



(51) International Patent Classification:

F23R 3/28 (2006.01) B22F 5/10 (2006.01)
B22F 5/00 (2006.01) B22F 3/105 (2006.01)

(21) International Application Number:

PCT/US2018/030351

(22) International Filing Date:

01 May 2018 (01.05.2018)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/574,799 20 October 2017 (20.10.2017) US
62/574,806 20 October 2017 (20.10.2017) US

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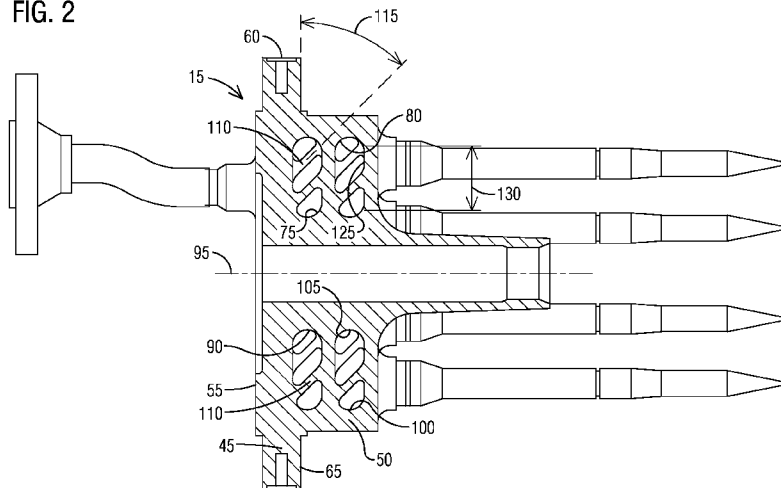
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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, 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: HYBRID MANUFACTURING OF A SUPPORT HOUSING

FIG. 2



(57) Abstract: A support housing (15) for use in distributing fuel in a gas turbine engine includes a main body (40) defining an inlet aperture, a plurality of outlet apertures, and a substantially planar mounting surface (65). A first fuel channel has a wall (125) that defines a first flow space (75) and a support member (110) extends across the first flow space (75) and has a long axis oriented at an oblique angle with respect to the mounting surface.



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

Published:

— *with international search report (Art. 21(3))*

HYBRID MANUFACTURING OF A SUPPORT HOUSING

TECHNICAL FIELD

[0001] The present disclosure is directed, in general, to hybrid manufacturing of components and more specifically to hybrid manufacturing including additive manufacturing of a support housing.

BACKGROUND

[0002] Conventional manufacture of some components can be very difficult and costly. The support housing used to distribute fuel in a gas turbine engine is one such part. The support housing includes internal chambers and flow paths that are difficult to form using conventional manufacturing techniques (e.g., casting, forging, machining, etc.).

SUMMARY

[0003] A support housing for use in distributing fuel in a gas turbine engine includes a main body defining an inlet aperture, a plurality of outlet apertures, and a substantially planar mounting surface. A first fuel channel has a wall that defines a first flow space and a support member extends across the first flow space and has a long axis oriented at an oblique angle with respect to the mounting surface.

[0004] A method of manufacturing a support housing includes coupling a base portion of the support housing to a positioning device, forming an outer wall and an inner wall on the base portion using an additive manufacturing process, the outer wall extending in a first direction, the outer wall and the inner wall spaced a first distance from one another, the first distance being at least a critical distance. The method also includes forming a support member between the inner wall and the outer wall and forming a cover wall using the additive manufacturing process, the cover wall extending from the outer wall to the support member to the inner wall and cooperating with the outer wall, the inner wall, and the base portion to enclose a first space.

[0005] In another construction, a support housing for use in distributing fuel in a gas turbine engine includes a base portion defining an inlet aperture and a substantially planar mounting surface, a boss portion extending from the base portion and defining a plurality of outlet apertures, a first fuel channel having a first wall that defines a first flow space, and a second fuel channel having a second wall that defines a second flow space, the first flow space and the second flow space being annular spaces that are spaced apart from one another. A first plurality of support members extend across the first flow space and have a long axis oriented at an oblique angle with respect to the mounting surface and a second plurality of support members extend across the second flow space and have a long axis oriented at an oblique angle with respect to the mounting surface.

[0006] The foregoing has outlined rather broadly the technical features of the present disclosure so that those skilled in the art may better understand the detailed description that follows. Additional features and advantages of the disclosure will be described hereinafter that form the subject of the claims. Those skilled in the art will appreciate that they may readily use the conception and the specific embodiments disclosed as a basis for modifying or designing other structures for carrying out the same purposes of the present disclosure. Those skilled in the art will also realize that such equivalent constructions do not depart from the spirit and scope of the disclosure in its broadest form.

[0007] Also, before undertaking the Detailed Description below, it should be understood that various definitions for certain words and phrases are provided throughout this specification and those of ordinary skill in the art will understand that such definitions apply in many, if not most, instances to prior as well as future uses of such defined words and phrases. While some terms may include a wide variety of embodiments, the appended claims may expressly limit these terms to specific embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Fig. 1 is a perspective view of a support housing that operates to distribute fuel in a gas turbine engine.

[0009] Fig. 2 is a section view of the support housing taken along line 2-2 of Fig. 1.

[0010] Fig. 3 is a section view of the support housing in a manufacturing position taken along line 3-3 of Fig. 1 at the start of manufacturing a boss portion.

[0011] Fig. 4 is a section view of the support housing in a manufacturing position taken along line 3-3 of Fig. 1 when the boss portion is about 50 percent complete.

[0012] Fig. 5 is a section view of the support housing in a manufacturing position taken along line 3-3 of Fig. 1 when the boss portion is complete.

[0013] Fig. 6 is an enlarged section view of a fuel channel of Fig. 3 in the manufacturing position illustrating several support members.

[0014] Fig. 7 is a section view of the fuel channel taken along line 4-4 of Fig. 5

[0015] Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

DETAILED DESCRIPTION

[0016] Various technologies that pertain to systems and methods will now be described with reference to the drawings, where like reference numerals represent like elements throughout. The drawings discussed below, and the various embodiments used to describe the principles of the present disclosure in this patent document are by way of illustration only and should not be construed in any way to limit the scope of the disclosure. Those skilled in the art will understand that the principles of the present disclosure may be implemented in any suitably arranged apparatus. It is to be understood that functionality that is described as being carried out by certain system elements may be performed by multiple elements. Similarly, for instance, an element may be configured to perform functionality that is described as being carried out by

multiple elements. The numerous innovative teachings of the present application will be described with reference to exemplary non-limiting embodiments.

[0017] Also, it should be understood that the words or phrases used herein should be construed broadly, unless expressly limited in some examples. For example, the terms “including,” “having,” and “comprising,” as well as derivatives thereof, mean inclusion without limitation. The singular forms “a,” “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. Further, the term “and/or” as used herein refers to and encompasses any and all possible combinations of one or more of the associated listed items. The term “or” is inclusive, meaning and/or, unless the context clearly indicates otherwise. The phrases “associated with” and “associated therewith,” as well as derivatives thereof, may mean to include, be included within, interconnect with, contain, be contained within, connect to or with, couple to or with, be communicable with, cooperate with, interleave, juxtapose, be proximate to, be bound to or with, have, have a property of, or the like.

[0018] Also, although the terms "first", "second", "third" and so forth may be used herein to refer to various elements, information, functions, or acts, these elements, information, functions, or acts should not be limited by these terms. Rather these numeral adjectives are used to distinguish different elements, information, functions or acts from each other. For example, a first element, information, function, or act could be termed a second element, information, function, or act, and, similarly, a second element, information, function, or act could be termed a first element, information, function, or act, without departing from the scope of the present disclosure.

[0019] In addition, the term "adjacent to" may mean: that an element is relatively near to but not in contact with a further element; or that the element is in contact with the further portion, unless the context clearly indicates otherwise. Further, the phrase “based on” is intended to mean “based, at least in part, on” unless explicitly stated otherwise.

[0020] Fig. 1 illustrates a fuel assembly 10 for a gas turbine engine that includes a support housing 15, two fuel inlets 20 and several fuel outlets 25. Each fuel outlet 25 includes a nozzle 30 that distributes fuel for combustion to a different annular combustion sections. Therefore, fewer or more fuel outlets 25 may be provided to accommodate fewer or more combustion sections as may be required for the particular design or application. Two fuel inlets 20 are

provided to facilitate starting the gas turbine engine and normal operation of the gas turbine engine. Only one of the fuel inlets 20 is used to distribute fuel during the start up when very little fuel is required. However, following start up, as power is increased additional fuel is required and both fuel inlets 20 are used to distribute the necessary fuel. As with the fuel outlets 25, fewer or more inlets 20 could be employed if desired.

[0021] The support housing 15 supports the fuel outlets 25 and nozzles 30 and also supports fuel inlet pipes 35. The support housing 15, better illustrated in Fig. 2 includes a main body 40 that is made up of a base portion 45 and a boss portion 50. The base portion 45 is a cylindrically-shaped portion that defines a first end 55 of the main body 40 and the fuel inlets 20. The base portion 45 also includes a flange 60 having a mounting surface 65 and a plurality of through holes 70 that facilitate the attachment of the support housing 15 to the gas turbine engine.

[0022] The boss portion 50 extends from the base portion 45 in a direction substantially normal to the mounting surface 65 and defines a first flow space 75, a second flow space 80, and a second end 85 from which the fuel outlets 25 extend. In the illustrated construction, each of the first flow space 75 and the second flow space 80 is defined by an oval wall 90 having a long axis that is substantially parallel to the mounting surface 65. Each of the first flow space 75 and the second flow space 80 is annular and extends around a centerline 95 of the support housing 15. Each oval wall 90 includes a first or outer wall 100 and a second or inner wall 105. The inner wall 105 and outer wall 100 are spaced apart from one another a distance that is greater than a critical distance which will be discussed with regard to Fig. 3. One of the fuel inlets 20 provides fuel to the first flow space 75 and the other inlet 20 provides fuel to the second flow space 80. Each fuel outlet 25 is arranged to receive fuel from either or both of the first flow space 75 and the second flow space 80. In other constructions or arrangements, different quantities of flow spaces or differently-shaped flow spaces may be employed.

[0023] Support members 110 are positioned within each of the first flow space 75 and the second flow space 80 with each support member 110 extending across its respective flow space 75, 80. Each support member 110 defines a long axis that is arranged at an oblique angle 115 with respect to the mounting surface 65. The choice of the angle 115 will be described with regard to Fig. 3.

[0024] Turning to Figs. 3-5, one possible sequence of construction for the support housing 15 is illustrated. To construct the support housing 15 the base portion 45 is connected to a positioner 120 that may allow rotation of the base portion 45 about its centerline 95 as well as rotation of the centerline 95 with respect to a vertical. The base portion 45 can be manufactured using conventional techniques including machining it from a plate material, casting, forging or the like. The boss portion 50 is then added to the base portion 45 using an additive manufacturing process.

[0025] The boss portion 50 is well-suited to manufacture using an additive manufacturing process such as direct metal laser sintering (DMLS) or selective laser sintering (SLS). Of course, other processes such as laser metal deposition (LMD) or Electron beam melting (EBM) could be employed. The invention should not be limited by the specific process employed and could use any number of suitable processes and suitable energy sources including lasers, electron beams, plasma systems and the like.

[0026] For each of these processes, as well as other suitable processes, the boss portion 50 is built-up in a layer-by-layer fashion. The additive manufacturing processes may allow for the use of materials that might otherwise be difficult to use in forming the boss portion 50.

[0027] With continued reference to Figs. 3-5, the positioner 120 is rotated to position the central axis 95 of the support housing 15 at about a forty-five degree angle with respect to the vertical axis. Other angles between zero degrees and about sixty degrees are possible as well, with still other angles being suitable for different support housings.

[0028] Fig. 3 illustrates the support housing 15 just after beginning the process of adding the boss portion 50. As can be seen, a portion of the outer wall 100 of the first flow space 75 is completed and part of a first support member 115a and a second support member 115b are completed. Fig. 4 illustrates the support housing 15 with the boss portion 50 about fifty percent complete. Finally, Fig. 5 illustrates the complete boss portion 50.

[0029] During an additive manufacturing process such as those employed to manufacture the support housing 15, a critical length exists which represents the maximum horizontal distance that can be bridged across with an empty space or no support devices positioned beneath. For

example, two vertical walls spaced apart 10 mm might easily be bridged to enclose the space between the walls and the bridging surface. However, 20 mm may be too far to bridge as the added material will tend to sag or droop into the space as the top surface is added. Thus, the critical length is the maximum length that can be bridged for a particular process, material, and application. Typically, this critical length falls between 10 mm and 25 mm.

[0030] The arrangement of the support housing 15, when positioned with the central axis 95 oriented vertically includes a top surface 125 for each of the flow spaces 75, 80 that have a length 130 greater than the critical length. Using the positioner 125 to rotate the central axis 95 to about 45 degrees effectively reduces the length 130 by about thirty percent. However, as illustrated in Fig. 6, the formation of support members 110 significantly reduces the effective length and facilitates high-quality bridging from the outer wall 100 to the support member 110 and from the support member 110 to the inner wall 105. Because the support members 110 are formed along a vertical axis when the support member 15 is tipped, the support members 110 end with long axes that extend at the oblique angle 115 with respect to the mounting surface 65.

[0031] As illustrated in Fig. 4, the support members 110 are formed with large fillet portions 135 at the ends to reduce any potential stress risers at the intersections of the oval wall 90 and the support member 110.

[0032] As illustrated in Fig. 7, each of the support members 110 includes a substantially circular cross section when sectioned normal to the long axis of the support member 110. In addition, the support members 110 can be positioned in two rows that extend around the centerline 95 as illustrated in Fig. 6 or in fewer or more rows as may be required by the size of the flow space 75, 80. As can be seen in Fig. 7, the support members 110 are staggered with respect to one another (i.e., located at different circumferential positions with respect to the centerline 95). Of course many different arrangements of the support members 110 are possible.

[0033] In addition, other constructions may include elongated support members. Elongated members would have a section view that might resemble a curved oval shape or a simple oval or ellipse. The only limitation to the support members 110 is that they should allow a free flow of fuel around the annular flow spaces 75, 80.

[0034] As discussed with regard to Figs. 3-5, one method of constructing the support housing 15 includes forming the boss portion 50 using an additive manufacturing process onto a conventionally manufactured base portion 45. As illustrated in Figs. 3-5, the boss portion 50 is formed layer-by-layer without rotating the support housing 15 during manufacture. In another construction, the boss portion 50 is formed while rotating the support housing 15 about the centerline 95. This effectively results in building the boss portion 50 layer-by-layer but also builds the support housing 15 from the outer diameter toward the inner diameter. In still other constructions, the base portion 45 is also formed using additive manufacturing techniques.

[0035] The terms “substantially” and “about” are meant to cover typical manufacturing and design tolerances for the specific feature they are used to describe. Thus, a manufacturing tolerance for two members being parallel might be ten degrees. In that example, “about” or “substantially” means parallel plus or minus ten degrees.

[0036] Although an exemplary embodiment of the present disclosure has been described in detail, those skilled in the art will understand that various changes, substitutions, variations, and improvements disclosed herein may be made without departing from the spirit and scope of the disclosure in its broadest form.

[0037] None of the description in the present application should be read as implying that any particular element, step, act, or function is an essential element, which must be included in the claim scope: the scope of patented subject matter is defined only by the allowed claims. Moreover, none of these claims are intended to invoke a means plus function claim construction unless the exact words "means for" are followed by a participle.

CLAIMS

What is claimed is:

1. A support housing for use in distributing fuel in a gas turbine engine, the support housing comprising:
 - a main body defining an inlet aperture, a plurality of outlet apertures, and a substantially planar mounting surface;
 - a first fuel channel having a wall that defines a first flow space; and
 - a support member extending across the first flow space and having a long axis oriented at an oblique angle with respect to the mounting surface.
2. The support housing of claim 1, wherein the main body includes a cylindrical base portion, and wherein the mounting surface is an annular surface formed on the base portion.
3. The support housing of claim 1, wherein the main body includes a first end and a second end opposite the first end, and wherein the inlet aperture is formed in the first end and the outlet apertures are formed in the second end.
4. The support housing of claim 1, wherein the wall of the first fuel channel is oval and defines a long axis that is substantially parallel to the mounting surface.
5. The support housing of claim 4, wherein the first fuel channel is annular.
6. The support housing of claim 1, wherein the support member is substantially circular in cross section.
7. The support housing of claim 1, further comprising a plurality of support members each disposed within the first flow space.
8. The support housing of claim 1, further comprising a second fuel channel spaced apart from the first fuel channel.

9. The support housing of claim 8, further comprising a plurality of support members each disposed within the second flow space.
10. The support housing of claim 1, wherein the wall is formed using an additive manufacturing process.
11. A method of manufacturing a support housing, the method comprising:
coupling a base portion of the support housing to a positioning device;
forming an outer wall and an inner wall on the base portion using an additive manufacturing process, the outer wall extending in a first direction, the outer wall and the inner wall spaced a first distance from one another, the first distance being at least a critical distance;
forming a support member between the inner wall and the outer wall; and
forming a cover wall using the additive manufacturing process, the cover wall extending from the outer wall to the support member to the inner wall and cooperating with the outer wall, the inner wall, and the base portion to enclose a first space.
12. The method of claim 11, further comprising forming the base portion from a plate material.
13. The method of claim 11, further comprising casting the base portion.
14. The method of claim 11, further comprising adjusting the positioning device such that first direction is between 15 degrees and 50 degrees with respect to a vertical orientation.
15. The method of claim 11, wherein the positioning device is adjusted to 45 degrees with respect to the vertical orientation.
16. The method of claim 11, wherein the forming an outer wall step includes applying a layer of powdered material on a portion of the outer wall and the inner wall and exposing the layer of powdered material on the portion of the outer wall and the inner wall to an energy beam to fuse the powdered metal to the outer wall and the inner wall.

17. The method of claim 16, wherein the energy beam includes a laser and the additive manufacturing process is one of a direct metal laser sintering (DMLS) and a selective laser sintering (SLS) process.

18. The method of claim 16, wherein the forming a support member step includes applying a layer of powdered material on a portion of the support member and exposing the layer of powdered material on the portion of the support member to an energy beam to fuse the powdered metal to the support member.

19. The method of claim 16, further comprising rotating the positioning device about a central axis that extends in the first direction.

20. The method of claim 11, wherein the first distance is between 10 mm and 25 mm.

21. A support housing for use in distributing fuel in a gas turbine engine, the support housing comprising:

a base portion defining an inlet aperture and a substantially planar mounting surface;

a boss portion extending from the base portion and defining a plurality of outlet apertures;

a first fuel channel having a first wall that defines a first flow space;

a second fuel channel having a second wall that defines a second flow space, the first flow space and the second flow space being annular spaces that are spaced apart from one another;

a first plurality of support members extending across the first flow space and having a long axis oriented at an oblique angle with respect to the mounting surface; and

a second plurality of support members extending across the second flow space and having a long axis oriented at an oblique angle with respect to the mounting surface.

22. The support housing of claim 21, wherein each of the first plurality of support members and the second plurality of support members are parallel to one another.

23. The support housing of claim 21, wherein the first wall is oval and defines a long axis that is parallel to the planar mounting surface.

24. The support housing of claim 23, wherein the first wall includes a first end wall and a second end wall and wherein the first end wall and the second end wall are separated by a distance greater than a critical distance.

25. The support housing of claim 21, wherein the base portion is formed from a plate material.

26. The support housing of claim 21, wherein the boss portion is formed using an additive manufacturing process.

27. The support housing of claim 26, wherein the energy beam includes a laser and the additive manufacturing process is one of a direct metal laser sintering (DMLS) and a selective laser sintering (SLS) process.

28. The support housing of claim 21, wherein each of the first plurality of support members is substantially circular in cross section.

29. The support housing of claim 21, wherein only the first flow space provides fuel to the gas turbine engine during starting.

30. The support housing of claim 21, wherein both the first flow space and the second flow space deliver fuel to the gas turbine engine during operation.

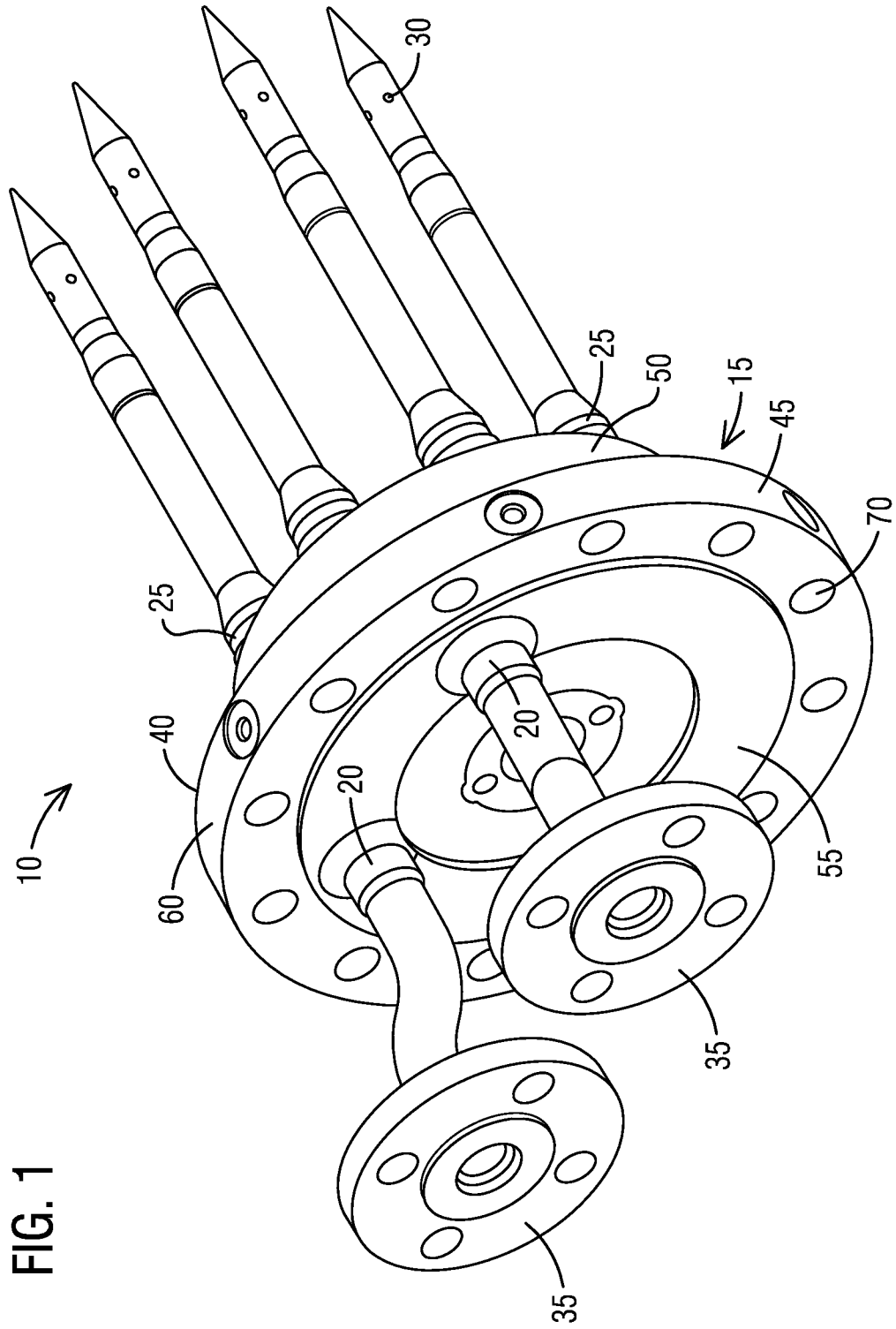


FIG. 1

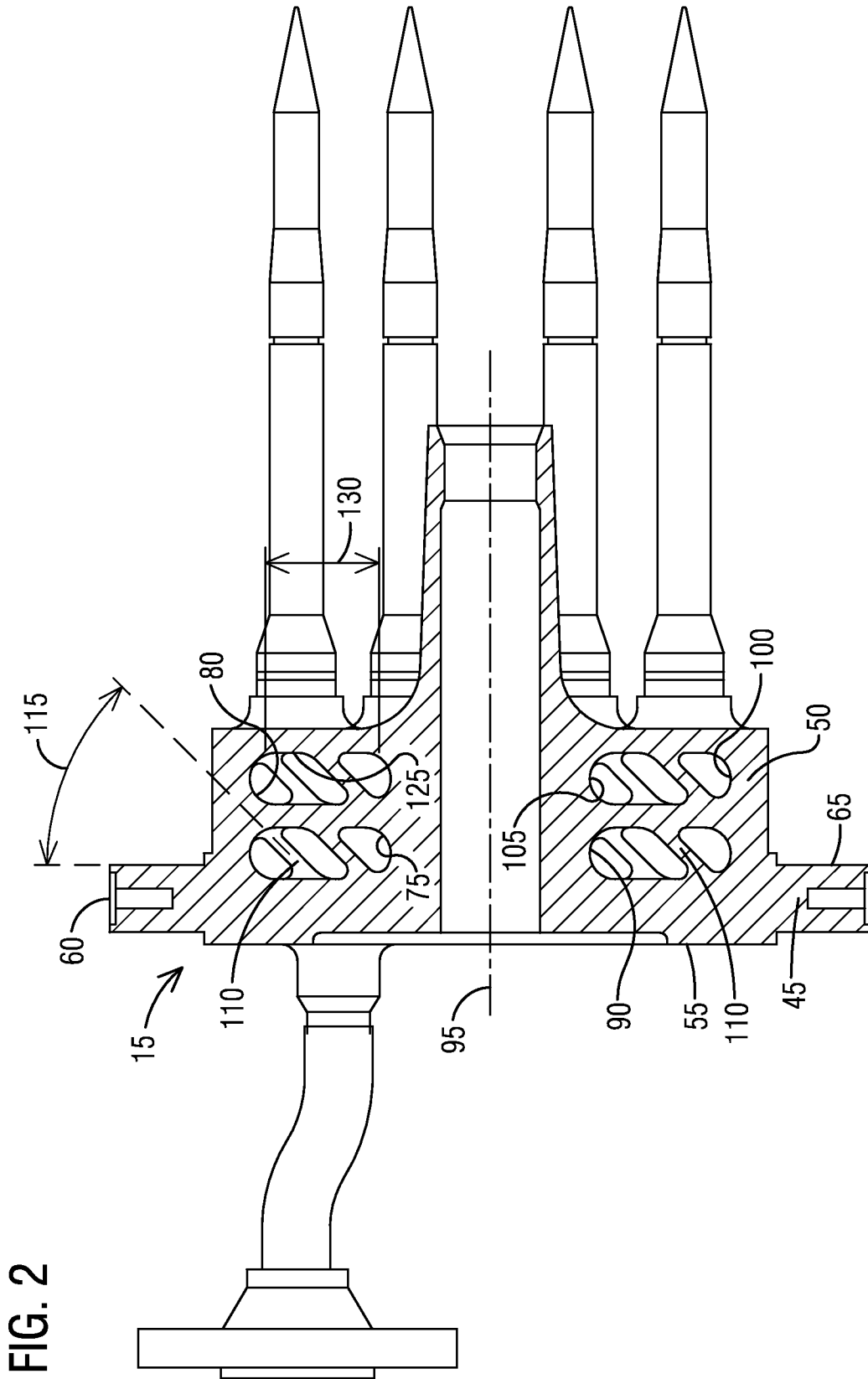


FIG. 3

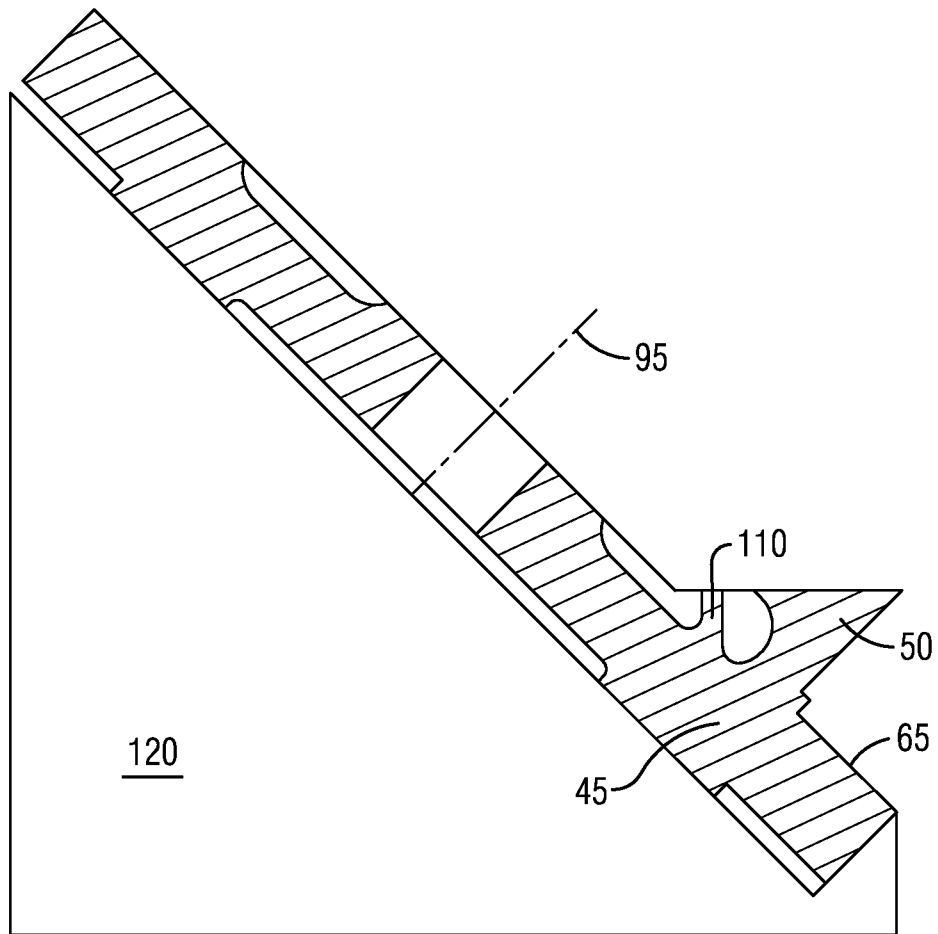


FIG. 4

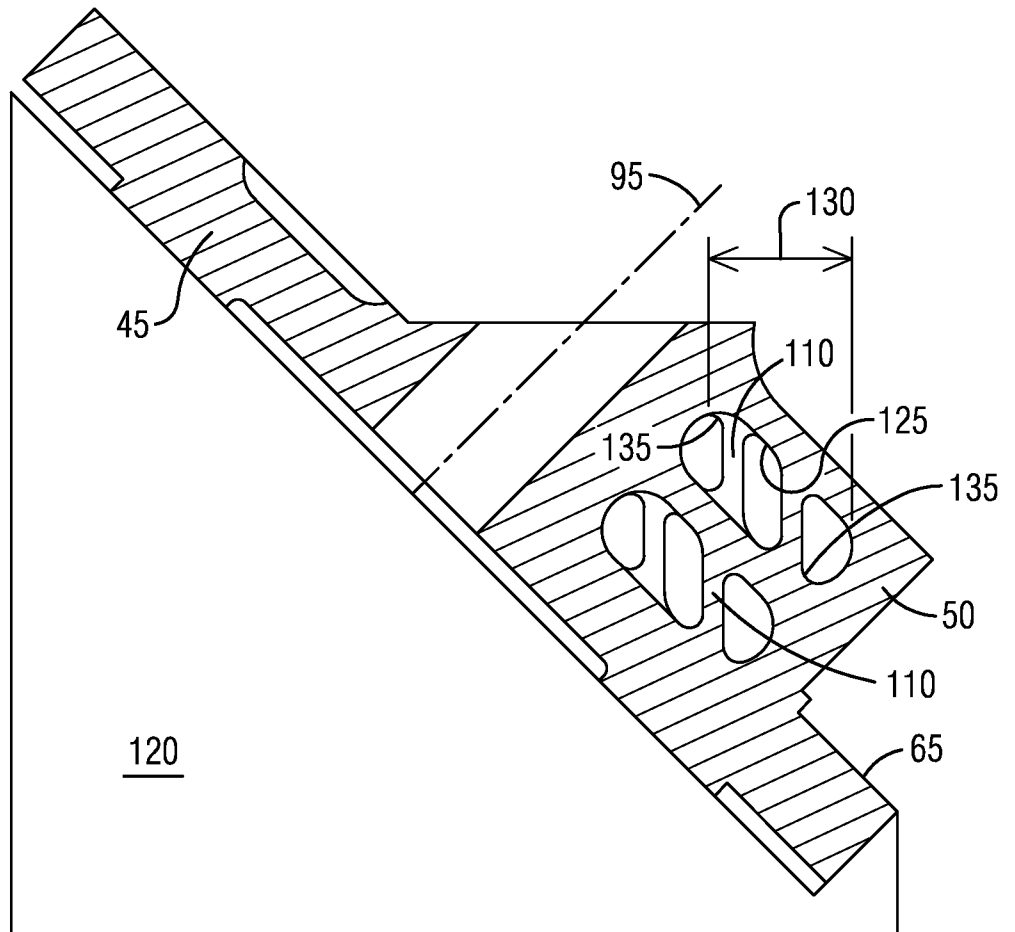


FIG. 5

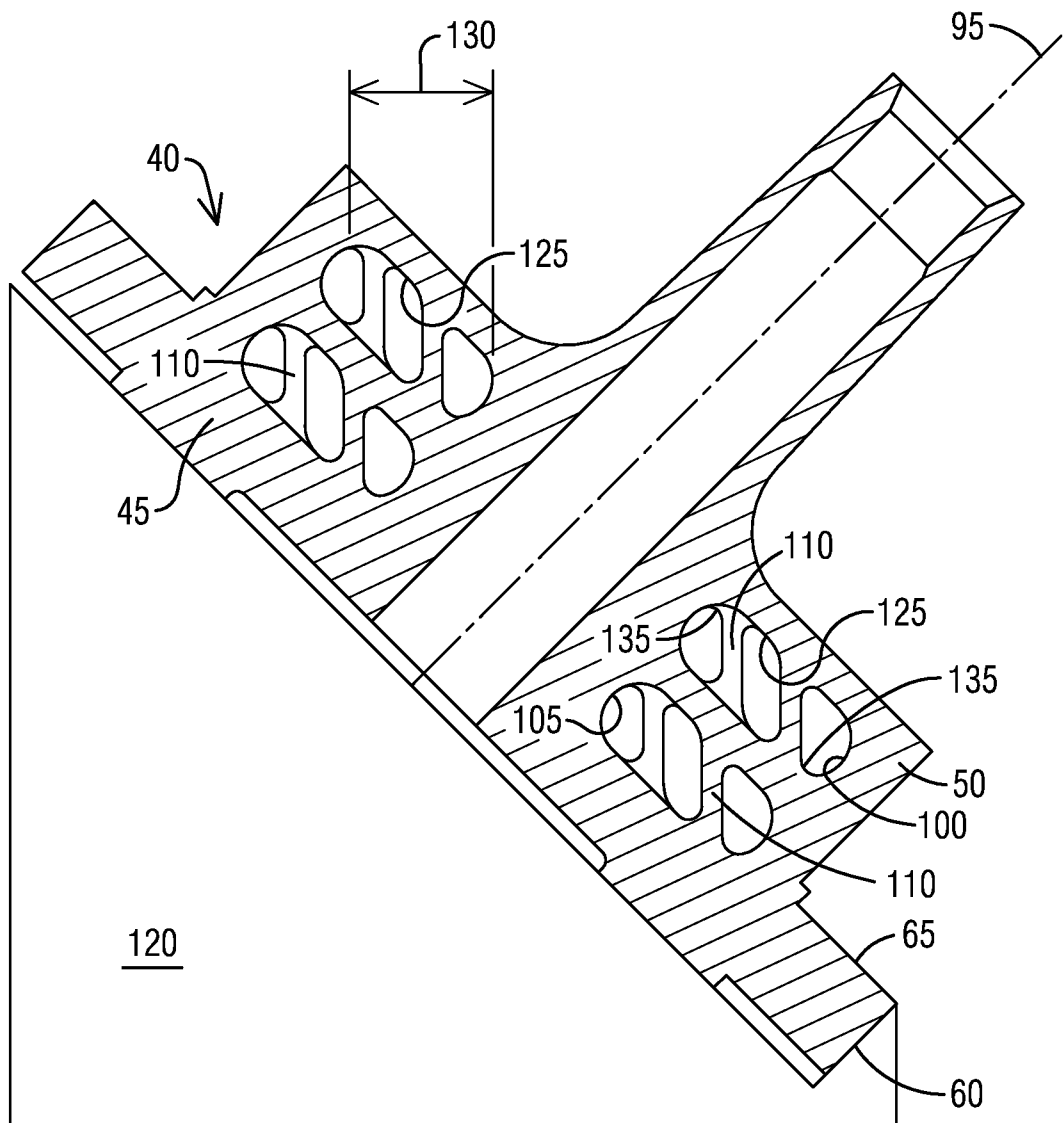


FIG. 6

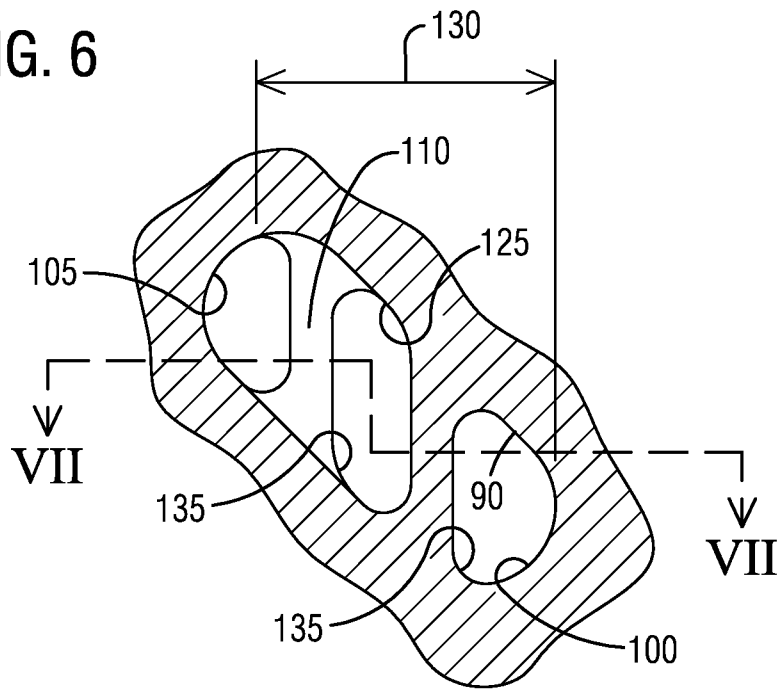
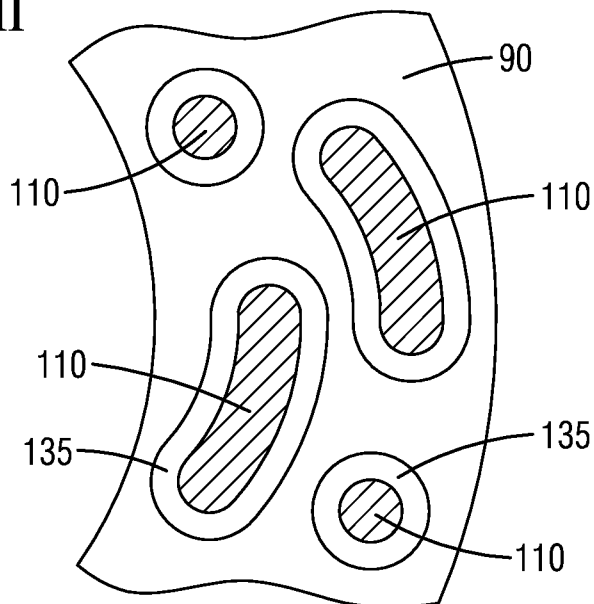


FIG. 7
View VII-VII



PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 2017P22331 WO	FOR FURTHER ACTION see Form PCT/ISA/220 as well as, where applicable, item 5 below.	
International application No. PCT/US2018/030351	International filing date (<i>day/month/year</i>) 1 May 2018 (01-05-2018)	(Earliest) Priority Date (<i>day/month/year</i>) 20 October 2017 (20-10-2017)
Applicant SIEMENS ENERGY, INC.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 5 sheets.

It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the **language**, the international search was carried out on the basis of:

- the international application in the language in which it was filed
- a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

b. This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).

c. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. **Certain claims were found unsearchable** (See Box No. II)

3. **Unity of invention is lacking** (see Box No III)

4. With regard to the **title**,

- the text is approved as submitted by the applicant
- the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

- the text is approved as submitted by the applicant
- the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the **drawings**,

- a. the figure of the **drawings** to be published with the abstract is Figure No. 2
 - as suggested by the applicant
 - as selected by this Authority, because the applicant failed to suggest a figure
 - as selected by this Authority, because this figure better characterizes the invention
- b. none of the figures is to be published with the abstract

Box No. IV Text of the abstract (Continuation of item 5 of the first sheet)

A support housing (15) for use in distributing fuel in a gas turbine engine includes a main body (40) defining an inlet aperture, a plurality of outlet apertures, and a substantially planar mounting surface (65). A first fuel channel has a wall (125) that defines a first flow space (75) and a support member (110) extends across the first flow space (75) and has a long axis oriented at an oblique angle with respect to the mounting surface.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2018/030351

A. CLASSIFICATION OF SUBJECT MATTER
INV. F23R3/28 B22F5/00 B22F5/10 B22F3/105
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)
F23R B22F
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	US 2016/236271 A1 (XU JINQUAN [US]) 18 August 2016 (2016-08-18) paragraphs [0044], [0045], [0050]; figures 3,4,5	1-10, 21-30
X	EP 3 053 674 A1 (ALSTOM TECHNOLOGY LTD [CH]) 10 August 2016 (2016-08-10) paragraphs [0029], [0031], [0032]; figures 3,4	11-14, 16-20
A	EP 3 076 084 A1 (GEN ELECTRIC TECHNOLOGY GMBH [CH]) 5 October 2016 (2016-10-05) paragraphs [0016], [0017], [0024] paragraphs [0042], [0043], [0043], [0045]; figures 1-12	1-30
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Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents :

<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"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</p> <p>"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</p> <p>"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</p> <p>"&" document member of the same patent family</p>
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Date of the actual completion of the international search 9 July 2018	Date of mailing of the international search report 20/07/2018
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