(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 005 959**
A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 79300923.4

(22) Date of filing: 24.05.79

(51) Int. Cl.²: F 28 F 1/12
B 21 D 13/04

(30) Priority: 31.05.78 GB 2533478
27.03.79 GB 7910746

(43) Date of publication of application:
12.12.79 Bulletin 79/25

(84) Designated Contracting States:
DE FR IT NL SE

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(54) Heat exchanger fins and apparatus for making same.

(57) Fins for heat exchangers are arranged with louvres (46,47,56,57) or other inclined surfaces (44,45,54,55) which lie along planes which are inclined to the general direction of flow (A) of heat exchange medium over the fins.

In one form the fins have mutually inclined V-shaped portions (44,45,54,55) with louvres (46,47,56,57) formed in the flanks (44,45,54,55) of the V. In this case the louvres (46,47,56,57) are in sets spaced from one another. The louvres (46,47,56,57) are inclined to the planes of the flanks (44,45,54,55) and in opposite directions on each flank (44,45,54,55).

In another form the fins are made up of side by side strips (11,12,13) of corrugated material. The flanks (15) of the corrugations are inclined to the general direction of flow (A) of medium over the fin and the strips (11,12,13) are displaced from one another in their longitudinal direction.

In each case the arrangement provides for a large gap between the strips (11,12,13) or the louvres (46,47,56,57) without a reduction in the number of strips (11,12,13) or louvres (46,47,56,57). The fins may be used in conjunction with tubes (31,50) through which another heat exchange medium is passed.

An apparatus is also provided for making the corrugated fins.

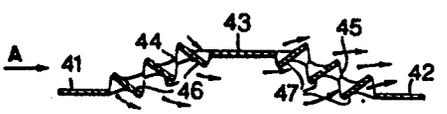

FIG.1

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TITLE MODIFIED
see front page

HEAT EXCHANGERS

This invention relates to heat exchangers and in particular to secondary surface elements for heat exchangers.

Louvred sheet material is already known for use in heat exchangers and the material may take several forms, such as in a fin and tube heat exchanger in which the tubes pass through apertures in a plurality of secondary surface fins. Corrugated sheet material is also used in which such material is located between tubes and louvres are formed in the flanks of the corrugations. In such arrangements the louvres are inclined or twisted relative to the plane of the associated sheet and gaps are formed in the material through which heat exchange medium can pass.

There has also been proposed in our British patent application No. 6608/77 corrugated sheet material in which there is formed a plurality of side by side strips which are displaced from one another in their longitudinal direction so that the surfaces of the strips lie in planes generally perpendicular to said longitudinal direction and the edges of the strips are exposed to heat exchange medium passing over the material.

The various known forms of secondary surface elements for heat exchangers suffer from disadvantages either in relation to their heat exchange properties, or their ease of manufacture, or both, and it is an object of the invention to provide secondary surface elements which have good heat exchange characteristics and are relatively straightforward to make.

According to one aspect of the invention a secondary surface element for a heat exchanger comprises sheet material formed with successive mutually inclined integral portions,

each arranged to be inclined to the general direction of flow of heat exchange medium over the elements and the mutually inclined portions having louvres formed therein, each louvre lying in a plane inclined to the plane of the associated portion of the element. The louvres should be inclined at less than a right angle to the general direction of flow.

Preferably the sheet material is formed in successive V-shaped portions, the louvres being formed in the flanks of the V and lying in planes inclined to the flanks of the V.

According to another aspect of the invention a secondary surface element for a heat exchanger comprises corrugated sheet material formed of a plurality of corrugated strips, each strip being similarly shaped and corresponding portions of the flanks of the corrugations in adjacent strips being displaced from one another in the longitudinal direction of the strips whereby the leading edge of each flank is displaced in one direction from the trailing edge of the corresponding flank of an immediately adjacent strip, the strips being joined to one another to form a unitary structure, and the flanks of the corrugations each being inclined in the opposite direction to said displacement at an acute angle to the longitudinal direction of the strip.

According to a further aspect of the invention apparatus for forming the secondary surface element comprises a pair of rolls and drive means for driving at least one of the rolls so that the rolls rotate in opposite directions, each roll being formed of a set of laminae arranged side by side along the axis of the associated roll and each lamina in a set having a corrugated profile with circumferentially spaced teeth, corresponding edges of the teeth of adjacent laminae being angularly displaced from one another about the axis of the associated roll, and the teeth of one set

of laminae being arranged in mesh with the teeth of the other set of lamina, and the teeth of the laminae lying on helical paths extending around the associated roll and the element being formed by feeding sheet material between the rolls.

Further features of the invention will appear from the following description of various embodiments of the invention given by way of example only and with reference to the drawings in which:

Fig. 1 shows diagrammatically and in cross-section one arrangement of secondary surface element,

Fig. 2 is a section through a heat exchanger having secondary surface element similar to that of Fig. 1 taken on the line 2-2 in Fig. 3,

Fig. 3 is a section on the line 3-3 in Fig. 2,

Fig. 4 is a side elevation of part of another form of secondary surface element,

Fig. 4A is an enlarged view of part of the element of Fig. 4,

Fig. 5 is a cross-section on the line 5-5 in Fig. 4,

Fig. 5A is a cross-section on the line 5A-5A in Fig. 4A,

Fig. 6 is a cross-section corresponding to that of Fig. 5 of part of a complete secondary surface element,

Fig. 7 is a perspective view of the element of Fig. 6 in combination with heat exchanger tubes,

Fig. 8 is a side elevation of apparatus for making the secondary surface elements of Figs. 4 to 7, and

Fig. 9 is an enlarged view of part of the apparatus of Fig. 8.

Referring to the drawings and firstly to Fig. 1, a secondary surface element for heat exchangers is shown which is intended for use in a heat exchanger of the fin and tube kind, only the fin being shown in Fig. 1.

The fin of Fig. 1 has a leading edge portion 41 and a trailing edge portion 42 lying in a common plane. An intermediate portion 43 lies parallel to the leading edge and trailing edge portions 41, 42 but in a plane offset from the plane of these portions. Mutually inclined integral portions 44 and 45 join and are arranged symmetrically with respect to the portions 41, 42 and 43 to be of generally inverted V-shape with the apex of the V flattened at 43. It will be appreciated that a succession of inclined portions similar to those at 44 and 45 may be provided, extending in the direction indicated by the arrow A. This direction is also the direction in which heat exchange medium, for example air, flows to the fin in its use in a heat exchanger.

The inclined portion 44 is formed with a set of louvres 46 extending between plane lateral edges of the fin, each of the louvres 46 making an acute angle to and intersecting the inclined portion 44. In this case the louvres 46 are also at an angle to the plane in which the portion 41 lies.

The inclined portion 45 is also formed with a set of louvres 47 which are inclined in the opposite direction to the louvres 46. The louvres 47 are inclined to and intersect the portion 45 and also, in this case, the louvres 47 are inclined to the plane of the portion 42.

In the limiting case the angle of the louvres 46 and 47 relative to their respective inclined portions 44 and 45 may be such that the louvres are parallel to the planes of the portions 41 and 42.

Referring now to Figs. 2 and 3, a secondary surface element or fin of the kind shown in Fig. 1 may be incorporated in a heat exchanger of the fin and tube kind in the manner illustrated in Figs. 2 and 3. In Figs. 2 and 3 only one fin is illustrated but it will be appreciated that a large number of spaced apart and parallel fins will generally be employed.

The heat exchanger of Figs. 2 and 3 has four rows of tubes 50, tubes in the second and fourth rows being offset with respect to those in the first and third rows. The tubes 50 pass through apertures in the fins which are in close contact with and secured, for example by solder, to the tube to give good heat transfer between the tubes and the secondary surface fins.

Each fin has a leading edge 51, a trailing edge 52 and an intermediate portion 53 parallel to but offset from the leading and trailing edges. Extending between and integral with the portions 51 and 53, and 53 and 52, are mutually inclined portions 54 and 55 respectively.

Sets of parallel louvres 56 are formed in the portion 54 between the tubes 50 of the first row and a tube 50 passes through the portion 54 downstream of the louvres 56 with respect to the direction of flow A.

Similar louvres 56A are formed in the portion 54 in between the tubes of the second row, as seen in Fig. 3, which figure also indicates the lateral extent of the louvres and the unlouvred area of the portion 54. The louvres 56 and 56A are similarly arranged to the louvres 46 of Fig. 1.

Sets of parallel louvres 57 are also formed in the inclined portion 55 laterally of and between the tubes 50 of the third row and further sets of louvres 57A are formed in the portion 55 between the tubes of the fourth row. The louvres 57 and 57A are inclined in the opposite direction to the louvres 56 and 56A. The louvres 57 and 57A are similarly arranged to the louvres 47 of Fig. 1.

Air flow to the fin of Figs. 2 and 3 is in the direction A and, in passing over the fin, the air passes from one side to the other of the fin through the louvres 56 and 56A and then back through the louvres 57 and 57A.

It will be seen that the fin of Figs. 2 and 3 is of generally inverted V-shape having a flattened apex at 53, the louvres being formed in the mutually inclined flanks 54 and 55 of the V. A succession of V-shaped portions may be formed along the air flow path. The arrangement of Figs. 2 and 3 is in the general form of a fin and tube heat exchanger in which a heat exchange relationship is set up between a fluid passing through the tubes and a fluid passing over the fins.

Although in the arrangements of Fig. 1 and Figs. 2 and 3 there is provided intermediate portions 43 and 53 respectively, the inclined portions may be joined directly at the apex of the V. Similarly the leading and/or trailing ends of the inclined portions may constitute the leading and trailing edges by dispensing with the portions 41 and 42 and/or 51 and 52.

The louvred fin of Fig. 1 and Figs. 2 and 3 may be made from sheets of metal foil in which the louvres are formed in known manner, the louvred sheet being shaped by bending to the desired configuration, as described. The fin provides an improved air flow path over the fin because the louvres provide relatively large gaps without reducing the number of louvres present.

Referring now to Figs. 4 to 9 and firstly to Figs. 4, 4A, 5 and 5A, a secondary surface element is shown suitable for use sandwiched between heat exchanger tubes in the manner shown in Fig. 7. The element of Figs. 4, 4A, 5 and 5A is of corrugated form and is made from metal sheet or foil, the corrugations in this case being of truncated triangular form each with flat crests 17. It will, however, be appreciated that corrugations of other shapes can be formed, for example of generally sinusoidal shape or with relatively wider or narrower flat crests, provided that these are such that the material retains a unitary structure.

In Figs. 4, 4A, 5 and 5A only three strips 11, 12 and 13 are shown as making up the element but it will be appreciated that a unitary sheet will normally have a greater number of strips.

Each of the strips 11, 12 and 13 is displaced from its adjacent strips by an amount d and the extent of the displacement d may be selected according to pitch P of the corrugations. The height of the secondary surface is given as h.

The flanks 15 of the corrugations are each inclined at an acute angle α to the longitudinal direction of the strips. The angle α is preferably in the range 60°-80°. The direction of displacement of the strips is opposite to the direction of inclination of the flanks 15. It will be appreciated that each strip 11, 12 and 13 has a leading and trailing edge, such as at 11a, 12a and 11b, 12b, having regard to a direction of flow A of fluid over the material which direction A is at a right angle to the longitudinal direction of the strips. Adjacent strips are interconnected at the crests 17 at 17a to form a unitary structure.

The displacement of adjacent strips from one another can be of any desired amount, ranging from a small displacement d by which the corrugations are aligned with one another in rows lying perpendicular to the longitudinal direction of the strips, to a larger displacement d of the order of a third the pitch P of the corrugations.

In use of the material in heat exchangers it is generally advantageous to maintain a large displacement or gap between the leading edges 11a of the flanks 15 of the strips and the corresponding trailing edges 11b of the flanks of the preceding strips. At the same time the widths W of the strips should be kept narrow, but the achievement of these characteristics may have to be a compromise with the requirements of the manufacturing process.

Referring now to Fig. 6 a complete secondary surface element is shown in which the direction of displacement d

of the adjacent strips is reversed centrally of the element. At the same point in the strips as the reversal of displacement takes place the direction of inclination of the flanks of the corrugations is also reversed. The central strip 30 may be parallel to the general direction of flo A, as shown, or it may be of V-shaped profile, the limbs of the V lying parallel to the sets of strips to each side of the strip 30. As seen in Fig. 6, the element is of symmetrical configuration about the strip 30 and this, together with the inclination of the flanks, enables the material to be readily formed, as will be described.

It will be appreciated that, with the material having corrugations of the kind described and shown, the free edges 11a, 11b of the strips can extend the full height h of the material. This compares with louvred material in which the louvres do not extend the full height but are formed along only a portion of the flanks of the corrugations.

Referring now particularly to Fig. 7, the material of Fig. 6 is assembled with tubes 31 so that an element is bounded on each side by a row of tubes 31. A heat exchange fluid is passed through the tubes 31 and a flow of further fluid, usually air, passes over the element in the general direction of arrows A to set up a heat exchange relationship between the two fluids. Alternatively the secondary surface element may be sandwiched between sheets in layers to form a cross-flow or a counter-flow heat exchanger.

Apparatus for forming the corrugated material of Figs. 4-7 is shown in Figs. 8 and 9 of the drawings and it comprises a pair of rolls 20 and 21 mounted on parallel shafts 22 and 23 for rotation in opposite directions, each roll being made up of laminae 24 arranged side by side in contact with one

another and each lamina having an outer profile formed with circumferentially-spaced teeth 25. Adjacent laminae in each roll are angularly displaced from one another about the axis of the associated roll by a predetermined amount, as will be explained, and the teeth mesh together on rotation with a suitable space between them to receive the metal sheet or foil to be corrugated. The teeth 25 are helically arranged, that is, each tooth on each lamina lies along a helical path extending around the associated roll. This gives rise to the flanks of the teeth extending at an acute angle to lines parallel to the axis of the associated roll, which angle is the same for all the teeth so that the teeth may mesh with one another. Moreover, the helical paths on which the teeth of each lamina lie are equally spaced from one another circumferentially of the lamina.

One way of imagining the constructions of the rolls is to consider a pair of matching helical gear wheels. Divide each gear wheel into a plurality of laminae along lines at right angles to the axes of the wheels and then displace each lamina a small amount angularly in relation to its next adjacent lamina in the opposite direction to the inclination of the flanks of the teeth and in a manner such that the gear wheels can mesh together. This results in a pair of rolls in accordance with the present invention and indeed the apparatus may be constructed generally as described. Alternatively helical teeth may be machined in an assembly of generally disc like laminae which are then angularly displaced from one another.

Upon feeding a sheet of heat-conducting material, for example metal sheet or foil, between these rolls, corrugated sheet material, such as shown in Figs. 4-7 of the drawings, is formed. In this case the teeth 25 of the rolls are shaped to produce the truncated triangular corrugations shown.

CLAIMS

1. A secondary surface element for a heat exchanger comprising sheet material characterised by being formed with successive mutually inclined integral portions (44, 45; 54, 55), each arranged to be inclined to the general direction of flow (A) of heat exchange medium over the elements and the mutually inclined portions having louvres (46, 47; 56, 57) formed therein, each louvre lying in a plane inclined to the plane of the associated portion (44, 45; 54, 55) of the element.

2. A secondary surface element according to claim 1 characterised in that the sheet material is formed in successive V-shaped portions (44, 45; 54, 55), the louvres (46, 47; 56, 57) being formed in the flanks of the V and lying in planes inclined to the flanks of the V.

3. A secondary surface element according to claim 2 characterised in that the apices of the V-shaped portions are flattened to provide portions (43; 53) which are arranged to be generally parallel to said general direction of flow (A) of the heat exchange medium.

4. A secondary surface element according to claim 2 or 3 characterised in that the planes of the louvres (46, 47; 56, 57) in one flank of each V-shaped portion are oppositely inclined to the planes of the louvres of the other flank.

5. A secondary surface element according to any one of claims 2, 3 or 4 characterised in that ends of the V-shaped portions are integral with portions (41, 42; 51, 52) lying generally parallel to the general direction of flow (A) of heat exchange medium over the element.

6. A secondary surface element according to any one of the preceding claims characterised by a plurality of apertures for receiving tubes (50) so that the tubes extend through the element generally perpendicular to said general direction of flow (A) of heat exchange medium over the elements.

7. A secondary surface element according to any one of the preceding claims characterised in that the louvres (46, 47; 56, 57) are formed in sets there being two or more sets (56, 56A; 57, 57A) formed in each inclined portion and spaced from one another.

8. A secondary surface element according to claim 7, as appendant to claim 6, characterised in that the apertures are formed in the element between the sets of louvres (56, 56A; 57, 57A).

9. A secondary surface element for a heat exchanger comprising corrugated sheet material formed of a plurality of corrugated strips (11, 12, 13), each strip being similarly shaped and corresponding portions of the flanks (15) of the corrugations in adjacent strips being displaced from one another in the longitudinal direction of the strips whereby the leading edge (12a) of each flank is displaced in one direction from the trailing edge (11b) of the corresponding flank of an immediately adjacent strip, the strips being

joined to one another to form a unitary structure, characterised in that the flanks (15) of the corrugations are each inclined in the opposite direction to said displacement at an acute angle (α) to the longitudinal direction of the strips.

10. A secondary surface element according to claim 9 characterised in that the direction of displacement of the edges of the strips is reversed across the element to provide at least two groups of strips, the displacement (d) of the edges of each group being in opposite directions to one another and the direction of inclination of the flanks of each group being opposite to the direction of displacement of the strips of that group.

11. A secondary surface element according to claim 10 characterised in that the element is arranged symmetrically about a central longitudinal strip (30).

12. A secondary surface element according to any one of claims 9 to 11 characterised in that the angle (α) of the flanks (15) of the corrugations to the longitudinal direction of the strips is in the range 60° - 80°.

13. A secondary surface element according to any one of claims 9 to 12 characterised in that the displacement (d) between the leading edges and the trailing edges of adjacent strips is such that the corrugations are in alignment in a direction at a right angle to the longitudinal direction of the strips.

14. A secondary surface element according to any one of claims 9 to 13 characterised in that the displacement (d) between the leading edges and the trailing edges of adjacent strips is of the order of one third the pitch of the corrugations.

15. A secondary surface element according to any one of claims 9 to 14 characterised in that the element is arranged to have the crests (17) of the corrugations in contact with heat exchange tubes (31) and a flow of heat exchange medium over the element is in a direction (A) at right angles to the longitudinal direction of the strips.

16. Apparatus for forming a secondary surface element according to any one of claims 9 to 15 comprising a pair of rolls and drive means for driving at least one of the rolls so that the rolls rotate in opposite directions, each roll being formed of a set of laminae arranged side by side along the axis of the associated roll and each lamina in a set having a corrugated profile with circumferentially spaced teeth, corresponding edges of the teeth of adjacent laminae being angularly displaced from one another about the axis of the associated roll, and the teeth of one set of laminae being arranged in mesh with the teeth of the other set of laminae, characterised by the teeth (25) of the laminae (24) lying on helical paths extending around the associated roll (20; 21), and the element being formed by feeding sheet material between the rolls.

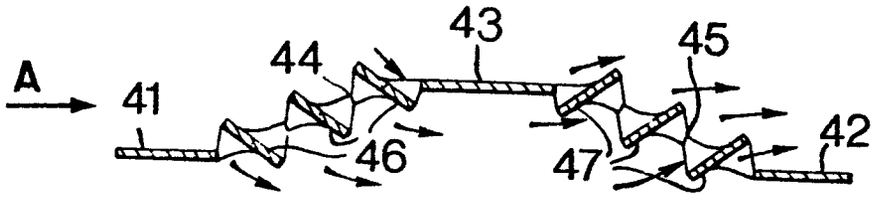


FIG.1

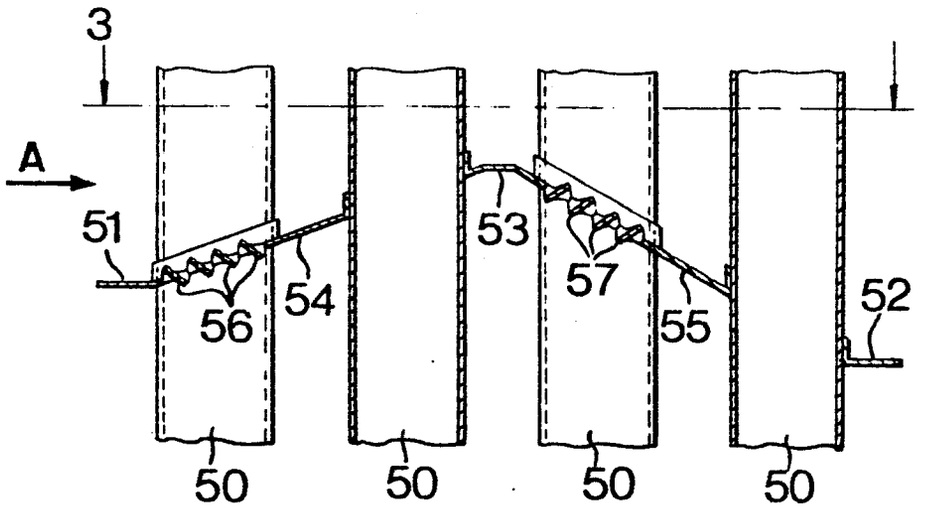


FIG.2

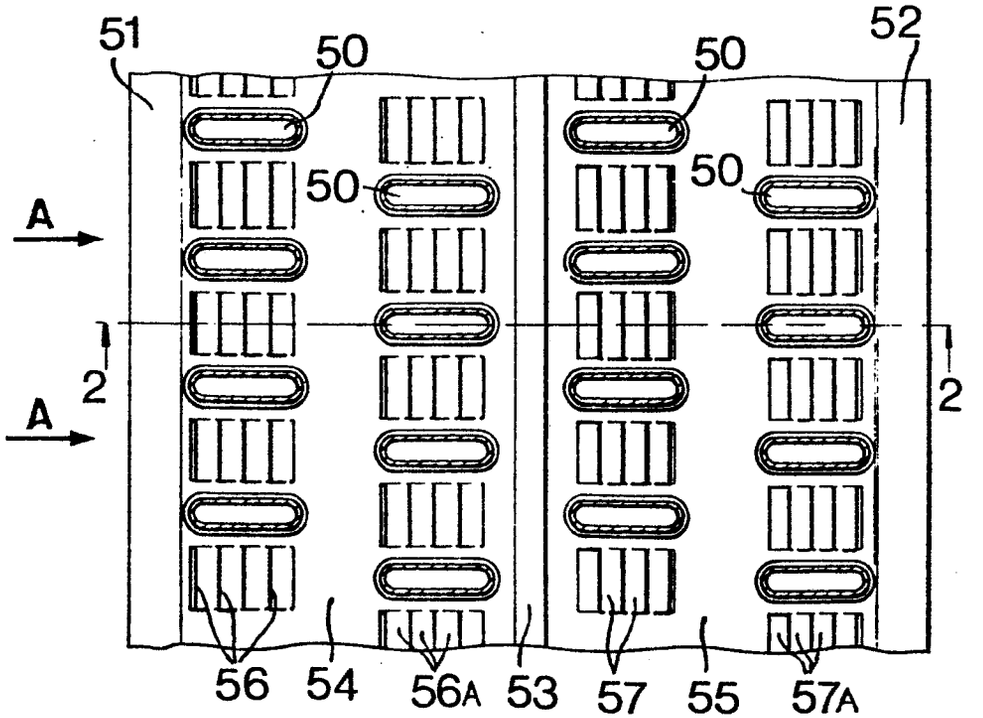


FIG.3

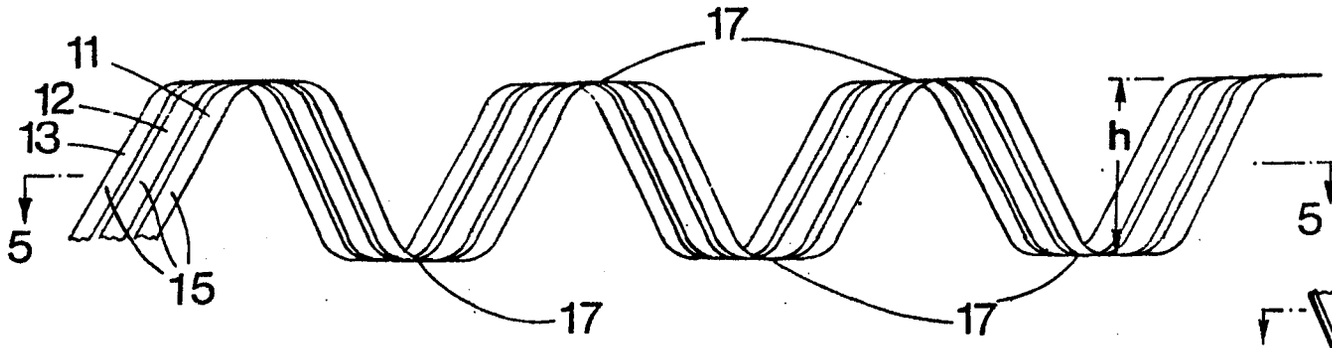


FIG.4

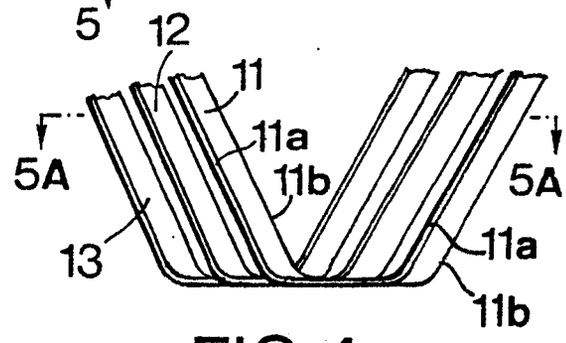


FIG.4A

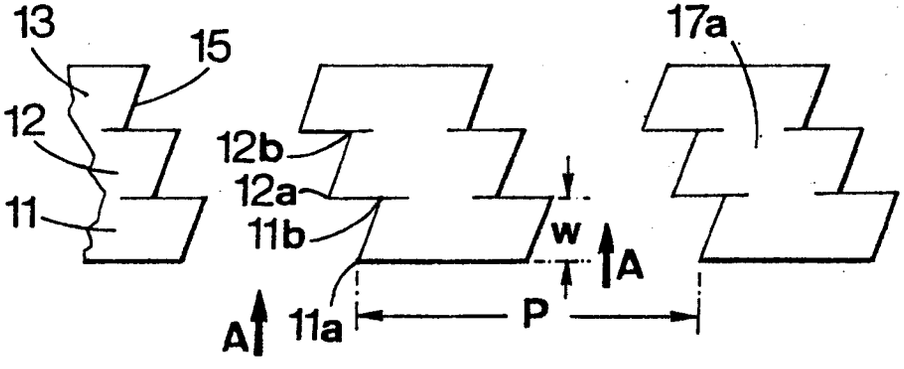
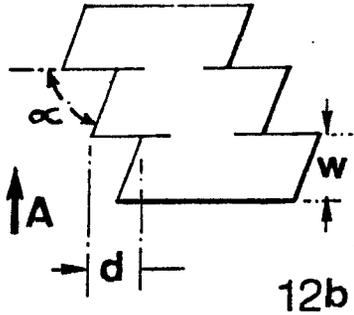


FIG.5



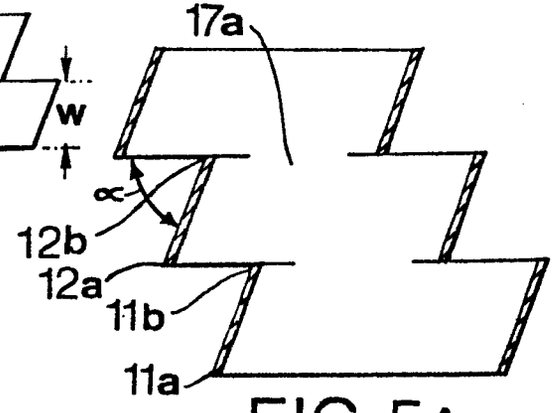


FIG.5A

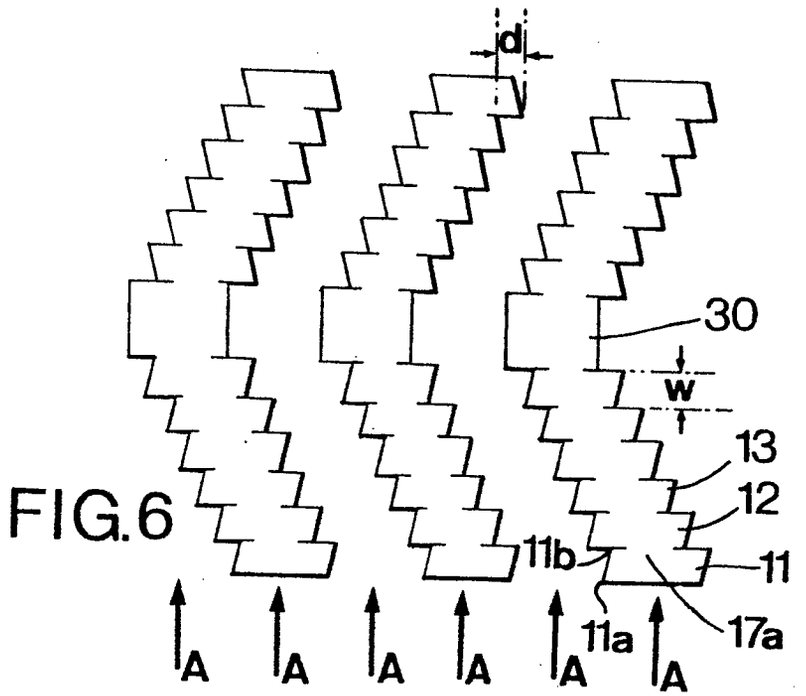


FIG.6

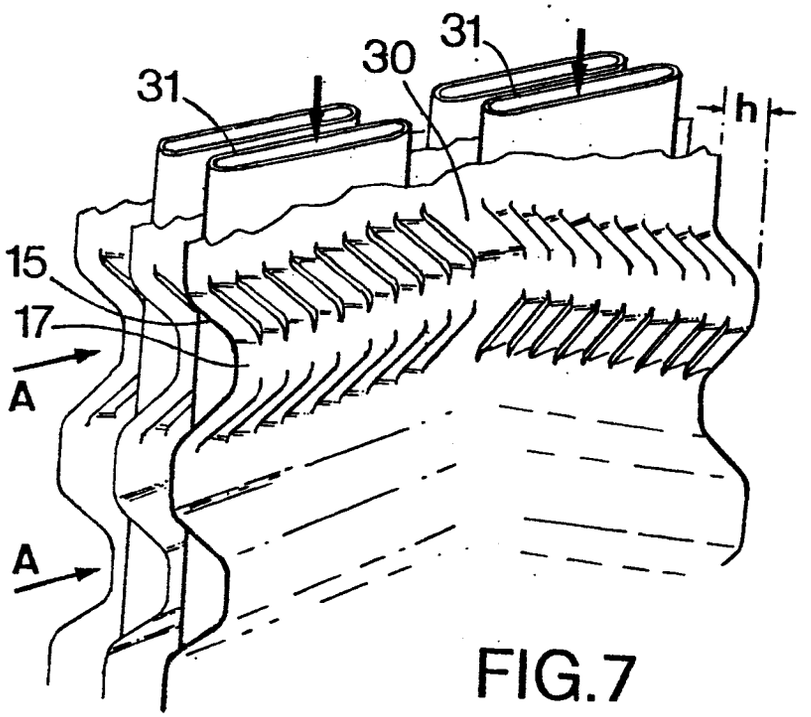


FIG.7

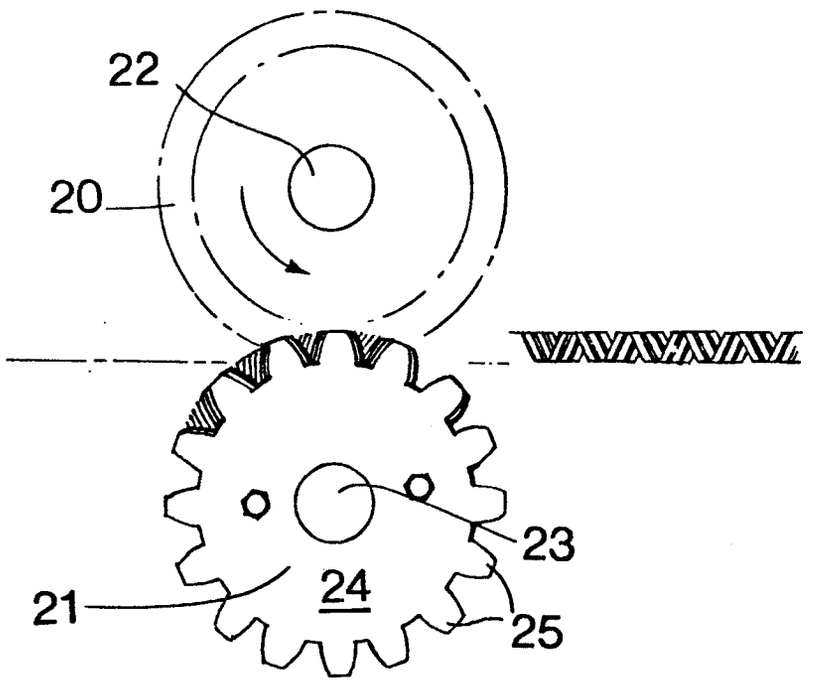


FIG.8

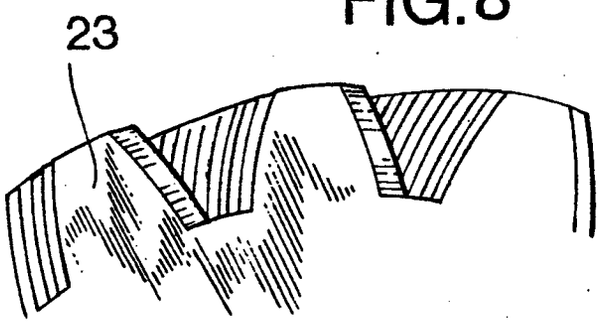


FIG.9

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 79 30 0923

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	BE - A - 410 189 (DIETERLEN) * Page 27, paragraph 3 - page 28, paragraph 3; figures 48 and 50-53 *	1,2,4, 6-8
	FR - A - 2 270 544 (NIPPON-DENSO) * Page 3, line 21 - page 5, line 14; figures 2,3,5 *	1,2,3, 5,9, 10,13
	CH - A - 219 262 (BECK) * Page 4, lines 4-69; figures 1-5 *	1,2,5, 6,8
	CH - A - 220 298 (BECK) * Page 3, lines 11-51; figures 1-4 *	1,2
	US - A - 3 796 258 (MALHOTRA) * Whole document *	1,2,6
	US - A - 1 416 570 (MODINE) * Whole document *	1,2,6
	US - A - 3 083 662 (ZEIDLER) * Whole document *	1,2,3, 5,13

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CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

F 28 F 1/12
B 21 D 13/04

TECHNICAL FIELDS SEARCHED (Int.Cl.³)

F 28 F
B 21 D

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

☒ The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	04-09-1979	JOHANSSON

EPO Form 1503.1 06.78

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EUROPEAN SEARCH REPORT

Application number

EP 79 30 0923

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	NL - C - 1056 (BERAN) * Whole document * --	16
PD	FR - A - 2 380 828 (COVRAD) * Page 2, line 24 - page 4, line 29; figures 1-8 * & DE - A - 2 806 421 --	2,3,9, 10,11, 13,16
A	US - A - 3 940 966 (DEANE)	1
A	US - A - 3 433 044 (RHODES)	1
A	US - A - 3 993 125 (RHODES)	1
A	US - A - 3 265 127 (NICKOL)	1
A	DE - B - 1 132 163 (EISENWERKE) ----	1

CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

TECHNICAL FIELDS SEARCHED (Int. Cl.³)