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(71) Applicant: **DENSO CORPORATION**
Kariya-City Aichi-Pref. 448 (JP)

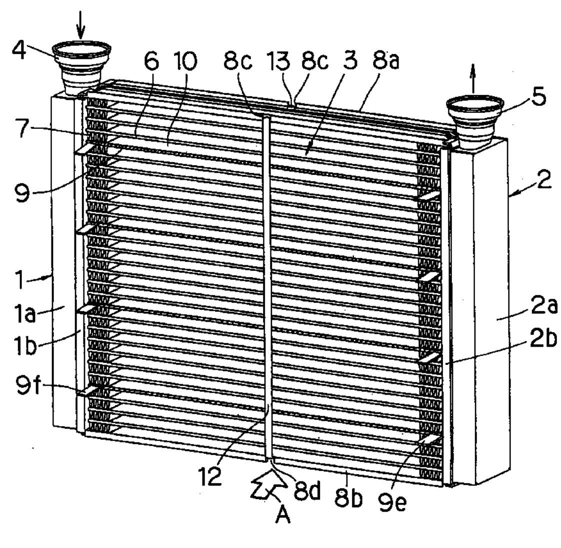
(72) Inventors:
- **Fukuoka, Mikio**
  Kariya-shi, Aichi 448-8661 (JP)
- **Nakamura, Mitsugu**
  Kariya-shi, Aichi 448-8661 (JP)
- **Kuroyanagi, Isao**
  Kariya-shi, Aichi 448-8661 (JP)
- **Ohara, Toshio**
  Kariya-shi, Aichi 448-8661 (JP)
- **Kamiya, Sadayuki**
  Kariya-shi, Aichi 448-8661 (JP)
- **Naruse, Shinji**
  Kariya-shi, Aichi 448-8661 (JP)
- **Aki, Yoshifumi**
  Kariya-shi, Aichi 448-8661 (JP)
- **Yamamoto, Michiyasu**
  Kariya-shi, Aichi 448-8661 (JP)

(74) Representative:
Klingseisen, Franz, Dipl.-Ing. et al
Patentanwälte,
Dr. F. Zumstein,
Dipl.-Ing. F. Klingseisen,
Postfach 10 15 61
80089 München (DE)

(54) Core unit of heat exchanger having electric heater

(57) A core unit (3) of a heat exchanger is composed of a plurality of parallel flat tubes (6), a plurality of corrugated fins (7), a support member (100) disposed between two of the corrugated fins (7) and an electric heater (9) disposed inside the support member (100). The support member (100) has a pair of parallel plates (10, 11) bonded to the corrugated fins (7) at the summits of corrugation of the corrugated fins (7). The electric heater (9) is composed of a heating element (9a) and an insulation member (9d) inserted between the heating element (9a) and the parallel plates (10, 11).

FIG. 1



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Description

CROSS REFERENCE TO RELATED APPLICATION

The present application is based on and claims priority from Japanese Patent Applications Hei 9-24154 filed on February 6, 1997, Hei 9-92417 filed on April 10, 1997 and Hei 9-215042 filed on August 8, 1997, the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is related to a heat exchanger of a heater in which an electric heater is disposed integrally therewith to heat air in addition to hot water heated by a vehicle engine.

2. Description of the Related Art

Conventional heat exchangers having an integrated electric heater therein are disclosed in JP-A-5-69732 and JP-A-63-203411. A heat exchanger of a heater in which hot water or engine coolant is used to heat air is provided with an integrated electric heater. When the coolant temperature is low, for example when the engine is just started, the electric heater is turned on to generate heat, thereby heating air. This structure reduces pressure loss in the heating air blow system of the heater as compared with a structure having a separate PTC heater. Because the PTC heater has a positive temperature characteristic sharply changing the resistance thereof at a set temperature, it is not necessary to provide a temperature control circuit so that the driving circuit thereof can be made simple.

The electric heater is composed of a PTC element and electrodes and is soldered to a heat exchanger core. Therefore, the PTC element is exposed to high-temperature air for soldering (e.g. 600 °C for soldering aluminum members) and, accordingly, the electric characteristic of the heater element may be damaged substantially.

In a common air conditioning system for a vehicle, a heat exchanger of a heater is disposed at a downstream side of a heat exchanger for cooling air to control reheating by the heat exchanger of the heater, thereby controlling temperature of the air blown into the passenger compartment of the vehicle. Therefore, condensed water formed on the heat exchanger for cooling air or snow coming from the air inlet may adhere the front surface of the heat exchanger of the heater. Because the electric heater is exposed to the outside from the heat exchanger core, the water or snow may cause short circuiting or electric leakage.

In the above conventional device disclosed in the publication, it is only disclosed that the set temperature of the PTC heater is 80 °C. There is no explanation about how to decide the set temperature. Our experiments have revealed that the heat generated by the PTC heater may not be utilized for the heating air to be heated if the set temperature of the PTC heater is not suitable.

In a core unit of a heat exchanger, a plurality of flat tubes for conducting water or engine coolant are parallelly disposed, and each of a plurality of corrugated fins is disposed between two of the flat tubes. If a PTC heater is installed in place of one of the flat tubes, the heat of the PTC heater is conducted via the corrugated fins and the adjacent flat tubes to the water. If the PTC heater is powered when the water temperature is low, temperature of portions of the corrugated fins adjacent to the PTC heater becomes higher than the temperature of portions of the corrugated fins adjacent to the flat tubes. If the set temperature of the PTC is too high, the heat generated by the PTC heater is transmitted to the water. That is, the PTC heater can not heat the heating air to be used for the heater effectively. On the other hand, if the set temperature is too low, the PTC heater can not generate power sufficient to heat the heating air.

SUMMARY OF THE INVENTION

The present invention has been made, in view of the above problems, to provide a core unit of a heat exchanger in which an electric heater can be installed without damage.

According to a feature of the present invention, a core unit of a heat exchanger is composed of a plurality of parallel flat tubes, a plurality of corrugated fins, a support member disposed between two of the corrugated fins, and an electric heater disposed inside the support member. The support member has a pair of parallel plates bonded to the corrugated fins at the summit of corrugation, and the electric heater comprises a heating element and an insulation member inserted between the heating element and the parallel plates.

Accordingly, the support plates can be soldered to the corrugated fins before the electric heater is inserted between the two support plates. Therefore, the electric characteristic of the electric heater is not damaged during the soldering step of the core unit. Although the corrugated fins have complicated shape, the electric heater can be inserted easily without damage on the corrugated fins. Further, because the electric heater is inserted between and insulated from the two support plates, electric current can be supplied to the electric heater without passing metal portions (tubes, etc.) of the core unit, so that electric corrosion of the metal portions of the core unit can be prevented. Moreover, even if the height of the corrugations of the corrugated fins are formed uneven, solder melts and moves due to capillarity and fills gaps between the summits of the corrugation of the corrugated fins and the support plates. Thus, the summits of corrugation of the corrugated fins can be soldered to the support plates with sure, and heat generated by the electric heater can be conducted from the support plates to the corrugated fins effectively.

It is another object of the present invention to prevent short circuiting and electric leakage caused by condensed water or the like.

According to another feature of the present invention, a core unit of a heat exchanger core having an air inlet side and an air outlet side includes a plurality of parallelly disposed flat tubes which conduct heat carrier, a plurality of corrugated fins, a U-shaped support member having a pair of plates parallelly extending along the flat tubes, an opening end portion and a U-shaped closing end portion, and an electric heater disposed between the support plates and insulated from the support member. The support member is disposed between the summits of corrugation of adjacent two of the corrugated fins, the U-shaped closing end portion is disposed at the air inlet side, and each of the plates is bonded to one of the corrugated fins at the summits of corrugation. The opening end portion preferably projects from an end of the electric heater. The opening end portion may spread in a skirt-shape. The support member may have the same thickness as the core unit in the air flow direction, and the electric heater may have smaller thickness in the direction of core thickness than the support member.

Because the U-shaped closing portion of the support member is disposed at the air inlet side of the heat exchanger core, the closing portion prevents water from entering the inside of the support member even if water adheres to an upstream portion of the core unit. Therefore, condensed water can not adhere to the electric heater, and the short circuiting or electric leak of the electric heater due to water is prevented. Because the opening portion of the support member projects from an end of the electric heater, water can be prevented from adhering to the electric heater even if water moves along the surface of the support member to the opening portion.

It is another object of the present invention is to provide an improved core unit of a heat exchanger for heating air by hot water or engine coolant having a PTC heater which can heat the heating air at a maximum efficiency.

According to another feature of the present invention, a core unit of a heat exchanger core includes a plurality of parallelly disposed flat tubes which conduct heat carrier, a plurality of corrugated fins having summits of corrugation disposed between two of the flat tubes, and an electric heater disposed between two of the summits of corrugation instead of one of the flat tubes. The electric heater has a positive temperature characteristic sharply changing resistance thereof at a set temperature and heats portions of the fins adjacent to the flat tubes at a temperature equal to temperature of water in the flat tubes if the water temperature is equal to or higher than 60 °C and temperature of air to be heated is equal to or lower than 0 °C.

Usually, the diesel engine operates at a high efficiency, and the water temperature thereof can not rise sufficiently even after engine has warmed up. In such a highly efficient engine, the water temperature may not rise up to 60 °C. If the water temperature in the flat tubes does not rise above 60 °C, the heat generated by the PTC heater is not transmitted to the water, so that the PTC heater can heat the heating air efficiently.

According to another feature of the present invention, a core unit of a heat exchanger core includes a plurality of parallelly disposed flat tubes which conduct heat carrier, a plurality of corrugated fins each of which is disposed between two of the flat tubes, a PTC heater disposed at a portion of the core unit instead of the flat tubes. The corrugated fins have summits of corrugation disposed between two of the flat tubes which has a height between 3.9 mm and 5 mm, and the set temperature of the PTC heater is between 85 °C and 110 °C. The electric heater is preferably a three-layered sandwich structure composed of an electric heater element and two flat electrodes on opposite sides of the electric heater element and is inserted between the corrugated fins and the two electrodes, and the two electrodes are press-fitted to the summits of the corrugation. The PTC heater may have a heater element whose positive temperature characteristic sharply changing resistance thereof at temperature between 120 °C and 170 °C.

According to the inventor's study, the height and the set temperature of the PTC heater are set as the above, the heat of the PTC heater is not transmitted to the water under the conditions: the heating air temperature $\leqq$ 0 °C; the water temperature in the flat tubes $\geqq$ 60 °C.

Further, the height of the fins between 3.9 mm and 5 mm reduces the difference in the temperature between the fins and the heating air, so that the corrugated-fin-type heat exchanger core unit can provide both sufficient heat radiation performance and effective heating of the heating air by the PTC heater.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and characteristics of the present invention as well as the functions of related parts of the present invention will become clear from a study of the following detailed description, the appended claims and the drawings. In the drawings:

Fig. 1 is a perspective view illustrating a heat exchanger having an electric heater integrated therewith according to a first embodiment of the present invention;
Fig. 2 is an enlarged perspective view of a portion where the electric heater is installed;
Fig. 3A is a fragmentary perspective view of the electric heater shown in Fig. 2, Fig. 3B is a cross-sectional side view of the electric heater, Fig. 3C is a cross-sectional elongation of the electric heater, and Fig. 3D is a plan view of the electric heater;
Fig. 4 is a schematic view illustrating a portion where an electric heater is disposed,
Fig. 5 is an enlarged perspective view of a portion where an electric heater of a heat exchanger according to a second embodiment of the present invention;
Fig. 6 is a cross-sectional view of the portion where the electric heater shown in Fig. 5 is installed;
Fig. 7 is a schematic view illustrating air flow system of the vehicle air conditioner including the heat exchanger according to the second embodiment;
Fig. 8 is a cross-sectional view of a variant of the electric heater according to the second embodiment of the present invention;
Fig. 9 is a perspective view of a second variant of the heat exchanger of an electric heater according to the second embodiment of the present invention;
Fig. 10 is a cross-sectional view of a third variant of the electric heater according to the second embodiment;
Fig. 11 is a cross-sectional view of a fourth variant of the electric heater according to the second embodiment;
Fig. 12 is a cross-sectional view of a fifth variant of the electric heater according to the second embodiment;
Fig. 13 is a cross-sectional view of a sixth variant of the electric heater according to the second embodiment;
Fig. 14 is a schematic view illustrating a main portion of a heat exchanger core unit according to a third embodiment of the present invention;
Fig. 15 is a driving circuit diagram for the PTC heater integrated in the core unit shown in Fig. 14;
Fig. 16 is a schematic diagram showing temperature distribution of the corrugated fin adjacent to the PTC heater shown in Fig. 15;
Fig. 17 is a graph showing relationship between the set temperature of the PTC heater and the height of the corrugated fins at water temperature of 60 °C;
Fig. 18 is a graph showing relationship between the set temperature of the PTC heater and the height of the corrugated fins at water temperature of 80 °C;
Fig. 19 is a graph showing relationship between the set temperature of the PTC heater and the temperature of the heating air with the height of the fins being 4.5 mm;
Fig. 20 is a graph showing relationship between the temperature of the PTC heater and the temperature of the heating air with the height of the fins being 4.0 mm; and
Fig. 21 is a graph showing temperature distribution of the corrugated fin.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention are described with reference to the appended drawings.

In Figs. 1 and 2, the heat exchanger for a heater has a hot-water inlet tank 1, a hot-water outlet tank 2 and a heat exchanger core unit 3 disposed between the tanks 1 and 2. The hot-water inlet tank 1 has an inlet pipe 4 through which hot water or engine coolant flows from a vehicle engine (not shown). The hot-water outlet tank 2 has an outlet pipe 5 through which the hot water is discharged and returned to the engine. The heat exchanger is symmetrical, and therefore the hot-water inlet tank 1 and the hot-water outlet tank 2 can be exchanged.

The inlet tanks 1 is composed of a tank body 1a, and the outlet tank 2 is composed of a tank body 2a. Sheet metals 1b and 2b close the open end of the tank bodies 1a and 2a respectively. The vertical direction of the heat exchanger in Figs. 1 and 2 is the longitudinal direction of the tanks 1 and 2. Each of the sheet metals 1b and 2b has a plurality of elliptic tube receiving holes (not shown). The elliptic tube receiving holes are formed in the vertical direction in Figs. 1 and 2 in a single line or a plurality of lines.

The heat exchanger core unit 3 has a plurality of the flat tubes 6 stacked in the vertical direction. One of a plurality of corrugated fins 7 is disposed between each pair of the flat tubes 6 and soldered thereto. Each of the corrugated fins 7 has a plurality of louvers extending at an angle from the direction **A** of heating air to increase the heat exchange rate.

Opposite ends of each of the flat tubes 6 are inserted into corresponding tube receiving holes of the sheet metals 1b and 2b of the inlet and outlet tanks 1 and 2 and soldered thereto. Side plate 8a and 8b are disposed on the outermost corrugated fins 7 and are soldered to the same outermost corrugated fins 7 and to the sheet metals 1b and 2b.

A pair of support plates 10 and 11 is disposed between the summits of the corrugation of adjacent two of the corrugated fins 7 in place of one of the flat tube 6 at each one of four portion of the core unit 3 and extend in parallel with each other at a distance L. The distance L is the same as thickness of the electric heater 9. Each of four electric heaters 9 is inserted between the support plates 10 and 11 to be held therein.

Elements and components 1-8b of the core unit 3 as well as the support plates 10 and 11 are made of aluminum or aluminum alloy. Each of the support plates 10 and 11 is made of a thin sheet having thickness between 0.1 and 0.5 mm and width (in the direction of the hot air) having nearly the same size as the corrugated fins 7. The length (in the horizontal direction in Fig. 1) of the support plates 10 and 11 is nearly the same as the distance between the sheet metals 1b and 2b.

The electric heater 9 has a three-layered sandwich structure composed of a flat heating element 9a and long flat electrodes 9b and 9c disposed on the opposite surfaces of the heating element 9a as shown in Fig. 3. An insulating cover 9d made of insulating material covers the circumferences of the electrodes 9b and 9c. The heating element 9a is a PTC heater element made from resistance material (such as barium titanate), which has a positive temperature characteristic increasing the resistance sharply at a set temperature T0 (e.g. around 90 °C). The thickness of the heating element 9a is between 1.0 - 2.0 mm.

The electrodes 9b and 9c is made of aluminum, copper or stainless or the like and has the thickness between 0.1 - 0.5 mm. The length of the electrodes 9b and 9c (horizontal size in Fig. 1) is nearly equal to the length of the support plates 10 and 11. The heating element 9a and the electrodes 9b and 9c are pressed to each other to provide good electric conduction.

The insulating cover 9d is press-fitted into the space between the support plates 10 and 11 to insulate the support plates 10 and 11 from the plates 9b and 9c and to conduct heat generated by the heating element 9a to the support plates 10 and 11. For this purpose, the thickness t1 of the insulating cover 9d disposed between the support member and one of the plates 9b and 9c is formed between 25μ-100μ.

The thickness t2 of the insulating cover 9d at the opposite sides of the heating elements is about 1-2 mm to protect the heating elements 9a. The insulating cover 9d is preferably made of high temperature resistive resin (e.g. polyimide).

Terminals 9e and 9f are formed integrally with the plus electrode 9b and the minus electrode 9c respectively to be connected to an outside circuit. The terminals 9e and 9f project from the rear side (down stream side of air flow **A** in Fig. 1) of the core unit 3. The terminal 9e is formed at the right side of the plus electrode 9b, and the terminal 9f is formed at the left side of the minus terminal 9c. Both terminals 9e and 9f may project toward the rear side (air flow direction **A**).

The terminals 9e and 9f are connected to an outside circuit (not shown) so that the electric heaters 9 can be energized by a vehicle electric source.

Reference numerals 12 and 13 indicate fastening members or bands made of anticorrosion metal respectively disposed on a surface of the air inlet side and on a surface of the air outlet side of the core unit 3. Each of the fastening members 12 and 13 has hook portions at the opposite ends thereof to engage grooves 8c and 8d formed at middle of the upper and lower side plates 8a and 8b. The fastening members 12 and 13 provides the support plates 10 and 11 with fastening force to hold the electric heater 9.

In assembling, the tubes 6 and corrugated fins 7 are alternately stacked on one another, and the support plates 10 and 11 are inserted between the corrugation summits of the corrugated fins 7 which are located in four hatched portions. In order to keep the distance between two plates 10 and 11, a dummy spacer (not shown) is inserted into the support plate 10.

The spacer is made of material (such as carbon) which is resistant to the soldering heat and is not soldered to aluminum. The tanks 1 and 2, the pipes 4 and 5 and the side plates 8a and 8b are also assembled in a well-known manner.

The above assembled unit is held by an assembling tool (not shown) and sent to a brazing furnace to be brazed or soldered. The assembled unit is heated at a soldering temperature (600 °C) to melt solder in aluminum clad members of the core unit 3.

Thereafter, the assembled unit is taken out from the furnace and is cooled until the temperature of the assembled unit goes down to the ambient temperature. Then, the flat heating element 9a is inserted between the electrodes 9b and 9c to form the three-layered sandwich unit, which is covered by the insulating cover 9d.

Thereafter, the dummy spacers are removed from the support plates 10 and 11, and each of the electric heaters 9 is inserted thereto in a manner that the insulating cover 9d is press-fitted to the support member 10. Thereafter, the hooks of the fastening members 12 and 13 are engaged with the grooves 8c and 8d of the upper and lower side plates 8a and 8b to fasten the core unit 3 tight.

In operation, when the passenger compartment is to be warmed, the motor-driven fan 15 is operated to pass air through the spaces between the flat tubes 6 and the corrugated fins 7 in the direction indicated by the arrow **A** in Fig. 1. On the other hand, a water pump (not shown) is operated and hot water flows into the inlet tank 1 from the inlet pipe 4.

The hot water is distributed to a plurality of flat tubes 6 and transfer the heat thereof to the air to be heated while the water flows along the flat tubes. All the water flowing along the flat tubes 6 are collected in the outlet tank 2 and goes out of the outlet pipe 5 to the engine.

When the temperature of the hot water of the engine is lower than a preset temperature (e.g. 80 °C), the electric source voltage of the vehicle is applied across the terminals 9e and 9f of the electrodes 9b and 9c. consequently, the heating elements 9a are energized to generate heat, which is conducted to the corrugated fins 7 via the electrodes 9b and 9c, the insulating cover 9d and the support plates 10 and 11. Therefore, the air is heated in a short time even if the water is not sufficiently hot.

Since the heating element 9a is composed of a PTC element which has a positive temperature characteristic the resistance of which increases sharply at a preset temperature T0, it regulates the temperature thereof to the preset temperature by itself.

Since the corrugated fins 7 and the support plates 10 and 11 are soldered beforehand, the solder melts in the subsequent soldering step of the core, is guided by the capillarity to the gaps between the summits of the corrugation of the corrugated fins 7 and support plate and fills the gaps even though the gaps forms due to irregular height of the corrugation.

The insulating cover 9d of the electric heater 9 can be made of adhesive resinous material to bond the electric heater 9 to the support plates 10 and 11. In this case, the fastening members can be omitted.

(Second Embodiment)

A second embodiment is described with reference to Figs. 5-7. As shown in Fig. 5, each of the portions of the heat exchanger core unit 3 where the electric heaters are installed has a U-shaped support member 100 extending in the longitudinal direction of the flat tubes 6 between the summits of the corrugation of adjacent two of the corrugated fins. A U-shaped closing portion 10a of the support member 100 is located at the air inlet side of the heat exchanger core unit 3, and the opening portion 10b thereof is located at the air outlet side of the heat exchanger core unit 3.

The support member 100 has plates 10 and 11 extending in parallel at a distance L1, and they are soldered to the summits of the corrugations in the same manner as in the first embodiment. The electric heater 9 is inserted from the opening portion 10b into the inside of the support member 100 to be held therein. The electric heater 9 is held by an insulating member as described before.

Total thickness L2 of the support member 100 is same as thickness L3 of the flat tube 6 so that the support member 100 can be installed between the corrugated fins 7 instead of the flat tube 6. In Fig. 6, D is the thickness of the core unit 3 as well as the width of the flat tubes 6 and the corrugated fins 7 in the air flow direction.

Each of the support members 100 is made of a thin sheet having thickness between 0.1 and 0.5 mm and width (in the direction of the hot air) having nearly the same size as the core thickness D. The length (in the horizontal direction in Fig. 1) of the support member 100 is nearly the same as the distance between the sheet metals 1b and 2b.

The electric heater 9 has a three-layered sandwich structure composed of a flat heating element 9a and long flat electrodes 9b and 9c disposed on the opposite surfaces of the heating element 9a as shown in Figs. 5 and 6. An insulating cover 9d covers the electrodes 9b and 9c. The heating element 9a is a PTC heater element which has a positive temperature characteristic to increase the resistance sharply at a prescribed temperature T0 (e.g. around 200 °C). The thickness of the heating element 9a is between 1.0 - 2.0 mm.

The electrodes 9b and 9c of the heating element 9a is made of aluminum, copper, stainless or the like and has the thickness between 0.1 - 0.5 mm. The length of the electrodes 9b and 9c (horizontal size in Fig. 1) is nearly equal to the length of the support member 100.

Since the support member 100 has the U-shaped closing portion 10a, the electric heater can be held by a single fastening member 12 disposed on the opening portions 10b.

Fig. 7 illustrates an air conditioner to which a heat exchanger of a heater **H** according to this embodiment is installed. Outside air or inside air is introduced by a motor-driven fan 15 disposed in the upstream side of a resinous case 14 and sent to an evaporator 16 of the refrigerating cycle to be cooled and dried. The cooled air is separated by an air-mix door 17 into a flow passing the heat exchanger **H** for cooling air and a flow passing a bypass 18 so that the air heated by the heat exchanger **H** and the air passing the bypass 18 can be mixed and adjusted by turning the air-mix door 17, thereby controlling temperature of the air blown into the compartment of a vehicle.

The present invention can be applied to an air conditioner for a vehicle in which hot water supplied to the heat exchanger **H** is controlled by a hot-water control valve to control the temperature of the air blown into the vehicle compartment instead of the air-mix door 17.

In assembling, the heat exchanger core is assembled first. The tubes 6 and corrugated fins 7 are alternately stacked on one another, and one of the U-shaped support member 100 which extends along the tubes 6 is inserted between the corrugation summits of the corrugated fins 7 which are located in portions (four hatched portions). Other steps are substantially the same as those of the first embodiment.

In operation, when the passenger compartment is to be warmed, the motor-driven fan 15 is operated to pass air to be heated through the spaces between the flat tube and the corrugated fins. On the other hand, a water pump (not shown) is operated and hot water flows into the inlet tank 1 from the inlet pipe 4. The hot water is distributed to a plurality of flat tubes 6 and transfer the heat thereof to the air to be heated while the water flows along the flat tubes. All the water flowing along the flat tubes 6 are collected in the outlet tank 2 and goes out of the outlet pipe 5 to the engine.

When the temperature of the hot water of the engine is lower than a preset temperature (e.g. 80 °C), the electric source voltage of the vehicle is applied in the same manner as described before.

As shown in Fig. 7, the heat exchanger **H** for heating air is disposed at a downstream side of the heat exchanger 16 for cooling air in the case of the vehicle air conditioner. Therefore, condensed water generated in the heat exchanger 16 may be carried by the cooled air to the heat exchanger **H** and may adhere to the surface of the heat exchanger **H**. Snow may come from the air inlet into the case 14, melt and adhere to the upstream surface of the heat exchanger **H**.

The U-shaped closing portions 10a of the support member 100 are located at the air inlet side of the heat exchanger **H**, and the opening portions 10b are located at the air outlet side thereof. Even if the condensed water adheres to the upstream side of the heat exchanger **H** of the heater, the closing portions 10a keep off water or snow from the electric heater 9.

As shown in Fig. 6, the opening portion 10b projects a little from the downstream side of the electric heater 9. Even if water moves along the outer surface of the support members 100 to the opening portion 10b, the water can not adhere to the surface of the electric heater 9.

The electric terminals 9e and 9f of the electric heater 9 project from the downstream side of the heat exchanger core unit 3 in the air flow **A**, water does not adhere to the terminals 9e and 9f. Therefore, deterioration of the terminals 9e and 9f, short-circuiting and electric leakage can be prevented. Since the electric heaters 9 can be held in the U-shaped support members 100, the electric heater 9 can be positioned accurately.

Since the heating element 9a and the electrodes 9b and 9c of the electric heater 9 are covered by the insulating cover 9d and insulated from the support plate 10, electric current can not flow into the metal members of the heat exchanger **H**, and the electric corrosion of the metal members such as tubes or fins can be prevented.

Fig. 8 shows a variant of the second embodiment. The opening portion 10b of the support member 100 projects slightly from the end of the electric heater 9. The opening portion 10b is positioned at the downstream side of the corrugated fins in the air flow and is expanded at the end thereof like a skirt. Accordingly, the water moving along the surface to the opening portion 10b of the support member 100 is prevented from adhering to the electric heater with more sure.

Fig. 9 shows a second variant of the second embodiment. The heat exchanger **H** according to the second variant is a type in which hot water is returned as compared with the heat exchanger **H** according to the first embodiment, so called full-pass (one way) type, in which the hot water flows in one way direction in all the flat tubes from the hot water inlet tank 1 to the hot water outlet tank 2. In other words, the tank disposed on a side of the core unit 3 is divided into the hot water inlet tank 1 and the hot water outlet tank 2, and a connecting tank 19 is disposed to return the water to the opposite side of the tanks 1 and 2. Hot water is introduced from the inlet tank 1 through the flat tubes 6 on the left side of the core unit 3 into the connecting tank 19. From the connecting tank 19, the hot water is introduced to the outlet tank 2 through the flat tubes 6 on the right side of the core unit 3 and goes out from the outlet 5. The electric heater 9 can be installed in this type in the same manner as in the first embodiment.

Fig. 10 shows a third variant of the second embodiment. Two rows of the flat tubes 6 are disposed in the thickness of the core and, therefore, the thickness D of the core unit 3 is about twice as thick as the thickness of electric heater. A stopper portion 10e is formed at the middle of the support member 100 to hold the electric heater 9 in position. The middle portions of the support member 100 are pinched to be in contact with each other. Thus, the same electric heater 9 can be used to any heat exchanger H of a heater having core with different thickness.

Fig. 11 shows a fourth variant of the second embodiment. A separate stopper member (made of resin or metal) 10f is disposed inside the support member 100.

Fig. 12 shows a fifth variant of the second embodiment. The plate 10 of the support member 100 is pinched to form the stopper 10e.

Fig. 13 shows a sixth variant of the second embodiment. The support member 100 has a reinforcement rib 10g between the stopper portion 10e and the closing portion 10a. The reinforcement rib 10g is formed by pinching middle portions of the plates 10 and 11. The reinforcement rib 10g increases the stiffness of the portion between the stopper portion 10e and the closing portion 10a. The reinforcement rib 10g of the seventh embodiment can be formed on either one of the two plates 10 and 11.

The stopper 10e and the reinforcement rib 10g can be formed along the whole length of the tubes of the core continuously or intermittently

[Third Embodiment]

The PTC heater 9 shown in Fig. 14 is composed of a flat heating element 9a and long flat electrodes 9b and 9c disposed on the opposite surfaces of the heating element 9a. The heating element 9a is a PTC heater element which has a positive temperature characteristic to increase the resistance sharply at a prescribed temperature T0.

The electrodes 9b and 9c of the PTC heater element 9a are bonded by adhesive insulating material 10 to the summits of corrugation of the corrugated fins 7. The opposite ends of the PTC heater element 9a (horizontal direction in Fig. 1) are bonded by adhesive insulating material 10 to the sheet metals 1b and 1c. The adhesive insulating material 10 is made of adhesive, electrically insulating and heat conductive resin. Heat generated by the PTC heater element 9a is conducted by the corrugated fins 7 to heat the heating air.

Fig. 15 shows an electric driving circuit of the PTC heater 9. The four PTC heaters 9 are parallelly connected to a vehicle electric source 12 via a switch 9. The switch 11 is controlled by a control circuit 13. The control circuit 13 receives signals from a water temperature sensor 14 for detecting temperature of the water flowing from the engine into the heat exchanger of a heater and a switch 15 operated when the heater operates. If the water temperature is lower than a certain temperature (e.g. 80 °C), the control circuit 13 turns on the switch 11 to power the PTC heaters 9.

In operation, an air blower operates and drive air to the spaces between the flat tubes 6 and the corrugated fins 7. On the other hand, hot water is driven by a water pump (not shown) installed in the engine to flow from the engine through the inlet pipe 4 into the inlet tank 1. Then, the hot water is distributed into a plurality of the flat tubes 6 to heat the heating air via the corrugated fins while passing the tubes 6. Thereafter, the hot water flows into the outlet tank 2, gets together, flows out of the outlet pipe 5 of the heat exchanger and returns to the engine.

If the temperature of water flowing out of the engine is low, the switch 11 of the electric circuit closes to power the four PTC heaters 9. The PTC heaters 9 self-controls the temperature and rises to the temperature T0, which is transmitted to the heating air through the adjacent corrugated fins 7. Thus, the heating air is heated in a short time even if the water temperature is low.

In order to utilize the heat generated by the PTC heater 9 effectively, the set temperature T0 is an important factor.

Fig. 16 shows temperature distribution of the corrugated fin 7 disposed between the surface of the PTC heater 9 and the surface of the adjacent corrugated fin 6.

The following relations expressed by E1 and E2 are known, where temperature of the heating air flowing in the direction vertical to the drawing is Tair, set temperature (surface temperature) of the PTC heater 9 is T0, height of the corrugated fin 7 is hf, height of a certain position of the corrugated fin 7 is x, and temperature of the fin at the height x of the certain position is θ:

$$(\theta\text{-Tair})/(\text{T0-Tair}) = \cosh[m(hf-x)]/\cosh(m \cdot hf) \qquad \text{E1:}$$

$$\text{E2: } \theta = \cosh[m(hf-x)]/\cosh(m \cdot hf) \times (\text{T0-Tair}) + \text{Tair},$$

where m is a dimensionless number expresses in the following expression E3.

$$m = \sqrt{2h_0/\lambda f \cdot b}, \qquad \text{E3:}$$

where h_0 is a coefficient of heat transfer of the fin surface, b is a thickness of the fin, and λf is a coefficient of heat conductivity of the fin material.

In order to utilize the heat generated by the PTC heater 9 effectively, the temperature θ of the portions of the corrugated fins 7 adjacent to the flat tubes 6 (the portions at x=hf) is made equal to the temperature Tw of the peripheral surface of the tubes (or the water temperature in the tubes) in order to prevent the heat generated by the PTC heater 9 from transferring to the water.

If x = hf , and θ = Tw , the expression E1 is expressed by the following expression E4.

$$(\text{Tw-Tair})/(\text{T0-Tair}) = 1/[\cosh(m \cdot hf)] \qquad \text{E4:}$$

The set temperature T0 of the PTC heater 9 to satisfy the above condition can be obtained from the following expression E5.

$$\text{T0} = (\text{Tw-Tair}) \cosh(m \cdot hf) + \text{Tair} \qquad \text{E5:}$$

Fig. 17 shows relationship between the height hf of the fin and the set temperature T0 of the PTC heater 9 with various heating air temperatures Tair under the following conditions:

the heating air temperature Tair Tw = 60 °C, h_0 = 300 W/m^2 K, b =0.06 mm, λf = 193 W/m K (fin material:A3003).

Thus, m is calculated by the expression E3 as follows:

m = 227.626

In the air conditioner for a vehicle, outside dry air is introduced to the heater in order to prevent frosting of the windshield glass. Therefore, Tair is the outside temperature in winter. Because a recent highly-efficient-engine can provide hot water of 60 °C at the highest in winter, 60 °C is selected as Tw.

Fig. 18 shows relationship between the height hf of the fin and the set temperature T0 of the PTC heater 9 with various heating air temperatures Tair when Tw is 80 °C under the same conditions as above.

Fig. 19 shows relationship between the set temperatures T0 and the heating air temperatures Tair at various water temperatures Tw with the height of the corrugated fins being 4.5 mm. When the water temperature Tw changes from 60 °C to 80 °C and the heating air temperature Tair is 0 °C or lower, the set temperature of the PTC heater 9 changes from 96 °C to 126 °C.

Fig. 20 shows relationship between the set temperatures T0 and the heating air temperatures Tair at various water temperatures Tw when the height of the fins hf is 4.0 mm. When the water temperature Tw changes from 60 °C to 80 °C and the heating air temperature Tair is 0 °C or lower, the set temperature of the PTC heater 9 changes from 87 °C to 118 °C.

Fig. 21 is a graph showing relationship between temperatures on the fin surfaces and distances x of the fin surfaces from the PTC heater 9 with following conditions:

The height hf is 4.5 mm, the water temperature Tw is 60 °C, and the heating air (outside air) temperature Tair is 0 °C.

If the set temperature T0 of the PTC heater 9 is higher than 100 °C, the temperature of the portions (at x = 4.5 mm) of the corrugated fins 7 adjacent to the flat tubes 6 becomes higher than the temperature Tw (60 °C) of the water in the flat tubes 6. In this case, the heat of the corrugated fins, which is transferred from the PTC heater 9, is transferred to water and the heat generated by the PTC heater 9 is not utilized efficiently.

In the heat exchanger of a heater for a vehicle, the shorter width of the elliptic opening of the flat tube 6 is about 1.4 mm. It is found preferable that the height of the corrugated fins 7 is equal to or larger than 3.9 mm in combination with the above sized tubes. If the height of the fins is less than 3.9 mm, the ratio of the heat conduction area of the corrugated fins to the number of the flat tubes 6 is too small to have a sufficient heat radiation capacity. The height hf of the fins is, preferably, smaller than 5 mm. Otherwise, temperature of the middle portions of the corrugated fins becomes excessively lower than the temperature of the portions of the corrugated fins 7 adjacent to the tubes. This reduces the difference between the fin temperature, and the heating air temperature becomes too small for efficient heat transfer. Thus, the desirable height hf of the corrugated fins 7 is between 3.9 and 5.0 mm.

In Fig. 17, when the heating air (outside air) Tair is 0 °C, the set temperature T0 of the PTC heater 9 is between 80 °C and 120 °C if the height hf of the fins being between 3.9 and 5.0. In order to provide the above set temperature in this embodiment, the heater element 9a has positive temperature characteristic sharply changing the resistance thereof at temperature between 120 °C and 170 °C.

The present invention can be applied to various heat exchanger core having fins other than the corrugated fins, such as plate fins or the like.

The position of the PTC heater 9 can be changed in accordance with various specifications of the heat exchanger of the heaters.

In the foregoing description of the present invention, the invention has been disclosed with reference to specific embodiments thereof. It will, however, be evident that various modifications and changes may be made to the specific embodiments of the present invention without departing from the broader spirit and scope of the invention as set forth in the appended claims. Accordingly, the description of the present invention in this document is to be regarded in an illustrative, rather than restrictive, sense.

Claims

1. A core unit of a heat exchanger, said core comprising:

a plurality of parallel flat tubes (6);
a plurality of corrugated fins (7) each of which is disposed between adjacent two of the flat tubes (6);
a support member (100) disposed at a portion of said core unit between two of said corrugated fins (7); and
an electric heater (9) disposed inside said support member (100), wherein

said support member (100) comprises a pair of parallel plates (10, 11) bonded to said corrugated fins (7) at the summit of corrugation, and

said electric heater (9) comprises a heating element (9a) and an insulation member (9d) inserted between said heating element (9a) and said parallel plates (10, 11).

2. A core unit as claimed in claim 1, wherein

said flat tubes (6), said corrugated fins (7) and said support plates (10, 11) are made of aluminum and soldered with each other.

3. A core unit as claimed in claim 1, wherein
said electric heater (9) further comprises a plus electrode (9b), a minus electrode (9c) and an insulating cover surrounding said two electrodes, and
said electric heater (9) is inserted between said two support plates (10, 11).

4. A core unit as claimed in claim 3, wherein
each of said plus electrode (9b) and said minus electrode (9c) has a connecting terminal integrally formed thereon.

5. A core unit as claimed in claim 4, wherein
each of said connecting terminals projects from corresponding one of said plus electrode (9b) and said minus electrode (9c) in a direction of thickness of said heat exchanger core.

6. A core unit as claimed in claim 4 further comprising means (12, 13) for holding said electric heater (9) under pressure between said two support plates (10, 11).

7. A core unit of a heat exchanger having an air inlet side and an air outlet side, said core comprising:

a plurality of parallelly disposed flat tubes (6) which conduct heat carrier;
a plurality of corrugated fins (7) each of which is disposed between two of the corrugated fins (7);
a support member (100) having a pair of plates (10, 11) parallelly extending along said flat tubes (6), an opening end portion (10b) and a U-shaped closing end portion (10a), said support member (100) disposed between summits of corrugation of adjacent two of said corrugated fins (7), said U-shaped closing end portion (10a) is disposed at said air inlet side, each of said plates (10, 11) being bonded to one of said corrugated fins (7) at summits of corrugation; and
an electric heater (9) disposed between said support plates (10, 11) and insulated from said support member (100).

8. A core unit as claimed in claim 7, wherein
said opening end portion (10b) projects from an end of said electric heater (9).

9. A core unit as claimed in claim 7, wherein
said opening end portion (10b) spreads in a skirt-shape.

10. A core unit as claimed in claim 7, wherein
said support member (100) has the same thickness as said core unit in the air flow direction, and
said electric heater (9) has smaller thickness in the direction of core thickness than said support member (100), and
said support member (100) comprises means (10e, 10f) for positioning said electric heater (9) therein.

11. A core unit as claimed in claim 10, wherein
said means (10e, 10f) for positioning comprises a stopper projecting inside from at least one of said two plates (10, 11).

12. A heat exchanger for a heater as claimed in claim 11, wherein
one of said plates (10, 11) has a reinforcement rib disposed between said stopper and said closing end portion (10a).

13. A core unit as claimed in claim 11, wherein
said means (10e, 10f) for positioning comprises a stopper member disposed between said electric heater (9) and said closing end portion (10a).

14. A core unit as claimed in any one of claim 7, wherein
each of said flat tubes (6), corrugated fins (7) and support member (100) is made of aluminum and soldered to each other.

15. A core unit as claimed in claim 7, wherein
said electric heater (9) comprises a plus electrode (9b), a minus electrode (9c), a heating element (9a) disposed between said two electrodes, and an insulating cover member (9d) covering said two electrodes, and
said cover member (9d) is pressed fitted between said plates (10, 11) to hold said electric heater (9) therein.

16. A core unit as claimed in claim 15, wherein
each of said plus electrode (9b) and said minus electrode (9c) has a connecting terminals (9e, 9f) projecting therefrom.

17. A core unit as claimed in claim 7 further comprising

a fastening member (12, 13), disposed on said air outlet side of said core unit, said for holding said electric heater (9) in said support member (100).

18. A core unit of a heat exchanger, said core unit comprising:

a plurality of parallelly disposed flat tubes (6) which conduct heat carrier;
a plurality of corrugated fins (7) having summits of corrugation disposed between two of said flat tubes (6); and
an electric heater (9) disposed between two of said summits of corrugation instead of one of said flat tubes (6), said electric heater (9) having a positive temperature characteristic sharply changing resistance thereof at a set temperature, wherein
said electric heater (9) with said set temperature heats portions of said fins (7) adjacent to said flat tubes (6) at a temperature equal to temperature of water in said flat tubes (6) if said water temperature is equal to or higher than 60 °C and temperature of air to be heated is equal to or lower than 0 °C.

19. A core unit of a heat exchanger comprising:

a plurality of parallelly disposed flat tubes (6) which conduct heat carrier;
a plurality of corrugated fins (7) each of which is disposed between two of said flat tubes (6);
an electric heater (9) disposed at a portion of said core unit (3) instead of said flat tubes (6), said electric heater (9) having a positive temperature characteristic sharply changing resistance thereof at a set temperature, wherein
said fins has summits of corrugation disposed between two of said flat tubes (6) which has a height between 3.9 mm and 5 mm, and
said set temperature of said electric heater (9) is between 85 °C and 110 °C.

20. A core unit as claimed in claim 18, wherein
said core unit is made of aluminum alloy,
said electric heater (9) is a three-layered sandwich structure composed of an electric heater element (9a) and two flat electrodes (9b, 9c) on opposite sides of said electric heater element (9a) and is inserted between said corrugated fins (7) and said two electrodes, and
said two electrodes are press-fitted to said summits of the corrugation.

21. A core unit as claimed in claim 1, wherein
said heater element (9a) has a positive temperature characteristic sharply changing resistance thereof at a set temperature which is between 120 and 170.

22. A method of manufacturing a core unit of a heat exchanger composed of a plurality of parallelly disposed flat tubes (6), corrugated fins (7) having summits of corrugation, a pair of support plates (10, 11) and an electric heater (9), said method comprising steps of:

stacking said flat tubes (6) and said corrugated fins (7) alternately, and placing said pair of support plates (10, 11) between said summits of corrugation at a portion where said electric heater (9) is to be disposed;
soldering said flat tubes (6), said corrugated fins (7) and said support plates (10, 11) into a unit; and
inserting said electric heater (9) between said two plates (10, 11).

FIG. 1

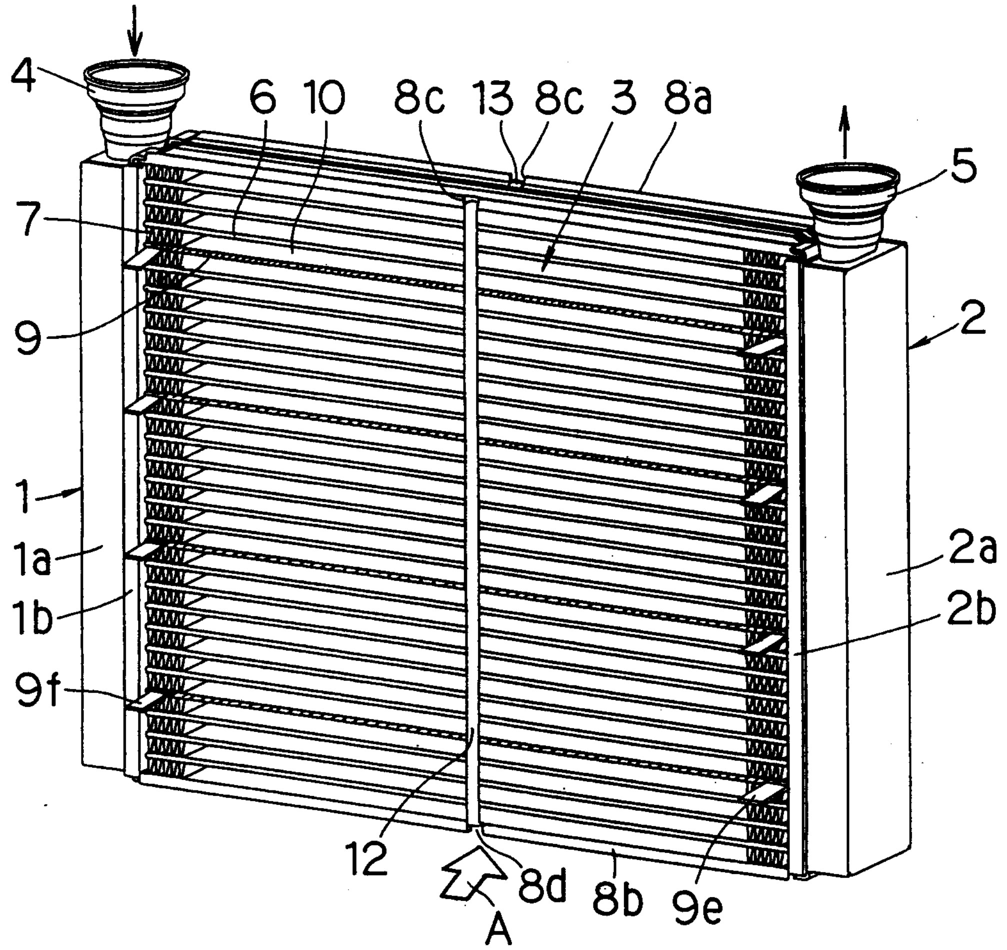

4
6
10
8c
13
8c
3
8a
5
7
9
2
1
1a
2a
1b
2b
9f
12
8d
8b
9e
A

FIG. 2

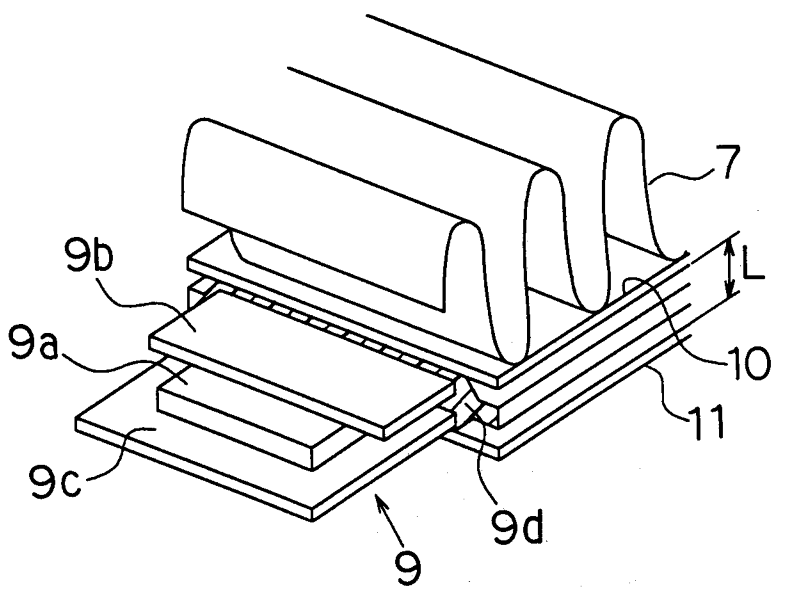

7
L
9b
9a
10
11
9c
9d
9

FIG.3A

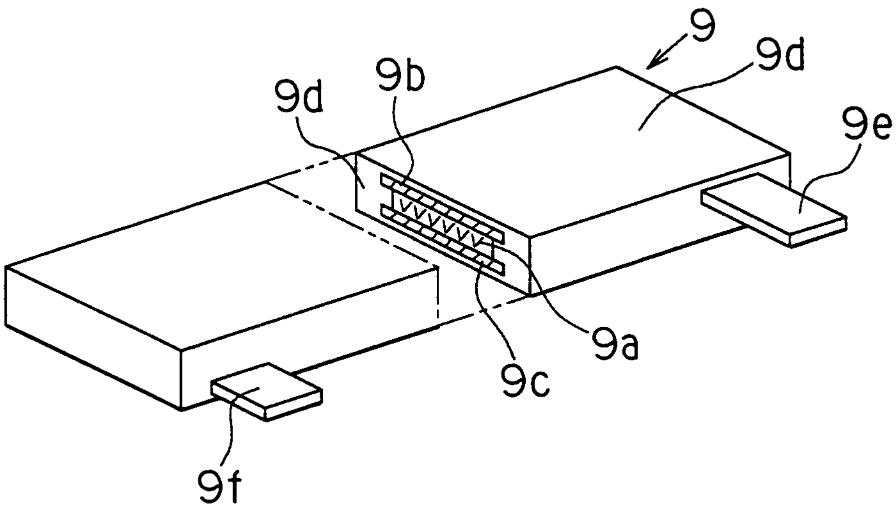


FIG.3B

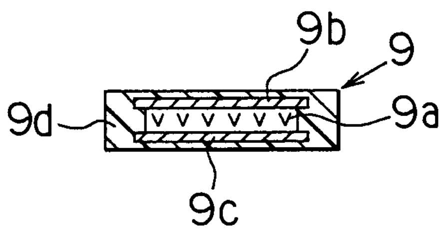


FIG.3C

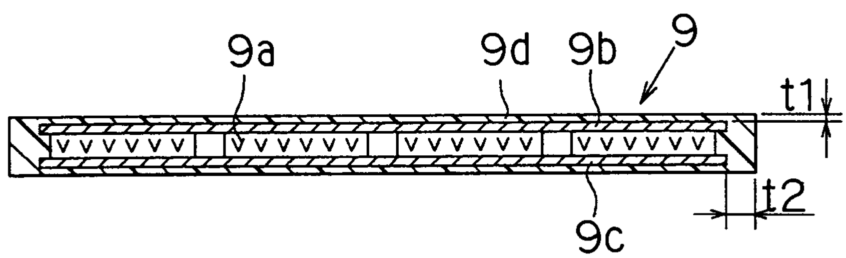


FIG.3D

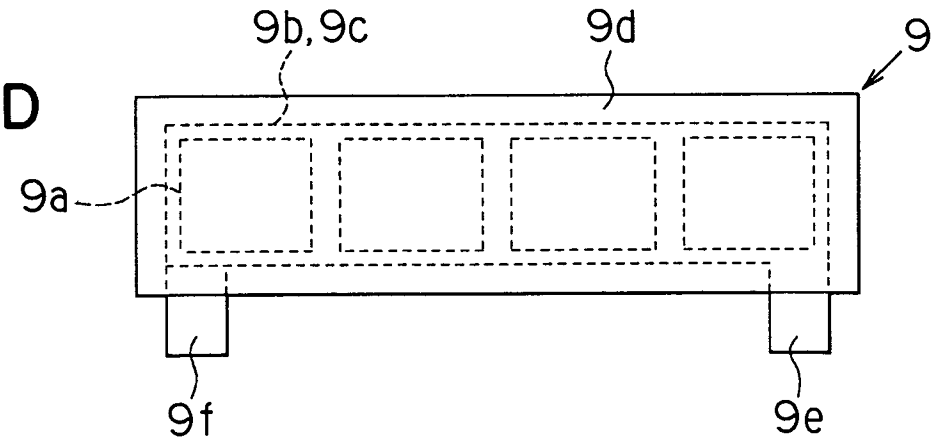


FIG. 4

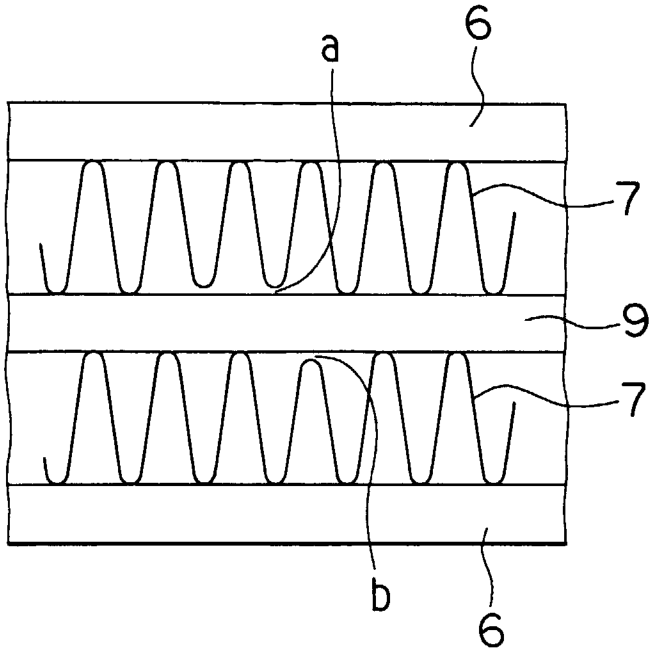


FIG. 5

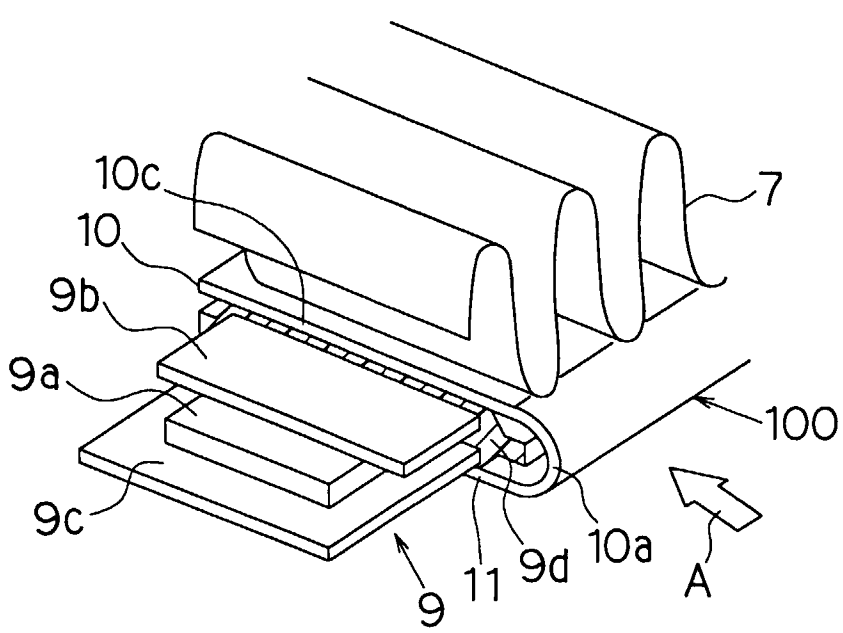


FIG. 6

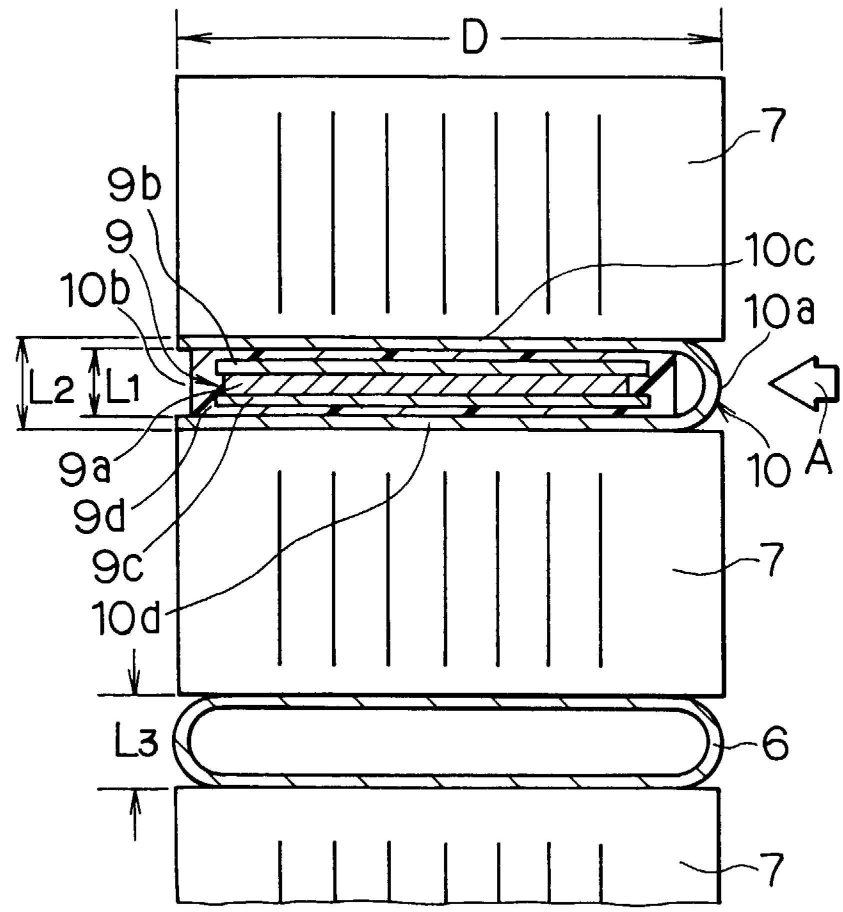


FIG. 7

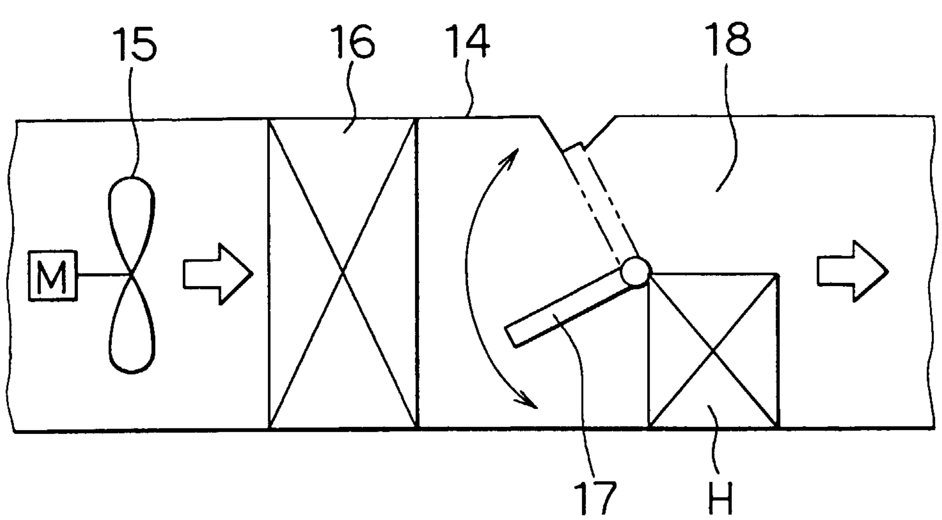


FIG. 8

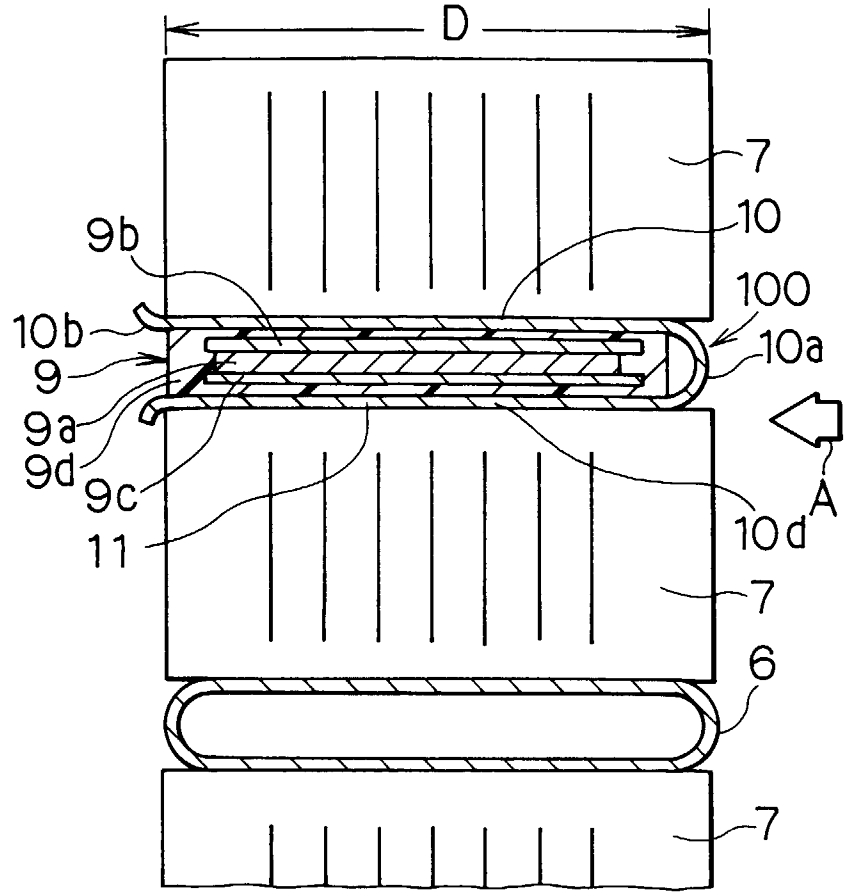

D
7
10
9b
100
10b
10a
9
9a
9d
9c
11
10d
A
7
6
7

FIG. 10

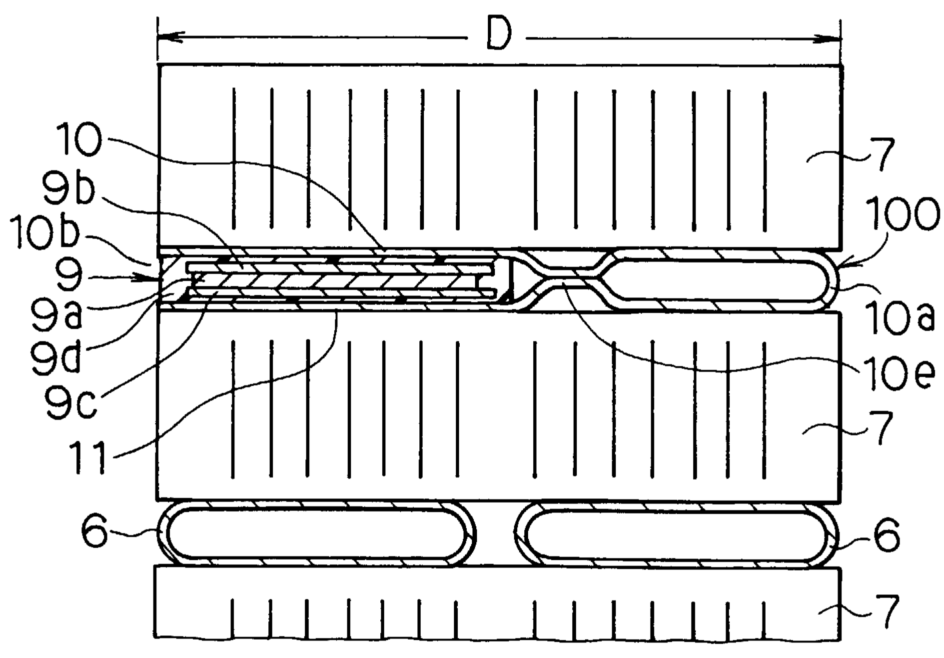

D
10
7
9b
100
10b
9
9a
10a
9d
10e
9c
7
11
6
6
7

FIG. 9

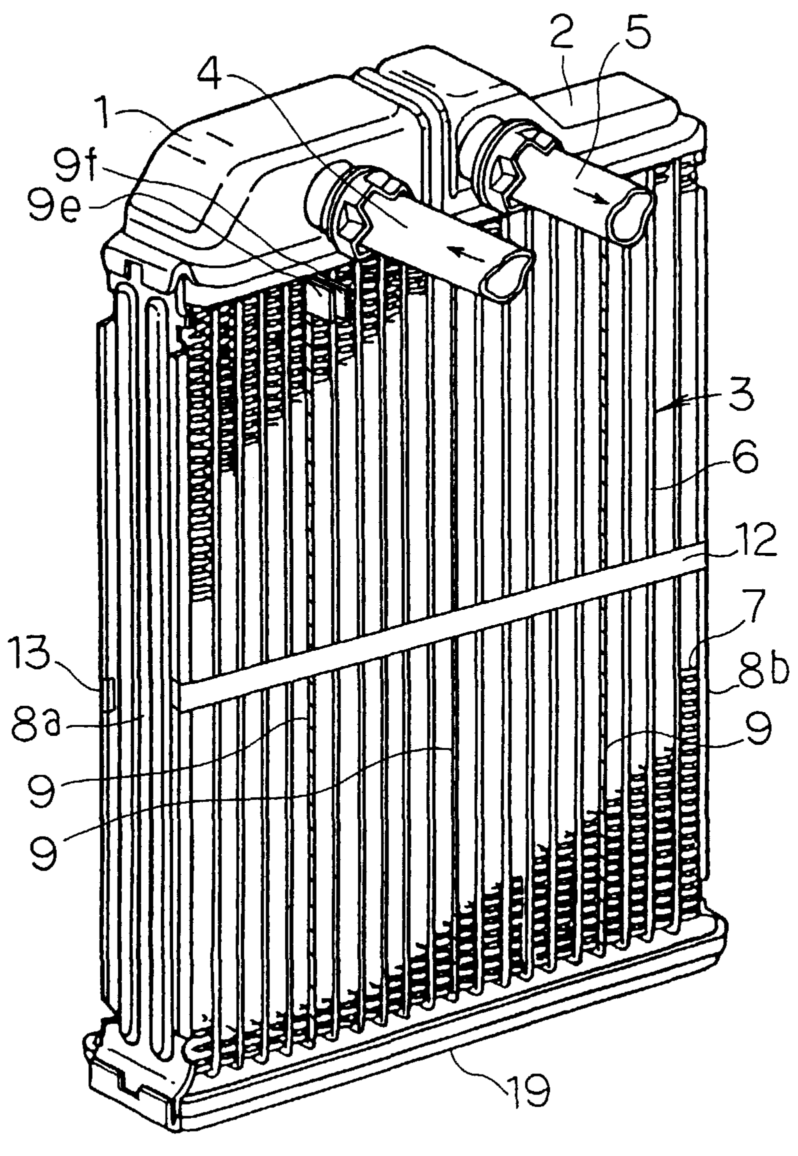


FIG. 11

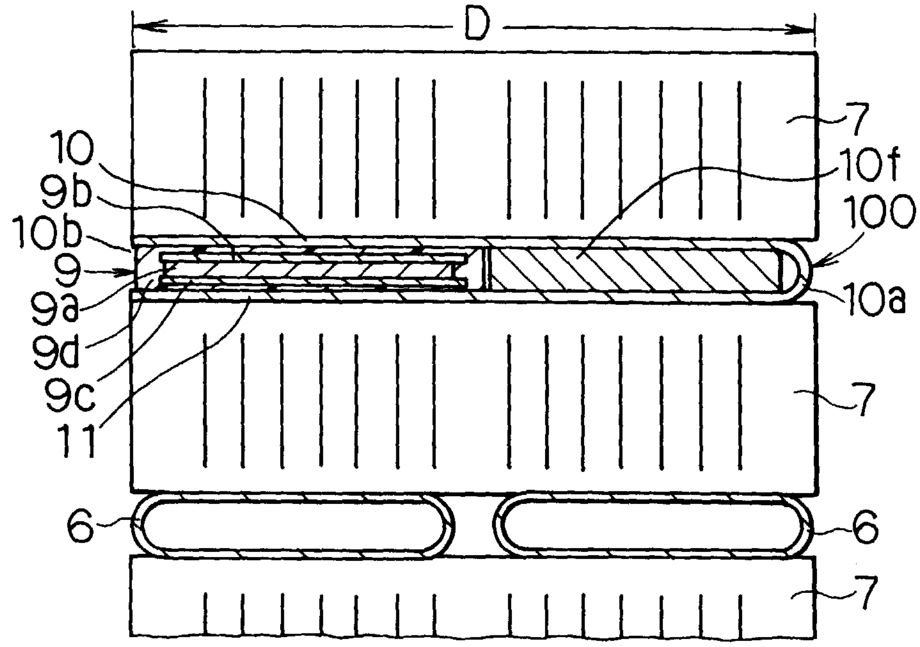

D
7
10
9b
10b
9
9a
9d
9c
11
10f
100
10a
7
6
6
7

FIG. 12

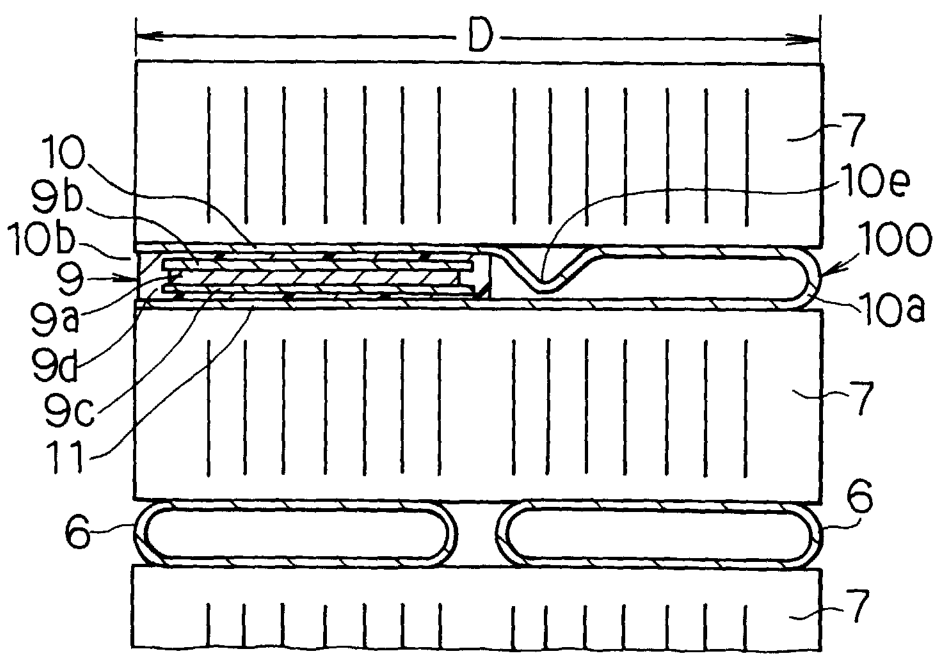

D
7
10
9b
10b
9
9a
9d
9c
11
10e
100
10a
7
6
6
7

FIG. 13

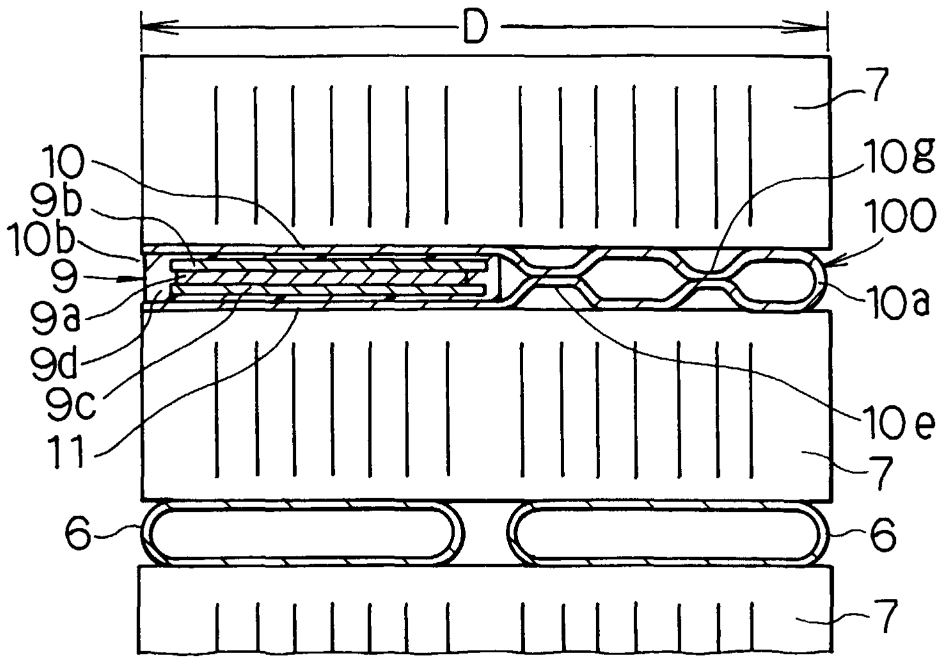

D
7
10
9b
10b
9
9a
9d
9c
11
10g
100
10a
10e
7
6
6
7

FIG. 14

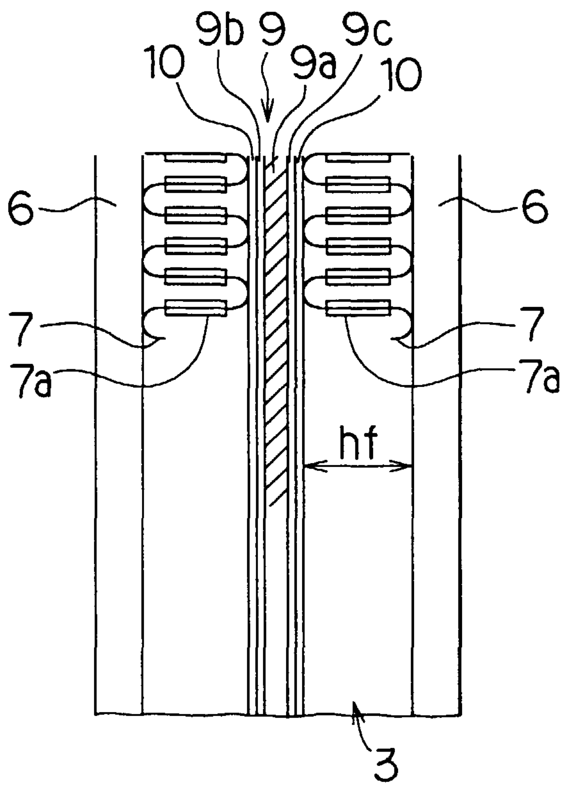

10
9b
9
9a
9c
10
6
6
7
7a
7
7a
hf
3

FIG. 15

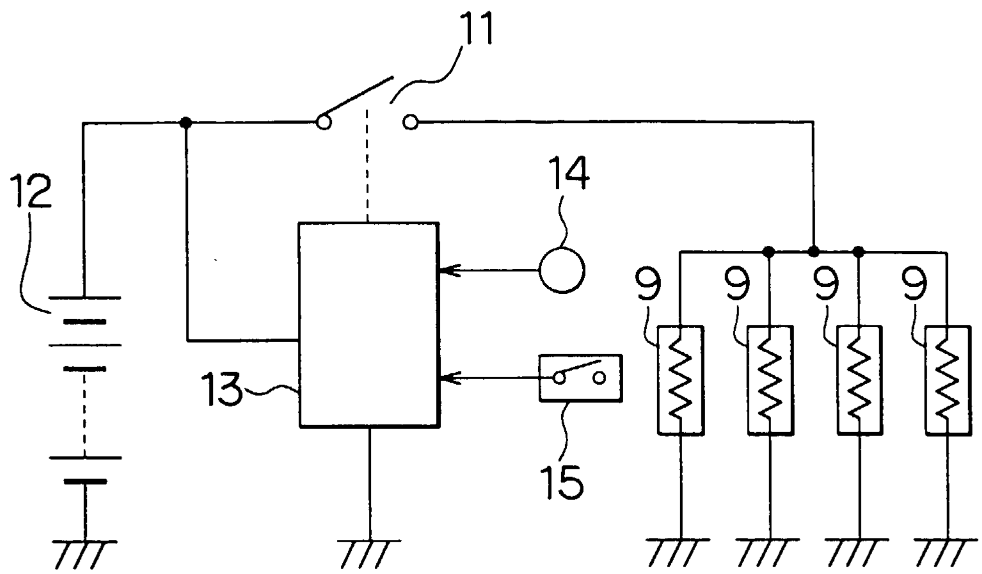


FIG. 16

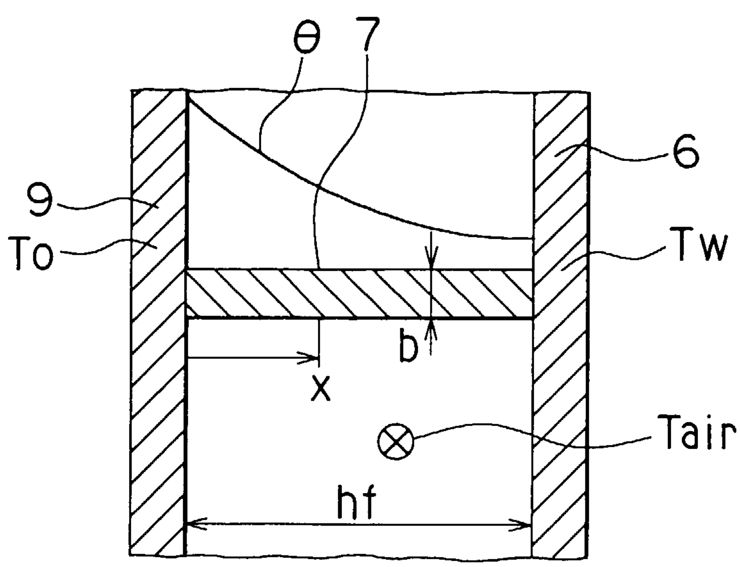


FIG. 17

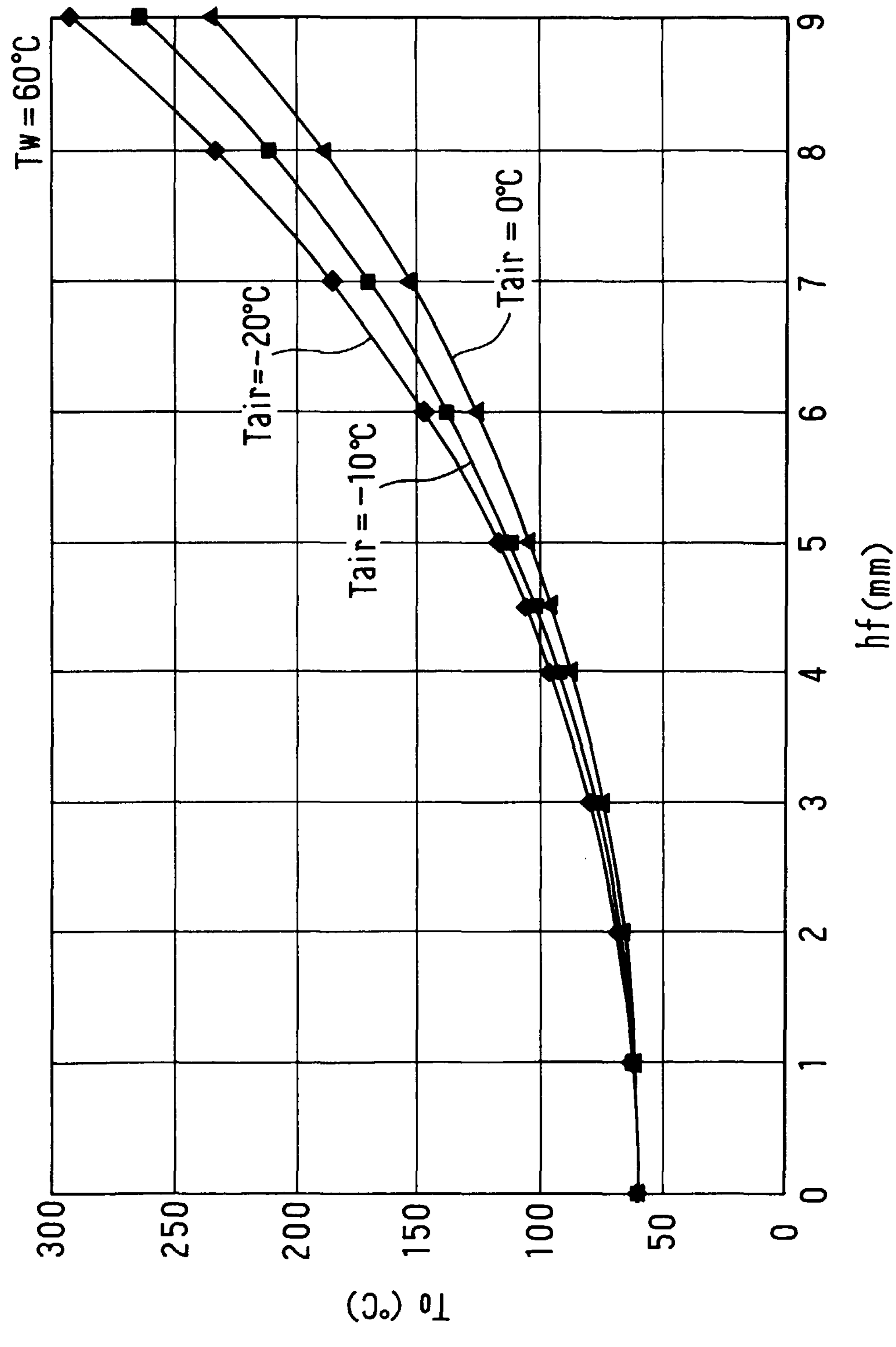

Tw = 60°C
Tair = -20°C
Tair = -10°C
Tair = 0°C
To (°C)
hf (mm)
0
50
100
150
200
250
300
0
1
2
3
4
5
6
7
8
9

FIG.18

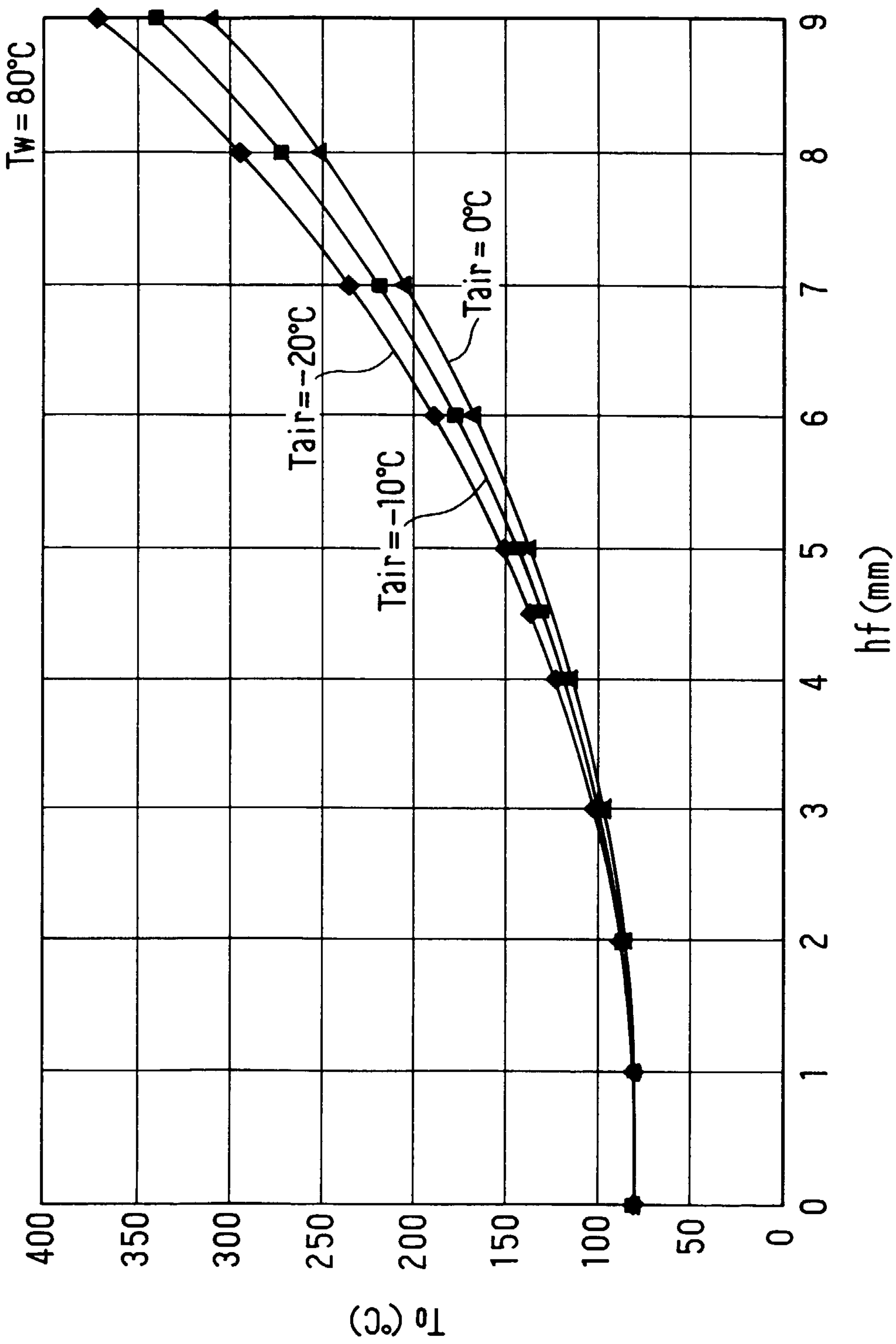

Tw = 80°C
Tair = 0°C
Tair = -20°C
Tair = -10°C
T_0 (°C)
hf (mm)
0
50
100
150
200
250
300
350
400
0
1
2
3
4
5
6
7
8
9

FIG. 19

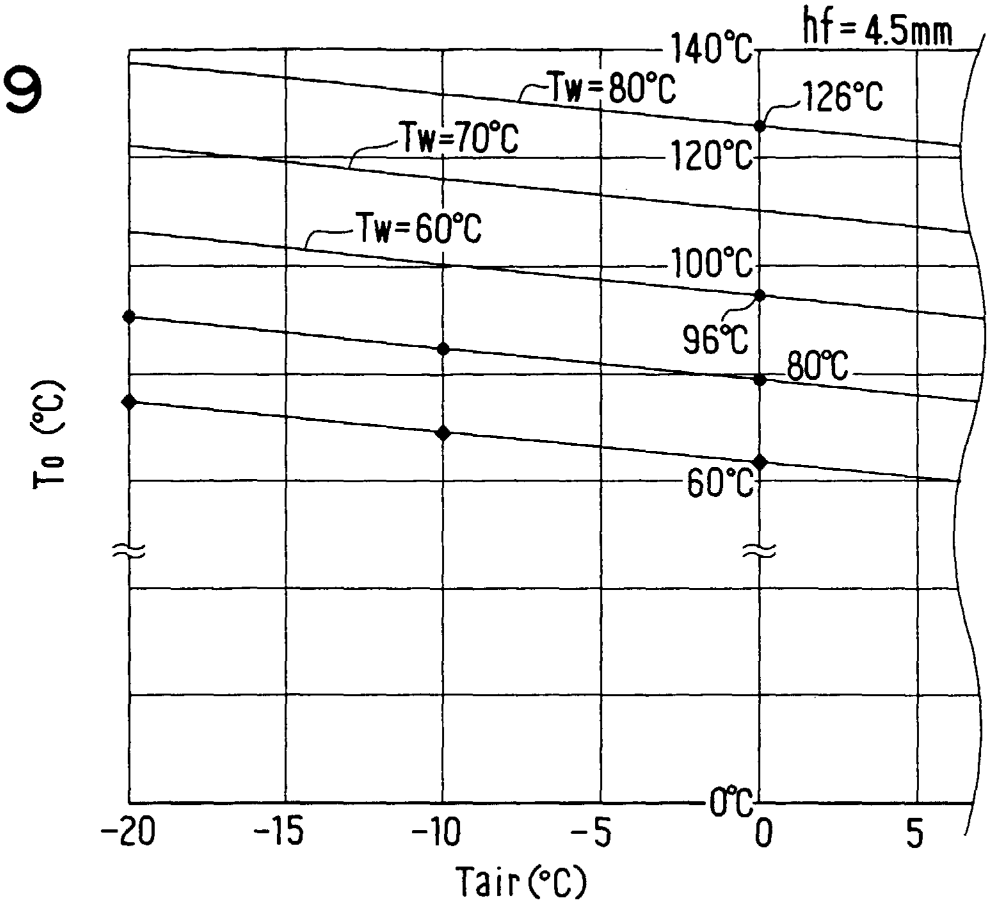

hf=4.5mm
140°C
Tw=80°C
126°C
Tw=70°C
120°C
Tw=60°C
100°C
96°C
80°C
60°C
0°C
To (°C)
-20
-15
-10
-5
0
5
Tair (°C)

FIG. 20

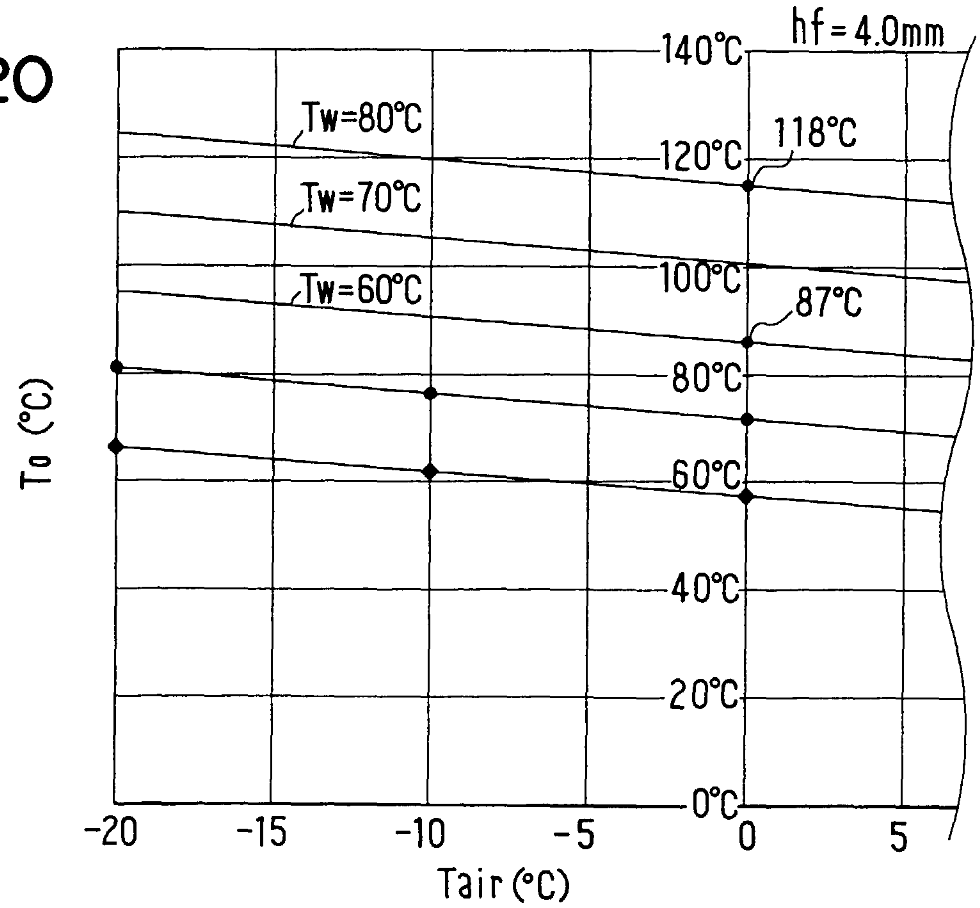
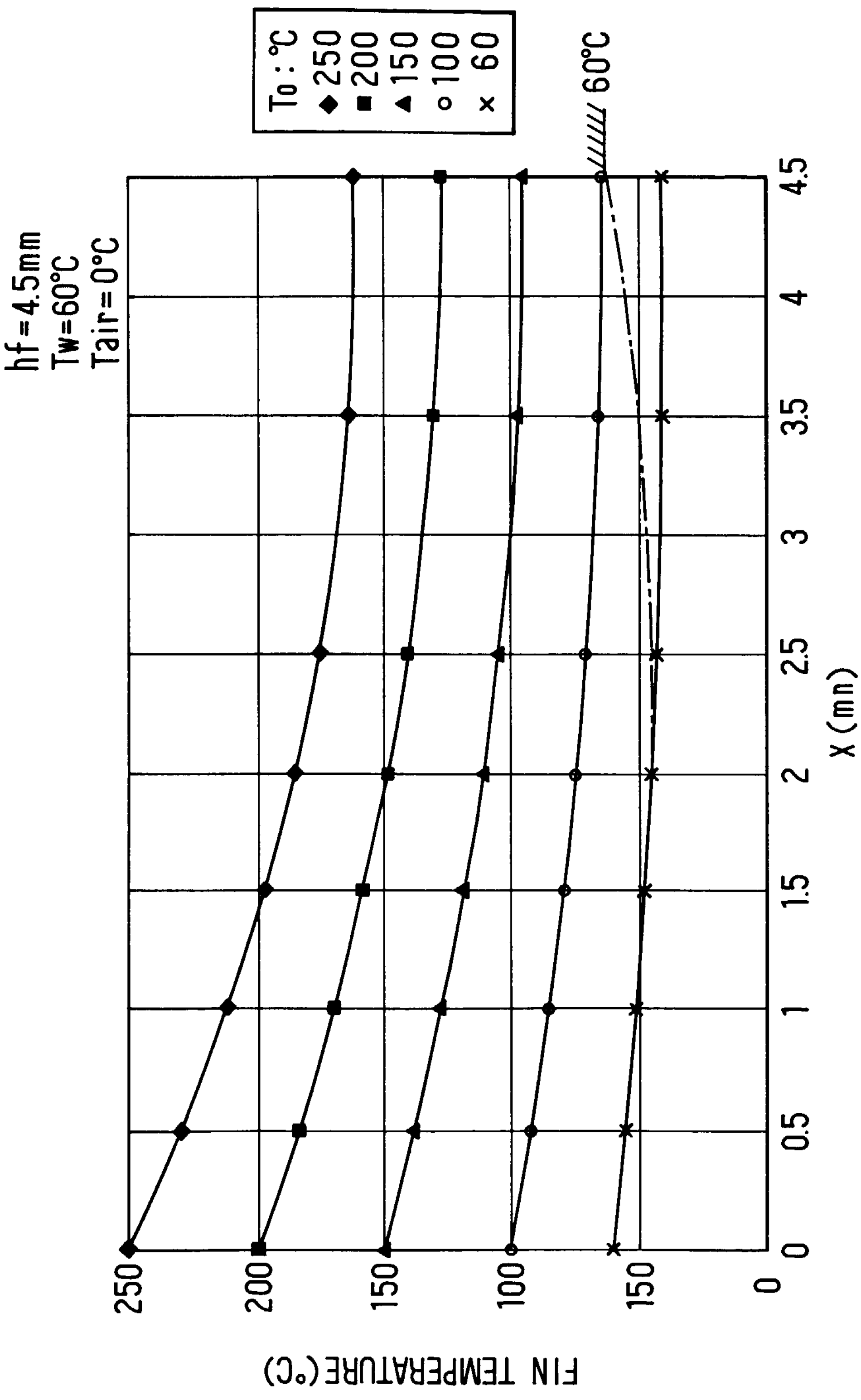

hf=4.0mm
140°C
Tw=80°C
118°C
120°C
Tw=70°C
100°C
Tw=60°C
87°C
80°C
60°C
40°C
20°C
0°C
To (°C)
-20
-15
-10
-5
0
5
Tair (°C)

FIG. 21


hf=4.5mm
Tw=60°C
Tair=0°C
To : °C
◆ 250
■ 200
▲ 150
○ 100
× 60
60°C
FIN TEMPERATURE (°C)
250
200
150
100
150
0
X (mm)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5