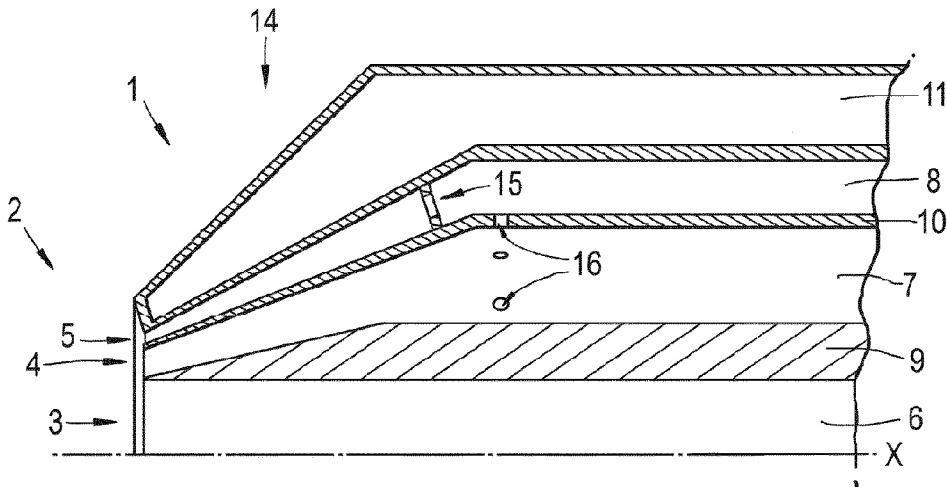




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 (72) Inventeurs/Inventors:
 DISSELHORST, JOHANNES HERMANUS MARIA, NL;
 DE JONG, JOHANNES CORNELIS, NL;
 GAO, CHENGMING, NL;
 SCHOUWENAAR, ROBERT, NL
 (73) Propriétaire/Owner:
 AIR PRODUCTS AND CHEMICALS, INC., US
 (74) Agent: OSLER, HOSKIN & HARCOURT LLP

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Process, reactor and burner (1, 20, 30, 60, 90) for the gasification of a hydrocarbon fuel. The burner comprises coaxial channels for the separate supply of an oxidizer gas, a hydrocarbon fuel and a moderator gas. A coaxial channel with the smallest width (8, 35, 72) is bordered by a separating wall (10, 53) with at least one gas exchange passage (16, 22, 52, 88, 97). The gas exchange passage can for example be formed by a retracted end (21, 97) of the separating wall and/or by openings in the separating wall (16, 52, 88).

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(71) Applicant (for all designated States except US): **SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B.V.** [NL/NL]; Carel van Bylandtlaan 30, NL-2596 HR The Hague (NL).(71) Applicant (for US only): **SHELL OIL COMPANY** [US/US]; PO Box 2463, One Shell Plaza, Houston, Texas 77252-2463 (US).(72) Inventors: **DISSELHORST, Johannes Hermanus Maria**; Baknummerstraat 21, NL-1901 HJ Castricum (NL). **DE JONG, Johannes Cornelis**; Gouwestraat 13, NL-2407 BB Alphen aan den Rijn (NL). **GAO, Chengming**; Grasweg 31, NL-1031 HW Amsterdam (NL). **SCHOUWENAAR, Robert**; Grasweg 31, NL-1031 HW Amsterdam (NL).(74) Agent: **MATTHEZING, Robert Maarten**; PO Box 384, NL-2501 CJ The Hague (NL).

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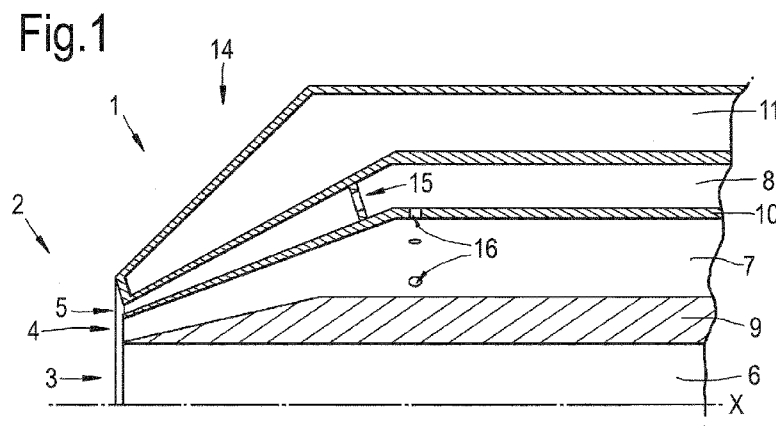
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(54) Title: BURNER, REACTOR AND PROCESS FOR GASIFICATION OF A HYDROCARBON FEED



(57) Abstract: Process, reactor and burner (1, 20, 30, 60, 90) for the gasification of a hydrocarbon fuel. The burner comprises coaxial channels for the separate supply of an oxidizer gas, a hydrocarbon fuel and a moderator gas. A coaxial channel with the smallest width (8, 35, 72) is bordered by a separating wall (10, 53) with at least one gas exchange passage (16, 22, 52, 88, 97). The gas exchange passage can for example be formed by a retracted end (21, 97) of the separating wall and/or by openings in the separating wall (16, 52, 88).

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BURNER, REACTOR AND PROCESS FOR GASIFICATION OF A
HYDROCARBON FEED

The present invention relates to a burner with a plurality of coaxial burner channels. The invention also relates to a gasification reactor and a process for the production of synthesis gas by partial combustion of a hydrocarbon feed using such a burner.

5

Synthesis gas is a gas comprising carbon monoxide and hydrogen gas and is typically used as a fuel gas or as a feedstock for the synthesis of methanol, ammonia, various other chemicals, or gaseous or liquid hydrocarbons.

10

WO 2008/006869 discloses a process for the manufacture of syngas using a multi-outlet burner with separate passages for a hydrocarbon fuel and for an oxidizer gas separated by a passage for a moderator gas, typically steam. At the burner front the steam flow lifts the flames and reduces the risk of damage by thermal stresses. To minimize use of moderator gas the moderator passage should be kept very narrow. This causes large temperature gradients resulting in very high thermal stresses in the separating passage walls. Moreover, after a shutdown of one of the channels, the remaining flows may cause a backflow into the shut passage.

15

20

It is an object of the invention to reduce thermal stresses in the burner. It is a further object of the invention to reduce the risk of backflow after a shutdown of one of the flows.

25

The object of the invention is achieved with a burner for the gasification of a hydrocarbon fuel comprising coaxial channels for the separate supply of an oxidizer gas, a hydrocarbon fuel and a moderator gas, wherein a coaxial channel with the smallest width is bordered by a separating wall with at least one gas exchange passage.

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The channel with the smallest width is typically used for the supply of the moderator gas, while the channel at the other side of the separating wall with the at least one gas exchange passage is typically used for supplying the oxidizer gas. The burner may comprise a retracted end of the separating wall. It has been found that this effectively reduces thermal stresses while the flame lifting potential of the moderator gas flow is unaffected. The retraction can for example be between 1 to 6 times the width of the narrower channel adjacent the retracted wall end, for instance between 2 to 4 times this width.

The gas exchange passage is formed by at least one opening in the separating wall. If the flow in one of the channels stops, the pressure in that channel drops and part of the flow in the other channel enters the channel via the gas exchange opening. This way, a positive flow in the direction of the burner front is maintained. A backflow of hot gas from the gasification zone into the shutdown channel can effectively be prevented. The total area of the one or more openings in the separating wall can for example be between 0.3 and 3 times the outlet area of the narrowest channel, e.g., between 0.6 and 1.5 times this area.

Optionally, one or more of the channels is defined by channel walls with end sections converging towards the burner front. This creates backpressure in the respective channels in case of forward flow. In such a configuration, the one or more gas exchange passages may include openings positioned upstream of the converging section. Alternatively or additionally, backpressure can be created by one or more restrictions in the channel,

positioned downstream of the one or more gas exchange passages.

During operation there is little gas exchange via the gas exchange openings, because the back pressure of the oxidizer supply is close to the backpressure of the moderator gas flow. However, after a shut-down of the oxidizer supply, the backpressure of the oxidizer content drops, and moderator gas will flow into the oxidizer channel. This prevents a back flow in the oxidizer channel and maintains a positive flow towards the burner front in the respective channels under all operating conditions.

In operation the coaxial channels of the burner are connected to inlet passages for the separate supply of one or more hydrocarbon fuels, an oxidizer gas and a moderator gas. One or more channels connected to an inlet for a moderator gas can be arranged adjacent to a channel connected to an inlet for an oxidizer gas, the wall separating these channels being provided with the gas exchange passage(s). The burner can for example have at least 3 coaxial channels, e.g., 3 - 7 coaxial channels, or more than 7 coaxial channels, if so desired.

The width of the outlet of the moderator channel(s) is relatively small compared to the width of the oxidizer gas channel(s) and the fuel channel(s). For instance, at the burner front the outlet area of the moderator gas outlet can be about 0.1 - 0.3 times the outlet area of the oxidizer outlet.

According to an embodiment the channel with the smallest width is connected to an inlet passage for the supply of moderator gas. The channel at the other side of the separating wall with the at least one gas exchange passage is connected to an inlet passage for the supply of oxidizer gas.

The inlet passage for the supply of moderator gas is connected to a source of a moderator gas. The inlet passage for the supply of oxygen gas is connected to a source of an oxidizer gas.

5 The burners may for instance comprise hollow wall members with internal cooling fluid (e.g. water) passages.

Optionally, the burner may be provided with a suitable ceramic or refractory lining applied onto or
10 suspended closely to the outer surface of the burner for resisting the heat load during operation or during heat-up or shut down of the reactor.

Oxidizer gas is a gas comprising oxygen, such as air or concentrated oxygen, such as pure oxygen having a
15 purity of between 95 and 100 vol.%. The oxidizer gas can also comprise a mixture of oxygen and moderator gas, e.g., with a moderator gas content between 5 and 30 wt% by weight of the total mixture. The presence of some moderator gas in the oxidizer allows a process operator
20 to control the flow velocity of the moderator gas in the moderator gas channel and the total flow of the moderator gas, so as to obtain an optimum amount of moderator gas for the process.

The moderator gas can for example be or comprise
25 steam and/or or carbon dioxide.

The hydrocarbon feed can for example be a gas or a liquid, such as an emulsion or a slurry, which is pumpable at gasifier feed pressure and temperature and comprises a carbonaceous component, such as slurries of
30 solid carbonaceous fuels dispersed in liquid hydrocarbons. The carbonaceous component may for example comprise butanes, pentanes, hexanes, natural gasolines, kerosenes, gas oils, naphthas, diesel fuels, crude oils, residual (whether atmospheric or vacuum), pitch, biomass,

as well as hydrocarbons which may contain other atoms such as oxygen, e.g., in such proportions as not to interfere with self-sustaining combustion.

Suitable hydrocarbon feeds include for example heavy
5 crude oil residues, e.g., having a kinematic viscosity between 1 and 3000 cSt, preferably between 1 and 1000 cSt as measured at the temperature of the hydrocarbon feed as it is supplied to the burner.

Alternatively, or additionally, the hydrocarbon feed
10 may comprise a dense phase of finely divided particles of solid carbonaceous fuel, such as pulverized coal, e.g., in a suspension gas comprising nitrogen, carbon dioxide and/or a gaseous fuel.

The exit flow velocity of the hydrocarbon feed at the
15 outlet at the burner front can for example be between 2 and 20 m/s, e.g., between 2 and 20 m/s for a liquid hydrocarbon. For a gaseous hydrocarbon feed the flow velocity can for example be between 5 and 100 m/s, e.g., between 15 and 40 m/s.

The exit flow velocity of the moderator gas can for
20 example be at least 5 times the exit flow velocity of the liquid hydrocarbon feed if the moderator gas channel is adjacent to the liquid feed channel, for instance between 40 and 200 m/s, e.g., between 40 and 150 m/s, e.g.,
25 between 60 and 120 m/s. In this way the moderator gas aids in the atomisation of the liquid. If the moderator gas channel is not adjacent to a liquid feed channel its exit flow velocity can for example be between 10 and 60 m/s., e.g., between 20 and 40 m/s.

The exit flow velocity of the oxidiser gas can for
30 example be between 30 and 150 m/s, e.g., between 60 and 120 m/s, e.g., between 70 and 100 m/s.

Optionally, one or more of the channels may comprise a swirl velocity component. This will improve mixing of

the reactants. The angle between the flow direction and the azimuthal direction may for example be between 0 and 60 degrees, e.g., between 30 and 45 degrees.

5 The process can be performed in a reactor provided with at least one burner as disclosed above. The burner can for example be arranged at the top end of such a reactor. The reactor may for instance comprise a vertically oriented cylindrical vessel having an outlet for the mixture of carbon monoxide and hydrogen, e.g., at
10 its lower end. Such gasification reactors are for example described in Chapter 5.4 of *Gasification*, by Chris Higman and Maarten van der Burgt, Elsevier Science (USA), 2003 pages 128-147.

The process is typically performed at a temperature
15 of between 1000 and 1800°C measured at the syngas outlet of the reactor. The pressure of the produced syngas is, e.g., between 0.3 and 12 MPa, e.g., between 3 and 8 MPa. The process can for example be performed near or at a crude oil refinery because the produced synthesis gas can
20 directly be applied as a feedstock for the production of hydrogen or as a fuel gas, for example, for heating the furnaces of the refinery or more efficiently for the firing of gas turbines to produce electricity and heat. Hydrogen as prepared by the above process may be
25 advantageously used in a hydroprocessing process, such as hydrogenation, hydrocracking, isomerisation-dewaxing or catalytic dewaxing type processes.

The mixture of carbon monoxide and hydrogen as prepared, sometimes also referred to as synthesis gas,
30 may also be advantageously used as a feedstock for the synthesis of methanol, ammonia or hydrocarbons via the Fischer-Tropsch process, which latter synthesis yields gaseous hydrocarbons and liquid hydrocarbons such as gasoline, middle distillates, lube oils and waxes.

The invention will be further explained by reference to the accompanying drawings.

Figure 1: shows schematically in cross section a first exemplary embodiment of a burner;

5 Figure 2: shows schematically in cross section a second exemplary embodiment of a burner;

Figure 3: shows schematically in cross section a third exemplary embodiment of a burner;

10 Figure 4: shows schematically in cross section a fourth exemplary embodiment of a burner;

Figure 5: shows schematically in cross section a fifth exemplary embodiment of a burner.

Figure 1 shows a burner 1 in a cross section along its longitudinal axis X. Only the upper half is shown,
15 the lower half being a mirror image of the upper half. The burner 1 has a burner front 2 with three concentric outlets 3, 4, 5 and three coaxial channels 6, 7, 8 leading to the respective outlets 3, 4, 5 at the burner front 2: a central first channel 6 surrounded by a
20 annular second channel 7, which is in turn surrounded by an annular outer channel 8. The central channel 6 is bordered by a cylindrical first separating wall 9. The annular second channel 7 is bordered by the first separating wall 9 and a second cylindrical separating
25 wall 10 around the first wall 9. The annular outer channel 8 is bordered by the second separating wall 10 and a cooled third cylindrical wall 11 around the second wall 10. The third wall comprises a hollow barrel with channels for a cooling fluid (not shown). The burner 1
30 comprises a converging section 14, where the first, second and third walls 9, 10, 11 are configured to converge the annular second and third channels 7, 8 towards the burner front 2. The cylindrical first channel 6 does not have a converging section. To equalize flow

distribution in the outer channel 8, the converging section of the outer channel is provided with one or more restrictions 15. Upstream of the converging section 14, the separating wall 10 between the second and third channel 7, 8 is provided with gas exchange openings 16.

The central channel 6 is connected to a source of a hydrocarbon fuel, e.g., a dense phase mixture of finely divided coal particles and nitrogen gas. The annular second channel 7 is connected to a source of an oxidizer gas. The outer annular third channel 8 is connected to a source of a moderator gas, such as steam. The flow velocity of the hydrocarbon feed in the central channel 6 is, e.g., between 2 and 20 m/s. The flow velocity of the moderator gas in the outer channel 8 is for example between 10 and 30 m/s. In the annular second channel 7 the flow velocity of the oxidiser gas is, e.g., between 40 and 100 m/s. The reactants enter a gasification zone in front of the burner front 2. In the gasification zone the hydrocarbon fuel is partially combusted by the oxidizer. The moderator gas lifts the flame from the burner front 2 to reduce damage of the burner front 2 by thermal stress.

In case of a shutdown of the supply of oxidizer gas, the oxidizer gas flow in the second channel 7 would stop and the pressure in the second channel 7 would drop. Moderator gas would flow from the outer channel 8 into the annular second channel 7 via the gas exchange openings 16 to maintain a positive flow of moderator gas in the second channel 7 and to prevent a back flow of hot gases in the second channel 7.

Figure 2 shows an exemplary embodiment of a burner similar to the burner of Figure 1, with the difference that the second separating wall 10 is provided with a retracted end 21 defining another gas exchange passage

between the oxidizer flow channel 7 and the moderator gas flow channel 8. This way the thermal load by heat radiation from the hot reactor to the retracted tip 21 of the separating wall 10 is substantially reduced, resulting a reduced risk of deformation of the tip. If the pressure in one of the adjacent channels drops, the corresponding outlet will be filled with the other gas flow.

A third embodiment of a burner 30 is shown in Figure 3. This burner 30 has a central oxidizer gas flow channel 31 connected to a source of an oxidizer gas. The central channel 31 is bordered by a first cylindrical separating wall 32. At a converging section 33 of the burner 30, the first separating wall 32 converges to narrow down the central channel towards the burner front 34. Coaxial second, third and fourth channels 35, 36, 37 converge to the same extent. The annular second and fourth 35, 37 channels supply a moderator gas to the respective outlets. The channel 36 between the moderator gas channels 35, 37 supplies a hydrocarbon fuel, such as a heavy crude oil residue.

A series of gas exchange openings 52 is provided in the separating wall 53 connecting the central oxidizer gas channel 31 and the inner moderator gas channel 35. The gas exchange openings 52 are positioned upstream of the converging section 33 of the burner 30. If the supply of oxidizer gas to the channel 31 is stopped the gas exchange openings 52 will assure that a purge is maintained in the outlet of the channel 31.

A fourth exemplary embodiment of a burner 60 is shown in Figure 4. This burner 60 comprises six coaxial channels 68 - 73 with respective outlets 74 - 79 at the burner front 80: a central first channel 68, annular

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second, third, fourth and fifth channels 69, 70, 71, 72 and an outer annular sixth channel 73.

The central downstream channel 68 and the annular fifth channel 72 are connected to a supply of oxidiser gas. The annular third channel 70 is connected to a supply of hydrocarbon fuel. The annular second, fourth and sixth channels 69, 71, 73 are connected to a supply of moderator gas.

The burner 60 comprises a converging section 86 wherein particularly the moderator gas channels 69, 71 narrow down towards the burner front 80. Upstream of the converging section 86 gas exchange openings 87 connect the first channel 68 with the oxidizer flow to the second channel 69 with the moderator gas flow. Similarly, gas exchange openings 88 connect the fifth channel 72 with the oxidizer flow to the fourth channel 71 with the moderator gas flow.

A further embodiment of a burner 90 is shown in Figure 5. This embodiment is similar to the burner 60 of Figure 4, with the difference that the separating walls 91, 92 with the gas exchange openings 87, 88 have retracted ends 93, 94. Also the separating wall 95 between the fifth and the sixth channels 72, 73 has a retracted end 99, but less retracted than the other two retracted ends 93, 94. The retracted ends 93, 94 and 99 define gas exchange openings 96, 97 at the burner front between the oxidizer flow channels 68, 72 and respective moderator gas flow channels 69, 71, 73.

The embodiments of the present invention for which an exclusive property or privilege is claimed are defined as follows:

1. A burner for gasification of a hydrocarbon fuel, the burner comprising:

coaxial channels for the separate supply of an oxidizer gas, a hydrocarbon fuel and a moderator gas, wherein a coaxial channel with the smallest width is bordered by a separating wall with at least one gas exchange passage, the at least one gas exchange passage being formed by at least one opening in the separating wall;

wherein the coaxial channels are connected to inlet passages for the separate supply of one or more of the hydrocarbon fuel, the oxidizer gas and the moderator gas; and

wherein the inlet passage for the supply of the moderator gas is connected to a source of the moderator gas and the inlet passage for the supply of the oxidizer gas is connected to a source of the oxidizer gas.

2. The burner of claim 1, comprising a retracted end of the separating wall.

3. The burner of claim 2, wherein the retracted end is retracted over a distance of 1 to 6 times the width of the narrowest channel.

4. The burner of claim 3, wherein the retracted end is retracted over a distance of 2 to 4 times the width of the narrowest channel.

5. The burner of claim 1, wherein the total area of the one or more openings in the separating wall is between 0.3 and 3 times an outlet area of the narrowest channel.

6. The burner of claim 1, wherein the total area of the one or more openings in the separating wall is between 0.6 and 1.5 times an outlet area of the narrowest channel.

7. The burner of claim 1 wherein the coaxial channel connected to the inlet passage for the moderator gas is adjacent to the coaxial channel connected to the inlet passage for the oxidizer gas, wherein the wall separating said coaxial channels is provided with the at least one gas exchange passage.

8. The burner of claim 1, wherein the coaxial channel with the smallest width is connected to the inlet passage for the supply of moderator gas.

9. The burner of any one of claims 1 to 8, wherein the coaxial channels are defined by channel walls with end sections converging towards a burner front of the burner to form a converging section.

10. The burner of claim 9, wherein the one or more gas exchange passages include the at least one opening positioned upstream of the converging section.

11. The burner of claim 9, wherein upstream of the converging section gas exchange openings connect a first coaxial channel with the oxidizer flow to a second coaxial channel with the moderator gas flow; and wherein gas exchange openings connect a fifth coaxial channel with an oxidizer flow to a fourth coaxial channel with a moderator gas flow.

12. The burner of any one of claims 1 to 8, comprising one or more restrictions in one of the coaxial channels, positioned downstream of the at least one gas exchange passage.

13. A reactor for the production of syngas by partial combustion of a hydrocarbon feed, the reactor comprising at least one burner according to any one of claims 1 to 12, wherein at least one channel of the coaxial channels is connected to a supply of a non-gaseous hydrocarbon feed, at least one other channel of the coaxial channels is operatively connected to a supply of a gaseous

hydrocarbon feed and at least one channel of the coaxial channels is operatively connected to a supply of a non-hydrocarbon moderator gas.

14. A process for the production of syngas by partial combustion of a hydrocarbon feed in a reactor comprising at least one burner with a burner front and coaxial channels for separate supply at the burner front of an oxidizer gas, a hydrocarbon fuel and a moderator gas, wherein the coaxial channels are connected to inlet passages for the separate supply of one or more of the hydrocarbon fuel, the oxidizer gas and the moderator gas and the inlet passage for the supply of the moderator gas is connected to a source of the moderator gas and the inlet passage for the supply of the oxidizer gas is connected to a source of the oxidizer gas; wherein a flow of the oxidizer gas and a flow of the moderator gas flow through adjacent coaxial channels separated by a separating wall comprising a gas exchange passage, the gas exchange passage being formed by at least one opening in the separating wall.

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Fig.1

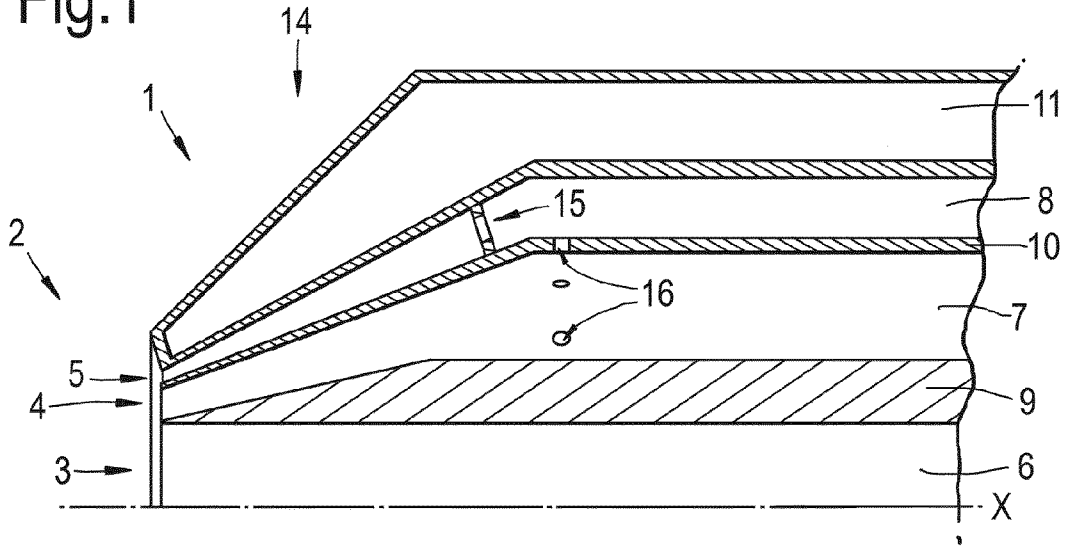


Fig.2

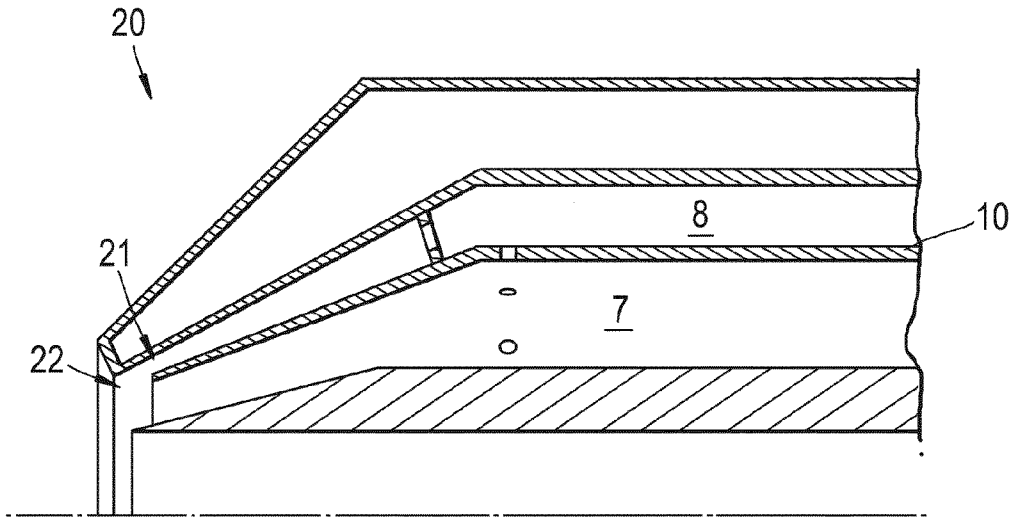


Fig.3

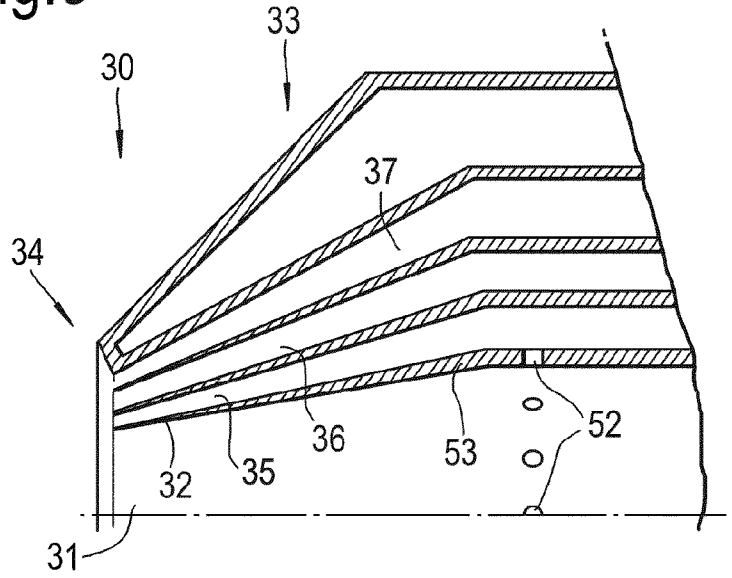


Fig.4

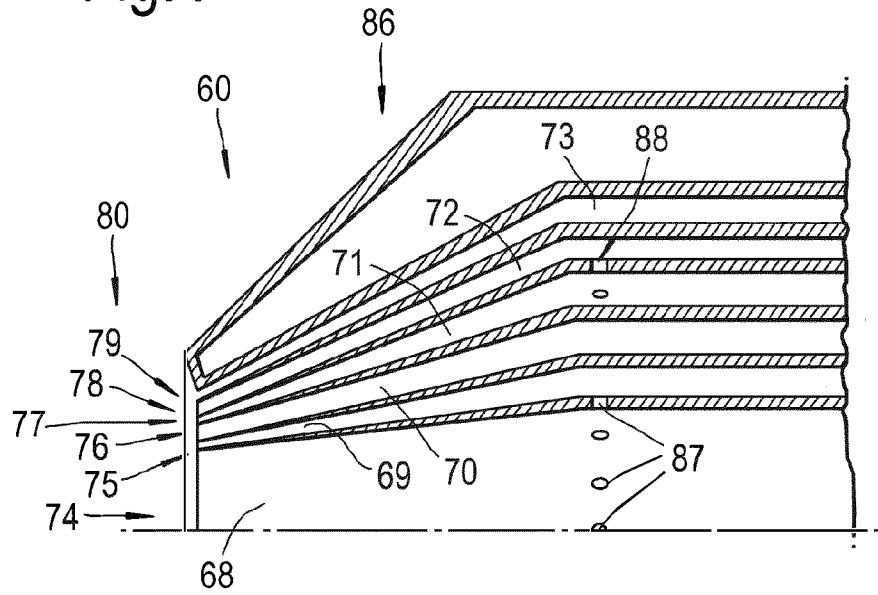


Fig.5

