



## Description

**[0001]** The present invention relates to a gas turbine burner for reactive fuels, in particular for annular combustors.

### Background of the Invention

**[0002]** In a gas turbine engine, a working fluid, like air, being compressed by a compressor enters a burner section where combustion of a mixture of the working fluid and a fuel occurs. The resulting combustion gas drives a turbine through the expansion and deflection of the gas through the turbine of the gas turbine engine. The turbine work or a part thereof is transferred to the compressor through an interconnecting shaft. The compressor discharge temperature in modern gas turbine engines may be well above 420°C. In case the gas turbine engine is operated with highly reactive fuels, like hydrogen, auto-ignition of a hydrogen/air mixture may occur with these temperatures. Since the burner is situated after the compressor it may have surface temperatures like the temperature of the compressor discharge. Thus, a risk for flashbacks may be disadvantageously enhanced.

**[0003]** In diffusion combustion, the oxidizer (e.g. air) combines with the fuel by diffusion, and as a result, the flame speed is limited by the rate of diffusion with relatively high emissions. Premix combustion is a combustion process intended to be used for low exhaust pollution. Fuel and air are mixed before entering a combustion chamber. As an example, fuel is introduced by a jet in crossflow arrangement where the fuel is injected perpendicular to the airstream passing through the burner. Unfortunately, near these fuel jets there are always low speed zones, where the fuel concentration is sufficiently high to be ignited by the hot burner geometry. Consequently, it is currently avoided to use highly reactive fuels in this kind of combustion system.

**[0004]** Modern gas turbines featuring advanced dual fuel Dry Low Emission, DLE combustion systems experience limitations in the ability to use high amounts of hydrogen in the fuel. The main hurdles are flashback risk and high Nitrogen Oxide emissions, NO<sub>x</sub>.

**[0005]** The problem has up to now been tried to be solved by adjusting the fuel concentration in the standard burner, also the swirl number has been adjusted. These measures have not been enough to enable stable operation with low emissions for highly reactive fuels such as blends with high amounts of hydrogen.

**[0006]** It is an objective of the present invention to provide a burner with which the above-mentioned shortcomings can be mitigated, and especially, a secure and reliable operation of the burner can be ensured.

**[0007]** This objective may be solved by a burner according to claim 1.

## Summary of the Invention

**[0008]** Accordingly, the present invention provides a burner for a gas turbine with a supply zone for supplying fuel and air and a subsequent mixing zone for premixing fuel and air, the mixing zone having an upstream end and a downstream end and comprising a plurality of premix jet pipes for mixing air and fuel, each with an inlet and an outlet, arranged around a central burner axis and extending between the upstream end and the downstream end, wherein closer to the upstream end the premix jet pipes are straight and parallel to each other and wherein closer to the downstream end the premix jet pipes are bent away from the central burner axis wherein a bending of the premix jet pipes increases with the distance between premix jet pipe and central burner axis, wherein a diameter of the premix jet pipes is between 0.5 mm and 10 mm.

**[0009]** The multiple premix jet pipes premixing main fuel with air offer an opportunity to operate with up to 100% hydrogen in the fuel. This is enabled by the fact that the relatively small diameter of the tubes prevents the flame to protrude upstream into the burner, so called flashback. The risk for flashback is also reduced by the fact that there is low or no swirl in the tubes. The stability of the combustion system is maintained by outer recirculation zones created by the plug flow created by the bundle of the premixed jets combined with sudden expansion outside the burner.

**[0010]** It is preferable, that the bending of the premix jet pipes is not limited to the radial direction but also has a tangential component, thereby creating a collective gross swirl of the exiting flow, if needed.

**[0011]** Preferably inlets of premix jet pipes at the upstream end of the mixing zone are connected to an air plenum. Hence, air can be supplied to all premix jet pipes commonly avoiding the need to connect individually to a relatively large number of premix jet pipes. Further, the air flow is balanced, and assembly is easy.

**[0012]** Preferably the downstream end of the burner is formed by a convex end cover with evenly distributed openings, wherein premix jet pipe outlets are aligned with the openings of the end cover.

**[0013]** Moreover, the plurality of premix jet pipes is surrounded by a shell extending between the air plenum and the end cover such that a space is formed in which the premix jet pipes extend, the space being closed at the downstream end and having an annular gap at its upstream end between the shell and the air plenum. Fuel fed through this gap to this space is equally distributed therein and enters the premix jet pipes through lateral openings arranged in the premix jet pipes. Under operating conditions, the premix jet pipes are surrounded by main fuel, cooling the burner body and tip.

**[0014]** Preferably the burner comprises a pilot fuel cavity arranged in the shell and extending in circumferential direction and from which pilot fuel channels branch off and extend parallel to the premix jet pipes in the direction

to the downstream end. The stability and the start-up ability of the burner are further enhanced by the outer pilot adding pilot fuel in the outer recirculation zones.

**[0015]** It is advantageous when the burner comprises a fuel stem with hollow struts connecting the fuel stem mechanically to the shell, and fluidly to the space and the pilot fuel cavity for providing fuel. It also enables combustion air to reach the air plenum and the premix pipes with low pressure drop without swirl. This construction finally allows for a simple and safe provision of fuel and air to the mixing zone.

**[0016]** The proposed burner has an architecture that enables main burner geometry to be kept inside existing DLE (= dry low emission) burner types for normal gaseous fuel which makes this burner type very attractive for retrofit in existing DLE systems. Also, Additive Manufacturing is beneficial to achieve the multiple small air and fuel passages.

**[0017]** This burner type can be adapted to many types of combustion systems but is especially suited for an annular gas turbine combustor characterized by a plurality of burners, combustor backwall, outer wall and inner wall.

#### Brief Description of the Drawings

**[0018]** The present invention will be described with reference to drawings in which:

FIG 1 shows schematically a sectional view of the gas turbine burner according to the invention,

FIG 2 shows a close-up view of the premix pipes of the burner of FIG 1,

FIG 3 shows a view of the burner of FIG 1 from the upstream side and

FIG 4 shows a view from the downstream side of an example of a plurality of burners in an annular combustor.

**[0019]** FIG 1 shows a burner 1 for a gas turbine according to the invention in a sectional view. Said burner 1 comprises a supply zone 2 for supplying fuel and air and a subsequent mixing zone 3 for premixing fuel and air, the mixing zone 3 having an upstream end 4 and a downstream end 5.

**[0020]** The mixing zone 3 comprises a plurality of premix jet pipes 6 for mixing air and fuel, each with an inlet 7 and an outlet 8, arranged around a central burner axis 9 and extending between the upstream end 4 and the downstream end 5. It can be seen from FIG 1 that closer to the upstream end 4 the premix jet pipes 6 are straight and parallel to each other and closer to the downstream end 5 the premix jet pipes 6 are bent away from the central burner axis 9 wherein a bending of the premix jet pipes 6 increases with the distance between premix jet pipe 6 and central burner axis 9. The pipe bending

shown in Fig 1 is indicated only in the radial direction. However, bending of pipes is not limited to this direction, also tangential bending is possible.

**[0021]** The diameter 11 of the premix jet pipes 6 is between 0.5 mm and 10 mm to prevent the flame to protrude upstream into the burner 1, so called flashback.

**[0022]** Inlets 7 of the premix jet pipes 6 at the upstream end 4 of the mixing zone 3 are connected to an air plenum 12.

**[0023]** The downstream end 5 of the mixing zone 3 is formed by a convex end cover 13 with evenly distributed openings 14, and premix jet pipe outlets 8 are aligned with the openings 14 of the end cover 13.

**[0024]** The plurality of premix jet pipes 6 is surrounded by a shell 15 extending between the air plenum 12 and the end cover 13 such that a space 16 is formed in which the premix jet pipes 6 extend, the space 16 being closed at the downstream end 5 and having an annular gap 17 at its upstream end 4 between the shell 15 and the air plenum 12.

**[0025]** Lateral openings 18 are arranged in the premix jet pipes 6.

**[0026]** A pilot fuel cavity 19 is arranged in the shell 15 and extending in circumferential direction and from which pilot fuel channels 20 branch off and extend parallel to the premix jet pipes 6 in the direction to the downstream end 5.

**[0027]** The burner 1 is built on a traditional fuel stem 21 bringing fuel from outside the gas turbine. Hollow struts 22 connect the fuel stem 21 mechanically to the shell 15, and fluidly to the space 16 and the pilot fuel cavity 19 for providing fuel. The main fuel 25 and the pilot fuel 26 are led in channels 23 inside the struts 22 and are transported to the premix jet pipes 6, which are surrounded by main fuel, cooling the burner body and tip, and the pilot fuel cavity 19. The pilot fuel 26 is tangentially distributed in the pilot fuel cavity 19 and then distributed to the pilot fuel nozzles 24.

**[0028]** This open structure defined by the struts 22 enables combustion air 27 to reach the premix jet pipes 6 with low pressure drop without swirl.

**[0029]** FIG 2 shows a close-up view of the premix jet pipes 6 with a part of the air plenum 12 as well as the pilot fuel cavity 19 of the burner 1 of FIG 1. The pilot fuel cavity 19 is arranged in the shell 15 and extends in circumferential direction. Pilot fuel channels 20 branch off the pilot fuel cavity 19 and extend parallel to the premix jet pipes 6 in the direction to the downstream end 5.

**[0030]** The close-up view of FIG 2 shows quite clearly the lateral openings 18 which are arranged in the premix jet pipes 6 as well as the detailed structure of the premix jet pipes 6 themselves with their inlets 7 on the left of FIG 2 to the air plenum 12 as well as their outlets 8 on the right of FIG 2 to the combustion chamber 28 through openings 14 in the convex end cover 13.

**[0031]** FIG 3 shows a view of the burner of FIG 1 from the upstream side at the position of the fuel stem 21, which is positioned on the central burner axis 9. From

the fuel stem 21 struts 22 branch off in downstream direction outwardly in order to connect to the shell 15 surrounding the evenly in a circle distributed premix jet pipes 6, which are also shown in FIG 3 unless hidden by the stem 21 and the struts 22 in this view.

**[0032]** FIG 4 shows a view from the downstream side in upstream direction of an example of a plurality of burners 1 in an annular combustor. Each burner 1 shows an inner circle with premix jet pipe 6 outlets 8 surrounded by a ring with evenly distributed pilot fuel nozzles 24.

### Claims

1. Burner (1) for a gas turbine with a supply zone (2) for supplying fuel and air and a subsequent mixing zone (3) for premixing fuel and air, the mixing zone (3) having an upstream end (4) and a downstream end (5) and comprising a plurality of premix jet pipes (6) for mixing air and fuel, each with an inlet (7) and an outlet (8), arranged around a central burner axis (9) and extending between the upstream end (4) and the downstream end (5), wherein closer to the upstream end (4) the premix jet pipes (6) are straight and parallel to each other and wherein closer to the downstream end (5) the premix jet pipes (6) are bent away from the central burner axis (9) wherein a bending of the premix jet pipes (6) increases with the distance between premix jet pipe (6) and central burner axis (9), wherein a diameter (11) of the premix jet pipes (6) is between 0.5 mm and 10 mm. 15
2. Burner (1) according to claim 1, wherein the bending of the premix jet pipes (6) has also a tangential component. 20
3. Burner (1) according to claim 1 or claim 2, wherein inlets (7) of the premix jet pipes (6) at the upstream end (4) of the mixing zone (3) are connected to an air plenum (12). 25
4. Burner (1) according to claim 1 or claim 2, wherein the downstream end (5) of the mixing zone (3) is formed by a convex end cover (13) with evenly distributed openings (14), wherein premix jet pipe outlets (8) are aligned with the openings (14) of the end cover (13). 30
5. The burner (1) according to claim 4, wherein the plurality of premix jet pipes (6) is surrounded by a shell (15) extending between the air plenum (12) and the end cover (13) such that a space (16) is formed in which the premix jet pipes (6) extend, the space (16) being closed at the downstream end (5) and having an annular gap (17) at its upstream end (4) between the shell (15) and the air plenum (12). 35
6. Burner (1) according to one of the preceding claims, 40

wherein lateral openings (18) are arranged in the premix jet pipes (6).

7. Burner (1) according to claim 1 further comprising a pilot fuel cavity (19) arranged in the shell (15) and extending in circumferential direction and from which pilot fuel channels (20) branch off and extend parallel to the premix jet pipes (6) in the direction to the downstream end (5). 45
8. Burner (1) according to claim 1, comprising a fuel stem (21) with hollow struts (22) connecting the fuel stem (21) mechanically to the shell (15), and fluidly to the space (16) and the pilot fuel cavity (19) for providing fuel. 50

FIG 1

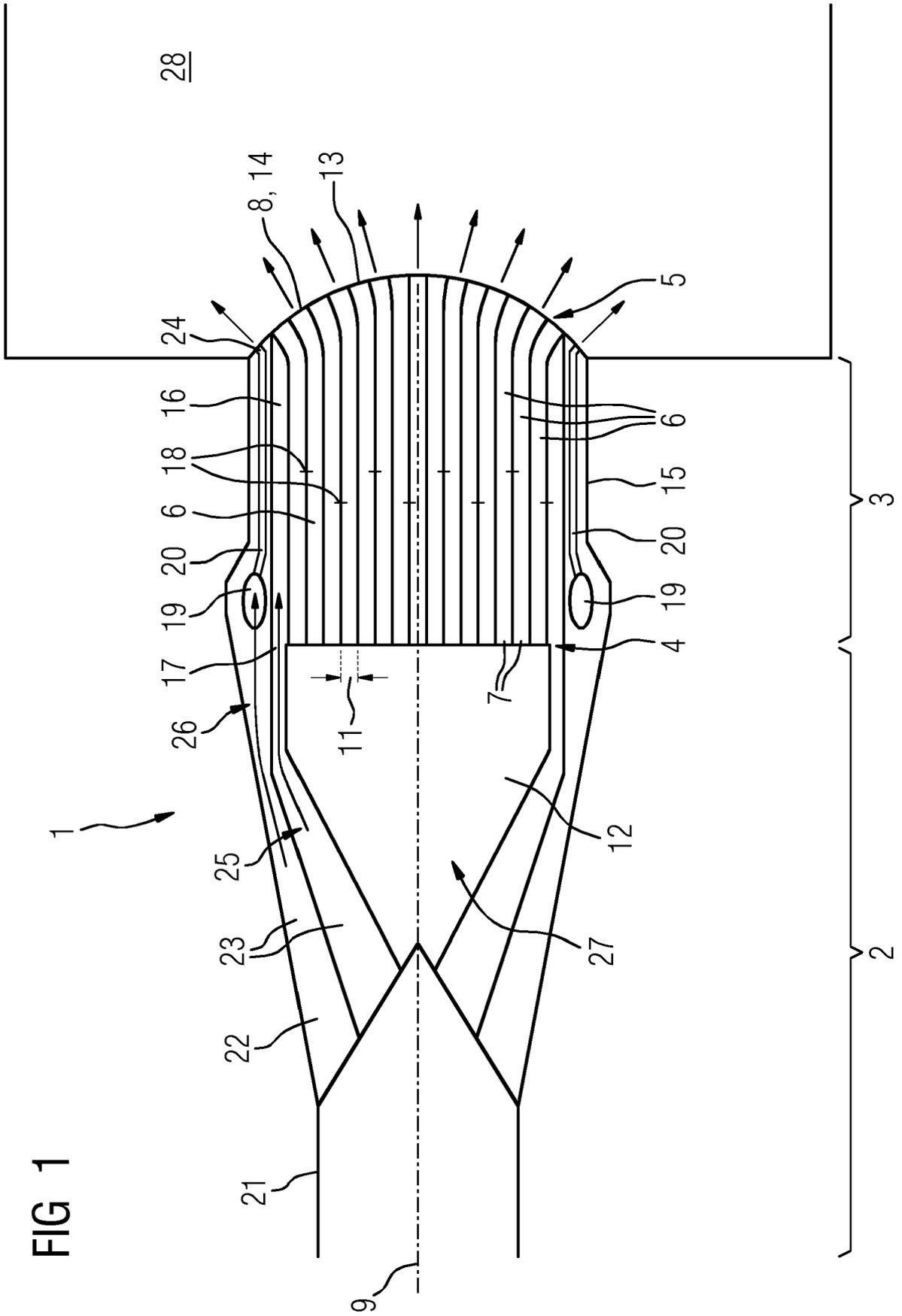


FIG 2

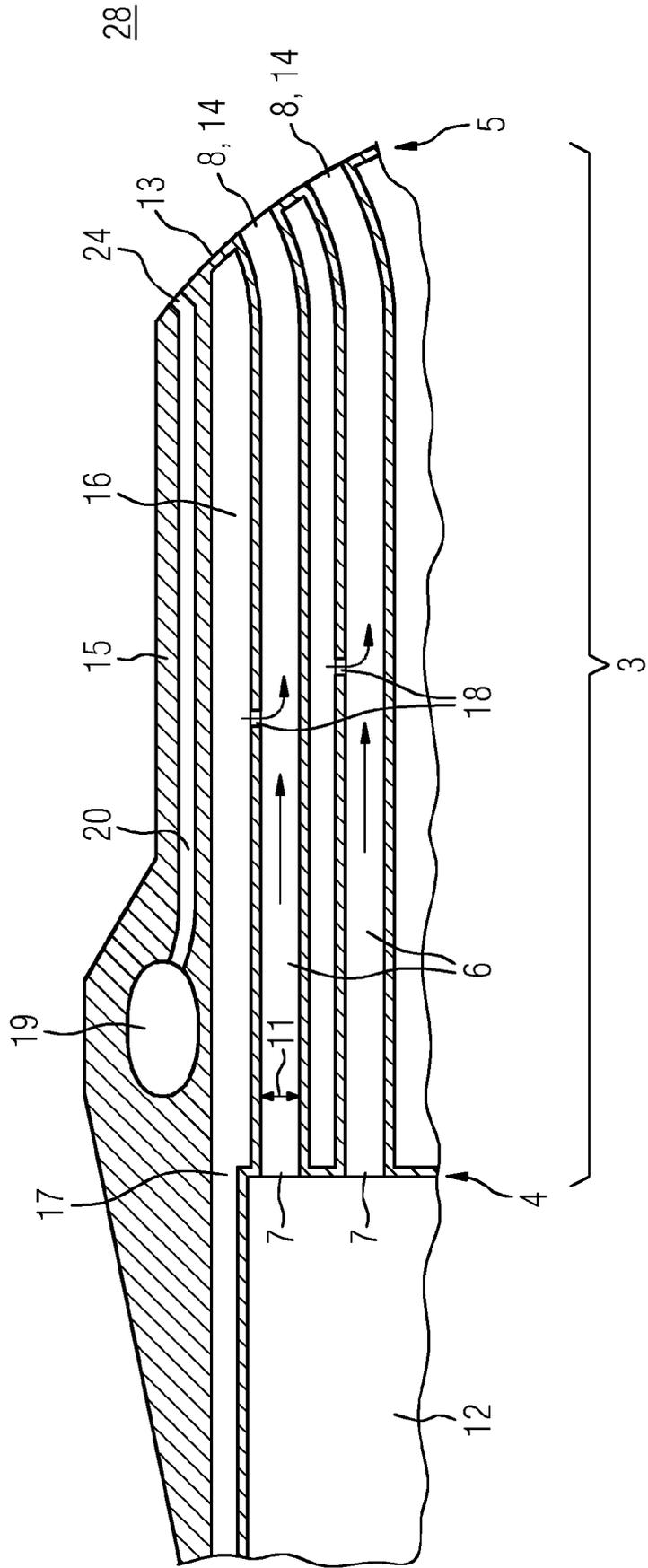


FIG 3

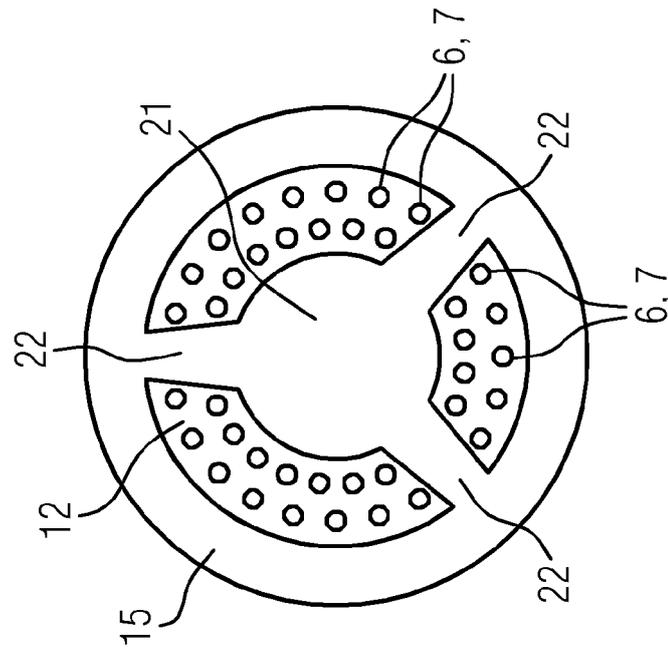
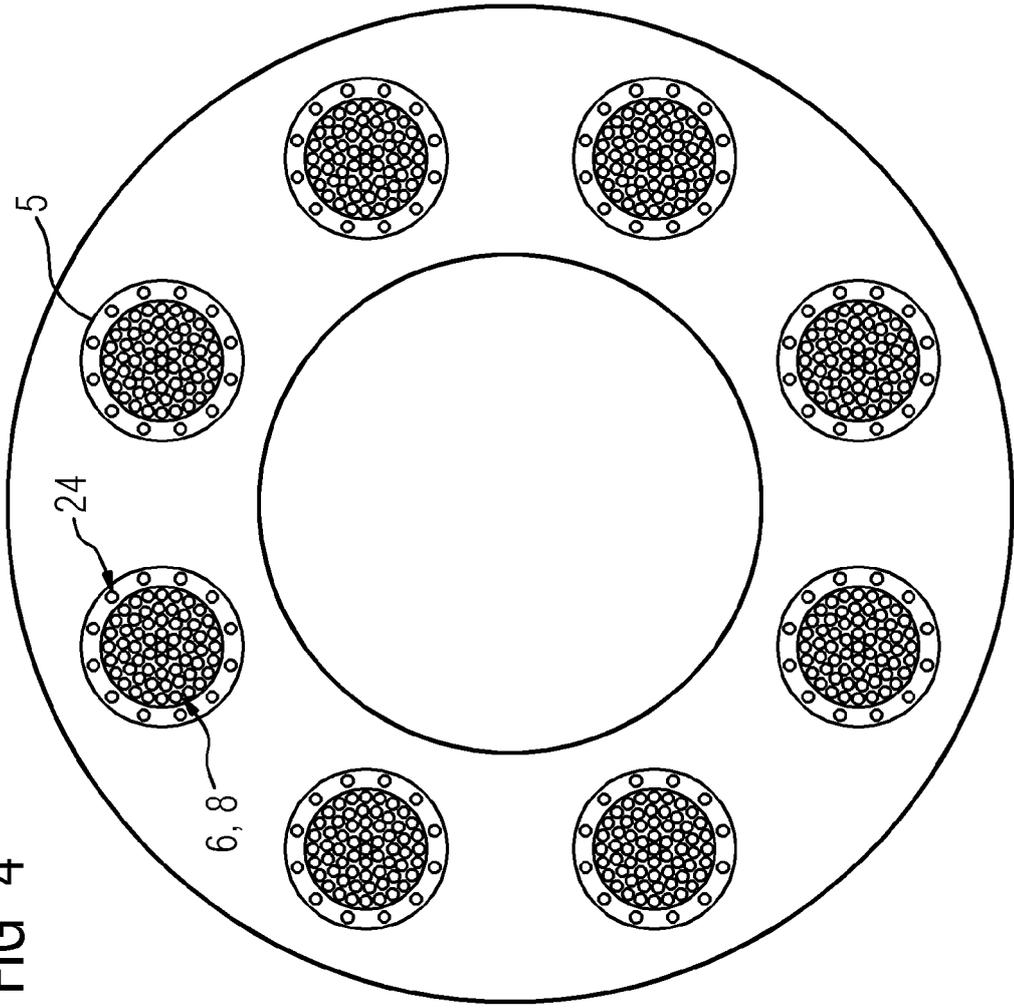


FIG 4





EUROPEAN SEARCH REPORT

Application Number  
EP 18 19 9840

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Y	* abstract; paragraph [0020] - paragraph [0034]; figures 1-7 *	5-8	
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 3 December 2018	Examiner Munteh, Louis
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone                      Y : particularly relevant if combined with another document of the same category                      A : technological background                      O : non-written disclosure                      P : intermediate document</p> <p>T : theory or principle underlying the invention                      E : earlier patent document, but published on, or after the filing date                      D : document cited in the application                      L : document cited for other reasons                      &amp; : member of the same patent family, corresponding document</p>			

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