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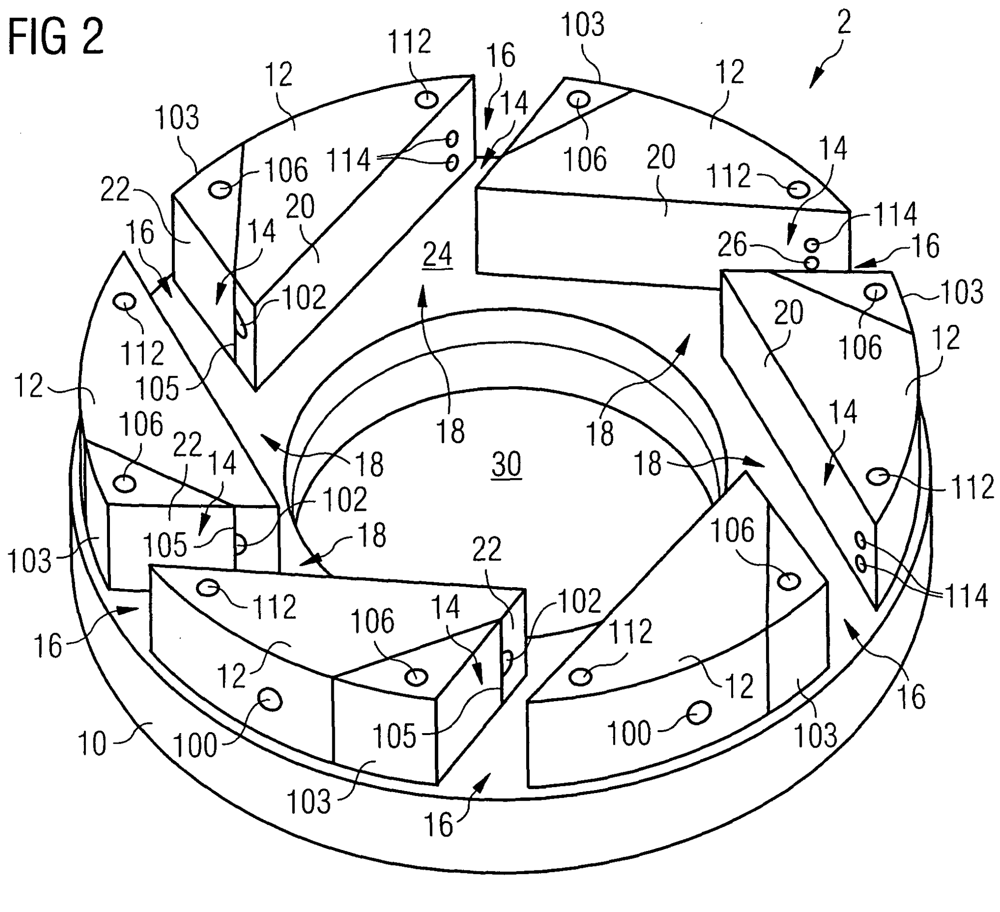
(54) **Burner, in particular for a gas turbine**

(57) A burner, in particular a gas turbine burner, comprising at least one swirler (2), the swirler (2) having vanes (12) with vane walls delimiting external air passages (14) between the vanes (12) wherein at least one of the vanes (12) comprise at least one main inlet opening (100), at least one main outlet opening (102) located in a vane wall and at least one internal main passage (104) extending from the at least one main inlet opening (100) through the vane (12) to the at least one main outlet opening (102) and a fuel injection system inside at least one of the vanes (12) which comprises at least one fuel outlet opening (108) being open towards the internal main passage (104) so as to allow for injecting fuel into the at least one internal main passage (104) and thereby mixing air with fuel.

FIG 2



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Description

[0001] The present invention relates to a burner and in particular to gas turbine burner comprising at least one swirler.

[0002] In a gas turbine burner a fuel is burned to produce hot pressurised exhaust gases which are then fed to a turbine stage where they, while expanding and cooling, transfer momentum to turbine blades thereby imposing a rotational movement on a turbine rotor. Mechanical power of the turbine rotor can then be used to drive a generator for producing electrical power or to drive a machine. However, burning the fuel leads to a number of undesired pollutants in the exhaust gas which can cause damage to the environment. Therefore, it takes considerable effort to keep the pollutants as low as possible. One kind of pollutant is nitrous oxide (NO_x). The rate of formation of nitrous oxide depends exponentially on the temperature of the combustion flame. It is therefore attempted to reduce the temperature over the combustion flame in order to keep the formation of nitrous oxide as low as possible.

[0003] There are two main measures by which reduction of the temperature of the combustion flame is achievable. The first is to use a lean stoichiometry, e.g. a fuel/air mixture with a low fuel fraction. The relatively small fraction of fuel leads to a combustion flame with a low temperature. The second measure is to provide a thorough mixing of fuel and air before the combustion takes place. The better the mixing is the more uniformly distributed the fuel is in the combustion zone. This helps to prevent hotspots in the combustion zone which would arise from local maxima in the fuel/air mixing ratio.

[0004] Modern gas turbine engines therefore use the concept of pre-mixing air and fuel in lean stoichiometry before the combustion of the fuel/air mixture. Usually the pre-mixing takes place by injecting fuel into an air stream in a swirling zone of a combustor which is located upstream from the combustion zone. The swirling leads to a mixing of fuel and air before the mixture enters the combustion zone.

[0005] DE 38 19 898 A1 describes a burner for a combustion chamber of a gas turbine with a swirler having flow profile shaped swirler vanes. The swirler vanes comprise internal fuel channels that open out to the external air passages between the swirler vanes on the pressure sides of the vanes. Combustion air passes through the external air passages and mixes with the fuel exiting from the internal fuel channels in the swirler vanes. Further downstream the fuel evaporates within the preheated air stream. The swirled fuel/air mix then enters the combustion zone and is ignited by the heat of the air.

[0006] If the air injection system comprises a control mechanism for controlling air allocation to the distributed air inlet openings, it is possible to adapt the air injection to different conditions of the burner. This provides flexible control of fuel placement through a wide range of burner conditions. The combustion system thus will be enabled to accommodate the changes in air density and flow rates experienced, for example at off-design conditions, more readily than it is possible with existing burner systems.

[0007] The injected amount of fuel is dependent on one or more burner conditions and on the load conditions of the gas turbine engine.

[0008] With respect to the mentioned state of the art it is an objective of the invention to provide a burner, in particular a gas turbine burner, which is advantageous in providing a homogenous fuel/air mixture.

[0009] This objective is solved by a burner according to claim 1. The dependent claims describe advantageous developments of the invention.

[0010] An inventive burner comprises at least one swirler, the swirler having vanes with vane walls delimiting external air passages between the vanes wherein at least one of the vanes comprise at least one main inlet opening, at least one main outlet opening located in a vane wall and at least one internal main passage extending from the at least one main inlet opening through the vane to the at least one main outlet opening. It further comprises a fuel injection system inside at least one of the vanes which comprises at least one fuel outlet opening being open towards the internal main passage so as to allow for injecting fuel into the at least one internal main passage and thereby mixing air with fuel. In particular, all of the vanes may comprise at least one main inlet opening, at least one main outlet opening located in a vane wall and at least one internal main passage extending from the at least one main inlet opening through the vane to the at least one main outlet opening. Further, a fuel injection system may be provided in all vanes, as well.

[0011] The fuel injection system may either be a liquid fuel injection system or a gaseous fuel injection system. When it is a liquid fuel injection system the inventive burner helps to atomise the liquid fuel before it is introduced into an external air passage which in turn reduces the fraction of nitrous oxide in the exhaust gases of a gas turbine engine due to a more uniform distribution of the liquid fuel in the air stream.

[0012] It is particularly advantageous when turbulence of the fuel/air mix is provided as upstream as possible. Therefore the fuel injection opening that opens out to the internal main passage of a vane is used to already inject fuel into an air stream flowing in from the main inlet opening before exiting the vane and to produce turbulence in the air flow.

[0013] Consequently, a better distribution of the injected fuel can be achieved over the cross sectional area of the internal main passage. In addition, the homogeneity of the fuel/air mixture over the cross sectional area can be increased. This in turn reduces the formation of hot spots which are the main areas of nitrous oxide formation. As a consequence, reduction of the number and the temperature of hot spots reduce the emission of nitrous oxides from the burner.

[0014] The fuel/air mix then exits from the main outlet opening located in one of the vane walls delimiting an external air passage. A second air flow passes through the external air passages further increasing the portion of air in the fuel/air mix exiting from the main outlet opening of the internal main passage and further increasing the turbulence.

[0015] The preferred location of the fuel injection system is between mid-height and 2/3rds of the vane height as measured from the vane root or floor of the external air passages.

[0016] Advantageously the main inlet opening of the internal main passage is positioned in the vane wall that faces radially outwards. This allows for a straight internal main passage which ensures a minimum pressure loss. The internal main passage can also be curved when using different production methods.

[0017] In a further development of the inventive burner, the fuel/air mix is injected into the second air flow in the external air passage by the main outlet opening, wherein the cross-section of the main outlet opening is reduced compared to the cross-section of the internal main passage. The reduction of the cross-section may advantageously be achieved by a prefilmer lip which partly covers the main outlet opening. The prefilmer lip not only reduces the cross-section of the main outlet opening but also results in a separation of the flow at the prefilmer lip causing an additional turbulence in the fuel/air mix in the external air passage downstream of the prefilmer lip. As a consequence, the droplet size of the atomised fuel introduced into the external air passage is reduced.

[0018] The prefilmer lip may be a wedge-like element fixed to the main wall of the vane. This provides a simple design with little assembly effort. The prefilmer lip may have a straight edge running across the main outlet opening which provides a sharp edge for increased flow separation and thus atomising and mixing.

[0019] The main outlet opening can be provided with turbulence enhancing features, in particular if it is driven with gaseous fuel. Those features may be present on the circumference of the main outlet opening and may e.g. comprise triangular cuts on the circumference. The turbulence enhancing features provide additional mixing and direction of a gaseous fuel/air mixture leaving the internal main passage. Turbulence enhancing features in or on the prefilmer lip are possible, although they are less preferable than the turbulence enhancing features on the main outlet opening.

[0020] In another advantageous embodiment of the invention the burner comprises an additional fuel injection system inside all or at least one of the vanes which comprises at least one fuel outlet opening being open towards an external air passage so as to allow for injecting gaseous or liquid fuel into the external air passage. Preferably, the main outlet opening and the additional outlet opening are positioned at opposite vane walls.

[0021] Further features, properties and advantages of the present invention will become clear from the following description of embodiments of the invention in conjunction with the accompanying drawings.

Figure 1	schematically shows a section through an inventive burner of a combustion chamber assembly.
Figure 2	shows a perspective view of a swirler shown in Figure 1.
Figure 3	shows perspective view of a vane of the swirler shown in Figure 2.
Figure 4	shows a top view of the vane shown in Figure 3.

[0022] Figure 1 shows a longitudinal section through a burner and a combustion chamber assembly for a gas turbine engine. A burner with a burner head 1 with a swirler 2 for mixing air and fuel is attached to an upstream end of a combustion chamber comprising, in flow series, a combustion pre-chamber 3 which is sometimes also called transition piece and a combustion main chamber 4. In general, the pre-chamber 3 may be implemented as a one part continuation of the burner towards the main chamber 4, as a one part continuation of the main chamber 4 towards the burner, or as a separate part between the burner and the main chamber 4. The burner and the combustion chamber assembly show rotational symmetry about a longitudinally symmetry axis S.

[0023] A fuel conduit 5 is provided for leading a gaseous or liquid fuel to the burner which is to be mixed with in-streaming air 6 in the swirler 2. The fuel air mixture 7 is then led towards a primary combustion zone 9 in the main chamber 4 where it is burnt to form hot, pressurised exhaust gases 8 streaming in a direction indicated by arrows to a turbine (not shown) of the gas turbine engine.

[0024] The swirler 2 is shown in detail in Figure 2. It comprises a ring-shaped swirler vane support 10 carrying six swirler vanes 12. The swirler vanes 12 can be fixed to the burner head 1 with their sides opposite to the swirler vane support 10.

[0025] Between neighbouring swirler vanes 12 external air passages 14 are formed which each extend between an air inlet opening 16 and an air outlet opening 18. The external air passages 14 are delimited by opposing end faces 20, 22 of neighbouring swirler vanes 12, by the surface 24 of the swirler vane support 10 that faces towards the burner head 1 and by a surface of the burner head 1 to which the swirler vanes 12 are to be fixed. The end faces 20, 22, the surfaces of the swirler vane support 10 and of the burner head 1 form external air passage walls delimiting the external air passages 14.

[0026] Figure 3 schematically shows a perspective view of an isolated swirler vane 12 with a fuel injection system. The top face 101 of the swirler vane 12 according to the orientation of the vane 12 as shown in Fig. 3 would be connected to the swirler vane support 10. The preferred location of the fuel injection system is between mid-height and 2/3rds of the vane height as measured from the vane root or floor of the external air passages 14.

[0027] The swirler vane fuel injection system comprises an internal main passage 104 which in turn comprises a main inlet opening 100 and a main outlet opening 102. The main inlet opening 100 is located in the wall of the swirler vane 12 that faces radially outwards when the vane is fixed to the swirler vane support 10. The main outlet opening 102 is placed in one of the swirler vane walls that delimit the external air passage 14. Air A can be introduced into the internal main passage 104 through the main inlet opening 100.

[0028] A wedge 103 is attached to the swirler vane 12. The wedge comprises, in the present embodiment, a liquid fuel inlet opening 106, a liquid fuel injection passage 110 and a liquid fuel outlet opening 108. The liquid fuel inlet opening 106 is located in the wall of the wedge 103 which is to be fixed to the burner head 1 and a liquid fuel outlet opening 108 is located in the wall of the wedge that is fixed to the swirler vane 12. So the liquid fuel outlet opening 108 connects a bended liquid fuel injection passage 110 to the internal main passage 104. Although a liquid fuel injection system is described with respect to the present embodiment, the invention can also be implemented with a gaseous fuel injection system comprising a gaseous fuel outlet opening instead of the liquid fuel outlet opening 108, a gaseous fuel inlet opening instead of the liquid fuel inlet opening 106 and a gaseous fuel injection passage instead of the liquid fuel injection passage 110.

[0029] The wedge 103 partly covers the main outlet opening 102 and comprises an edge 105 which extends over this opening.

[0030] Figure 4 shows a view onto the top face 101 of the vane with the attached wedge. Here, the transition from the liquid fuel injection passage 110 to the internal main passage 104 can be seen more clearly. The liquid fuel injection passage 110 in the wedge 103 opens out into the internal main passage 104 of the vane 12 and provides a flow connection to the internal main passage 104. The internal main passage 104 can be straight or e.g. curved when using different production methods.

[0031] The Wedge 103 forms a prefilmer lip 105 by reducing the cross-sectional area of the main outlet opening 102 by covering a part of the main outlet opening 102.

[0032] The wedge 103 can be attached to the swirler vane 12 by fastening bolts 118, screws, by other suitable connecting means or, e.g., by welding.

[0033] In operation of the swirler of the present embodiment, liquid fuel F flows from the liquid fuel inlet opening 106 in the wedge 103 through the liquid fuel injection passage 110 into the internal main passage 104 where it is mixed with air A. Some fraction of the liquid fuel forms a film flowing along the wedge face 107 towards the wedge's edge 105.

[0034] In operation of the swirler, air A is introduced through the main inlet opening 100 and flows through the internal main passage 104 to the main outlet opening 102. The main inlet opening 100, the internal main passage 104 and the main outlet opening 102 are implemented to direct air into the vane 12, to let it mix with fuel exiting the liquid fuel outlet opening 108 and to then direct the fuel/air mix F/A out of the vane 12. The edge 105 of the wedge 103 generates turbulences in the fuel/air mixture F/A due to a separation of flow of the fuel/air mixture flowing through the opening. Those turbulences atomize the liquid fuel flowing along the wedge face 107 towards the main outlet opening 102.

[0035] As has been already mentioned, a gaseous fuel injection system may be present instead of the liquid fuel injection system. In such a case, the mixing quality of the fuel/air concentration in the flow leaving the main outlet opening 102 depends on where the fuel enters the internal main passage 104. Closer to the main inlet opening 100, potentially yields higher mixing whereas gas fuel injected closer to the main outlet opening 102 will have more pilot like characteristics.

[0036] The main outlet opening 102 of the internal main passage may comprise additional turbulence enhancing features at its circumference. These features can, e.g. be implemented as triangular cuts on the circumference (not shown).

[0037] Finally the fuel/air mix F/A is delivered into the external air passage 14 where it is again mixed with air and at the same time swirled.

[0038] The fuel/air mixture then leaves the external air passage 14 through the air outlet opening 18 and streams through a central opening 30 of the swirler vane support 10 into the pre-chamber 3 (see Figure 1). From the pre-chamber 3 it streams into the combustion zone 9 of the main chamber 4 where it is burned.

[0039] As an option, there is an additional liquid or gaseous fuel injection system which comprises at least one fuel inlet opening 112, at least one gas passage 116 and at least one gas outlet opening 114. In the present embodiment, the additional fuel injection system is a gaseous fuel injection system.

[0040] The gas injection system is integrated in the vane 12 and at least one gas inlet opening 112 is located in the vane face to be fixed to the burner head 1. Gas G is taken in through the gas inlet opening 112 and then directed through the at least one gas passage 116. The gas exits through the at least one gas outlet opening 114 into the external air passage 14 where it mixes with air. So the gas turbine can be operated with liquid fuel or with gaseous fuel.

[0041] Although the swirler of the present embodiment has six swirler vanes and six external air passages, the invention may be implemented with a swirler having a different number of swirler vanes and external air passages, which may either be higher or lower than in the described embodiment. The walls 20, 22, 24 of the external air passage 14 may be straight or curved when using different production methods.

[0042] The parts of the burner are usually made of machined metal, in particular stainless steel. The internal fuel channels can comprise different sections with different diameters. Their inlets are located in the face which is attached to the burner head.

Claims

1. A burner, in particular a gas turbine burner, comprising:

   - at least one swirler (2), the swirler (2) having vanes (12) with vane walls delimiting external air passages (14) between the vanes (12) wherein at least one of the vanes (12) comprise at least one main inlet opening (100), at least one main outlet opening (102) located in a vane wall and at least one internal main passage (104) extending from the at least one main inlet opening (100) through the vane (12) to the at least one main outlet opening (102) and
   - a fuel injection system inside at least one of the vanes (12) which comprises at least one fuel outlet opening (108) being open towards the internal main passage (104) so as to allow for injecting fuel into the at least one internal main passage (104) and thereby mixing air with fuel.

2. The burner, as claimed in claim 1, wherein the fuel injection system is located between mid-height and 2/3rds of the vane height.

3. The burner, as claimed in claim 1, wherein the main outlet opening (102) of the internal main passage (104) is positioned in one of the vane walls that delimit the external air passage (14).

4. The burner, as claimed in claim 1, which has an axial and a radial direction wherein the vanes (12) comprise a wall that faces radially outwards and wherein the main inlet opening (100) of the internal main passage (104) is positioned in the vane wall that faces radially outwards.

5. The burner, as claimed any of the preceding claims, wherein the fuel injection system is a liquid fuel injection system.

6. The burner, as claimed in any of the claims 1 to 4, wherein the fuel injection system is a gaseous fuel injection system.

7. The burner, as claimed in any of the preceding claims, wherein the cross-section of the main outlet opening (102) is reduced compared to the cross-section of the internal main passage (104).

8. The burner, as claimed in claim 7, wherein the cross-section is reduced by a prefilmer lip (105) which partly covers the main outlet opening (102).

9. The burner, as claimed in claim 8, wherein the prefilmer lip (105) is a wedge-like element (103) fixed to the vane wall in which the main outlet opening (102) is located.

10. The burner, as claimed in claim 8 or 9, wherein the prefilmer lip (105) has a straight edge running across the main outlet opening (102).

11. The burner, as claimed in any of the preceding claims, wherein the main outlet opening (102) is provided with turbulence enhancing features.

12. The burner, as claimed in claim 11, wherein the turbulence enhancing features comprise triangular cuts on the circumference of the main outlet opening (102).

13. The burner, as claimed in any of the preceding claims, comprising an additional fuel injection system inside at least one of the vanes which comprises at least one fuel outlet opening (114) being open towards an external air passage (14) so as to allow for injecting fuel into the external air passage (14).

14. The burner, as claimed in claim 13, wherein the main outlet opening (102) and the outlet opening (114) of the additional fuel injection system are positioned on opposite vane walls.

FIG 1

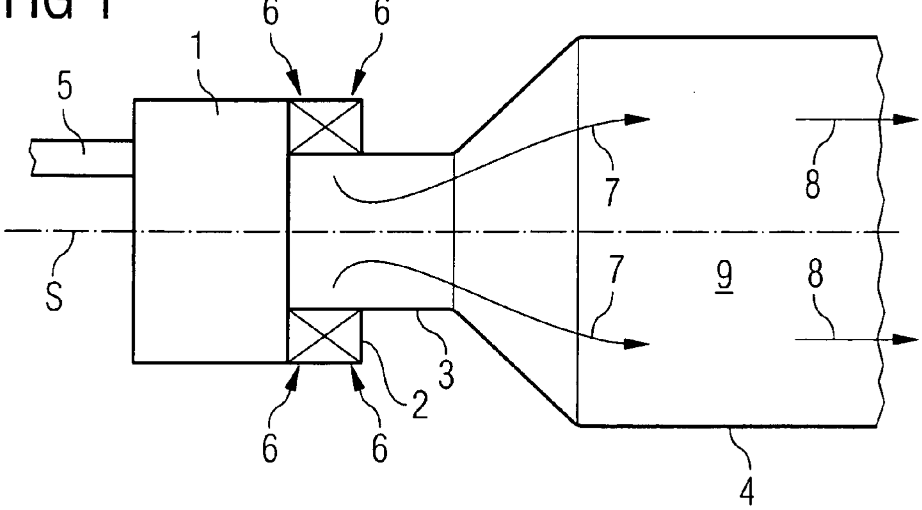
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FIG 2

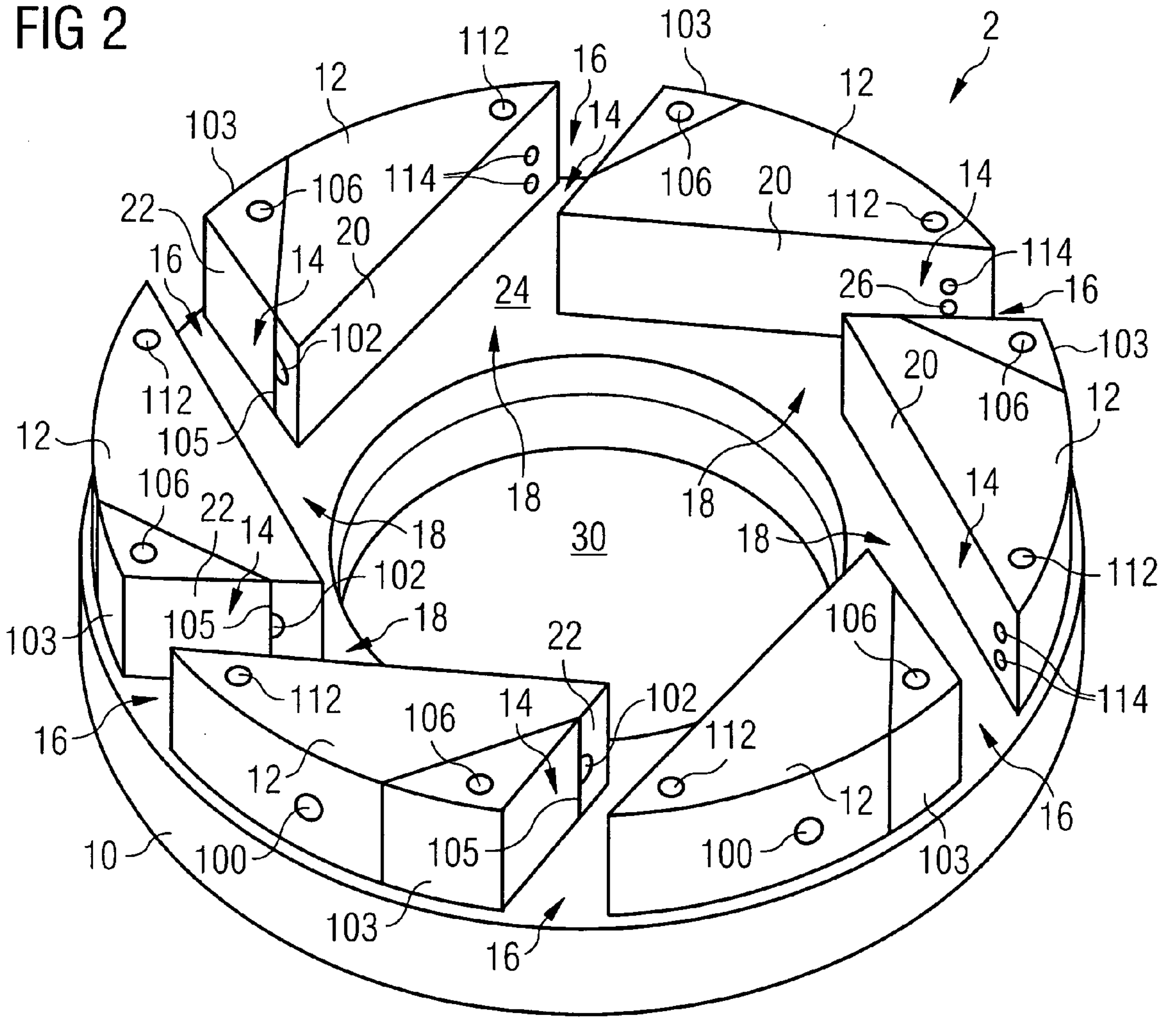
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FIG 3

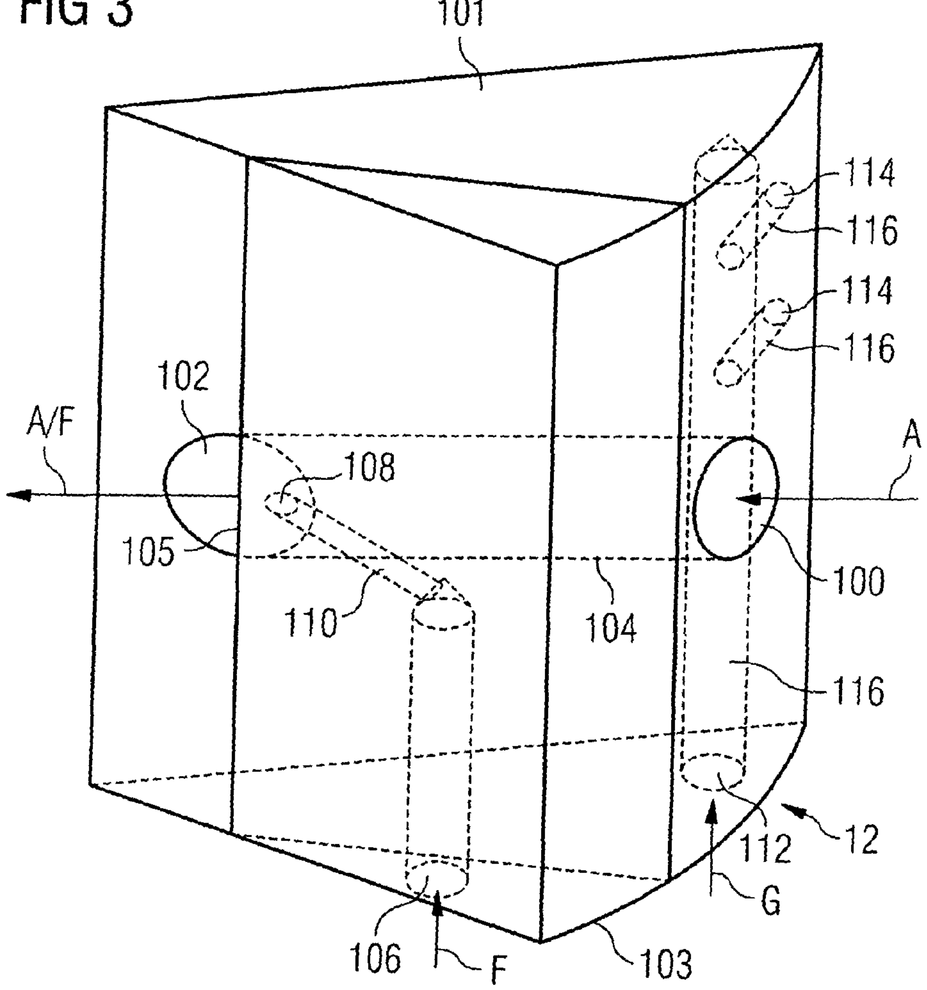
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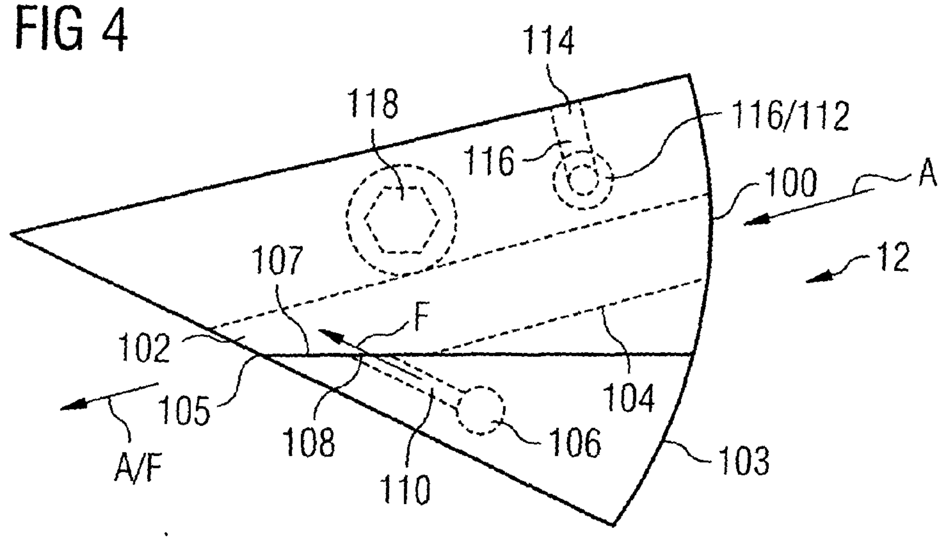
FIG 4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EUROPEAN SEARCH REPORT

Application Number
EP 06 02 2322

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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CATEGORY OF CITED DOCUMENTS

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1

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