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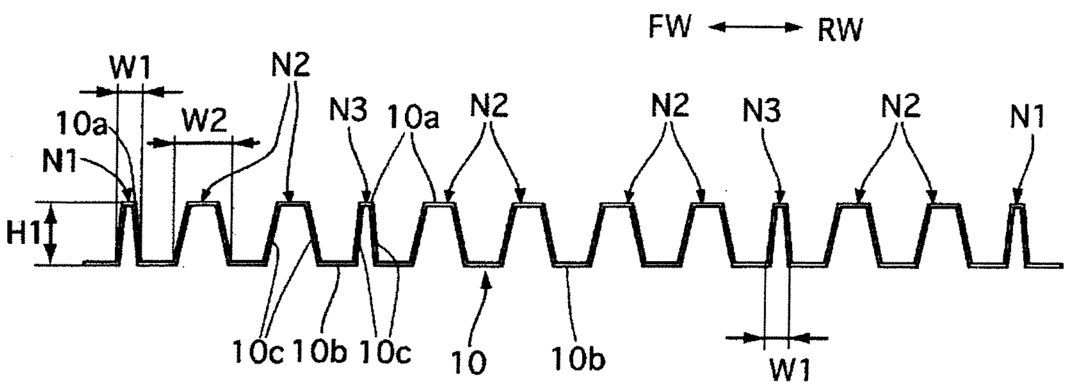
(54) **Core structure of heat exchanger**

(57) A core structure includes a plurality of flat tubes (5) and a plurality of corrugated inner fins (10; 20; 30). Each corrugated inner fin (10; 20; 30) has top portions (10a) for being fixed to an inner surface of an upper wall portion (5a) of the tube (5), bottom portions (10b) for being fixed to an inner surface of the lower wall portion (5b) thereof, and slanted portions (10c) for connecting the top portion (10a) with adjacent bottom portions (10b) thereof. The corrugated inner fin (10; 20; 30) has first corrugations (N1; N4) located at both end sides of the corrugated inner fin (10; 20; 30) and second corrugations (N2; N5) located between the first corrugations (N1), where each of the first and the second corrugations (N1, N2; N4, N5) have the top portion (10a) and the adjacent slanted portions (10c) and project from the bottom portions (10b). The first corrugations (N1; N4) have is set to be smaller in a front-back directional length of the corrugated inner fin (10; 20; 30) than a front-back directional length of the second corrugations.

FIG. 5



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Description

[0001] The present invention relates to a core structure of a heat exchanger, which has a plurality of flat tubes each containing a corrugated inner fin in a state where the inner fin is fixed to an inner surface of the flat tube.

[0002] A conventional core structure of a heat exchanger of this kind is disclosed in Japanese Utility Model laid-open publication No. (Jikkaisyo) 59 - 148978, Japanese Patents laid-open publication No. (Tokkaihei) 07 - 265985, No. (Tokkkaihei) 08 - 71836, No. (Tokkaihei) 09 - 229578, and No. 2004 - 061032. These conventional core structures have a plurality of flat tubes and corrugated inner fins contained in the flat tubes and fixed to their inner surfaces by brazing. The flat tubes has an upper flat wall portion, a lower flat wall portion arranged in parallel to the upper flat portion, a first arc wall portion continued to connect one end portions of the upper and lower wall portions, and a second arc wall portion continued to connect the other end portions of the upper and lower wall portions, and are integrally formed horizontally long and vertically short.

[0003] These flat tubes and corrugated inner fins of the conventional core structure are manufactured as follows.

[0004] The flat tubes and the corrugated inner fins are formed by press working, respectively. In this formation, the vertical length of the corrugated inner fin is formed to be slightly longer than the vertical length between the inner surfaces of the upper and lower flat wall portions of the flat tube. Then, the corrugated inner fin is inserted into the flat tube, and the upper and lower wall portions of the tube are pressed from above and below so that top portions and bottom portions of the corrugated inner fin can be in close contact with the upper and lower surfaces of the flat tube. The corrugated inner fin and the flat tube are brazed with each other in a state where they are kept to be in close contact therewith.

[0005] On the other hand, recently, there is an attempt to form thinner corrugated inner fins so as to decrease their weights and drag force of heat transfer medium flowing along the corrugated inner fins in the flat tubes. The thinner corrugated inner fins, however, encounter a problem in that they tend to experience compressive buckling or be improperly tilted during the press working of the flat tubes containing the corrugated inner fins. This causes faulty brazing between the corrugated inner fins and the flat tubes. We have found that these compressive buckling and improper tilt in the press working happen especially at top portions and/or bottom portions of the both end sides of the corrugated inner fins.

[0006] In addition, there is an attempt to decrease the thickness of the wall portions of the flat tubes so as to decrease their weights, ensuring compression strength thereof.

[0007] It is, therefore, an object of the present invention to provide a core structure of a heat exchanger which overcomes the foregoing drawbacks and can improve the compressive strength of a corrugated inner fin in order to prevent it from experiencing compressive buckling and/or being improperly tilted when a flat tube containing the corrugated inner fin is pressed from above and below, so that the corrugated inner fin and the flat tube can be surely brazed with each other.

[0008] According to an aspect of the present invention there is provided an inner fin adapted for a heat exchanger core structure of a heat exchanger where a core part is arranged between a pair of tanks. The core structure includes a plurality of flat tubes having an upper wall portion and a lower wall portion; and a plurality of corrugated inner fins formed in a corrugated shape so that each corrugated inner fin has top portions for being fixed to an inner surface of the upper wall portion, bottom portions for being fixed to an inner surface of the lower wall portion, and slanted portions for connecting the top portion with adjacent bottom portions thereof. The corrugated inner fin has first corrugations located at both end sides of the corrugated inner fin and second corrugations located between the first corrugations, where each of the first and the second corrugations has the top portion and the adjacent slanted portions which project from the bottom portions. The first corrugations of the corrugated inner fin are set to have a smaller front-back directional length than the front-back directional length of the second corrugations.

[0009] Therefore, the core structure of the invention can improve the compressive strength of the corrugated inner fin in order to prevent it from experiencing compressive buckling and/or being improperly tilted when the flat tube containing the corrugated inner fin is pressed from above and below, so that the corrugated inner fin and the flat tube can be surely brazed with each other.

[0010] Preferably, the corrugated inner fin has at least one third corrugation which is smaller in the front-back directional length than the second corrugations and arranged between the second corrugations.

[0011] This can improve the entire strength of the flat tube containing the corrugated inner fin, allowing the corrugated inner fin to be thinner.

[0012] Preferably, the number of the third corrugations located at a front side of the corrugated inner fin is larger than the number of the third corrugations located at a rear side of the corrugated inner fin.

[0013] This can improve a heat transfer efficiency when heat transfer medium flows through the core part of the heat exchanger.

[0014] The objects, features and advantages of the present invention will become apparent as the description proceeds when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a front view showing a condenser having a core structure of a first embodiment according to the present invention;

FIG. 2 is a rear perspective view showing the condenser shown in FIG. 1;

FIG. 3 is an enlarged side perspective view showing the flat tube containing the inner fin of the first embodiment;

FIG. 4 is an enlarged side perspective view showing the inner fin of the first embodiment;

FIG. 5 is an enlarged side view showing the inner fin of the first embodiment, taken along a line S5 - S5 in FIG. 4;

FIG. 6 is a schematic diagram showing how to manufacture the inner fin of the first embodiment;

FIG. 7 is a plan view showing an upper rotating roller that has teeth for forming the inner fin of the first embodiment;

FIG. 8 is a plan view showing a lower rotating roller that is arranged under the upper rotating roller and has teeth for forming the inner fin of the first embodiment together with the upper rotating roller;

FIG. 9 is a perspective view showing the flat tube and the inner fin shown in FIGS. 4 and 5 before the inner fin is inserted into the flat tube;

FIG. 10 is a perspective view showing the flat tube and the inner fin contained in the flat tube before the flat tube is pressed in its height direction for brazing the tube and the inner fin;

FIG. 11 is a side perspective view showing an inner fin, contained in a flat tube, used in a core structure of a second embodiment according to the present invention;

FIG. 12 is a side perspective view showing the inner fin of the second embodiment; and

FIG. 13 is a side view showing an inner fin used in a core structure of a third embodiment according to the present invention.

[0015] Throughout the following detailed description, similar reference characters and numbers refer to similar elements in all figures of the drawings, and their descriptions are omitted for eliminating duplication.

[0016] A core structure of a heat exchanger of a first preferred embodiment according to the present invention will be described with reference to the accompanying drawings. Incidentally, in the following description, terms "right " and "left" are used with respect to those of a motor vehicle body, not with respect to those of the drawings.

[0017] Referring to FIGS. 1 and 2 of the drawings, there is shown a condenser C having a core part 3 of the first embodiment of the present invention.

[0018] The condenser C is used for an air conditioning system of a motor vehicle in this embodiment, and includes a right tank 1, a left tank 2, the core part 3 arranged between the right and left tanks 1 and 2, an upper reinforced member 7, and a lower reinforced member 8.

[0019] The right tank 1 is formed like a circular cylinder, and is fixed at its top end portion with an upper cap 4a for covering its upper opening and at its bottom portion with a lower cap 4b for covering its lower opening. The right tank 1 is provided at its upper portion with an inlet connector 1b having a communicating passage 1a fluidically communicating with a first room R1 formed inside the right tank 1. The inlet connector 1b is connected with a not-shown compressor.

[0020] The left tank 2 is also formed like a circular cylinder, and is fixed at its top end portion with a left upper cap 4a for covering its upper opening and at its bottom portion with a lower cap 4b for covering its lower opening. The left tank 2 is provided at its lower portion with an outlet connector 2b having a communicating passage 2a fluidically communicating with a second room R1 formed inside the left tank 1. The outlet connector 2b is connected with a not-shown expansion valve through a not-shown receiver.

[0021] The right and left tanks 1 and 2 are fixed with each other by the upper reinforced member 7 connecting the upper portions thereof and by the lower reinforced member 8 connecting the lower portions thereof.

[0022] The core part 2 includes a plurality of flat tubes 5 each containing a corrugated inner fin 10, which is shown in FIGS. 3 to 5, and a plurality of corrugated outer fins 6. The corrugated outer fins 6 and the flat tubes 5 are arranged alternately with each other, extending between the right and left tanks 1 and 2. The flat tubes 5 are connected with the right and left tanks 1 and 2 so that right end portions of the flat tubes 5 are fluidically communicating with the first room R1 of the right tank 1 and left end portions of the flat tubes 5 are fluidically connecting with the second room R2 of the left tank 2.

[0023] In the following drawings, a front side direction is indicated as "FW" and a rear side direction is indicated as "RW".

[0024] As shown in FIG. 3, the flat tube 5 is formed from one aluminum sheet by press forming to have an upper flat wall portion 5a, a lower flat wall portion 5b, a front arc wall portion 5c, rear arc wall portion 5d, and upper and lower folded wall portions 5e. The lower wall portion 5b is arranged in parallel to the upper flat wall portion 5a, and the front arc wall portion 5c is integrally formed with front end portions of the upper and lower flat wall portions 5a and 5b to connect therewith. The rear arc wall portion 5d is formed by confronting and brazing an upper rear arc wall portion and a lower rear arc wall portion with each other, and the upper and lower folded wall portions 5e are faxed and fixed with each other by brazing. The flat tube 5 is formed vertically long and horizontally short, and contains the corrugated inner fin 10.

[0025] As shown in FIGS. 4 and 5, the corrugated inner fin 10 is formed in a corrugated form by press forming to have a plurality of top portions 10a and a plurality of bottom portions 10b so that the top portions 10a and the bottom portions 10b are arranged alternately with each other. The top portions 10a and the bottom portions 10b are formed to be flat so that they can fit inner surfaces of the upper wall portion 5a and the lower wall portions 5b of the flat tube 5, respectively. Each top portion 10a is connected with its adjacent bottom portions 10b by slanted portions 10c. In addition, the height H1, shown in FIG. 4, of the corrugated inner fin 10 is slightly higher than the length H2, shown in FIG. 3, formed between the inner surfaces of the flat tube 5.

[0026] Hereinafter, a corrugation is defined by the top portion 10a and its two adjacent slanted portions 10c. Therefore, the corrugated inner fin 10 is formed to have many corrugations, which project upwardly from the bottom portions 10b. As shown in FIG. 5, in this embodiment, first front-back directional lengths W1 of at least first corrugations N1, which are formed at both end sides of the corrugated inner fin 10, are set to be smaller than second front-back directional lengths W2 of the second corrugations N2 arranged between the both-end corrugations N1 except for the front-back directional lengths of third corrugations N3. The third corrugations N3 are arranged between the second corrugations N2 to have the same front-back directional lengths W1 as those of the first corrugations N1. The number of the third corrugations N3 is set to be lower than that of the second corrugations N2. In this embodiment, the corrugated inner fin 10 has the first corrugation N1, two second corrugations N2, the third corrugation N3, four second corrugations N2, the third corrugation N3, two second corrugations N2, and the first corrugation N1, in these order in a direction from the front side toward the rear side.

[0027] Incidentally, the third corrugations N3 are not indispensable in the invention.

[0028] All parts of the core part C are made of alminum, and one-side parts of their connecting parts are provided with a clad layer of brazing material or a brazing sheet for brazing process. Then, by brazing, the top portions 10a of the corrugated inner fin 10 are fixed to the inner surface of the upper wall portion 5a of the flat tube 5, the bottom portions 10b of the corrugated inner fin 10 are fixed to the inner surfaces of the lower wall portion 5b of the flat tube 5, and the upper and lower folded portions 5e are fixed with each other.

[0029] The core part 3 of the first embodiment is manufactured as follows.

[0030] The flat tube 5 is press-formed to have the upper and lower wall portions 5a and 5b, the front and rear arc wall portions 5a and 5d, and the upper and lower folded wall portions 5e. In this state, the upper and lower wall portions 5e are separated from each other as shown in FIG. 9.

[0031] FIG. 6 shows how to manufacture the corrugated inner fins 10. A corrugated inner-fin manufacturing system includes a roll 12, five roller devices 13a to 13e, a cutter 14, and a not-shown conveying device.

[0032] The roll 15 is wound around it with aluminum material 11, to be supplied to the rollers 15 and 16, including core material made of aluminum, whose inner surface and outer surface are provided with brazing layers.

[0033] Each roller device 13a, 13b, 13c, 13d, and 13e includes a pair of upper rotary roll 15 rotatable in a rotation direction RA, shown in FIGS. 6 and 7, and a lower rotary roll 16 rotatable in a rotation direction RB, shown in FIGS. 6 and 8, opposite to the rotation direction RA.

[0034] A shown in FIG. 7, the upper rotary roller 15 has first teeth 15a and second teeth 15b. The first teeth 15a are arranged at positions corresponding to the first corrugations N1 and the third corrugations N3 so as to form lower-side surface configurations of the first and third corrugations N1 and N3. The second teeth 15b are wider than the first teeth 15a, and are arranged at positions corresponding to the second corrugations N2 so as to form the lower-side surface configurations of the second corrugations N2.

[0035] As shown in FIG. 8, the lower rotary roller 16 has first grooves 16a and second grooves 16b. The first grooves 16a are formed to receive the first teeth 15a so as to form upper-side surface configurations of the first corrugations N1 and the third corrugations N3. The second grooves 16b are formed to receive the second teeth 15b so as to form upper-side surface configurations of the second corrugations N2.

[0036] The upper rotary roller 15 and the lower rotary roller 16 are set to be vertically apart by a predetermined distance corresponding to a thickness of the corrugated inner fin 10, and the aluminum material 11 are inserted therebetween and press-formed to be corrugated.

[0037] The corrugated aluminum material 11 is conveyed to the cutter 14 moving upward and downward as indicated by an arrow UD, and then is cut into the corrugated inner fin 10 having a predetermined length.

[0038] The corrugated outer fins 6 are manufactured similarly to the corrugated inner fins 10.

[0039] The corrugated inner fin 10 is inserted into the inner space of the flat tube 5 as shown in FIGS. 9 and 10, and the upper and lower folded wall portions 5e are moved to contact with each other.

[0040] Then the flat tube 5 containing the corrugated inner fin 10 are pressed from above and below by using jigs, not shown, so that the top portions 10a of the corrugated inner fin 10a and the inner surface of the upper wall portion 5a of the flat tube 5 are surely in contact with each other and the bottom portions 10b of the corrugated inner fin 10 and the inner surface of the lower wall portion 5b of the flat tube 5 are in contact with each other.

[0041] In this press of the flat tube 5, the flat tube 5 containing the corrugated inner fin 10 is prevented from causing compressive buckling and/or being improperly tilted, because the two end portions of the inner fin 10 have the first corrugations N1 smaller in the front-back directional length than the second corrugations N2, to increase its compressive strength at the two end portions thereof, although both end portions of the flat tube containing the conventional corrugated inner fin have weak compressive strength. The third corrugations N3, also smaller in the front-back directional length than the second corrugations N2, increase the compressive strength at the intermediate portion of the flat tube 5, while the third corrugations N3 are not indispensable.

[0042] The flat tube 5, containing the corrugated inner fin 10, with the jigs is brought into a not-shown heating furnace to be heated to braze the corrugated inner fin 10 and the flat tube 5 with each other. After this heat treatment, all parts of the condenser C, including the right and left tanks 1 and 2, the upper and lower reinforced members 7 and 8, the corrugated outer fins 6, the flat tubes 5 with the corrugated inner fins 10, the inlet connector 1b and the outlet connector 2b, are temporally assembled with one another, and then the temporally assembled parts are brought into another heat furnace and are brazed to integrally form the condenser C.

[0043] Incidentally, the heat treatment of the flat tubes 5 and the heat treatment of the all parts are independently performed in the first embodiment, while they may be brazed at the same time.

[0044] The condenser C is mounted on a front portion of the motor vehicle body and is fluidically connected with parts of the air conditioning system.

[0045] The operation of the condenser C having the corrugated inner fins 10 of the first embodiment will be described.

[0046] The heat transfer medium having a temperature of approximately 70°C is led from the compressor to the first room R1 of the right tank 1 through the communicating passage 1a of the inlet connector 1b and a not-shown pipe, and flows through the flat tubes t toward the left tank 2, being cooled down to a temperature of approximately 40°C by the air caused when the motor vehicle and/or the air generated by a not-shown motor fan. The heat transfer medium flown into the left tank 2 is discharged toward the evaporator through the communicating passage 2a of the outlet connector 2b and a not-shown pipe.

[0047] In this heat transfer, the corrugated inner fins 10 improve a heat transfer efficiency of the condenser C by their large heat-transfer area. In addition, the corrugated inner fins 10 are set thinner, and accordingly decrease the drag force caused when the heat transfer medium flows in the flat tubes 5.

[0048] The core structure of the first embodiment has the following advantages.

[0049] The corrugated inner fin 10 has the first corrugations N1, which are smaller in the front-back directional length than the second corrugations N2 and are arranged at the two end portions of the corrugated inner fin 10. Therefore, the flat tube 5 containing the inner fin 10 has improved compressive strength especially at its both end portions, thereby being prevented from experiencing compressive buckling and/or being improperly tilted during the press working of the flat tube 5. This can provide sure and firm brazing thereof, and allows the corrugated inner fin 10 to be thinner than the conventional corrugated inner fins. Accordingly, the drag force can be decreased, thereby improving the heat transfer efficiency of the condenser C.

[0050] A core structure of a heat exchanger of a second embodiment according to the present invention will be described with reference to the accompanying drawings.

[0051] As shown in FIGS. 11 and 12, a corrugated inner fin 20 is inserted into a flat tube 5 and fixed to each other by using brazing, similarly to those of the first embodiment.

[0052] The corrugated inner fin 20 has first corrugations N4 at both end portions of the corrugated inner fin 20 and second corrugations N5 arranged at a front side thereof, and third corrugations N6 arranged at rear side thereof.

[0053] The first and third corrugations N4 and N6 are set to have a front-back directional length W1 smaller than a front-back directional length W2 of the second corrugations N5.

[0054] The other parts and how to manufacture a condenser with a core structure the second embodiment are similarly to those of the first embodiment, and their descriptions are omitted.

[0055] Therefore, the corrugated inner fin 20 can increase the compressive strength of the flat tube 5 containing the corrugated inner fin 20, especially at its two end portions.

[0056] In addition, the heat transfer efficiency between heat transfer medium and the air through the corrugated inner fin 10 when a flow amount of the heat transfer medium is small, because more of the heat transfer medium flows through a front portion of the flat tube 5, which causes a smaller drag force than that through a rear portion thereof.

[0057] Further, the second corrugations N5 are arranged at the front side of the corrugated inner fin 20, so that a strength at the front side becomes weaker than a strength at the rear side. This can absorb an impact force acting from an exterior of the condenser C, for example, when a jumping stone hits the flat tube 5 during the motor vehicle running.

[0058] Incidentally, in the second embodiment, the number of the third corrugations located at a front side of the corrugated inner fin are larger than the number of the third corrugations located at a rear side of the corrugated inner fins, where the number of the rear-side third corrugations may be zero or more.

[0059] A core structure, of a heat exchanger, of a third embodiment according to the present invention will be described with reference to the accompanying drawing.

[0060] As shown in FIG. 13, a corrugated inner fin 30, used in a flat tube of the core structure of the third embodiment, has at least two first corrugations N1 at each end portion of the corrugated inner fin 30.

[0061] This can further increase strength at both end portions of the flat tube containing the corrugated inner fin 30.

[0062] While the core structures have been particularly shown and described with reference to preferred embodiments thereof, it will be understood that various modifications may be made therein.

[0063] In the embodiments, the condenser C is used as the heat exchanger of the present invention, while it may employ an oil cooler and the like, using the corrugated inner fins 10, 20, or 30.

[0064] The first corrugations, the second corrugations, and the third corrugations are arranged symmetrically with respect to the front-back direction of the corrugated inner fin.

Claims

1. A core structure of a heat exchanger (c) where a core part (3) is arranged between a pair of tanks (1, 2), the core structure **characterized in that** it comprises :

a plurality of flat tubes (5) having an upper wall portion (5a) and a lower wall portion (5b); and
a plurality of corrugated inner fins (10; 20; 30) formed in a corrugated shape so that each corrugated inner fin (10; 20; 30) has top portions (10a) for being fixed to an inner surface of the upper wall portion (5a), bottom portions (10b) for being fixed to an inner surface of the lower wall portion (5b), and slanted portions (10c) for connecting the top portion (10a) with adjacent bottom portions (10b) thereof, the corrugated inner fin (10; 20; 30) having first corrugations (N1; N4) located at both end sides of the corrugated inner fin (10; 20; 30) and second corrugations (N2; N5) located between the first corrugations (N1; N4), where each of the first and the second corrugations (N1, N2; N4 N5) has the top portion (10a) and the adjacent slanted portions (10c) which project from the bottom portions (10b), wherein
the first corrugations (N1; N4) of the corrugated inner fin (10; 20; 30) have a front-back directional length set to be smaller than a front-back directional length of the second corrugations (N2; N5).

2. The core structure according to claim 1, **characterized in that**
the corrugated inner fin (10; 20; 30) has at least one third corrugation (N3; N6) which is smaller in the front-back directional length than the second corrugations (N2; N5) and is arranged between the second corrugations (N2; N5).

3. The core structure according to claim 2, **characterized in that**
the number of the third corrugations (N3; N6) located at a front side of the corrugated inner fin (10; 20; 30) is larger than the number of the third corrugations (N3; N6) located at a rear side of the corrugated inner fin (10; 20; 30).

4. The core structure according to claim 2, **characterized in that**
the first corrugations (N1 ; N4) , the second corrugations (N2; N5), and the third corrugations (N3; N6) are arranged symmetrically with respect to the front-back direction of the corrugated inner fin (10; 20; 30).

FIG. 1

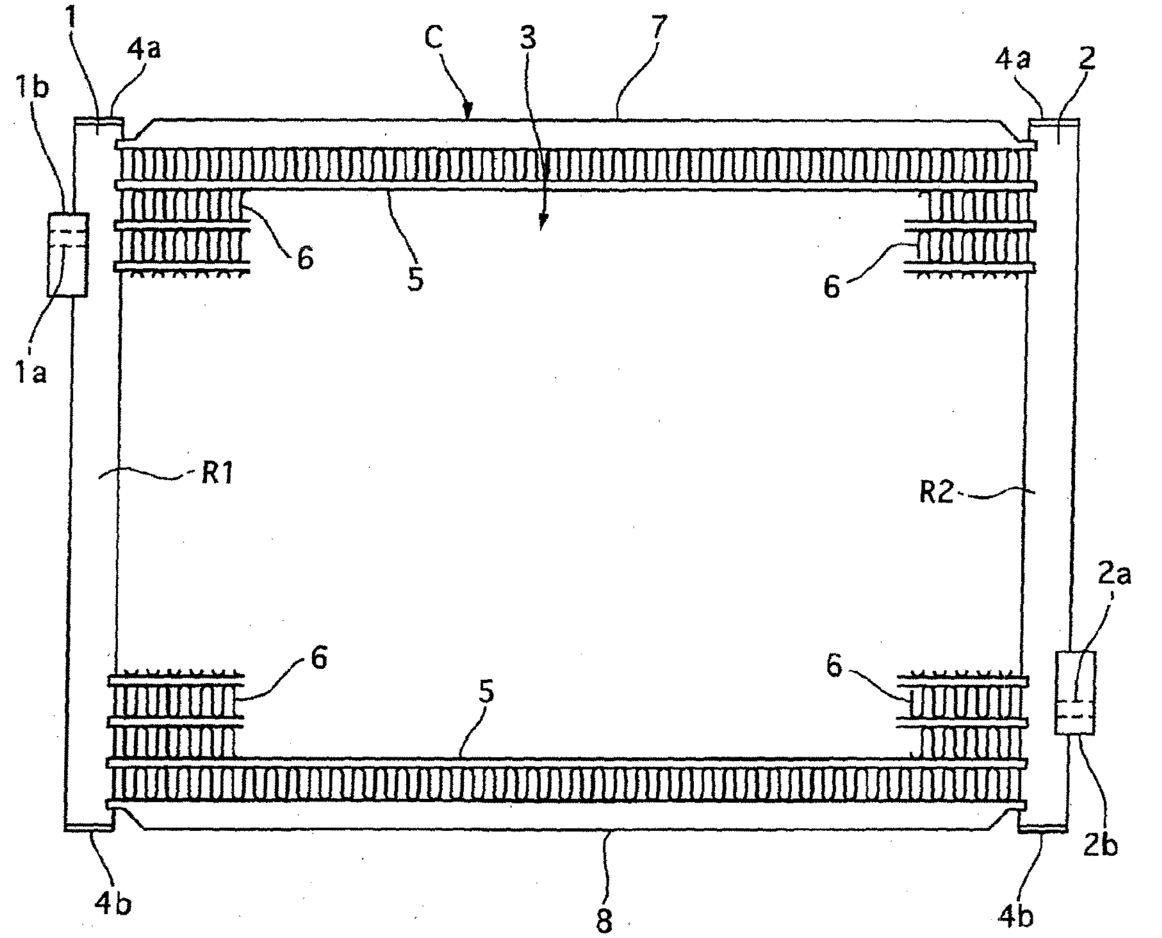


FIG. 2

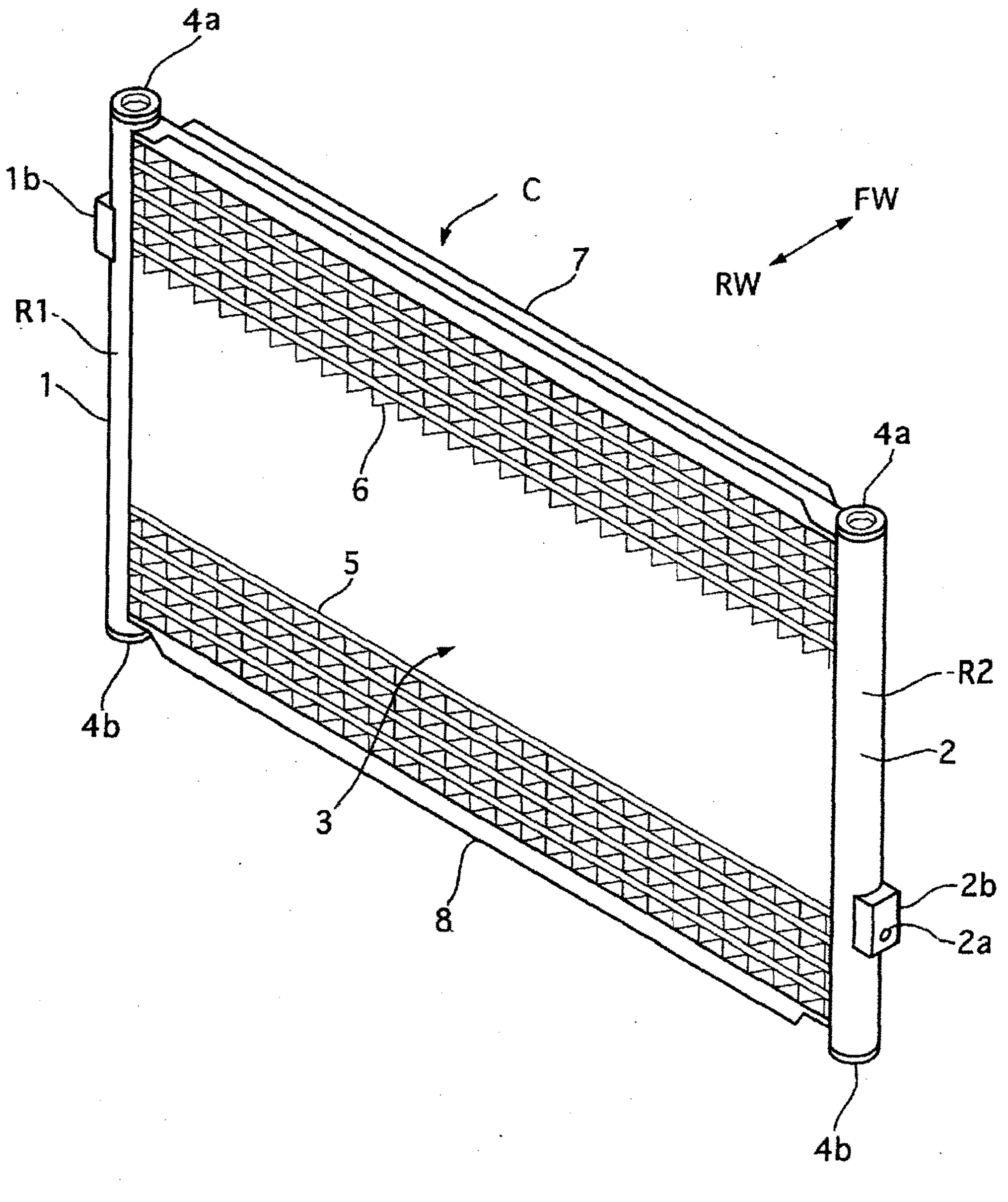
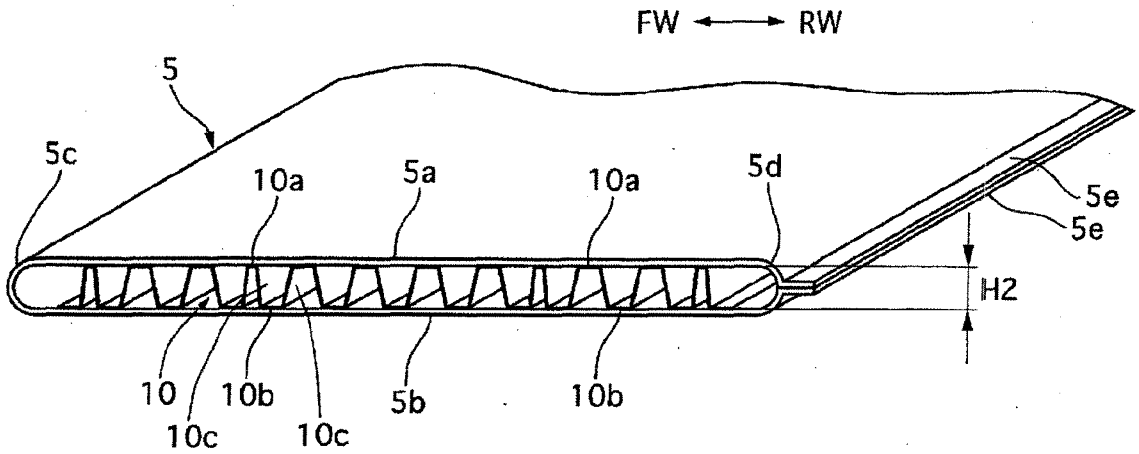


FIG. 3


FW
RW
5
5c
10a
5a
10a
5d
5e
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H2
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10b
5b
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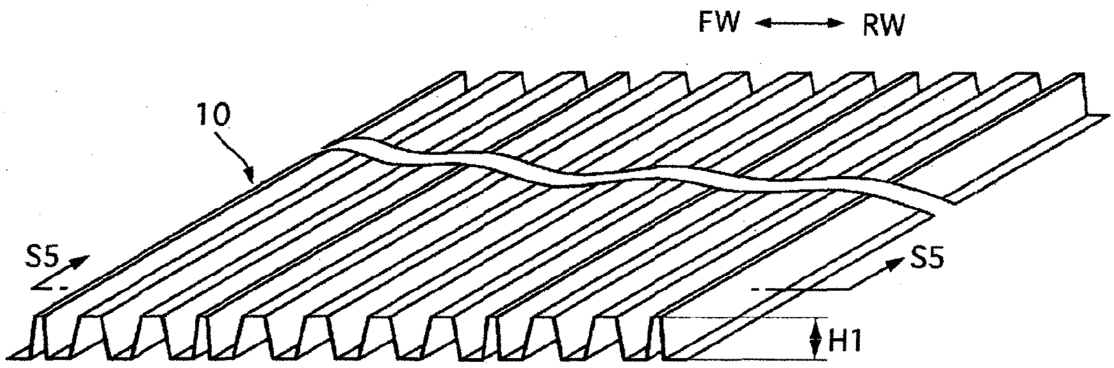
10c
10c

FIG. 4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RW
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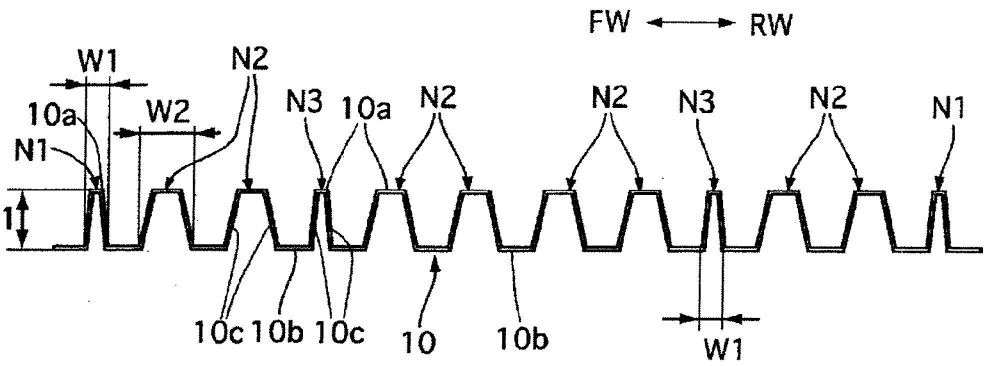
S5
S5
H1

FIG. 5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10c
10
10b
W1

FIG. 6

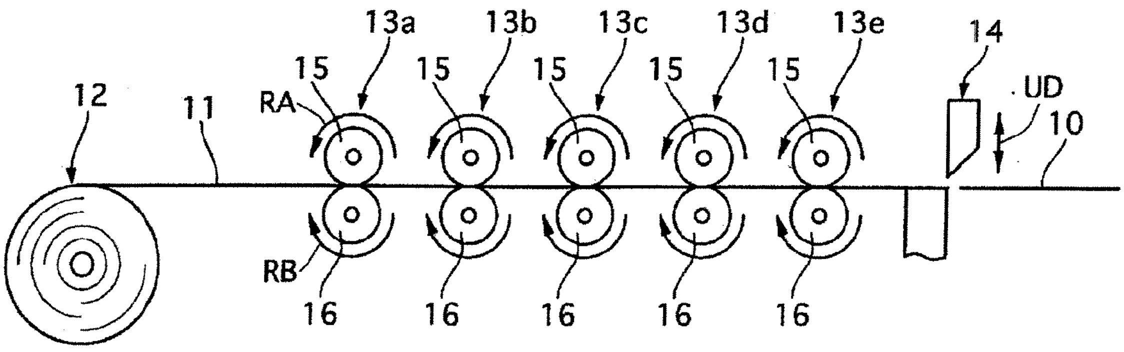
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FIG. 7

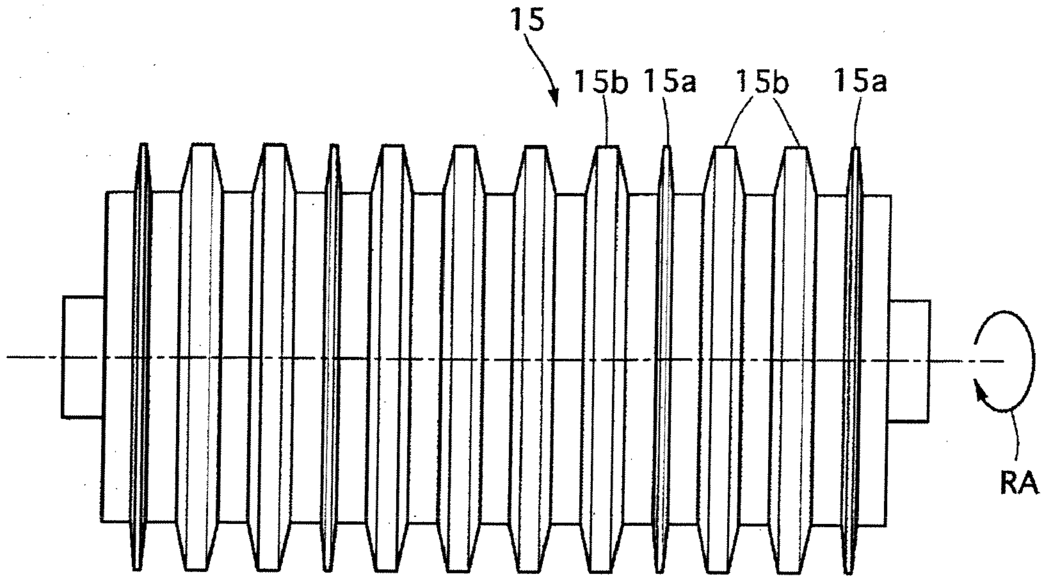


FIG. 8

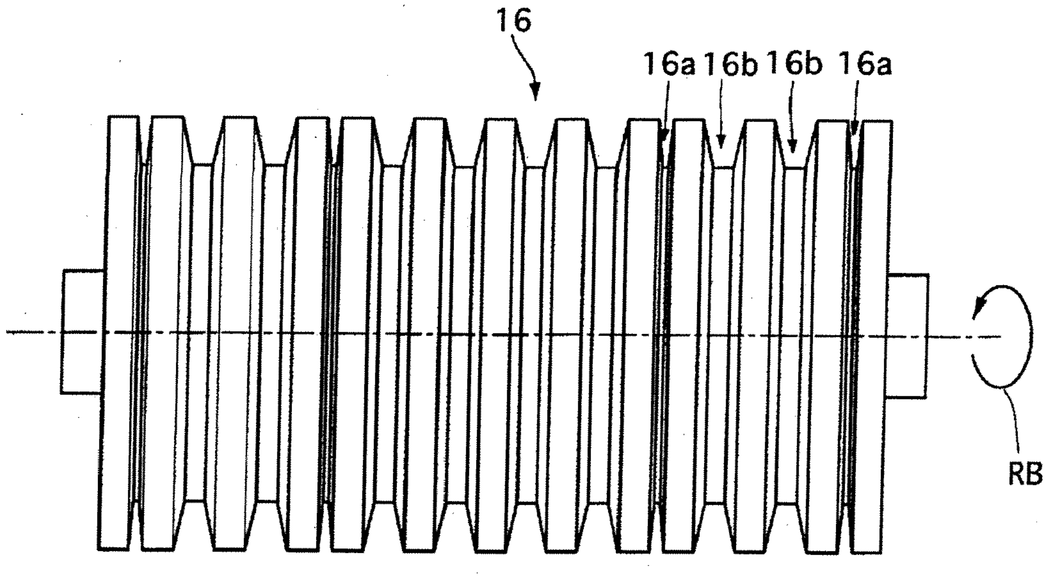


FIG. 9

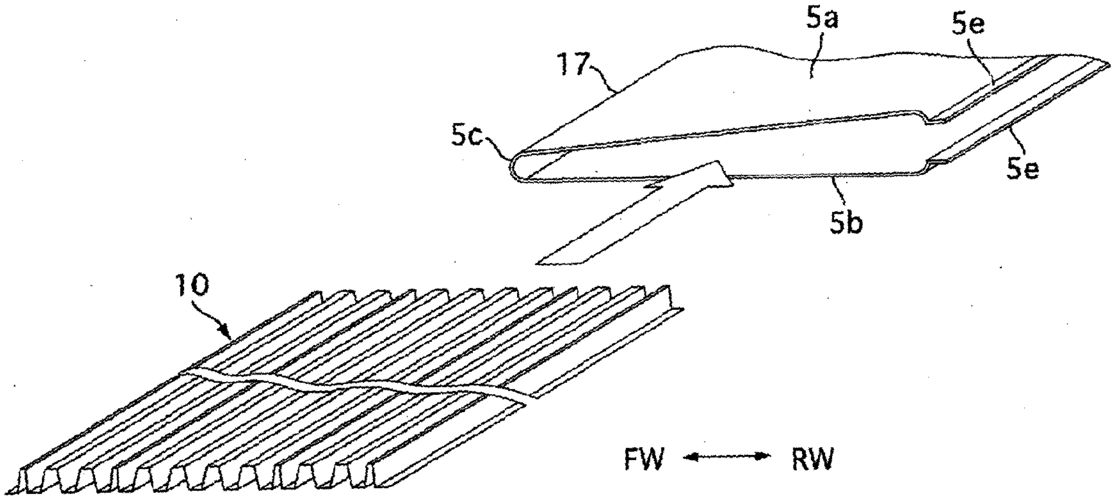


FIG. 10

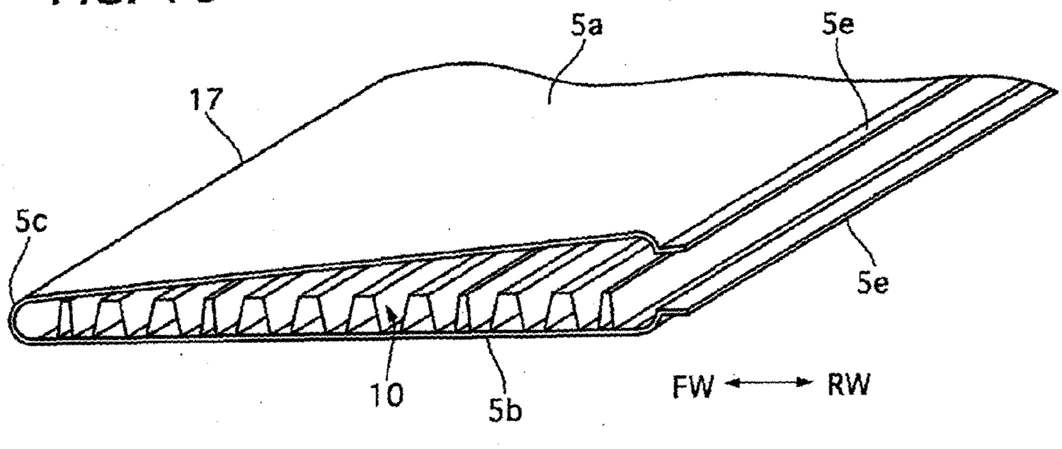


FIG. 11

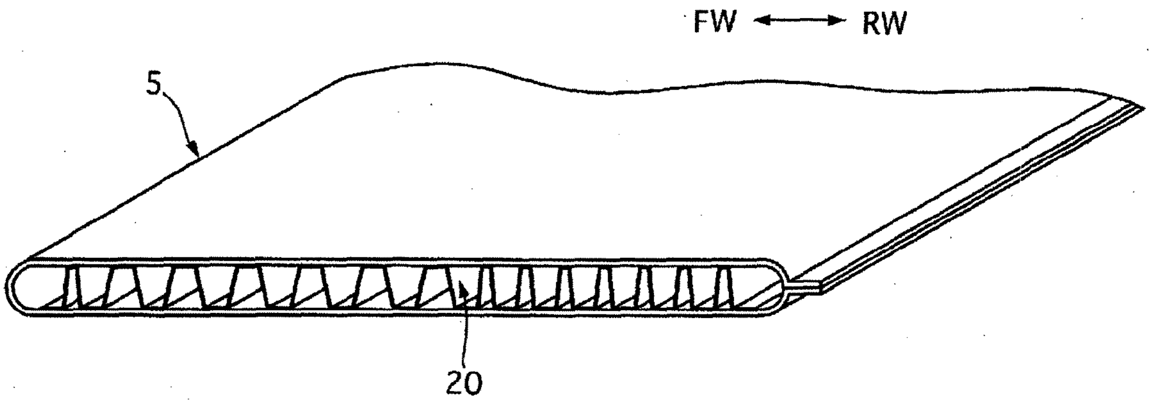


FIG. 12

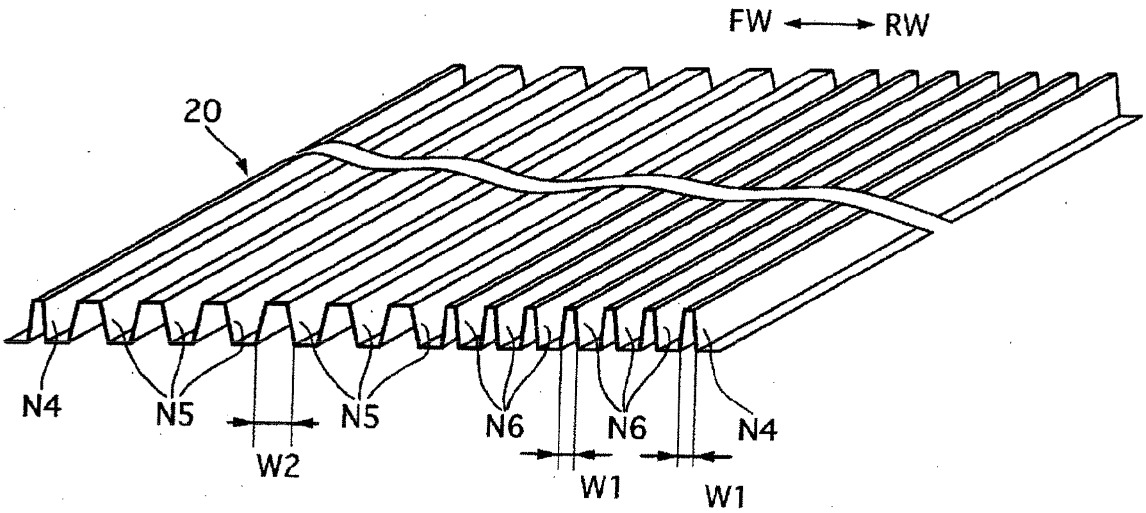
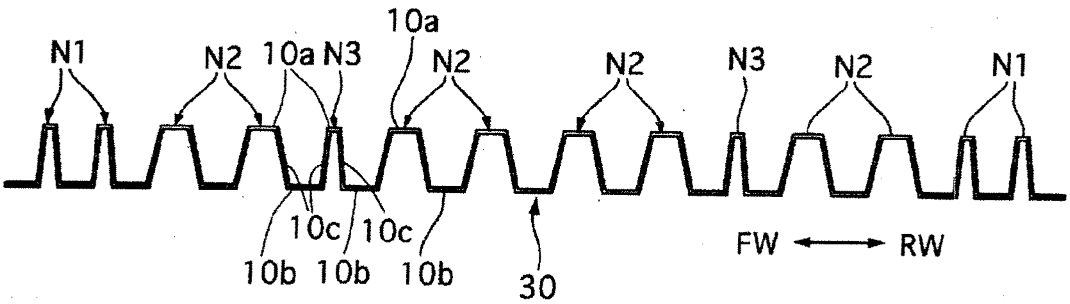

FW
RW
20
N4
N5
N5
N6
N6
N4
W2
W1
W1

FIG. 13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N2
10a
N3
10a
N2
N2
N3
N2
N1
10c
10c
10b
10b
10b
30
FW
RW

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EUROPEAN SEARCH REPORT

Application Number
EP 06 12 7250

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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F28D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	10 April 2007	MELLADO RAMIREZ, J

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