(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 May 2020 (14.05.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/097199 A1

(51) International Patent Classification:
F28D 19/04 (2006.01) *B21D 53/04* (2006.01)

(21) International Application Number:
PCT/US2019/060062

(22) International Filing Date:
06 November 2019 (06.11.2019)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/756,858 07 November 2018 (07.11.2018) US

(71) Applicant: **CARRIER CORPORATION** [US/US]; 13995 Pasteur Blvd., Palm Beach Gardens, Florida 33418 (US).

(72) Inventors: **HOYSALL, Dhruv Chanakya**; 411 Silver Lane, East Hartford, Connecticut 06108 (US). **ALAHYARI, Abbas A.**; 411 Silver Lane, East Hartford, Connecticut 06108 (US). **ESFORMES, Jack Leon**; 5896 Invincible Drive, Jamesville, New York 13078 (US).

(74) Agent: **WIMPE, James E.**; Cantor Colburn LLP, 20 Church Street, 22ND Floor, Hartford, Connecticut 06103 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

(54) Title: HEAT RECOVERY VENTILATOR

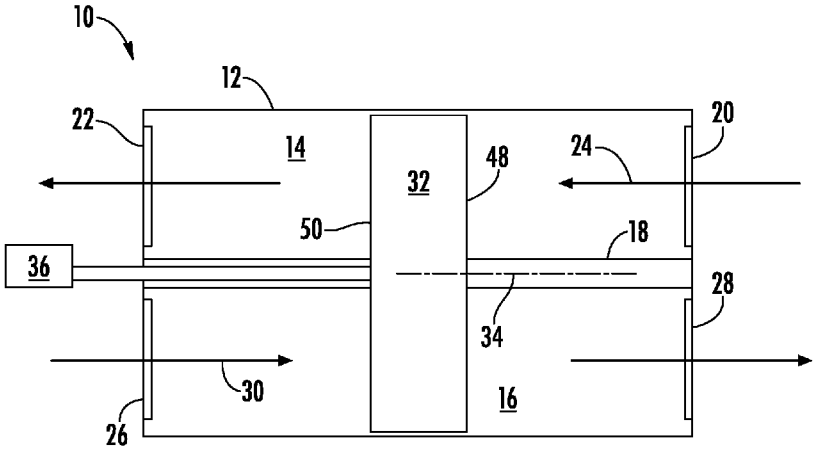

FIG. 1

(57) Abstract: A heat recovery wheel for a heat exchanger includes a wheel rim defining an outer perimeter of the heat recovery wheel, and a plurality of wheel passages located between the wheel rim and the wheel axis. The plurality of wheel passages are arranged in a plurality of radial layers relative to a wheel central axis. Each layer is defined by a first shaped material having a first cross-sectional shape and a second shaped material assembled to the first shaped material, the second shaped material having a second cross-sectional shape. Radially adjacent layers of the plurality of layers are secured directly to one another, and the plurality of wheel passages are configured for flow of a first airflow and a second airflow therethrough for thermal energy exchange between the first airflow and the second airflow.

[Continued on next page]

WO 2020/097199 A1

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

HEAT RECOVERY VENTILATOR

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Application No. 62/756858, filed on November 7, 2019, which is incorporated herein by reference in its entirety.

BACKGROUND

[0001] Exemplary embodiments pertain to the art of heat exchangers, and more particularly to rotary wheel heat recovery ventilators.

[0002] Heat exchangers are utilized in ventilation systems installed in, for example, residential, commercial and industrial spaces to extract and remove heat and/or moisture from one airstream and transfer that heat energy and/or moisture to a second airstream. In particular, rotary wheel heat exchangers, or heat recovery ventilators, are known wherein a wheel rotates in a housing through countervailing streams of exhaust and fresh air, in the winter extracting heat and moisture from the exhaust stream and transferring it to the fresh air stream. In the summer rotary wheel heat exchangers extract heat and moisture from the fresh air stream and transfer it to the exhaust stream, preserving building air conditioning while providing desired ventilation.

[0003] Heat transfer enhanced heat recovery wheels present an opportunity for the development of significantly more compact designs of ventilation systems, reducing material and fabrication cost. However, a number of challenges exist for the application of new designs: Wheel effectiveness, pressure drop, material cost and design complexity are some of the key challenges.

BRIEF DESCRIPTION

[0004] In one embodiment, a heat recovery wheel for a heat exchanger includes a wheel rim defining an outer perimeter of the heat recovery wheel, and a plurality of wheel passages located between the wheel rim and the wheel axis. The plurality of wheel passages are arranged in a plurality of radial layers relative to a wheel central axis. Each layer is defined by a first shaped material having a first cross-sectional shape and a second shaped material assembled to the first shaped material, the second shaped material having a second cross-sectional shape. Radially adjacent layers of the plurality of layers are secured directly to one another, and the plurality of wheel passages are configured for flow of a first airflow and

a second airflow therethrough for thermal energy exchange between the first airflow and the second airflow.

[0005] Additionally or alternatively, in this or other embodiments the first cross-sectional shape is the same as the second cross-sectional shape.

[0006] Additionally or alternatively, in this or other embodiments the first cross-sectional shape is different from the second cross-sectional shape.

[0007] Additionally or alternatively, in this or other embodiments the first cross-sectional shape is a first chevron pattern.

[0008] Additionally or alternatively, in this or other embodiments the first cross-sectional shape is a first trapezoidal pattern.

[0009] Additionally or alternatively, in this or other embodiments the first cross-sectional shape has a first angular alignment relative to the wheel central axis and the second cross-sectional shape has a second angular alignment different from the first angular alignment.

[0010] Additionally or alternatively, in this or other embodiments the first cross-sectional shape is circumferentially angularly offset from the second cross-sectional shape.

[0011] Additionally or alternatively, in this or other embodiments the heat recovery wheel includes a plurality of axially stacked layers of wheel passages relative to the wheel central axis, wherein the wheel passages of axially adjacent layers are circumferentially offset.

[0012] In another embodiment, a heat exchanger includes a housing. The housing defines a first airflow chamber through which a first airflow is directed and a second airflow chamber through which a second airflow is directed. A heat recovery wheel is positioned in the housing and is rotatable about a wheel axis. The heat recovery wheel includes a wheel rim defining an outer perimeter of the heat recovery wheel and a plurality of wheel passages located between the wheel rim and the wheel axis. The plurality of wheel passages are arranged in a plurality of radial layers relative to a wheel central axis. Each layer is defined by a first shaped material having a first cross-sectional shape and a second shaped material assembled to the first shaped material. The second shaped material has a second cross-sectional shape. Radially adjacent layers of the plurality of layers are secured directly to one another and the plurality of wheel passages are configured for flow of a first airflow and a second airflow therethrough for thermal energy exchange between the first airflow and the second airflow.

[0013] Additionally or alternatively, in this or other embodiments the first cross-sectional shape is the same as the second cross-sectional shape.

[0014] Additionally or alternatively, in this or other embodiments the first cross-sectional shape is different from the second cross-sectional shape.

[0015] Additionally or alternatively, in this or other embodiments the first cross-sectional shape is a first chevron pattern.

[0016] Additionally or alternatively, in this or other embodiments the first cross-sectional shape is a first trapezoidal pattern.

[0017] Additionally or alternatively, in this or other embodiments the first cross-sectional shape has a first angular alignment relative to the wheel central axis and the second cross-sectional shape has a second angular alignment different from the first angular alignment.

[0018] Additionally or alternatively, in this or other embodiments the first cross-sectional shape is circumferentially angularly offset from the second cross-sectional shape.

[0019] Additionally or alternatively, in this or other embodiments a plurality layers of wheel passages are axially stacked relative to the wheel central axis. The wheel passages of axially adjacent layers are circumferentially offset.

[0020] In another embodiment, a method of forming a heat recovery wheel includes forming a first cross-sectional shape in a first material layer, forming a second cross-sectional shape in a second material layer, assembling the first material layer directly to the second material layer thereby defining a passage layer having a plurality of wheel passages, and winding the passage layer about a central wheel axis, with radially adjacent passage layers directly abutting.

[0021] Additionally or alternatively, in this or other embodiments the first material layer is angularly offset from the second material layer.

[0022] Additionally or alternatively, in this or other embodiments radially adjacent passage layers are circumferentially offset.

[0023] Additionally or alternatively, in this or other embodiments the first cross-sectional shape is different from the second cross-sectional shape.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:

[0025] FIG. 1 is a schematic view of an embodiment of a heat recovery ventilator;

[0026] FIG. 2 is a schematic view of another embodiment of a heat recovery ventilator;

[0027] FIG. 3 is a cross-sectional view of an embodiment of a heat recovery wheel for a heat recovery ventilator;

[0028] FIG. 4 is a schematic illustration of a method of forming a heat recovery wheel;

[0029] FIG. 5 is a schematic illustration of shaped material sheets for a heat recovery wheel;

[0030] FIG. 6 is a schematic illustration of assembled shaped material sheets for a heat recovery wheel;

[0031] FIG. 7 is a schematic illustration of an embodiment of a heat recovery wheel; and

[0032] FIG. 8 is a schematic illustration of another embodiment of a heat recovery wheel.

DETAILED DESCRIPTION

[0033] A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

[0034] Referring now to FIG. 1, illustrated is a schematic view of an embodiment of a heat recovery ventilator 10. The heat recovery ventilator 10 includes a housing 12 having a first airflow chamber 14 and a second airflow chamber 16. In some embodiments, the first airflow chamber 14 and the second airflow chamber 16 are separated by an internal housing wall 18. The first airflow chamber 14 includes a first inlet port 20 and a first outlet port 22, through which a first airflow 24 is directed through the first airflow chamber 14. Similarly, the second airflow chamber 16 includes a second inlet port 26 and a second outlet port 28, through which a second airflow 30 is directed through the second airflow chamber 16. In some embodiments, the first airflow 24 is, for example, a return airflow from a conditioned or ventilated space, while the second airflow 30 is, for example, a fresh airflow. In the embodiment of FIG. 1, the first airflow 24 and the second airflow 30 are directed through the first airflow chamber 14 and the second airflow chamber 16, respectively, in opposite directions, while in another embodiment, such as schematically illustrated in FIG. 2, the first airflow 14 and the second airflow 16 are directed through the first airflow chamber 14 and the second airflow chamber 16, respectively, in the same direction.

[0035] Referring again to FIG. 1, a heat recovery wheel 32 is located in the housing 12 and is configured to rotate about a wheel axis 34. The heat recovery wheel 32 rotates continuously about the wheel axis 34, and in some embodiments is driven by a wheel motor 36 operably connected to the heat recovery wheel 32 by, for example, a shaft or belt. With the heat recovery wheel 32 rotating, the first airflow 24 and the second airflow 30 flow through a plurality of wheel passages 38 (shown in FIG. 3) in the heat recovery wheel 32. Thermal energy is transferred between the first airflow 24 and the second airflow 30 via the heat recovery wheel 32 structure.

[0036] Referring to the cross-sectional view of FIG. 3, the heat recovery wheel 32 includes a wheel outer rim 40 defining an outer perimeter of the heat recovery wheel 32. The plurality of wheel passages 38 are formed in one or more passage layers 42 arranged radially about the wheel axis 34. The passage layers 42 may be formed by generally circular elements, or may be formed in a spiral configuration about the wheel axis 34. The wheel passages 38 of the same passage layers 42 are separated by passage fins 46.

[0037] Referring now to FIG. 4, a view of a forming process of a heat recovery wheel 32 is shown. A first layer material 48 is fed into a first set of forming rollers 50 or other forming tools at which a first shaped material 52 having, for example, a first chevron pattern as shown in FIG. 5. Referring again to FIG. 4, a second layer material 54 is fed into a second set of forming rollers 56 or other forming tools at which a second shaped material 58 having, for example, a second chevron pattern as shown in FIG. 5. In some embodiments the first chevron pattern is the same as the second chevron pattern, while in other embodiments the second chevron pattern of the second shaped material 58 is different or opposite to the first chevron pattern of the first shaped material 52. In some embodiments, the first chevron pattern is aligned along a first axis 60 and the second chevron pattern is aligned along a second axis 62 offset from the first axis 60. In one embodiment, the second axis 62 is offset from the first axis 60 by 90 degrees.

[0038] The first shaped material 52 and the second shaped material 58 are assembled directly to each other at an assembly section 64 (shown in FIG. 4) to form an assembled sheet 66, as shown in FIG. 6. The assembled sheet 66 has the plurality of wheel passages 38 formed therein by the first chevron pattern and the second chevron pattern. The assembled sheet 66 is wound to produce the heat recovery wheel 32 comprising radially adjacent passage layers 42 directly abutting each other, without a parting element, for example, a parting sheet between the passage layers 42.

[0039] In another embodiment, shown in FIG. 7, the first shaped material 52 and the second shaped material 58 may be formed of other shapes to define the wheel passages 38 when formed into the assembled sheet 66. In the embodiment of FIG. 7, the first shaped material 52 has a first trapezoidal-shaped pattern 70 formed therein, while the second shaped material 58 has a second trapezoidal-shaped pattern 72 formed therein. Each trapezoidal shape has an open end 74 and a closed end 76 opposite the open end 74. In some embodiments, the closed end 76 has a closed end width greater than an open end width of the open end 74.

[0040] When assembled at the assembly section 64, the first shaped material 52 and the second shaped material 58 are offset such that when wound or rolled to for the heat recovery wheel 32, the first trapezoidal-shaped pattern 70 is angularly offset from the second trapezoidal-shaped pattern 72. Referring now to FIG. 8, in some embodiments, two or more assembled sheets 66 are stacked along the wheel axis 34. In such embodiments, a first assembled sheet 66a is angularly offset from a second assembled sheet 66b.

[0041] In some embodiments, the first shaped material 52 and/or the second shaped material 58 may be textured to further enhance heat transfer, and/or may be coated with an adsorbent material for moisture control in the heat recovery ventilator 10. Additionally, the first shaped material 52 and the second shaped material 58 may be coated with a hydrophobic and/or hydrophilic coatings to enhance moisture removal. The first shaped material 52 and the second shaped material 58 may be formed from a metallic material, or alternatively may be formed from a polymer or a composite material.

[0042] The first shaped material 52 and the second shaped material 58 and heat recovery wheel 32 of the present disclosure provides a solution to improve heat transfer of the heat recovery wheel 32 while maintaining a compact structure of the heat recovery wheel 32 by not including a parting sheet of a typical heat recovery wheel 32, and not increasing the length of the heat recovery wheel 32 to increase the performance.

[0043] The term “about” is intended to include the degree of error associated with measurement of the particular quantity based upon the equipment available at the time of filing the application.

[0044] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” and/or “comprising,” when used in this specification, specify the presence of

stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, element components, and/or groups thereof.

[0045] While the present disclosure has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the present disclosure. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present disclosure without departing from the essential scope thereof. Therefore, it is intended that the present disclosure not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this present disclosure, but that the present disclosure will include all embodiments falling within the scope of the claims.

What is claimed is:

1. A heat recovery wheel for a heat exchanger, comprising:

a wheel rim defining an outer perimeter of the heat recovery wheel; and

a plurality of wheel passages located between the wheel rim and the wheel axis, the plurality of wheel passages arranged in a plurality of radial layers relative to a wheel central axis, each layer defined by:

a first shaped material having a first cross-sectional shape; and

a second shaped material assembled to the first shaped material, the second shaped material having a second cross-sectional shape;

wherein radially adjacent layers of the plurality of layers are secured directly to one another; and

wherein the plurality of wheel passages are configured for flow of a first airflow and a second airflow therethrough for thermal energy exchange between the first airflow and the second airflow.

2. The heat recovery wheel of claim 1, wherein the first cross-sectional shape is the same as the second cross-sectional shape.

3. The heat recovery wheel of claim 1, wherein the first cross-sectional shape is different from the second cross-sectional shape.

4. The heat recovery wheel of claim 1, wherein the first cross-sectional shape is a first chevron pattern.

5. The heat recovery wheel of claim 1, wherein the first cross-sectional shape is a first trapezoidal pattern.

6. The heat recovery wheel of claim 1, wherein the first cross-sectional shape has a first angular alignment relative to the wheel central axis and the second cross-sectional shape has a second angular alignment different from the first angular alignment.

7. The heat recovery wheel of claim 1, wherein the first cross-sectional shape is circumferentially angularly offset from the second cross-sectional shape.

8. The heat recovery wheel of claim 1, further comprising a plurality of axially stacked layers of wheel passages relative to the wheel central axis, wherein the wheel passages of axially adjacent layers are circumferentially offset.

9. A heat exchanger, comprising:

a housing, the housing defining:

a first airflow chamber through which a first airflow is directed; and

a second airflow chamber through which a second airflow is directed; and

a heat recovery wheel disposed in the housing and rotatable about a wheel axis, the heat recovery wheel including:

a wheel rim defining an outer perimeter of the heat recovery wheel; and

a plurality of wheel passages located between the wheel rim and the wheel axis, the plurality of wheel passages arranged in a plurality of radial layers relative to a wheel central axis, each layer defined by:

a first shaped material having a first cross-sectional shape; and

a second shaped material assembled to the first shaped material, the second shaped material having a second cross-sectional shape;

wherein radially adjacent layers of the plurality of layers are secured directly to one another; and

wherein the plurality of wheel passages are configured for flow of a first airflow and a second airflow therethrough for thermal energy exchange between the first airflow and the second airflow.

10. The heat exchanger of claim 9, wherein the first cross-sectional shape is the same as the second cross-sectional shape.

11. The heat exchanger of claim 9, wherein the first cross-sectional shape is different from the second cross-sectional shape.

12. The heat exchanger of claim 9, wherein the first cross-sectional shape is a first chevron pattern.

13. The heat exchanger of claim 9, wherein the first cross-sectional shape is a first trapezoidal pattern.

14. The heat exchanger of claim 9, wherein the first cross-sectional shape has a first angular alignment relative to the wheel central axis and the second cross-sectional shape has a second angular alignment different from the first angular alignment.

15. The heat exchanger of claim 9, wherein the first cross-sectional shape is circumferentially angularly offset from the second cross-sectional shape.

16. The heat exchanger of claim 9, further comprising a plurality of axially stacked layers of wheel passages relative to the wheel central axis, wherein the wheel passages of axially adjacent layers are circumferentially offset.

17. A method of forming a heat recovery wheel, comprising:

forming a first cross-sectional shape in a first material layer;

forming a second cross-sectional shape in a second material layer;

assembling the first material layer directly to the second material layer thereby defining a passage layer having a plurality of wheel passages; and

winding the passage layer about a central wheel axis, with radially adjacent passage layers directly abutting.

18. The method of claim 17, further comprising angularly offsetting the first material layer from the second material layer.

19. The method of claim 17, further comprising circumferentially offsetting radially adjacent passage layers.

20. The method of claim 17, wherein the first cross-sectional shape is different from the second cross-sectional shape.

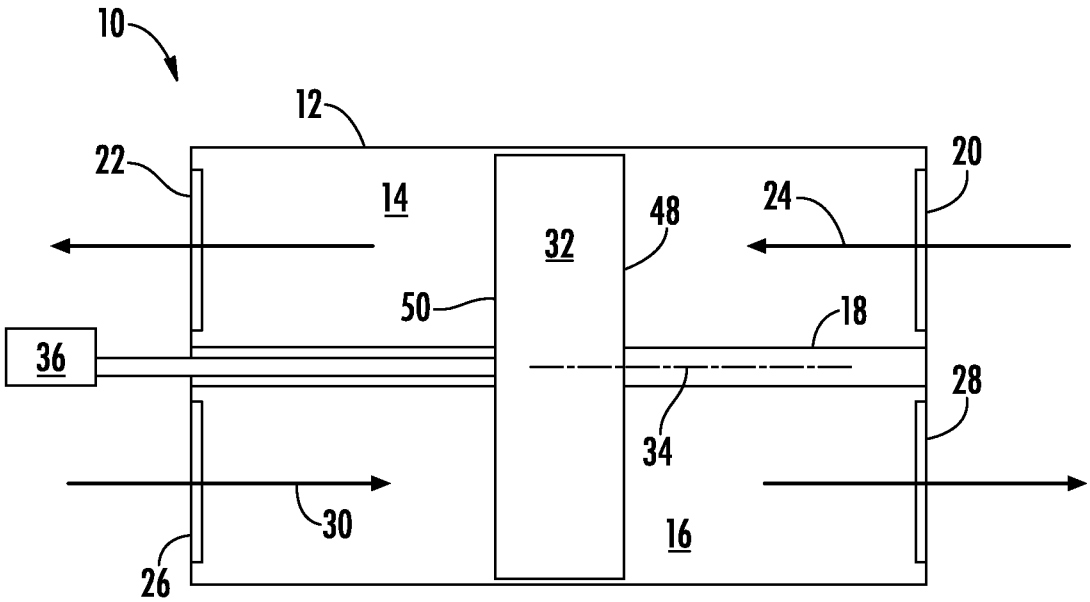
10
12
22
14
32
48
24
20
50
18
36
28
34
30
16
26

FIG. 1

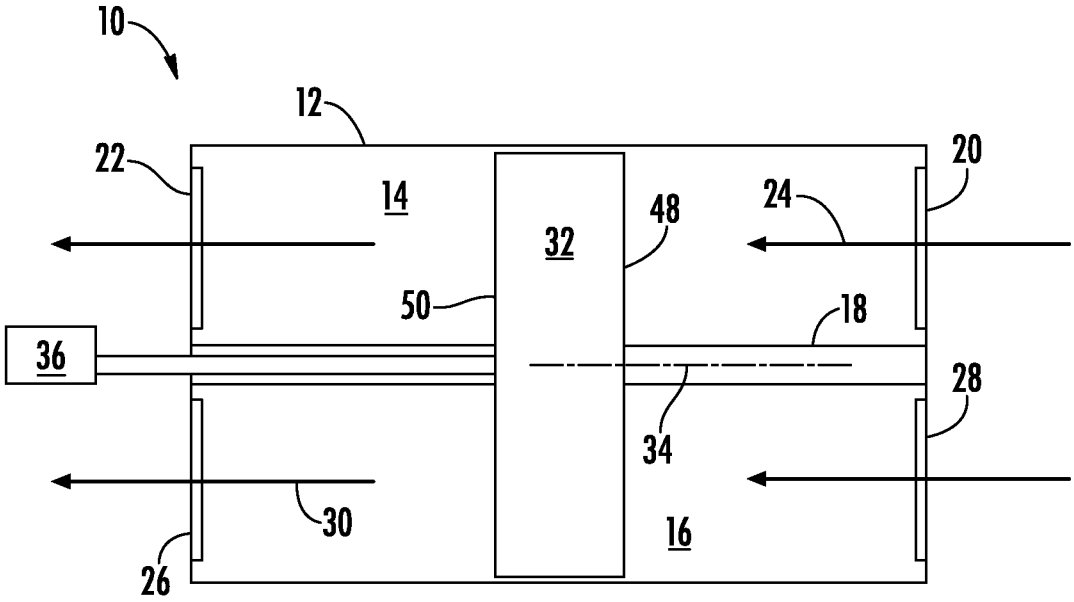
10
12
22
14
32
48
24
20
50
18
36
28
34
30
16
26

FIG. 2

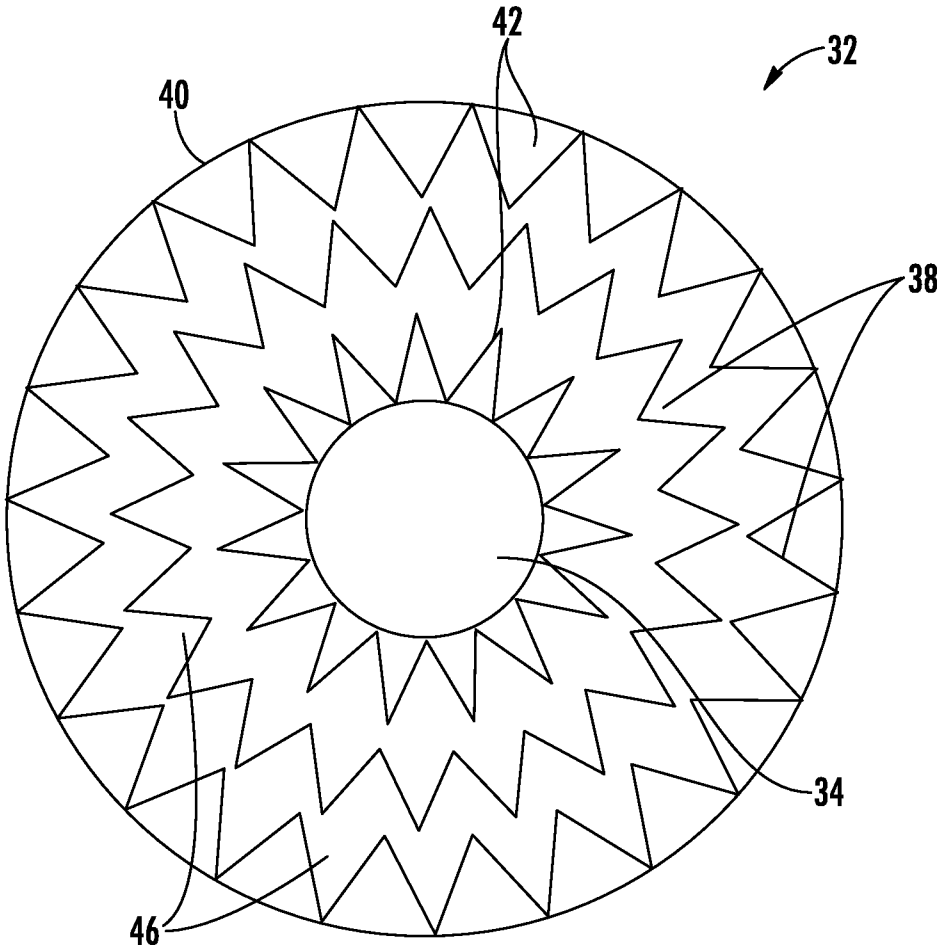

FIG. 3

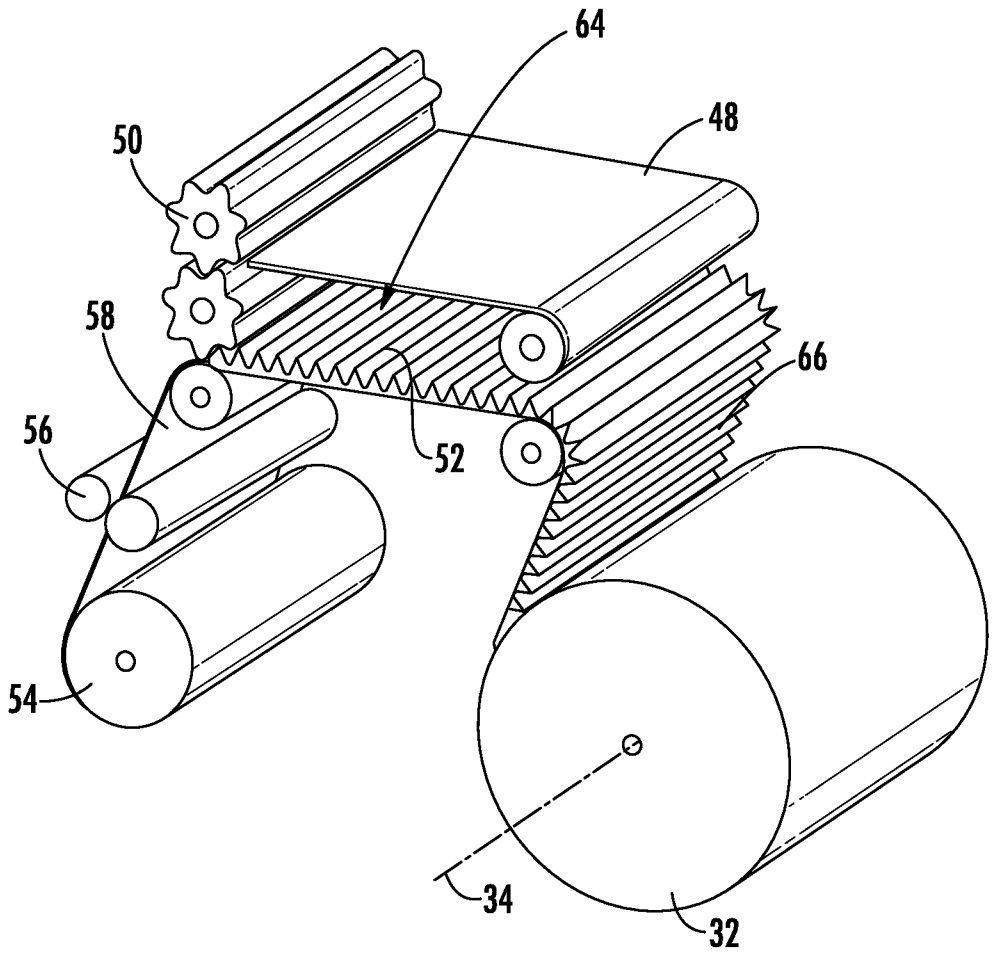

FIG. 4

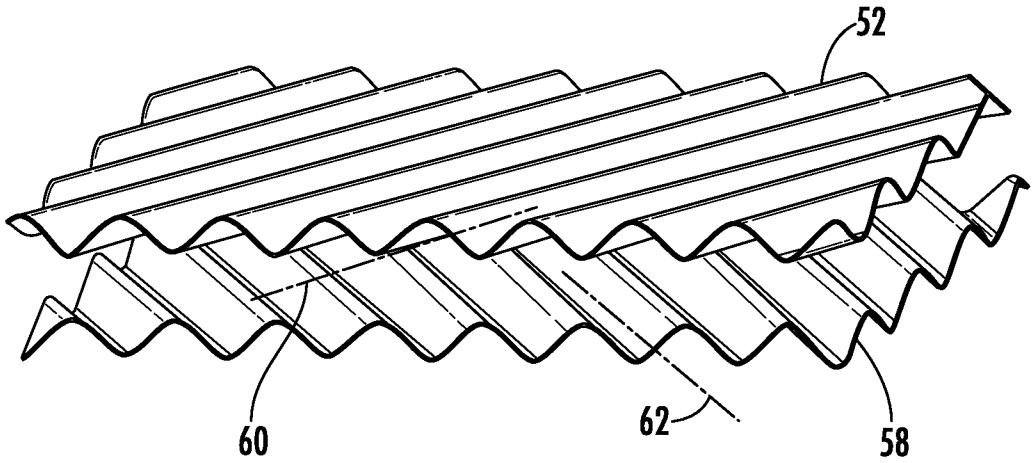

FIG. 5

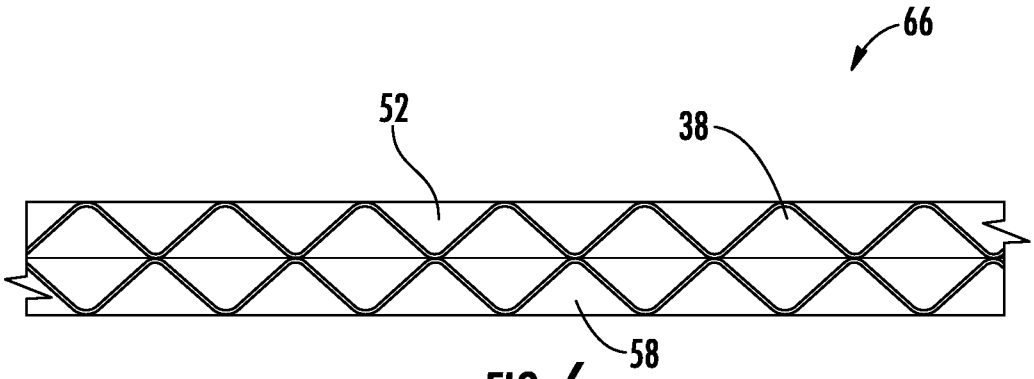

FIG. 6

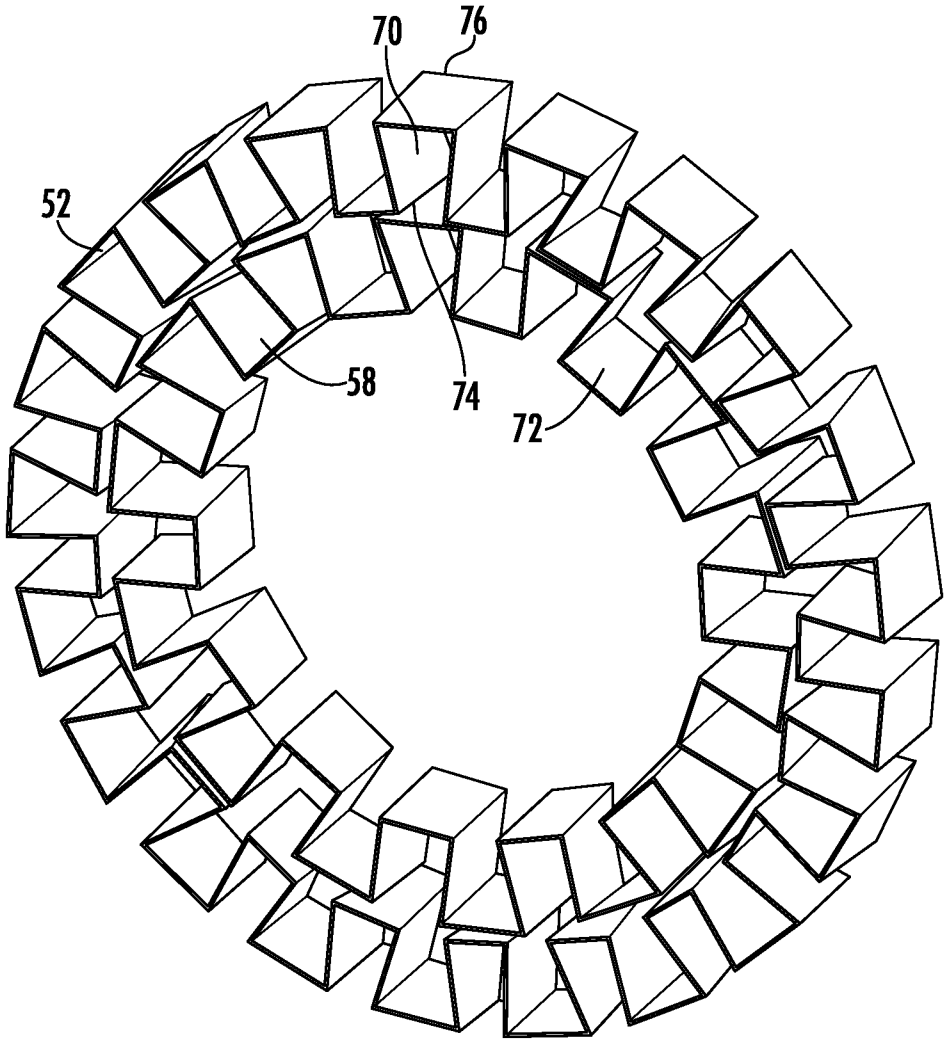

FIG. 7

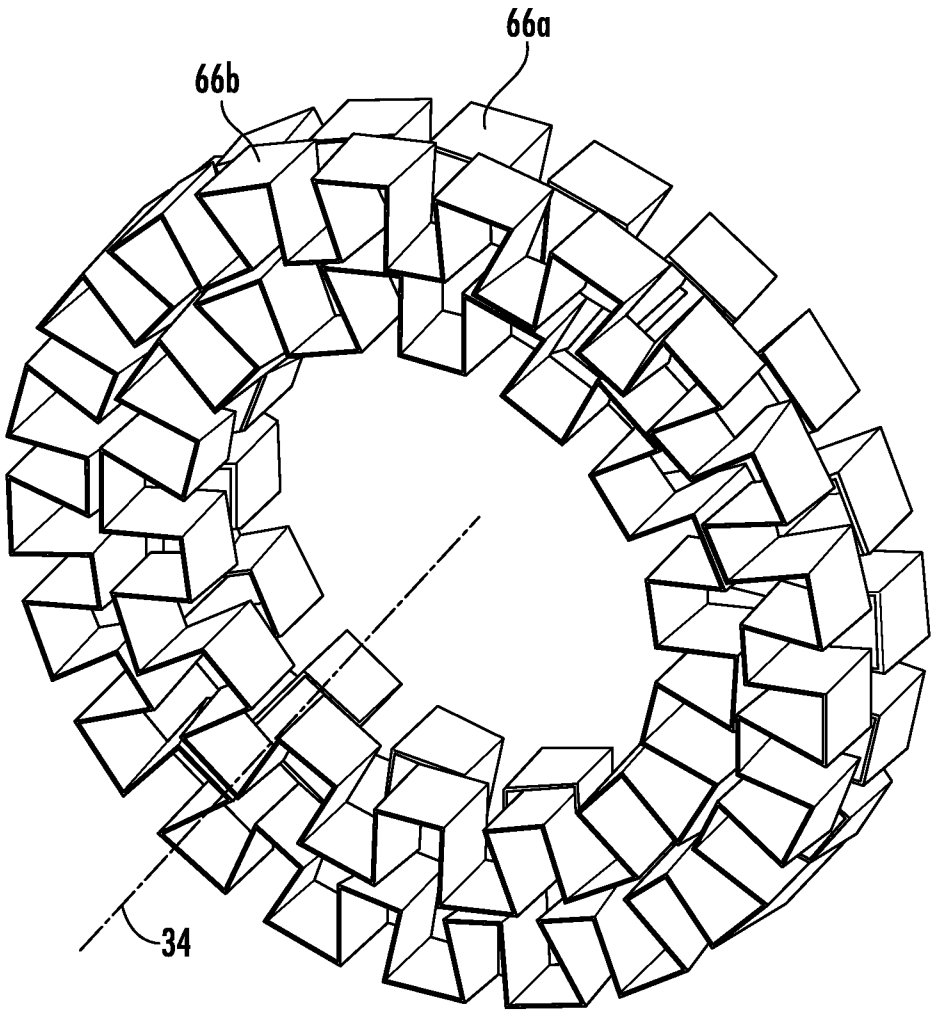

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2019/060062

A. CLASSIFICATION OF SUBJECT MATTER
INV. F28D19/04 B21D53/04
ADD.

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)
F28D F28F B21D

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 30 11 210 A1 (HAEBERLE WILHELM) 1 October 1981 (1981-10-01) the whole document -----	1,3-9, 11-20
X	DE 27 06 139 A1 (LTG LUFTTECHNISCHE GMBH) 17 August 1978 (1978-08-17) the whole document -----	1,2,9, 10,17
X	US 3 800 515 A (ASKER G ET AL) 2 April 1974 (1974-04-02) the whole document -----	1,9,17

☐ Further documents are listed in the continuation of Box C.

☒ See patent family 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 application or patent 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
11 March 2020	19/03/2020

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, Fax: (+31-70) 340-3016	Martínez Rico, Celia

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2019/060062

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 3011210 A1	01-10-1981	NONE	
DE 2706139 A1	17-08-1978	NONE	
US 3800515 A	02-04-1974	US 3664095 A	23-05-1972
		US 3800515 A	02-04-1974