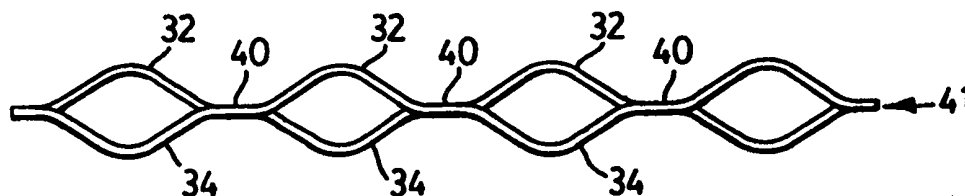




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(21) International Application Number: PCT/CA98/00826 (22) International Filing Date: 28 August 1998 (28.08.98) (30) Priority Data: 2,214,255 29 August 1997 (29.08.97) CA (71) Applicant: LONG MANUFACTURING LTD. [CA/CA]; 656 Kerr Street, Oakville, Ontario L6K 3E4 (CA). (72) Inventors: SO, Allen, K.; 4269 Tea Garden Circle, Mississauga, Ontario L5B 2Z1 (CA). STEFANOIU, Dan, Constantin; 3653 Indigo Crescent, Mississauga, Ontario L5N 7J1 (CA). ZURAWEL, Peter; 2218 Florian Road, Mississauga, Ontario L5A 2M4 (CA). (74) Agents: MOSS, W., Dennis et al.; Barrigar & Moss, Suite 901, 2 Robert Speck Parkway, Mississauga, Ontario L4Z 1H8 (CA).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i>

(54) Title: HEAT EXCHANGER TURBULIZERS WITH INTERRUPTED CONVOLUTIONS



(57) Abstract

A heat exchanger (10) is disclosed of the type having stacked plate pairs or tubes (12) defining flow passages, with turbulizer (18, 30, 45, 50, 55, 60) located inside such flow passages. The turbulizers (18, 30, 45, 50, 55, 60) are of the expanded metal type having rows of convolutions (32, 34). The convolutions (32, 34) are interrupted periodically to form non-convoluted pressure recovery zones (40) located between or downstream of the convolutions (32, 34). Also, the rows of convolutions (32, 34) can be spaced apart to provide longitudinal neutral zones (56, 61) between the rows of convolutions. The pressure recovery zones (40, 56, 61) and longitudinal neutral channels (62) reduce pressure drop in the heat exchanger (10) without appreciably reducing heat transfer.

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TITLE OF THE INVENTION

HEAT EXCHANGER TURBULIZERS WITH INTERRUPTED CONVOLUTIONS

TECHNICAL FIELD

5 The present invention relates to heat exchangers, and in particular, to turbulizers used in heat exchangers.

BACKGROUND ART

10 In heat exchangers made from multiple, stacked, tubes or plate pairs defining flow passages therein, it is common to use turbulizers located in the tubes or between the plates inside the plate pairs to enhance heat transfer, especially where a liquid, such as oil, passes through these flow passages. These turbulizers are commonly in the
15 form of expanded metal inserts and they have undulations or convolutions formed therein to create turbulence in the flow and in this way increase heat transfer in the heat exchanger.

20 While conventional turbulizers do increase heat transfer, a difficulty with these turbulizers is that they also increase flow resistance or pressure drop inside the heat exchanger. In fact, the flow resistance increases even more than the heat transfer gain produced by the
25 turbulizer, because only a part of the increased turbulence caused by the turbulizer is effective in promoting heat transfer. The balance is wasted in inefficient eddies or vortices.

30 The present invention periodically interrupts the convolutions in the turbulizer to form non-convoluted pressure recovery zones located between the convolutions. Surprisingly, this substantially reduces the pressure drop caused by the turbulizer without appreciably reducing heat
35 transfer.

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DISCLOSURE OF THE INVENTION

According to one aspect of the invention, there is provided a turbulizer for a heat exchanger comprising a planar member having a plurality of parallel rows of convolutions formed therein. The convolutions are interrupted periodically to form non-convoluted pressure recovery zones located between the convolutions.

According to another aspect of the invention, there is provided a heat exchanger comprising a pair of back-to-back plates having joined peripheral edges and raised central portions defining a flow passage therebetween. The central portions define spaced-apart inlet and outlet openings. A turbulizer as described next above is located in the flow passage between the inlet and outlet openings.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is an exploded perspective view of a preferred embodiment of a plate type heat exchanger according to the present invention;

Figure 2 is an enlarged perspective view of a portion of the turbulizer used in the heat exchanger of Figure 1;

Figure 3 is an elevational view of a portion of the turbulizer of Figure 2 taken in the direction of arrow 3 in Figure 2;

Figure 4 is a plan view of the turbulizer of Figures 2 and 3;

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Figure 5 is a perspective view of another embodiment of a turbulizer according to the present invention;

5 Figure 6 is an elevational view of a portion of the turbulizer of Figure 5 taken in the direction of arrow 6 in Figure 5;

10 Figure 7 is a plan view of the turbulizer shown in Figures 5 and 6;

Figure 8 is a perspective view of yet another embodiment of a turbulizer according to the present invention;

15 Figure 9 is an elevational view of a portion of the turbulizer of Figure 8 taken in the direction of arrow 9 in Figure 8;

20 Figure 10 is a plan view of the turbulizer shown in Figures 8 and 9;

25 Figure 11 is a perspective view of yet another embodiment of a turbulizer according to the present invention;

Figure 12 is an elevational view of a portion of the turbulizer of Figure 11 taken in the direction of arrow 12 in Figure 11;

30 Figure 13 is a plan view of the turbulizer shown in Figures 11 and 12;

35 Figure 14 is a perspective view of yet another embodiment of a turbulizer according to the present invention;

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Figure 15 is a side elevational view of the turbulizer shown in Figure 14; and

Figure 16 is a plan view of the turbulizer shown in
5 Figures 14 and 15.

BEST MODE FOR CARRYING OUT THE INVENTION:

Referring to Figure 1, a preferred embodiment of a
10 heat exchanger according to the present invention is generally indicated by reference numeral 10. Heat exchanger 10 is formed of a plurality of spaced-apart tube members or plate pairs 12, each having an upper plate 14, a lower plate 16 and a turbulizer 18 located therebetween. Plates
15 14, 16 are arranged back-to-back and have joined peripheral edges 20. Plates 14, 16 also have raised central portions 22 which define a flow passage therebetween in which turbulizers 18 are located. Raised central portions 22 also define spaced-apart inlet and outlet openings 24, 26 for
20 the flow of fluid, such as oil, through the plate pairs. When the heat exchanger is assembled, all of the inlet openings 24 are aligned and in communication forming an inlet header, and all of the outlet openings 26 are aligned and in communication forming an outlet header. Expanded
25 metal fins 28 are located between the plate pairs for allowing another fluid, such as air to flow transversely through the plate pairs. The plates 14,16 that are in contact with fins 28 are spaced apart by raised end bosses 29 to make room for fins 28 between plate central portions
30 22.

The plates 14, 16 and the fins 28 can be any shape and configuration desired and are not, *per se*, considered to be part of the present invention. In fact, plates 14, 16 can
35 be formed with outwardly disposed dimples which mate in

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adjacent plate pairs in which case, fins 28 would not be used.

Referring next to Figures 2, 3 and 4, a preferred embodiment of a turbulizer 30 is shown which could be used as the turbulizer 18 in Figure 1. It will be appreciated that Figures 5, 8, 11 and 14 show other preferred embodiments of turbulizers. Any one of these could be used as the turbulizer 18 in the heat exchanger 10 shown in Figure 1. The turbulizers shown in Figures 2, 5, 8, 11 and 14 are just illustrations of sections or portions of the turbulizers. It will be appreciated that these turbulizers can be made in any length or width desired depending upon the manufacturing method. The turbulizers usually are stamped or roll-formed out of aluminum about 0.01 inches (0.25 mm) thick. However, other materials and heavier or thinner materials can be used for the turbulizers as well.

Turbulizer 30 is a planar member having a plurality of convolutions 32, 34 formed therein. Convolutions 32, 34 are arranged in parallel rows. Where turbulizer 30 is elongate in shape, convolutions 32, 34 are arranged in parallel, longitudinal rows 36, and also in parallel transverse rows 38.

Convolutions 32, 34 are interrupted periodically to form non-convoluted pressure recovery zones 40 located between or downstream of the convolutions 32, 34 in each row of convolutions 36. In other words, the convolutions 32, 34 in each row are spaced-apart by pressure recovery zones 40, rather than being located contiguous to one another as is the case in conventional turbulizers.

Turbulizer 30 has a central plane containing pressure recovery zones 40 as indicated by arrow 41 in Figure 3, and convolutions 32, 34 extend alternately above (convolutions 32) and below (convolutions 34) the central plane 41.

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Convolutions 32, 34 are in the form of bridges, and
turbulizer 30 has a high pressure drop orientation in the
direction of the bridges, or in the longitudinal direction,
and a low pressure drop orientation in the direction
5 passing under the bridges or the transverse direction. In
the embodiment shown in Figure 2, the convolutions 32, 34
are interrupted in the high pressure drop direction by
pressure recovery zones 40 located between or downstream of
the convolutions. As seen best in Figure 4, the pressure
10 recovery zones 40 are located in transverse rows or neutral
channels 41 themselves.

When turbulizer 30 is used as the turbulizer 18 in
heat exchanger 10 of Figure 1, fluid flows in the high
15 pressure drop orientation or direction parallel to
longitudinal rows 36 from inlet openings 24 to outlet
openings 26. The fluid flows around and under or through
convolutions 32, 34. This causes turbulence and reduces
boundary layer growth increasing the heat transfer co-
20 efficient. However, pressure recovery zones 40 allow for a
pressure recovery to reduce flow resistance or pressure
drop in the fluid passing from inlet openings 24 to outlet
openings 26.

25 In turbulizer 30, convolutions 32, 34 are aligned in
the low pressure drop or transverse direction. Also,
pressure recovery zones 40 are aligned in the low pressure
drop or transverse direction to form neutral channels 41.
Pressure recovery zones 40 thus form continuous neutral
30 channels 41 in the low pressure drop direction. These
neutral channels 41 also provide areas that can be used to
eject the turbulizer from the dies used to produce the
turbulizer.

35 The width of the convoluted longitudinal rows 36 is
preferably as narrow as is practical for tool design and
maintenance purposes. For automotive cooling purposes, a

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preferred minimum width would be about 0.02 inches (0.5 mm). The maximum width should not exceed ten times the minimum. Typically, the maximum width would be about 0.2 inches (5 mm). The longitudinal length of pressure recovery zones 40 ranges from about 5% of the longitudinal or centerline to centerline spacing between convolutions 32, 34 to about 75% of the spacing between any two consecutive convolutions 32, 34. A preferable range would be between 0.02 inches (0.5 mm) to about 0.5 inches (1.25 cm), or about 40% to 50% of the centerline to centerline distance between longitudinally consecutive convolutions 32, 34.

The height of convolutions 32, 34 above or below the central plane 41 containing pressure recovery zones 40 depends upon the thickness of the material used for turbulizer 30. This height should not be less than the material thickness and typically ranges from this minimum to about 10 times the material thickness where aluminum is used for turbulizer 30. A good range is from 0.01 inches (0.25 mm) to 0.5 inches (1.25 cm).

The longitudinal length of convolutions 32, 34 is normally about 2 times the height of the convolutions. The height normally ranges from about 2 times the material thickness to about 20 times the material thickness. A good range is from 0.02 inches (0.5 mm) to about 1.0 inch (2.5 cm).

Referring next to Figures 5, 6 and 7, a turbulizer 45 is shown which is substantially similar to turbulizer 30 except as follows. In turbulizer 45, the convolutions 32, 34 are staggered in the low pressure drop or transverse direction. In other words, the convolutions 32 which extend above the central plane do not line up transversely with the convolutions 34 that extend below the central plane in the adjacent longitudinal rows 36. Convolutions 32, 34 in every other row of convolutions do line up, but they could

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be staggered as well if desired. The material thickness and dimensions of convolutions 32, 34 and pressure recovery zone 40 are similar to those of turbulizer 30 of Figure 2.

5 Referring next to Figures 8, 9 and 10, yet another embodiment of turbulizer 50 is shown wherein the convolutions are staggered in the low pressure drop or transverse direction. In turbulizer 50, all of the pressure recovery zones 40 are contained in a common reference plane
10 52 (see Figure 9) and all of the convolutions 54 extend in the same direction relative to this reference plane 52. In all other respects, turbulizer 50 is similar to turbulizers 30 and 45.

15 Referring next to Figures 11, 12 and 13, a turbulizer 55 is shown that is most similar to turbulizer 30 of Figure 2, except the convolutions 32, 34 are also interrupted in the low pressure drop direction to form further pressure recovery zones 56 located between some of the rows of
20 convolutions 36. Actually, pressure recovery zones 56 extend longitudinally the full length of turbulizer 55 to form longitudinal neutral channels 58 in the high pressure drop or longitudinal direction of turbulizer 55. For manufacturing purposes, the width of neutral channels 58
25 preferably is about the same as the width of the rows of convolutions 36. In turbulizer 55, the convolutions 32, 34 are aligned in the low pressure drop or transverse direction, but they could be staggered as well. Where convolutions 32, 34 are aligned in the low pressure drop or
30 transverse direction, it will be appreciated that pressure recovery zones 40 are aligned to give transverse neutral channels 59 in the low pressure drop direction, and pressure recovery zones 56 are aligned to give longitudinal neutral channels 58 in the high pressure drop direction.
35 Where convolutions 32, 34 are staggered, only longitudinal neutral channels 58 would be formed. In all other respects, turbulizer 55 is similar to turbulizers 30, 45 and 50.

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Referring next to Figures 14, 15 and 16, a turbulizer 60 is shown where the convolutions 32, 34 are interrupted only in the low pressure drop or transverse direction and only between some of the rows of convolutions 36. These
5 interruptions make pressure recovery zones 61 in the form of longitudinal neutral channels 62. In all other respects, turbulizer 60 is similar to turbulizers 30, 45, 50 and 55. In Figures 14 to 16, turbulizer 60 is shown cut to length in the middle of convolutions 32, 34. This has been done
10 for the purposes of illustration. In practice, the turbulizers would normally be cut to length between the convolutions, as is the case in Figures 1 to 13.

Having described preferred embodiments of the
15 invention, it will be appreciated that various modifications can be made to the structures described above. For example, instead of using plate pairs 12 as tube members defining the flow passages containing turbulizers 18, continuous flat or oblong tubes could be used instead.
20 In this case, turbulizers 18 would be inserted lengthwise into one end of the tubes. In turbulizers 18, the convolutions 32, 34 have been shown to be rounded with various curvatures. These convolutions can be any configuration, such as semi-circular, sinusoidal,
25 trapezoidal or even V-shaped, if desired. In heat exchanger 10 shown in Figure 1, turbulizer 18 is shown to be orientated such that the flow is in the high pressure drop or longitudinal direction. However, the turbulizer could be rotated 90 degrees so that the flow from inlet 24 to outlet
30 26 is in the low pressure drop direction if desired. It will also be appreciated that the various features of turbulizers 30, 45, 50, 55 and 60 could be mixed and matched, or a combination of these features could be employed in the same turbulizer. Also, any given heat
35 exchanger could have any one or a combination of the turbulizers described above. Other modifications to the

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structure described above will be apparent to those skilled in the art.

As will be apparent to those skilled in the art in the
5 light of the foregoing disclosure, many alterations and
modifications are possible in the practice of this
invention without departing from the spirit or scope
thereof. Accordingly, the scope of the invention is to be
construed in accordance with the substance defined by the
10 following claims.

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WHAT IS CLAIMED IS:

1. A turbulizer for a heat exchanger comprising:
a planar member having a plurality of parallel rows of convolutions formed therein, said convolutions being interrupted periodically to form non-convoluted pressure recovery zones located between said convolutions.
2. A turbulizer for a heat exchanger as claimed in claim 1 wherein the convolutions are in the form of bridges, the turbulizer having a high pressure drop orientation in the direction of the bridges and a low pressure drop orientation in the direction passing under the bridges.
3. A turbulizer for a heat exchanger as claimed in claim 2 wherein the convolutions are interrupted in the high pressure drop direction to form pressure recovery zones located between the convolutions.
4. A turbulizer for a heat exchanger as claimed in claim 2 wherein the convolutions are interrupted in the low pressure drop direction to form pressure recovery zones located between the rows of convolutions.
5. A turbulizer for a heat exchanger as claimed in claim 3 wherein the convolutions are aligned in the low pressure drop direction, the pressure recovery zones also being aligned to form neutral channels in the low pressure drop direction.
6. A turbulizer for a heat exchanger as claimed in claim 3 wherein the convolutions are staggered in the low pressure drop direction.
7. A turbulizer for a heat exchanger as claimed in claim 4 wherein the convolutions are aligned in the low pressure drop direction, the pressure recovery zones also being

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aligned to form neutral channels in the high pressure drop direction.

8. A turbulizer for a heat exchanger as claimed in claim 4 wherein the convolutions are staggered in the low pressure drop direction, the pressure recovery zones in the high pressure drop direction being aligned to form neutral channels in the high pressure drop direction.

9. A turbulizer for a heat exchanger as claimed in claim 3 wherein the convolutions are also interrupted in the low pressure drop direction to form further pressure recovery zones located between the convolutions in the low pressure drop direction.

10. A turbulizer for a heat exchanger as claimed in claim 9 wherein the convolutions are aligned in the low pressure drop direction, said pressure recovery zones and said further pressure recovery zones also being aligned to form neutral channels in both the low pressure drop and the high pressure drop directions.

11. A turbulizer for a heat exchanger as claimed in claim 4 wherein the convolutions are staggered in the low pressure drop direction, the pressure recovery zones being aligned to form neutral channels in the high pressure drop direction.

12. A turbulizer for a heat exchanger as claimed in claim 3 wherein the turbulizer has a central plane containing the pressure recovery zones, and wherein the convolutions in each row of convolutions extend alternately above and below the central plane.

13. A turbulizer for a heat exchanger as claimed in claim 3 wherein the turbulizer has a reference plane containing the pressure recovery zones, and wherein the convolutions

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all extend in the same direction relative to the reference plane.

14. A turbulizer for a heat exchanger as claimed in claim 6 wherein the turbulizer has a central plane containing the pressure recovery zones, and wherein the convolutions in each row of convolutions extend alternately above and below the central plane.

15. A turbulizer for a heat exchanger as claimed in claim 6 wherein the turbulizer has a reference plane containing the pressure recovery zones, and wherein the convolutions all extend in the same direction relative to the reference plane.

16. A turbulizer for a heat exchanger as claimed in claim 9 wherein the turbulizer has a central plane containing the pressure recovery zones, and wherein the convolutions in each row of convolutions extend alternately above and below the central plane.

17. A turbulizer for a heat exchanger as claimed in claim 7 wherein the turbulizer has a central plane containing the pressure recovery zones, and wherein the convolutions in each row of convolutions extend alternately above and below the central plane.

18. A heat exchanger comprising:

a plurality of spaced-apart tube members defining flow passages therebetween; said tube members defining spaced-apart inlet and outlet openings; and a turbulizer as claimed in claim 3 located in at least one of the flow passages between the respective inlet and outlet openings.

19. A heat exchanger comprising:

a plurality of spaced-apart tube members defining flow passages therebetween; said tube members defining spaced-

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apart inlet and outlet openings; and a turbulizer as claimed in claim 7 located in at least one of the flow passages between the respective inlet and outlet openings.

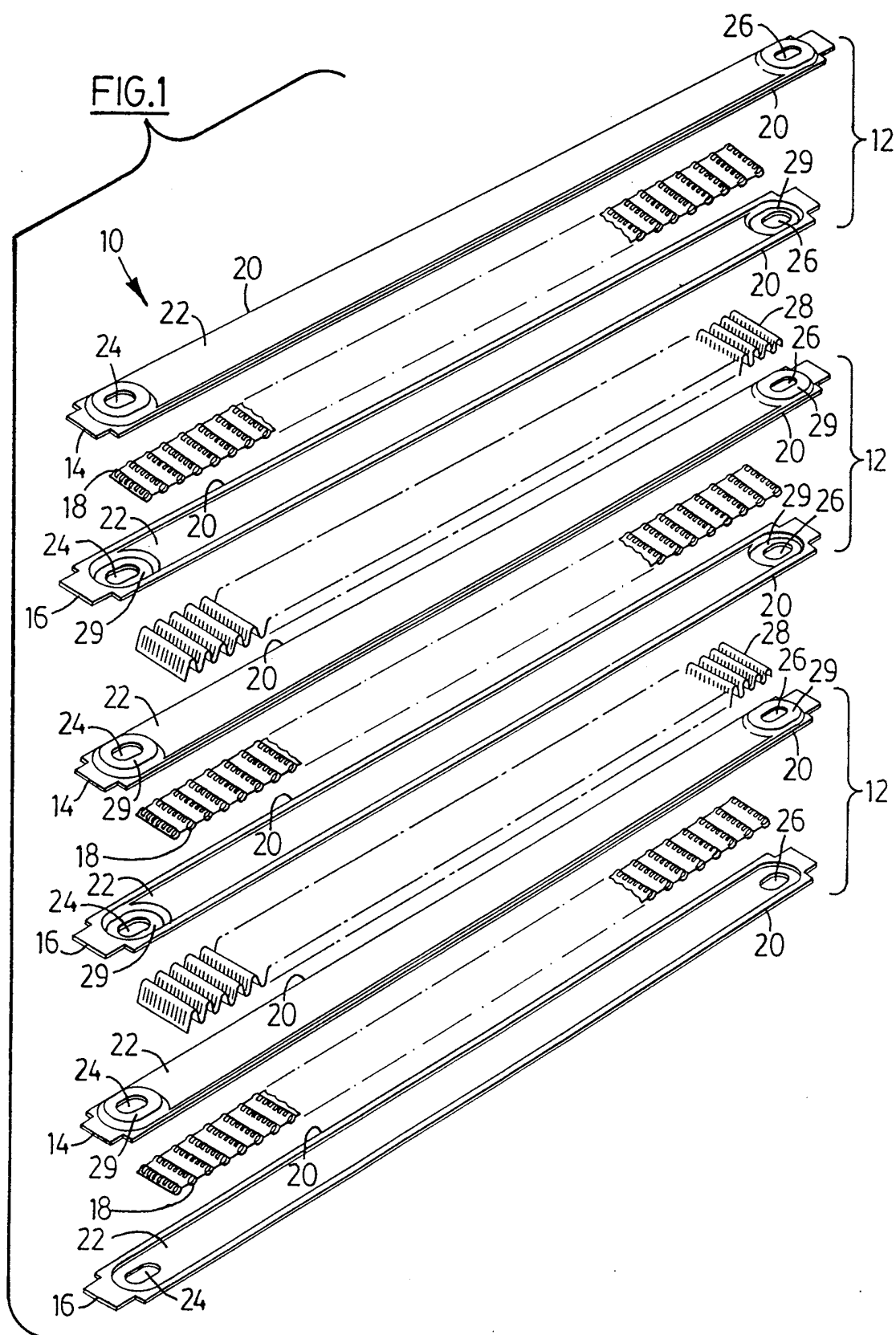
20. A heat exchanger comprising:

a plurality of spaced-apart tube members defining flow passages therebetween; said tube members defining spaced-apart inlet and outlet openings; and a turbulizer as claimed in claim 10 located in at least one of the flow passages between the respective inlet and outlet openings.

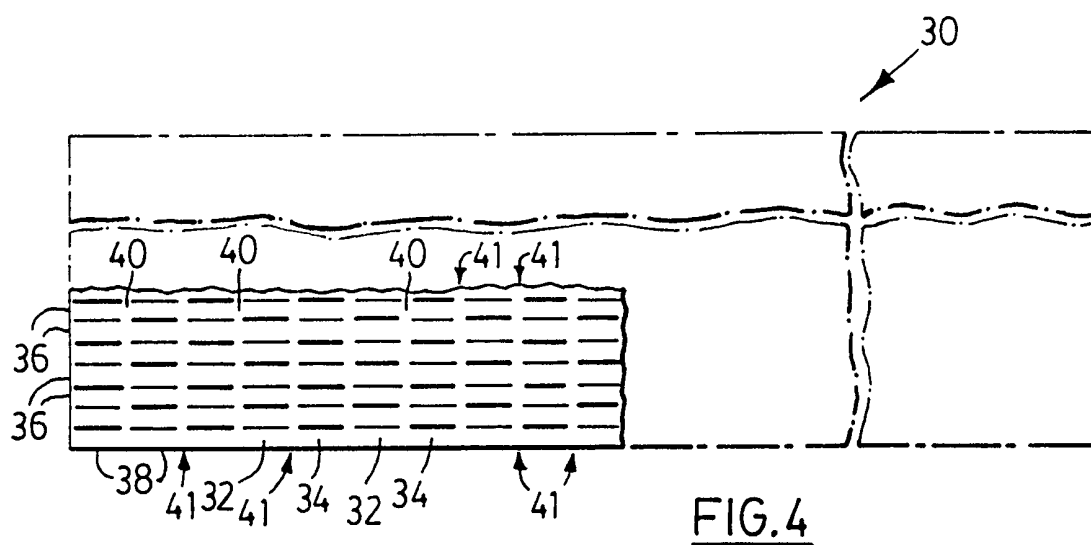
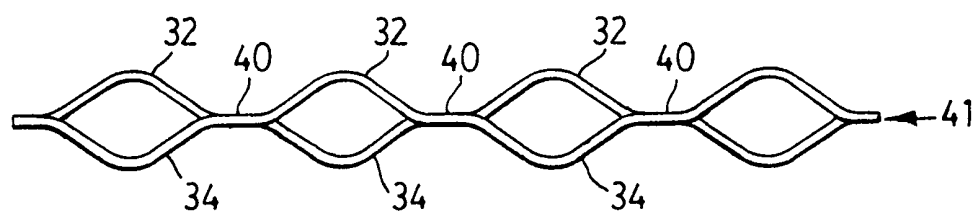
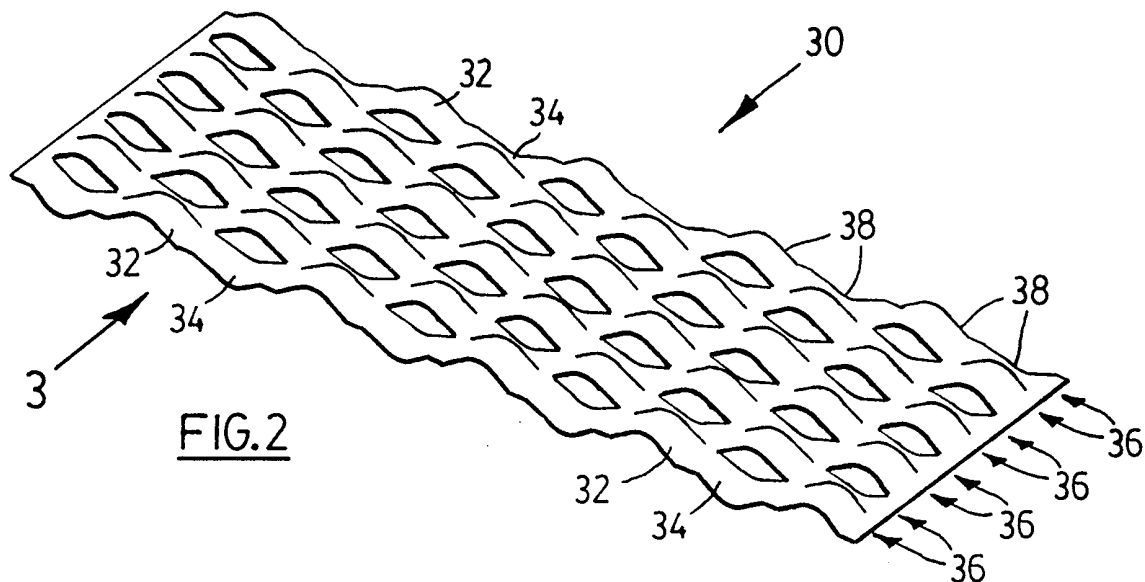
21. A heat exchanger as claimed in claim 18 wherein the tube members are formed of back-to-back plates having joined peripheral edges and raised central portions defining said flow passages.

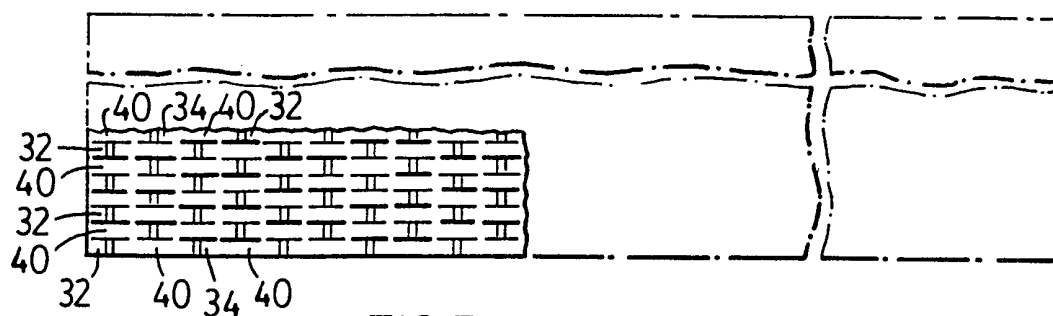
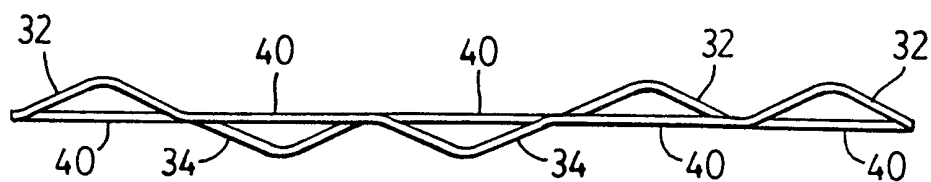
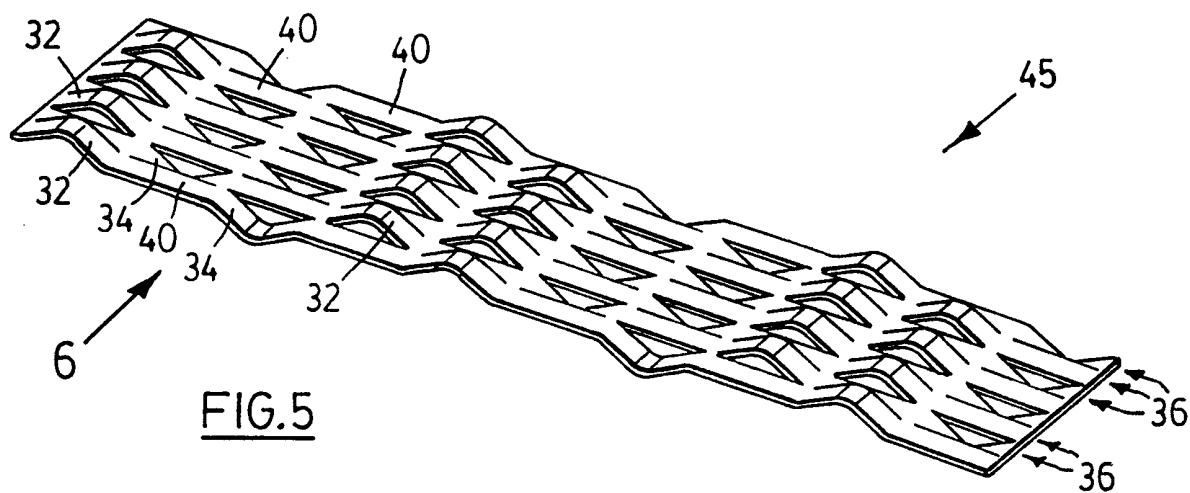
22. A heat exchanger as claimed in claim 19 wherein the tube members are formed of back-to-back plates having joined peripheral edges and raised central portions defining said flow passages.

23. A heat exchanger as claimed in claim 20 wherein the tube members are formed of back-to-back plates having joined peripheral edges and raised central portions defining said flow passages.

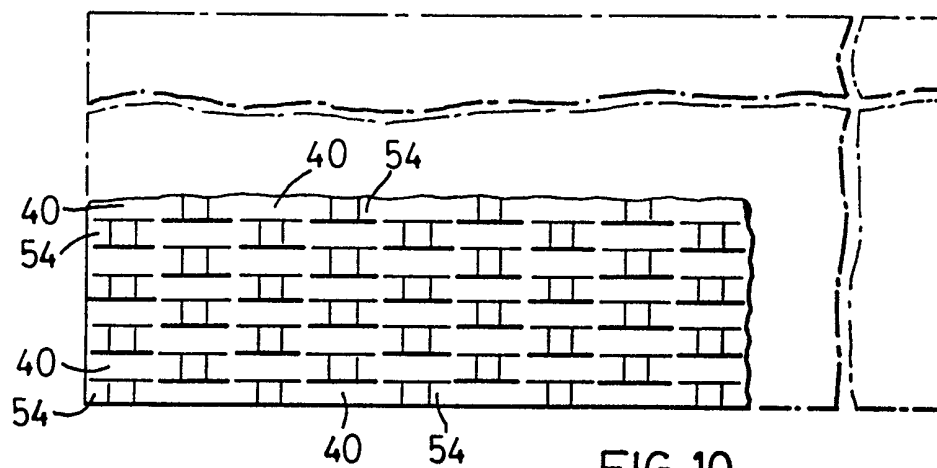
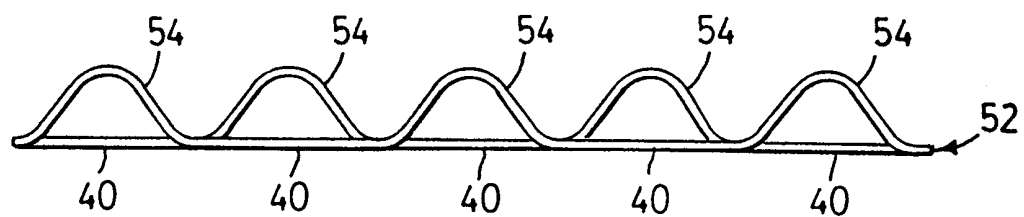
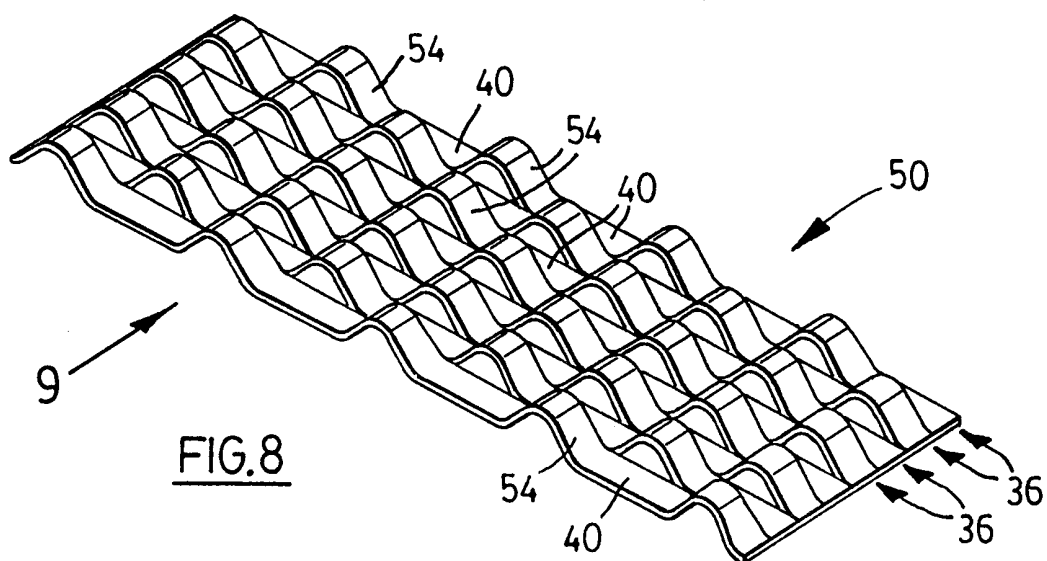


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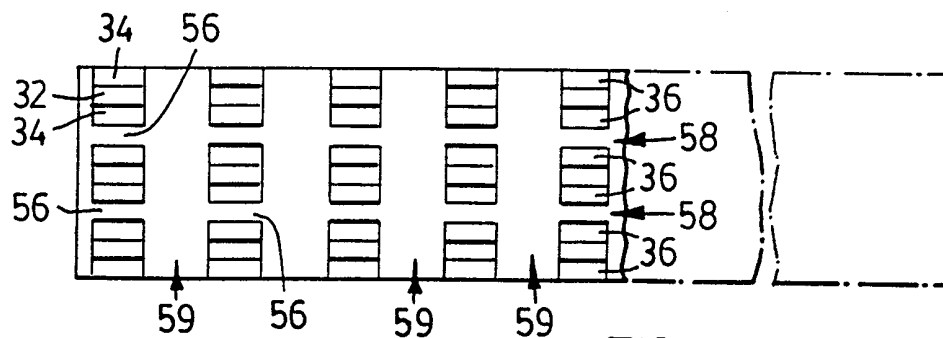
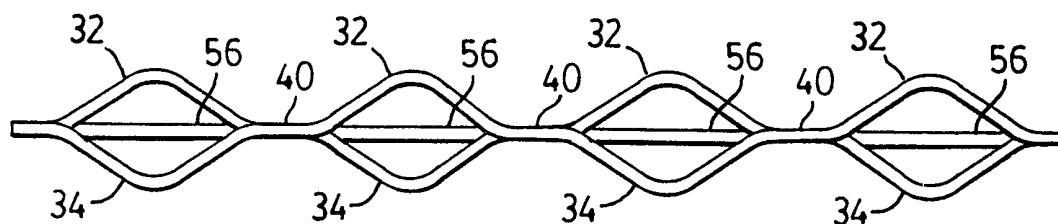
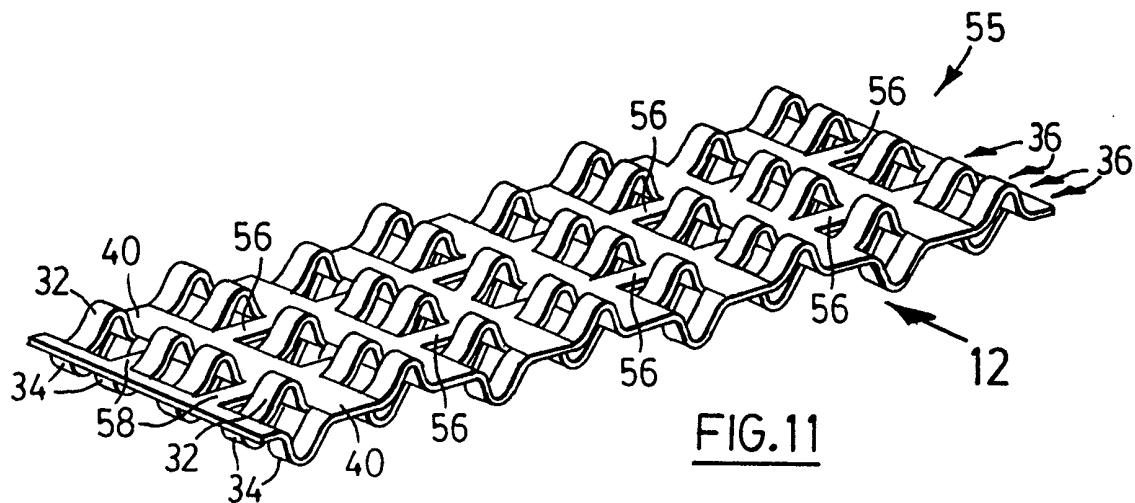




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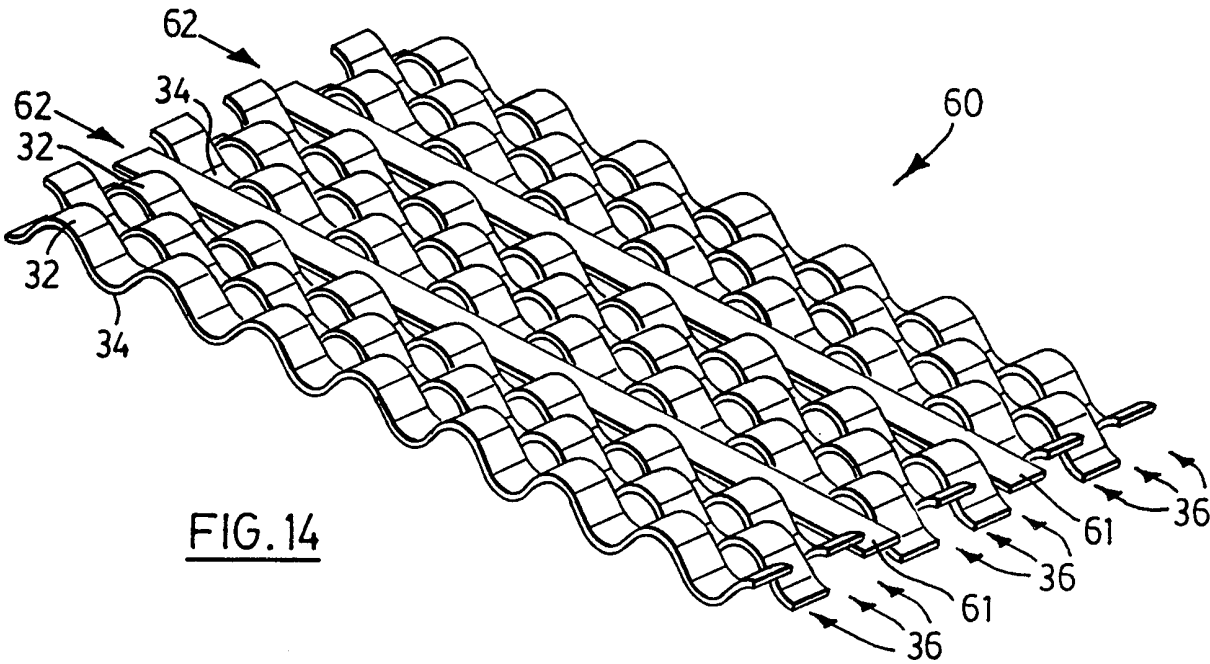


FIG. 14

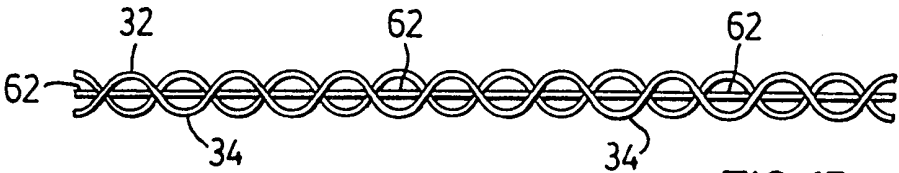


FIG. 15

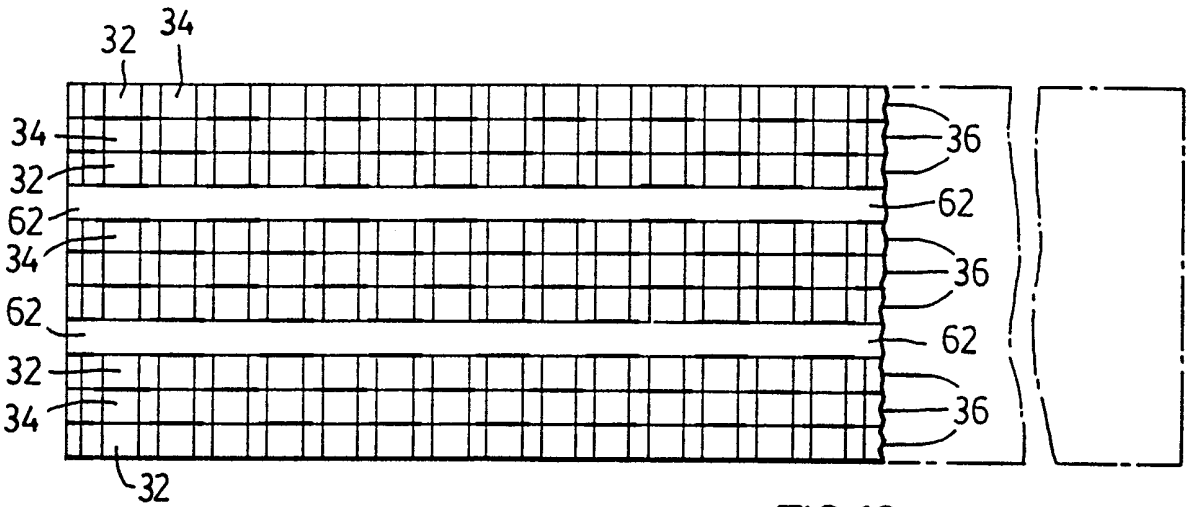


FIG. 16

INTERNATIONAL SEARCH REPORT

International Application No

PCT/CA 98/00826

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 F28F13/12

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 6 F28F

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	EP 0 203 458 A (SHOWA ALUMINIUM CORP.) 3 December 1986 see page 7, line 16 - page 8, line 25	1-3, 5, 12
Y	see page 11, line 3 - page 12, line 11; figures 1-5	18, 21
Y	FR 2 298 075 A (BORG-WARNER CORP.) 13 August 1976 see page 5, line 34 - page 6, line 8; figures 1, 6	18, 21
X	CH 529 986 A (STEEB) 15 December 1972 see column 4, line 30 - column 5, line 47; figures 4-6	1-3, 6, 13, 15, 18
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

11 November 1998

Date of mailing of the international search report

20/11/1998

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INTERNATIONAL SEARCH REPORT

International Application No

PCT/CA 98/00826

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 2 270 544 A (NIPPONDENSO CO LTD) 5 December 1975 see page 3, line 21 - page 5, line 14; figures 3,5 ---	1-3,18
A	US 4 815 534 A (FUERSCHBACH) 28 March 1989 see column 4, line 38 - column 5, line 45; figures 2-8 ---	1-3,5,6
A	GB 1 184 125 A (S.A. DES USINES CHAUSSON) 11 March 1970 see page 1, line 56 - page 2, line 44; figures 1-3 -----	1

INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

PCT/CA 98/00826

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 203458	A	03-12-1986	JP 1859505 C	27-07-1994
			JP 62238996 A	19-10-1987
			JP 1691700 C	27-08-1992
			JP 3005516 B	25-01-1991
			JP 61262593 A	20-11-1986
			DE 3660604 A	29-09-1988
			US 4804041 A	14-02-1989
FR 2298075	A	13-08-1976	CA 1046499 A	16-01-1979
			DE 2600996 A	22-07-1976
			GB 1510139 A	10-05-1978
			JP 51087848 A	31-07-1976
CH 529986	A	31-10-1972	DE 2113583 A	28-09-1972
			FR 2130070 A	03-11-1972
FR 2270544	A	05-12-1975	JP 1096395 C	14-05-1982
			JP 50144949 A	21-11-1975
			JP 56038874 B	09-09-1981
			DE 2520817 A	20-11-1975
			GB 1463047 A	02-02-1977
			US 3983932 A	05-10-1976
US 4815534	A	28-03-1989	CA 1276009 A	06-11-1990
GB 1184125	A	11-03-1970	BE 717835 A	16-12-1968