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# (54) HEAT RECOVERY STEAM GENERATOR AND THERMAL STEAM GENERATION PLANT

(57) A recovery steam generator (4) comprises:
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) supplied with water and extending at least partially within the flue-gases flowing chamber (11) so as to exploit the heat of the flue-gases to generate steam; the steam circuit (14) comprising:
- a superheating section (20) comprising at least two superheating banks (22; 27) arranged in series with each other;
- a plurality of connecting pipes (25, 29) configured to connect the at least two superheating banks (22; 27) in series with each other;
- at least a plurality of first injection pipes (30; 31) configured to inject a first heat transfer fluid into each of the connecting pipes (25; 25, 29);
- a control device (34) configured to regulate the flow rate of the first heat transfer fluid supplied via the first injection pipes (30; 31).

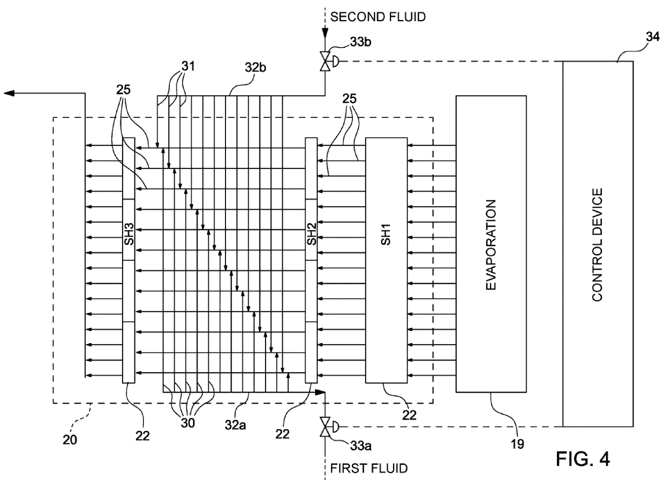


FIG. 4

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## Description

CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This Patent Application claims priority from Italian Patent Application No. 102021000010919 filed on April 29, 2021.

**[0002]** The present invention relates to a recovery steam generator and a plant including said recovery steam generator. In particular, the present invention relates to a recovery steam generator configured to produce steam using heat dispersed from gas turbines and/or industrial processes.

**[0003]** The present invention also relates to a thermal plant for generating steam comprising said recovery steam generator.

**[0004]** Thermal plants for generating steam normally comprise a recovery steam generator, 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]** Recovery steam generators normally comprise a flue-gases flowing chamber and a steam circuit supplied with water and extending at least partially within the flue-gases flowing chamber so as to exploit the heat of the flue-gases to generate steam; the steam circuit comprises in sequence at least one evaporation section and one superheating section.

**[0006]** The temperature control in the steam circuit is essential to avoid temperature rises beyond nominal conditions. In addition, the temperature control mode is essential to optimise the heat exchange between the flue-gases and the steam circuit and to optimise the efficiency of the plant thermal cycle. In particular, the temperature control in the superheating section has an important effect on improving heat transfer. The superheating section consists of several heat exchange banks and is arranged in the hottest section of the flue-gases flowing chamber. Non-efficient thermodynamic processes in one or more banks of the superheating section affect the heat transfer in the banks downstream of the superheating section with obvious disadvantages.

**[0007]** The temperature control in the steam circuit is particularly important when the steam generator operates with low flue-gas flow rates (i.e. system low load situations) or excessive flow rates (i.e. peak system load situations), in particular climatic conditions wherein outside temperatures are high (such as in summer) or during the system start-up steps.

**[0008]** Optimising the heat exchange results in an increase in the efficiency of the steam generator.

**[0009]** It is therefore an aim of the present invention to make a highly efficient steam generator.

**[0010]** Some solutions have already been implemented and disclosed in documents WO2008/152205A1, US2016/273406A1, US 2008/236139A1, US2011/203274A1, US2014/096535A1. However, such solutions are characterised by complex and bulky structures that are not efficient enough.

**[0011]** In accordance with such aims, the present invention relates to a recovery steam generator comprising:

a flue-gases flowing chamber extending along a longitudinal axis and provided with an inlet and an outlet; a steam circuit supplied with water and extending at least partially within the flue-gases flowing chamber so as to exploit the heat of the flue-gases to generate steam; the steam circuit comprising:

- a superheating section comprising at least two superheating banks arranged in series with each other;
- a plurality of connecting pipes configured to connect the at least two superheating banks in series with each other;
- at least a plurality of first injection pipes configured to inject a first heat transfer fluid into each of the connecting pipes;
- a control device configured to regulate the flow rate of the first heat transfer fluid supplied via the first injection pipes.

**[0012]** Thanks to a controlled injection of at least one heat transfer fluid into the connecting pipes between the superheating banks, the temperature of the steam in the superheating section can be controlled. The type and process parameters of the injected heat transfer fluid have an effect on the efficiency of the process and heat recovery.

**[0013]** It is also an aim of the present invention to implement a highly efficient thermal plant.

**[0014]** According to these aims, the present invention relates to a thermal plant as claimed in Claim 15.

**[0015]** Further characteristics and advantages of the present invention will become clear from the following description of a non-limiting embodiment thereof, with reference to the figures of the attached drawings, wherein:

- Figure 1 is a schematic side representation, with parts in section and parts removed for clarity's sake, of a thermal plant according to the present invention comprising a recovery steam generator;
- Figure 2 is a schematic side representation, with parts in section and parts removed for clarity's sake, of the recovery steam generator of Figure 1;
- Figure 3 is a schematic side representation, with parts in section and parts removed for clarity's sake, of the recovery steam generator of Figure 1 according to an alternative embodiment;
- Figure 4 is a schematic top representation of a first detail of the steam generator according to the embodiment of Figure 2;
- Figure 5 is a schematic perspective representation, with parts removed for clarity's sake, of a second detail of the recovery steam generator according to

the embodiment of Figure 2;

- Figure 6 and Figure 7 are respectively a schematic front and side view, with parts removed for clarity's sake, of a third detail of the recovery steam generator according to the embodiment of Figure 2.

**[0016]** In Figure 1 reference number 1 denotes a thermal plant for steam generation.

**[0017]** The plant 1 shown in Figure 1 is schematically represented and is not complete in all its parts.

**[0018]** In the non-limiting embodiment herein described and shown, the plant 1 is configured to produce electric energy and therefore the steam generated is used to generate electricity, as we shall see shortly in detail.

**[0019]** A variant not shown provides that the plant 1 is configured to produce thermal energy, that is useful for example in district heating applications.

**[0020]** The plant 1 comprises a gas turbine unit 2, a steam turbine unit 3, a steam generator 4, and a tank 5.

**[0021]** The gas turbine unit 2 is the first motor of the plant 1 and may be power-supplied by any fuel.

**[0022]** The gas turbine unit 2 is connected to a generator 6 and comprises a compressor 7, a combustion chamber 8 and a gas turbine 9.

**[0023]** The steam turbine unit 3 is coupled to a respective generator (not shown in the enclosed figures) and comprises at least one steam turbine (not shown).

**[0024]** The steam generator 4 recovers the residual heat from the combustion flue-gases generated by the gas turbine unit 2 and produces steam to be supplied to the steam turbine unit 3.

**[0025]** In particular, the steam generator 4 comprises a flue-gases flowing chamber 11, an inlet hood 12, a steam circuit 14 and a chimney 15.

**[0026]** The flue-gases flowing chamber 11 extends along a longitudinal axis A and is provided with an inlet 16 and an outlet 17.

**[0027]** In the non-limiting example herein described and shown, the flue-gases flowing chamber 11 extends along an axis A that is arranged, in use, substantially horizontally.

**[0028]** According to a variant not shown, the flue-gases flowing chamber may extend along an axis that is arranged, in use, substantially vertically.

**[0029]** The inlet 16 of the flue-gases flowing chamber 11 is supplied with flue-gases from the gas turbine 9. The flue-gases flow into the inlet hood 12 and the flue-gases flowing chamber 11 substantially following a feed direction D.

**[0030]** The outlet 17 of the flue-gases flowing chamber 11 is connected to the chimney 15, through which flue-gases are discharged into the atmosphere.

**[0031]** The steam circuit 14 is schematically represented in Figure 1. Substantially, the steam circuit 14 is supplied with water, preferably from the tank 5, and extends at least partially within the flue-gases flowing chamber 11 so as to exploit the heat of the flue-gases to generate steam.

**[0032]** The water in the tank 5 is preferably demineralised and is mostly water from a condenser (not shown) connected to the steam turbine unit 3.

**[0033]** In the steam circuit 14, the water from the tank 5 is transformed into steam. The feed direction V of the water and steam within the steam circuit 14 is substantially opposite to the direction D.

**[0034]** The steam circuit 14 comprises at least one evaporation section 19 and at least one superheating section 20, which is arranged downstream of the evaporation section 19 along the feed direction V.

**[0035]** In the non-limiting example herein described and shown, the steam circuit 14 further comprises an economiser section 21, arranged upstream of the evaporation section 19 along the feed direction V. The economiser section 21 is optional and may not be present.

**[0036]** Each section comprises respective heat exchange banks suitably configured to optimise the heat exchange between the flue-gases flowing in the flue-gases flowing chamber 11 and the water and steam flowing in the steam circuit 14.

**[0037]** In Figure 2 and Figure 3 two alternative configurations of the superheating section 20 of the steam generator 4 are represented.

**[0038]** In both configurations, the superheating section 20 is characterised by the steam circulation having a temperature higher than the saturation temperature.

**[0039]** In other words, superheated steam circulates in the superheating section 20.

**[0040]** With reference to Figure 2 and Figure 3, the superheating section 20 comprises a plurality of superheating banks 22 arranged in series.

**[0041]** The superheating banks 22 shown in Figure 2 and Figure 3 are supplied with the steam coming from the evaporation section 19 and are normally referred to as SH (SuperHeating) banks in technical jargon. The last superheating bank 22 supplies the steam turbine unit 3. In the non-limiting examples of Figures 2 and 3 there are three superheating banks 22.

**[0042]** In the configuration shown in Figure 3, the superheating section 20 comprises further superheating banks 27 arranged in series with each other, normally referred to as RH (ReHeating) banks in technical jargon, which are supplied with steam coming from the steam turbine unit 3. Preferably, the steam supplied to the superheating banks 27 is steam coming from the high-pressure stage of a steam turbine (not shown).

**[0043]** The last superheating bank 27 supplies the steam turbine unit 3. Preferably, the last superheating bank 27 supplies a medium pressure stage of a steam turbine (not shown).

**[0044]** Sometimes, the superheating banks 27 are also referred to as re-superheating banks to emphasise the fact that they are supplied with steam which has been already superheated by the superheating banks 22 and coming from the steam turbine unit 3.

**[0045]** Here and hereinafter the term superheating bank is intended to identify all the heat exchange banks of the superheating section 20 wherein superheated steam circulates irrespective of the origin of the steam circulating through them. The superheating banks 22 are connected to each other by means of a plurality of connecting pipes 25 (only one of which is visible in a side view). In the optional configuration of Figure 3, the superheating banks 27 (two in total) are connected to each other by a plurality of connecting pipes 29 (only one of which is visible in a side view) .

**[0046]** In other words, each superheating bank 22 is connected to the adjacent superheating bank 22 by a plurality of connecting pipes 25 and, if present, each superheating bank 27 is connected to the adjacent superheating bank 27 by a plurality of connecting pipes 29.

**[0047]** Preferably, the superheating banks 22 and 27 extend in respective planes orthogonal to the extension axis A of the flue-gases flowing chamber 11. In Figure 4 the configuration of Figure 2 is shown according to a view from above, which makes the connecting pipes 25 visible.

**[0048]** With reference to Figure 4, the steam circuit 14 comprises a plurality of first injection pipes 30, configured to inject a first heat transfer fluid into each of the connecting pipes 25, and a plurality of second injection pipes 31, configured to inject a second heat transfer fluid into each of the connecting pipes 25.

**[0049]** The first injection pipes 30 are connected to a first manifold 32a, and the second injection pipes 31 are connected to a second manifold 32b. The flow rate of the first heat transfer fluid supplied to the first manifold 32a is adjusted by a first valve 33a under the control of a control device 34, and the flow rate of the second heat transfer fluid supplied to the second manifold 32b is adjusted by a second valve 33b under the control of the control device 34.

**[0050]** The first heat transfer fluid is preferably different from the second heat transfer fluid.

**[0051]** In the non-limiting example herein described and shown, the first heat transfer fluid is steam and the second heat transfer fluid is water.

**[0052]** It should be understood that other heat transfer fluids may also be used, such as carbon dioxide $CO_2$.

**[0053]** The steam supplied to the connecting pipes 25 must have a pressure greater than the pressure of the steam circulating in the connecting pipes 25 to ensure a correct injection.

**[0054]** Therefore, the steam may be drawn from a steam source at a suitable pressure or may be drawn at any point in the steam circuit 14 upstream of the two superheating banks 22 connected by the connecting pipes 25 into which the steam is injected.

**[0055]** For example, the steam may be drawn at any point in the steam circuit 14 at the outlet of the evaporation section 19.

**[0056]** Water may be taken from a dedicated source or tank 5 or from any point in the steam circuit 14 arranged upstream of the evaporation section 19.

**[0057]** For example, water may be drawn from any point in the steam circuit 14 in the economiser section 21, if present.

**[0058]** According to a variant not shown, the steam circuit 14 comprises a plurality of injection pipes, configured to inject a single heat transfer fluid into each of the connecting pipes. In this case as well, the flow rate of the supplied heat transfer fluid is adjusted by a respective valve under the control of the control device. In this case as well, the heat transfer fluid may be steam, water or, for example, carbon dioxide $CO_2$.

**[0059]** Referring to Figure 5, each connecting pipe 25 is fluidically connected to a respective injection pipe 30 and a respective injection pipe 31.

**[0060]** The connecting pipes 25 extend along a path, which comprises at least an inlet portion 35, an outlet portion 36 and an intermediate portion 37 arranged between the inlet portion 35 and the outlet portion 36.

**[0061]** The inlet portion 35 is connected to a respective manifold pipe of the tube bundle (non-visible) defining the superheating bank 22 arranged upstream along the direction V, while the outlet portion 36 is connected to a respective manifold pipe of the tube bundle (non-visible) defining the superheating bank 22 arranged downstream along the direction V.

**[0062]** The intermediate portion 37 is planar. In other words, the intermediate portion 37 extends substantially along a plane, preferably orthogonal to the extension plane of the superheating banks 22.

**[0063]** The inlet portion 35 and the outlet portion 36 preferably have respective curved sections 39 40 to allow the connection between the manifold pipe of the tube bundle defining the superheating bank 22 and the intermediate portion 37.

**[0064]** In the non-limiting example herein described and shown, the curved sections 39 40 connect portions of the connecting pipe 25 arranged at 90°.

**[0065]** Preferably, the intermediate portion 37 of the connecting pipe 25 follows a path wound around itself so as to substantially define a loop, preferably rectangular.

**[0066]** The intermediate portion 37 comprises, in sequence, a first rectilinear section 41a connected to the inlet portion 35, a substantially U-shaped section 41b, a second rectilinear section 41c, and a final curved section 41d connected to the outlet portion 36.

**[0067]** Preferably, the injection pipes 30 and 31 fit in respective injection pipes 25 at respective connecting points 42 43 arranged substantially in the intermediate portion 37 of the connecting pipe 25 at a predetermined distance.

**[0068]** Preferably, downstream of each connecting point 42 43 along the steam flow direction V the connecting pipe 25 has a respective localised enlargement of the flowing section. In other words, downstream of the connecting points 42 43 along the steam flow direction V the connecting pipe 25 is provided with respective bulges 47 48.

**[0069]** Each bulge 47 48 is defined by an initial portion 50a 50b, wherein there is a gradual radial increase in the flowing section starting from the initial section of the connecting pipe 25 to a maximum value, by a central portion 51a 51b, wherein the flowing section is constant and at the maximum value, and by an end section 52a 52b, wherein there is a gradual return of the flowing section from the maximum value to the initial value of the connecting pipe 25.

**[0070]** Advantageously, the bulges 47 48 mitigate the thermal shock effects due to the temperature change caused by the injection of the first fluid and the second fluid.

**[0071]** Furthermore, the bulges 47 48 promote mixing of the steam circulating in the connecting pipes 25 with the first fluid and the second fluid.

**[0072]** Preferably, the injection pipe 30 of the first fluid substantially fits in the curved section 39 of the inlet portion 35, while the injection pipe 31 fits in the rectilinear section 41c of the intermediate portion 37.

**[0073]** Referring to Figure 6 and Figure 7, the injection pipe 30 preferably has a nozzle 55, preferably L-shaped, so that it can be positioned substantially at the centre of the connecting pipe 25. The centre of the connecting pipe 25 means a central position within the connecting pipe as shown in Figure 6. Such position allows an optimal mixing of the first fluid supplied with the injection pipe 30.

**[0074]** More preferably, the opening 56 of the nozzle 55 has a profile defined so that the ratio of the profile perimeter of the opening 56 to the flowing area of the opening 56 is greater than an optimum reference value. This increases the mixing of the steam flow and the flow of the first injected fluid having, in most cases, different temperatures.

**[0075]** According to a further variant not shown, the steam circuit comprises additional injection pipes configured to inject one or more heat transfer fluids into each of the connecting pipes 29 connecting the further superheating banks 27 of the configuration shown in Figure 3 under the control of the control device. Basically, the structure of the connecting pipes 29 and the additional injection pipes is similar to that shown in Figures 4 and 5.

**[0076]** In use, when the control device 34 deems it necessary to change the temperature or the flow rate of the steam circulating in the connecting pipes 25 (or also in the connecting pipes 29 according to the above-described variant), it adjusts the control valves 33a 33b so as to supply appropriate flow rates of the first fluid and, possibly, of the second fluid.

**[0077]** In particular, the control device 34 is configured to open the adjustment valves 33a 33b under specific operating conditions of the steam generator 4; for example at peak load or low load times, or during summer periods.

**[0078]** Obviously, the same considerations made for the connecting pipes 25 may be applied to the connecting pipes 29. Therefore, if required, the control device 34 may adjust the supply of one or more heat transfer fluids in the connecting pipes 29 as well.

**[0079]** Advantageously, the proposed solution enables a quick and effective increase in the plant performance. Furthermore, the presence of a plurality of injecting pipes 30, 31 capable of injecting one or more heat transfer fluids directly into the connecting pipes 25, 29 between the superheating banks 22, 27 allows to act effectively and rapidly.

**[0080]** Finally, it is clear that changes and variations can be made to the steam generator and plant herein described without departing from the scope of the enclosed claims.

## Claims

**1.** Recovery steam generator (4) 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) supplied with water and extending at least partially within the flue-gases flowing chamber (11) so as to exploit the heat of the flue-gases to generate steam; the steam circuit (14) comprising:

- a superheating section (20) comprising at least two superheating banks (22; 27) arranged in series with each other;
- a plurality of connecting pipes (25, 29) configured to connect the at least two superheating banks (22; 27) in series with each other;
- at least a plurality of first injection pipes (30; 31) configured to inject a first heat transfer fluid into each of the connecting pipes (25; 25, 29);
- a control device (34) configured to regulate the flow rate of the first heat transfer fluid supplied via the first injection pipes (30; 31).

**2.** Steam generator according to claim 1, wherein the first heat transfer fluid is water.

**3.** Steam generator according to claim 2, wherein the steam circuit (14) comprises an evaporation section (19) arranged upstream of the superheating section (20); the first injection pipes (31) being configured to draw water upstream of the evaporation section (19).

**4.** Steam generator according to claim 3, wherein the steam circuit (14) comprises an economiser section (21) arranged upstream of the evaporation section (19); the first injection pipes (31) being configured to draw water from the economiser section (21).

**5.** Steam generator according to claim 1, wherein the first heat transfer fluid is steam.

6. Steam generator according to claim 5, wherein the first injection pipes (30) are configured to draw steam upstream of the superheating banks (22; 29).

7. Steam generator according to claim 5 or 6, wherein the steam circuit comprises an evaporation section (19) arranged upstream of the superheating section (20); the first injection pipes (30) being configured to draw steam from the evaporation section (19) or from a point between the evaporation section (19) and the superheating section (20).

8. Steam generator according to claim 1, wherein the first heat transfer fluid is carbon dioxide.

9. Steam generator according to claim 1, wherein the steam circuit (14) comprises at least a plurality of second injection pipes (31; 30) configured to inject a second heat transfer fluid into each of the connecting pipes (25; 25, 29); the second heat transfer fluid being different from the first heat transfer fluid; the control device (34) being configured to regulate the flow rate also of the second heat transfer fluid supplied via the second injection pipes (31; 30) .

10. Steam generator according to claim 9, wherein the first heat transfer fluid is steam and the second heat transfer fluid is water.

11. Steam generator according to claim 10, wherein the steam circuit (14) comprises an evaporation section (19) disposed upstream of the superheating section (20); the first injection pipes (30) being configured to draw steam upstream of the superheating banks (22; 29) and the second injection pipes (31) being configured to draw water upstream of the evaporation section (19).

12. Steam generator according to claim 11, wherein each first injection pipe (30) is coupled to the respective connecting pipe (25; 25, 29) and is provided with a respective discharge nozzle (55) configured to discharge the first heat transfer fluid substantially in a central portion inside the respective connecting pipe (25; 25, 29).

13. Steam generator according to any one of the preceding claims, wherein the first injection pipes (30) are connected to a first manifold (32a) provided with a first valve (33a); the control device (34) being configured to adjust the first valve (33a) to control the flow rate of the first heat transfer fluid fed to the first manifold (32a).

14. Steam generator according to any one of claims 9 to 13, wherein the second injection pipes (31) are connected to a second manifold (32b) provided with a second valve (33b), the control device (34) being configured to adjust the second valve (33b) to control the flow rate of the second heat transfer fluid fed to the second manifold (32b).

15. Thermal steam generation plant comprising at least one recovery steam generator (4) as claimed in any one of the preceding claims.

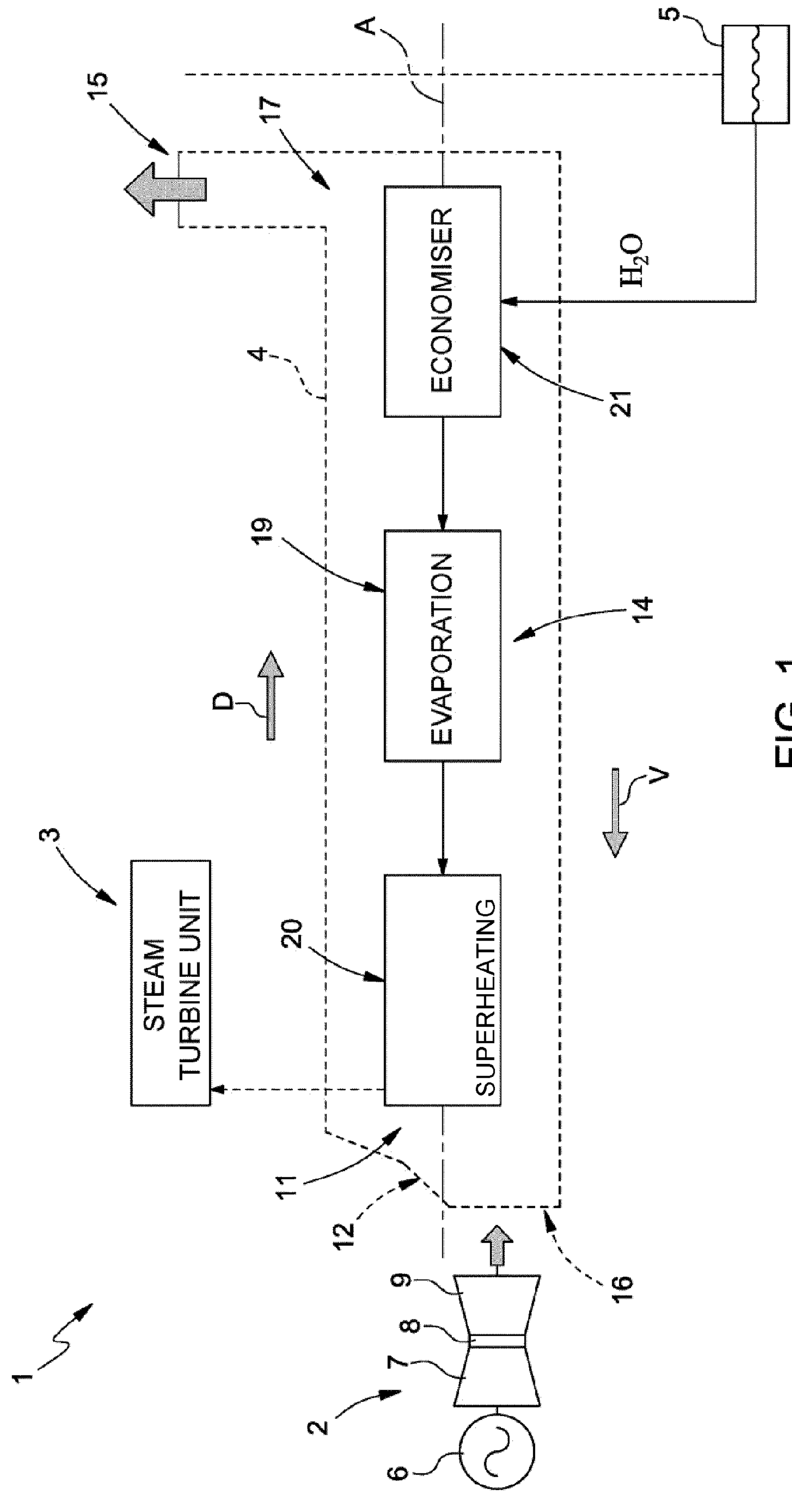
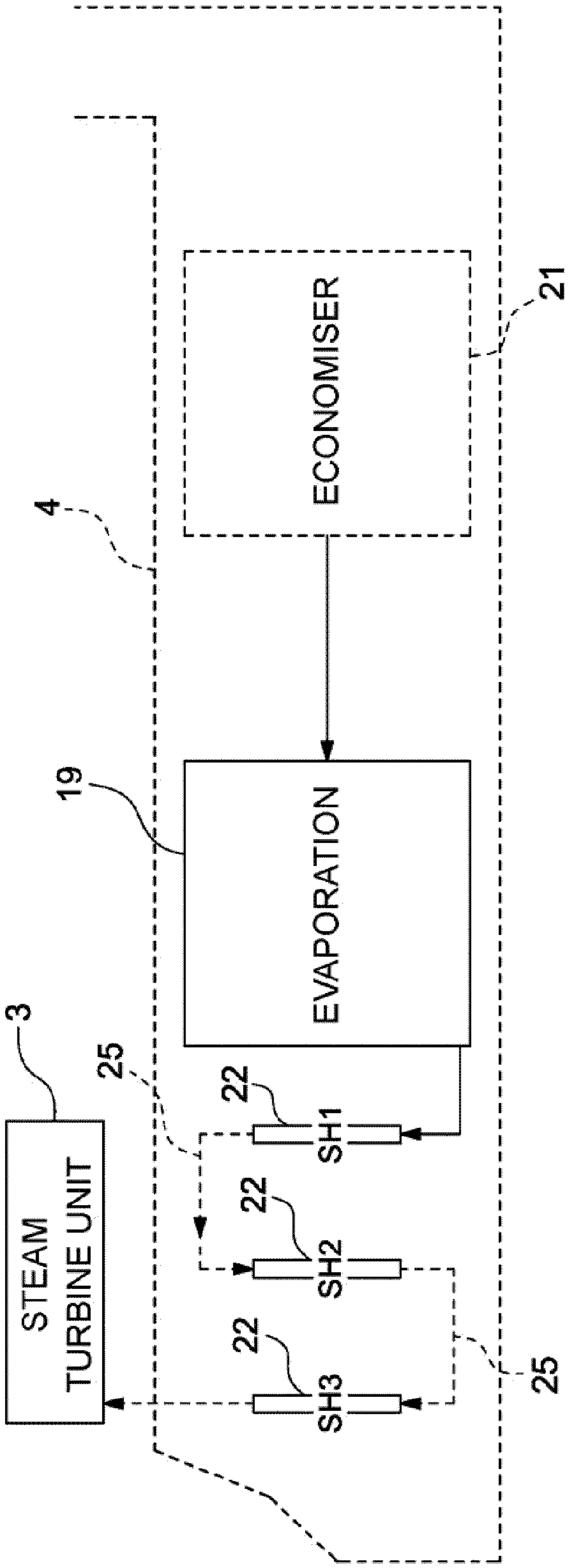

ECONOMISER
EVAPORATION
SUPERHEATING
STEAM
TURBINE UNIT
$H_2O$
A
D
V
1
2
3
4
5
6
7
8
9
11
12
14
15
16
17
19
20
21

FIG. 1


STEAM TURBINE UNIT
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25
22
SH1
SH2
SH3
22
22
25
19
EVAPORATION
ECONOMISER
21

FIG. 2

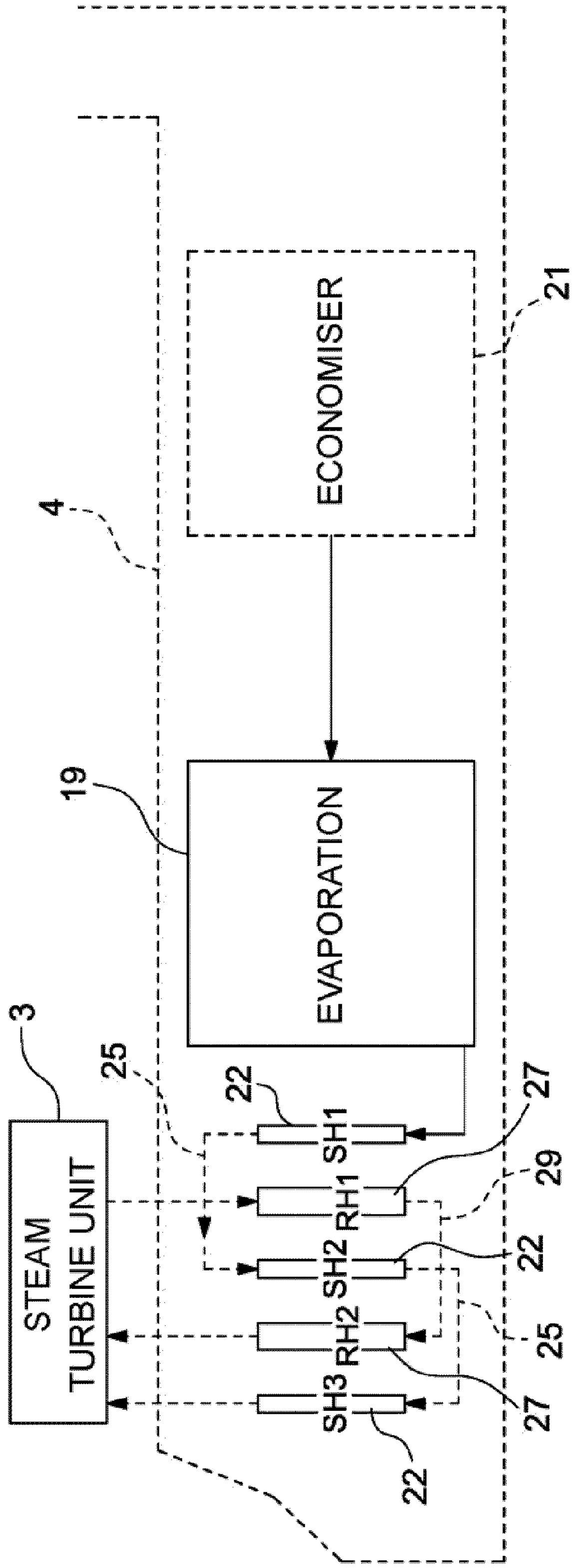
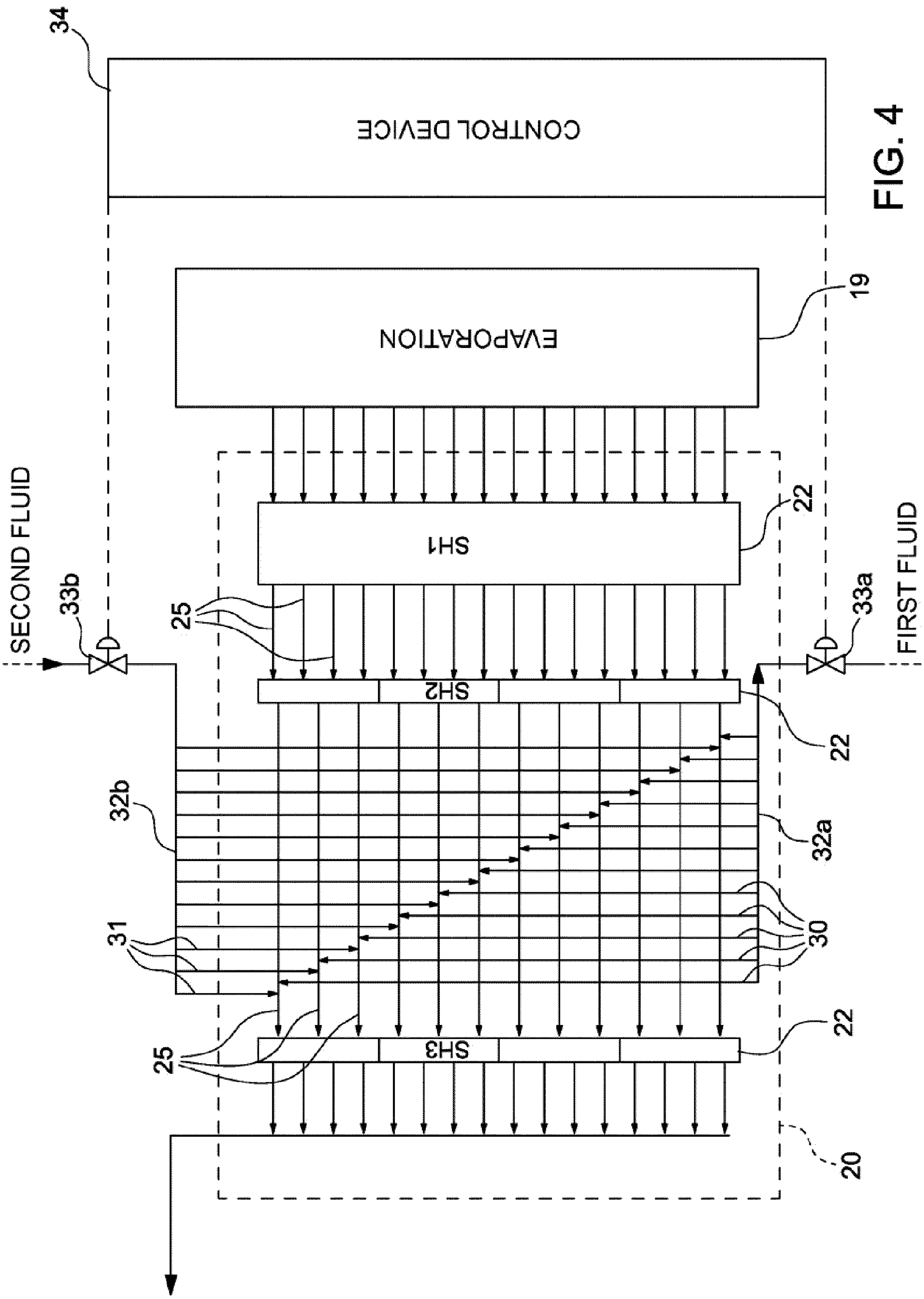
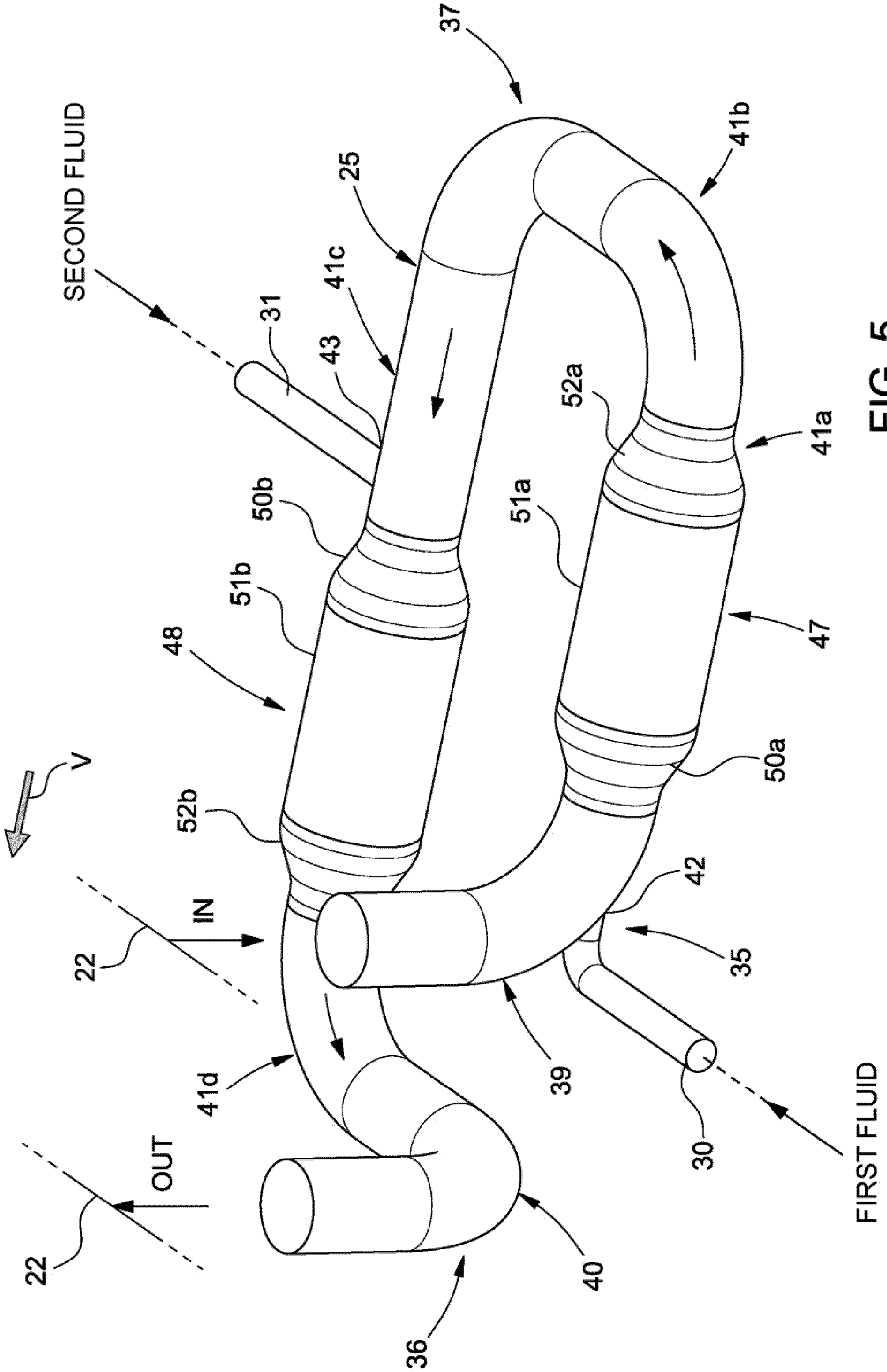

STEAM TURBINE UNIT
3
4
25
22
SH1
RH1
SH2
RH2
SH3
27
29
22
25
27
22
19
EVAPORATION
ECONOMISER
21

FIG. 3



34
CONTROL DEVICE
EVAPORATION
19
SH1
22
SH2
22
SH3
22
25
25
SECOND FLUID
33b
FIRST FLUID
33a
32b
32a
31
30
20


FIG. 4


37
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41c
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52a
41a
51a
50b
51b
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V
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52b
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IN
22
35
39
41d
30
FIRST FLUID
OUT
22
40
36

FIG. 5

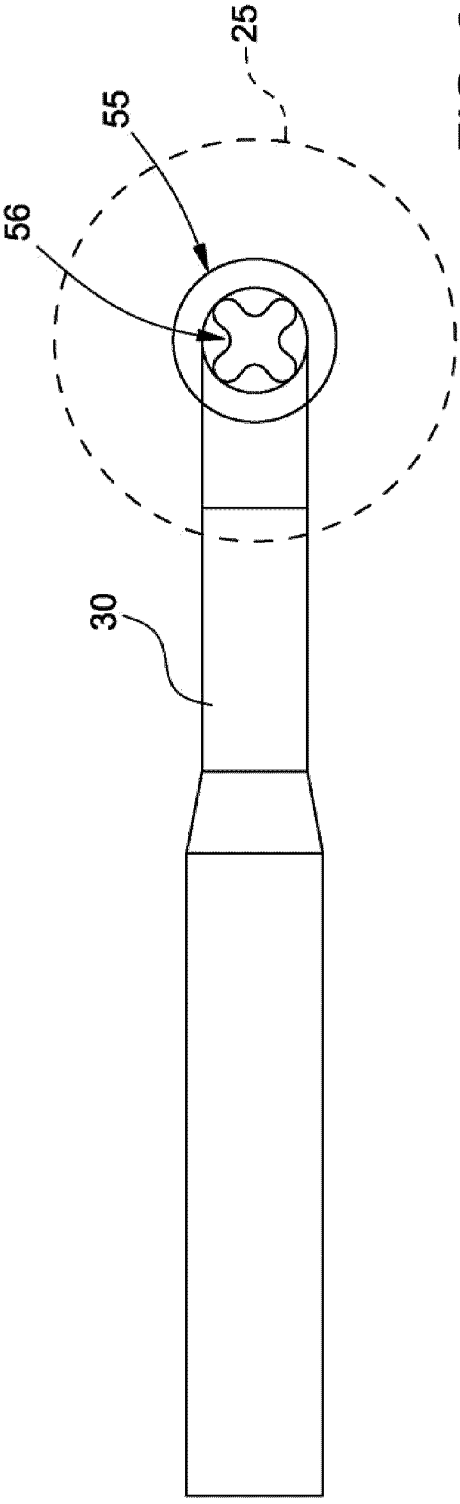


FIG. 6

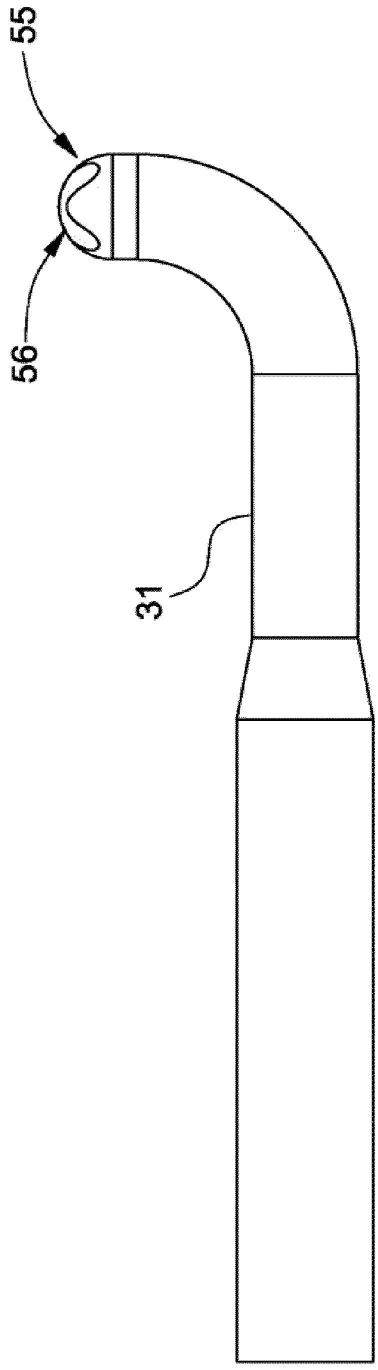


FIG. 7

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# EUROPEAN SEARCH REPORT

Application Number
EP 22 17 0899

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
| X<br>A | WO 2008/152205 A1 (AAF CONSULT OY [FI]; JANKA PENTTI [FI] ET AL.) 18 December 2008 (2008-12-18)<br>* page 3, line 30 - page 7, line 19; figures 1A,1B * | 1-4,13, 15<br>8-12,14 | INV.<br>F22G1/02<br>F22G5/12<br>F22G7/12<br>F22G5/14<br>F01K23/10 |
| X | US 2016/273406 A1 (OLIA HAMID [CH] ET AL) 22 September 2016 (2016-09-22)<br>* paragraphs [0029] - [0042]; figures 1,2 * | 1-7,13, 15 | |
| X | US 2008/236139 A1 (ONAKA IKUO [JP] ET AL) 2 October 2008 (2008-10-02)<br>* paragraphs [0027] - [0030]; figure 1 * | 1-4,13, 15 | |
| X | US 2011/203274 A1 (BERGER FRED [DE]) 25 August 2011 (2011-08-25)<br>* paragraphs [0027] - [0033]; figure 1 * | 1-4,13, 15 | |
| X | US 2014/096535 A1 (ESAKKI LAKSHMANAN [IN] ET AL) 10 April 2014 (2014-04-10)<br>* paragraphs [0013] - [0016]; figure 1 * | 1-4,13, 15 | TECHNICAL FIELDS SEARCHED (IPC) |
| A | US 2008/302102 A1 (CHENG XU [US] ET AL) 11 December 2008 (2008-12-11)<br>* paragraphs [0015] - [0019]; figure 1 * | 1-15 | F22G<br>F01K |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| Munich | 9 September 2022 | Röberg, Andreas |

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| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| WO 2008152205 A1 | 18-12-2008 | NONE | |
| US 2016273406 A1 | 22-09-2016 | CA 2932219 A1 | 11-06-2015 |
| | | CN 105765180 A | 13-07-2016 |
| | | EP 3077632 A1 | 12-10-2016 |
| | | KR 20160093030 A | 05-08-2016 |
| | | US 2016273406 A1 | 22-09-2016 |
| | | WO 2015082364 A1 | 11-06-2015 |
| US 2008236139 A1 | 02-10-2008 | JP 4929010 B2 | 09-05-2012 |
| | | JP 2008248808 A | 16-10-2008 |
| | | US 2008236139 A1 | 02-10-2008 |
| US 2011203274 A1 | 25-08-2011 | CN 102162376 A | 24-08-2011 |
| | | DE 102011011123 A1 | 25-08-2011 |
| | | EP 2363577 A1 | 07-09-2011 |
| | | JP 5615202 B2 | 29-10-2014 |
| | | JP 2011174465 A | 08-09-2011 |
| | | US 2011203274 A1 | 25-08-2011 |
| US 2014096535 A1 | 10-04-2014 | CN 203584580 U | 07-05-2014 |
| | | GB 2509210 A | 25-06-2014 |
| | | US 2014096535 A1 | 10-04-2014 |
| US 2008302102 A1 | 11-12-2008 | CA 2633277 A1 | 07-12-2008 |
| | | CN 101368723 A | 18-02-2009 |
| | | EP 2067936 A2 | 10-06-2009 |
| | | EP 2107220 A2 | 07-10-2009 |
| | | GB 2449998 A | 10-12-2008 |
| | | HK 1124650 A1 | 17-07-2009 |
| | | US 2008302102 A1 | 11-12-2008 |

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## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description

- IT 102021000010919 **[0001]**
- WO 2008152205 A1 **[0010]**
- US 2016273406 A1 **[0010]**
- US 2008236139 A1 **[0010]**
- US 2011203274 A1 **[0010]**
- US 2014096535 A1 **[0010]**