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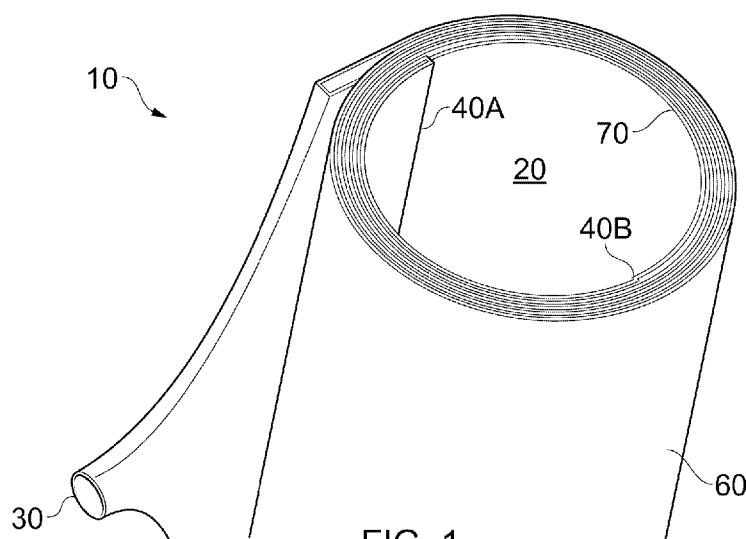


FIG. 1

(57) Abstract: The field of the invention relates to a burner. The burner is for treating an effluent stream from a manufacturing process tool and comprises: a spiral plenum chamber defining a combustion chamber for treating the effluent stream, the spiral plenum chamber being configured to convey combustion reactants to support combustion within the combustion chamber. In this way, the spiral plenum helps prevent heat loss from the combustion chamber, enabling a more uniform temperature distribution within the combustion chamber thereby reducing the need for localized elevated temperatures within the combustion chamber which would otherwise be to the generation of undesirable combustion by-products.



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BURNER

FIELD OF THE INVENTION

The field of the invention relates to a burner.

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BACKGROUND

Burners, such as radiant burners are known and are typically used for treating an effluent gas stream from a manufacturing process tool used in, for example, the semiconductor or flat panel display manufacturing industry. During such manufacturing, residual perfluorinated compounds (PFCs) and other compounds exist in the effluent gas stream pumped from the process tool. PFCs are difficult to remove from the effluent gas and their release into the environment is undesirable because they are known greenhouse gases.

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Known radiant burners use combustion to remove the PFCs and other compounds from the effluent gas stream. Typically, the effluent gas stream is a nitrogen stream containing PFCs and other compounds. A fuel and oxygen are mixed with the effluent gas stream and that gas stream mixture is conveyed into a combustion chamber that is laterally surrounded by the exit surface of a foraminous gas burner. Fuel gas and air are simultaneously supplied to the foraminous burner to affect combustion at the exit surface. Subsequent combustion of the additional fuel and oxygen results in destruction of the PFCs as they pass through a high temperature flame.

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Although techniques exist for processing the effluent gas stream, they each have their own shortcomings. Accordingly, it is desired to provide an improved technique for processing an effluent gas stream.

SUMMARY

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According to a first aspect, there is provided a burner for treating an effluent stream from a manufacturing process tool, the burner comprising: a spiral plenum chamber defining a combustion chamber for treating the effluent stream, the

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spiral plenum chamber being configured to convey combustion reactants to support combustion within the combustion chamber.

5 The first aspect recognizes that a problem with existing burners is that the heat loss from those burners can be high. As such, existing burners have to operate at higher than desirable temperatures at some locations within the burner in order that the compounds within the effluent stream within the burner can be abated effectively. Those elevated temperatures can lead to undesirable by-products being generated to such NO_x. Accordingly, a burner may be provided. The
10 burner may treat an effluent stream from a manufacturing process tool. The burner may comprise a spiral or helical plenum chamber. The spiral plenum chamber may define a combustion chamber which treats the effluent stream. The spiral plenum chamber may convey combustion reactants to the combustion chamber to support combustion within the combustion chamber. In this way, the
15 spiral plenum helps prevent heat loss from the combustion chamber, enabling a more uniform temperature distribution within the combustion chamber thereby reducing the need for localized elevated temperatures within the combustion chamber which would otherwise result in the generation of undesirable combustion by-products.

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In one embodiment, the spiral plenum chamber has an inlet for receiving the combustion reactants and is configured to pre-heat the combustion reactants when being conveyed to the combustion chamber. The spiral plenum helps to heat the combustion reactants in order to recover some of the heat lost from the
25 combustion chamber, to reduce heat loss and to help to maintain the temperature within the combustion chamber.

In one embodiment, the spiral plenum chamber has a plurality of turns. Increasing the number of turns helps decrease the heat loss from the combustion
30 chamber and increase the heat transfer to the combustion reactants.

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In one embodiment, the spiral plenum chamber is formed from a rolled elongate planar sheet. Using a rolled sheet is a particularly convenient way to create the spiral plenum chamber.

- 5 In one embodiment, at least that portion of the spiral plenum chamber defining a surface of the combustion chamber is made of a material differing from a remainder of the spiral plenum chamber. Changing the materials forming the spiral plenum chamber at different locations helps to match material properties to the environment. In particular, a highly chemical resistant and/or high
- 10 temperature resistant material may be provided for that portion which forms an inner turn of the spiral plenum and the defining surface of the combustion chamber. Less resistive materials may then be used for the remainder of the spiral plenum chamber.
- 15 In one embodiment, the spiral plenum chamber defines a plurality of apertures configured to convey the combustion reactants into the combustion chamber. Accordingly, the spiral plenum chamber may have apertures through which the combustion reactants may pass from the plenum into the combustion chamber. This provides a convenient technique for delivering the combustion reactants into
- 20 the combustion chamber.

- In one embodiment, the plurality of apertures are located to extend at least partially along an axial length of the combustion chamber. Accordingly, the apertures may be arranged along the length of the combustion chamber in order
- 25 to deliver combustion reactants at different locations within the combustion chamber.

- In one embodiment, the plurality of apertures are located to extend along at least one of a row and a helix extending at least partially along the axial length of the combustion chamber. Accordingly, the apertures may be aligned as a linear row
- 30 and/or as a helix or spiral extending around the combustion chamber.

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In one embodiment, the plurality of apertures are orientated to convey the combustion reactants into the combustion chamber with a tangential component. Accordingly, the apertures they deliver the combustion reactants other than radially in order to encourage the flow of the combustion reactants around the combustion chamber. This helps to create a layer of combustion reactants proximate the surface of the spiral plenum chamber which helps prevent reactive chemicals from damaging that surface. Furthermore, once the combustion chamber achieves its operating temperature, a flameless combustion of the combustion reactants can occur.

In one embodiment, the plurality of apertures have differing sizes. Accordingly, the size of the apertures may vary in order to deliver different quantities of combustion reactants to different locations within the combustion chamber to suit the conditions required at those locations.

In one embodiment, the apertures are located in a shoulder portion formed to couple one surface of the spiral plenum chamber with an adjacent surface of the spiral plenum chamber. Providing a shoulder, ridge, bar or elongate face is particularly convenient as this both helps to terminate the spiral plenum chamber and provides a suitably orientated surface in which to locate the apertures in order to convey the combustion reactants into the combustion chamber with a tangential component.

In one embodiment, the plurality of apertures form a group of apertures and the spiral plenum chamber comprises a plurality of the groups of apertures, each group located at a different circumferential position of the combustion chamber. Accordingly, more than one set of apertures may be provided in order to help deliver the combustion reactants more uniformly within the combustion chamber.

In one embodiment, the spiral plenum chamber comprises a second plurality of apertures configured to convey second combustion reactants into the combustion chamber. Accordingly, different combustion reactants may be delivered into the

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combustion chamber using a different set of apertures. Providing different apertures helps to separate reactive combustion reactants prior to delivery into the combustion chamber.

5 In one embodiment, the second plurality of apertures are collocated with the plurality of apertures. Accordingly, the two sets of apertures may be located together in order to deliver the different combustion reactants to the same location in the combustion chamber.

10 In one embodiment, the second plurality of apertures have differing sizes. Again, the size of the apertures may vary in order to deliver different quantities of combustion reactants to different locations within the combustion chamber to suit the conditions required at those locations

15 In one embodiment, the spiral plenum chamber defines at least one second plenum configured to convey the second combustion reactants to the second plurality of apertures. Accordingly, a further, separate or isolated, plenum may be provided in order to prevent premixing of the combustion reactants prior to the delivery into the combustion chamber.

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In one embodiment, the spiral plenum chamber comprises an inner sleeve concentrically located within the spiral plenum chamber and defining the apertures. Accordingly, the spiral plenum chamber may be provided with an inner sleeve through which the combustion reactants pass into the combustion chamber in order to simplify construction.

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In one embodiment, the burner comprises a top plate which couples with the spiral plenum chamber to define the combustion chamber, the top plate having a top plate inlet for receiving the second combustion reactants and defining conduits configured to pre-heat the second combustion reactants when being conveyed to the combustion chamber. Accordingly, the second combustion

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reactants may first pass through the top plate in order to preheat those combustion reactants and help reduce heat loss through the top plate.

Further particular and preferred aspects are set out in the accompanying
5 independent and dependent claims. Features of the dependent claims may be combined with features of the independent claims as appropriate, and in combinations other than those explicitly set out in the claims.

Where an apparatus feature is described as being operable to provide a function,
10 it will be appreciated that this includes an apparatus feature which provides that function or which is adapted or configured to provide that function.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will now be described further, with
15 reference to the accompanying drawings, in which:
Figures 1 to 3 illustrate a spiral plenum chamber according to one embodiment;
Figure 4 illustrates a top plate which is fitted to one open end of the spiral plenum chamber;
Figure 5 shows the internal layout of the top plate in more detail; and
20 Figure 6 illustrates an alternative arrangement for shoulders of the spiral plenum chamber.

DESCRIPTION OF THE EMBODIMENTS

Before discussing the embodiments in any more detail, first an overview will be
25 provided. One embodiment provides a spiral or helix plenum which surrounds a combustion chamber. The plenum helps to insulate the combustion chamber and pre-heat combustion reactants being supplied to the combustion chamber. This helps to reduce heat loss from the combustion chamber and reduce the temperature variation within the combustion chamber. This helps to increase the
30 average temperature within the combustions chamber while reducing the peak temperature within the combustion chamber. This helps to increase the

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abatement efficiency of the combustion chamber while reducing the amount of undesirable combustion by-products.

Spiral Plenum

- 5 Figures 1 to 3 illustrate a spiral plenum chamber 10 according to one embodiment. The spiral plenum chamber 10 is formed by rolling a single sheet in a spiral or helix of a number of turns. In this embodiment, the sheet is rolled to have five turns. This provides the spiral plenum chamber 10 with an outer surface 60, an inner surface 70, turn walls 75 and a continuous spiral or helix
- 10 plenum 80. In this embodiment, that section of the sheet used to form the inner surface 70 is made of a material that is more resistant to chemical attack and more resistant to heat than the material used in the remainder of the sheet which forms the turn walls 75 and the outer surface.
- 15 The spiral terminates with a pair of shoulders 40A, 40B which extend along the axial length of the combustion chamber 20. The shoulders 40A, 40B are positioned at circumferentially-opposite locations on the inner surface 70 of the spiral plenum chamber 10. As can be seen in Figure 3, the shoulders 40A, 40B define a plurality of outlets 50. These outlets 50 may have different sizing and
- 20 positioning to vary the combustion conditions within the combustion chamber 20. Although the shoulders 40A, 40B are a linear arrangement, it will be appreciated that these could instead be formed as helixes spiralling around the inner surface 70 in a similar way to a screw thread.
- 25 An inlet 30 is defined in the outer surface 60. Accordingly, the inlet 30 is in fluid communication with the outlets 50 via the four turns of the spiral plenum 80.

In operation, the combustion reactants (in this example an oxidant, such as air) is provided through the inlet 30 and is conveyed through the turns of the spiral

30 plenum 80 before being ejected out of the outlets 50 on the shoulders 40A, 40B to support combustion of fuel within the combustion chamber 20. The presence of the multiple turns helps to insulate the combustion chamber 20 by reducing

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heat loss. Also, the combustion reactants flowing through the spiral plenum are pre-heated. This helps to increase the temperature and reduce temperature variations (increase temperature homogeneity) within the combustion chamber 20. This means that a higher average temperature within the combustion

5 chamber 20 can be achieved with less-elevated localised temperature variations which would otherwise cause the production of unwanted by-products such as NO_x. Also, the higher average temperature increases the abatement effectiveness of the combustion chamber 20.

- 10 The orientation of the outlets 50 inject the air into the combustion chamber 20 in a tangential direction A. This helps to create a vortex within the combustion chamber 20 to improve mixing of gases within the combustion chamber and further reduce temperature variations. Also, as the operating temperature within the combustion chamber 20 increases, flameless combustion occurs.
- 15 Furthermore, the flow of the air in the direction A helps to prevent reactive chemicals within the combustion chamber 20 from interacting with the inner surface 70.

Top Plate

- 20 Figure 4 illustrates a top plate 90 which is fitted to one open end of the spiral plenum chamber 10. The top plate 90 is provided with a number of inlets 100 through which a second combustion reactants is provided. In this example, the fuel is provided to the inlets 100. The fuel is conveyed into the combustion chamber 20 for mixing and combustion with the air provided from the outlets 50.
- 25 The top plate 90 is provided with a number of inlets 105 through which the effluent stream to be treated is provided. A pilot 110 is provided to initiate and monitor the combustion within the combustion chamber 20.

- Figure 5 shows (one quarter of the whole for clarity) the internal layout of an
- 30 embodiment of the top plate 90' in more detail. As can be seen, the inlets 120, 105 communicate with outlets 125, underneath the top plate 90, via conduits 130 formed within the top plate 90. The conduits 130 form a labyrinth that helps to

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preheat the combustion reactants as they flow from the inlets 120, 105 to the outlets 125 and to cool the top plate 90 reducing heat loss.

Co-located Delivery

- 5 Figure 6 illustrates an alternative arrangement for the shoulders 40'. In this embodiment, the shoulders 40' are provided with a separate plenum 140 which is fed by the outlets 125. The separate plenum 140 feeds a second plurality of apertures 150 which are similarly distributed along the length of the shoulder 40'. This arrangement delivers both the fuel and the air together, tangentially within
10 the combustion chamber 20. Also, the fuel air remain separated prior to delivery into the combustion chamber 20 which prevents flashback increasing safety.

- Accordingly, embodiments to reduce the fuel flow requirement for an abatement system for PFC (Perfluorocompounds) or other compounds. This heat-shield/heat
15 exchanger arrangement reduces heat loss from the abatement system whilst additionally protecting the internal walls of the abatement system from the corrosive effects of the decomposition products of compounds such as PFCs including fluorine and hydrogen fluoride.

- 20 Such an approach alleviates problems with existing PFC abatement systems which tend to suffer from a number of problems which include high fuel flow requirements, high NO_x emissions and corrosion problems.

- Analysis of the performance of a number of PFC abatement systems suggest that
25 the primary cause of high fuel flow requirements is a combination of the use of very short residence time at elevated temperature and simple heat loss from the combustion environment. This is addressed in embodiments by reducing the heat loss and providing an increased residence time. However, this leads to a number of other problems, not the least is the confinement of the chemically aggressive
30 combustion environment in a robust chamber whilst minimising heat loss.

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The decomposition of PFCs leads to formation of many highly reactive species including fluorine and hydrogen fluoride which at combustion temperatures are extremely corrosive to almost any material of construction. This problem is alleviated by performing the decomposition of the PFCs away from the walls of the combustion system, which reduces the concentration of reactive species at the walls and delays, if not stops, corrosion.

The embodiments described above provide several functions. The spiral plenum chamber 10 forms the vertical walls of the combustion chamber 20 in which the burning fuel/air mixture and a gas stream, containing gases to be abated, mix. The spiral plenum chamber 10 provides a method of cooling the internal wall of the combustion chamber 20 and preheats the incoming combustion air supplied via the inlet 30 which improves the efficiency of the combustion system. The spiral wall provides an enhanced heat transfer surface area which reduces the loss of heat from the combustion chamber 20 while simultaneously preheating the incoming air. The spiral geometry of the walls and the spiral air flow result in a strong temperature gradient, with the temperature of the outside surface of the system significantly below the inner wall surface temperature. With each turn in the spiral the temperature of the spiral metalwork falls towards the outermost surface, this reduces the heat loss by radiative transfer which can be substantial at combustion chamber temperatures.

The inner wall 70 of the combustion chamber 20 is constructed from a corrosion resistant material such as a high Nickel alloy, whereas the outer walls can be constructed from a conventional stainless steel such as SS304, SS316 or SS310.

The plurality of outlets 50 induce a rapidly rotating gas flow inside the combustion chamber 20 which is used to: 1) sweep reactive species away from the inner wall 70; and 2) provide sufficient recirculation of combustion products that the combustion enters a flameless combustion regime in which the hot flame front disappears and is replaced by a more homogeneous reacting gas mixture. Use of

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flameless combustion significantly reduces NO_x emissions by reduction of peak temperatures normally found in conventional flames.

Variations in the position of the plurality of outlets 50 on the vertical surface

- 5 provides a method to distribute the air in the combustion chamber 20 such that fuel/air ratio can be optimised along the axial extent of the combustion chamber 20. For example providing a relatively limited supply of air towards the uppermost of the combustion chamber 20 such that the combustion is in a fuel rich state, limiting excess temperatures, and then providing excess air (oxygen)
- 10 towards the lower most portion of the combustion chamber to “burn out” the remainder of the fuel and combustion products to reduce other emissions such as CO and other PICS (products of incomplete combustion).

The upper wall or top plate 90 of the combustion chamber 20 has a plurality of

- 15 pipes feeding the combustion chamber with fuel and waste gas to be abated. The pitch diameter and number of inlets for both fuel and waste gas can be varied to optimise the combustion, this includes injection of fuel through a lance concentric to the waste gas inlets or in an annular channel concentric to the waste gas inlets.

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A pilot flame apparatus is also provided which is used to both start the combustion and also monitor the combustion via a flame ionisation signal.

One embodiment of the top plate 90 or upper wall of the combustion chamber 20

- 25 has the fuel supply pipes feeding a labyrinth of cooling passages before entering the combustion chamber 20 thus cooling the upper wall and preheating the fuel.

In one embodiment, fuel is fed via a fuel rail or shoulder and injected through a plurality of holes in parallel with the air holes.

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The heat shield / air preheater spiral geometry provides a significant advantage as the continuous nature of the spiral metal allows for conduction along its length

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and an enhanced surface area over which the incoming air can pick up the heat that would otherwise escape. Having multiple turns, the outermost portion of the spiral is cooled by the coolest air such that the temperature difference between the air to be preheated and the metal surface is maintained in much the same

5 when operating a two-fluid-stream heat exchanger in an efficient, counter-current fashion. Additionally this helps reduce the radiative heat transfer as each turn of the spiral ensures that the outermost walls are effectively cooled.

As outlined above, the position of the air hole can be varied to alter the oxygen

10 concentration profile of the combustion chamber 20. Also the position of fuel and process gas inlets can be varied to optimise the performance. In another embodiment the fuel supply passes through a labyrinth before entering the combustion chamber 20. In one embodiment, the fuel is injected into the combustion chamber 20 via a fuel rail.

15 Although illustrative embodiments of the invention have been disclosed in detail herein, with reference to the accompanying drawings, it is understood that the invention is not limited to the precise embodiment and that various changes and modifications can be effected therein by one skilled in the art without departing

20 from the scope of the invention as defined by the appended claims and their equivalents.

REFERENCE SIGNS

- spiral plenum chamber 10
- combustion chamber 20
- 5 inlet 30, 100, 105, 120
- shoulders 40A, 40B, 40'
- outlets 50, 125
- outer surface 60
- an inner surface 70
- 10 turn walls 75
- spiral plenum 80
- top plate 90, 90'
- pilot 110
- conduits 130
- 15 plenum 140
- apertures 150

CLAIMS

1. A burner for treating an effluent stream from a manufacturing process tool, the burner comprising:
 - 5 a spiral plenum chamber defining a combustion chamber for treating said effluent stream, said spiral plenum being configured to convey combustion reactants to support combustion within said combustion chamber.
2. The burner of claim 1, wherein said spiral plenum chamber has an inlet for
10 receiving said combustion reactants and is configured to pre-heat said combustion reactants when being conveyed to said combustion chamber.
3. The burner of claim 1 or 2, wherein at least that portion of said spiral plenum chamber defining a surface of said combustion chamber is made of a
15 material differing from a remainder of said spiral plenum chamber.
4. The burner of any preceding claim, wherein said spiral plenum chamber defines a plurality of apertures configured to convey said combustion reactants into said combustion chamber.
20
5. The burner of claim 4, wherein said plurality of apertures are located to extend at least partially along an axial length of said combustion chamber.
6. The burner of claim 4 or 5, wherein said plurality of apertures are located
25 to extend along at least one of a row and a helix extending at least partially along said axial length of said combustion chamber.
7. The burner of any one of claims 4 to 6, wherein said plurality of apertures are orientated to convey said combustion reactants into said combustion
30 chamber with a tangential component.

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8. The burner of any one of claims 4 to 7, wherein said plurality of apertures are located in a shoulder portion formed to couple one surface of said spiral plenum chamber with an adjacent surface of said spiral plenum chamber.

5 9. The burner of any one of claims 4 to 8, wherein said plurality of apertures form a group of apertures and comprising a plurality of said groups of apertures, each group located at a different circumferential position of said combustion chamber.

10 10. The burner of any preceding claim, comprising a second plurality of apertures configured to convey second combustion reactants into said combustion chamber.

11. The burner of claim 10, wherein said second plurality of apertures are
15 collocated with said plurality of apertures.

12. The burner of claim 10 or 11, wherein said second plurality of apertures have differing sizes.

20 13. The burner of any one of claims 10 to 12, wherein said spiral plenum chamber defines at least one second plenum configured to convey said second combustion reactants to said second plurality of apertures.

14. The burner of any one of claims 4 to 13, comprising an inner sleeve
25 concentrically located within said spiral plenum chamber and defining said apertures.

15. The burner of any preceding claim, comprising a top plate which couples with said spiral plenum chamber to define said combustion chamber, said top
30 plate having a top plate inlet for receiving said second combustion reactants and defining conduits configured to pre-heat said second combustion reactants when being conveyed to said combustion chamber.

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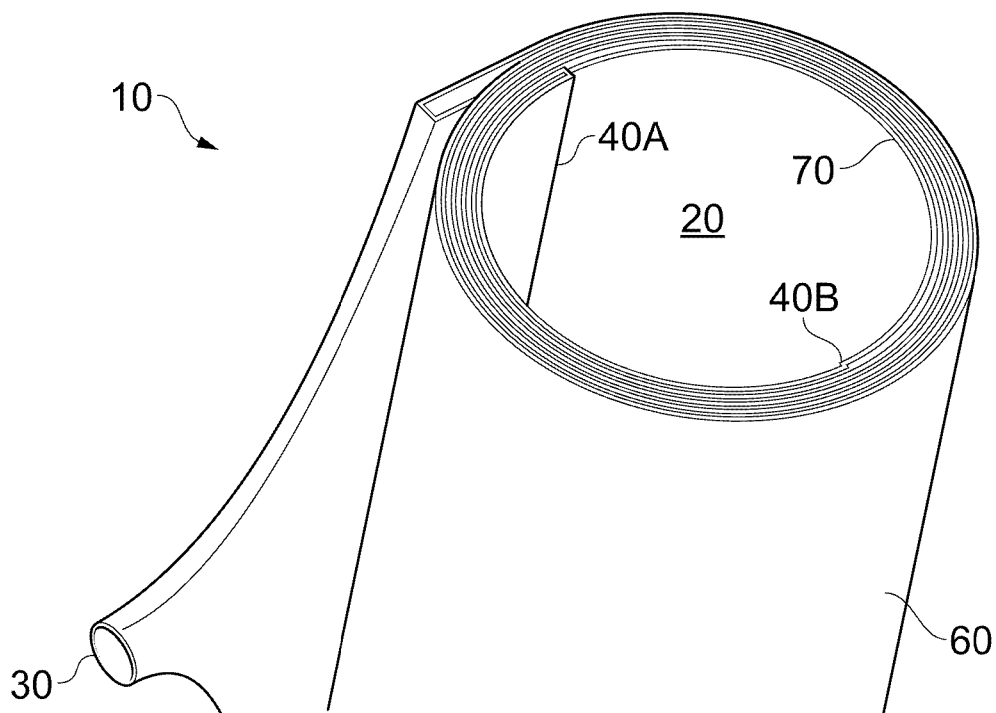


FIG. 1

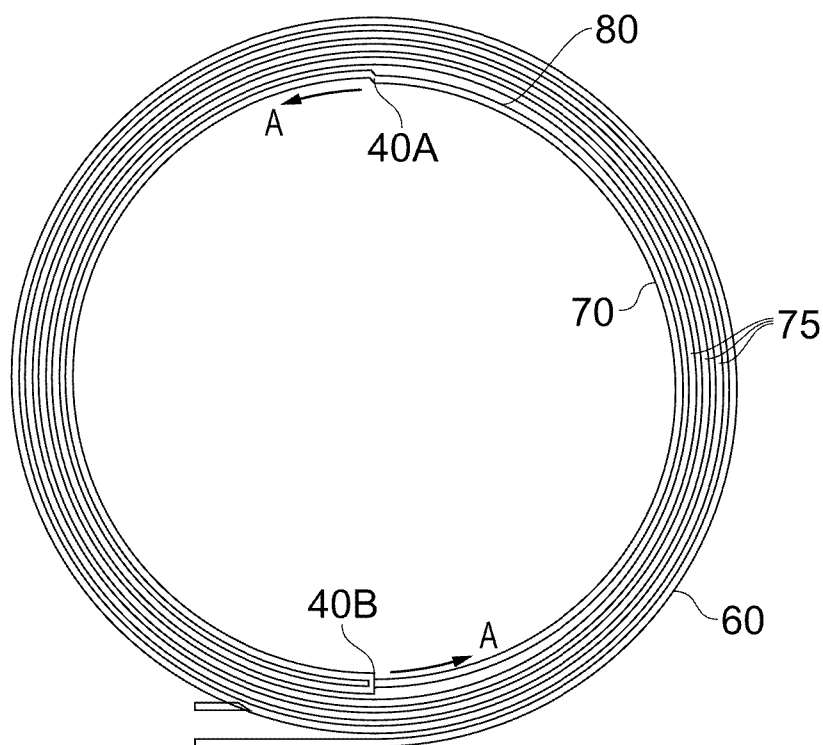


FIG. 2

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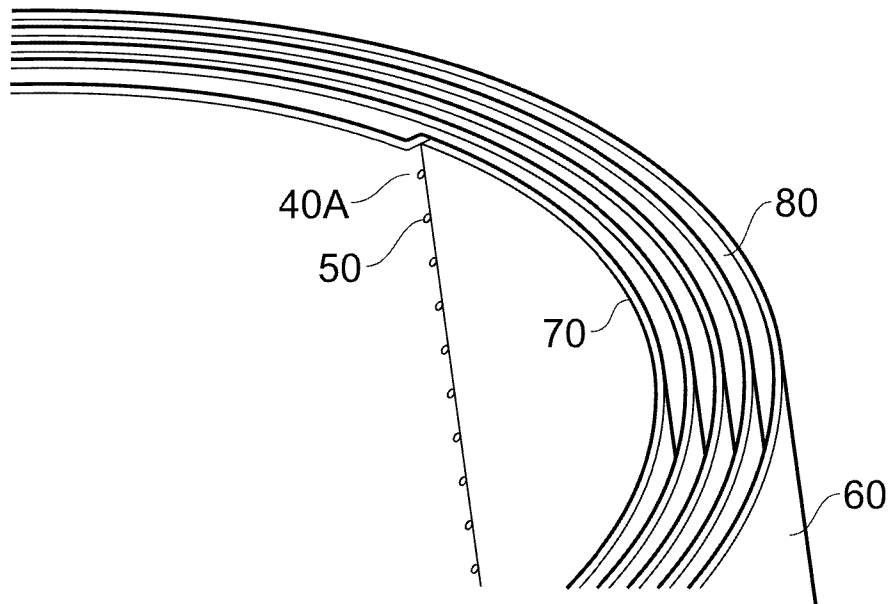


FIG. 3

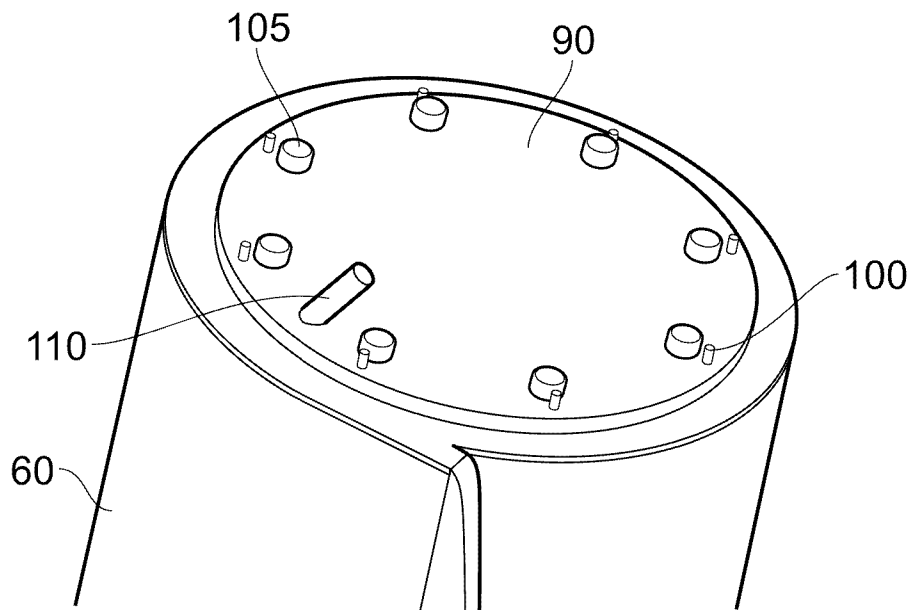


FIG. 4

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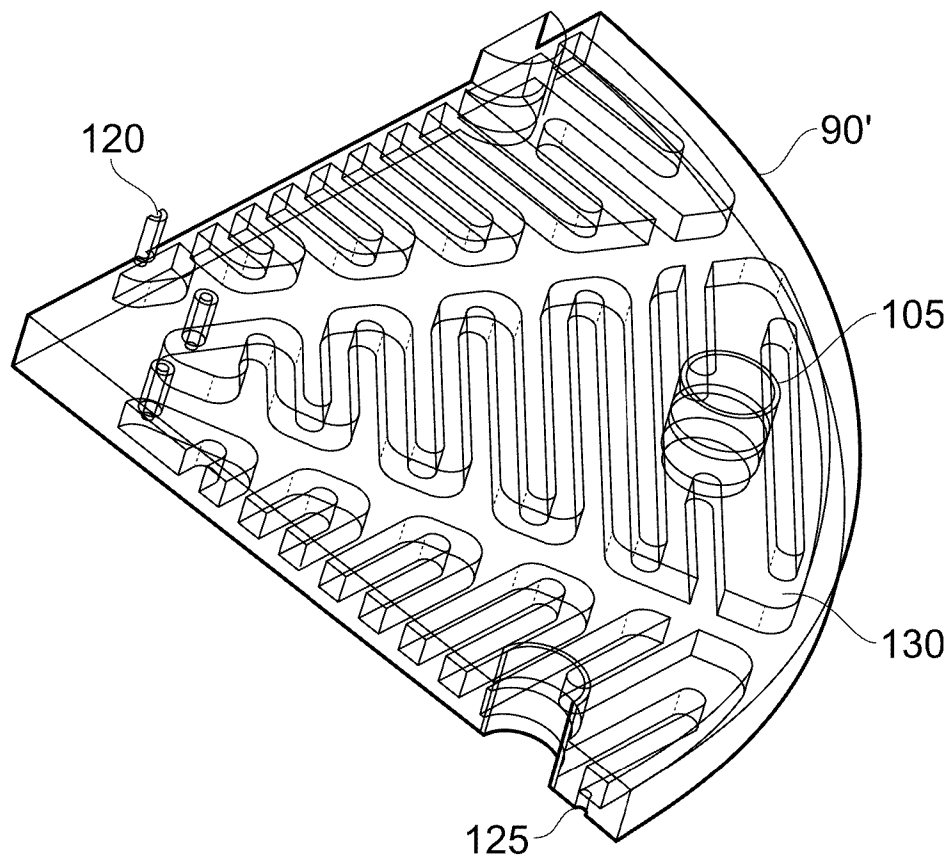


FIG. 5

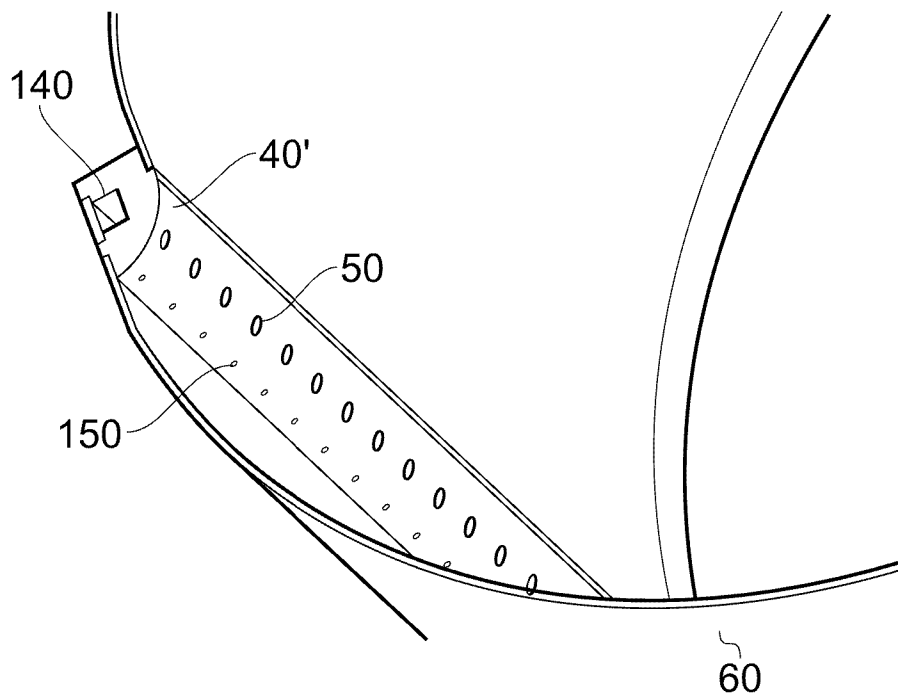


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2020/050684

A. CLASSIFICATION OF SUBJECT MATTER
 INV. F23G7/06
 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)
 F23G

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 A	GB 1 276 199 A (UNIVERSAL OIL PROD CO [US]) 1 June 1972 (1972-06-01) page 1, line 14 - line 20; figures 1-3 page 1, line 70 - line 92 page 2, line 46 - line 81 page 3, line 119 - page 5, line 39 -----	1-7, 9-12,14 13,15
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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

15 May 2020

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

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