



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
16.03.2005 Bulletin 2005/11

(51) Int Cl.7: **H05B 3/14**, H05B 3/50,
F24H 3/04

(21) Application number: **04021604.6**

(22) Date of filing: **10.09.2004**

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IT LI LU MC NL PL PT RO SE SI SK TR**
Designated Extension States:
AL HR LT LV MK

(30) Priority: **10.09.2003 JP 2003318830**
10.09.2003 JP 2003318828
10.09.2003 JP 2003318831
10.09.2003 JP 2003318832
30.06.2004 JP 2004193538
30.06.2004 JP 2004193537

(71) Applicant: **Denso Corporation**
Kariya-city, Aichi-pref., 448-8661 (JP)

(72) Inventors:
• **Morikawi, Junji, c/o Denso Corp.**
Kariya-city, Aichi-pref. 448-8661 (JP)
• **Oya, Yasuhiro, c/o Denso Corp.**
Kariya-city, Aichi-pref. 448-8661 (JP)
• **Akiyama, Yoshinori, c/o Denso Corp.**
Kariya-city, Aichi-pref. 448-8661 (JP)

(74) Representative: **Vollnhals, Aurel**
Tiedtke-Bühling-Kinne & Partner (GbR),
TBK-Patent,
Bavariaring 4
80336 München (DE)

(54) **High manufacturable and high performance structure of electric heater**

(57) A highly manufacturable and high performance structure of an electric heater is provided which includes a heater assembly, retainer frames, and spring clampers. The retainer frames are placed on an upper and a lower end surfaces of the heater assembly. The spring

clampers are fitted in the retainer frames to produce compression pressures which clamp the heater assembly firmly to complete the structure of the electric heater. The use of the spring clamber facilitate ease of assembling of the electric heater without sacrificing the performance of the electric heater.

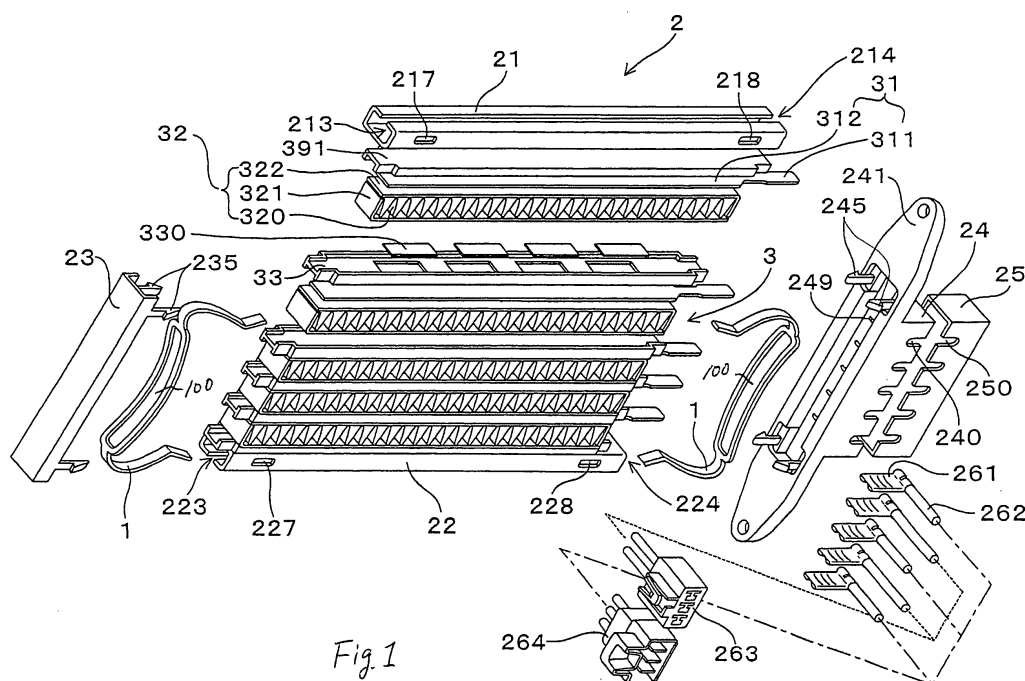


Fig. 1

Description

BACKGROUND OF THE INVENTION

1 Technical Field of the Invention

[0001] The present invention relates generally to an improved structure of an electric heater equipped with heating elements such as thermistors of a positive temperature coefficient type, and more particularly to such an electric heater which is high in manufacturability and performance.

2 Background Art

[0002] Fig. 44 illustrates a conventional structure of an electric heater. For example, Japanese Patent No. 3274234 and Japanese Patent Second Publication No. 8-8391 disclose similar heater structures for a radiator.

[0003] The electric heater 9 consists essentially of first and second retainer frames 91 and 92, side retainer frames 93 and 94, and a heater assembly 95 retained by the frames 91, 92, 93, and 94.

[0004] The heater assembly 95 is made up of radiator fin assemblies 951, electric heating elements 952, and electrode plates 953 which are laid to overlap each other in an illustrated manner. The first and second retainer frames 91 and 92 extend in a lateral direction of the heater assembly 95. The side retainer frames 93 and 94 extend in a vertical direction of the heater assembly 95.

[0005] Spring strips 910 and 920 are disposed between the first retainer frame 91 and an upper surface of the heater assembly 95 and between the second retainer frame 92 and a lower surface of the heater assembly 95 to produce spring pressures which act on the heater assembly 95 in a vertical direction.

[0006] In assembling of the electric heater 9, the first and second side retainer frames 93 and 94 are pressed against the heater assembly 95 to deform the spring strips 910 and 920 elastically. Next, the side retainer frames 93 and 94 are joined to the first and second retainer frames 91 and 92 firmly to exert spring pressures produced by the spring strips 910 and 920 on the heater assembly 95 constantly, thereby clamping the radiator fin assemblies 951, the heating elements 952, and the electrode plates 953 vertically in surface-to-surface abutment with each other.

[0007] In operation, the electric power is supplied to the heating elements 952 through the electrode plates 953 to produce thermal energy which is, in turn, transmitted to the radiator fin assemblies 951, so that a medium such as air flowing through the radiator fin assemblies 951 is heated. It is, thus, advisable that the radiator fin assemblies 951, the heating elements 952, and the electrode plates 953 be placed in close contact with each other in terms of the thermal transfer therebetween. The electric heater 9 is designed to enhance such thermal transfer by means of the spring strips 910

and 920 which clasp the radiator fin assemblies 951, the heating elements 952, and the electrode plates 953 together.

[0008] The assembling of the radiator fin assemblies 951, the heating elements 952, and the electrode plates 953 is, as described above, accomplished with the spring pressures produced by the spring strips 910 and 920 with the aid of the frames 91 to 94. This structure, however, is low in assemblability of the heater assembly 95, thus resulting in decrease in manufacturability of the electric heater 9. This also leads to a decrease in performance of the electric heater 9.

[0009] Specifically, the first and second retainer frames 91 and 92 are placed on the upper and lower ends of the heater assembly 95 and then clamped inwardly of the heater assembly 95 using some sort of a press. In order to retain the shape of this clamped assembly, it must be held in a direction perpendicular to the drawing using some clasper. Subsequently, the side retainer frames 93 and 94 are fitted on the ends of the first and second retainer frames 91 and 92 while keeping the components of the assembly close to each other and deforming the spring strips 910 and 920 to a certain degree.

[0010] Heater, radiators, heat exchangers in which the side retainer frames 93 and 94 are made of a flexible resin material have been proposed in terms of lightweight of the structure. Such a resin material has the problem in that a drop in rigidity thereof results from creeping at higher ambient temperatures.

SUMMARY OF THE INVENTION

[0011] It is therefore a principal object of the invention to avoid the disadvantages of the prior art.

[0012] It is another object of the invention to provide a highly manufacturable and high performance structure of an electric heater.

[0013] According to one aspect of the invention, there is provided an electric heater designed to heat, for example, air. The heater comprises: (a) a heater assembly made up of a fin radiator, an electric heating element, and an electrode plate for supplying electric power to the heating element which are laid to overlap each other in a first direction, the heater assembly having first ends opposed to each other in the first direction and second ends opposed to each other in a second direction substantially perpendicular to the first direction, the heater assembly also having a first and a second major surface which are opposed to each other in a thickness-wise direction thereof and through which a medium to be heated passes the fin radiators; (b) a first and a second retainer frames placed on the first ends of the heater assembly, respectively; and (c) a metallic clamping member jointed to the first and second retainer frames, respectively, to produce a compression pressure acting on the first and second retainer frames to clamp the fin radiator, the heating element, the electrode plate, and

the first and second retainer frames together in the first direction.

[0014] The heating element is activated by the electric power supplied through the electrode plate. The thermal energy produced by the heating element is transmitted to the fin radiator through the electrode plate and to the medium (e.g., air) to be heated. Thus, the greater areas of contacts between the heating element and the electrode plate and between the fin radiator and the electrode plate, the more effectively the thermal energy will be conducted to the medium. This is accomplished in the above structure of the electric heater by holding the fin radiator, the heating element, the electrode plate, and the first and second retainer frames together close to each other using the metallic clamping member.

[0015] The use of the clamping member facilitates ease of assembling of the electric heater, thus resulting in an improved manufacturability thereof.

[0016] In the preferred mode of the invention, the metallic clamping member is made up of C-shaped frames each of which consists of a support strip and a first and a second clamping arms extending from ends of the support strip in opposite directions. The support strips is placed on the second ends of the heater assembly. The first clamping arms is fitted in the first retainer frame, while the second clamping arms is fitted in the second retainer frame.

[0017] Each of the first and second retainer frames is made of a hollow strip member having open ends oriented to the second ends of the heater assembly. The first and second clamping arms are fitted at ends thereof into the open ends of the first and second retainer frames.

[0018] Each of the first and second clamping arms is made up of a base portion continuing from the support strip, an end portion extending from the base portion, and a V-shaped bend which has ends connecting with the base portion and the end portion, respectively, in a lengthwise direction of the first ends of the heater assembly. The V-shaped bend has a bottom edge oriented inward of the heater assembly. The first and clamping second arms are fitted in the first and second retainer frames in abutment of the bottom edges with the first and second retainer frames to produce the compression pressure. The formation of the V-shaped bends results in an increased interval between the tips of the end portions of the first and second clamping arms, thus facilitating fitting of the first and second clamping arms into the first and second retainer frames.

[0019] The support strips of the clamping member may alternatively be placed on the first major surface of the heater assembly. The first clamping arms may be fitted in the first retainer frame, while the second clamping arms may be fitted in the second retainer frame.

[0020] The metallic clamping member may alternatively be made of a closed-loop strip which extends to encompass the first and second major surfaces of the heater assembly.

[0021] Each of the first and second retainer frames may have an opening oriented toward the first major surface of the heater assembly. The closed-loop strip may alternatively be designed to be fitted into the openings of the first and second retainer frames to produce the compression pressure.

[0022] The closed-loop strip may alternatively be designed to extend over the first and second major surfaces of the heater assembly through the first and second retainer frames to produce the compression pressure.

[0023] The metallic clamping member may be made of one of a tool steel and a spring steel.

[0024] Each of the first and second retainer frames may be made of a hollow strip member which has openings oriented to the second ends of the heater assembly. The metallic clamping member may be made up of a first and a second clamping arm each of which has a first and a second clamping arms fitted into the openings of the first and second retainer frames and which are placed on the second ends of the heater assembly to serve as side frames. The first and second clamping arms and/or the first and second retainer frames have engagement portions which establish firm engagement between the first clamping arm and the first retainer frame and between the second clamping arm and the second retainer frame. This results in a simplified structure of the electric heater which is easy to assemble.

[0025] Each of the first and second clamping arms may be made up of a base portion, an end portion extending from the base portion, and a V-shaped bend which has ends connecting with the base portion and the end portion, respectively, in the lengthwise direction of the first ends of the heater assembly. The V-shaped bend has a bottom edge oriented inward of the heater assembly. The V-shaped bends of the first and second clamping arms establish the firm engagement with the engagement portions provided on the first and second retainer frames.

[0026] The engagement portions may be implemented by protrusions form on inner surfaces of the first and second retainer frames.

[0027] The engagement portions may alternatively be implemented by slits form in inner surfaces of the first and second retainer frames.

[0028] Each of the first and second clamping arms may be made up of a base portion, an end portion extending from the base portion, and a V-shaped bend which has ends connecting with the base portion and the end portion, respectively, in the lengthwise direction of the first ends of the heater assembly. The V-shaped bend has a bottom edge oriented inward of the heater assembly. The engagement portions may be implemented by protrusions which are formed on the first and second clamping arms and oriented toward inner surfaces of the first and second retainer frames.

[0029] The metallic clamping member may be made of first and second clamping arms each of which has a support portion and a first and a second clamping arms extend-

ing from ends of the support portion. The support portion is placed on the second ends of the heater assembly to serve as side frames. Each of the first and second clampers engage the heater assembly to define detent mechanisms which work to lock movement of the heater assembly in the thickness-wise direction thereof.

[0030] The detent mechanisms may be provided by openings formed in the first and second clampers which extend along the second ends of the heater assembly and in which portions of the heater assembly are fitted.

[0031] The heater assembly may also include a retainer which includes a body in which the heating element is retained and extensions continuing from the body. The extensions has a width smaller than that of the body and is fitted within the openings of the first and second clampers.

[0032] The retainer of the heater assembly may have cuts in which the first and second clampers are fitted to define the detent mechanisms to lock the movement of the heater assembly in the thickness-wise direction thereof.

[0033] The first and second clampers may be made of an elastic metallic member.

[0034] The heater assembly may also include an insulating heater element retainer on which the heating element is retained. The electrode plate has a connector terminal which protrudes from one of the second ends of the heater assembly. The clamping member is made up of a first and a second clamber placed on the second ends of the heater assembly to serve as side frames. The insulating heater element retainer includes a heating element retaining portion in which the heating element is retained and a terminal retaining portion in which the connector terminal of the electrode plate is retained. The terminal retaining portion is made up of a bottom wall and a pair of insulating walls extending from the bottom wall in the first direction of the heater assembly to define an insulating retainer groove within which the connector terminal is retained inside the insulating walls. One of the first and second clampers works to hold the terminal retaining portion in abutment with the insulating walls. The insulating walls are placed between the connector terminal and the one of the first and second clampers to insulate the connector terminal electrically from the one of the first and second clampers.

[0035] The heating element retaining portion may be made up of a bottom wall and a pair of walls extending from the bottom wall in the first direction to define an insulating retainer within which one of the fin radiator and the electrode plate is retained.

[0036] The heater assembly may include an insulating heater element retainer on which the heating element is retained. The insulating heater element retainer has a groove formed in a surface thereof oriented to the first direction within which the electrode plate is retained and a cut formed in an end thereof in which the clamping member is fitted. The electrode plate has a connector

terminal projecting from the insulating heater element retainer on a side of the first major surface of the heater assembly. The insulating heater element retainer works to insulate electrically between the electrode plate and the clamping member.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037] The present invention will be understood more fully from the detailed description given hereinbelow and from the accompanying drawings of the preferred embodiments of the invention, which, however, should not be taken to limit the invention to the specific embodiments but are for the purpose of explanation and understanding only.

[0038] In the drawings:

Fig. 1 is an exploded perspective view which shows an electric heater according to the first embodiment of the invention;

Fig. 2 is a front view of the electric heater, as illustrated in Fig. 1;

Fig. 3 is a perspective view which shows a heater assembly of the electric heater of Fig. 1;

Fig. 4 is a perspective view which shows a spring clamber which clamps the heater assembly of Fig. 3;

Fig. 5(a) is an illustration which shows a left side spring clamber expanded for installation in retainer frames;

Fig. 5(b) is an illustration which shows a step of inserting the spring clamber of Fig. 5(a);

Fig. 5(c) is an illustration which shows the spring clamber of Figs. 5(a) and 5(b) after fitted in retainer frames;

Fig. 6(a) is an illustration which shows a right side spring clamber expanded for installation in retainer frames;

Fig. 6(b) is an illustration which shows a step of inserting the spring clamber of Fig. 6(a);

Fig. 6(c) is an illustration which shows the spring clamber of Figs. 6(a) and 6(b) after fitted in retainer frames;

Fig. 7 is a perspective view which shows a retainer plate on which heating elements are retained;

Fig. 8 is a partial view which shows an end portion of the retainer plate of Fig. 7;

Fig. 9 is a sectional view, as taken along the lines A-A in Fig. 8;

Fig. 10 is a front view of the electric heater according to the second embodiment of the invention;

Fig. 11 is partially sectional view which shows a spring clamber fitted within a retainer frame in the second embodiment;

Fig. 12 is a partially exploded perspective view which shows a retainer frame and a heater assembly in the second embodiment;

Fig. 13 is a partially perspective view which shows

how to fit a spring clasper into a retainer frame;
 Fig. 14 is a front view which shows a modification
 of a spring clasper fitted in retainer frames;
 Fig. 15(a) is a front view which shows an electric
 heater on which spring claspers are installed ac-
 cording to the third embodiment of the invention;
 Fig. 15(b) is a side view of Fig. 15(a);
 Fig. 16(a) is a front view which shows an electric
 heater on which spring claspers are installed ac-
 cording to the fourth embodiment of the invention;
 Fig. 16(b) is a side view of Fig. 16(a);
 Fig. 17(a) is a partially vertical sectional view which
 shows a first modification of an internal structure of
 a first retainer frame;
 Fig. 17(b) is a partially plan view which shows an
 inside wall of the first retainer frame of Fig. 17(a);
 Fig. 18(a) is a partially vertical sectional view which
 shows a second modification of an internal structure
 of a first retainer frame;
 Fig. 18(b) is a partially plan view which shows an
 inside wall of the first retainer frame of Fig. 18(a);
 Fig. 19(a) is a partially vertical sectional view which
 shows a third modification of an internal structure
 of a first retainer frame;
 Fig. 19(b) is a partially plan view which shows an
 inside wall of the first retainer frame of Fig. 19(a);
 Fig. 20 is a partially vertical sectional view which
 shows a first modification of a clamping arm of a
 spring clasper;
 Fig. 21 is a partially vertical sectional view which
 shows a second modification of a clamping arm of
 a spring clasper;
 Fig. 22(a) is an illustration which shows a right side
 spring clasper expanded for installation in retainer
 frames;
 Fig. 22(b) is an illustration which shows a step of
 inserting the spring clasper of Fig. 22(a);
 Fig. 22(c) is an illustration which shows the spring
 clasper of Figs. 22(a) and 22(b) after fitted in re-
 tainer frames;
 Fig. 23 is a partially plan view which show a retainer
 frame on which heating elements are retained;
 Fig. 24 is a partially perspective view which shows
 a retainer frame;
 Fig. 25 is a partially perspective view which shows
 connector terminals projecting from a heater as-
 sembly;
 Fig. 26 is a partially perspective view which shows
 a right side spring clasper fitted on a right side end
 of the heater assembly of Fig. 25;
 Fig. 27 is a partially perspective view which shows
 an assembly of a heater assembly and retainer
 frames in which a spring clasper is fitted according
 to the fifth embodiment of the invention;
 Fig. 28 is a partially perspective view which shows
 an assembly of a heater assembly and retainer
 frames according to the fifth embodiment of the in-
 vention;

Fig. 29 is a front view which shows an electric heater
 according to the fifth embodiment of the invention;
 Fig. 30 is a side view which shows a heater assem-
 bly on which frame retainers are installed according
 to the fifth embodiment of the invention;
 Fig. 31 is a partially plan view which shows a retain-
 er plate on which a connector terminal of an elec-
 trode plate is retained according to the fifth embod-
 iment of the invention;
 Fig. 32 is a partially plan view which shows a mod-
 ification of a spring clasper which may be used in
 the structure of Fig. 31;
 Fig. 33 is a partially plan view which shows an elec-
 trode plate fitted on a retainer plate and the spring
 clasper, as illustrated in Fig. 32;
 Fig. 34 is a partially perspective view of the elec-
 trode plate, as illustrated in Fig. 33;
 Fig. 35 is a perspective view which shows a modi-
 fied form of a retainer plate;
 Fig. 36 is a partially plan view of Fig. 35;
 Fig. 37 is a sectional view, as taken along the line
 A-A of Fig. 36;
 Fig. 38 is a sectional view, as taken along the line
 B-B of Fig. 36;
 Fig. 39 is side view of a heater assembly in which
 the retainer plates, as illustrated in fig. 35, are in-
 stalled;
 Fig. 40 is a partially perspective view which shows
 a heater assembly in which the retainer plates, as
 illustrated in Fig. 35, are installed and from which
 connector terminals project;
 Fig. 41 is a partially plan view which shows an elec-
 trode plate fitted on the retainer plate, as illustrated
 in Fig. 35;
 Fig. 42 is a sectional view, as taken along the line
 C-C in Fig. 41;
 Fig. 43 is a partially perspective view which shows
 a modified form of the retainer plate, as illustrated
 in Fig. 35; and
 Fig. 44 is a front view which shows a conventional
 electric heater.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0039] Referring to the drawings, wherein like refer-
 ence numbers refer to like parts in several views, par-
 ticularly to Figs. 1 to 3, there is shown an electric heater
 2 according to the first embodiment of the invention
 which includes a heater assembly 3 made of a lamination
 of radiator fin assemblies 32, electric heating ele-
 ments 330, electrode plates 31 for supplying electric
 power to the heating elements 330, a first insulating
 plate 391, and a second insulating plate 392. The heater
 assembly 3 has, as clearly shown in Fig. 3, upper and
 lower end surfaces 301 and 302 opposed to each other
 in a vertical direction of the heater assembly 3, side sur-
 faces 303 and 304, and front and rear surfaces 305 and

306. A medium such as air to be heated passes through the radiator fin assemblies 32 in a direction from the front surface 305 to the rear surface 306 (i.e., a thickness-wise direction of the heater assembly 3).

[0040] The heater assembly 3 is retained firmly by first and second retainer frames 21 and 22 placed substantially in abutment of entire side surfaces thereof with those of the first and second insulating plates 391 and 392, respectively.

[0041] The electric heater 2 also includes a pair of metallic spring claspers 1 which clasp the first and second retainer frames 21 and 22 together to produce inward spring pressures which work to retain or clasp the radiator fin assemblies 32, the heating elements 330, the electrode plates 31, and the first and second retainer frames 21 and 22 together.

[0042] The spring claspers 1 also serve as side frames extending along the side walls of the heater assembly 3. Each of the spring claspers 1 is, as clearly shown in Figs. 4, and 5(a) to 6(c), formed by a C-shaped frame made up of first and second clamping arms 11 and 12 and a support strip 10 connecting with the first and second clamping arms 11 and 12. The support strips 10 are disposed in partial abutment with the side surfaces 303 and 304 of the heater assembly 3. The first and second clamping arms 11 and 12 of each of the claspers 1 are, as clearly shown in Figs. 5(c) and 6(c), fitted within channels of the first and second retainer frames 21 and 22, respectively.

[0043] The first and second retainer frames 21 and 22 are, as described above, made of C-channel strips and has the end openings 213, 214, 223, and 224. The fitting of the clamping arms 11 and 12 of each of the spring claspers 1 within the first and second retainer frames 21 and 22 is achieved by inserting the tip ends of the clamping arms 11 and 12 into the end openings 213 and 223 (or 214 and 224) of the first and second retainer frames 21 and 22, respectively.

[0044] The first and second clamping arms 11 and 12, as can be seen from Figs. 4 to 6(c), consist of slightly curled base portions 111 and 121, end portions 113 and 123 extending from the base portions 111 and 121, and V-shaped bends 112 and 122 formed between the base portions 111 and 121 and the end portions 113 and 123, respectively. The bends 112 and 122 orient the end portions 113 and 123 outwardly, thereby facilitating ease of fitting of the clamping arms 11 and 12 in the first and second retainer frames 21 and 22.

[0045] The fitting of the spring claspers 1 in the first and second retainer frames 21 and 22 is accomplished by inserting the clamping arms 11 and 12 into the first and second retainer frames 21 and 22 to bring the bends 112 and 122 elastically in abutment with the surfaces of the first and second retainer frames 21 and 22, thereby clamping the heater assembly 3 vertically, as viewed in Fig. 1.

[0046] Each of the metallic spring claspers 1 is, as described above, made of a C-shaped frame consisting

of the first and second clamping arms 11 and 12 and the support strip 10. The support strip 10 is, as clearly shown in Fig. 4, made of a rectangular ring. The claspers 1 are made of a spring steel such as SK5 or a tool steel.

[0047] The base portions 111 and 121 of each of the claspers 1 are curved inwardly and coupled with the end portions 113 and 123 through the V-shaped bends 112 and 122. The end portions 113 and 123 extend straight outward.

[0048] In operation, the heating elements 330 are electrically activated to produce heat energy which is, in turn, transmitted to the radiator fin assemblies 32. The medium (e.g., air) flows from the front surface 305 to the rear surface 306 of the heater assembly 3. When passing through the radiator fin assemblies 32, the medium is exposed to the heat from the radiator fin assemblies 32 and elevated in temperature thereof.

[0049] The heater assembly 3 is, as can be seen from Figs. 1, 2, and 3, made up of the first insulating plate 391, the electrode plate 31, the radiator fin assembly 32, a retainer plate 33 in which the heating elements 330 are retained, the electrode plate 31, the radiator fin assembly 32, the second insulating plate 392 which are laid to overlap each other in that order. Specifically, the heater assembly 3 includes the five electrode plates 31, the five radiator fin assemblies 32, and the four retainer plates 33 each having the four heating elements 330 held therein.

[0050] The metallic spring claspers 1 are snapped on the first and second retainer frames 21 and 22 and the side surfaces 303 and 304. Side frames 23 and 24 are fitted into the heater assembly 3 from outside the metallic spring claspers 1.

[0051] Each of the radiator fin assemblies 32 is made up of two L-shaped frames 321 and 322 and a corrugated fin 320. The corrugated fin 320 is fitted within a chamber surrounded by the L-shaped frames 321 and 322 joined together by brazing or soldering. The L-shaped frames 321 and 322 and the corrugated fin 320 are made of an aluminum- or copper-based material.

[0052] Each of the heating elements 330 is implemented by a positive temperature coefficient sensitivity (PTC) plate made of a barium titanate semiconductor porcelain.

[0053] Each of the retainer plates 33 within which the heating elements 330 are retained is, as clearly shown in Figs. 1, 7, 8, and 9, made up of an H-shaped strip body 331, an end extension 333 extending from one end of the strip body 331, and a terminal extension 334 extending from the other end of the strip body 331. The terminal extension 334 works to retain a connector terminal 311 of one of the electrode plates 31, as will be described later in detail. The extensions 333 and 334 are smaller in width than the strip body 331. The strip body 331 has formed therein four openings 332 within which the heating elements 330 are fitted.

[0054] Each of the retainer plates 33 is, as can be

seen from Fig. 9, of an H-shape in cross section to form grooves on opposed major surfaces thereof which extend along the length of the retainer plate 33. Specifically, the retainer plate 33 has side flanges 331 which hold the radiator fin assembly 32 and the electrode plate 31 firmly.

[0055] Each of the electrode plates 31 is made of a metallic strip and has the terminal 311 which couples or mates to one of females or receptacle terminals 261, as will be described later. The electrode plate 31 is made of brass or copper-based material.

[0056] The first insulating plate 391, as shown in Fig. 1, works to insulate between the electrode plate 31 of an uppermost one of the radiator fin assemblies 32 and the first retainer frame 21 electrically. The second insulating plate 392 works to insulate between the electrode plate 31 of a lowermost one of the radiator fin assemblies 32 and the second retainer frame 22 electrically. The first insulating plate 391 is made of a C-channel strip serving to retain the electrode plate 31. Similarly, the second insulating plate 392 is made of a C-channel strip serving to retain the radiator fin assembly 32. The first and second insulating plates 391 and 392 may be made of a resin material such as nylon or PPS resin in terms of both electric and thermal insulation. The first and second insulating plates 391 and 392 may alternatively be made of an H-shaped strip like the retainer plates 33 and also be omitted in terms of the number of the radiator fin assemblies 32 and electrical properties of the first and second retainer frames 21 and 22.

[0057] Each of the first and second retainer frames 21 and 22 is, as clearly shown in Fig. 1, made of a C-channel strip which is substantially rectangular in cross section. The first and second retainer frames 21 and 22 have end openings 213, 214, 223, and 224, respectively, which are oriented to open laterally of the heater assembly 3. The first and second retainer frames 21 and 22 has formed in side walls thereof rectangular holes 217, 218, 227, and 228 into which barbed claws 235 and 245 of the side frames 23 and 24 are fitted. Fig. 1 omits the holes 217, 218, 227, and 228 formed on the side of the rear surface 306 of the heater assembly 3 for the brevity of illustration.

[0058] The side frames 23 and 24, as described above, cover the metallic spring clampers 1 and engage the heater assembly 3 firmly. The left side frame 23 is made of a C-channel strip and has the barbed claws 235 which extend over the metallic spring clamp 1 to snap into the holes 217 of the first retainer frame 21 and the holes 227 of the second retainer frame 22. The right side frame 24 has flanges 241 formed on ends thereof and the barbed claws 245 which extend over the metallic spring clamp 1 to snap into the holes 218 of the first retainer frame 21 and the holes 228 of the second retainer frame 22. The side frame 24 also has slots 249 through which the terminals 311 of the electrode plates 31 pass. The side frame 24 also has formed in a side wall thereof terminal slots 240 through which the recep-

tacle terminals 261 pass and couple with the terminals 311 of the electrode plates 31.

[0059] The side frame 24 also has a protective casing 25 joined to a major body of the side frame 24 to cover the receptacle terminals 261.

[0060] The receptacle terminals 261 have leads 262 coupling with sockets 263 and 264 into which plugs are inserted which extend from an external power supply (not shown).

[0061] The assembling of the electric heater 2 will be described below.

[0062] First, the heating elements 330 are, as illustrated in Fig. 1, installed in the retainer plates 33. Next, the first insulating plate 391, the electric plate 31, the radiator fin assembly 32, the retainer plate 33, the electrode plate 31, the radiator fin assembly 32 . . . the radiator fin assembly 32, and the second insulating plate 392 are laid to overlap each other in this order to make the heater assembly 3.

[0063] In the above process, the radiator fin assemblies 32 and the electrode plates 31 are retained or fitted in the grooves (i.e., channels) of the retainer plates 33 and the first and second insulating plates 391 and 392.

[0064] The first and second retainer frames 21 and 22 are placed on the upper and lower surfaces of the heater assembly 3.

[0065] Subsequently, the metallic spring clampers 1 are expanded outward, as illustrated in Figs. 5(a), 5(b), 6(a), and 6(b) until the distance $L0$ between the bends 112 and 122 of the clamping arms 11 and 12 is reached. The distance $L0$ is greater than the distance $L1$ between the inside walls 219 and 229 of the first and second retainer frames 21 and 22.

[0066] The clamping arms 11 and 12 of the spring clampers 1 are, as shown in Figs. 5(b) and 6(b), inserted into the end openings 213, 214, 223, and 224 of the first and second retainer frames 21 and 22 from outside the side surfaces 303 and 304. When the spring clampers 1 are subjected to no load, the distance $L0$ between the bends 112 and 122 is smaller than the distance $L1$ between the inside walls 219 and 229. Thus, when the spring clampers 1 have snapped into the first and second retainer frames 21 and 22 to bring the bends 112 and 122 into abutment with the inside walls 219 and 229, it produces elastic pressure to urge the inside walls 219 and 229 in facing directions to clasp the heater assembly 3 firmly.

[0067] Finally, the side frames 23 and 24 are fitted into the side surfaces 303 and 304 of the heater assembly 3 from outside the spring clampers 1. The fitting of the side frame 24 is so achieved that the terminals 311 of the electrode plates 31 pass through the slots 249 to make joints with the receptacle terminals 261 disposed inside the protective casing 25.

[0068] As described above, the heating elements 330 are activated by the electric power supplied through the electrode plates 31. The thermal energy produced by the heating elements 330 is transmitted to the radiator

fin assemblies 32 through the electrode plates 31 and to the medium (e.g., air) to be heated. Thus, the greater areas of contacts between the heating element 330 and the electrode plate 31 and between the radiator fin assembly 32 and the electrode plate 31, the more effectively the thermal energy will be conducted to the medium.

[0069] The firm installation of the heater assembly 3 between the first and second retainer frames 21 and 22 is accomplished with the inwardly oriented compression elastic pressures which are produced by the spring clampers 1, thereby establishing close adhesion between the heating element 330 and the heating plate 31 and between the radiator fin assembly 32 and the electrode plate 31, which facilitates the conduction of the thermal energy from the heating elements 330 to the radiator fin assemblies 32 to enhance the heating efficiency of the electric heater 1.

[0070] The use of the spring clampers 1 results in decreased parts of the electric heater 2 as compared with the conventional structures of the electric heater and also facilitates ease of assembling of the electric heater 2. The spring clampers 1 are made of a metallic material and thus less susceptible to creeping, thereby minimizing a reduction in rigidity thereof to improve the service life of the electric heater 2.

[0071] Figs. 10 to 13 show the electric heater 2 according to the second embodiment of the invention which has a metallic spring clamber 4 different in structure from that of the spring clampers 1 of the first embodiment.

[0072] The spring clamber 4 is, as clearly shown in Fig. 10, made of a closed-loop strip encompassing the upper and lower end surfaces 301 and 302 and the side surfaces 303 and 304 of the heater assembly 3. The heater assembly 3 is identical in structure with the one in the first embodiment, and Fig. 10 omits an internal structure thereof for the brevity of illustration.

[0073] The electric heater 2 also includes a first retainer frame 41 and a second retainer frame 42 installed on the upper and lower end surfaces 301 and 302 of the heater assembly 3. The first retainer frame 41 is, as clearly shown in Figs. 11, 12, and 13, made of a C-channel strip which has an opening oriented frontward (i.e., to the side of the front surface 305 of the heater assembly 3). The first retainer frame 41 has an inner chamber (i.e., the C-channel) which is defined by an inner bottom surface 411, an inner upper surface 412, and an inner side surface 413 and in which the part of the spring clamber 4 is secured. The second retainer frame 42 is identical in structure with the first retainer frame 41, and explanation and illustration thereof will be omitted here.

[0074] The spring clamber 4 is, as can be seen from Fig. 13, fitted or snapped into the first and second retainer frames 41 and 42 from the side of the front surface 305 into abutment of an inner peripheral surface 401 with the side surfaces 303 and 304 of the heater assembly 3 and the bottom surfaces 411 of the first and second

retainer frames 41 and 42, thereby exerting an inward spring pressure or compression pressure on the heater assembly 3.

[0075] The heater assembly 3 is, like the first embodiment, made up of, as shown in Fig. 12, the radiator fin assemblies 32, the electric heating elements 330, the retainer plates 33, the electrode plates 31, and the first and second insulating plates 391 and 392 which are laid to overlap each other in the vertical direction.

[0076] The spring clamber 4 is, as shown in Figs. 10 and 11, fitted within the first retainer frame 41 in partial abutment with the inner bottom surface 411. Specifically, as can be seen from Fig. 10, the spring clamber 4 is placed in contact with two points on the inner bottom surface 411 of the first retainer frame 41 and simultaneously two points on the upper inner surface 412 of the second retainer frame 42.

[0077] Fig. 14 shows a modification of the spring clamber 41 which is placed in contact with two points on the upper inner surface 412 and a single point on the inner bottom surface 411 of the first retainer frame 41 and simultaneously in contact with two points on the inner bottom surface 411 and a single point on the inner upper surface 412 of the second retainer frame 42.

[0078] Figs. 15(a) and 15(b) show the electric heater 2 according to the third embodiment of the invention which has two spring clampers 5. Each of the spring clampers 5 is, as clearly illustrated in Fig. 15(b), of a C-shape and made up of a pair of spring arms 51 and 52 and a support strip 50 connecting with the spring arms 51 and 52.

[0079] The support strip 50 of each of the spring clampers 5 is placed in abutment with the front surface 305 of the heater assembly 3. Simultaneously, the spring arms 51 and 52 elastically hang on the first and second retainer frames 21 and 22, respectively. Other arrangements of the electric heater 2 are identical with those in the first embodiment, and explanation thereof in detail will be omitted here.

[0080] Figs. 16(a) and 16(b) show the electric heater 2 according to the fourth embodiment of the invention which has two spring clampers 6. Each of the spring clampers 6 is, as clearly illustrated in Fig. 16(b), made of a closed-loop strip and fitted elastically in abutment with the front and rear surfaces 305 and 306 of the heater assembly 3 and the first and second retainer frames 21 and 22 to clamp the first and second retainer frames 21 and 22 and the heater assembly 3 together. The fitting of the spring clampers 6 on the heater assembly 3 through the first and second retainer frames 21 and 22 is achieved by snapping the spring clampers 6 on the first and second retainer frames 21 and 22 from a lateral direction of the heater assembly 3. Other arrangements of the electric heater 2 are identical with those in the first embodiment, and explanation thereof in detail will be omitted here.

[0081] Figs. 17(a) and 17(b) show a modification of an internal structure of the first retainer frame 21 of the

electric heater 2 in the first embodiment which establish firm engagement with the clamping arm 11 of the spring clasper 1.

[0082] The first retainer frame 21 has two protrusions 211 formed on the inside wall 219 by a press or a hammer (only a right side one is shown for the brevity of illustration). The joint of the spring clasper 1 to the first retainer frame 21 is, as clearly shown in Fig. 17(a), accomplished by snapping the clamping arm 11 on the protrusion 211 to establish firm engagement of the V-shaped bend 112 with the protrusion 211.

[0083] Fig. 17(b) is a plan view which illustrates the protrusion 211, as indicated by half-tone dot meshing, formed on the inside wall 219 of the first retainer frame 21. The second retainer frame 22 has the same internal structure as that of the first retainer frame 21. Specifically, the joint of the second arm 12 of the spring clasper 1 to the second retainer frame 22 is achieved in the same manner as described above, and explanation thereof in detail will be omitted here.

[0084] Figs. 18(a) and 18(b) show a second modification of the internal structure of the first retainer frame 21 which establish the firm engagement with the clamping arm 11 of the spring clasper 1.

[0085] The first retainer frame 21 has two cut-out tabs 212 formed on the inside wall 219 (only a right side one is shown for the brevity of illustration). The joint of the spring clasper 1 to the first retainer frame 21 is, as clearly shown in Fig. 18(a), accomplished by snapping the clamping arm 11 on the tab 212 to establish firm engagement of the V-shaped bend 112 with the tab 212.

[0086] Figs. 19(a) and 19(b) show a third modification of the internal structure of the first retainer frame 21 which establish the firm engagement with the clamping arm 11 of the spring clasper 1.

[0087] The first retainer frame 21 has two slits 216 formed in the inside wall 219 (only a right side one is shown for the brevity of illustration). The slit 216, as clearly shown in Fig. 19(b), extend perpendicular to the length of the first retainer frame 21. The joint of the spring clasper 1 to the first retainer frame 21 is, as clearly shown in Fig. 19(a), accomplished by snapping the clamping arm 11 in the slit 216 to establish a firm lock of the V-shaped bend 112 in the tab 212.

[0088] Fig. 20 shows a first modification of the spring claspers 1 (only a right side one is shown for the brevity of illustration).

[0089] The clamping arm 11 of the spring clasper 1 has a protrusion 118 formed on the base portion 111 by a press or a hammer. The protrusion 118 projects inwardly of the spring clasper 1 and works to provide additional abutment of the clamping arm 11 with the inside wall 219 of the first retainer frame 21, thereby enhancing the firm engagement of the spring clasper 1 with the first retainer frame 21. The clamping arm 12 of the spring clasper 1 has the same structure, and explanation thereof in detail will be omitted here.

[0090] Fig. 21 shows a second modification of the

spring claspers 1 (only a right side one is shown for the brevity of illustration).

[0091] The clamping arm 11 of the spring clasper 1 has a cut-out tab 119 formed on the base portion 111. The tab 119 projects inwardly of the spring clasper 1 and works to provide additional abutment of the clamping arm 11 with the inside wall 291 of the first retainer frame 21, thereby enhancing the firm engagement of the spring clasper 1 with the first retainer frame 21. The clamping arm 12 of the spring clasper 1 has the same structure, and explanation thereof in detail will be omitted here.

[0092] Referring back to Figs. 1 and 4, each of the spring claspers 1 has a slit 100 extending in a lengthwise direction thereof through which the terminals 311 of the electrode plates 31 pass when the spring clasper 1 is fitted in the first and second retainer frames 21 and 22.

[0093] Each of the retainer plates 33 within which the heating elements 330 are retained, as described already in Fig. 7, has the end extension 333 extending from one end of the strip body 331, and the terminal extension 334 extending from the other end of the strip body 331. When the spring claspers 1 are installed in the first and second retainer frames 21 and 22, the end extension 333 and the terminal extension 334 are fitted in the slits 100 of the spring claspers 1.

[0094] The terminal extension 334 works to retain the connector terminal 311 of one of the electrode plates 31. The extensions 333 and 334 are opposed to each other in the lengthwise direction of the retainer plate 33 and smaller in width than the strip body 331.

[0095] Each of the retainer plates 33, as clearly shown in Fig. 23, has shoulders 3331 and 3341 formed between the strip body 331 and the end extension 3330 and between the strip body 331 and the terminal extension 3340. The extension 333 also has side surfaces 3330 facing frontward and rearward of the heater assembly 3. Similarly, the extension 334 has side surfaces 3340 facing frontward and rearward of the heater assembly 3.

[0096] Fig. 24 shows the structure of the first insulating plate 391 which, as already described, insulates between the electrode plate 31 of an uppermost one of the radiator fin assemblies 32 and the first retainer frame 21 electrically. The first insulating plate 391, as shown in Fig. 24, includes a C-shaped strip body 341 in which one of the electrode plates 31 is retained, a terminal extension 344, and an end extension 363 opposed to the terminal extension 344. The extensions 344 and 363 are smaller in width than the strip body 341 and identical in shape and size with each other.

[0097] The first insulating plate 391 has shoulders 361 and 347 and side surfaces 3360 and 3340 which face, like the retainer plates 33, frontward and rearward of the heater assembly 3. The second insulating plate 392, as shown in Fig. 25, has a terminal extension 375 and shoulders 371. The terminal extension 375 has side

surfaces 3370 facing frontward and rearward of the heater assembly 3. The second insulating plate 392 has, like the first insulating plate 391, an end extension which is omitted in Fig. 25 for the brevity of illustration. Specifically, the second insulating plate 392 has substantially the same structure as that of the first insulating plate 391.

[0098] The heater assembly 3 has, as shown in Fig. 25, the extensions 344 and 375 of the first and second insulating plates 391 and 392, the extensions 334 of the retainer plates 33, and the terminals 311 of the electrode plates 31 project from the side surface 304. The terminals 311 of the electrode plates 31 are retained firmly and oriented outward by the extension 344 of the first insulating plate 391 and the extensions 334 of the retainer plates 33. The heater assembly 3 has similar arrangements on the left side surface 303.

[0099] The fitting of each of the spring clampers 1 is, as already described, by expanding the spring clamber 1 outward, as clearly shown in Fig. 22(a), inserting it, as shown in Fig. 22(b), into the end openings 213, 214, 223, and 224 of the first and second retainer frames 21 and 22 from outside the side surfaces 303 and 304 so that the extensions 344 and 375 of the first and second insulating plates 391 and 392, the extensions 334 of the retainer plates 33, and the terminals 311 of the electrode plates 31 projecting from the side surface 304 may pass through the slit 100 of the spring clamber 1, and snapping, as shown in Fig. 22(c), the clamping arms 11 and 12 on the inside walls 219 and 229 of the first and second retainer frames 21 and 22. The clamping arms 11 and 12 may alternatively be forced into the end openings 213, 214, 223, and 224 of the first and second retainer frames 21 and 22 without being expanded before inserted thereinto.

[0100] Fig. 26 illustrates the side surface 304 of the heater assembly 3 where the spring clamber 1 is installed in the first and second retainer frames 21 and 22. The spring clamber 1 is placed in abutment of an inside surface 102 thereof (see Fig. 4) with the shoulders 347 and 371 of the first and second insulating plates 391 and 392 and the shoulders 3341 of the retainer plates 33 and also in abutment of an inner peripheral surface 101 thereof with the side surfaces 3340 and 3370 of the first and second insulating plates 391 and 392 and the side surfaces 3340 of the retainer plates 33. Specifically, the slit 100 of the spring clamber 1 serves as a lock holder 6, as illustrated in Fig. 26, which locks movement of the first and second insulating plates 391 and 392 and the retainer plates 33 in the thickness-wise direction of the heater assembly 3, thereby keeping the first and second insulating plates 391 and 392 and the retainer plates 33 arrayed flush with the front and rear surfaces 305 and 306 of the heater assembly 3.

[0101] As apparent from the above discussion, the spring clampers 1 work to clamp the first and second insulating plates 391 and 392, the radiator fin assemblies 32, and the retainer plates 33 vertically, serve as

side frames of the heater assembly 3 to retain the first and second insulating plates 391 and 392, the radiator fin assemblies 32, and the retainer plates 33 laterally and also to hold them from moving in the thickness-wise direction of the heater assembly 3.

[0102] Figs. 27 to 31 show the electric heater 2 according to the fifth embodiment of the invention.

[0103] Each of the retainer plates 33 in which the heating elements 330 are retained has detent cuts 34 formed in the ends thereof. The detent cuts 34 formed in each end of the retainer plates 33 are, as clearly shown in Fig. 28, aligned vertically. The spring clampers 150 which are different in structure from the spring clampers 1 only in that the slit 100 is not formed are, as clearly shown in Figs. 27 and 29, fitted in the detent cuts 34 firmly.

[0104] Specifically, the detent cuts 34 and the spring clampers 150 work as the lock holder 6 to lock the movement of the retainer plates 33 and the corrugated fins 320 in the thickness-wise direction of the heater assembly 3.

[0105] The spring clampers 150, as described above, do not have the slit 100 and thus are allowed to be decreased in width thereof as compared with the spring clampers 1. The decrease in width of the spring clampers 150 permits the heater assembly 3 to be decreased in width.

[0106] The heater assembly 3 of this embodiment is, as can be seen from Figs. 27 and 30, made up of the radiator fin assemblies 32, the electrode plates 31, and the retainer plates 33 which are laid to overlap each other. Specifically, the heater assembly 3 is made of five heater units 30 each consisting of the radiator fin assembly 32, the electrode plate 31, and the retainer frame 33. The five heater units 30 are grasped by the spring clampers 150 with the support strips 10 fitted in the detent cuts 34 and the clamping arms 11 and 12 snapped in the first and second retainer frames 21 and 22 to exert the compression pressure on the heater units 30 vertically.

[0107] Each of the retainer plates 33, as shown in Figs. 27 and 31, has an inside end wall 3411 and inside side walls 342 which define each of the detent cuts 34 and with which the spring clamber 150 is placed in abutment, thereby holding, as described above, the retainer plates 33 and the radiator fin assemblies 32 from moving undesirably in the thickness-wise and lateral directions of the heater assembly 3.

[0108] Each of the retainer plates 33, as clearly shown in Figs. 30 and 31, has upper and lower retainer grooves 35 each defined by a flat strip 350 and upright side walls 351 extending from the flat strip 350 vertically. The upper and lower grooves 35 extend in a lengthwise direction of the retainer plates 33. The upper retainer groove 35 works to retain the electrode plates 31 and a lower part of the radiator fin assembly 32 firmly. The lower retainer groove 35 works to retain an upper portion of the radiator fin assembly 32 firmly.

[0109] A front one of the upright side walls 351, as clearly shown in Figs. 27 and 31, has a cut 352 from which the terminal 311 of the electrode plate 31 extends frontward of the heater assembly 3. The terminal 311 extends from the end of the strip body 312 of each of the electrode plates 31 in the frontward direction of the heater assembly 3. The terminal 311 is formed integrally with the strip body 312 to be flush therewith.

[0110] All the terminals 311 project frontward of the heater assembly 3, thus permitting electrical joints to be achieved easily with female terminals such as the receptacle terminal 261 illustrated in Fig. 1, especially in a case where lateral space is unavailable and also allowing the lateral size of the electric heater 2 to be decreased.

[0111] Figs. 32, 33, and 34 show a modification of the terminals 311 of the electrode plates 31.

[0112] The terminal 311 of each of the electrode plates 31 stands upright from the strip body 312 and projects frontward of the heater assembly 3. This structure permits the length of the electrode plates 31 to be decreased, thus allowing the lateral size of the electric heater 2 to be reduced.

[0113] The spring claspers 150 may alternatively be, as can be seen in Figs. 32 and 33, made of a round bar.

[0114] Fig. 35 shows retainer plates 5 which are a modification of the retainer plates 33 used in the above embodiments.

[0115] Each of the retainer plates 5 is made of an insulating material such as nylon and includes a heating element retaining strip 51, a terminal retaining extension 52, and an end extension 53. The terminal retaining extension 52 includes a bottom wall 520 and upright insulating side walls 521. The side walls 521 extend from side edges of the bottom wall 520 vertically of the heater assembly 3 to define, as shown in Fig. 38, a terminal retaining groove 526 within which the connector terminal 311 of each of the electrode plates 31 is retained firmly inside the side walls 521. A vertical array of the terminal retaining extensions 52 is, like the first embodiment, held in the slit 100 of the spring clasper 1 in abutment of the side walls 521 with the inner peripheral surface 101. The side walls 521 also work to insulate the connector terminal 311 electrically from the spring clasper 1.

[0116] Each of the retainer plates 5 is of an H-shape in cross section as a whole. The terminal retaining extension 52 and the end extension 53 are identical in shape with each other for facilitating assembling of the heater assembly 3. Specifically, the retainer plates 5 is shaped to be symmetrical with respect to a vertical center line of the heater assembly 3.

[0117] The heater element retaining strip 51 of each of the retainer plates 5 includes, as clearly shown in Figs. 35 to 37, a bottom wall 510 and upright side walls 511 extending from side edges of the bottom wall 510 to define a retaining groove 515 opening upward of the heater assembly 3. Within the retaining groove 515, the

radiator fin assembly 32 is retained. The bottom wall 510 has formed therein four openings 519 within which the heating elements 330 are fitted.

[0118] The heating element retaining strip 51 is of an H-shape in cross section and defines, as clearly shown in Fig. 37, a retaining groove 516 together with the upright side walls 511. The retaining groove 516 opens downward of the heater assembly 3 and retains therein the strip body 312 of the electrode plate 31.

[0119] The terminal retaining extension 52, as described above, includes, as clearly shown in Figs. 35, 36, 38, 41, and 42, the bottom wall 520 and the upright insulating side walls 521. The side walls 521 extend from the side edges of the bottom wall 520 vertically of the heater assembly 3 to define a groove 525 opening upward.

[0120] The upright side walls 511 and 521 have the height greater than the thickness of the connector terminal 311 of the electrode plate 31, thus ensuring, as can be seen from Fig. 42, the stability in retaining the electrode plate 31.

[0121] The assembling of the electric heater 2 of this embodiment will be described below.

[0122] First, the heating elements 330 are installed in the retainer plates 5. Next, as illustrated in Figs. 39 and 40, the first insulating plate 391, the electric plate 31, the radiator fin assembly 32, the retainer plate 5, the electrode plate 31, the radiator fin assembly 32 . . . the radiator fin assembly 32, and the second insulating plate 392 are laid to overlap each other in this order to make the heater assembly 3.

[0123] The first and second retainer frames 21 and 22 are placed on the upper and lower surfaces of the heater assembly 3.

[0124] Subsequently, the metallic spring claspers 1 which are identical in structure with the ones in the first embodiment are expanded outward and fitted into the end openings 213, 214, 223, and 224 of the first and second retainer frames 21 and 22 from outside the side surfaces 303 and 304 of the heater assembly 3 in the same manner as described above.

[0125] Finally, the side frames 23 and 24 are fitted into the side surfaces 303 and 304 of the heater assembly 3 from outside the spring claspers 1.

[0126] Upon completion of the assembling of the heater assembly 3, the terminal extensions 344 and 375 of the first and second insulating plates 391 and 392, and the terminal extensions 52 of the retaining plates 5, as clearly shown in Fig. 40, project from the side surface 304 of the heater assembly 3.

[0127] The spring clasper 1 is placed in abutment of the inner peripheral surface 101 thereof, as illustrated in Fig. 4, with the upright side walls 3340 and 3370 of the terminal extensions 344 and 375 of the first and second insulating plates 391 and 392 and the upright side walls 521 of the retainer plates 5, as illustrated in Figs. 41 and 42. Specifically, the slit 100 of the spring clasper 1 serves to lock the movement of the first and second

insulating plates 391 and 392 and the retainer plates 5 in the thickness-wise direction of the heater assembly 3, thereby keeping the first and second insulating plates 391 and 392 and the retainer plates 5 arrayed flush with the front and rear surfaces 305 and 306 of the heater assembly 3.

[0128] The side walls 3340 and 521 are placed between the inner peripheral surface 101 of the spring clasper 1 and the connector terminal 311 of each of the electrode plates 31 to insulate the connector terminal 311 electrically from the spring clasper 1.

[0129] Although not illustrated in Fig. 40, the another spring clasper 1 is fitted on the side surface 303 of the heater assembly 3 and works to keep the first and second insulating plates 391 and 392 and the retainer plates 5 arrayed flush with the front and rear surfaces 305 and 306 of the heater assembly 3 in the same manner as described above.

[0130] Fig. 43 shows the electric heater 2 according to the sixth embodiment in which the retainer plates 5 are employed in the structure, as illustrated in Fig. 27, instead of the retainer plates 33.

[0131] Each of the retainer plates 5 has an insulating wall 56 formed between the upper retainer groove 35 and the cut 34. The insulating wall 56 has a thickness enough to insulate the electrode plate 31 electrically from the spring clasper 150. Other arrangements of the electric heater 2 are identical with those in Fig. 27, and explanation thereof in detail will be omitted here.

[0132] The retainer plates 5 of this embodiment may alternatively designed like the ones of Fig. 28. The round spring clasper 1, like the one of Fig. 32, may also be used in this embodiment.

[0133] While the present invention has been disclosed in terms of the preferred embodiments in order to facilitate better understanding thereof, it should be appreciated that the invention can be embodied in various ways without departing from the principle of the invention. Therefore, the invention should be understood to include all possible embodiments and modifications to the shown embodiments which can be embodied without departing from the principle of the invention as set forth in the appended claims.

[0134] A highly manufacturable and high performance structure of an electric heater is provided which includes a heater assembly, retainer frames, and spring claspers. The retainer frames are placed on an upper and a lower end surfaces of the heater assembly. The spring claspers are fitted in the retainer frames to produce compression pressures which clamp the heater assembly firmly to complete the structure of the electric heater. The use of the spring clasper facilitate ease of assembling of the electric heater without sacrificing the performance of the electric heater.

Claims

1. An electric heater comprising:

a heater assembly made up of a fin radiator, an electric heating element, and an electrode plate for supplying electric power to the heating element which are laid to overlap each other in a first direction, said heater assembly having first ends opposed to each other in the first direction and second ends opposed to each other in a second direction substantially perpendicular to the first direction, said heater assembly also having a first and a second major surface which are opposed to each other in a thickness-wise direction thereof and through which a medium to be heated passes the fin radiators; a first and a second retainer frames placed on the first ends of said heater assembly, respectively; and a metallic clamping member jointed to said first and second retainer frames, respectively, to produce a compression pressure acting on said first and second retainer frames to clamp the fin radiator, the heating element, the electrode plate, and the first and second retainer frames together in the first direction.

2. An electric heater as set forth in claim 1, wherein said metallic clamping member is made up of C-shaped frames each of which consists of a support strip and a first and a second clamping arms extending from ends of the support strip in opposite directions, the support strips being placed on the second ends of said heater assembly, the first clamping arms being fitted in said first retainer frame, the second clamping arms being fitted in said second retainer frame.

3. An electric heater as set forth in claim 2, wherein each of said first and second retainer frames is made of a hollow strip member having open ends oriented to the second ends of said heater assembly, and wherein the first and second clamping arms are fitted at ends thereof into the open ends of said first and second retainer frames.

4. An electric heater as set forth in claim 2 or 3, wherein each of the first and second clamping arms is made up of a base portion continuing from the support strip, an end portion extending from the base portion, and a V-shaped bend which has ends connecting with the base portion and the end portion, respectively, in a lengthwise direction of the first ends of said heater assembly, the V-shaped bend having a bottom edge oriented inward of said heater assembly, and wherein the first and second clamping arms are fitted in said first and second retainer

frames in abutment of the bottom edges with said first and second retainer frames to produce the compression pressure.

5. An electric heater as set forth in claim 1, wherein said metallic clamping member is made up of C-shaped frames each of which consists of a support strip and a first and a second clamping arms extending from ends of the support strip in opposite directions, the support strips being placed on the first major surface of said heater assembly, the first clamping arms being fitted in said first retainer frame, the second clamping arms being fitted in said second retainer frame. 5
6. An electric heater as set forth in claim 1, wherein said metallic clamping member is made of a closed-loop strip which extends to encompass the first and second major surfaces of said heater assembly. 10
7. An electric heater as set forth in claim 1, wherein each of said first and second retainer frames has an opening oriented toward the first major surface of said heater assembly, and wherein said metallic clamping member is made of a closed-loop strip which is fitted into the openings of said first and second retainer frames to produce the compression pressure. 15
8. An electric heater as set forth in claim 1, wherein said metallic clamping member is made up of a closed-loop strip which extends over the first and second major surfaces of said heater assembly through said first and second retainer frames to produce the compression pressure. 20
9. An electric heater as set forth in any one of claims 1 to 8, wherein said metallic clamping member is made of one of a tool steel and a spring steel. 25
10. An electric heater as set forth in claim 1, wherein each of said first and second retainer frames is made of a hollow strip member which has openings oriented to the second ends of said heater assembly, and wherein said metallic clamping member is made of first and second clampers each of which has a first and a second clamping arms fitted into the openings of said first and second retainer frames and which are placed on the second ends of said heater assembly to serve as side frames, the first and second clamping arms and/or said first and second retainer frames have engagement portions which establish firm engagement between the first clamping arm and said first retainer frame and between the second clamping arm and said second retainer frame. 30
11. An electric heater as set forth in claim 10, wherein 35

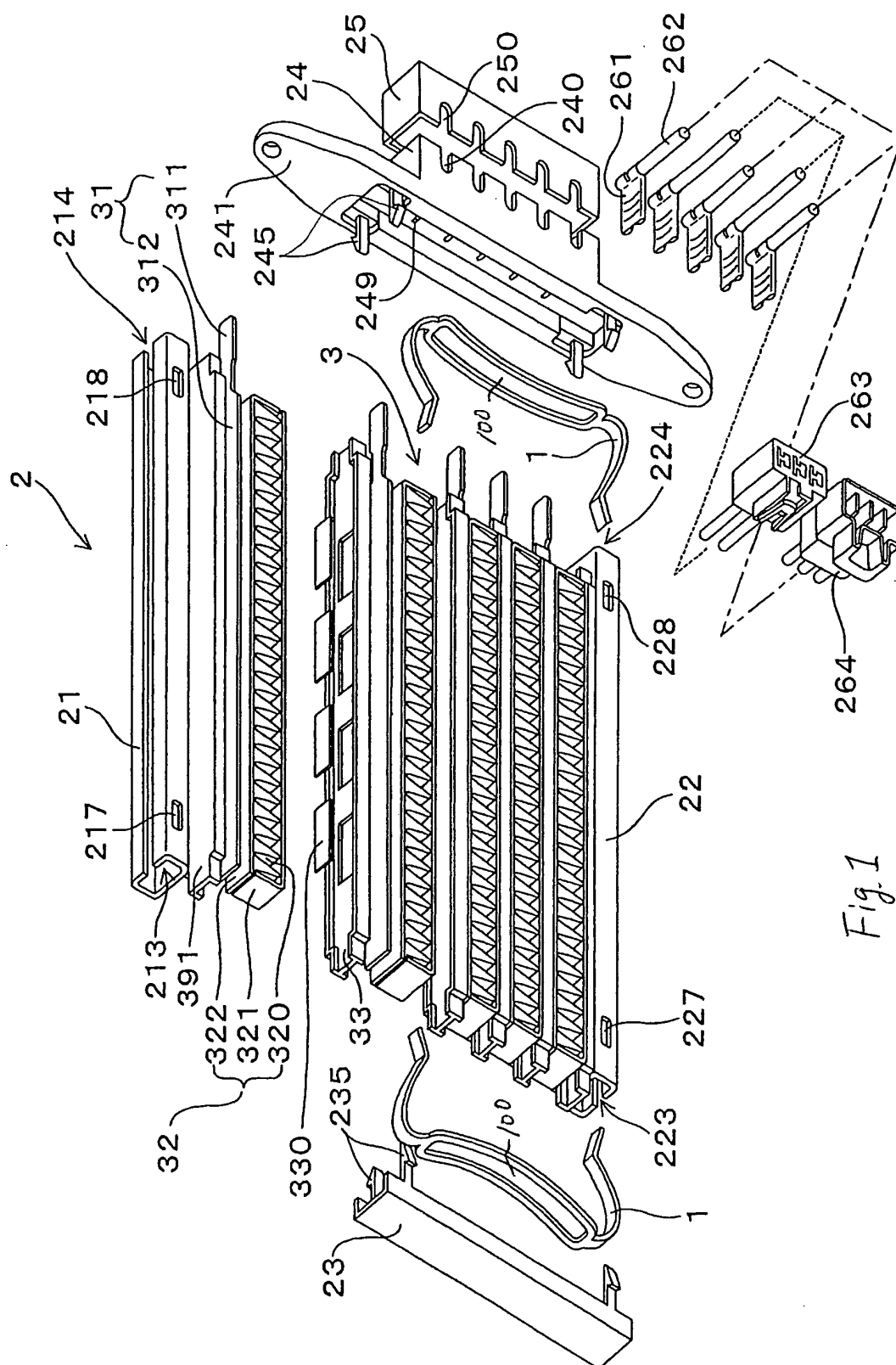
each of the first and second clamping arms is made up of a base portion, an end portion extending from the base portion, and a V-shaped bend which has ends connecting with the base portion and the end portion, respectively, in a lengthwise direction of the first ends of said heater assembly, the V-shaped bend having a bottom edge oriented inward of said heater assembly, and wherein the V-shaped bends of the first and second clamping arms establish the firm engagement with the engagement portions provided on said first and second retainer frames.

12. An electric heater as set forth in claim 11, wherein the engagement portions are implemented by protrusions form on inner surfaces of the first and second retainer frames. 40
13. An electric heater as set forth in claim 11, wherein the engagement portions are implemented by slits form in inner surfaces of the first and second retainer frames. 45
14. An electric heater as set forth in claim 10, wherein each of the first and second clamping arms is made up of a base portion, an end portion extending from the base portion, and a V-shaped bend which has ends connecting with the base portion and the end portion, respectively, in a lengthwise direction of the first ends of said heater assembly, the V-shaped bend having a bottom edge oriented inward of said heater assembly, and wherein the engagement portions are implemented by protrusions which are formed on the first and second clamping arms and oriented toward inner surfaces of the first and second retainer frames. 50
15. An electric heater as set forth in claim 1, wherein said metallic clamping member is made of first and second clampers each of which has a support portion and a first and a second clamping arms extending from ends of the support portion, the support portion being placed on the second ends of said heater assembly to serve as side frames, and wherein each of the first and second clampers engage said heater assembly to define detent mechanisms which work to lock movement of said heater assembly in the thickness-wise direction thereof. 55
16. An electric heater as set forth in claim 15, wherein the detent mechanisms are provided by openings formed in the first and second clampers which extend along the second ends of said heater assembly and in which portions of said heater assembly are fitted.
17. An electric heater as set forth in claim 16, wherein said heater assembly also includes a retainer which includes a body in which the heating element is re-

tained and extensions continuing from the body, the extensions having a width smaller than that of the body and being fitted within the openings of the first and second clampers.

18. An electric heater as set forth in claim 15, wherein the retainer of said heater assembly has cuts in which the first and second clampers are fitted to define the detent mechanisms to lock the movement of said heater assembly in the thickness-wise direction thereof. 5 10
19. An electric heater as set forth in any one of claims 15 to 18, wherein the first and second clampers are made of an elastic metallic member. 15
20. An electric heater as set forth in claim 1, wherein said heater assembly also includes an insulating heater element retainer on which the heating element is retained, the electrode plate having a connector terminal which protrudes from one of the second ends of said heater assembly, wherein said clamping member is made up of a first and a second clasper placed on the second ends of said heater assembly to serve as side frames, wherein the insulating heater element retainer includes a heating element retaining portion in which the heating element is retained and a terminal retaining portion in which the connector terminal of the electrode plate is retained, the terminal retaining portion being made up of a bottom wall and a pair of insulating walls extending from the bottom wall in the first direction of said heater assembly to define an insulating retainer groove within which the connector terminal is retained inside the insulating walls, and wherein one of the first and second clampers holding the terminal retaining portion in abutment with the insulating walls, the insulating walls being placed between the connector terminal and the one of the first and second clampers to insulate the connector terminal electrically from the one of the first and second clampers. 20 25 30 35 40
21. An electric heater as set forth in claim 20, wherein the heating element retaining portion is made up of a bottom wall and a pair of walls extending from the bottom wall in the first direction to define an insulating retainer within which one of the fin radiator and the electrode plate is retained. 45 50
22. An electric heater as set forth in claim 1, wherein said heater assembly also includes an insulating heater element retainer on which the heating element is retained, the insulating heater element retainer having a groove formed in a surface thereof oriented to the first direction within which the electrode plate is retained and a cut formed in an end thereof in which the clamping member is fitted, 55

wherein the electrode plate has a connector terminal projecting from the insulating heater element retainer on a side of the first major surface of said heater assembly, and wherein said insulating heater element retainer works to insulate electrically between the electrode plate and the clamping member.



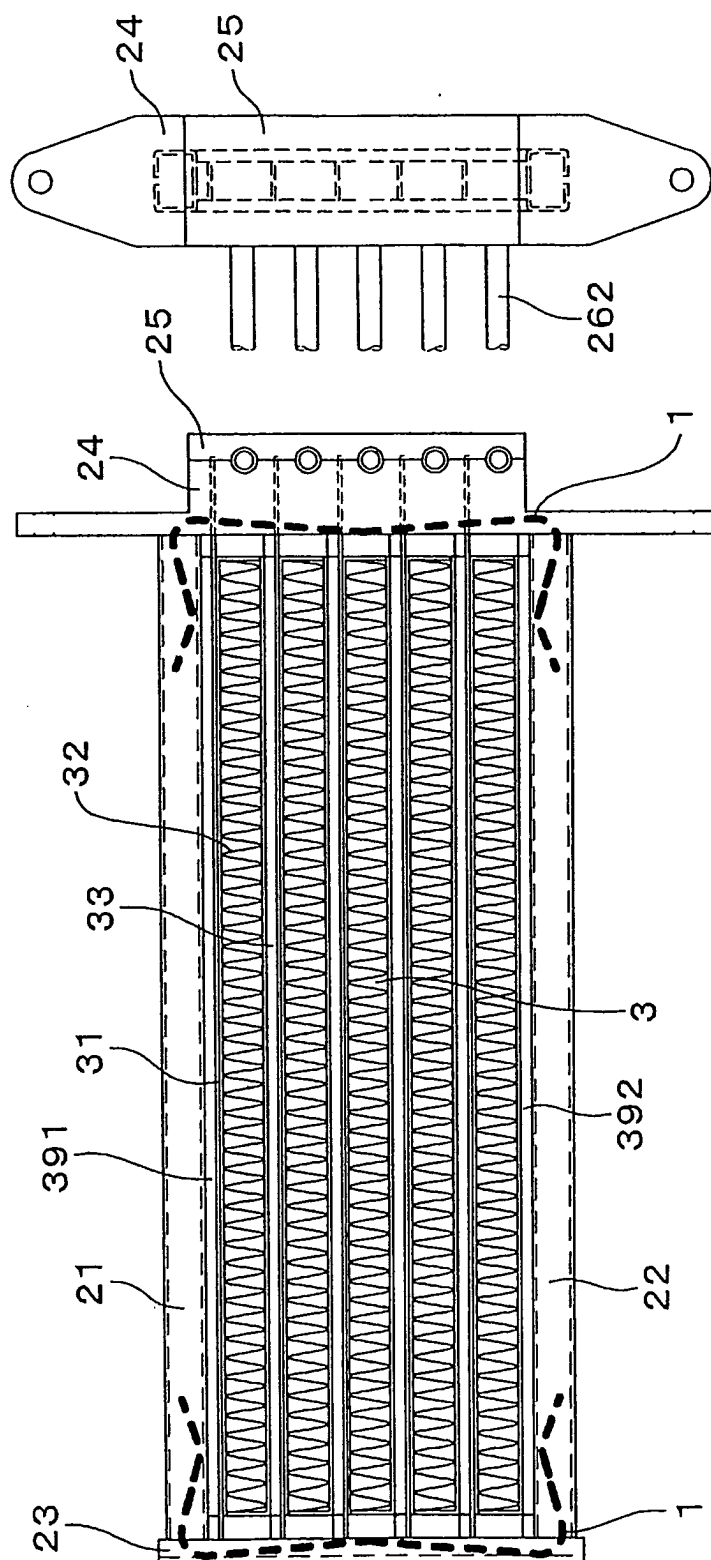


Fig. 2

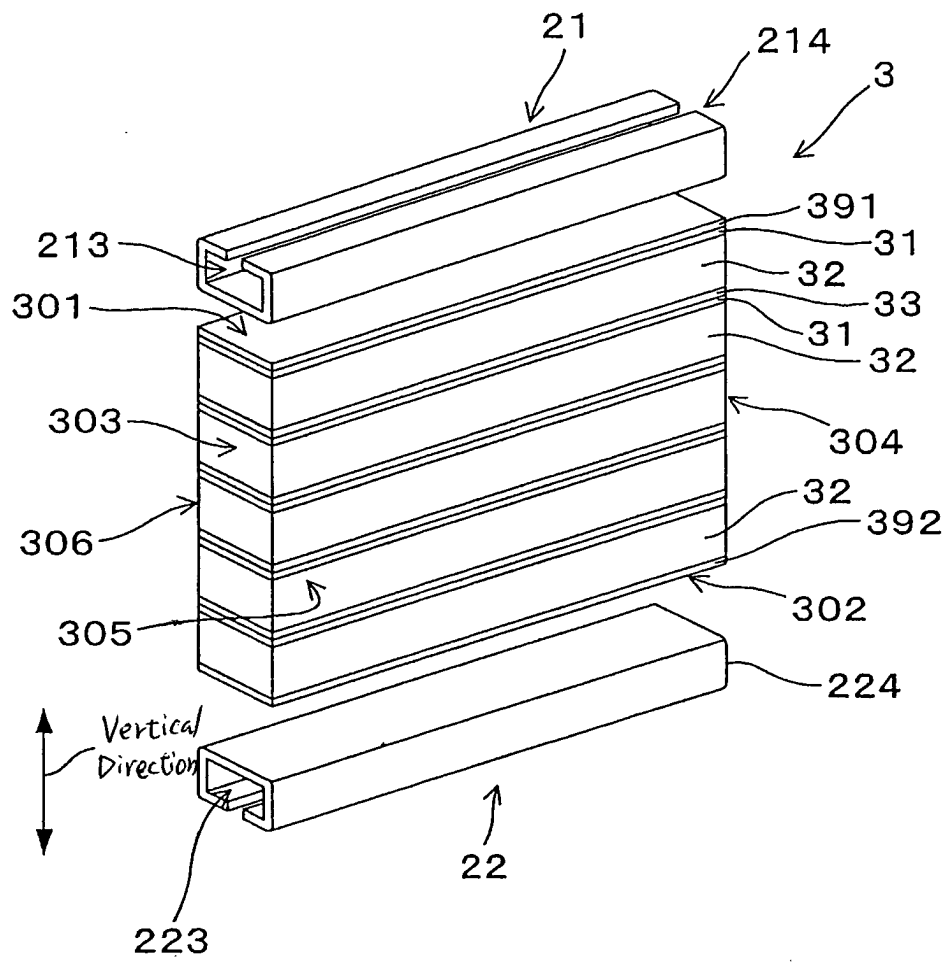


Fig. 3

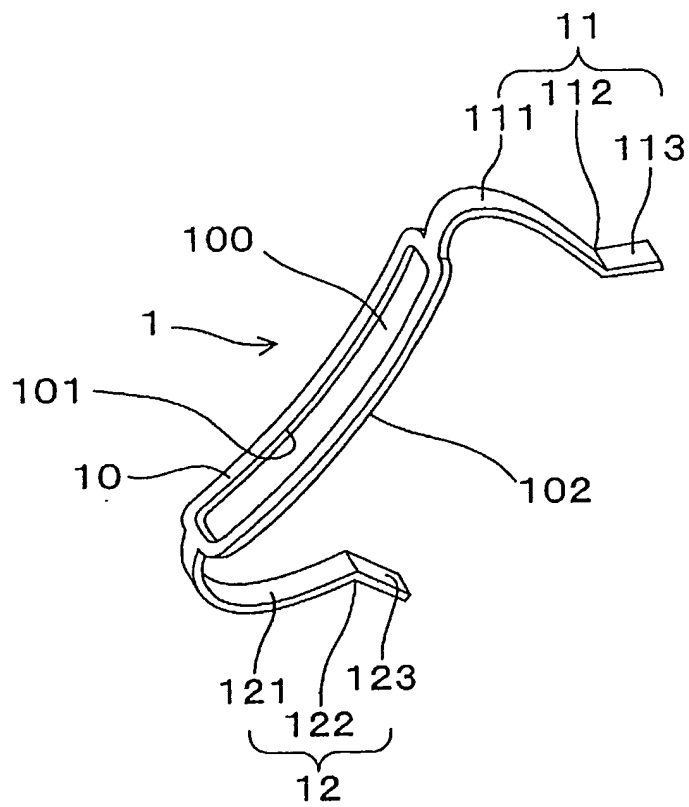


Fig. 4

Fig.5(a)

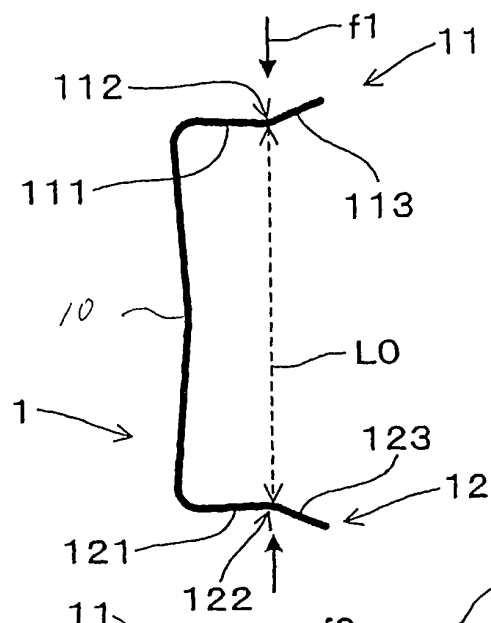


Fig.5(b)

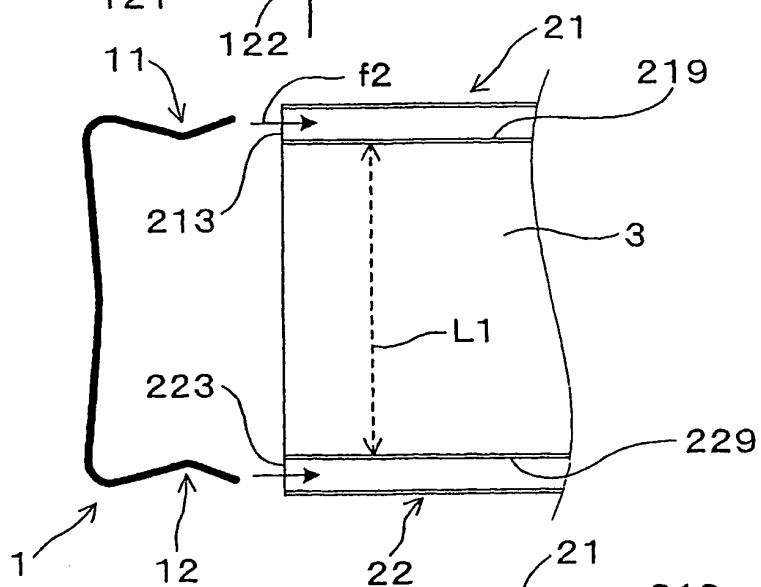


Fig.5(c)

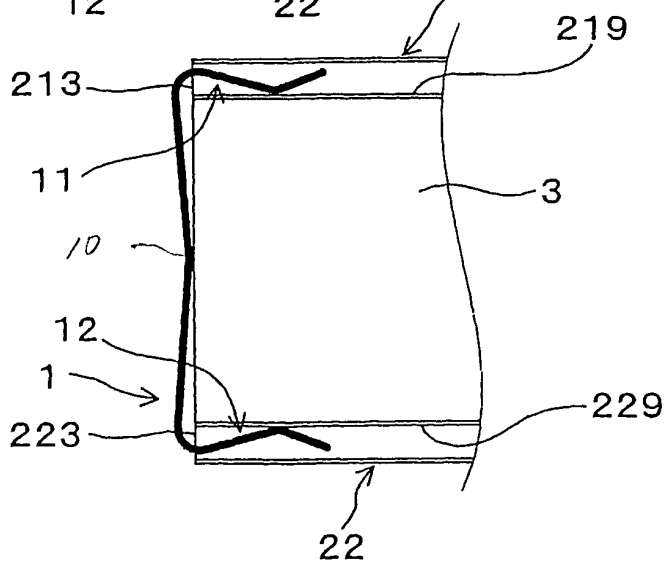


Fig. 6(a)

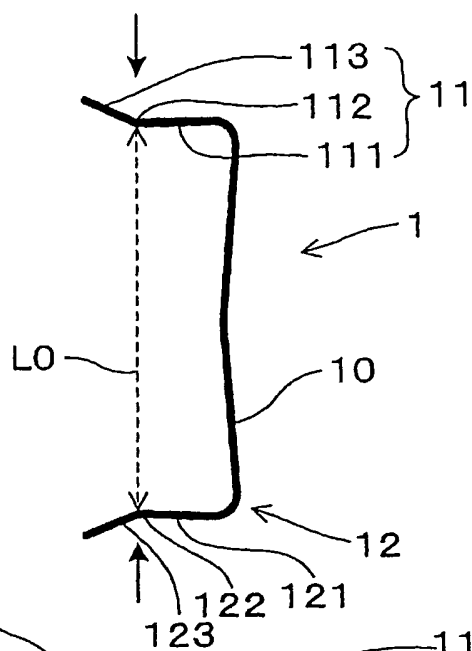


Fig. 6(b)

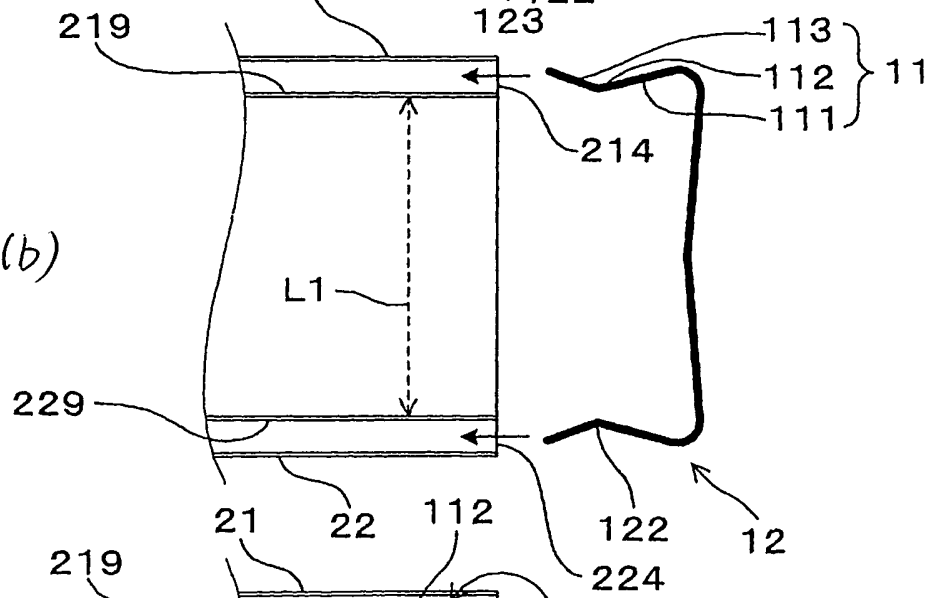
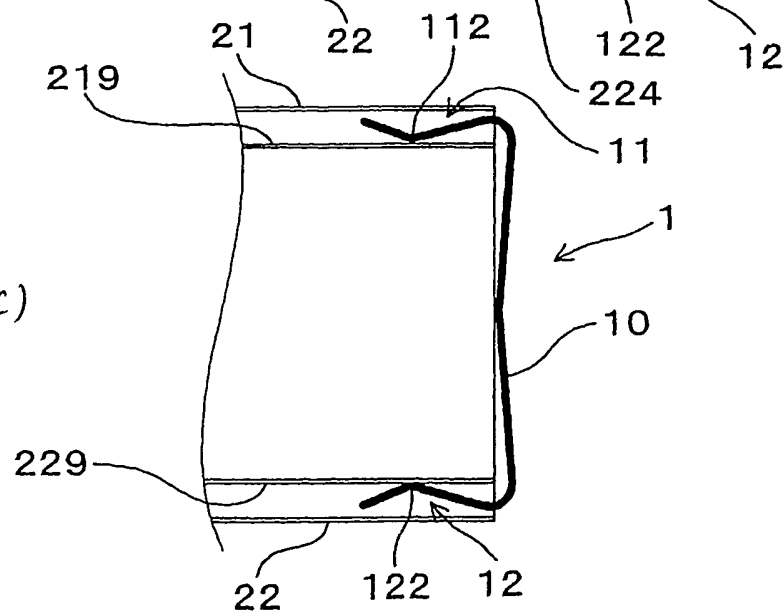


Fig. 6(c)



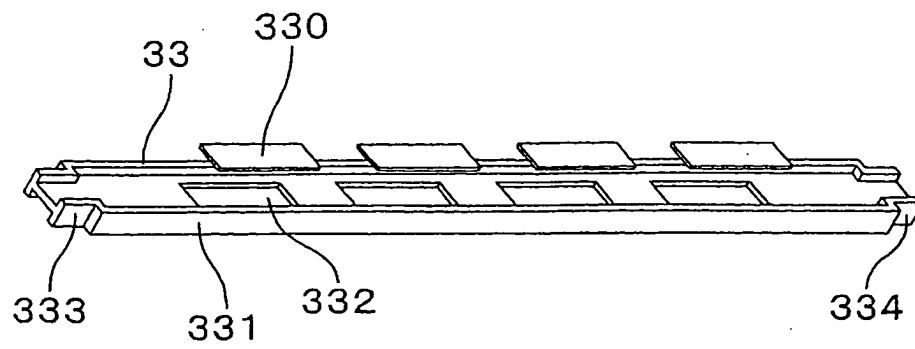


Fig. 7

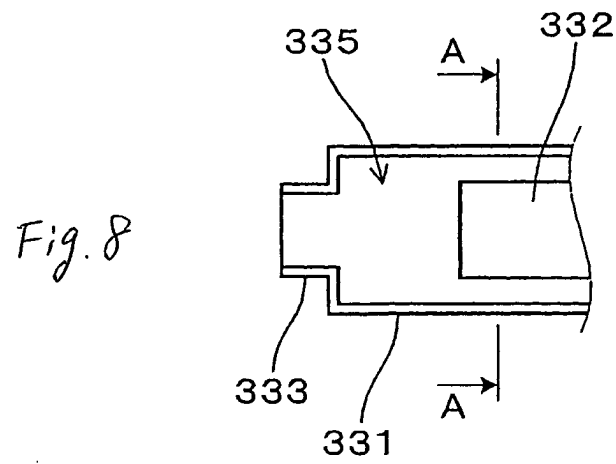


Fig. 8

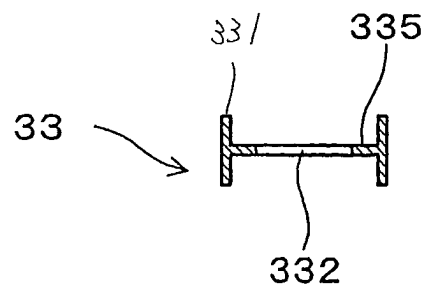


Fig. 9

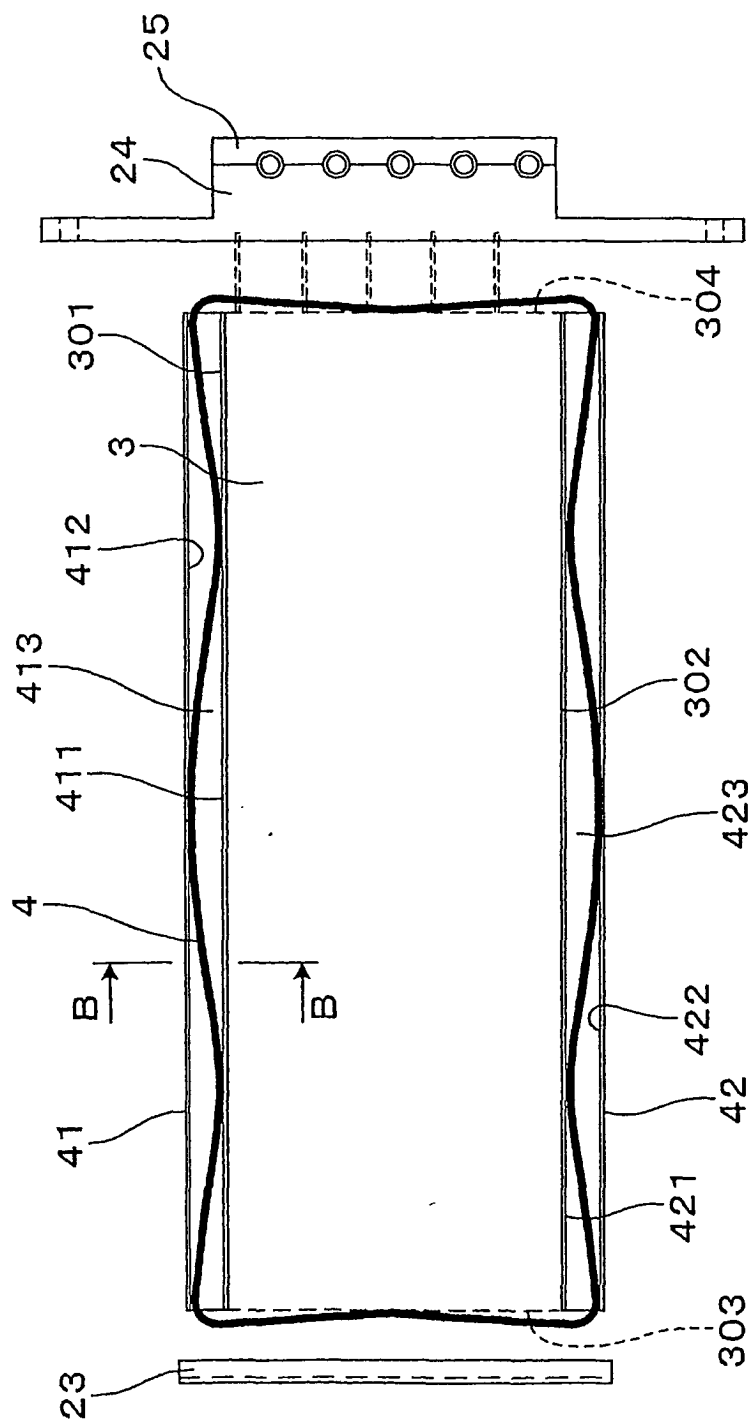


Fig. 10

Fig. 11

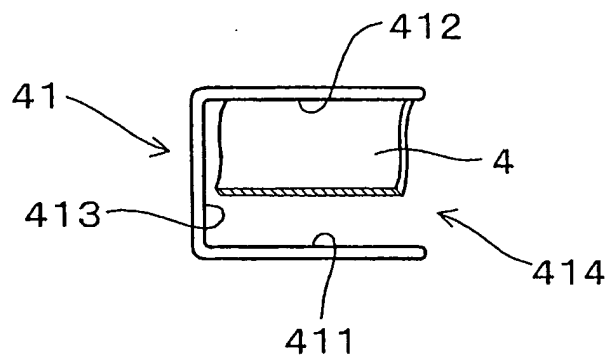


Fig. 12

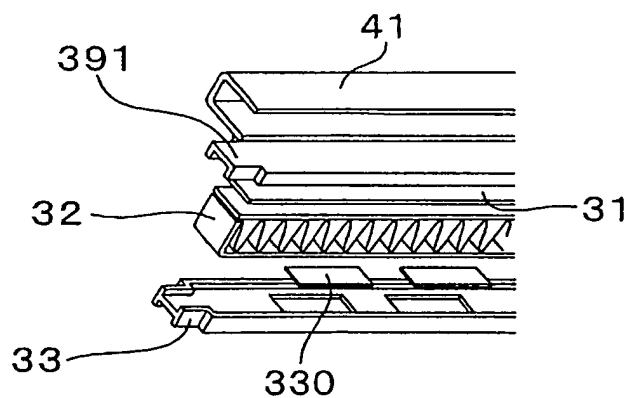
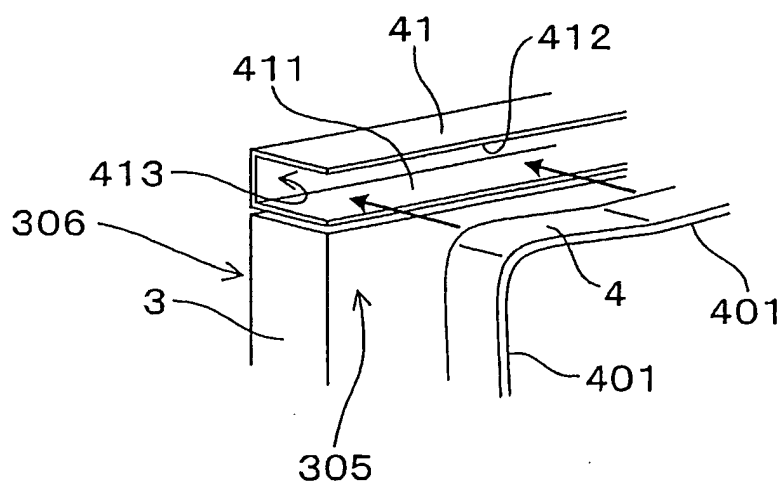


Fig. 13



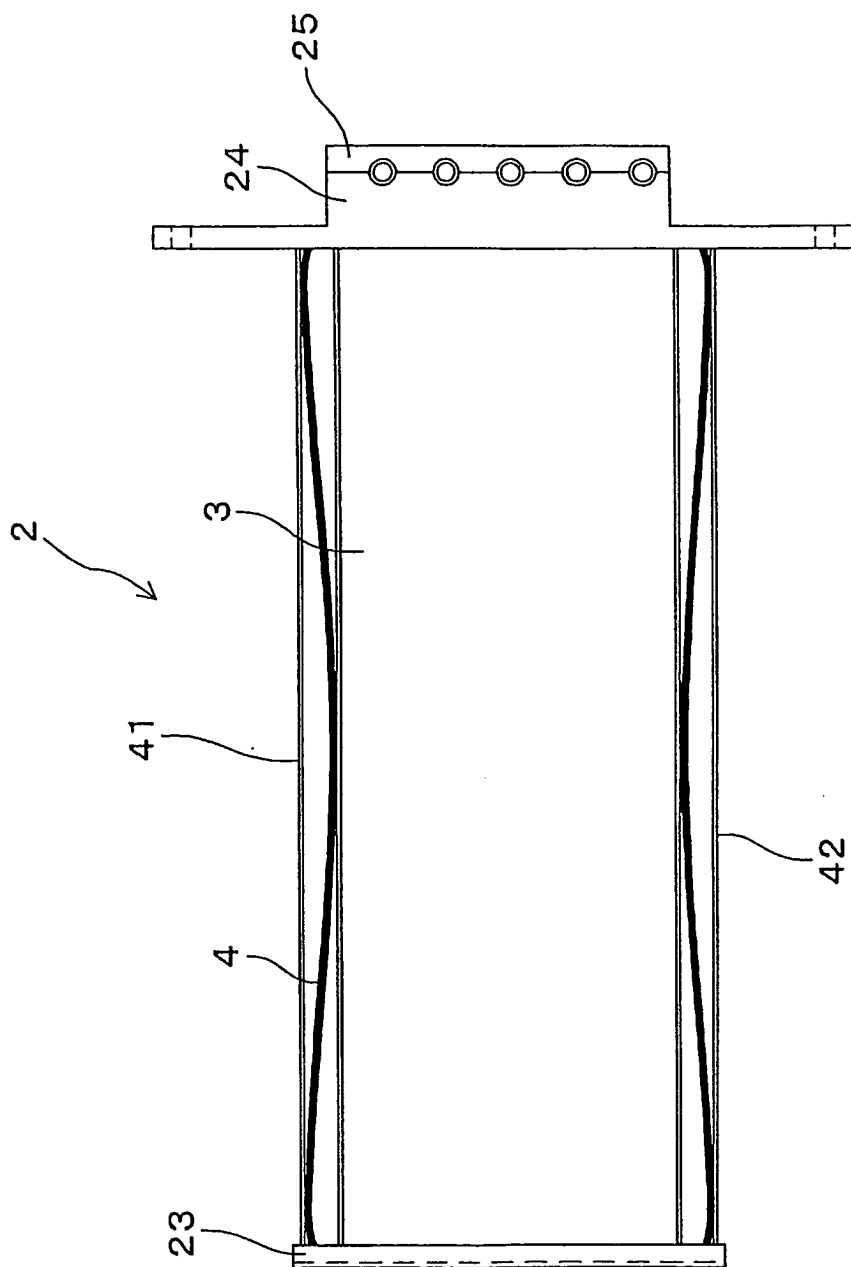


Fig. 14

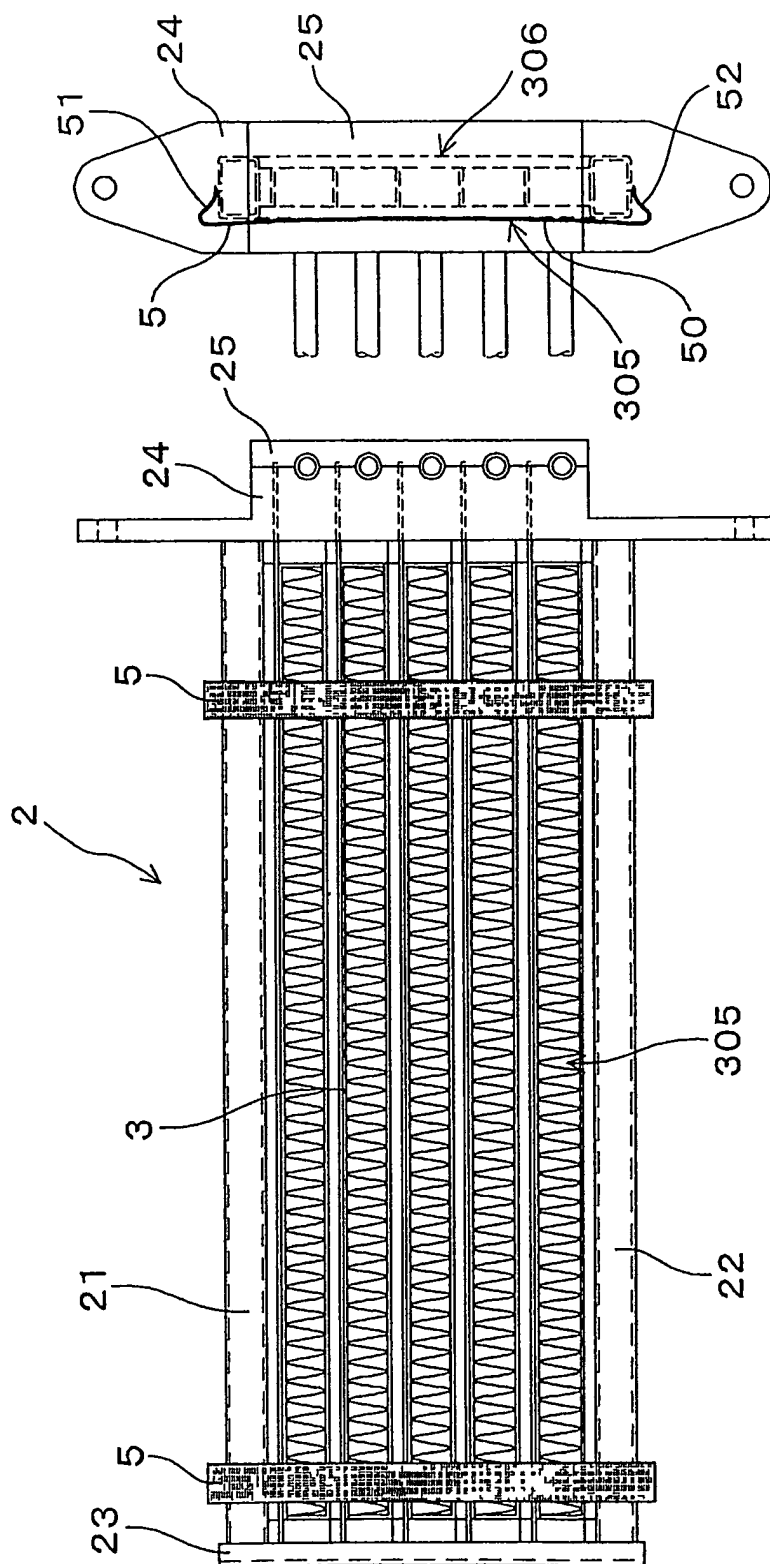


Fig. 15(b)

Fig. 15(a)

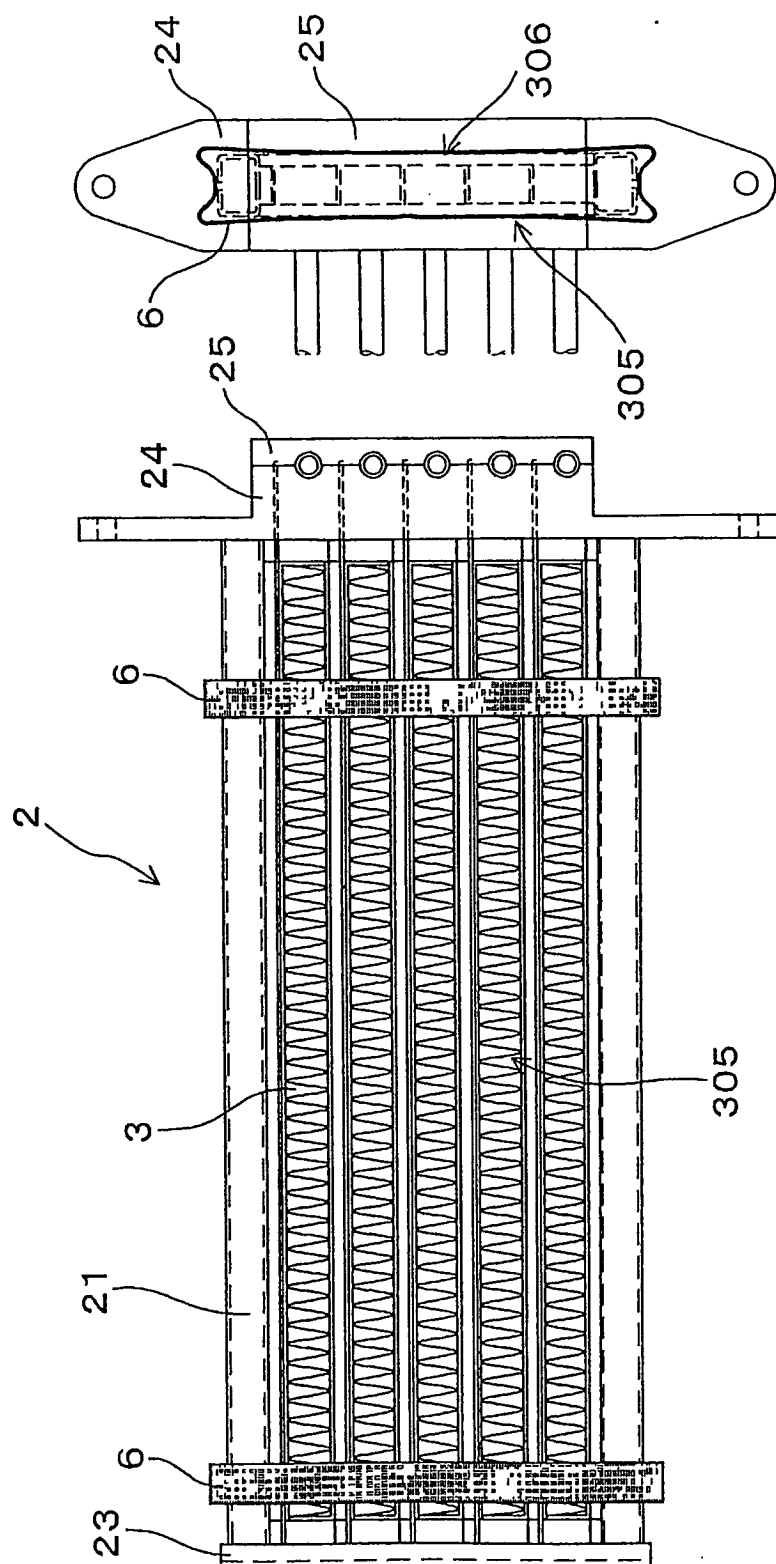


Fig 16(b)

Fig 16(a)

Fig 17(a)

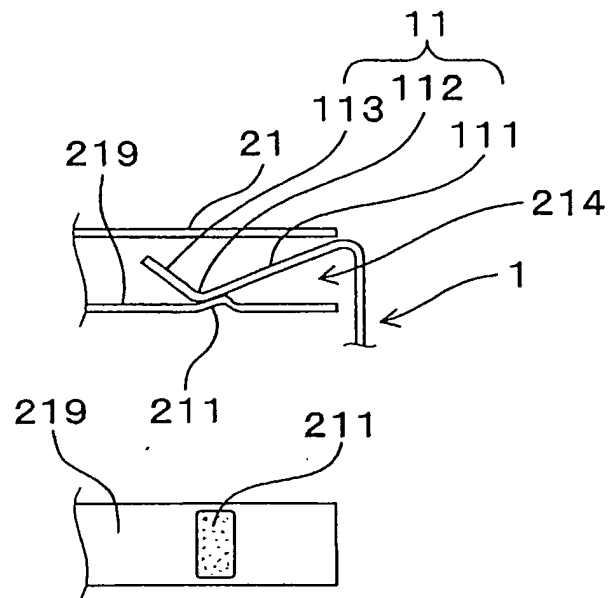


Fig 17(b)

Fig. 18(a)

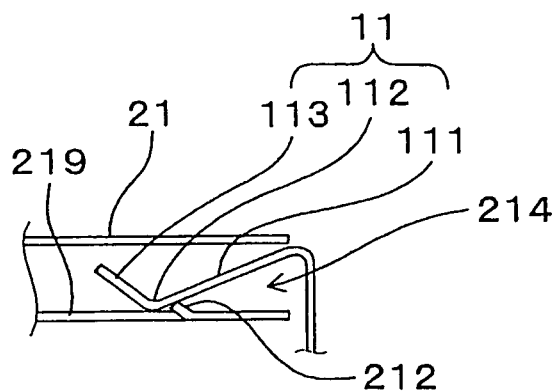


Fig. 18(b)

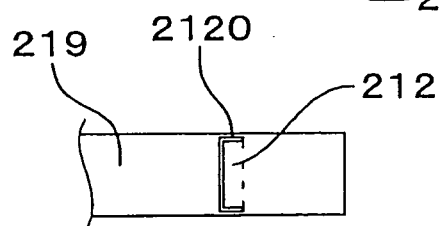


Fig. 19(a)

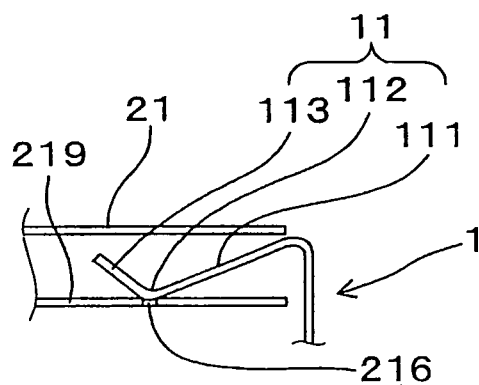
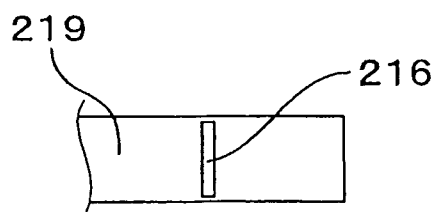


Fig. 19(b)



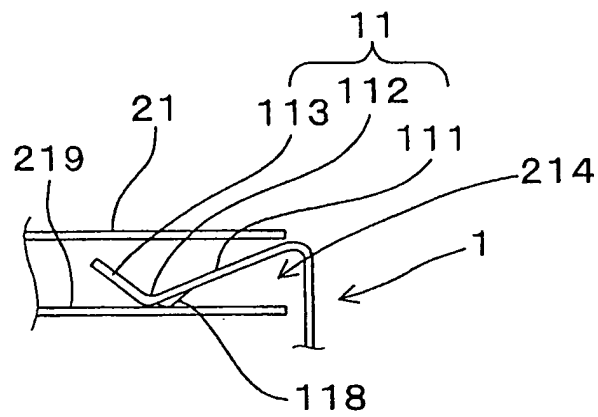


Fig. 20

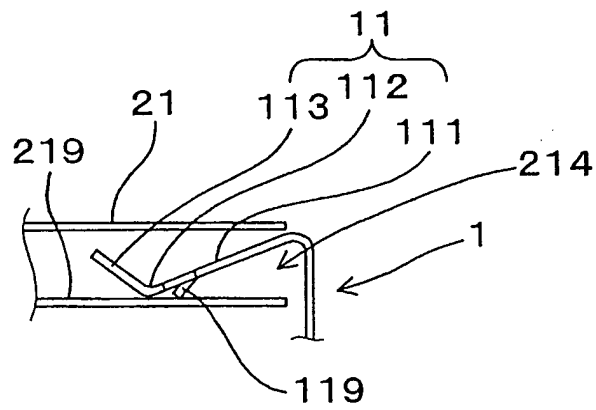


Fig. 21

Fig. 22(a)

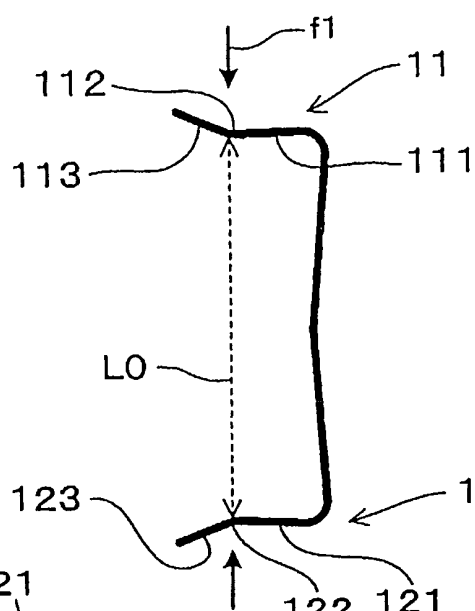


Fig. 22(b)

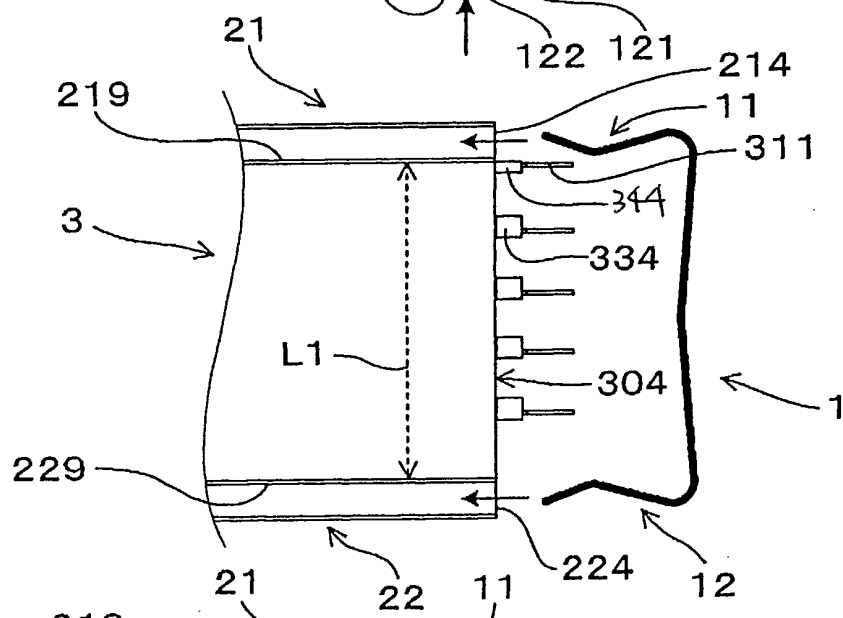
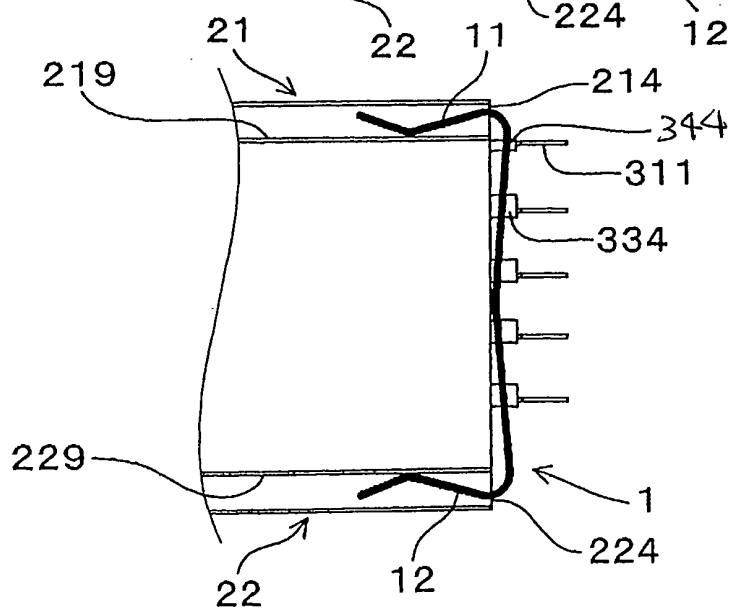


Fig. 22(c)



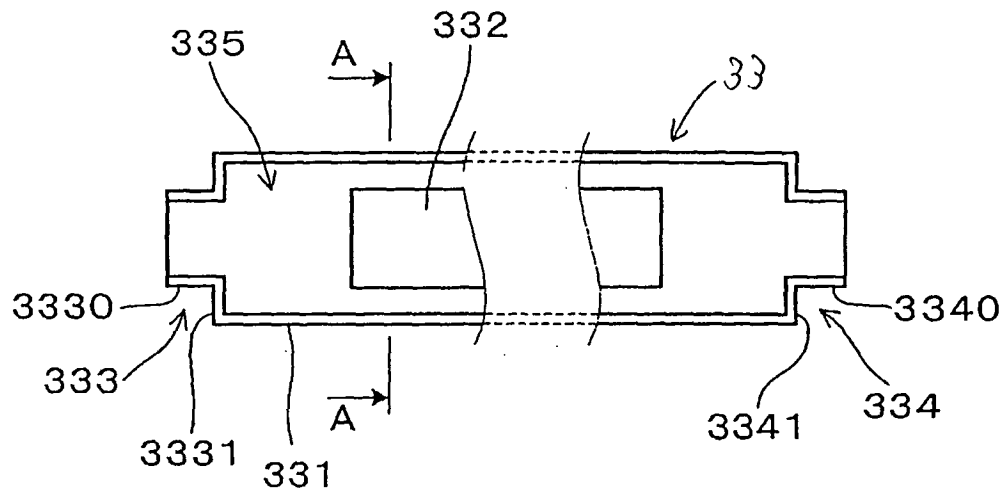


Fig. 23

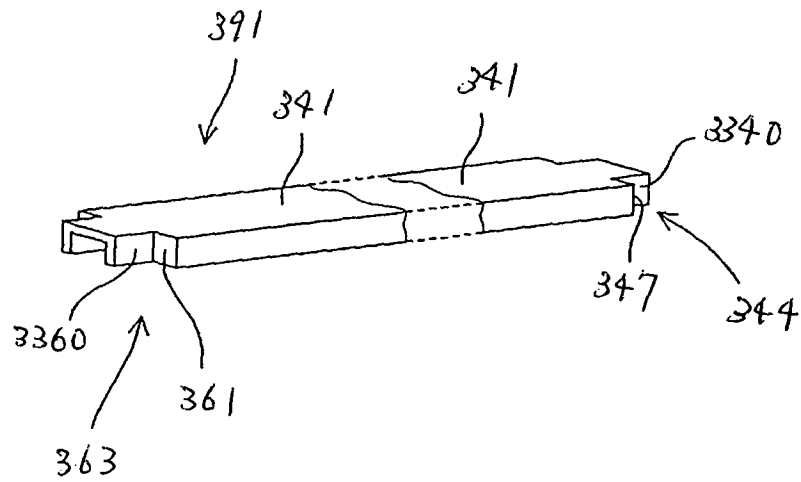


Fig. 24

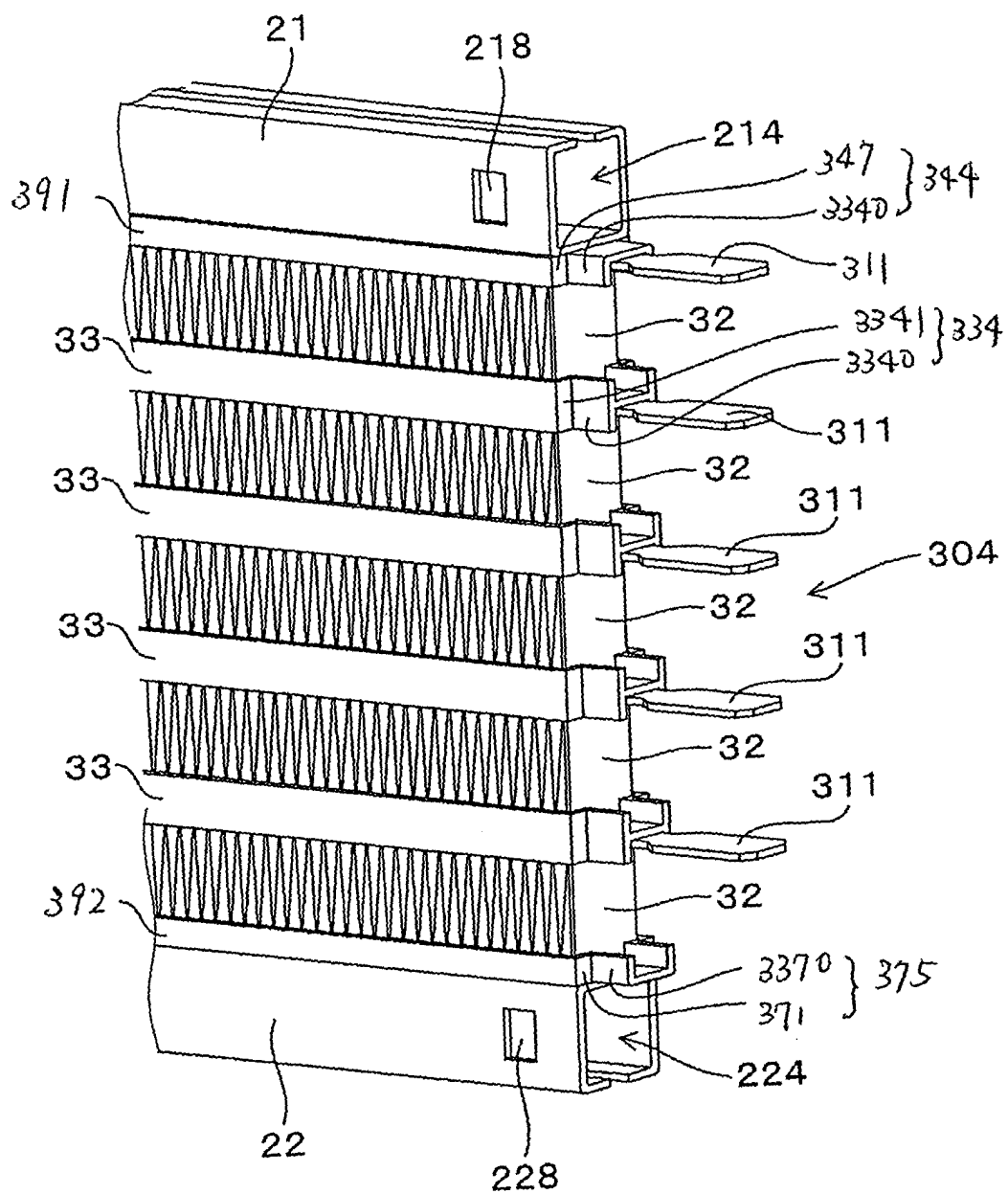


Fig 25

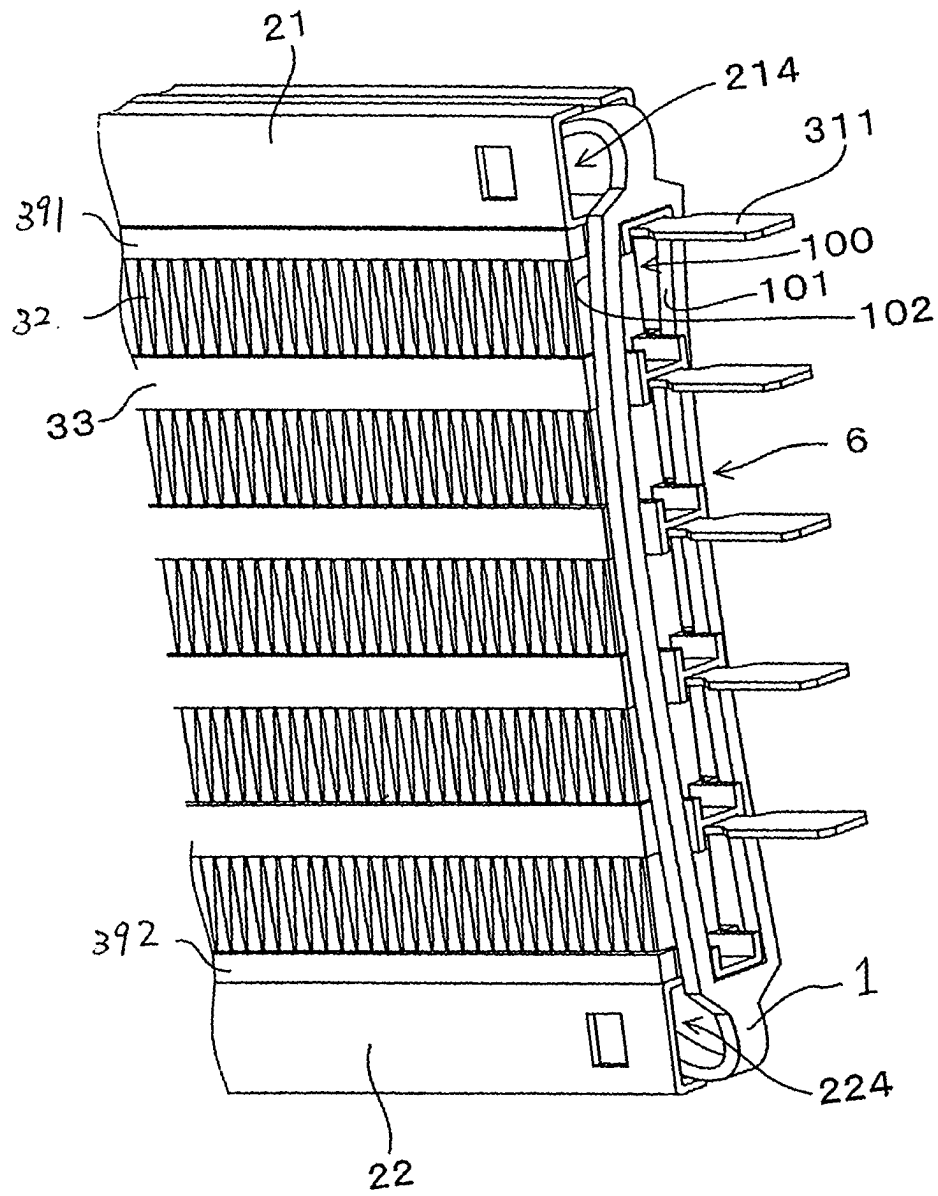


Fig 26

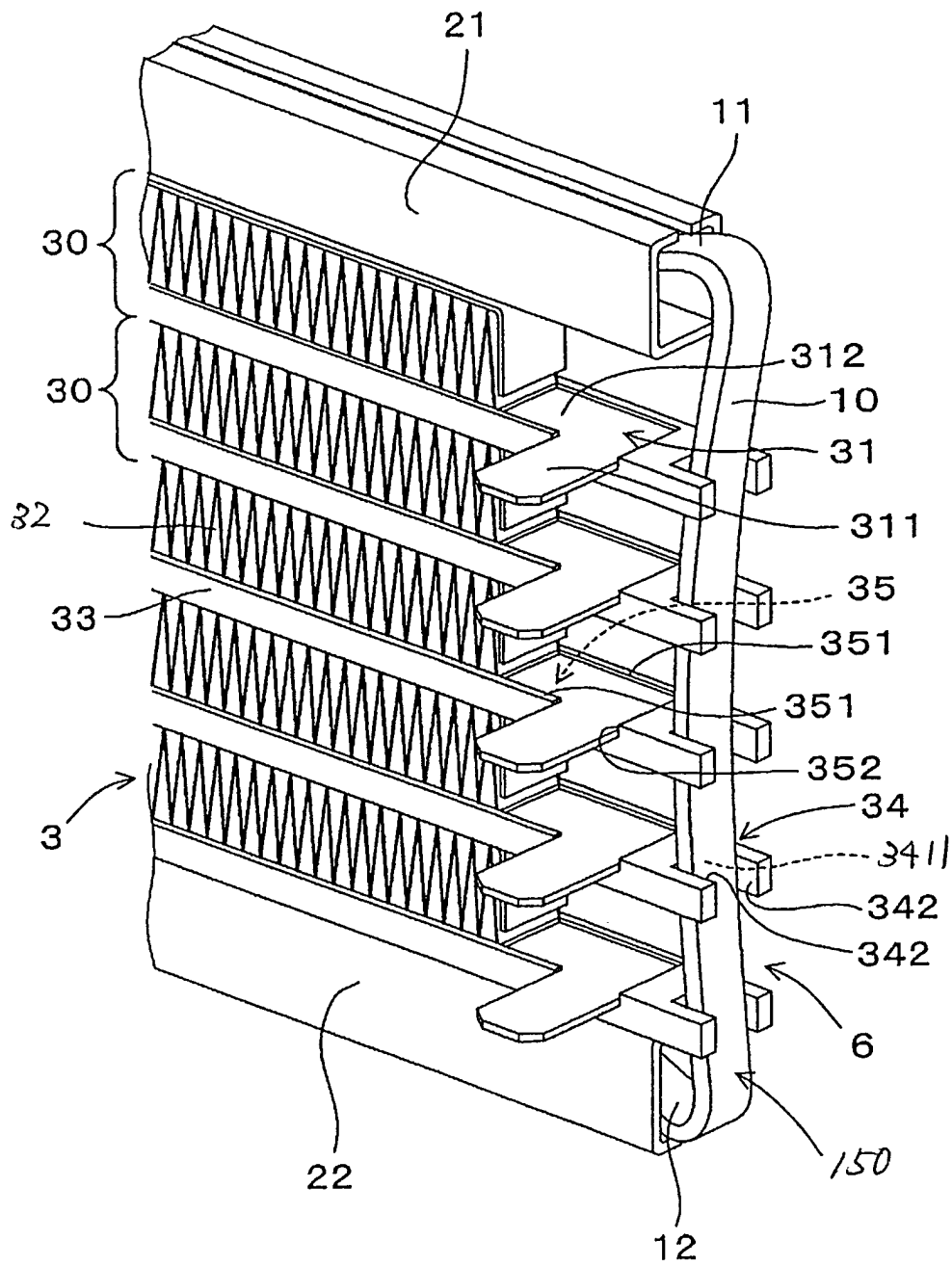


Fig 27

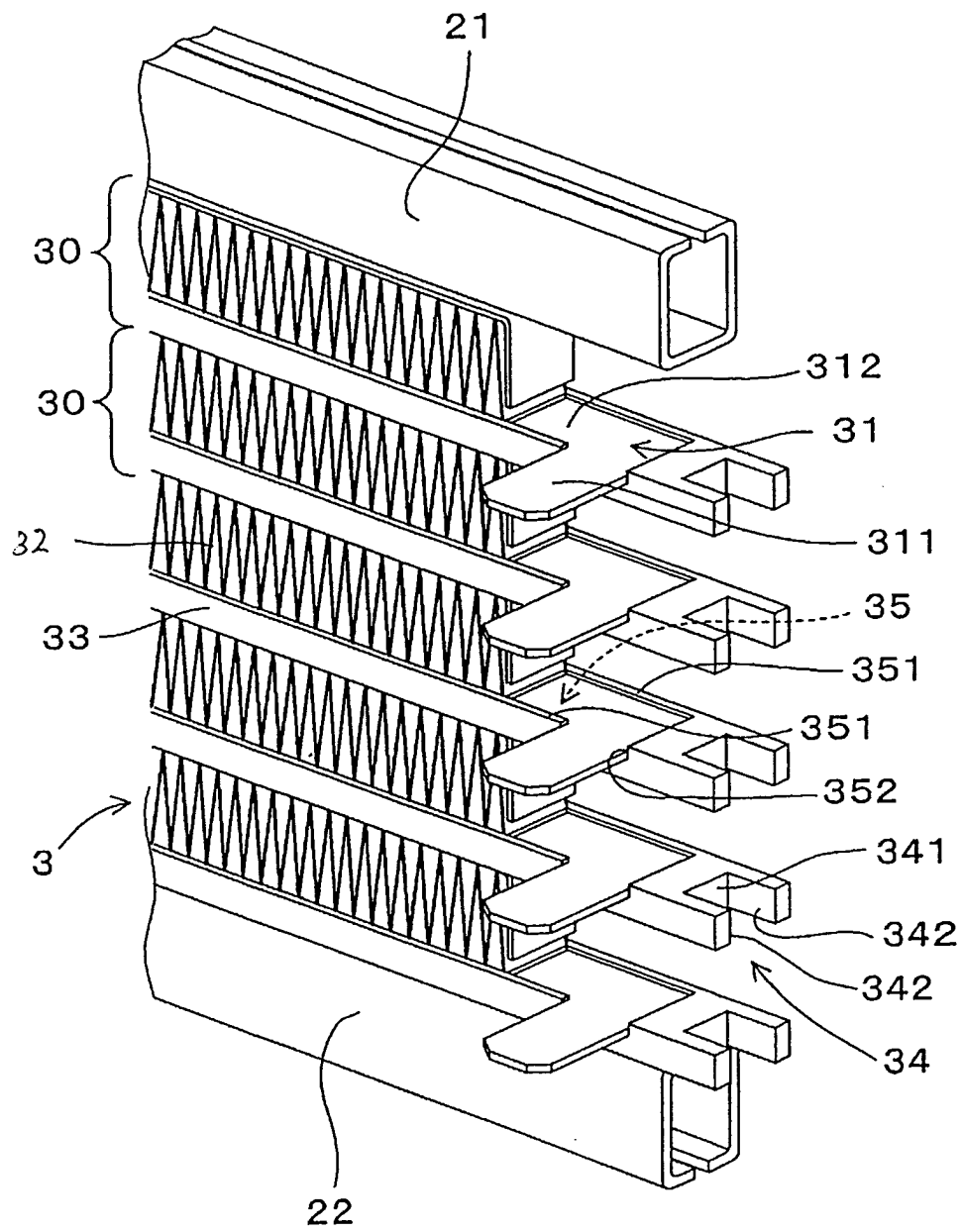


Fig 28

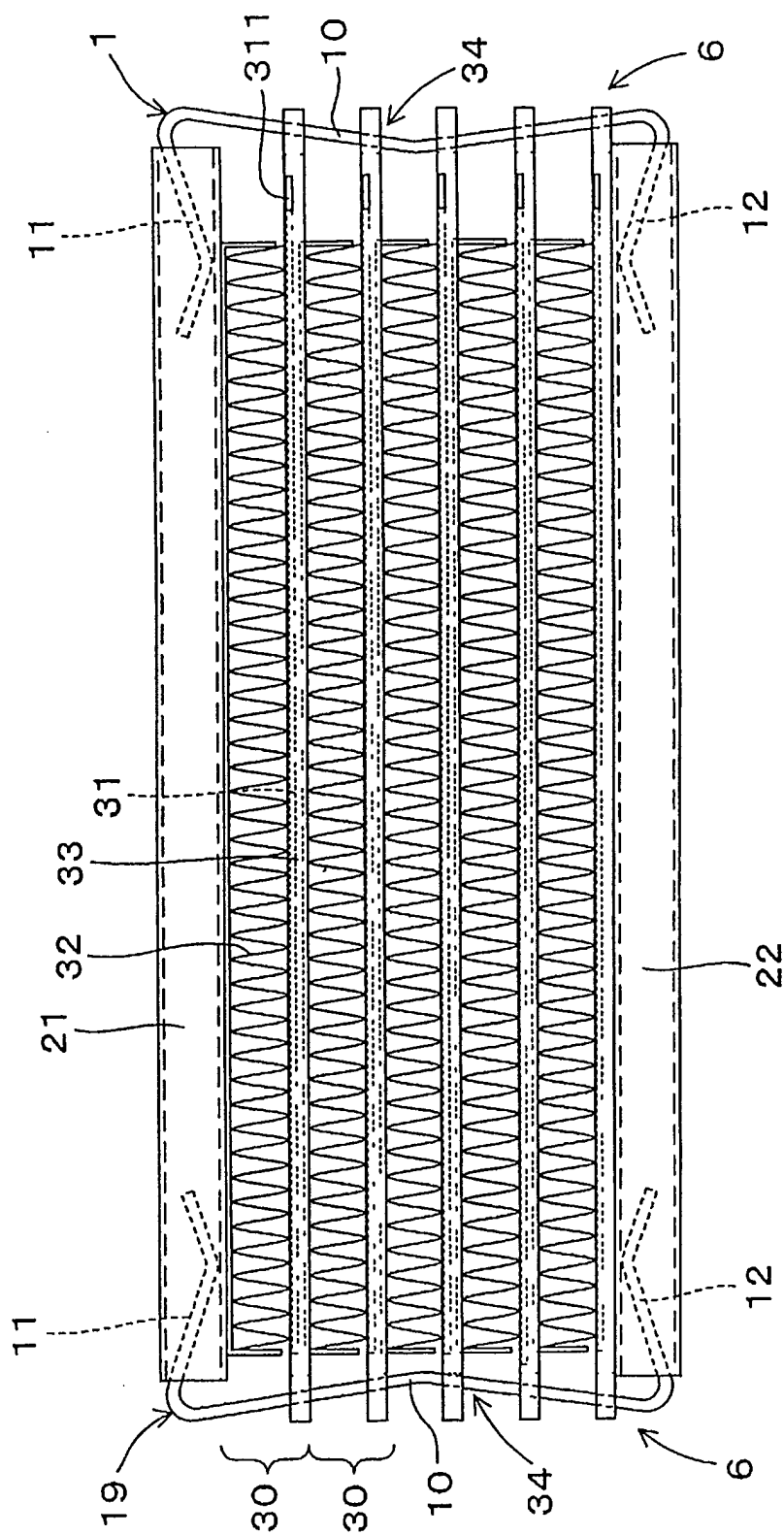


Fig. 29

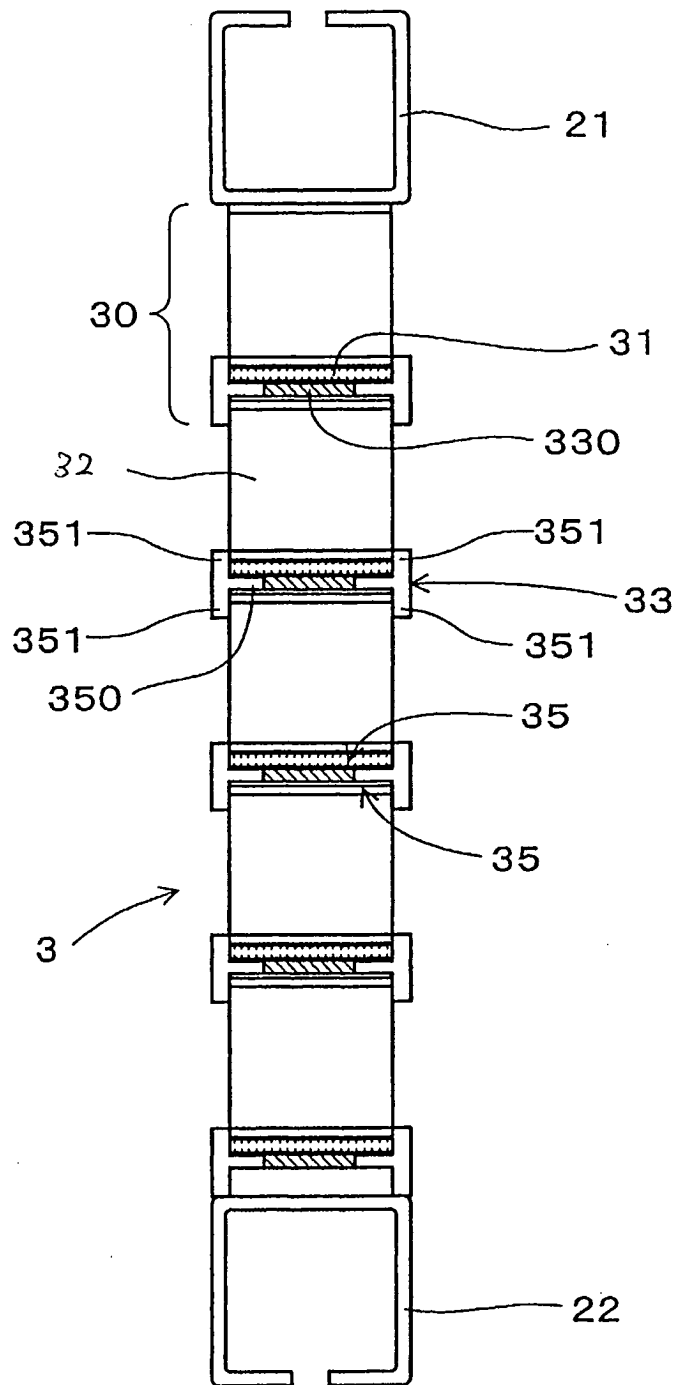


Fig. 30

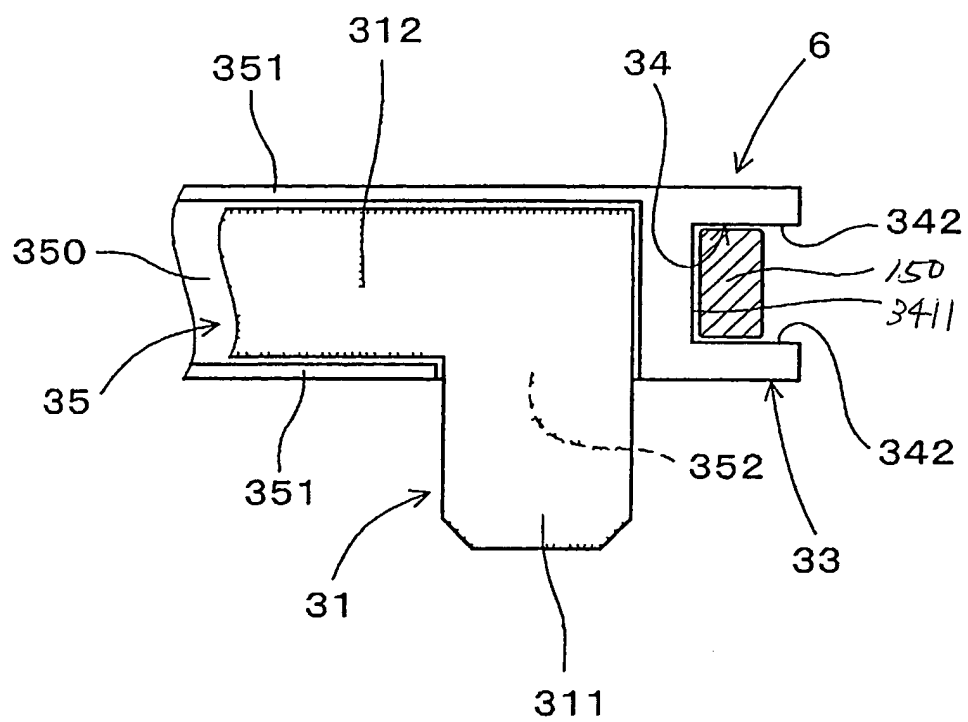


Fig. 31

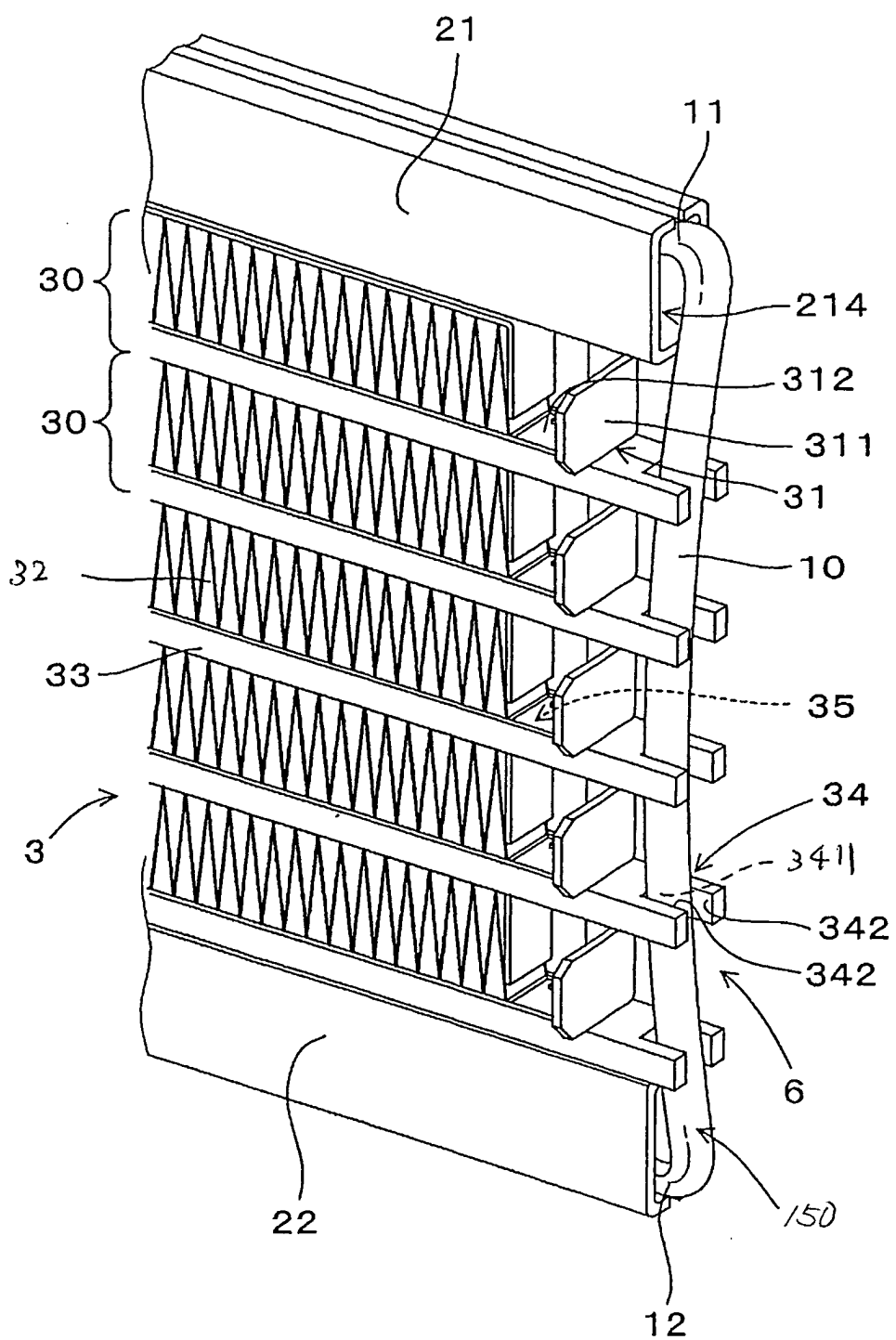


Fig. 32

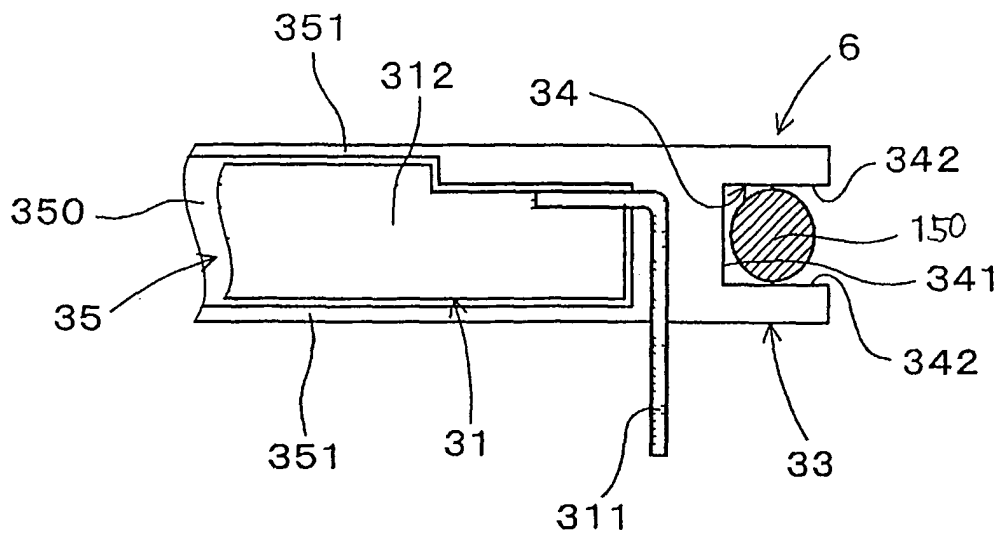


Fig.33

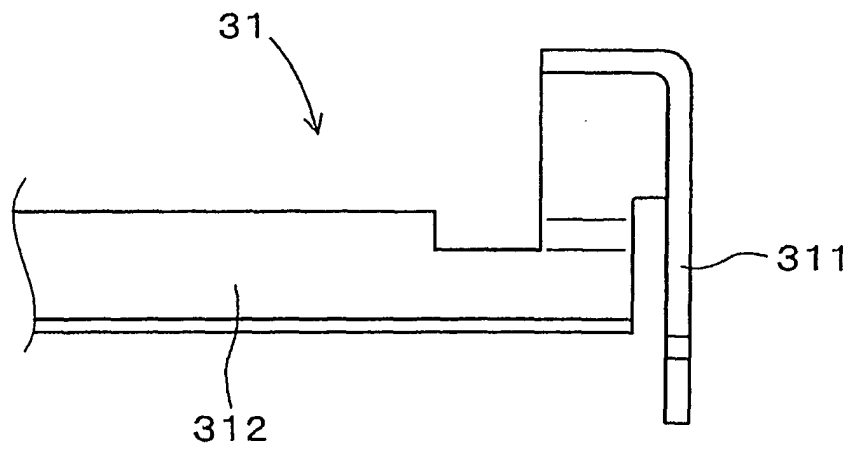


Fig.34

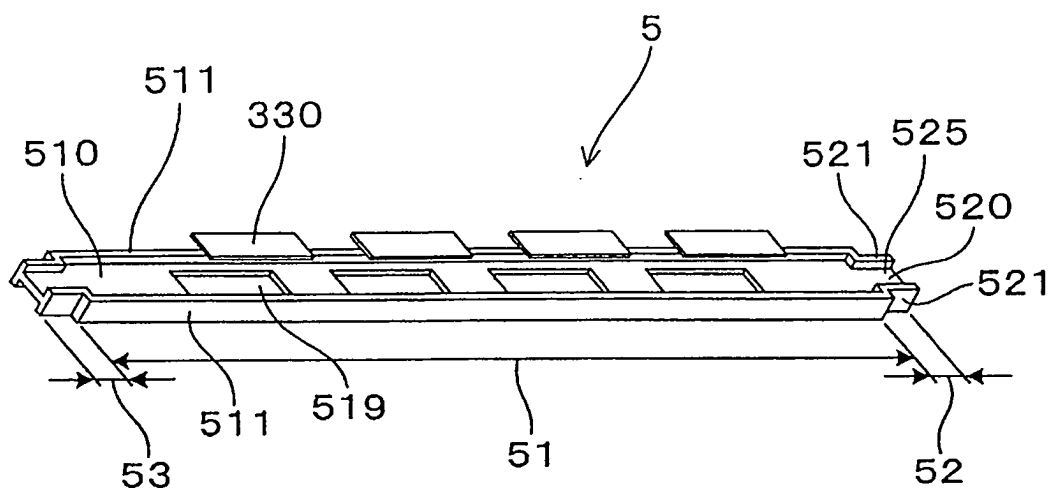


Fig. 35

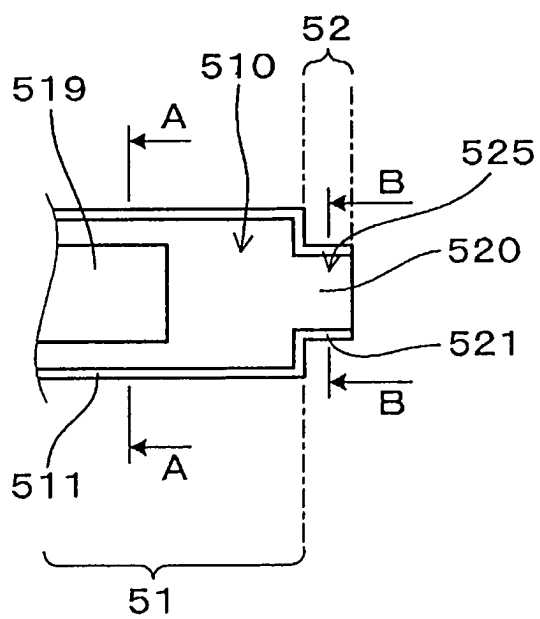


Fig. 36

Fig. 37

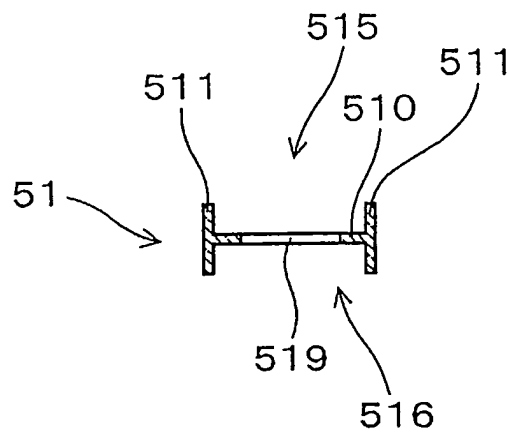
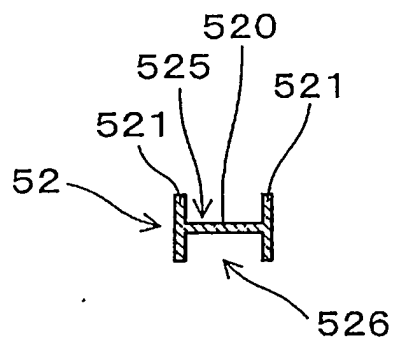


Fig. 38



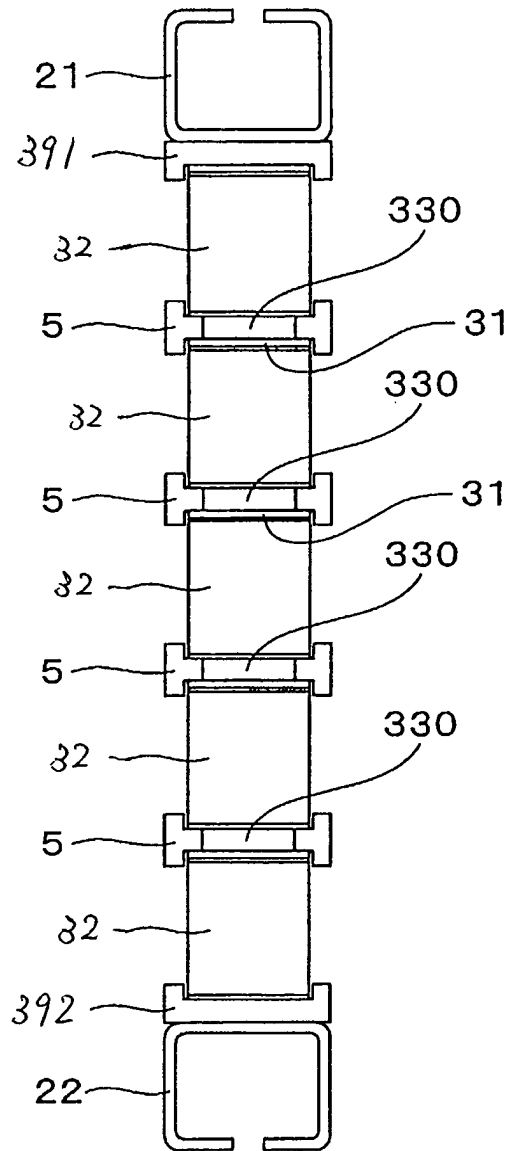


Fig. 39

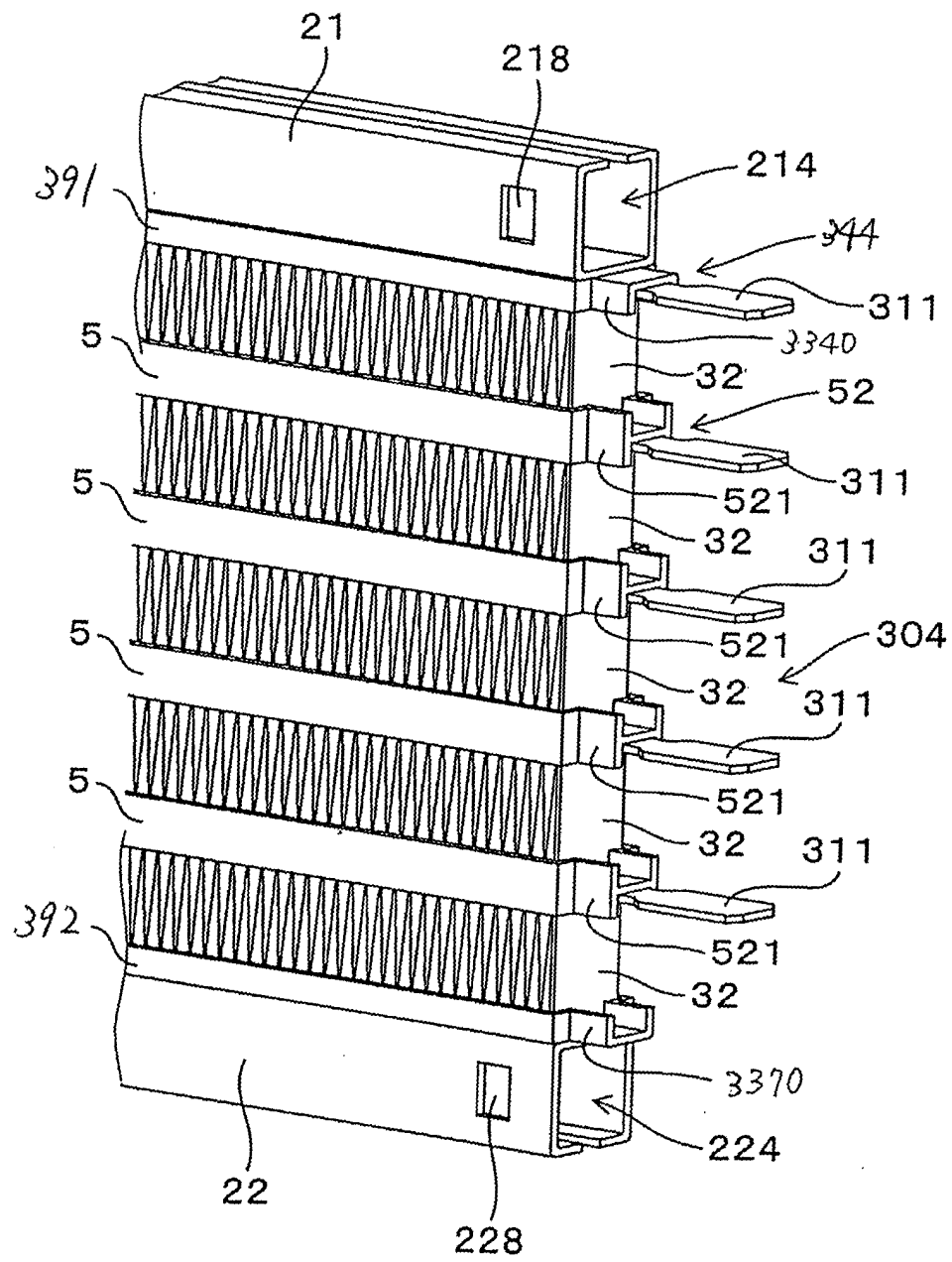


Fig 40

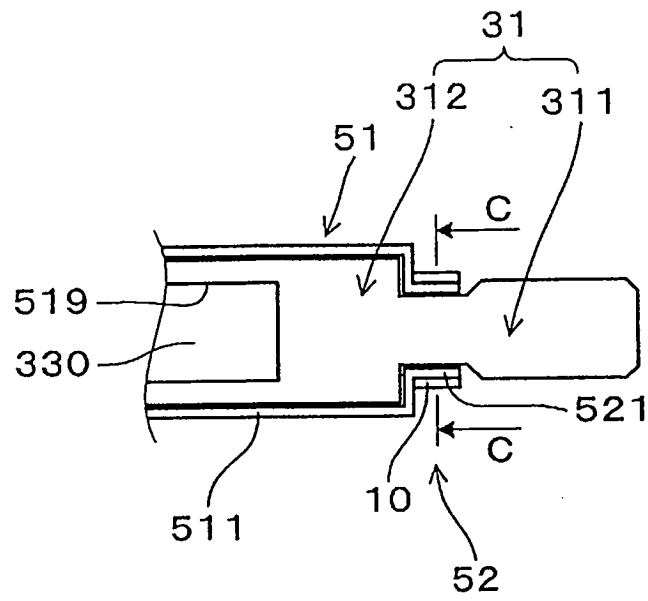


Fig. 41

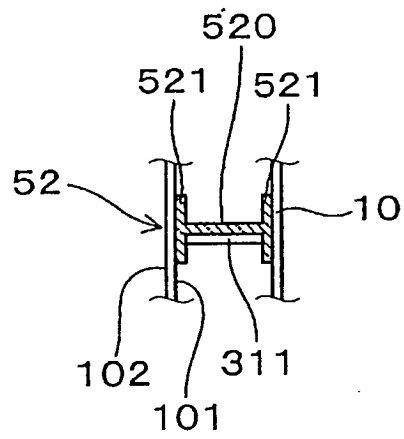


Fig. 42

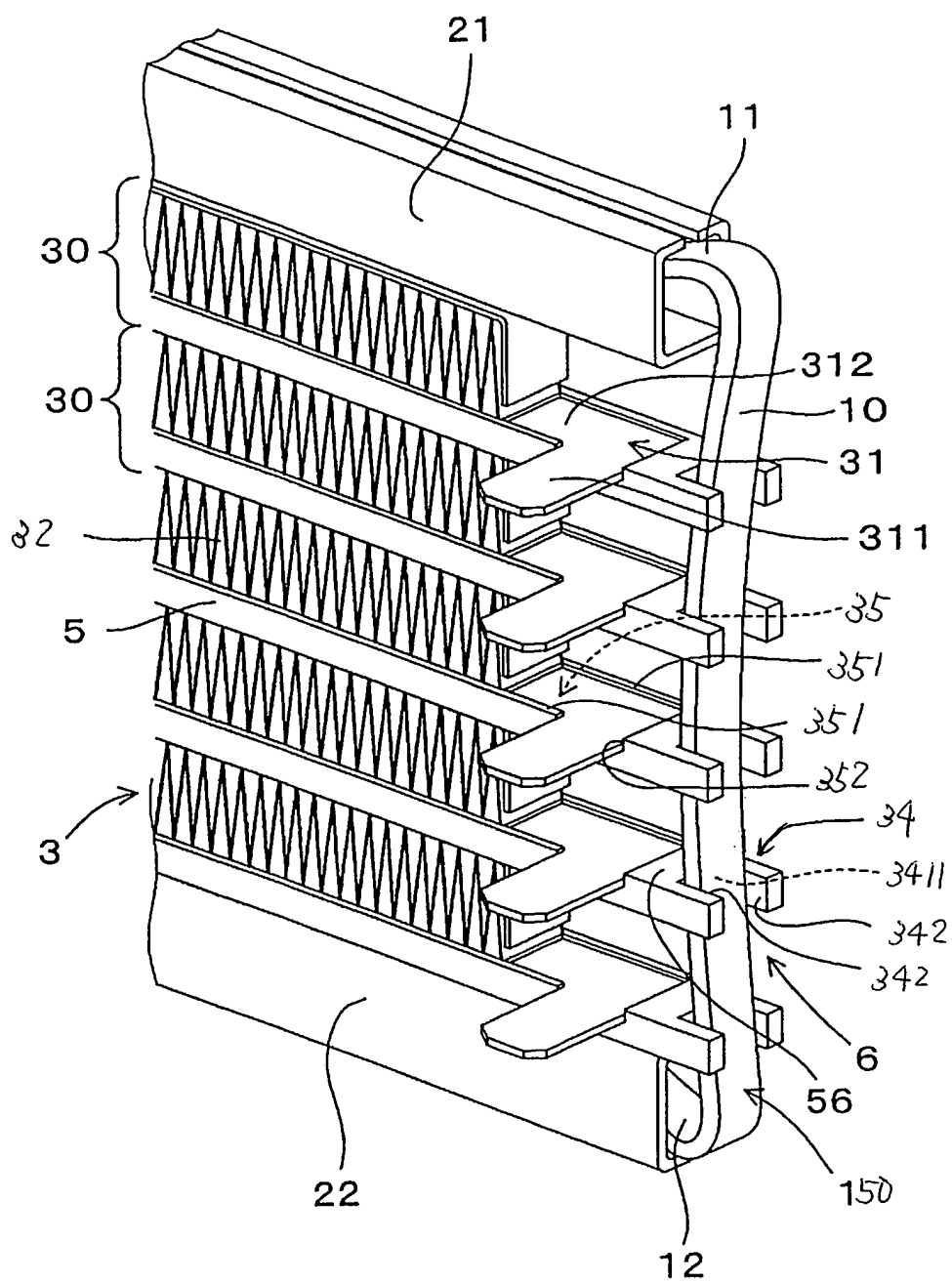


Fig. 43

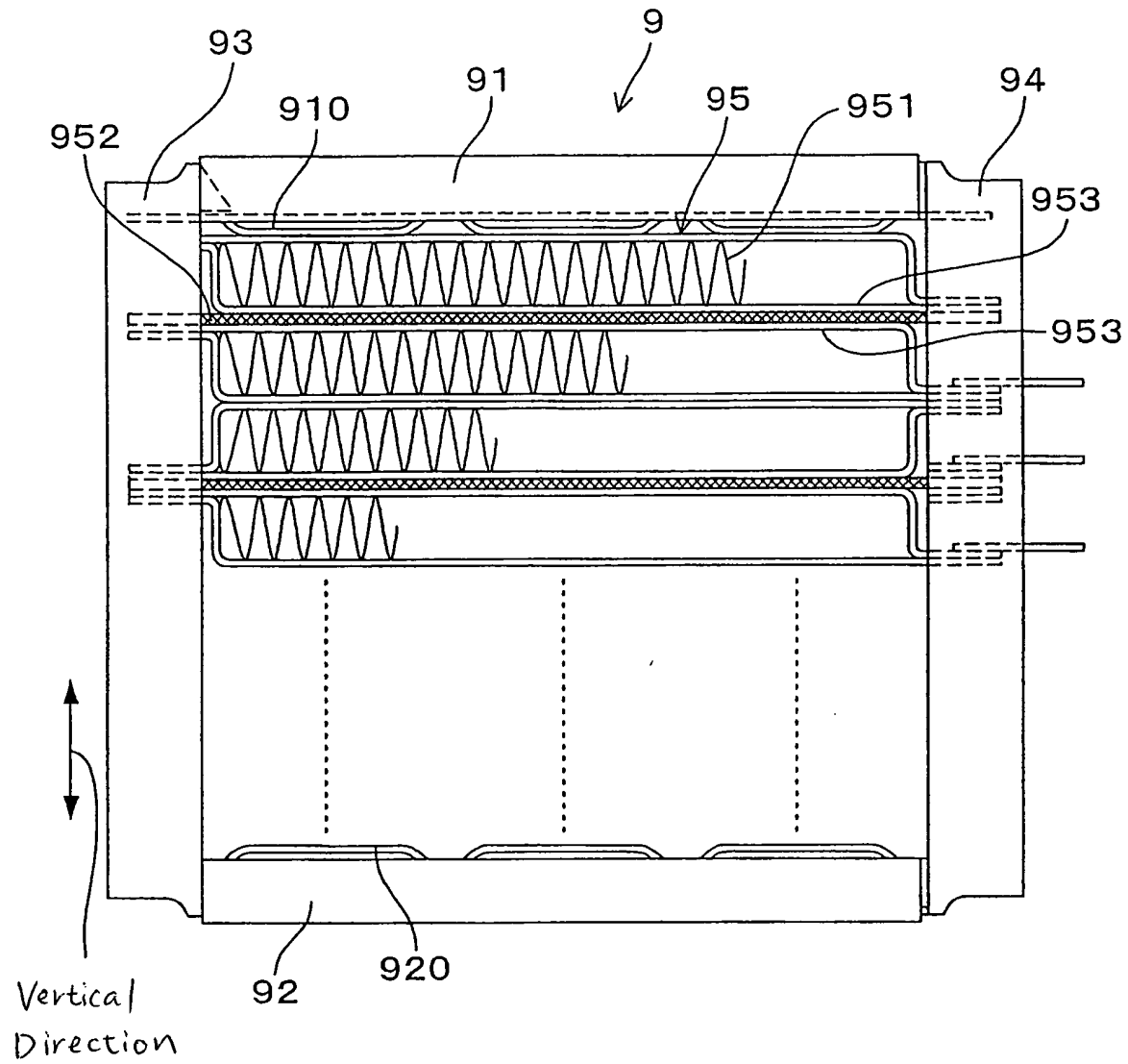


Fig 44

PRIOR ART



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 02 1604

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 5 562 844 A (DAVID JOSEF ET AL) 8 October 1996 (1996-10-08)	1-3, 5-10, 15-22	H05B3/14 H05B3/50 F24H3/04
Y	* abstract * * figures 2-4 * * column 3, lines 5-20 * * column 4, lines 19-65 * * column 5, lines 4-7 *	4,11-14	
Y	US 5 256 857 A (CURHAN JEFFREY A ET AL) 26 October 1993 (1993-10-26) * abstract * * figures 1-5 * * claim 1 *	4,11-14	
A	US 4 814 584 A (BOHLENDER FRANZ ET AL) 21 March 1989 (1989-03-21) * abstract * * figure 2 *	1-22	
A	DE 199 11 547 A (BEHR GMBH & CO) 21 September 2000 (2000-09-21) * abstract * * claim 1 * * figure 1 *	1-22	TECHNICAL FIELDS SEARCHED (Int.Cl.7) H05B F24H
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 18 November 2004	Examiner DE LA TASSA LAFORGUE
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			

1
EPO FORM 1503 03 92 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 04 02 1604

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

18-11-2004

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
US 5562844	A	08-10-1996	EP	0575649 A1	29-12-1993
			AT	145981 T	15-12-1996
			DE	59207626 D1	16-01-1997
			ES	2098394 T3	01-05-1997
			JP	3274234 B2	15-04-2002
			JP	7019781 A	20-01-1995
US 5256857	A	26-10-1993	CA	2048965 A1	23-02-1992
			JP	6123498 A	06-05-1994
US 4814584	A	21-03-1989	EP	0262243 A1	06-04-1988
			DE	3677603 D1	28-03-1991
			JP	63164193 A	07-07-1988
DE 19911547	A	21-09-2000	DE	19911547 A1	21-09-2000
			FR	2791004 A1	22-09-2000

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82