

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
18 December 2008 (18.12.2008)

PCT

(10) International Publication Number
WO 2008/154391 A1

(51) International Patent Classification:

F28F 1/04 (2006.01) *F28F 1/18* (2006.01)
C25C 3/22 (2006.01) *F28F 13/18* (2006.01)
F28F 1/10 (2006.01)

(21) International Application Number:

PCT/US2008/066134

(22) International Filing Date: 6 June 2008 (06.06.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

60/942,269 6 June 2007 (06.06.2007) US

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(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, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, 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, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,

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(54) Title: HEAT EXCHANGER

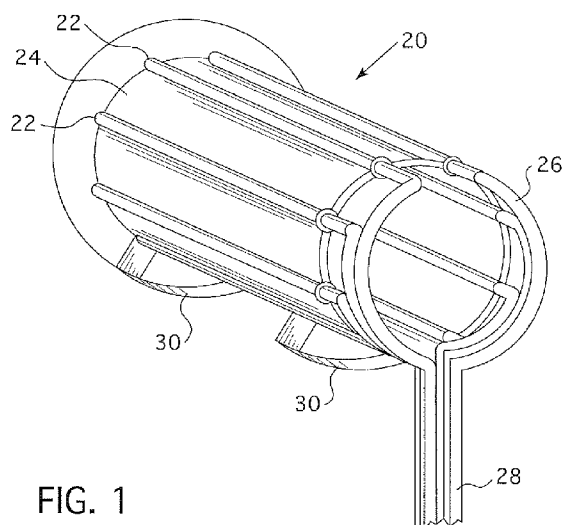


FIG. 1

(57) Abstract: A heat exchanger suitable for long term use in the unfiltered hot exhaust gas of an aluminum smelter is disclosed. In one embodiment, the heat exchanger comprises fluid carrying tubes connected together with web members to form a cylindrical shell. A header located at each end of the cylindrical shell is provided for feeding fluid to and from the tubes of the heat exchanger. Shrouds can be placed over the headers to affect hot gas turbulence and help minimize scaling. The surfaces of the cylindrical shell, when in un-scrubbed exhaust gas of an aluminum smelter, will be in contact with particles and/or dust and possibly caustic fumes and, therefore, may be treated with a relevant slip coating selected, for example, from the Teflon family.

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FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL,
NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG,
CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

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))*

HEAT EXCHANGER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This applications claims the benefit of US provisional patent application number 60/942,269 filed on June 6, 2007, the entirety of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] Heat exchange devices, or heat exchangers, are devices for transferring heat from one medium to another, typically from one fluid to another or to the environment, without allowing the fluids to mix.

SUMMARY OF THE INVENTION

[0003] A counter flow heat exchanger suitable for long term use in the unfiltered hot exhaust gas of an aluminum smelter is disclosed. In one embodiment, the heat exchanger comprises fluid carrying tubes connected together with web members to form a cylindrical shell. A header located at each end of the cylindrical shell is provided for feeding fluid to and from the tubes of the heat exchanger. Shrouds can be placed over the headers to affect hot gas turbulence and help minimize scaling. The surfaces of the cylindrical shell, when in un-scrubbed exhaust gas of an aluminum smelter, will be in contact with particles and/or dust and possibly caustic fumes and, therefore, may also be treated with a coating selected, for example, from the Teflon family.

[0004] The foregoing has outlined, rather broadly, the present invention so that those skilled in the art may better understand the detailed description of the invention that follows. Additional features of the invention will be described hereinafter that form the subject of the claims of the invention. Those skilled in the art should appreciate that they can readily use the disclosed conception and specific embodiment as a basis for designing or modifying other structures for carrying out the same purposes of the present invention without departing from the spirit and scope of the invention in its broadest form.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Other aspects, features, and advantages of the invention will become more fully apparent from the following detailed description, the appended claim, and the accompanying drawings in which common parts are given common reference numerals wherein:

[0006] Fig. 1 is a perspective view of a heat exchanger coupled to a header at one end in accordance with the principles of the invention;

[0007] Fig. 2 is a perspective view of another embodiment of the heat exchanger where the header is not shown;

[0008] Fig. 3 is another perspective view of the embodiment of Fig. 2;

[0009] Fig. 4 is a view of a plurality of heat exchangers of Figs. 1 or 2 coupled together to form a cylinder where the axes of the cylinder is parallel to the hot gas flow;

[0010] Fig. 5 is a view of a plurality of heat exchangers of Figs. 1 or 2 coupled together to form two concentric cylinders where the axes of the cylinders are parallel to the hot gas flow; and

[0011] Fig. 6 is an enlarged view of a plurality of heat exchangers coupled together with web members to form a cylindrical shell where each heat exchanger is a smaller cylindrical shell having tubes and fins where the fins may be used when the nature of the exhaust gas is compatible with such use.

DETAILED DESCRIPTION

[0012] Heat exchangers are available in different designs however, in the prior art, heat exchangers of similar designs are frequently identified with names that are different. The heat exchanger in this application consists of a plurality of tubes located in a stream of hot gas where the tubes contain a fluid for receiving heat from the hot gas. The tubes can have a cross section which is rectangular, circular, elliptical or the like, and may have external or internal fins provided the fins are compatible with the exhaust. Temperature of the fluid in the tubes is less than the temperature of the stream of hot gas, and heat is transferred from the hot gas to the lower temperature fluid in the tubes.

[0013] As used herein: A cross flow or transverse flow heat exchanger is where the axes of the tubes are perpendicular to the flow of the hot gas;

[0014] A parallel flow heat exchanger is where the axes of the tubes are parallel to the flow of the hot gas and the fluid in the tubes move in the same direction as the flow of the hot gas; and

[0015] A counter flow heat exchanger is where the axes of the tubes are parallel to the flow of the hot gas and the fluid in the tubes move in a direction opposite to the flow of the hot gas.

[0016] The heat exchanger here disclosed is a counter flow heat exchanger where the overall velocity of the fluid in the tubes is parallel but opposite to the direction of the flow of gas outside the tubes.

[0017] Referring to the embodiment shown in Fig. 1, the heat exchanger 20 consist of cylindrical shell which is open at both ends and supports one or more hollow elements such as tubes having a circular, elliptical, oval etc. cross-section. In some embodiments, the cylindrical shell and the tubes can be made of aluminum, stainless steel, carbon steel etc. that may have been treated with a galvanization process. In some embodiments, the tubes 22 of the heat exchanger 20 can be connected together with web members 24, where the web members can be of the same material as the tubes, or of a different but compatible material. For example, the tubes can be of copper and the web members can be of treated aluminum (to prevent corrosion), or both the tubes and the web members can be of copper or aluminum. In some embodiments, the tubes and web members can be joined together by braising or soldering, which ever is appropriate for the environment within which the heat exchanger will be operating, to form a cylindrical shell which is open at each end. It is also noted that the cylindrical shell can be made of two sheets of aluminum laminated together and shaped to form a cylindrical shell, and the two sheets of aluminum are separated to form tubes for receiving a fluid. In some embodiments, the tubes in the cylindrical shell are evenly spaced, are parallel to each other and are parallel to the longitudinal axis of the cylindrical shell. In some embodiments, the tubes extend from one end of the cylindrical shell to the other end and are designed to receive a fluid, such as water, a chemical substance, oil, aqueous solution, etc. for receiving heat. The surfaces of the cylindrical shell, when in the un-scrubbed exhaust gas of an aluminum smelter, will be in contact with particles and/or dust and possibly caustic fumes and, therefore, in some embodiments, may also be treated in accordance with relevant surface

treatment techniques with a relevant slip coating to produce an increased slip effect.

[0018] In some embodiments, located at one end of the cylindrical shell is an inlet header or manifold 26 having a plurality of parallel header tubes 28, one for each tube 22 in the cylindrical shell, for conducting fluid to the tubes 22. Depending on the flow of the conducting fluid, the parallel header tubes may be a single large tube that feeds each tube 22 equally in some embodiments. In some embodiments, the inlet header tubes are formed to have a common radius substantially equal to the radius of the cylindrical shell and positioned at the end of the cylindrical shell. In some embodiments, an outlet header which is similar to the inlet header is located at the other end of the cylindrical shell and is provided to carry heated fluid from the heat exchanger, after it has been heated, to a specific location. In some embodiments, the axis of the tubes in the cylindrical shell are parallel to the axis of the cylindrical shell and, in operation, the cylindrical shell is positioned to be aligned with the flow of the gas in the exhaust duct of an aluminum smelter. But, as noted above, the fluid in the tubes will flow in a direction which is opposite to the direction of flow of the hot gas.

[0019] To influence the flow of the hot gas around and through the cylindrical shell and minimize the pressure drop of the exhaust gas through the heat exchanger, and reduce the possibility of accumulating scaling on the heat exchanger, a shroud can be positioned around the input header and the output header, in some embodiments.

[0020] The tubes 22 in the cylindrical shell for the fluid are shown as having a circular cross section. However, the tubes 22 can have any desired cross section. The number of the tubes 22 in the heat exchanger and whether the cross section of the tubes should be circular, elliptical, or rectangular can be determined from the following: the exhaust flow rate; exhaust temperature; incoming fluid temperature; the amount of heat that is to be extracted; and, the rate of flow of the liquid.

[0021] The heat exchanger shown in Fig. 1 is a counter flow heat exchanger. Thus, in operation, hot exhaust gas flows through the heat exchanger in a direction which is opposite to the flow of the fluid in the heat exchanger. In some embodiments, support members 30 are provided to secure the heat exchanger within the exhaust duct of an aluminum smelter. In some

embodiments, the support members can encircle the cylindrical shell fully or partially. The length of the cylindrical shell can be increased or decreased as necessary to fit into exhaust ducts (or a bypass where needed) of various lengths to provide a heat exchanger having a desired heat transfer area.

[0022] In some embodiments, in addition to placing a shroud around the input and output headers, coatings can be applied to the heat exchanger to keep scaling to a minimum. In some embodiments, the coating is a Teflon-type coating. It is to be noted that as the axis of the heat exchanger is parallel to the exhaust gas flow, scaling on the heat exchanger tubes will be substantially less than will occur in other arrangements. In some embodiments, when a coating is used, its main contribution will be on the shrouds covering the input and output headers and on the supply and exit tube(s).

[0023] After an extended period of testing, no substantial scaling formed on the heat exchanger tube of a subscale heat exchanger which was placed in the hot exhaust gas of an aluminum smelter upstream of the scrubber. It was also found that the coating not only reduced the sedimentation even further, but also did not adversely affect the heat transfer characteristics of the tube.

[0024] It is noted that the low heat transfer coefficient of the counter flow heat exchanger here disclosed, which is caused by tangential flow as opposed to impingement, can be offset by increasing the heat transfer area. In addition, if desired, the cross sectional area of the tubes can be changed to be either larger or smaller.

[0025] The heat exchanger here disclosed minimizes scaling without sacrificing heat transfer and, therefore, can be used for extended periods of time in hot exhaust gas that is populated with particles from an aluminum smelter.

[0026] Referring to Fig. 2, there is shown the cylindrical shell of another embodiment of a heat exchanger where the tubes in the cylindrical shell trace a spiral path from one end, which is connected to an input header, to the other end of the cylindrical shell, which is connected to an output header.

[0027] Referring to Fig. 3, there is shown still another embodiment of the cylindrical shell of the heat exchanger. In this embodiment the various tubes for the fluid are closely spaced in parallel relationship with each other and each tube follows a spiral path having a common radius to form a cylindrical shell. Adjacent tubes can be attached to each other or be separated with a web member having

a very small dimension. Each end of the cylindrical shell is connected to a header, one header for the input and one header for the output, and the headers can be covered with a shroud to reduce hot gas turbulence and help minimize scaling.

[0028] Referring to Fig. 4 there is shown a sectional view of still another embodiment of the heat exchanger. In this embodiment, a plurality of heat exchangers such as the heat exchanger 20 shown in Fig. 1 are attached with web members 34 and configured to form a cylinder. In this embodiment, the web members 34 can extend from a web member 24 of one heat exchanger to a web member 24 of an adjacent heat exchanger; or from a tube 22 of one heat exchanger to a tube 22 of an adjacent heat exchanger; or from a web member of one heat exchanger to a tube 22 of an adjacent heat exchanger. It is understood that input and output shrouds are provided for each individual heat exchanger in addition to headers to reduce back pressure and particulate accumulation when necessary.

[0029] Referring to Fig. 5, there is shown a sectional view of still another embodiment of the heat exchanger. In this embodiment, a plurality of heat exchangers such as the heat exchanger 20 shown in Fig. 1 are attached with web members 34 and configured to form a first cylinder. Located within the first cylinder of heat exchangers, and concentric therewith, is a second plurality of heat exchangers such as the heat exchangers 20 of Fig. 1, connected with web members and configured to form a second cylinder. Support members 36 can be provided to connect the first cylinder of heat exchangers to the second cylinder of heat exchangers. It is to be understood that input and output shrouds are provided for each individual heat exchanger in addition to headers to reduce back pressure and particulate accumulation when necessary.

[0030] Referring to Fig. 6, there is shown a partial sectional plan view of a plurality of heat exchangers connected together with web members 38 to form a cylinder. In this embodiment, and in the prior embodiments where individual heat exchangers are connected to form a cylinder, the cylinder of heat exchangers can be viewed as being a large cylindrical shell of either tubes or sub units. In some embodiments, when the cylinder is made up of a plurality of sub units, each sub unit is a cylindrical shell having tubes as disclosed in Fig. 1. In some embodiments, the web members can be continuous from one end to the other

end; or have apertures through which hot exhaust gas can pass. Continuing with Fig. 6, the tubes or sub units can have external fins 40 which extend either partially, or fully along the length of the tubes or sub units. The fins are not restricted to the outside surface of the tubes or sub units, but the fins can be located on the inside of the tubes or sub units or they can be on both the inside and the outside of the tubes or sub units. The design of fins on the outside of the tubes depends on the nature of the exhaust and may be avoided in cases where they enhance sedimentation.

[0031] In some of the embodiments where heat exchangers are arranged to form a cylinder of heat exchangers, the web member which is connected to adjacent heat exchangers can be continuous without openings from one end of the cylinder to the other end; or, the web members can have apertures therein or there between to form partial web members. In some of the embodiments, tubes with circular, oval or elliptical cross-sections can be used.

[0032] While there has been described herein the principles of the invention, it is to be clearly understood to those skilled in the art that this description is made only by way of example and not as a limitation to the scope of the invention. Accordingly, it is intended, by the appended claims, to cover all modifications of the invention which fall within the true spirit and scope of the invention.

[0033] Although the present invention has been described in considerable detail with reference to certain versions thereof, other versions are possible. Therefore, the spirit and scope of the appended claims should not be limited to the description of the versions contained herein.

[0034] All features disclosed in the specification, including the claims, abstracts, and drawings, and all the steps in any method or process disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive. Each feature disclosed in the specification, including the claims, abstract, and drawings, can be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0035] Any element in a claim that does not explicitly state "means" for performing a specified function or "step" for performing a specified function should not be interpreted as a "means or step for" clause as specified in 35 U.S.C. .sctn.112.

What is claimed is:

1. An apparatus comprising:
 - at least two parallel positioned tubes each having a first end and a second end for conducting a fluid;
 - web members coupled between the at least two parallel positioned tubes; and
 - a header located at each of the first and second ends of the at least two parallel tubes;wherein the apparatus is adapted for use as a heat exchanger in the exhaust gas of an aluminum smelter.
2. The apparatus of claim 1 wherein the apparatus is configured so that exhaust gas of an aluminum smelter flows substantially parallel to the at least two parallel positioned tubes.
3. The apparatus of claim 2 wherein the apparatus is configured so that fluid flows through the two parallel positioned tubes in a first direction and so that the exhaust gas flows in a second direction opposite to the first direction.
4. An apparatus comprising:
 - a plurality of parallel tubes each having a first end and a second end for conducting a fluid in a first direction, wherein the plurality of parallel tubes is adapted to be surrounded by exhaust gas from a smelter so that the exhaust gas flows in a second direction parallel to the plurality of parallel tubes and opposite the first direction; wherein the apparatus is adapted for use as a heat exchanger in the exhaust gas of a smelter.
5. The apparatus of claim 4 wherein the smelter is an aluminum smelter.
6. The apparatus of claim 4 further comprising web members connecting the tubes together so that the tubes and the web members form a first cylindrical shell.
7. The apparatus of claim 5 further comprising a header located at each of the first and second ends of the parallel tubes.

8. The apparatus of claim 6 further comprising a coating over the first cylindrical shell.

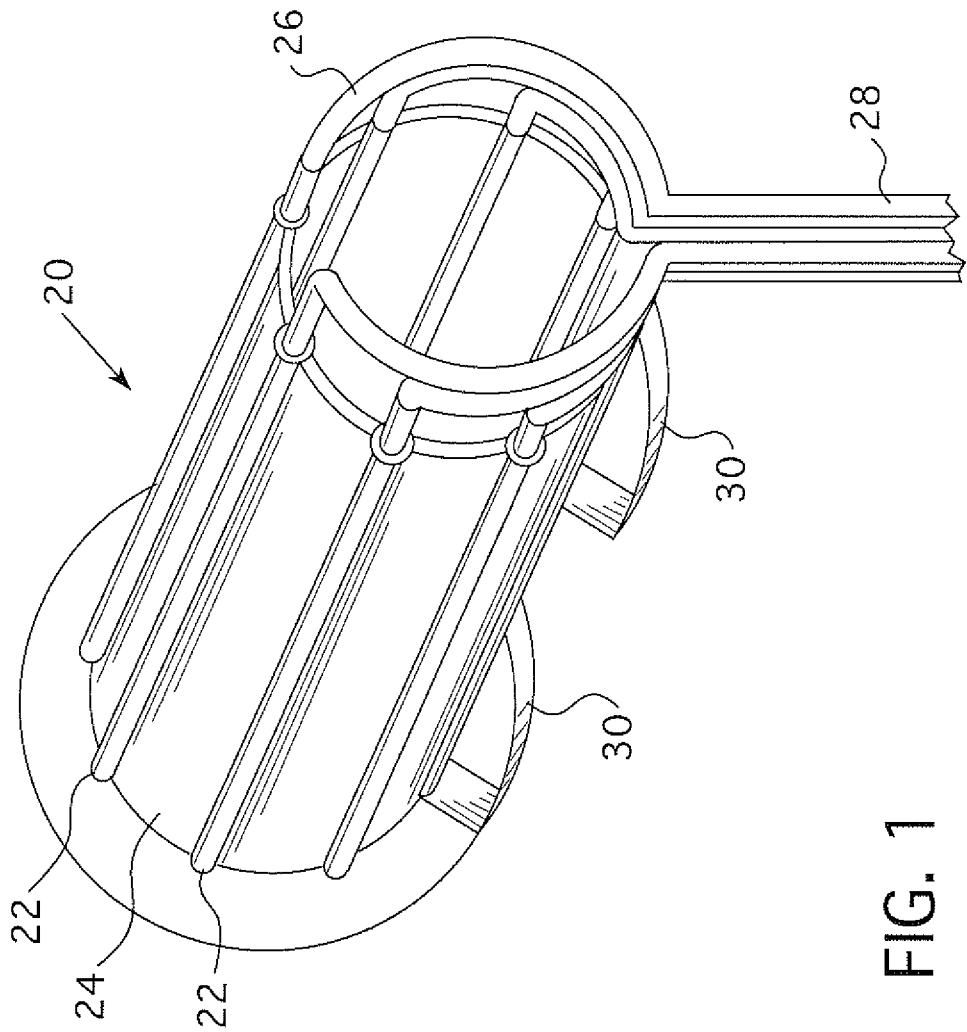


FIG. 1

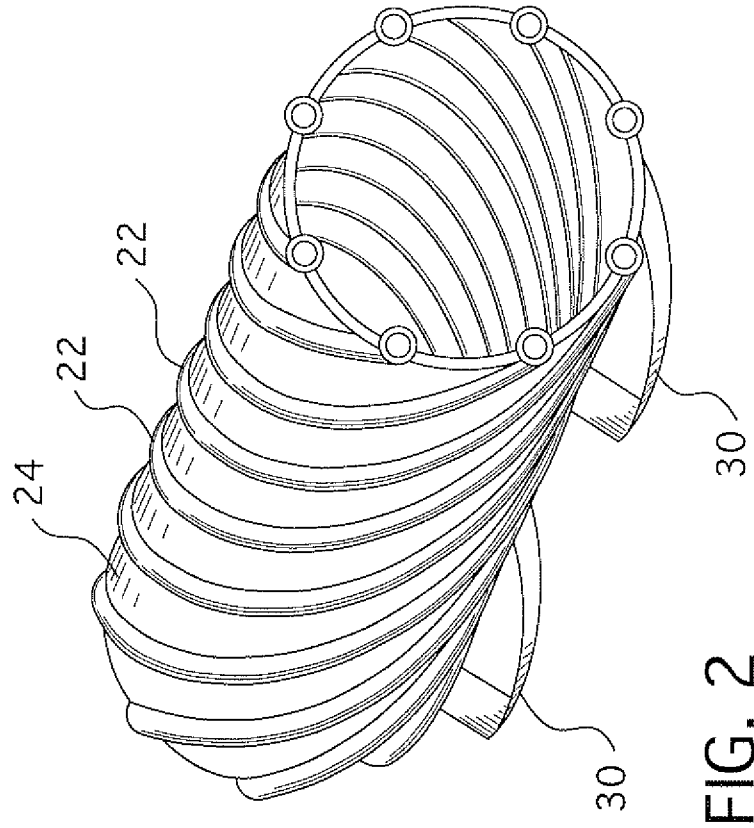


FIG. 2

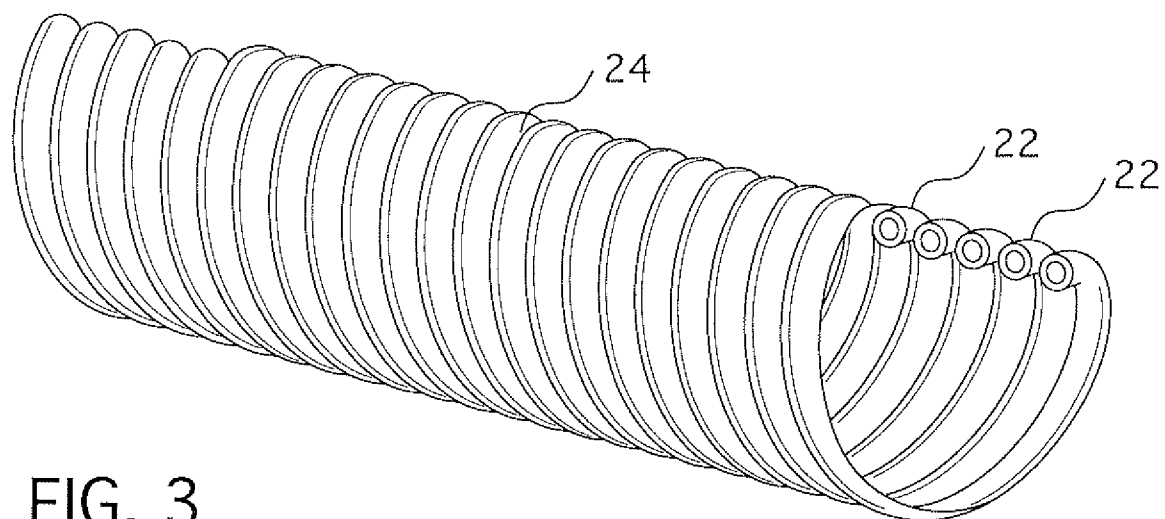


FIG. 3

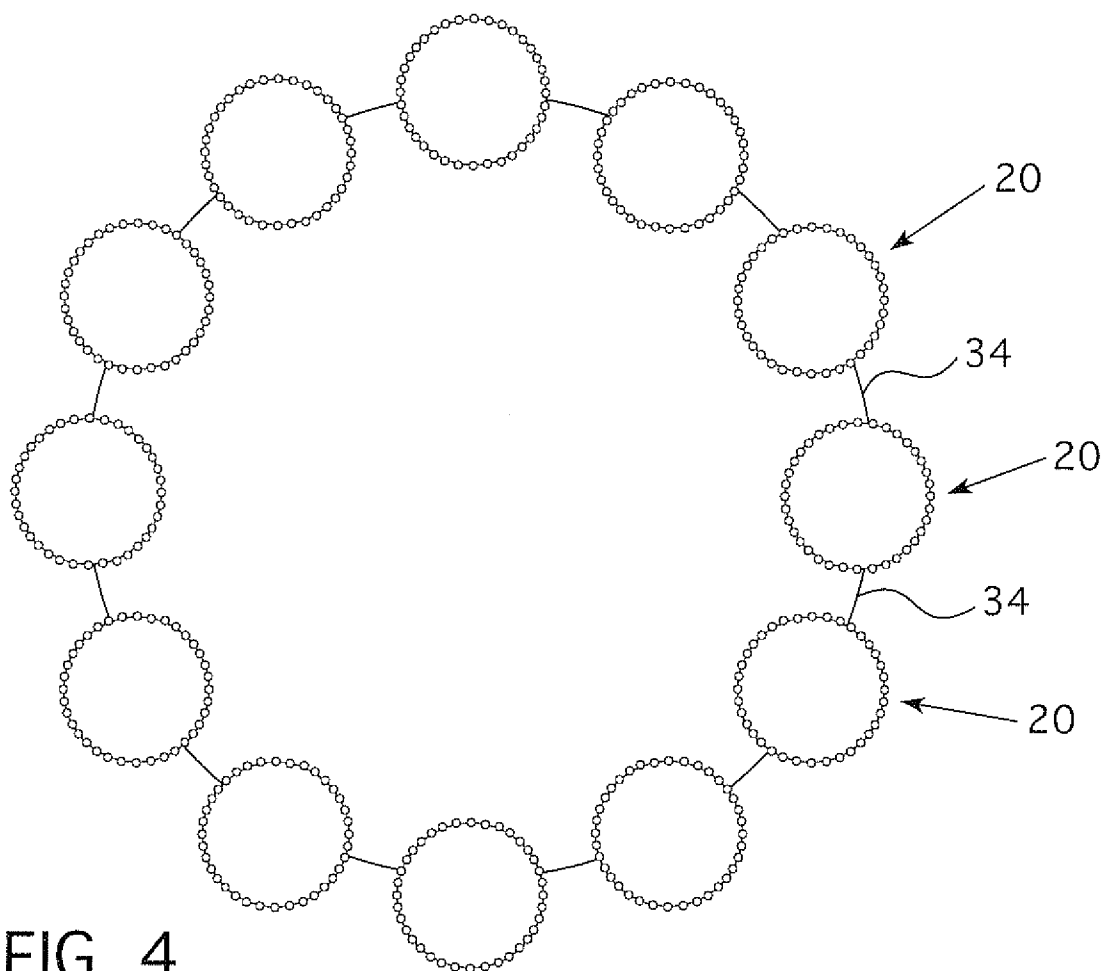


FIG. 4

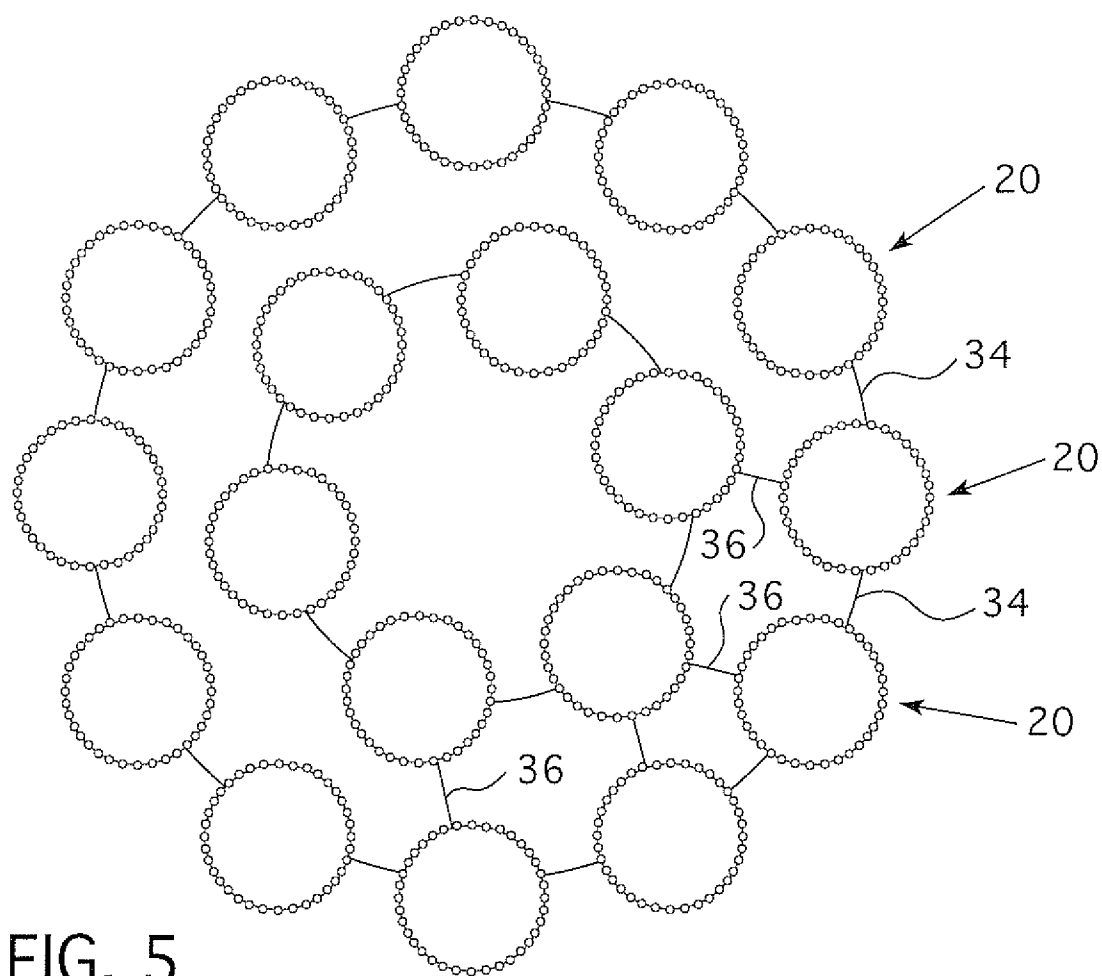


FIG. 5

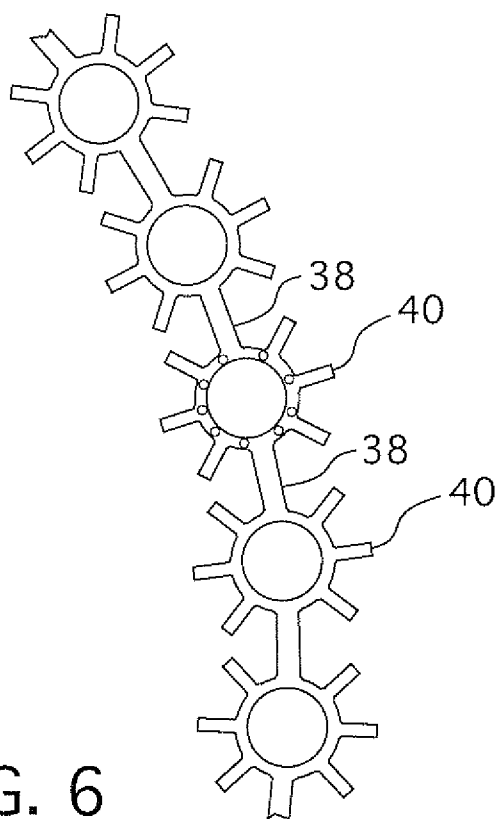


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/066134

A. CLASSIFICATION OF SUBJECT MATTER

INV. F28F1/04 C25C3/22 F28F1/10 F28F1/18 F28F13/18

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)

F28F C25C

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)

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



See patent family annex.

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Date of the actual completion of the international search

2 September 2008

Date of mailing of the international search report

08/09/2008

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INTERNATIONAL SEARCH REPORT

International application No

PCT/US2008/066134

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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