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(54) HEAT RECOVERY BOILER AND PLANT COMPRISING SAID HEAT RECOVERY BOILER

(57) A heat recovery boiler is provided with:
a flue-gases flowing chamber (11) extending along a longitudinal axis (A) and provided with an inlet (16) and an outlet (17);
a steam circuit (14) fed with water and extending at least in part inside the flue-gases flowing chamber (11) so as to exploit the heat of the flue-gases to generate steam;
an inlet diffuser (12) connected to the inlet (16) of the flue-gases flowing chamber (11) wherein flue-gases from a flue-gases source (9) flow in one advancing direction (D);
at least one first wall (22; 19; 20) of the inlet diffuser (12) being provided with at least one first bulge (30).

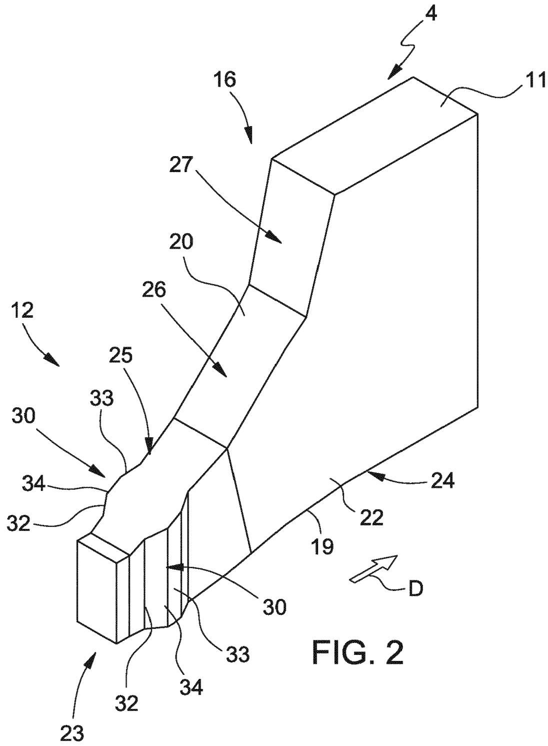

FIG. 2

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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This patent application claims priority from Italian patent application no. 102019000022395 filed on 28/11/2019.

TECHNICAL FIELD

[0002] The present invention relates to a heat recovery boiler and a plant comprising said heat recovery boiler. In particular, the present invention relates to a heat recovery boiler configured to produce steam by using the heat lost by gas turbines and/or industrial processes.

[0003] The present invention also relates to a steam generation thermal plant comprising said heat recovery boiler.

BACKGROUND ART

[0004] Steam generation thermal plants normally comprise a heat recovery boiler, which is connected to a source of hot flue gases. The source of hot flue gases may be a gas turbine or an industrial plant.

[0005] Sometimes, geometric-structural constraints prevent the connection between the heat recovery boiler and the hot flue-gases source from being substantially linear. In other words, it may happen that the hot flue-gases source is not aligned with the inlet of the heat recovery boiler.

[0006] Misalignment between the hot flue-gases source and the inlet of the heat recovery boiler causes non-homogeneity, in terms of temperature and speed, of the flue gases circulating in the boiler, with the creation of "hot" zones having a high concentration of hot flue gases and "cold" zones, where the concentration of hot flue gases is much lower.

[0007] This leads to inefficient heat exchange in the boiler and high risk of breakage of the boiler itself due to the occurrence of cracks caused by the high differences in temperatures to which the boiler structures are subjected. Moreover, if the boiler is provided with one or more afterburners, there is a higher risk of flame instability and/or increased pollution emissions.

DISCLOSURE OF INVENTION

[0008] It is therefore an object of the present invention to provide a boiler which is free from the prior art drawbacks noted herein; in particular, it is an object of the invention to provide a boiler which allows the above drawbacks to be overcome in a simple and inexpensive manner, both from the functional and the constructional point of view.

[0009] In particular, it is an object of the present invention to provide a heat recovery boiler which can be coupled in any way to a source of hot flue gases and which is, at the same time, efficient and reliable.

[0010] In accordance with these objects, the present invention relates to a heat recovery boiler comprising:

a flue-gases flowing chamber extending along a longitudinal axis and provided with an inlet and an outlet;
a steam circuit fed with water and extending at least in part inside the flue-gases flowing chamber so as to exploit the heat of the flue-gases to generate steam;
an inlet diffuser connected to the inlet of the flue-gases flowing chamber wherein flue-gases from a flue-gases source flow in one advancing direction;
at least one first wall of the inlet diffuser being provided with at least one first bulge.

[0011] The presence of the bulge in the inlet diffuser allows the creation therein of at least one mixing zone capable of making the flow of flue gases flowing in the inlet diffuser uniform, in terms of speed and temperature. This brings about a significant reduction in the risk of cracks and an increase in boiler efficiency, especially when the boiler and the flue-gases source are not aligned.

[0012] Therefore, the presence of the bulge allows the flue-gases source and the boiler inlet diffuser to be coupled in any way without affecting the reliability and efficiency of the boiler.

[0013] Moreover, a further object of the present invention is to provide a steam generation plant as claimed in claim 15.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Further features and advantages of the present invention will be apparent from the following description of a non-limiting embodiment thereof, with reference to the figures of the accompanying drawings, wherein:

- Figure 1 is a schematic view, with parts in section and parts removed for clarity, of a steam generation plant comprising the heat recovery boiler according to the present invention;
- Figure 2 is a schematic perspective view, with parts in section and parts removed for clarity, of a detail of the heat recovery boiler in Figure 1;
- Figure 3 is a schematic perspective view, with parts in section and parts removed for clarity, of the figure's detail in accordance with a variant.

BEST MODE FOR CARRYING OUT THE INVENTION

[0015] In Figure 1, reference number 1 indicates a combined cycle plant for the production of energy.

[0016] The plant 1 shown in Figure 1 is represented schematically and is not complete with all its parts.

[0017] The plant 1 is preferably only configured to produce electrical energy.

[0018] A variant not shown provides that the plant 1 is configured for the production of thermal energy useful, for example, in district heating applications.

[0019] The plant 1 comprises a gas turbine unit 2, a steam turbine unit 3, a boiler 4, and a tank 5.

[0020] The gas turbine unit 2 is the first engine of the combined cycle plant 1 and can be supplied with any fuel.

[0021] The gas turbine unit 2 is connected to a generator (not shown) and comprises a compressor 7, a combustion chamber 8, and a gas turbine 9.

[0022] The steam turbine unit 3 is coupled to a respective generator (not shown in the attached figures) and comprises a high-pressure steam turbine, a medium-pressure steam turbine, and a low-pressure steam turbine (not shown in the attached figures).

[0023] The boiler 4 recovers the residual heat of the combustion fumes generated by the gas turbine unit 2 and produces steam to be fed to the steam turbine unit 3.

[0024] In particular, the boiler 4 comprises a flue-gases flowing chamber 11, an inlet diffuser 12, and a steam circuit 14 and a chimney 15.

[0025] The flue-gases flowing chamber 11 extends along a longitudinal axis A and is provided with an inlet 16 and an outlet 17.

[0026] In the non-limiting example described and illustrated herein, the flue-gases flowing chamber extends along an axis A which is arranged, in use, substantially horizontal.

[0027] According to a variant, not shown, the flue-gases flowing chamber can extend along an axis which is arranged, in use, substantially vertical.

[0028] The inlet diffuser 12 is connected to the inlet 16 of the flue-gases flowing chamber 11 and is fed with the flue gases from the gas turbine 9. The flue gases flow into the inlet diffuser 12 and into the flue-gases flowing chamber 11 substantially in one advancing direction D.

[0029] The outlet 17 of the flue-gases flowing chamber 11 is connected to the chimney 15, through which the flue gases are discharged into the atmosphere.

[0030] The steam circuit 14 is schematically represented in Figure 1. Basically, the steam circuit 14 is fed with water, preferably coming from the tank 5, and extends at least in part inside the flue-gases flowing chamber 11 so as to exploit the heat of the flue gases to generate steam.

[0031] The water in the tank 5 is preferably demineralized and is mostly water coming from a condenser (not shown) connected to the steam turbine unit 3.

[0032] With reference to Figure 2, the inlet diffuser 12 is provided with a bottom wall 19, a top wall 20, two side walls 22, a flue-gases inlet 23, and a flue-gases outlet 24.

[0033] It is understood that the bottom wall 19 and the top wall 20 can be inverted in configurations of the boiler 4 different from that of the non-limiting example described and illustrated herein (for example, with a vertical flue-gases flowing chamber).

[0034] The bottom wall 19 and the top wall 20 diverge from each other along the advancing direction D. In other words, the distance between the bottom wall 19 and the top wall 20 increases along the advancing direction D and towards the inlet 16 of the flue-gases flowing chamber 11.

[0035] In the non-limiting example described and illustrated herein, the side walls 22 also diverge from each other along the advancing direction D.

[0036] Preferably, the divergence between the bottom wall 19 and the top wall 20 is greater than the divergence between the side walls 22.

[0037] Preferably, the inlet diffuser 12 comprises a first portion 25 comprising the flue-gases inlet 23, in which the top wall 20 has a first inclination with respect to a direction parallel to the axis A, a second portion 26 in which the top wall 20 has a second inclination with respect to a direction parallel to the axis A, which is greater than the first inclination, and a third portion 27 comprising the flue-gases outlet 24, in which the top wall 20 has a third inclination with respect to a direction parallel to the axis A, which is greater than the second inclination.

[0038] The second portion 26 is arranged between the first portion 25 and the third portion 27.

[0039] The third portion 27 is coupled to the inlet 16 of the flue-gases flowing chamber 11.

[0040] The bottom wall 19 preferably has a constant inclination with respect to a direction parallel to the axis A in the first portion 25, in the second portion 26 and in the third portion 27.

[0041] At least one of the side walls 22, the bottom wall 19 and the top wall 20 of the inlet diffuser 12 is provided with a bulge 30.

[0042] "Bulge" 30 herein and hereinafter is intended to mean a protrusion of the wall on which the bulge 30 is arranged towards the outside of the inlet diffuser 12.

[0043] In other words, the bulge 30 involves an increase in the passage section of the inlet diffuser 12 and a decrease in the passage section of the inlet diffuser 12. The section decrease is arranged downstream of the section increase along the advancing direction D.

[0044] Basically, the bulge 30 defines a widening and a subsequent narrowing of the passage channel defined by the inlet diffuser 12. In the non-limiting example described and illustrated herein, the inlet diffuser 12 is provided with two bulges 30.

[0045] A first bulge on one side wall 22 and a second bulge 30 on the other side wall 22.

[0046] Preferably, the first bulge 30 and the second bulge 30 face each other.

[0047] Preferably, the first bulge 30 and the second bulge 30 are substantially identical.

[0048] In the non-limiting example described herein, the bulge 30 is provided with a diverging portion 32 and with a converging portion 33 placed downstream of the converging portion 32 along direction D. Preferably, an intermediate portion 34 is arranged between the diverging portion 32 and the converging portion 33 and does not cause a variation in the passage section.

[0049] In the non-limiting example described and illustrated herein, the bulge 30 is prismatic.

[0050] According to a variant, not shown, the bulge is cylindrical and has a curvilinear plan outline.

[0051] Preferably, the bulge 30 extends along the entire height of the side wall 22 on which it is placed. "Height of the side wall 22" is intended to mean the distance between the bottom wall 19 and the top wall 20.

[0052] Preferably, the bulge 30 is arranged near the flue-gases inlet 23 of the inlet diffuser 12.

[0053] In the non-limiting example described herein, the bulge 30 is arranged in the first portion 25 of the inlet diffuser 12.

[0054] The size of the bulge 30 depends on the passage section of the inlet diffuser 12 in the area where the bulge 30 is arranged.

[0055] In other words, the effect of homogenizing the flow velocities is high.

[0056] Figure 3 shows a variant of the present invention wherein the inlet diffuser 12 is provided with at least one perforated plate 35.

[0057] Preferably, the perforated plate 35 is arranged transverse to the advancing direction D.

[0058] In the non-limiting example described and illustrated herein, the inlet diffuser 12 is provided with a first perforated plate 35 arranged downstream of the bulge 30 and with a second perforated plate 35 arranged at the bulge 30.

[0059] Preferably, the second perforated plate 35 is arranged between the diverging portion 32 and the converging portion 33 of the bulge 30. In the non-limiting example described and illustrated herein, the second perforated plate 35 is arranged in the intermediate portion 34, preferably at the boundary between the intermediate portion 34 and the converging portion 33.

[0060] It is understood that the inlet diffuser 12 can also comprise only one of the perforated plates 35 shown in Figure 3.

[0061] In the non-limiting example described and illustrated herein, the inlet diffuser 12 also comprises a plurality of fins 37 arranged downstream of the bulge 30.

[0062] Preferably, the fins 37 are arranged between the bulge 30 and the first perforated plate 35.

[0063] Preferably, the fins 37 are substantially uniformly distributed between the bottom wall 19 and the top wall 20.

[0064] Preferably, the fins 37 are arranged on respective planes transverse to a direction H. "Direction H" is intended to mean a direction which is substantially orthogonal to direction D and intersects the bottom wall 19 and the top wall 20.

[0065] Preferably, the fins 37 are inclined with respect to direction D.

[0066] In the non-limiting example described and illustrated herein, the fin 37a proximal to the bottom wall 19 is arranged parallel to the bottom wall 19, whereas the fin 37b proximal to the top wall 20 is parallel to the top wall 20.

[0067] The fins 37 comprised between the fin 37a and the fin 37b have inclinations comprised between the inclination of the fin 37a and the inclination of the fin 37b.

[0068] According to a variant, not shown, some or all of the fins 37 are parallel to each other.

[0069] In the non-limiting example described and illustrated herein, the inlet diffuser 12 is further provided with an auxiliary burner 38, supplied with fuel by means of a dedicated supply duct 39 (see Figure 1).

[0070] Preferably, the auxiliary burner 38 is arranged downstream of the bulge 30.

[0071] More preferably, the auxiliary burner 38 is arranged downstream of the fins 37.

[0072] Advantageously, the bulge 30 causes the flow to mix, thus allowing the velocities and temperatures of the flow of flue gases flowing in the inlet diffuser 12 to become uniform.

[0073] The succession of an increase and a decrease in the passage section of the inlet diffuser 12 causes the generation of swirling zones, which optimally mix the flow.

[0074] Advantageously, pressure drops due to the presence of one or more bulges are limited.

[0075] Due to the presence of at least two bulges 30 and at least two of a number of imposed pressure drop devices (for example, a perforated plate 35 and the fins 37), 90% of the surface downstream of the bulges 30 is hit by speeds comprised between +/- 25% of the average speed.

[0076] In the known solutions lacking the bulge 30 and with the same imposed pressure drop, the percentage of the surface downstream of the imposed pressure drop devices hit by speeds comprised between +/- 25% of the average speed falls to 13%.

[0077] These results highlight the effect of the high flow homogenization caused by the bulge 30 compared to traditional configurations.

[0078] Finally, the present invention makes it possible to avoid the use of complex and expensive homogenization systems.

[0079] Lastly, it is clear that modifications and variations may be made to the boiler and the plant described herein without departing from the scope of the appended claims.

Claims

1. A heat recovery boiler comprising:

   a flue-gases flowing chamber (11) extending along a longitudinal axis (A) and provided with an inlet (16) and an outlet (17);
   a steam circuit (14) fed with water and extending at least in part inside the flue-gases flowing chamber (11) so as to exploit the heat of the flue-gases to generate steam;
   an inlet diffuser (12) connected to the inlet (16) of the flue-gases flowing chamber (11) wherein

flue-gases from a flue-gases source (9) flow in one advancing direction (D);
at least one first wall (22; 19; 20) of the inlet diffuser (12) being provided with at least one first bulge (30).

2. The boiler according to claim 1, wherein the inlet diffuser (12) is provided with a second bulge (30).

3. The boiler according to claim 2, wherein the second bulge (30) is on a second wall (22) opposite the first wall (22).

4. The boiler according to claim 3, wherein the second bulge (30) substantially faces the first bulge (30).

5. The boiler according to anyone of claims from 2 to 4, wherein the second bulge (30) is substantially identical to the first bulge (30).

6. The boiler according to anyone of the previous claims, wherein the first bulge (30) is provided with a diverging portion (32) and with a converging portion (33) placed downstream of the converging portion (32) along the advancing direction (D).

7. The boiler according to claim 6, wherein the first bulge (30) is provided with an intermediate portion (34), which does not cause a variation of the passage section of the inlet diffuser (12); the intermediate portion (34) being placed between the diverging portion (32) and the converging portion (33).

8. The boiler according to anyone of the previous claims, wherein the inlet diffuser (12) is provided with a flue-gases inlet (23); the first bulge (30) being arranged near the flue-gases inlet (23) of the inlet diffuser (12).

9. The boiler according to anyone of the previous claims, wherein the inlet diffuser (12) comprises a bottom wall (19), a top wall (20) and two side walls (22); the first wall being one of the side walls (22).

10. The boiler according to claim 9, wherein the bottom wall (19) and the top wall (20) diverge along the advancing direction (D).

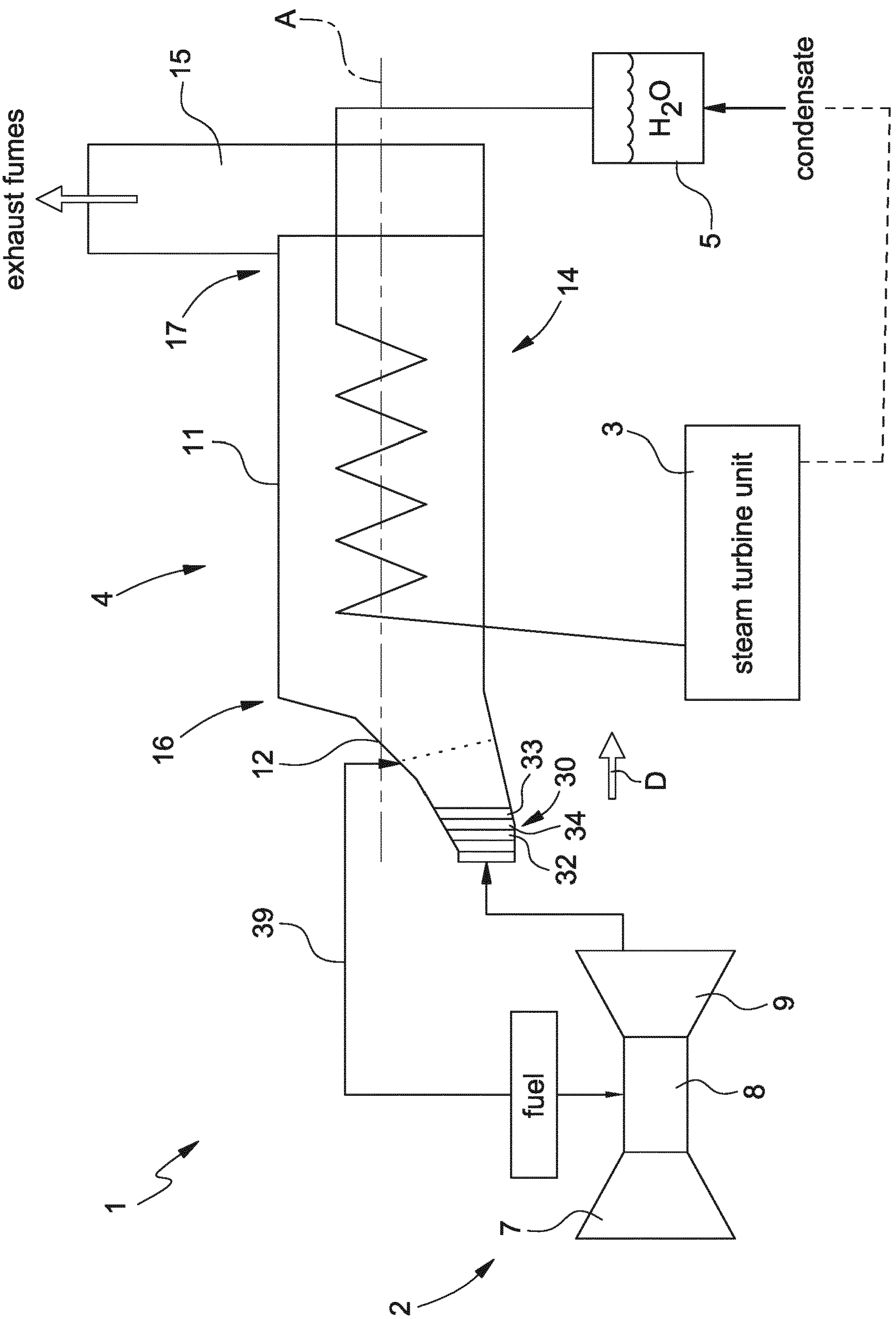
11. The boiler according to claim 9 or 10, wherein the first bulge (30) extends along the entire height of the side wall (22) on which it is placed.

12. The boiler according to anyone of the previous claims, wherein the inlet diffuser (12) comprises at least one perforated plate (35) arranged substantially transverse to the advancing direction (D).

13. The boiler according to claim 12, wherein the perforated plate (35) is placed at the first bulge (30) and/or downstream of the first bulge (30) along the advancing direction (D).

14. The boiler according to anyone of the previous claims, wherein the inlet diffuser (12) comprises a plurality of fins (37) arranged downstream of the first bulge (30) along the advancing direction (D).

15. A steam generation thermal plant comprising at least one heat recovery boiler (4) as claimed in anyone of the previous claims.


exhaust fumes
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H_2O
condensate
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11
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30
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fuel
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FIG. 1

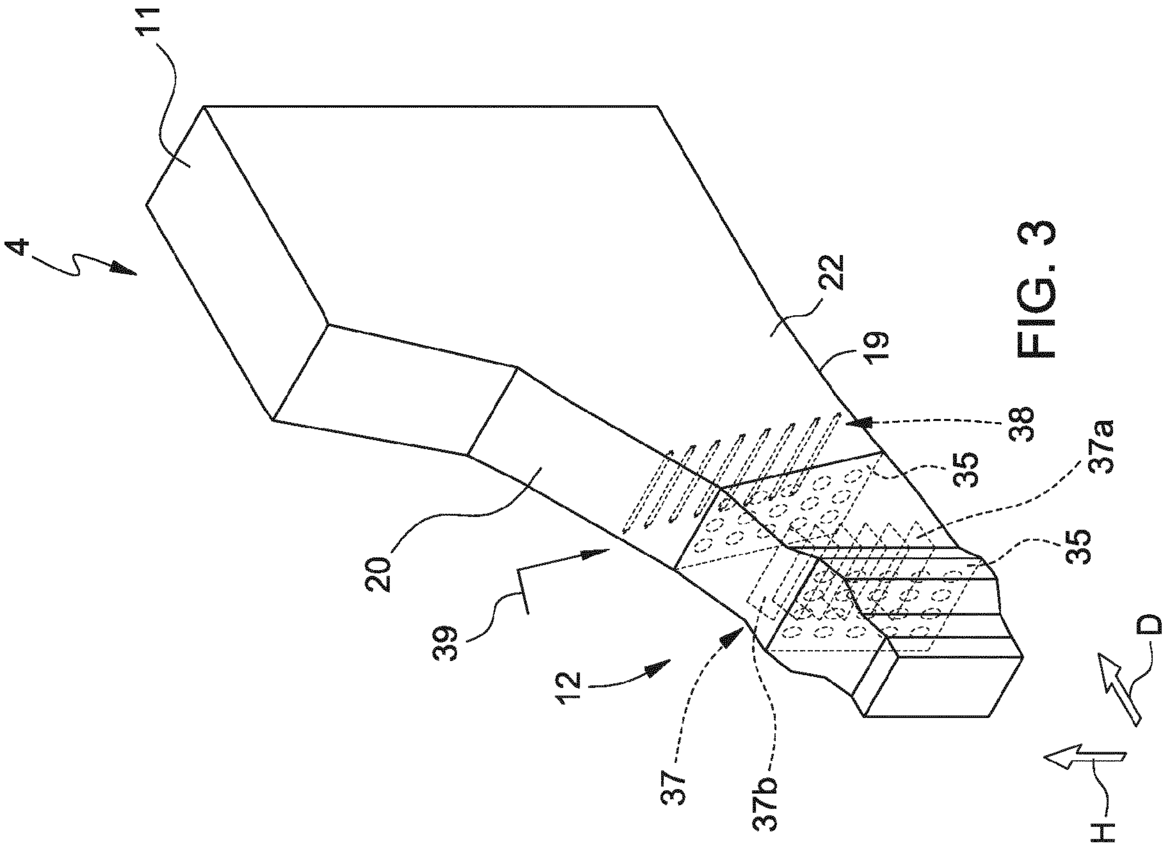
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FIG. 3

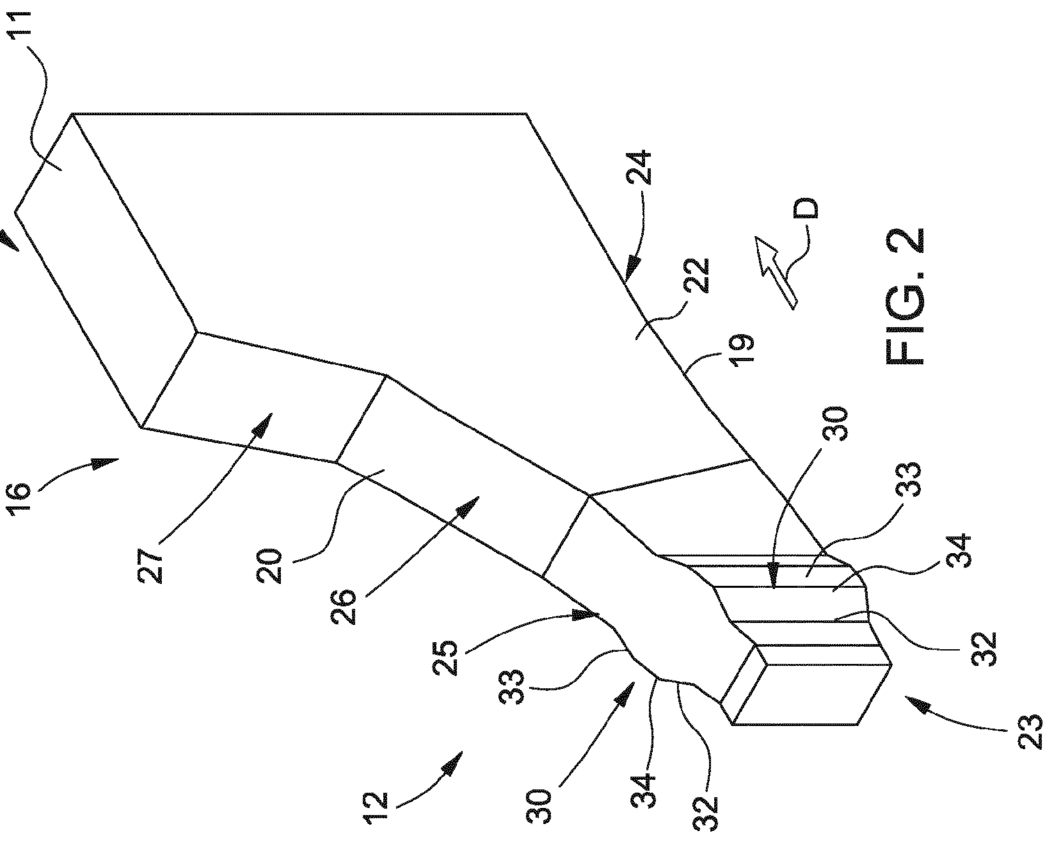
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FIG. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 20 21 0469

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The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
Munich	19 April 2021	Röberg, Andreas

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