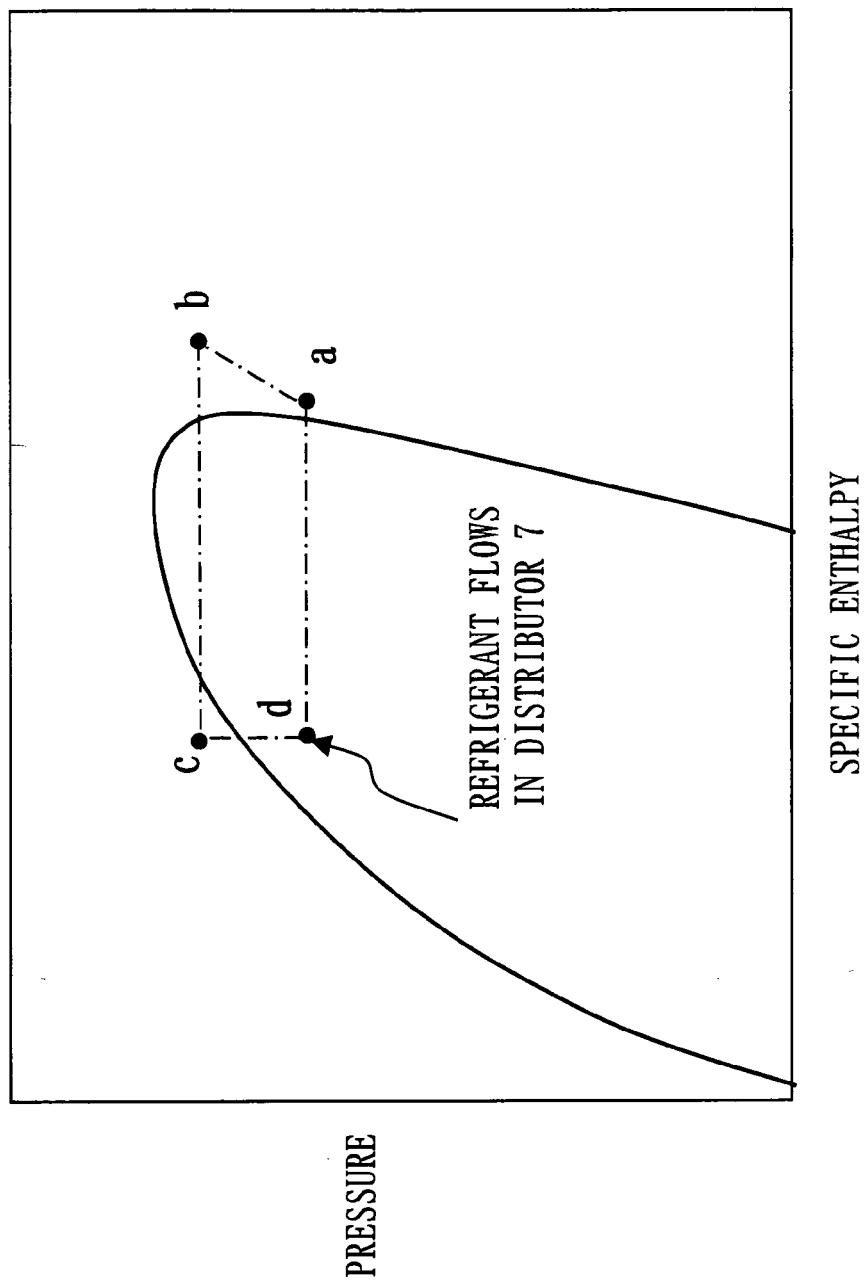


Fig. 3

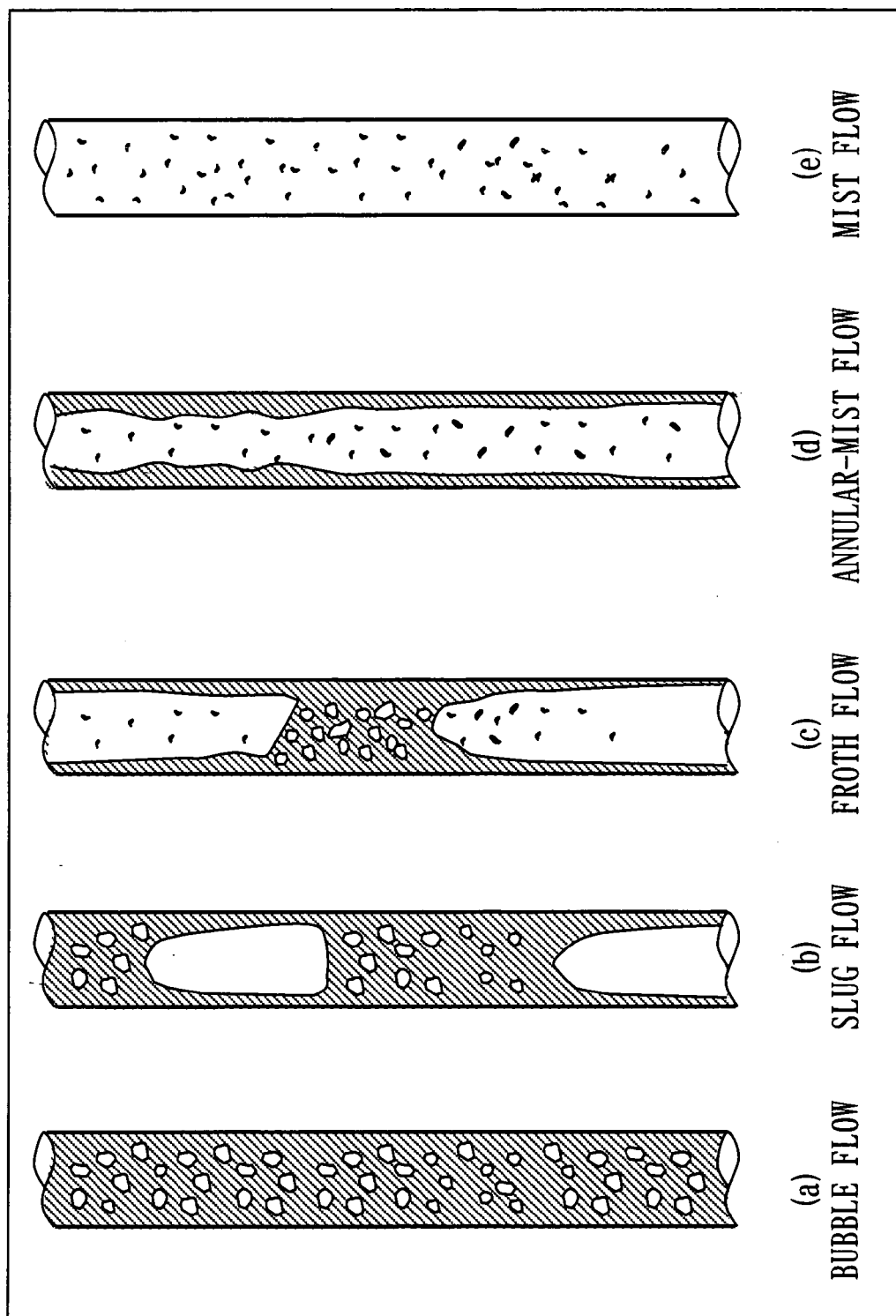


Fig. 4

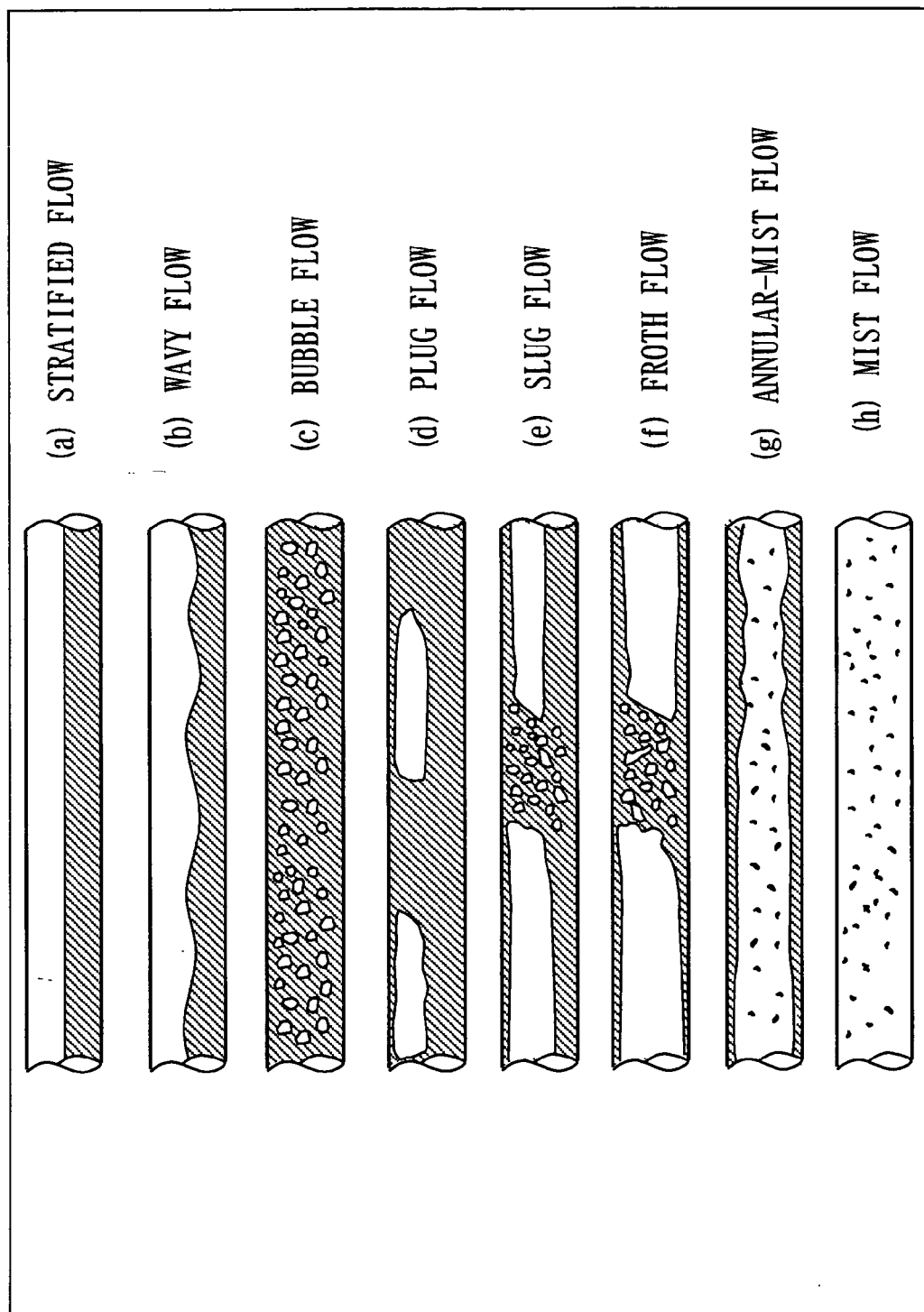


Fig. 5

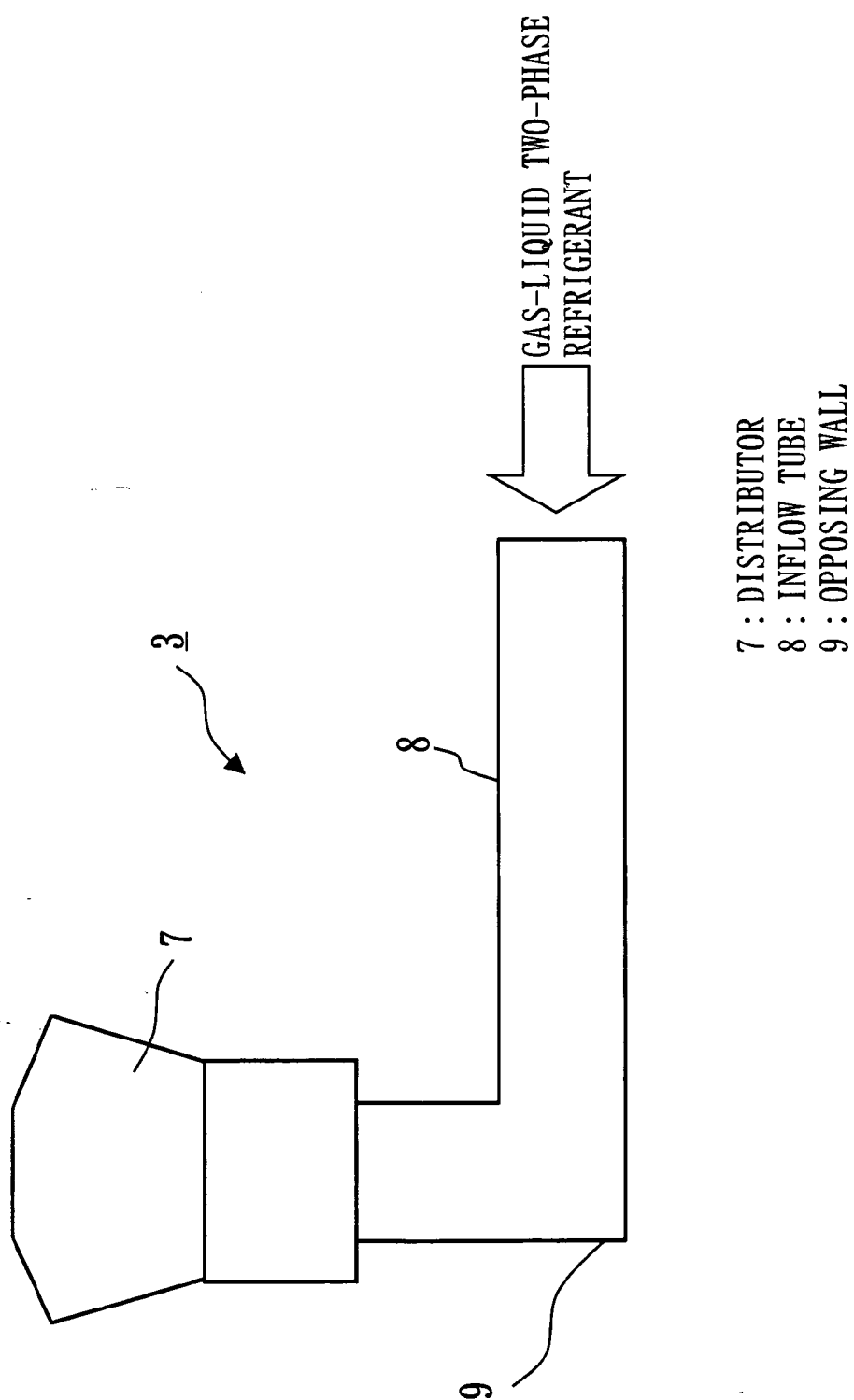


Fig. 6

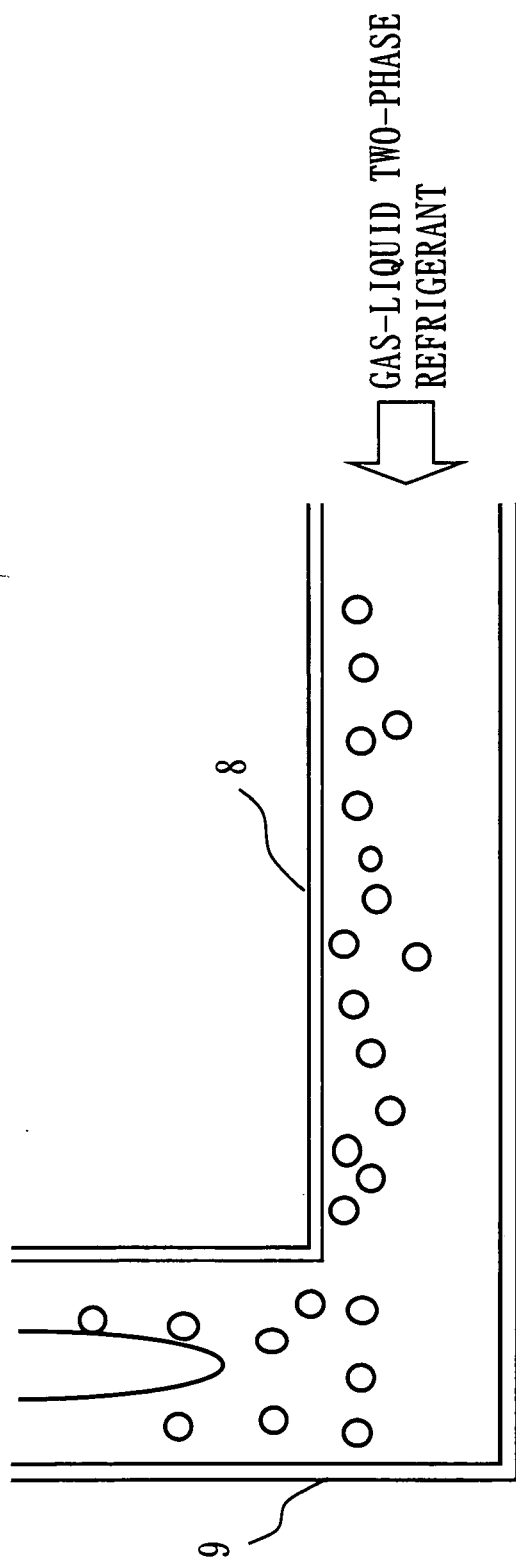
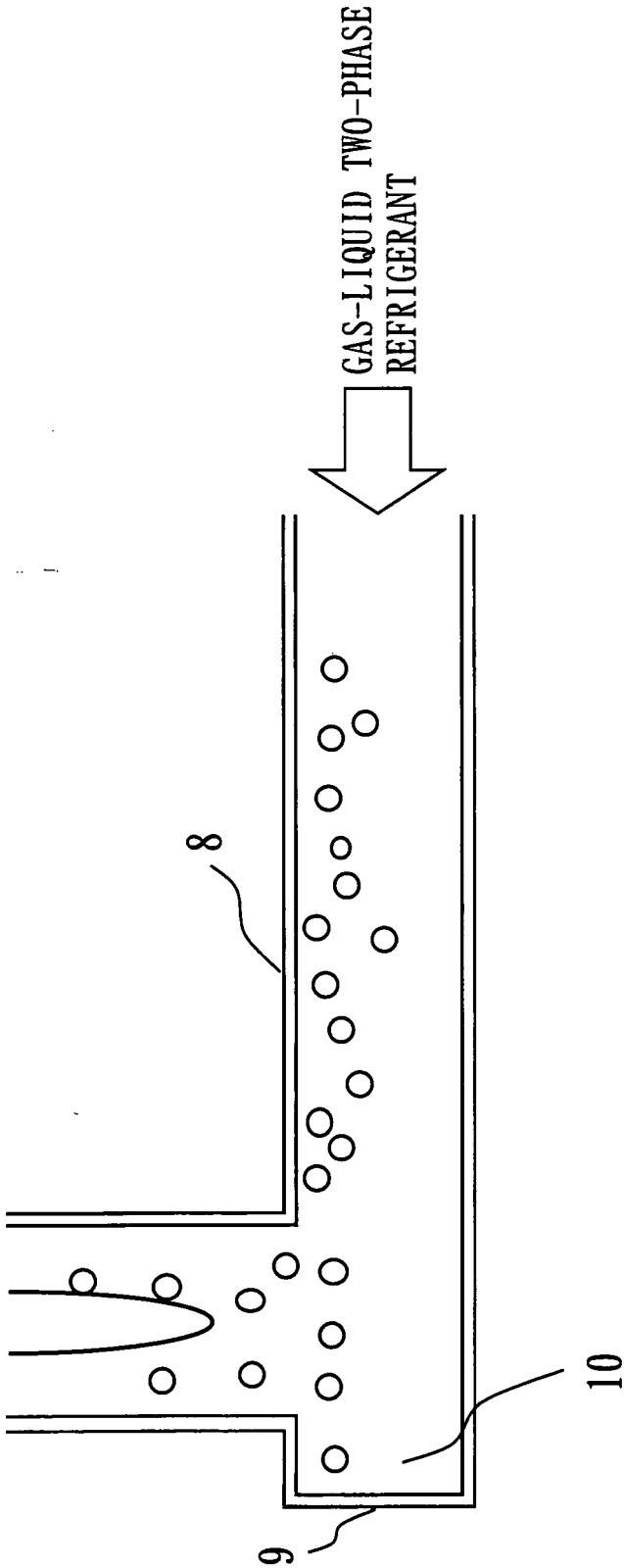


Fig. 7



10 : DEPRESSION

Fig. 8

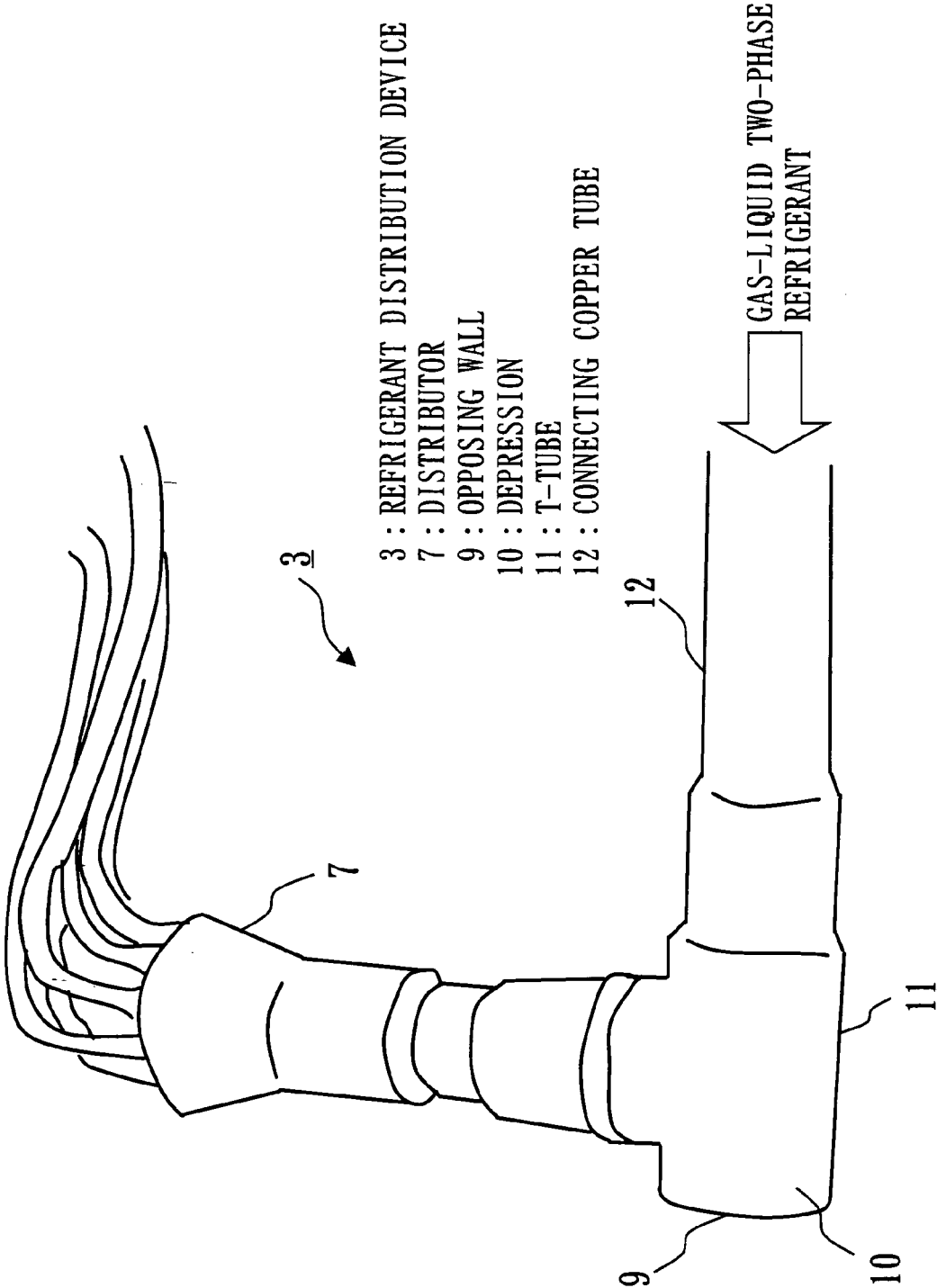


Fig. 9

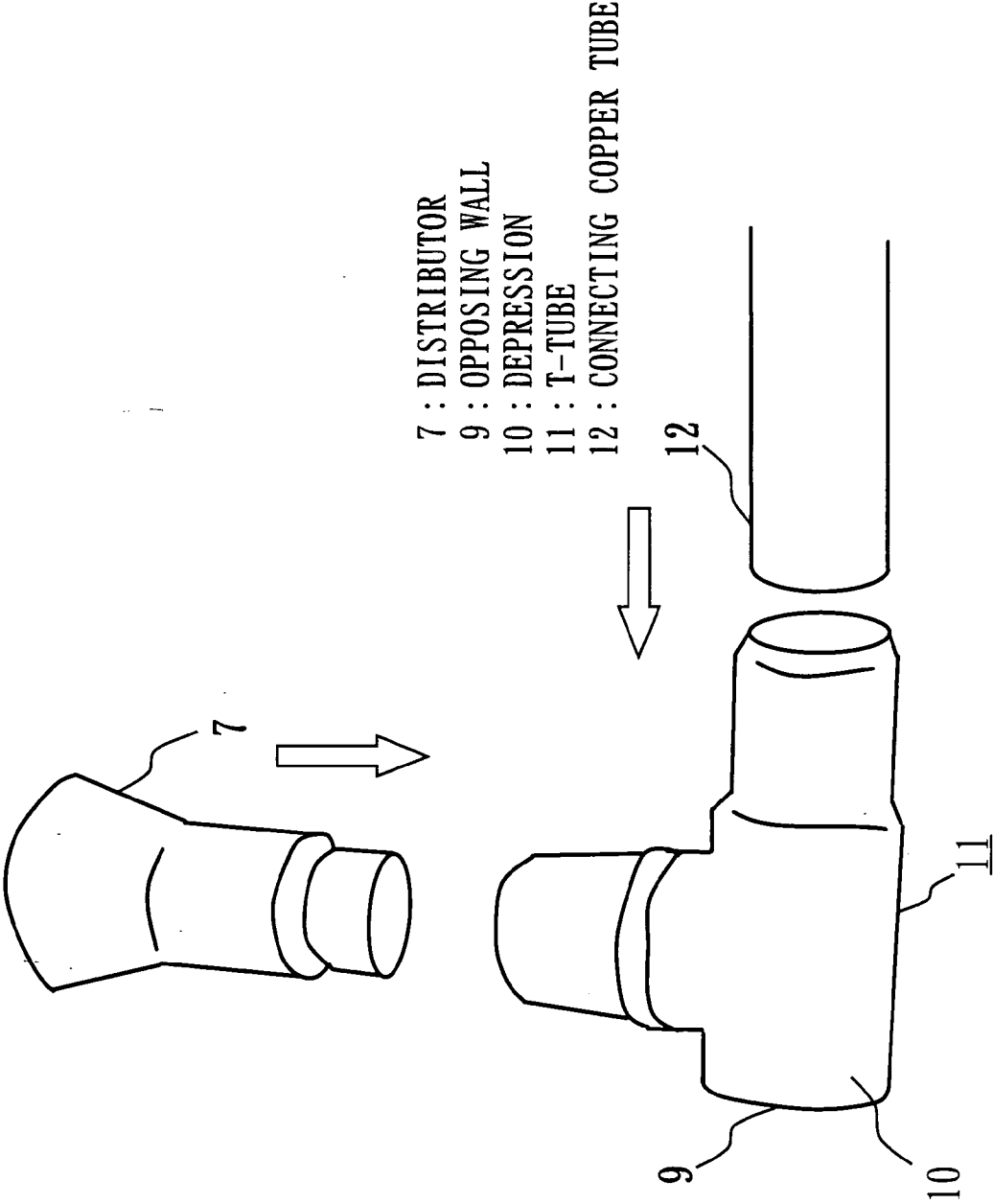


Fig. 10A

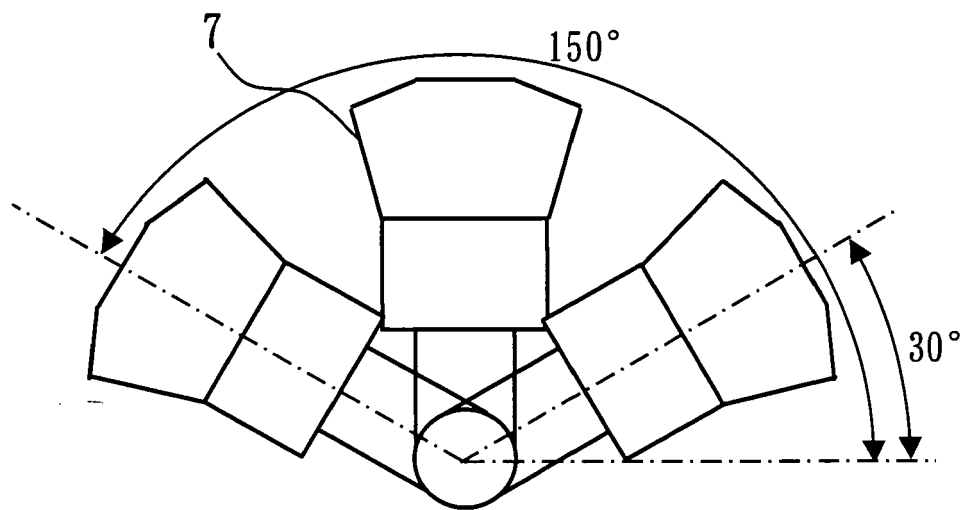


Fig. 10B

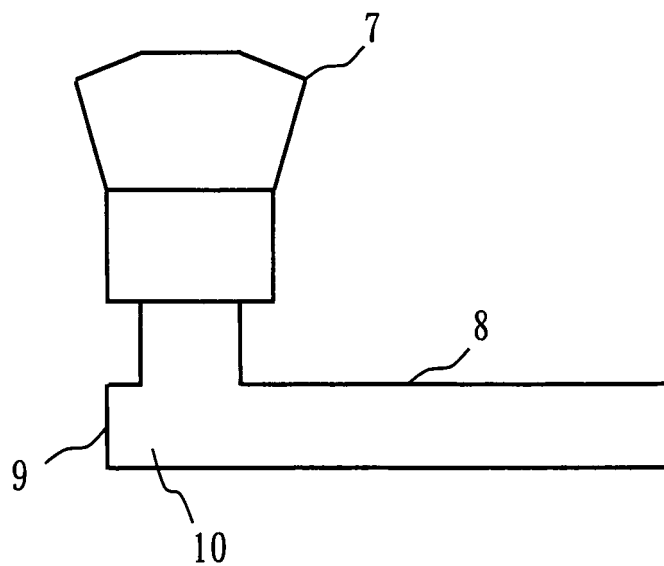


Fig. 11

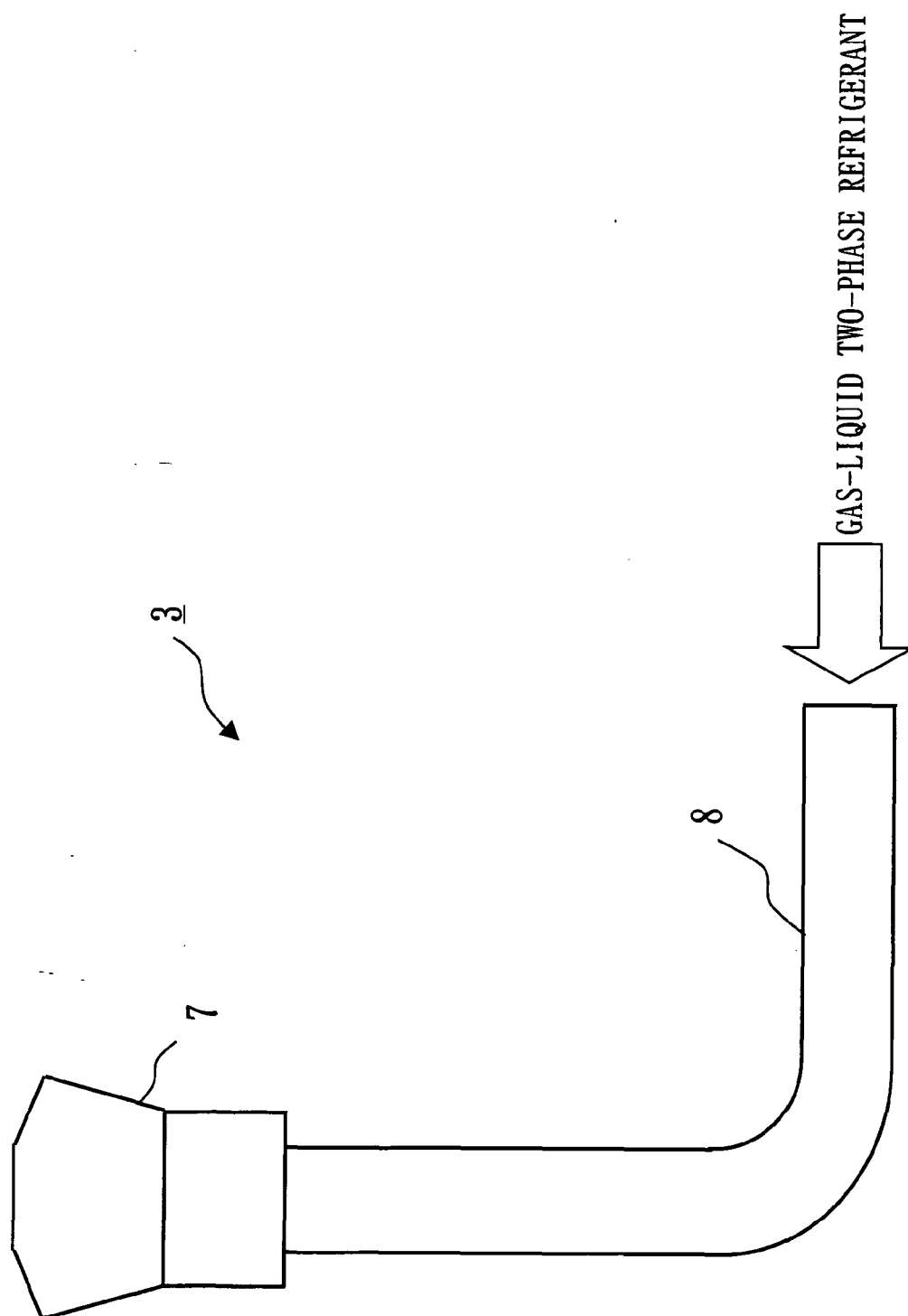
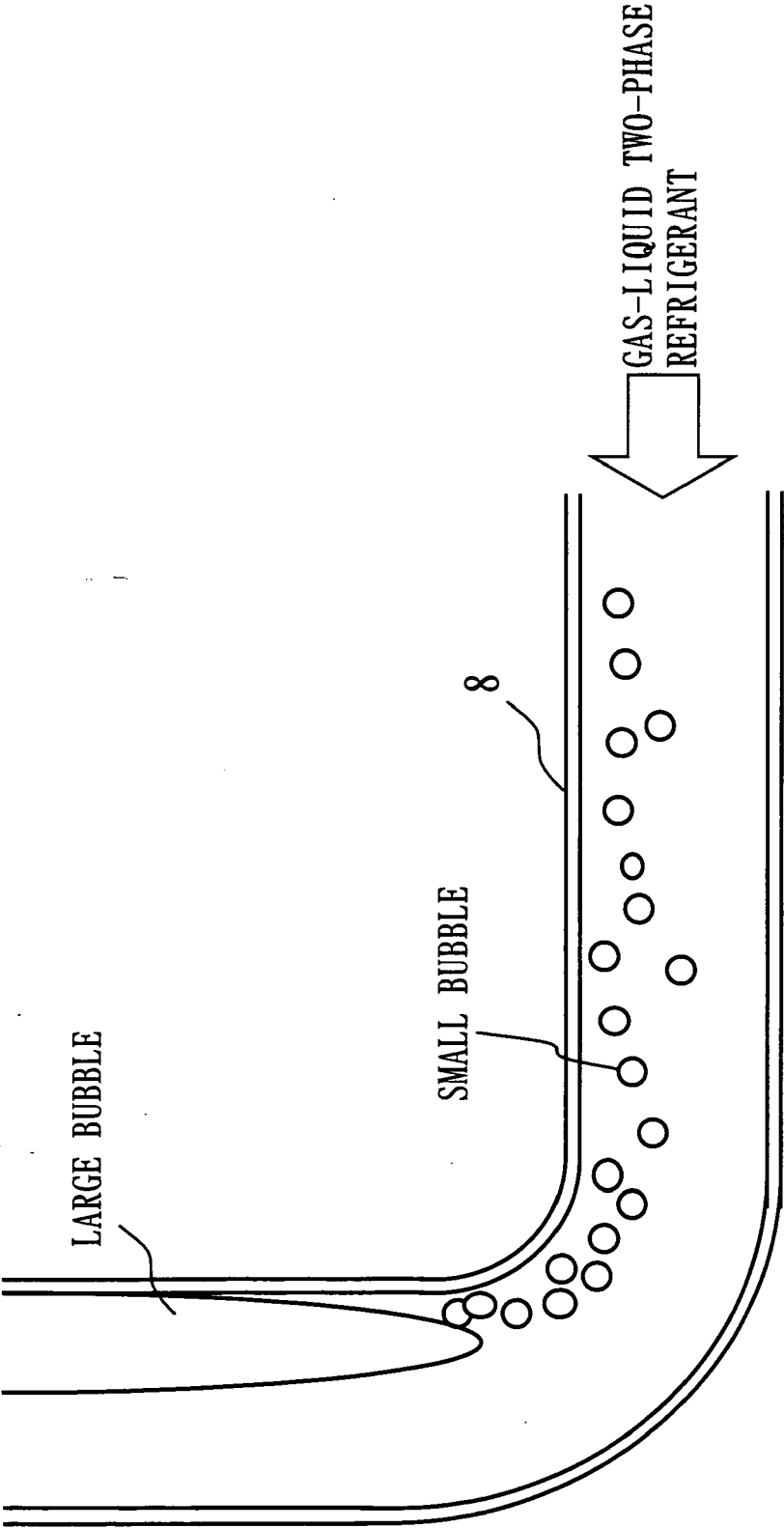


Fig.12





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 25 3249

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 29 November 2007	Examiner Valenza, Davide
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	

3
EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 07 25 3249

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