PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : F28D 9/00 — A1

(11) International Publication Number: WO 94/15162

(43) International Publication Date: 7 July 1994 (07.07.94)

(21) International Application Number: PCT/GB93/02633

(22) International Filing Date: 22 December 1993 (22.12.93)

(30) Priority Data:

9226929.9	24 December 1992 (24.12.92)	GB
9319066.8	15 September 1993 (15.09.93)	GB

(71)(72) Applicant and Inventor: ROSE, Michael, David [GB/GB]; Rose Environmental, Unit 1, Ventureline, Limberline Road, Hilsea, Portsmouth PO3 5BJ (GB).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: ROSE, Stephen, Christopher [GB/GB]; Rose Environmental, Unit 1, Ventureline, Limberline Road, Hilsea, Portsmouth PO3 5BJ (GB).

(74) Agent: BARKER, BRETTELL & BOUTLAND; Prudential Buildings, Room 24, 97-101 Above Bar Street, Southampton, Hampshire SO9 4GT (GB).

(81) Designated States: AT, AU, BB, BG, BR, BY, CA, CH, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, KZ, LK, LU, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SK, UA, US, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

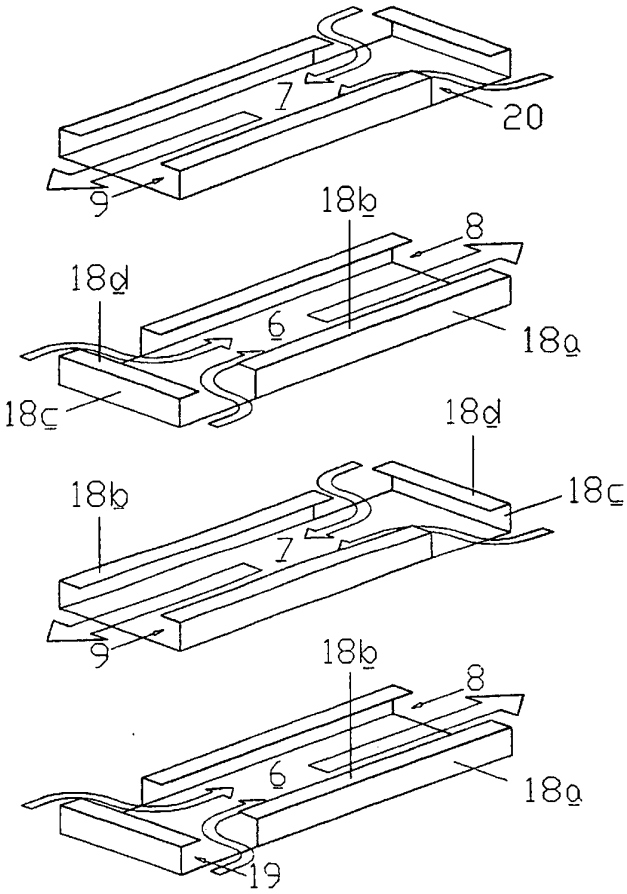
Published

With international search report.

(54) Title: IMPROVEMENTS IN OR RELATING TO PLATE-TYPE HEAT EXCHANGERS

(57) Abstract

With reference to the figure, a plate-type heat exchanger (5) comprises a close-packed stack of metal plates (18) of identical form, alternate plates in the stack being turned through 180°. The major parts of the longitudinal edges of the plates are formed with upright flanges (18a) with inwardly-extending extensions (18b). One end of each plate (18) is formed with an upright flange (18c) and inward extension (18d). The flanges and extensions (18a, 18b) etc., serve as plate stack spacers. Gaps (19, 20) and non-flanged ends define openings for air flows (6 and 7). The heat exchanger (5), (and modifications thereof) have particular use in air ventilating units, a number of which are described and illustrated in the accompanying disclosure.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	**GB**	United Kingdom	**MR**	Mauritania
AU	Australia	**GE**	Georgia	**MW**	Malawi
BB	Barbados	**GN**	Guinea	**NE**	Niger
BE	Belgium	**GR**	Greece	**NL**	Netherlands
BF	Burkina Faso	**HU**	Hungary	**NO**	Norway
BG	Bulgaria	**IE**	Ireland	**NZ**	New Zealand
BJ	Benin	**IT**	Italy	**PL**	Poland
BR	Brazil	**JP**	Japan	**PT**	Portugal
BY	Belarus	**KE**	Kenya	**RO**	Romania
CA	Canada	**KG**	Kyrgystan	**RU**	Russian Federation
CF	Central African Republic	**KP**	Democratic People's Republic of Korea	**SD**	Sudan
CG	Congo			**SE**	Sweden
CH	Switzerland	**KR**	Republic of Korea	**SI**	Slovenia
CI	Côte d'Ivoire	**KZ**	Kazakhstan	**SK**	Slovakia
CM	Cameroon	**LI**	Liechtenstein	**SN**	Senegal
CN	China	**LK**	Sri Lanka	**TD**	Chad
CS	Czechoslovakia	**LU**	Luxembourg	**TG**	Togo
CZ	Czech Republic	**LV**	Latvia	**TJ**	Tajikistan
DE	Germany	**MC**	Monaco	**TT**	Trinidad and Tobago
DK	Denmark	**MD**	Republic of Moldova	**UA**	Ukraine
ES	Spain	**MG**	Madagascar	**US**	United States of America
FI	Finland	**ML**	Mali	**UZ**	Uzbekistan
FR	France	**MN**	Mongolia	**VN**	Viet Nam
GA	Gabon				

IMPROVEMENTS IN OR RELATING TO PLATE-TYPE HEAT EXCHANGERS

This invention relates to plate-type heat exchangers and is particularly, but not exclusively, concerned with plate-type heat exchangers for air ventilating devices.

The invention has particular application to air ventilating devices for exhausting air from the interior of a building and for directing a replacement flow of air to the said interior.

Air ventilating devices are known which are adapted to be mounted in the outer wall of a building, and which incorporate a heat exchanger arranged to provide exchange of heat between the two flows of air. The existing devices are relatively bulky, require a relatively large hole to be provided in the wall and, in view of their size, can appear obtrusive when used in a domestic situation.

The present invention seeks to provide a relatively compact plate-type heat exchanger which can provide, in turn, a relatively compact air ventilating device.

According to the present invention, a plate-type heat exchanger comprises a close-packed stack of plates spaced from each other so as to define pairs of first and second fluid flow paths disposed in an alternate manner and in substantially parallel planes, wherein, on one exterior surface of the heat exchanger there is a first flow path opening in one plane and a second flow path opening in the immediately adjacent plane, the first and second openings being spaced substantially from each other.

The term 'exterior surface' includes both sides and ends of a heat exchanger according to the invention.

Thus, at one end of the heat exchanger, there may be first flow path opening in one plane, and at the opposite end of the heat exchanger

a second flow path opening in the immediately adjacent plane.

Each of the first and second flow paths may extends between one side of the heat exchanger and the opposite side thereof, each flow path taking place from adjacent one end of the heat exchanger to adjacent the opposite end thereof.

The first flow path may extend between one end of the heat exchanger and one side thereof, and adjacent the opposite end of the heat exchanger, and the second flow path may extend between one side of the heat exchanger, adjacent said one end thereof, and the said opposite end of the heat exchanger.

The heat exchanger may have the form of a polyhedron with first and second opposite ends and two oppositely- facing groups, each comprising at least two sides disposed between said ends, wherein the first flow path extends between at least one of the two oppositely-facing sides adjacent the first end of the heat exchanger to the second end thereof, and the second flow path extends between at least one of the two oppositely-facing sides adjacent the second end of the heat exchanger, to the first end thereof.

Preferably such a heat exchanger has the form of an octahedron, with the two groups each comprising three sides.

The invention also resides in an air ventilating device comprising the heat exchanger, in combination with fan means for promoting air flow through the flow paths of the heat exchanger.

The air ventilating device may comprise the heat exchanger disposed in a tubular structure located in the wall of a building together with the fan means operable to establish first and second air flow paths passing in counter direction between opposite sides of the wall.

The present invention also comprises a building having a wall with a ventilating device according to the invention installed therein.

Embodiments and aspects of the present invention will now be described, by way of example only, with reference to the accompanying drawings, wherein:

Figure 1 is an exploded view, in perspective, of a heat exchanger;

Figure 2 is a plan view, in section, of an air ventilating device, with parts removed;

Figure 3 is a similar view of the device, again with parts removed, taken in a different plane;

Figure 4 is an exploded view, in perspective, of part of one modification of the heat exchanger;

Figure 5 is an exploded view, in perspective, of part of another modification of the heat exchanger;

Figure 6 is an exploded view, in perspective of a third modification of the heat exchanger;

Figures 7 and 8 are views in perspective of two forms of modified air ventilating units;

Figure 9 is a side view in medial section of another form of air ventilating unit;

Figure 10 is a fragmentary view in perspective of yet a further form of air ventilating unit;

Figures 11 and 12 are plan views, taken in different horizontal planes, of a further form of air ventilating unit;

Figure 13 is an exploded view, in perspective, of the heat exchanger 5e of Figures 11 and 12;

Figure 14 is a view in perspective of the air ventilating unit of Figures 11 and 12;

Figure 15 is an exploded view, in perspective, of a modified heat exchanger 5f;

Figure 16 is a view in perspective of modified heat exchanger 5f of Figure 15;

Figure 17 is a view in perspective of an air ventilating unit incorporating the modified heat exchanger 5f of Figures 15 and 16, and

Figures 18, 19, 20 and 21 are views in perspective of modified forms of air ventilating units.

Some of the above-listed figures have been prepared with the aid of a computer, and comprise wire-frame illustrations.

With reference to Figures 1, 2 and 3, an air ventilating device 1 comprises a tubular housing 2, a first fan 3 disposed at one end of the housing 2, a second fan 4 disposed at the other end of the housing 2, and a heat exchanger 5 disposed within the housing 2. The heat exchanger 5 defines a plurality of substantially parallel first and second flow paths 6, 7 disposed in an alternate manner and in substantially parallel planes. First duct means 8 are provided whereby the first flow paths 6 are in air flow communication with the first fan 3 and second duct means 9 are provided whereby the second flow paths 7 are in air flow communication with the second fan 4.

The fans 3, 4 are coaxially displaced, being rotatable about a substantially central common axis 15. The fans 3, 4 are driven by variable speed electric motors (not shown).

The ventilating device 1 is installed in a cavity wall 16 of a building. Fan 4 is an extraction fan which draws fresh atmospheric air into the interior 17 of the building. Fan 3 is an extraction fan which draws stale air out of the building.

The heat exchanger 5 is a plate-type heat exchanger comprising a close-packed stack of metal plates 18. The superimposed plates 18 are of identical form but alternate plates are turned through 180°.

The heat exchanger 5 is of prismatic form, having rectangular sides and ends spaced from each other so as to define pairs of first and second flow paths 6, 7. On opposite (side) exterior surfaces of the heat exchanger 5 there are openings 19 in one set of plates 18 for flow paths 6 and openings 20 in an alternate, parallel set of plates 18 for flow paths 7. The first and second openings 19, 20 are spaced substantially from each other.

The plates 18 have a rectangular (oblong) plan form. The major parts of the longitudinal edges of the plates 18 are formed with upright flanges 18a with inwardly-extending flange extensions 18b. One end of each plate 18 is formed with an upright flange 18c with an inwardly-extending flange extension 18d. The volumes bounded by the flanges 18a comprise the ducts 8 or 9, depending on the orientation of a plate 18.

The flanges 18a, 18b, 18c, 18d serve as spacers whereby the superimposed plates 18 are spaced vertically from each other.

Gaps exist between the flanges 18a, 18c. These gaps define the lateral air intakes or openings 19 or 20, again depending on plate orientation. The air openings 19, plus exterior baffles 21, form part of the duct means 8. The scoop-like baffles 21 are open to the interior 17 of the building.

In operation, fan 3 draws stale air from the interior 17 of the building, and expels it to the exterior thereof. The stale air,

which contains heat, enters the device 1 by way of the baffles 21, the lateral openings 19, and the flow paths 6. As the air passes along the flow paths 6 to the fan 3, it gives up heat to the adjacent metal plates 18 before being expelled to atmosphere.

At the same time, a counter-directional, substantially parallel, flow of air is caused to take place under the influence of the fan 4. This counter-directional flow enters the device by way of the sideways facing air openings 20 and the flow paths 7, before entering the interior 17 of the building. The second, inward, flow of air passes in heat exchange with the metal plates 18, whereby heat given up by the outward flow of air is transferred to the inward flow, before this inward flow is discharged to the building interior 17 by the fan 4.

Thus stale air drawn from the building interior 17 is continually replaced by heated fresh air. It has been estimated that about 80% of heat is recovered by the device 1.

As the air flow openings 19, 20 face in lateral directions (relative to the longitudinal axis of the device 1), air flow therethrough does not interfere with air flow through the fans 3, 4.

The air flow paths 6, 7 are generally 'Y'-shaped.

Grills 25, 26 may be provided in front of the fans 3, 4. Similar grills may be disposed in the air openings 20, 21.

The fans 3, 4 may be driven by a single motor.

The heat exchanger 5 need not be of metal.

In a non-illustrated modification, applicable to the arrangements yet to be described, the flange portions 18a, 18b, 18c, 18d are replaced by strips of material, for example, plastics material bonded to plain, i.e. flat, plates 18. The strips are preferably of

rectangular cross-section, viewed along their lengths and, like the flange portions 18a etc, serve as plate spacers. However, the ducts 8, 9 now comprise the remaining volumes between superimposed plates 18.

The ventilating device 1 described and illustrated is so compact that it can be installed in an opening of 220 mm x 220 mm, say one brick wide and three bricks deep, and can exchange about 216 cubic metres of air per hour.

Figure 4 illustrates a modified heat exchanger 5a (see also Figure 7) using plates 18 of Figure 1 modified whereby in Figure 4 the uppermost plate 18 of the heat exchanger 5a has one end and one side opening blanked-off as indicated by shaded areas 40, 41, and a different side opening 42 provided on the same side as blanked-off area 41, but spaced substantially therefrom. Side opening 42 is indicated by criss-cross shading.

In the lowermost plate 18 of Figure 4, one end and one side opening have been blanked-off as indicated by shaded areas 45, 46, and a different side opening 47 provided on the same side as the blanked-off area 46, but spaced substantially therefrom. Side opening 47 is indicated by criss-cross shading.

The modification illustrated by Figure 4 results in each of the first and second air flow paths 50, 51 extending from one side exterior surface of the heat exchanger 5a to the other and opposite side exterior surface thereof, each flow taking place from adjacent one end of the heat exchanger to adjacent the other and opposite end thereof.

The flow paths 50, 51 are generally S-shaped or serpentine.

In the modification illustrated by Figure 5, the two plates 18 of a heat exchanger 5b (see also Figure 8) each have one side opening blanked-off, as indicated by shaded areas 55, 56. The blanked-off

side openings indicated by shaded areas 55, 56, are on a common side of the heat exchanger. The modification results in the first air flow path 57 extending from the side opposite to said common side of the heat exchanger, adjacent one end thereof, to the opposite end of the heat exchanger. The second air flow path 58 extends from said one end exterior surface of the heat exchanger to said side exterior surface opposite and adjacent said opposite end of the heat exchanger.

The flow paths 57, 58 are generally 'L'-shaped.

In the modification illustrated by Figure 6, the two plates 18 of heat exchanger 5d (see also Figure 10) each have oppositely-disposed side openings blanked-off, as indicated by shaded areas 61, 62. The blanked-off openings are adjacent opposite ends of the heat exchanger.

This results in a first air flow path 63 extending from one side exterior surface of the heat exchanger, (the side opposite to the blanked-off opening indicated by shading 61), adjacent one end exterior surface of the heat exchanger, to the opposite end thereof. Also, a second air flow path 64 extending from one side of the heat exchanger, (the side opposite to the blanked-off opening indicated by shading 62), adjacent one end of the heat exchanger, (the end opposite to said one end referred to in the preceding sentence) to the opposite end thereof.

The flow paths 63, 64 are generally 'L'-shaped.

The modifications of the original heat exchanger illustrated by Figures 4, 5 and 6, result in alternative compact forms of heat exchanger.

In each case, the pairs of modified plates are repeated so as to form a heat exchanger stack of prismatic form.

Figures 7 and 8 show the heat exchangers 5a, 5b incorporated in air ventilating units 70, 71 respectively, both heat exchangers being demountably fixed to the inner face of outer wall 72 of a building. (Alternatively the heat exchangers could be partly built into the wall 72.)

In Figure 7, two laterally-spaced air flow ducts 75, 76 are located in the wall 72, each duct being aligned with air flow openings in one side of the heat exchanger 5a. Fans 77, 78 are disposed on the opposite side of the heat exchanger 5a. The fans 77, 78 have variable speed drive motors (not shown), controlled by voltage variation. The fans, motors and heat exchanger 5a are all contained in a suitable housing with air inlet and outlet grills (not shown).

With additional reference to Figure 4, in operation fan 77 pulls in fresh atmospheric air by way of the duct 75, through the heat exchanger 5a by way of substantially parallel air flows 51 and into the building interior 79. Simultaneously, fan 78 discharges air from the building interior 79 to the atmosphere, by way of substantially parallel air flows 50 and duct 76. The outgoing relatively warm and stale air gives up heat to the incoming relatively cool and fresh air, by way of the heat exchanger plates 18 of the heat exchanger 5a.

Air flows into and out of the ducts 75, 76 are represented by arrows 80, 81 respectively.

In Figure 8, fans 85, 86 are disposed at opposite ends of the heat exchanger 5b, on a common axis 87. Heat exchanger 5b is of the form illustrated by Figure 5.

The wall side-openings adjacent the ends of the heat exchanger 5b are connected by ducts (not shown, but represented by arrows 88, 89) to a single duct 90 located in the wall 72. The duct 90 is divided longitudinally by a central wall 95, so that air flow through the duct 90 is split into two, counter-directional flows, represented by

arrows 96, 97.

In operation, relatively cool atmospheric air is drawn in to the building interior 79 through one half of the duct 90 by way of the fan 85, and along substantially parallel flow paths 57. At the same time relatively warm air, which gives up heat to the incoming fresh air in heat exchanger 5b, is expelled from the interior 79, by way of the fan 86, heat exchanger 5b, and the other half of the duct 90, along substantially parallel flow paths 58.

Various modifications of Figures 7 and 8 are possible. For example, fans may be changed around. In Figure 7 fan 78 could be replaced by an extraction fan disposed at the inlet end of duct 76. Also, where desirable, axial flow fans could be replaced by radial flow fans, and vice versa. Also, a single duct with longitudinal division could be replaced by two ducts and vice versa. Such modifications apply where practicable to any of the air ventilating units disclosed herein.

In Figure 9, an air ventilating unit 101 of circular (lateral) cross-section is demountably located within a circular hole 102 formed within the outer wall 103 of a building having an interior 104 and exterior 107. The hole 102 may be lined with a sleeve 108.

The unit 101 includes a tubular housing 105. A resilient seal 109 of annular form is carried by one end of the housing 105 and extends between the housing and either the optional lining sleeve 108 or the hole 102. Another resilient seal of annular form, namely seal 106, is mounted substantially halfway along plate-type heat exchanger 5c, which is demountably located in the housing 105. The seal 106 prevents mixing of inward and outward air flows between the building interior 104 and the exterior 107 thereof. A further annular seal, namely seal 120, backs up seal 106.

The unit 101 comprises the plate-type heat exchanger 5c and fans 110, 111 for establishing first and second air flow paths 112, 113

passing in counter-direction (and in substantially parallel planes), between opposite sides of the wall 103. Heat exchanger 5c is of the same form as heat exchanger 5 (Figure 1).

Air flow paths 112 and 113 are basically the same as air flow paths 6 and 7 shown in Figures 2 and 3. Fans 110, 111 are substantially the same as fans 3, 4 of said Figures 2 and 3.

Fans 110, 111 are preferably driven by variable speed motors. (Not shown.)

Air flow paths 112, 113 differ in one respect from air flow paths 6, 7 of Figures 1 to 3. In Figure 9, the air flow paths 112, 113 each enter the heat exchanger 5c of the air ventilating unit 101 by way of laterally-facing, oppositely-disposed, openings, namely openings 121 for air flows 112 and openings 122 for air flows 113.

In Figure 10, an air ventilating unit 151 comprises a heat exchanger 5d, and radial fans 152, 153 disposed at opposite ends thereof. Heat exchanger 5d is of the prismatic form illustrated by Figure 6.

The L-shaped air flow paths are indicated by arrows 63, 64. The unit 151 is demountably mounted on an outer wall 154 of a building, and is connected to a single duct 155 located in the wall. The duct 155 is divided longitudinally by a central wall 156, so that air flow through the duct 155 is divided into the two, counter-directional air flow paths 63, 64.

With reference to Figures 11 and 12, an air ventilating unit 201 incorporates a plate-type heat exchanger 5e of non-prismatic form, made up of alternately placed stacked heat exchanger plates 180 shown in plan view.

With additional reference to Figure 13, the heat exchanger 5e has the form of a polyhedron or, more accurately, an octahedron, with first and second opposite ends 181, 182 and two oppositely-facing groups,

each comprising three sides (183, 184, 185) disposed between the ends 181, 182. The plates 180 have flanged edges and ends whereby the heat exchanger sides and ends are formed.

A first flow path 190 extends between two oppositely-facing sides 183 adjacent the first end 181 of the heat exchanger to the second end 182 thereof. A second flow path 191 extends between the two oppositely-facing sides 185 adjacent the second end 182 of the heat exchanger to the first end 181 thereof.

The flow paths 190, 191 are generally 'Y'-shaped.

The heat exchanger 5e is basically of the form shown in the exploded view provided by Figure 13, although the plan shapes of the plates 18 (Figure 13) and 180 (Figures 11 and 12) differ, of course.

Fans 192, 193 disposed on a common rotational axis 194 promote the air flows 190, 191.

The heat exchanger 5e and fans 192, 193 may be housed in a close-fitting duct 200.

Modifications of the heat exchanger 5e comprise use of only one side 183 and/or 185 and shortening the heat exchanger by dispensing with sides 184, so that the heat exchanger is of sexahedron form.

In a non-illustrated modification, at one end of a heat exchanger plate, instead of a fully-open flow path, the end can be partially blanked-off. Thus, with reference to Figure 5 for example, the entry end for flow path 58 can be partially closed.

Directions of air flows through a heat exchanger according to the invention may be reversed. Thus, again with reference to Figure 5, flow paths 57, 58 may be reversed, and with reference to Figure 15, described hereinafter, air flow paths 231, 232 may be reversed.

Core drills may be used to form holes in building walls, such as hole 102 (Figure 9) and holes which locate the ducts 75, 76 and 90 and 155 of Figures 7, 8 and 10 respectively. When core drills are used from within a building, this avoids the need for external scaffolding. A core drill capable of making a hole of about 110 mm diameter is considered to be suitable.

Figure 14 shows the air ventilating unit 201 of Figures 11, 12 and 13 with fan housings 187 in place and with part of the close-fitting duct 200 cut away. The fan housings 187 separate air flow paths 190, 191.

Figures 15, 16 and 17 illustrate a modified heat exchanger 5f, of prismatic form, wherein modified forms of the plates 18 of Figure 1 are employed.

In Figure 15 the uppermost plate 18 has the original oppositely-disposed side openings blanked-off as indicated by shaded areas 211, 212. One end opening is partially blanked-off, as indicated by shaded area 215. At the opposite end an opening 217 is formed, indicated by criss-cross shading.

In the lowermost plate 18, the original oppositely-disposed side openings are blanked-off, as indicated by shaded areas 213, 214. At one end an opening 218 is formed, indicated by criss-cross shading. The opposite end is partially blanked-off, as indicated by shaded area 216.

The blanking-off portions 215, 216 and the portions 18c flanking the openings 217 and 218 comprise barrier means whereby the first and second air flow paths 231, 232 of this modification are generally 'Y'-shaped.

The blanked-off portions 215 are shown shaded in Figure 16. Portions 215 and the portions flanking openings 218 overlap slightly. With reference to Figure 17, fan housings 235 extend from

the areas of overlap so as to keep the air flow paths 231, 232 separate. The heat exchanger 5f and fan housings 235 are enclosed in an outer housing 236 (shown cut away) so as to form an air ventilating unit 301.

Figure 18 shows an air ventilating unit 401 comprising a heat exchanger 5g of right cylindrical form, disposed in a close-fitting tubular housing 436. External seals 437, 438 are intended to close-off an annular space between the housing 436 and a circular hole in a building wall, (not shown, but corresponding to hole 102 of Figure 9), within which the unit 401 is to be fitted.

The housing 436 comprises a two-piece moulding of plastics material. The external seals 437, 438 are integral with the moulding.

The heat exchanger 5g is basically of the same form as heat exchanger 5f of Figures 15 to 17. Air flow paths 431, 432 correspond to air flow paths 231, 232 respectively. Blanked-off portions 418 correspond to blanked-off portions 215 and the portions of plates 18 flanking openings 418 correspond to those flanking openings 218. Fan housings 435 correspond to fan housings 235.

In Figure 19, an air ventilating unit 501 is shown, comprising a heat exchanger 5h of right cylindrical form enclosed in a tubular housing 536. The heat exchanger 5h is of substantially the same form as heat exchanger 5e of Figures 11 to 14, but with the widths of the heat exchanger plates altered to give the heat exchanger its right cylindrical form.

The housing 536 comprises a two-piece moulding of plastics material with integral external seals 537, 538. The housing 536 has integral end grills 550 through which air flow paths 531 and 532, (which correspond to air flow paths 190, 191 of Figure 13) take place. Internal ribs (not shown) support the heat exchanger plates.

Figure 20, which is a cut-away view in perspective, illustrates an air ventilating unit 601 comprising a heat exchanger 5i disposed in a tubular housing 636.

The heat exchanger 5i is basically of the same form as any of the heat exchangers 5 to 5h described above, except that it is formed and constructed so as to be a 'cross-flow' heat exchanger.

In the example illustrated, heat exchanger 5i is of right prismatic form, having side surfaces 650, 651, 652, 653. A first flow of air 631 enters the heat exchanger side 650 by way of an annular space 654 between a fan duct 635 and the housing 636. Air leaves the heat exchanger 5i by way of side 652, to leave the unit 601 by way of the interior of a second fan duct 655, connected to side 652.

A second, counterflow path of air 632 enters side 651 of the heat exchanger 5i by way of the annular space 654. This counterflow path 632 crosses air flow path 631 within the heat exchanger 5i, and then leaves the same by way of side 653 and the interior of a fan duct 635, which is connected to side 653.

An annular seal (not shown) is disposed between the heat exchanger 5i and the adjacent inner surface of the housing 636, so as to ensure that the air flows in this region do not mix.

With reference to Figure 21, the air ventilating unit 701 illustrated thereby is substantially of the same form as unit 601 of Figure 20, except that cross-flow heat exchanger 5j, which is basically the same as heat-exchanger 5i, is of right cylindrical form.

Reference numerals common to both Figures 20 and 21 refer to common components and features.

Heat exchanger side surfaces 650a and 651a of Figure 21 correspond to side surfaces 650 and 651 of Figure 20. There are surfaces

corresponding to side surfaces 652, 653 of Figure 20, but these are not shown in Figure 21.

There is also a heat exchanger 5j/casing 636 annular seal which prevents air flow mixing.

The heat exchanger 5i is, of course, disposed at an angle in the housing 636. Thus the longitudinal axes of the heat exchanger 5j, and the housing 636, are inclined to each other.

Any of the heat exchanger plates may have extended surfaces, to promote air flow thereover and to improve heat transfer. The extended surfaces may take the form of chevrons, made by embossing the plates.

Where desirable, the spacings between the heat exchanger plates may be varied.

Where possible, any of the features and arrangements disclosed herein may be added to, or substituted for, each other.

Thus, for example, the prismatic heat exchanger 5 of Figures 1 to 3 could be replaced by one of right cylindrical form.

Furthermore, the first and second fluid (air) flow paths could be of different form. Thus, for example, the flow path in one plane could be 'L'-shaped and the flow path in the adjacent plane could be 'S' or serpentine-shaped.

CLAIMS

1. A plate-type heat exchanger comprising a close-packed stack of plates spaced from each other so as to define pairs of first and second fluid flow paths disposed in an alternate manner and in substantially parallel planes, wherein, on one exterior surface of the heat exchanger there is a first flow path opening in one plane and a second flow path opening in the immediately adjacent plane, the first and second openings being spaced substantially from each other.

2. A heat exchanger as claimed in claim 1, wherein at one end of the heat exchanger, there is a first flow opening in one plane, and, at the opposite end of the heat exchanger, there is a second flow path opening in the immediately adjacent plane.

3. A heat exchanger as claimed in claim 2, wherein said first flow opening comprises an outlet and there are two oppositely-disposed inlet openings at the sides of the heat exchanger, adjacent said opposite end thereof.

4. A heat exchanger as claimed in claim 2, wherein said second flow opening comprises an outlet and there are two opposite-disposed inlet openings at the sides of the heat exchanger, adjacent said one end thereof.

5. A heat exchanger as claimed in claim 2, wherein said first flow opening comprises an inlet and there are two oppositely-disposed outlet openings at the sides of the heat exchanger, adjacent said opposite end thereof.

6. A heat exchanger as claimed in claim 2, wherein said second flow opening comprises an inlet and there are two oppositely-disposed outer openings at the sides of the heat exchanger, adjacent said one end thereof.

7. A heat exchanger as claimed in any one of claims 3 to 6 wherein the fluid flow path in each plane is generally 'Y'-shaped.

8. A heat exchanger as claimed in claim 1 wherein each of the first and second fluid flow paths extends between one side of the heat exchanger and the opposite side thereof, each flow path taking place from adjacent one end of the heat exchanger to adjacent the opposite end thereof.

9. A heat exchanger as claimed in claim 8, wherein the fluid flow path in each plane is generally serpentine.

10. A heat exchanger as claimed in claim 1 or 2, wherein the first flow path extends between one end of the heat exchanger and one side thereof adjacent the opposite end of the heat exchanger.

11. A heat exchanger as claimed in claim 1 or 2, wherein the second flow path extends between one side of the heat exchanger, adjacent said one end thereof, and said opposite end of the heat exchanger.

12. A heat exchanger as claimed in claim 10 or 11, wherein the fluid flow path in each plane is generally 'L'-shaped.

13. A heat exchanger as claimed in claim 2, wherein barrier means are provided at opposite ends of the heat exchanger, whereby the fluid flow path in each plane is generally 'Y'-shaped.

14. A heat exchanger as claimed in any one of claims 1 to 11, wherein the fluid flow paths in adjacent planes are of different form.

15. A heat exchanger as claimed in any one of claims 1 to 14, which is of prismatic form.

16. A heat exchanger as claimed in any of claims 1 to 8, which is of polyhedron form.

17. A heat exchanger as claimed in any one of claims 1 to 13, which is of right cylindrical form.

18. A heat exchanger as claimed in any one of claims 1 to 17, comprising a cross-flow heat exchanger.

19. A heat exchanger as claimed in any one of claims 1 to 18, wherein each heat exchanger plate is formed with upright flange portions whereby the stacked plates are spaced from each other.

20. A heat exchanger as claimed in claim 18, wherein some of the upright flange portions have cut away parts which define openings for fluid flow.

21. An air ventilating unit, comprising a heat exchanger as claimed in any one of claims 1 to 20, in combination with fan means for promoting airflow through the flow paths of the heat exchanger.

22. An air ventilating unit as claimed in claim 21, wherein the heat exchanger and fan means of the unit are disposed in a housing.

23. An air ventilating unit as claimed in claim 21 or 22, wherein the fan means comprise a pair of fans rotatable about a common axis.

24. An air ventilating unit as claimed in claim 21 or 22, wherein the fan means comprise a pair of fans rotatable about substantially parallel axes.

25. An air ventilating unit as claimed in claim 23 or 24, connected to one or more air flow ducts disposed in the wall of a building.

26. An air ventilating unit as claimed in any of claims 21 to 25, wherein flow path openings are disposed in adjacent planes at opposite ends of the heat exchanger, with the flow path openings at each end overlapping, the unit being provided with housings for the fans of said fan means, the housings extending from the areas of overlap.

27. An air ventilating unit as claimed in claim 22 or 23, wherein the fan means are disposed in fan ducts which define an annular air flow space with the housing.

28. An air ventilating unit as claimed in claim 21, 22 or 23, having external seals for sealing the housing with a hole extending through the wall of a building.

29. A building having a wall with an air ventilating unit as claimed in any one of claims 21, 22, 23, 26 or 27, installed therein.

30. A heat exchanger, substantially as hereinbefore described with reference to the accompanying drawings.

31. A air ventilating unit, substantially as hereinbefore described with reference to the accompanying drawings.

1/17

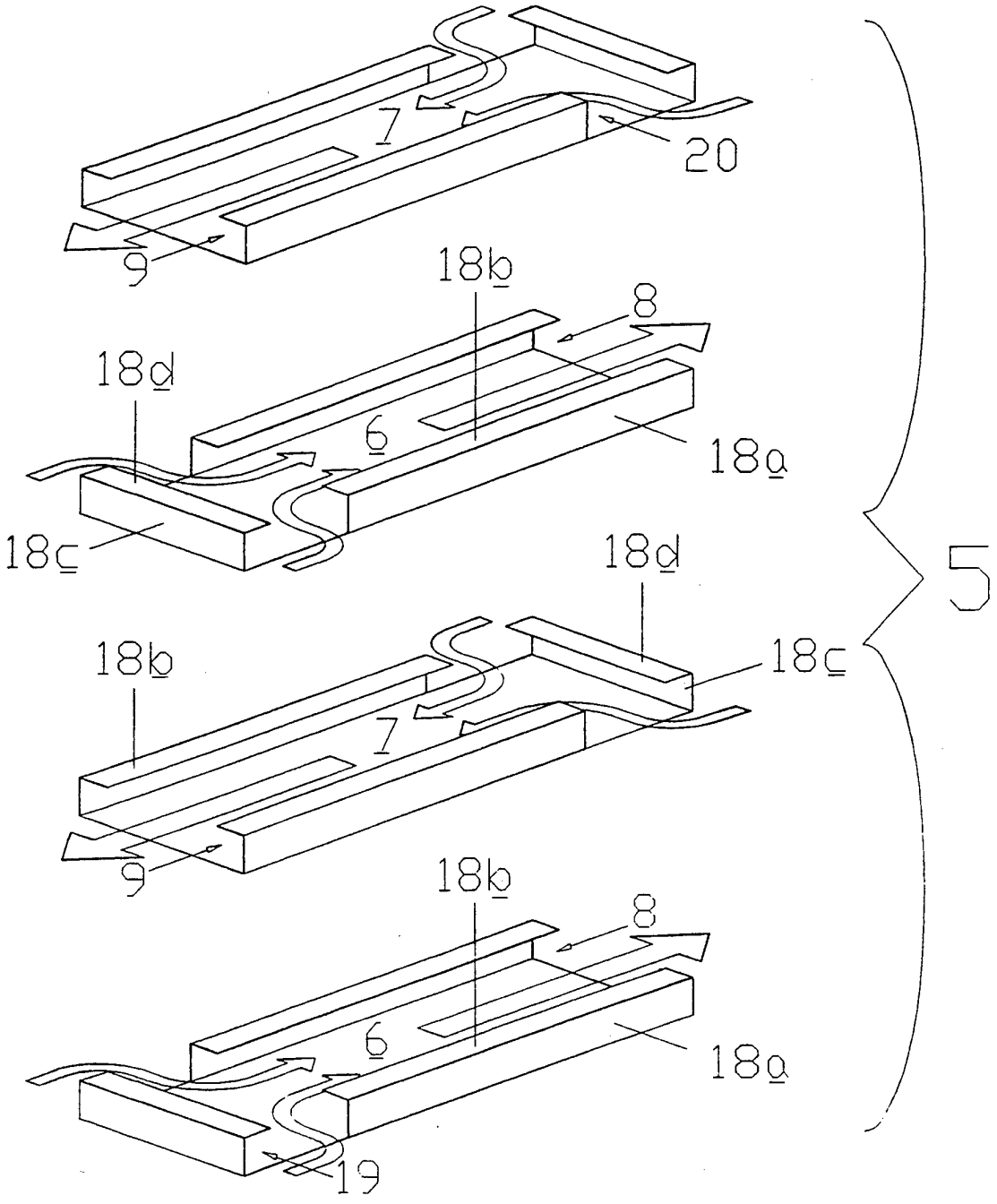


Fig. 1.

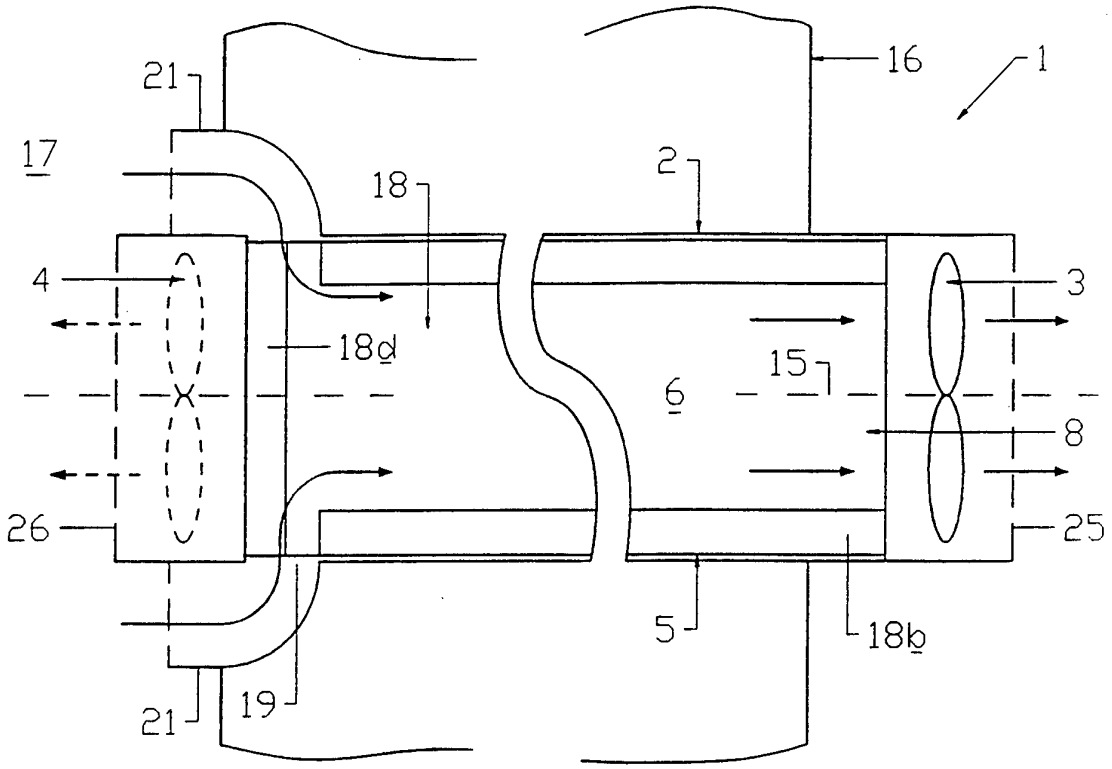

21
17
18
16
1
2
4
3
18d
15
6
8
26
25
5
18b
19
21

Fig. 2.

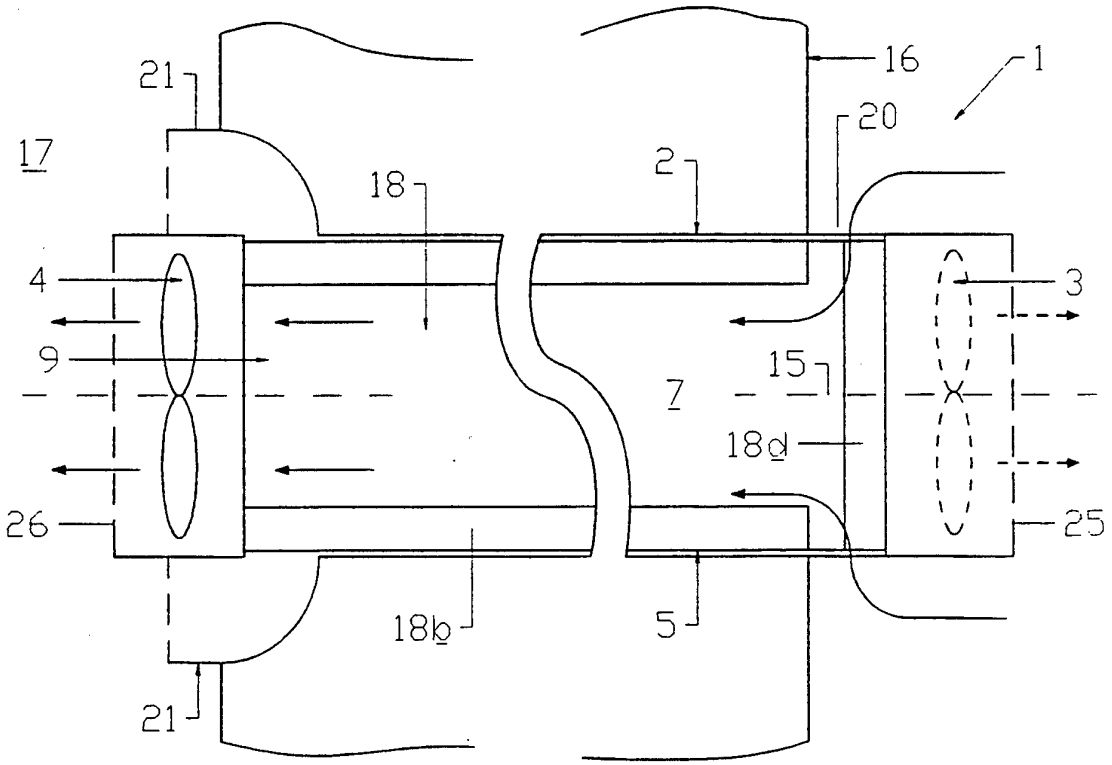

21
17
18
16
1
20
2
4
3
9
15
7
18d
26
25
18b
5
21

Fig. 3.

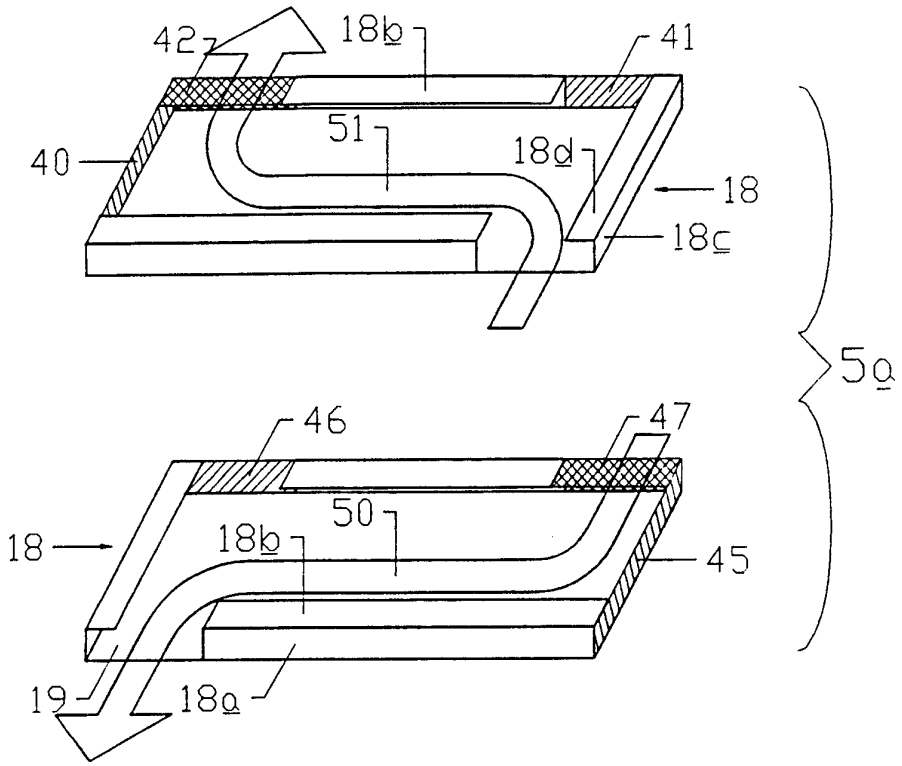

42
18b
41
51
40
18d
18
18c
5a
46
47
50
18
18b
45
19
18a

Fig. 4.

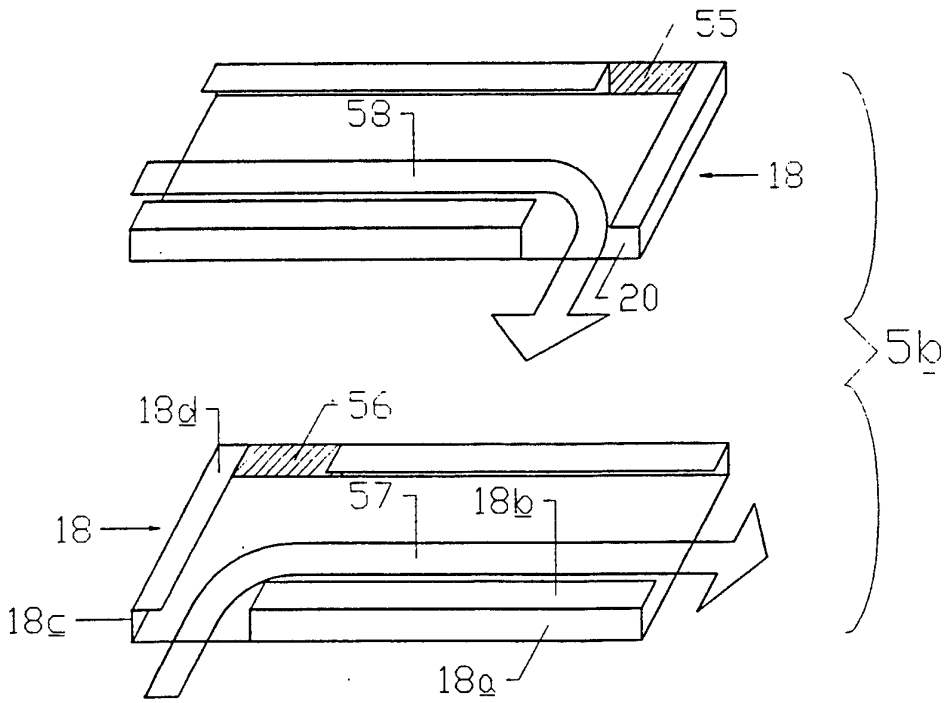

55
58
18
20
5b
18d
56
57
18b
18
18c
18a

Fig. 5.

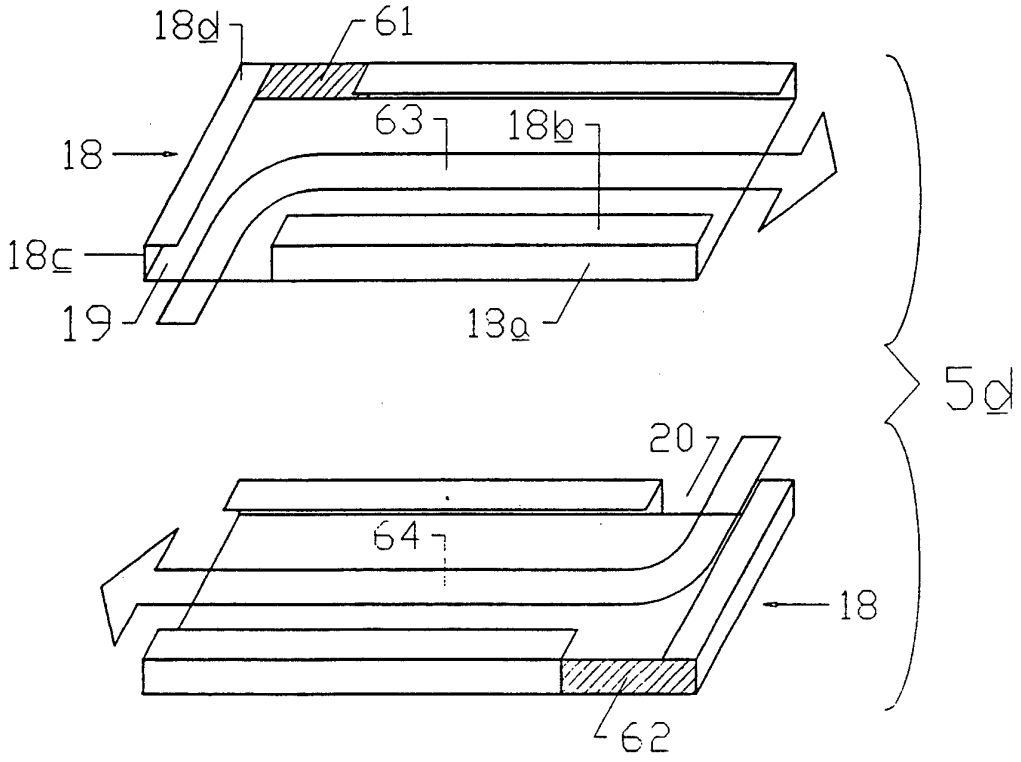


Fig. 6.

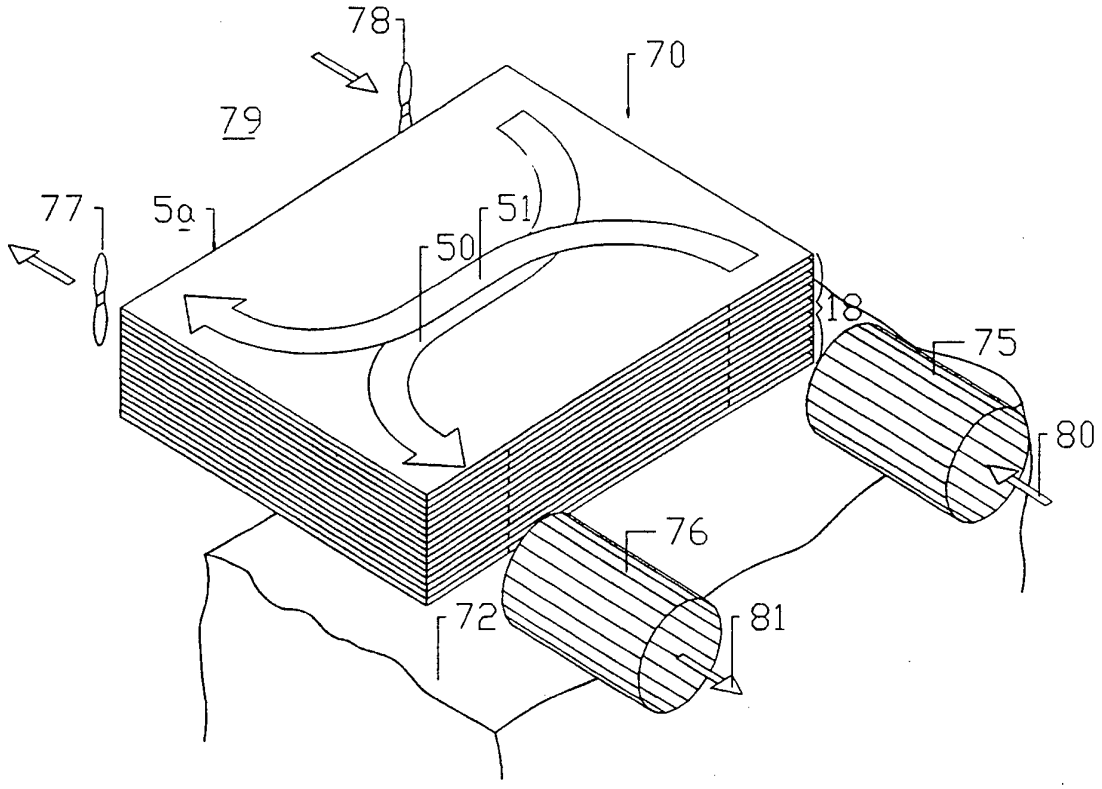

78
70
79
77
5a
51
50
18
75
80
76
72
81

Fig. 7.

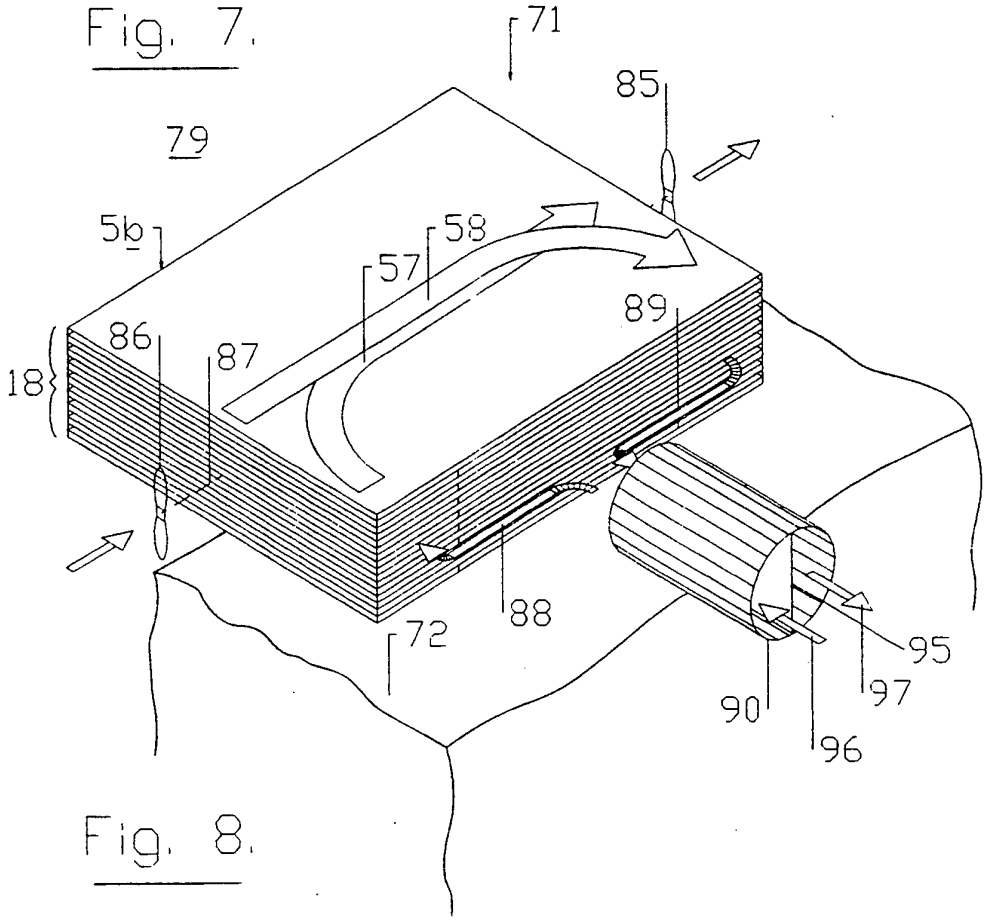

71
85
79
5b
58
57
89
86
87
18
88
72
95
97
90
96

Fig. 8.

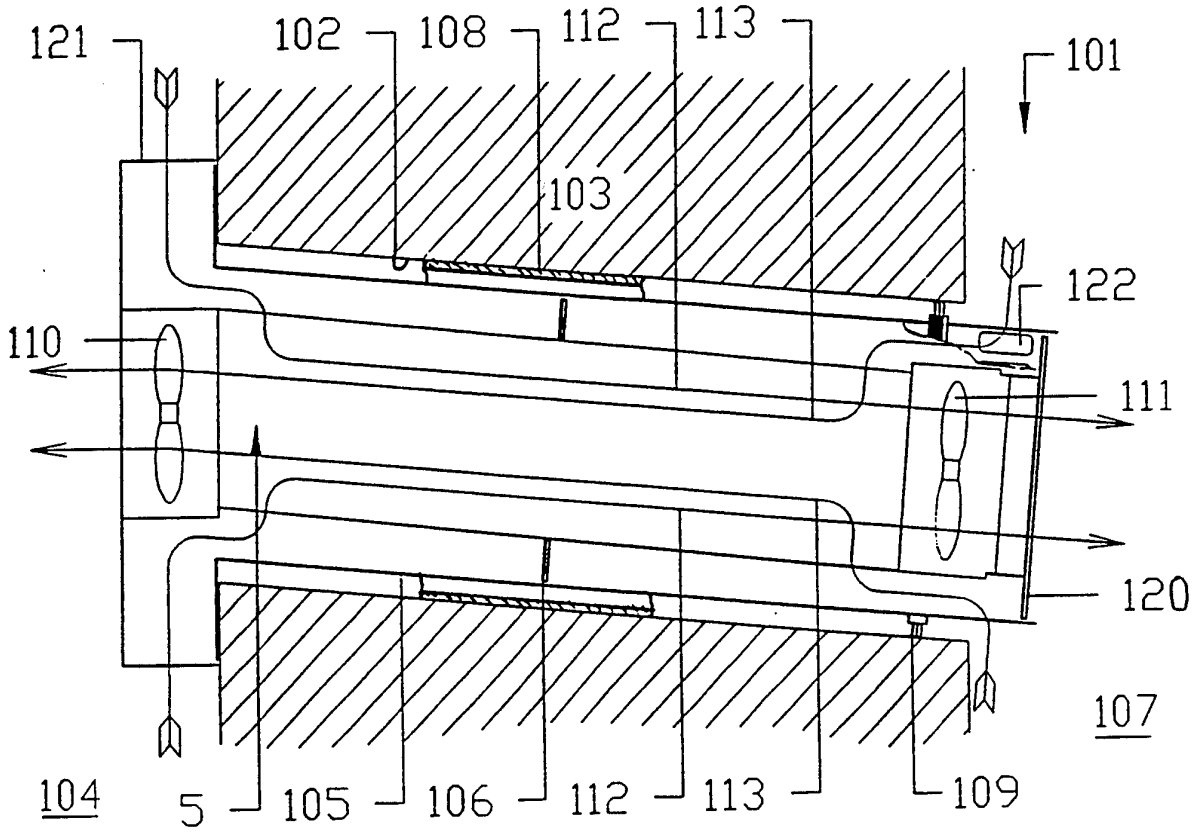

121
102
108
112
113
101
103
122
110
111
120
107
104
5
105
106
112
113
109

Fig. 9.

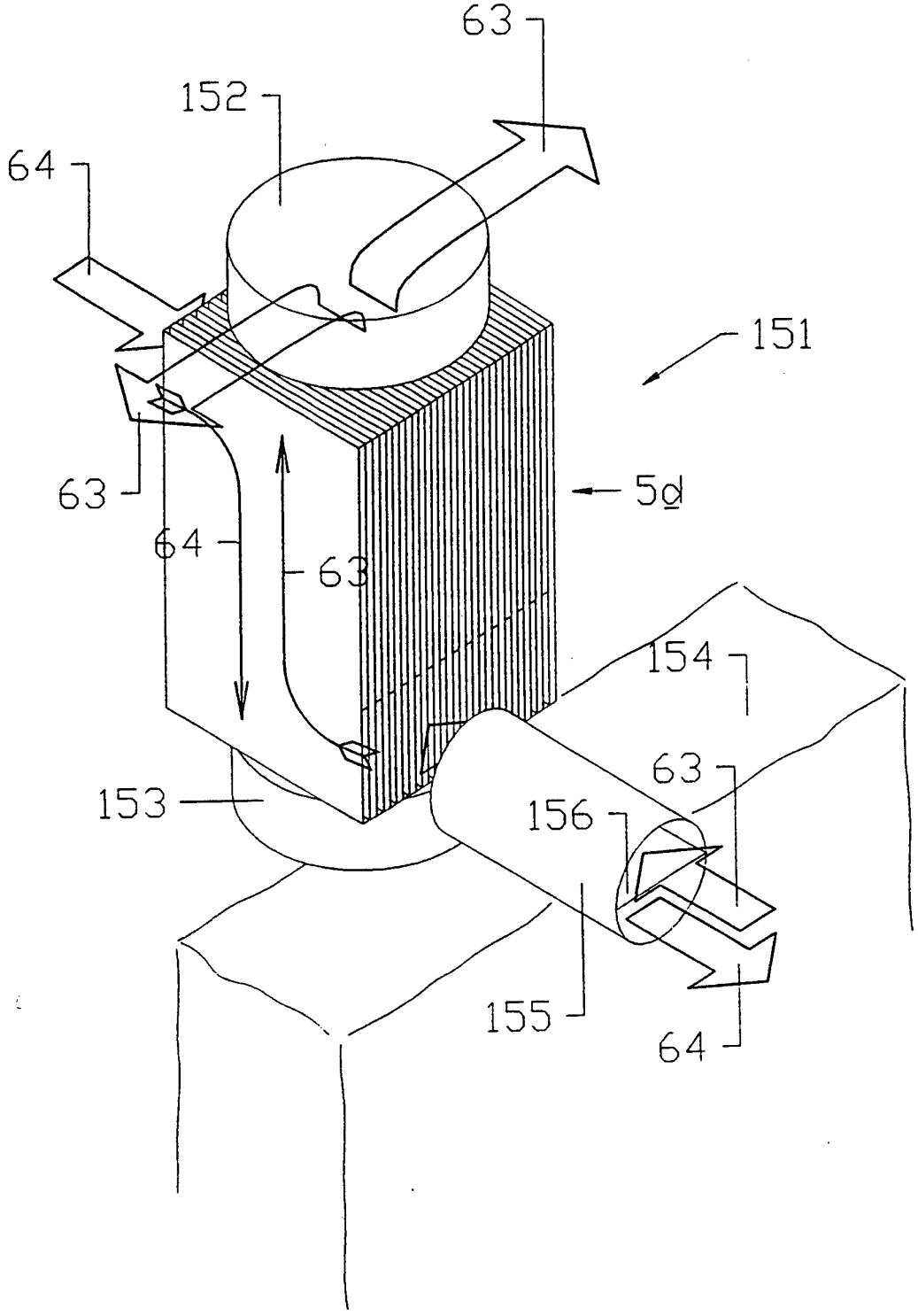


Fig. 10.

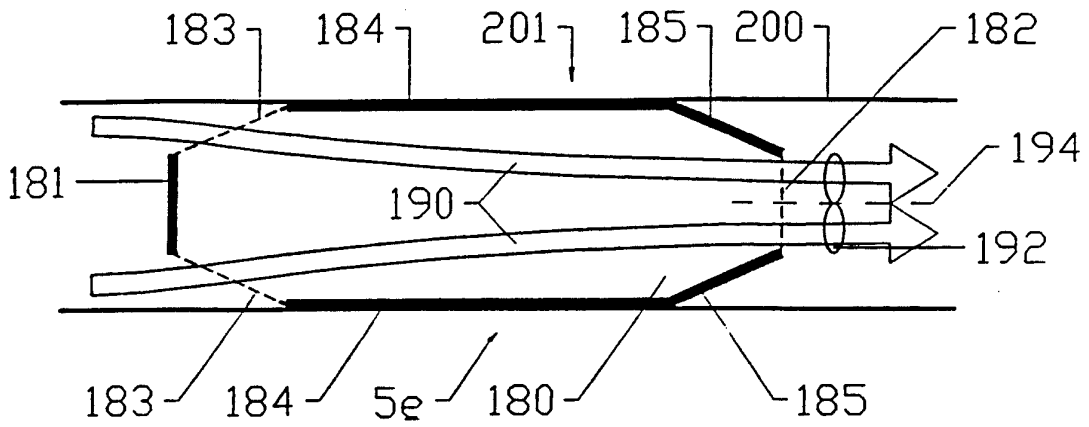

183
184
201
185
200
182
194
181
190
192
183
184
5e
180
185

Fig. 11.

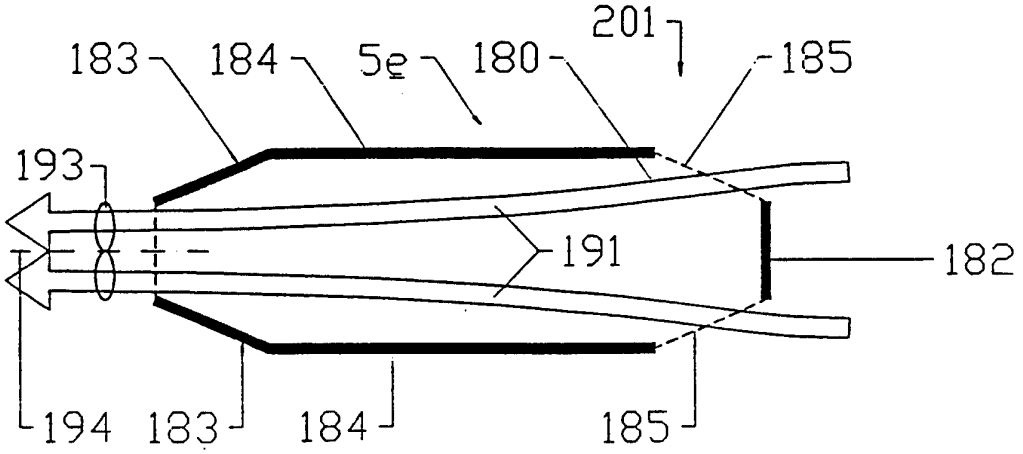

201
183
184
5e
180
185
193
191
182
194
183
184
185

Fig. 12.

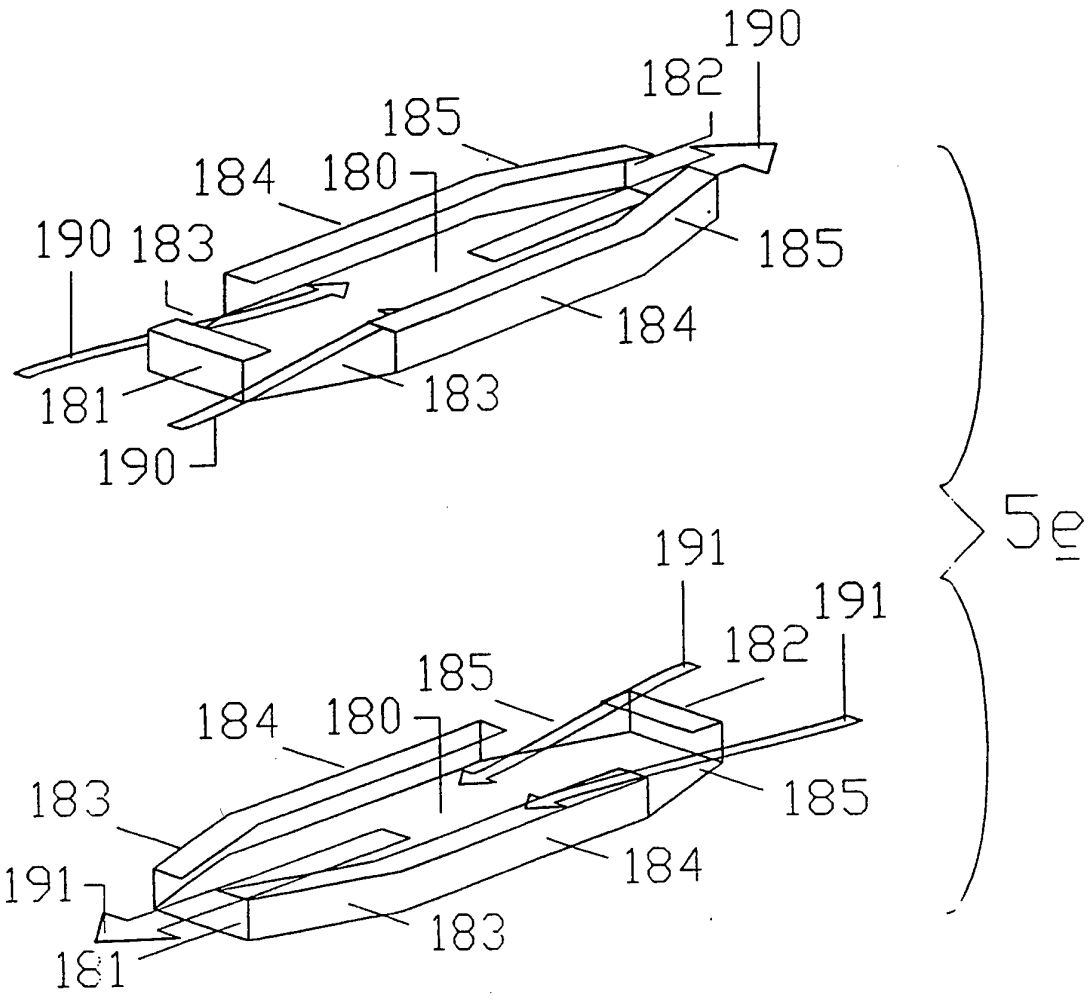

190
182
185
184
180
190
183
185
184
181
183
190
5e
191
191
182
185
184
180
183
185
184
191
183
181

Fig. 13.

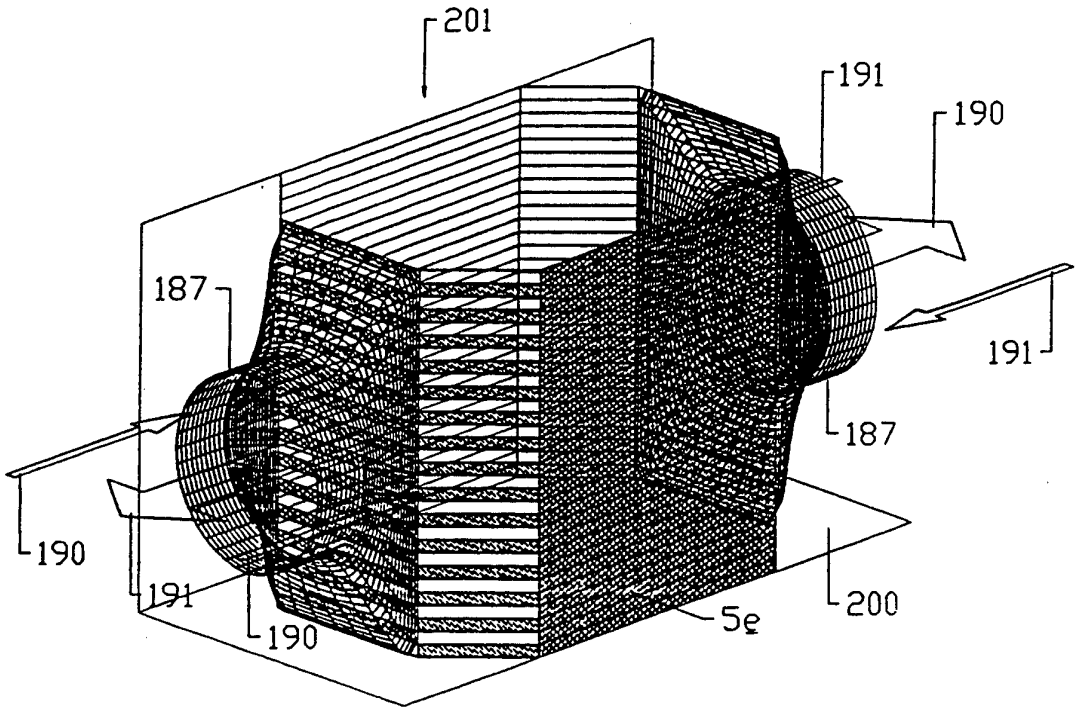


Fig. 14.

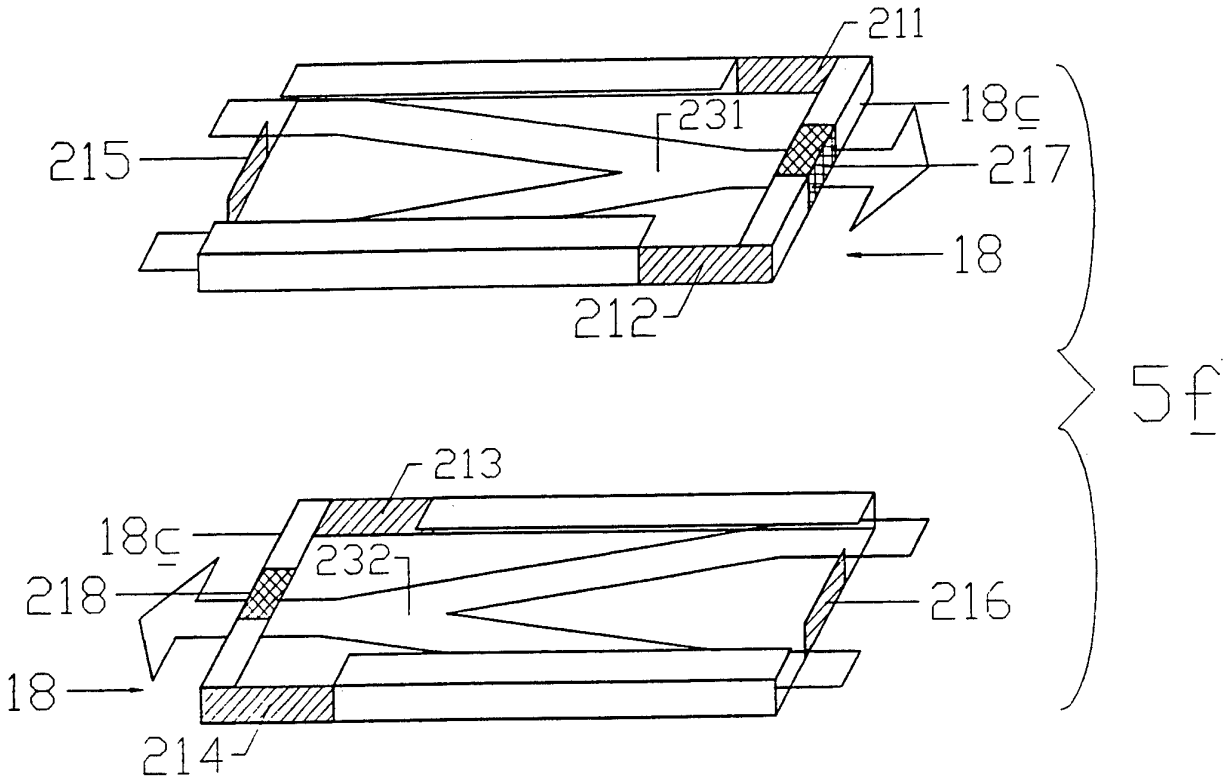


Fig. 15.

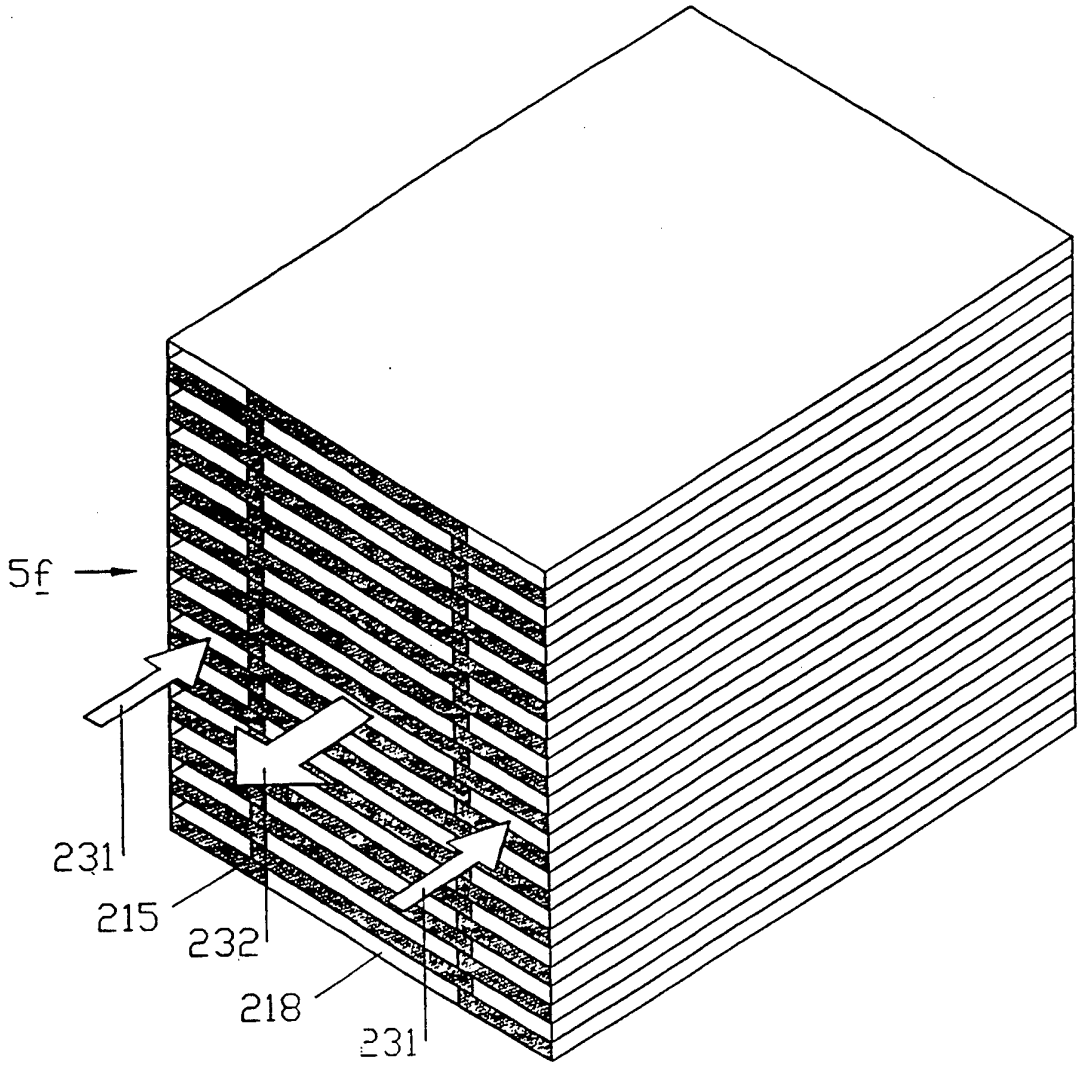


Fig. 16.

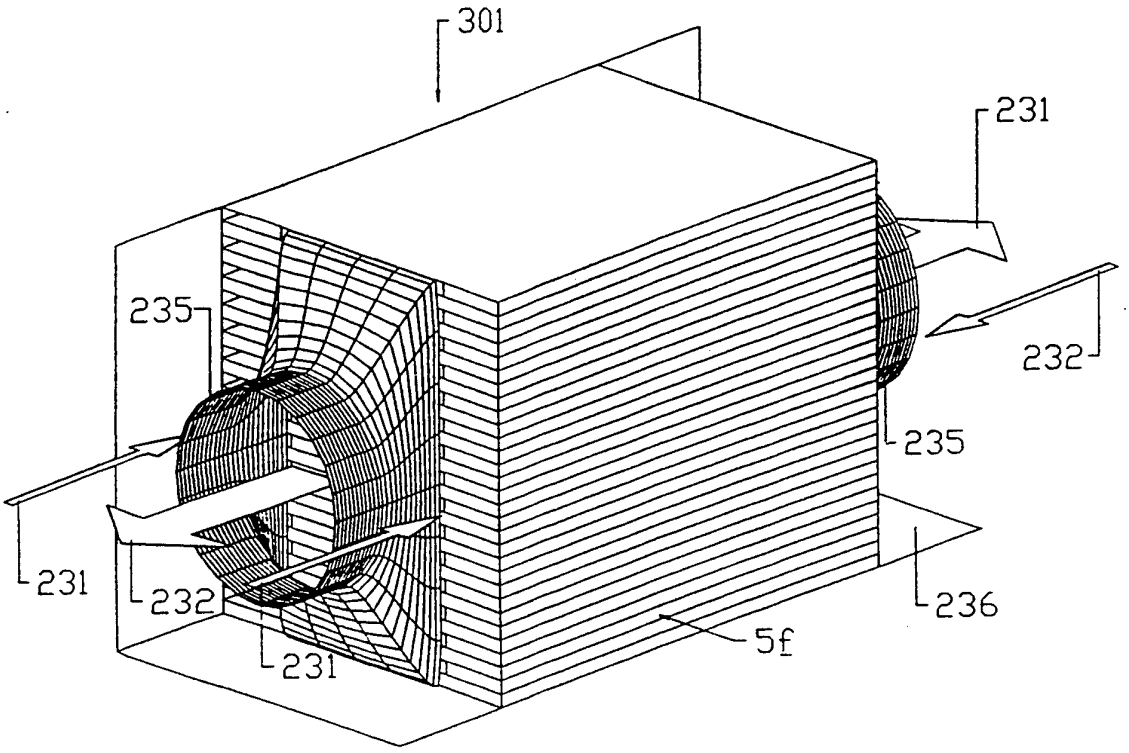


Fig. 17.

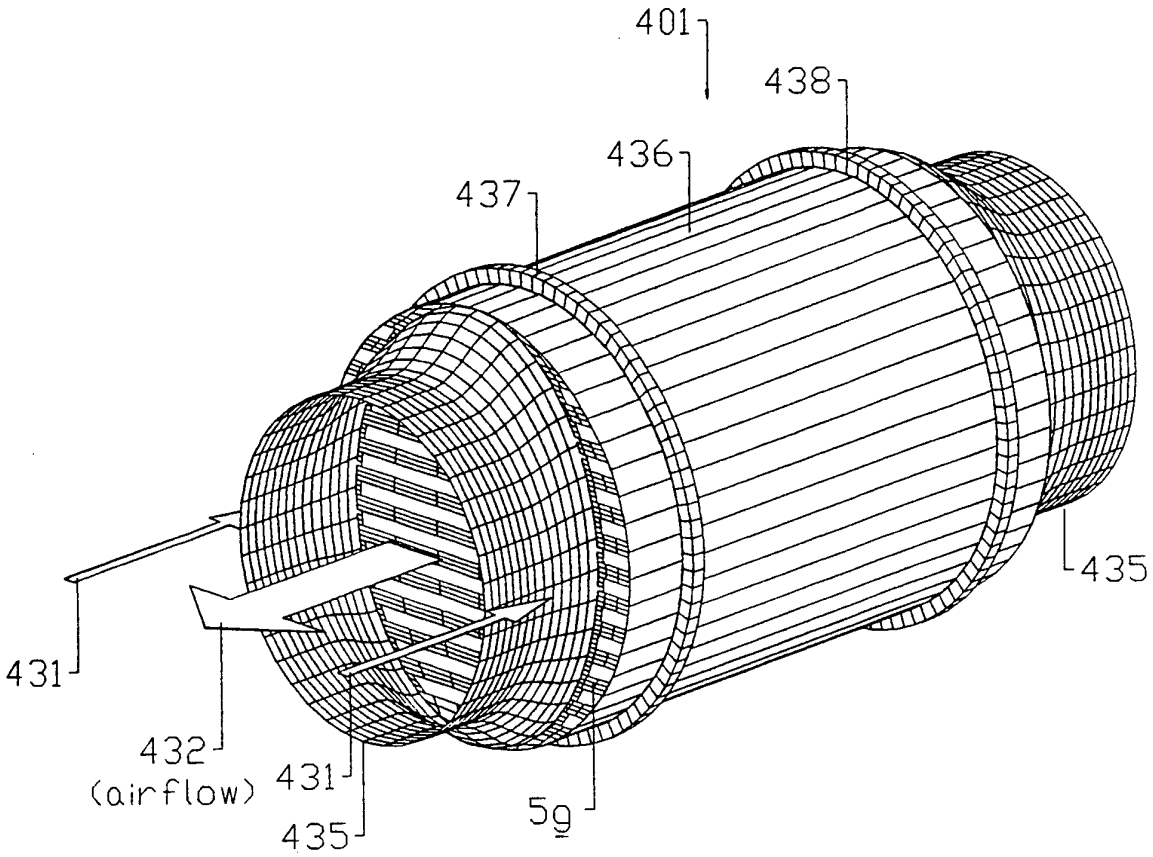


Fig. 18.

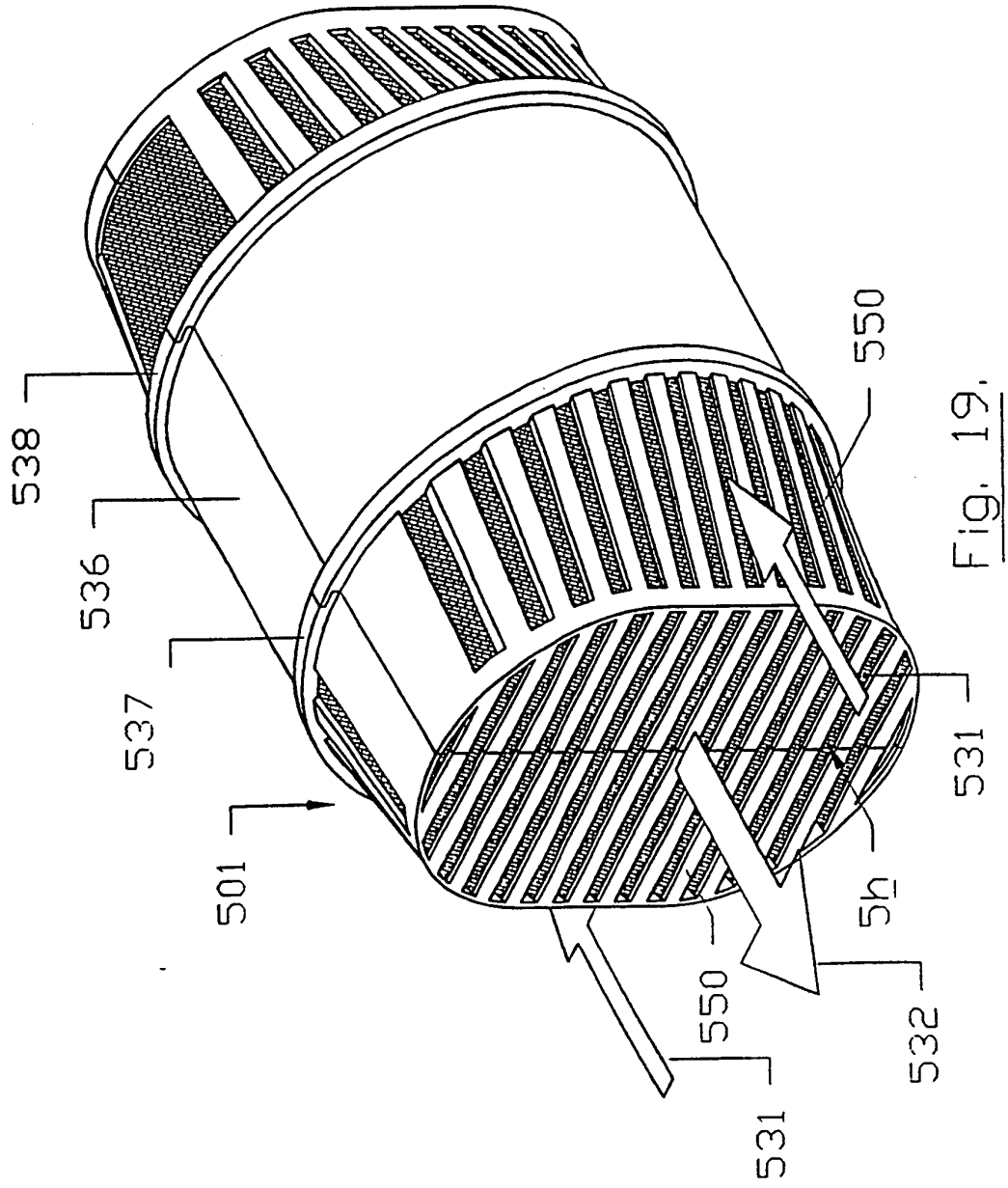


Fig. 19.

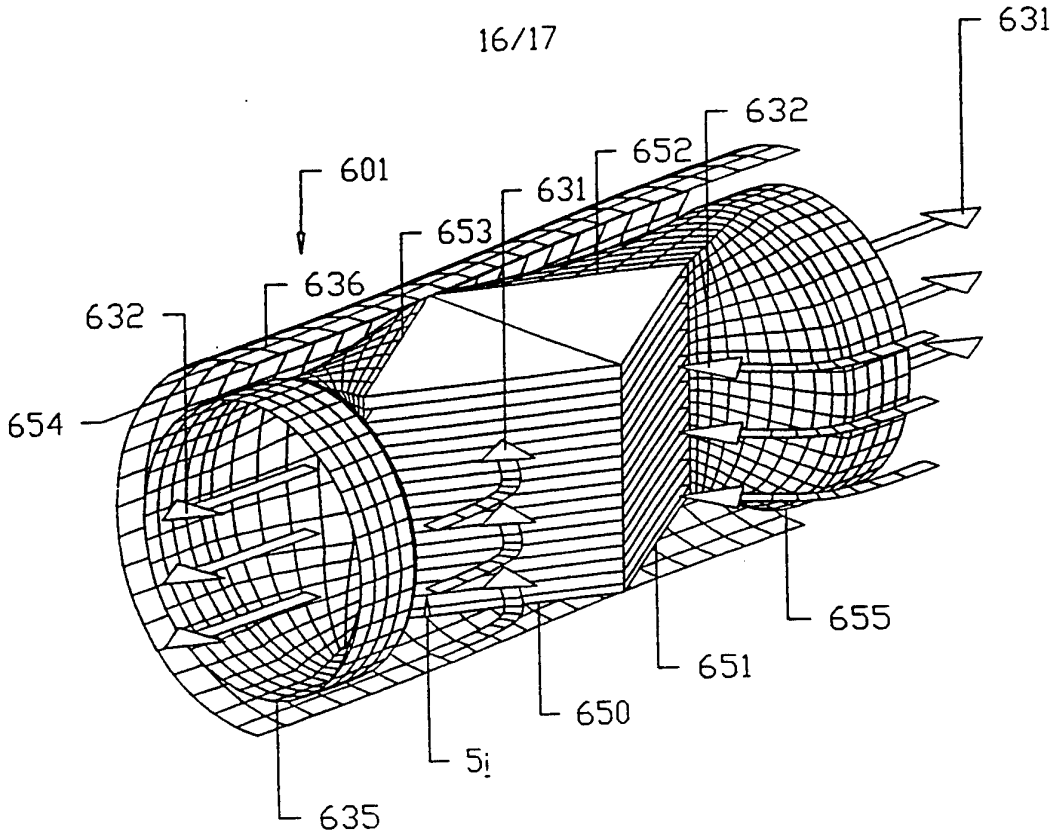


Fig. 20.

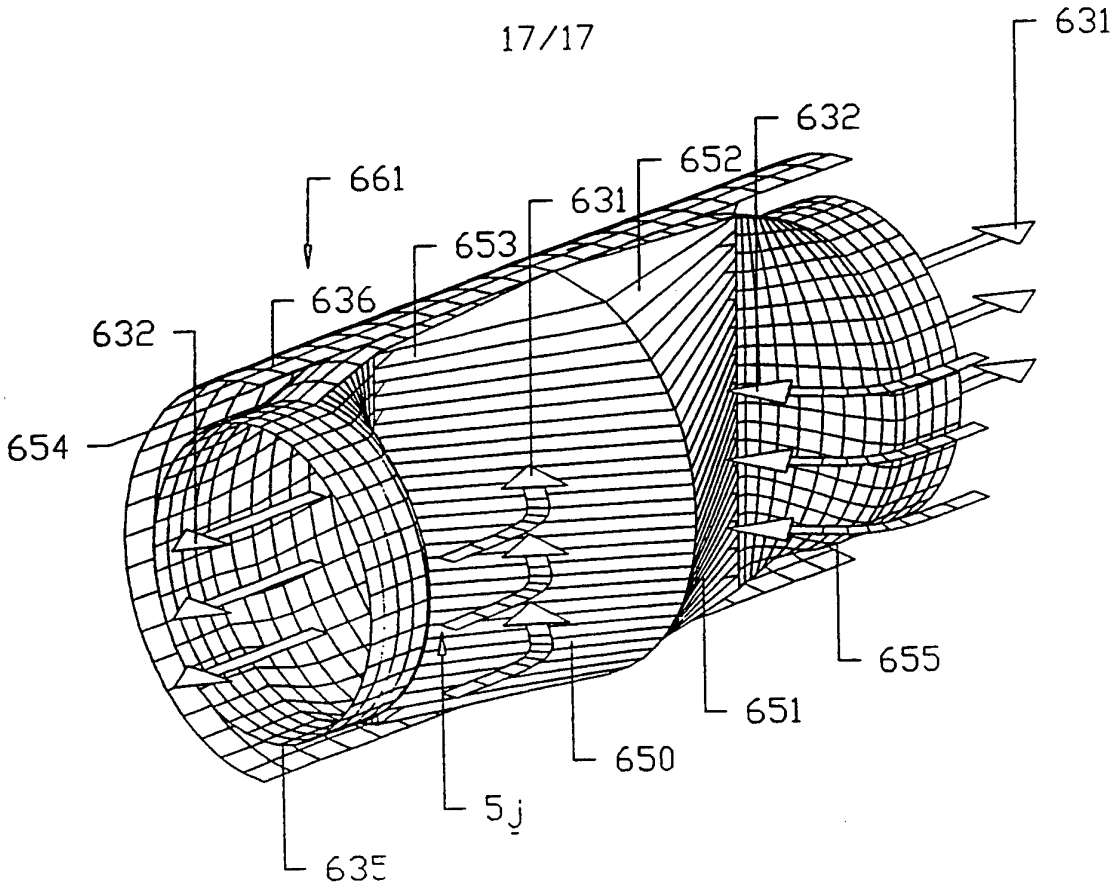


Fig. 21.

INTERNATIONAL SEARCH REPORT

Interna l Application No
PCT/GB 93/02633

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 F28D9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 F28D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR,A,1 284 416 (LUWA) 9 February 1962 see the whole document ---	1-15, 18-22
X Y	GB,A,1 007 879 (IMPERIAL CHEMICAL INDUSTRIES LTD.) 22 October 1965 see the whole document ---	1-8,13, 15,19 9
Y	FR,A,2 317 617 (ALUMINIUM SUISSE S.A.) 4 February 1977 see the whole document ---	9
X	FR,A,1 198 608 (COSTES) 8 December 1959 see the whole document ---	1,10-12
X	US,A,3 506 192 (OTTO) 14 April 1970 see the whole document ---	1,10-12
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 April 1994	20.04.94

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Smets, E

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Intern al Application No
PCT/GB 93/02633

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 196 175 (ATKIN) 1 October 1986 see the whole document	1,18-27
X	US,A,4 125 153 (STONEBERG) 14 November 1978 see the whole document	1,21-27
X	FR,A,2 313 651 (CHARRAUDEAU) 31 December 1976 see the whole document	1
X	US,A,4 116 271 (DE LEPELEIRE) 26 September 1978 see the whole document	1
X	EP,A,0 265 528 (SUMITOMO HEAVY INDUSTRIES, LTD.) 4 May 1988 see the whole document	1

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern al Application No
PCT/GB 93/02633

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR-A-1284416		NONE	
GB-A-1007879		NONE	
FR-A-2317617	04-02-77	CH-A- 588672 DE-A,C 2630551 GB-A- 1528864	15-06-77 20-01-77 18-10-78
FR-A-1198608		NONE	
US-A-3506192	14-04-70	NONE	
EP-A-0196175	01-10-86	US-A- 4799539	24-01-89
US-A-4125153	14-11-78	NONE	
FR-A-2313651	31-12-76	BE-A- 842384 JP-A- 52010949	16-09-76 27-01-77
US-A-4116271	26-09-78	NONE	
EP-A-0265528	04-05-88	JP-B- 5035356 JP-A- 62252891 DE-A- 3779993 WO-A- 8706686 US-A- 4805695	26-05-93 04-11-87 30-07-92 05-11-87 21-02-89