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(71) Applicant: **Siemens Aktiengesellschaft**
80333 München (DE)

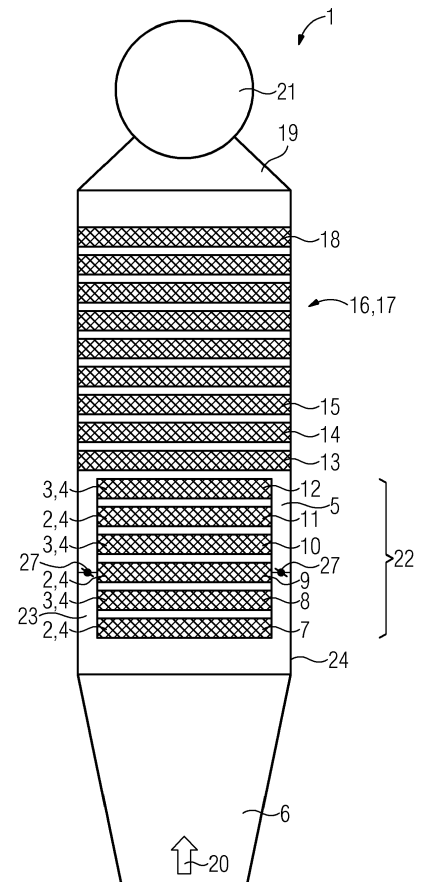
(72) Inventors:
• **Jyethi, Dipta Saurav**
Sector 10A Gurgaon (IN)
• **Schöttler, Michael**
91052 Erlangen (DE)

(54) **SUPERHEATER AND REHEATER STEAM TEMPERATURE CONTROL BY EXHAUST GAS BYPASS**

(57) A heat recovery steam generator (1) comprising superheater and reheater tube banks (2, 3) forming heat exchanger surfaces (4), with a device (5) for guiding exhaust gas (20) around the superheater and reheater tube banks (2, 3) is provided.

Furthermore, a method to control the steam outlet temperature of a heat recovery steam generator (1) is provided.

FIG 1



Description

FIELD OF THE INVENTION

[0001] The present invention relates to a heat recovery steam generator and a method to control the steam outlet temperature of a heat recovery steam generator.

[0002] More specifically, the invention relates to a heat recovery steam generator, where the exhaust gas flow is partly bypassed around superheater and reheater tube banks or where some superheater or reheater tube banks are blocked. Furthermore, the invention relates to a corresponding method of bypassing exhaust gas flow or blocking tube banks.

BACKGROUND OF THE INVENTION

[0003] In known combined cycle power plants, during start-up and part load operation of the heat recovery steam generator, there is typically an increase in the superheater and reheater temperatures. This is due to the fact that there is less amount of steam flow in the superheater and reheater during start-up and part load operations. Thus the heat exchanger surface is more than that is required at this condition.

[0004] A typical disadvantage of such known combined cycle power plants is that as a result the steam absorbs more heat from the gas turbine exhaust gas resulting in increase of superheater and reheater steam outlet temperature above the design temperature.

[0005] In order to solve this problem inter stage attemperators are usually used to control the superheater and reheater temperatures in a heat recovery steam generator when the steam temperature is more than the designed temperature. So spray of comparatively cold water in the inter stage superheater / reheater is done to reduce the steam temperature to the allowable level. A final attemperator improves the efficiency compared to the use of the interstage attemperator but is not accepted by many clients and discouraged by ASME (American Society of Mechanical Engineers).

[0006] As an alternative, steam bypass is used to control the final outlet temperature. Saturated steam from the drum outlet is mixed with the steam before the last superheater to control the steam temperature at the outlet of the last superheater. A typical disadvantage of such known combined cycle power plants is that the design and availability of steam bypass control valve is difficult regarding size and characteristic as the available pressure drop over the bypass control valve is too low.

[0007] It is therefore a goal of the present invention to provide a heat recovery steam generator, in which steam outlet temperature does not increase above design temperature. A further goal of the invention is to provide a method to control the steam outlet temperature of a heat recovery steam generator.

SUMMARY OF THE INVENTION

[0008] The object of the invention is achieved by the independent claims. The dependent claims describe advantageous developments and modifications of the invention.

[0009] In accordance with the invention there is provided a heat recovery steam generator comprising superheater and reheater tube banks forming heat exchanger surfaces, further comprising a device for guiding exhaust gas around at least a part of the superheater and reheater tube banks.

[0010] The essential idea of the present invention is that during the startup or part load operation, when there is less steam flow in the superheater and reheater section, the outlet steam temperature can be controlled by decreasing contact between the hot exhaust gases and the heat exchanger surfaces.

[0011] This can be achieved either by an embodiment, where the device is designed to guide at least a part of the exhaust gas around the superheater and reheater tube banks, i.e. bypassing (partly) the exhaust gas flow around the superheater and reheater tubes banks.

[0012] Or, this objective can be achieved by an embodiment, wherein the device is designed to guide the exhaust gas around at least a part of superheater and reheater tube banks, i.e. covering (partly) some superheater and reheater tube banks.

[0013] So only the required heat is absorbed by the superheater and reheater section and the excess heat can be transferred to the evaporators, intermediate pressure/low pressure sections, economizers, condensate preheaters, etc. Thus the process improves the overall efficiency of the boiler.

[0014] The method to control the steam outlet temperature of a heat recovery steam generator comprising superheater and reheater tube banks forming heat exchanger surfaces according to the present invention is characterized by the step of guiding exhaust gas at least partly around the superheater and reheater tube banks.

[0015] This is achieved either by bypassing at least a part of the exhaust gas around the superheater and reheater tube banks or by partly blocking the superheater and reheater tubes.

[0016] The advantages of this method largely correspond to the above-mentioned advantages of the heat recovery steam generator.

[0017] In particular, as per the ASME TDP-1-2013 Clause no. 3.2.3, it is discouraged to use attemperators downstream of the last superheating (reheating) element. Making use of the invention it is possible to adopt the code recommendation in a more effective way.

[0018] Further, the efficiency of the heat recovery steam generator in the low / part load is improved as the final steam temperature is controlled with a higher efficiency (even higher than steam bypass).

[0019] Finally, one can omit superheater and reheater attemperators, associated control valves, non-return

valves, bloc valves, safety valves, pipes etc. in the spray water line.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Embodiments of the invention are now described, by way of example only, with reference to the accompanying drawings, of which:

Figure 1 shows a schematic view of a heat recovery steam generator from above by providing a bypass channel between the walls of the heat recovery steam generator and heat exchanger surfaces of the tube banks;

Figure 2 shows a schematic view of a heat recovery steam generator with an external bypass duct outside the walls of the heat recovery steam generator;

Figure 3 shows a schematic view of the heat recovery steam generator of figure 2 with mixing arrangements;

Figure 4 shows a schematic view of a heat recovery steam generator with a bypass channel open to the superheater and reheater tube banks;

Figures 5 to 7 show various options, which enable the proper mixing of the exhaust gas and making a temperature homogenous exhaust gas after it is bypassed;

Figures 8 and 9 show two alternatives with blocking elements adjustably blocking at least a part of the heat exchanger surfaces formed by the tube banks, and

Figure 10 shows a schematic side view of heat recovery steam generator, where the heat exchanger surface is isolated horizontally.

[0021] The illustration in the drawings is in schematic form. It is noted that in different figures, similar or identical elements may be provided with the same reference signs.

DESCRIPTION OF THE DRAWINGS

[0022] Figure 1 shows a heat recovery steam generator 1 comprising different heat exchanger surfaces 4 arranged one after another beginning at the hot end 6 of the heat recovery steam generator 1 with third high pressure superheater 7, followed by third reheater 8, second high pressure superheater 9, second reheater 10, first high pressure superheater 11, first reheater 12, second high pressure evaporator 13, first high pressure evapo-

rator 14, high pressure economizer 15, some not otherwise specified intermediate pressure and low pressure heat exchanger surfaces 16, 17 and finally a condensate preheater 18 at the cold end 19 of the heat recovery steam generator 1. During operation gas turbine exhaust gas 20 enters the heat recovery steam generator 1 at its hot end 6 and leaves it the cold end through the stack 21. In the embodiment of figure 1 the exhaust gas 20 is prevented from passing through the superheater and reheater section 22 in its entirety by providing a bypass channel 23 between the walls 24 of the heat recovery steam generator 1 and heat exchanger surfaces 4 of the superheater and reheater tube banks 2,3. Dampers 27 are to be provided in each of the bypass channels 23 so that the bypass flow of exhaust gas 20 can be controlled to maintain the superheater and reheater steam outlet temperature. In the embodiment of figure 1, the device 5 for guiding exhaust gas around at least a part of the superheater and reheater tube banks 2, 3 is a closed bypass channel 23 allowing for bypassing all superheater and reheater tube banks at once.

[0023] Figure 2 indicates a similar concept as Figure 1, but in this case an external bypass duct 25 outside the walls 24 of the heat recovery steam generator 1 is used, without changing the existing boiler structure design. This can also be used to retrofit in operating plants, if this new concept shall be implemented. When the bypassed high temperature exhaust gas is mixed with the relatively less temperature exhaust gas 20 which passed through the superheater and reheater tube banks 2, 3 there are chances of temperature layer formation.

[0024] This can be taken care of by using suitable mixing arrangements 26, into which the external bypass 25 opens out and which are arranged immediately downstream of the superheater and reheater tube banks 2, 3 in the main direction of flow of the exhaust gas 20, for example a perforated tube to mix the hot exhaust gas with the colder exhaust gas (see figure 3).

[0025] In the embodiment of figure 4, the bypass channel 23 is a channel open to the superheater and reheater tube banks 2, 3, wherein dampers 27 are arranged in the bypass channel 23 between walls 24 of the heat recovery steam generator 1 and the tube banks 2, 3 for each superheater and reheater heat exchanger surfaces 4 allowing for bypassing selected heat exchanger surfaces 4. This embodiment indicates a more precise control of the exhaust gas bypass. The concept is similar to that of figure 1, but with a damper 27 in each heater bypass channel 23 it can be selected which heat exchanger surface 4 to bypass and which one not to bypass, thus having a better and more flexible control to maintain the superheater and reheater outlet temperature. For example the exhaust gas 20 can be bypassed around third high pressure superheater 7 and third high pressure reheater 8 only as per requirement and not bypassing the rest of the entire superheating and reheating section 22.

[0026] Figure 5, figure 6 and figure 7 show options, which enable the proper mixing of the exhaust gas 20

and making a temperature homogenous exhaust gas after it is bypassed. Formation of temperature layers cannot be avoided completely by these measures, but could be reduced further by suitable mixing arrangements (like the use of perforated tubes). The embodiment of figure 5 shows several bypass channels 23 not necessarily arranged close to the walls 24 of the heat recovery steam generator 1. Figures 6 and 7 show embodiments where the bypass channel 23 comprises a staggered arrangement of bypass channel sections 28.

[0027] Figure 8 and figure 9 show advantageous embodiments where the device 5 comprises blocking elements 29 adjustably blocking at least a part of the heat exchanger surfaces 4 formed by the tube banks 2, 3. In both embodiments, the blocking elements 29 are arranged to block at least a heat exchanger surface 4 over its full height, so that the flow of the exhaust gas 20 can be restricted to flow through some part of the superheater and reheater tube banks 2, 3 by isolating the corresponding heat exchanger surfaces 4 vertically with the help of one or more sets of dampers 27. This will reduce the effective heat absorption surface area, leading to less heat absorption in the superheater and reheater tube banks 2, 3 and more heat is available for the evaporators, intermediate and low pressure sections, economizers, condensate preheaters 18, etc. Again in these cases also either part of all the heat exchanger surfaces 4 or part of few heat exchanger surface sections can be isolated. The superheater / reheater outlet steam temperatures can be controlled by the percentage of heat exchange surface 4 covered. Fig 8 will be more preferred as in this case the dampers 27 will face reduced temperature.

[0028] Figure 10 is an option in which the heat exchanger surface 4 is isolated horizontally, i.e. where the blocking elements 29 are arranged to block a heat exchanger surface 4 over its entire width and over a part of its height, thus reducing all the superheater /reheater heat exchangers tube length & surface area equally, when tubes of the tube banks 2, 3 are vertically oriented. Figure 10 shows the damper 27 in its closed (down) and its open (up) position. This option has an advantage that all the steam tubes are equally heated and thus generates minimal thermal stress in the header, unlike in options shown in figure 8 and figure 9 wherein due to unequal heating of the heat transfer area there may be some additional thermal stress on the header, which needs to be taken care with suitable header design. These options (figures 8, 9 and 10) will also avoid temperature layer formations because no mixing of colder and hotter exhaust gas occurs. If the upper horizontal part is designed to isolate (as shown in the figure 10) then the use of Guillotine gate damper is also possible.

[0029] Although the present invention has been described in detail with reference to the preferred embodiment, it is to be understood that the present invention is not limited by the disclosed examples, and that numerous additional modifications and variations could be made thereto by a person skilled in the art without departing

from the scope of the invention.

Claims

1. A heat recovery steam generator (1) comprising superheater and reheater tube banks (2, 3) forming heat exchanger surfaces, **characterized by** a device (5) for guiding exhaust gas (20) around at least a part of the superheater and reheater tube banks (2, 3).
2. The heat recovery steam generator (1) according to claim 1, wherein the device (5) is designed to guide at least a part of the exhaust gas (20) around the superheater and reheater tube banks (2, 3).
3. The heat recovery steam generator (1) according to claim 1, wherein the device (5) is designed to guide the exhaust gas (20) around at least a part of superheater and reheater tube banks (2, 3).
4. The heat recovery steam generator (1) according to claims 1 or 2, wherein the device (5) comprises a bypass channel (23) between walls (24) of the heat recovery steam generator (1) and the tube banks (2, 3) and a damper (27) arranged in the channel.
5. The heat recovery steam generator (1) according to claims 1 or 2, wherein the device (5) is an external bypass duct (25) outside the walls (24) of the heat recovery steam generator (1).
6. The heat recovery steam generator (1) according to claim 5, wherein the external bypass (25) opens out into mixing arrangements (26) arranged immediately downstream of the superheater and reheater tube banks (2, 3) in the main direction of flow of the exhaust gas (20).
7. The heat recovery steam generator (1) according to claim 4, wherein the bypass channel (23) is at least one closed channel with an entrance and an exit allowing to bypass all superheater and reheater tube banks (2, 3) at once.
8. The heat recovery steam generator (1) according to claim 4, wherein the bypass channel (23) is a channel open to the superheater and reheater tube banks (2, 3), wherein dampers (27) are arranged in the bypass channel (23) between walls (24) of the heat recovery steam generator (1) and the tube banks (2, 3) for each superheater and reheater heat exchanger surface (4) allowing to bypass selected heat exchanger surfaces (4).
9. The heat recovery steam generator (1) according to claim 2, wherein the bypass channel (23) comprises

a staggered arrangement of bypass channel sections (28).

10. The heat recovery steam generator (1) according to claims 1 or 3, wherein the device (5) comprises blocking elements (29) adjustably blocking at least a part of the heat exchanger surfaces (4) formed by the tube banks (2, 3). 5
11. The heat recovery steam generator (1) according to claim 10, wherein the blocking elements (29) are arranged to block at least a heat exchanger surface (4) over its full height. 10
12. The heat recovery steam generator (1) according to claim 10, wherein the blocking elements (29) are arranged to block a heat exchanger surface (4) over its entire width and over a part of its height. 15
13. The heat recovery steam generator (1) according to one of the preceding claims, wherein tubes of the tube banks (2, 3) are vertically oriented. 20
14. A method to control the steam outlet temperature of a heat recovery steam generator (1), comprising superheater and reheater tube banks (2, 3) forming heat exchanger surfaces (4), **characterized in** guiding exhaust gas (20) at least partly around the superheater and reheater tube banks (2, 3). 25
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15. The method according to claim 14, wherein at least a part of the exhaust gas (20) is bypassed around the superheater and reheater tube banks (2, 3).
16. The method according to claim 14, wherein exhaust gas (20) is bypassed around at least a part of superheater and reheater tube banks (2, 3) by blocking this part. 35

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FIG 1

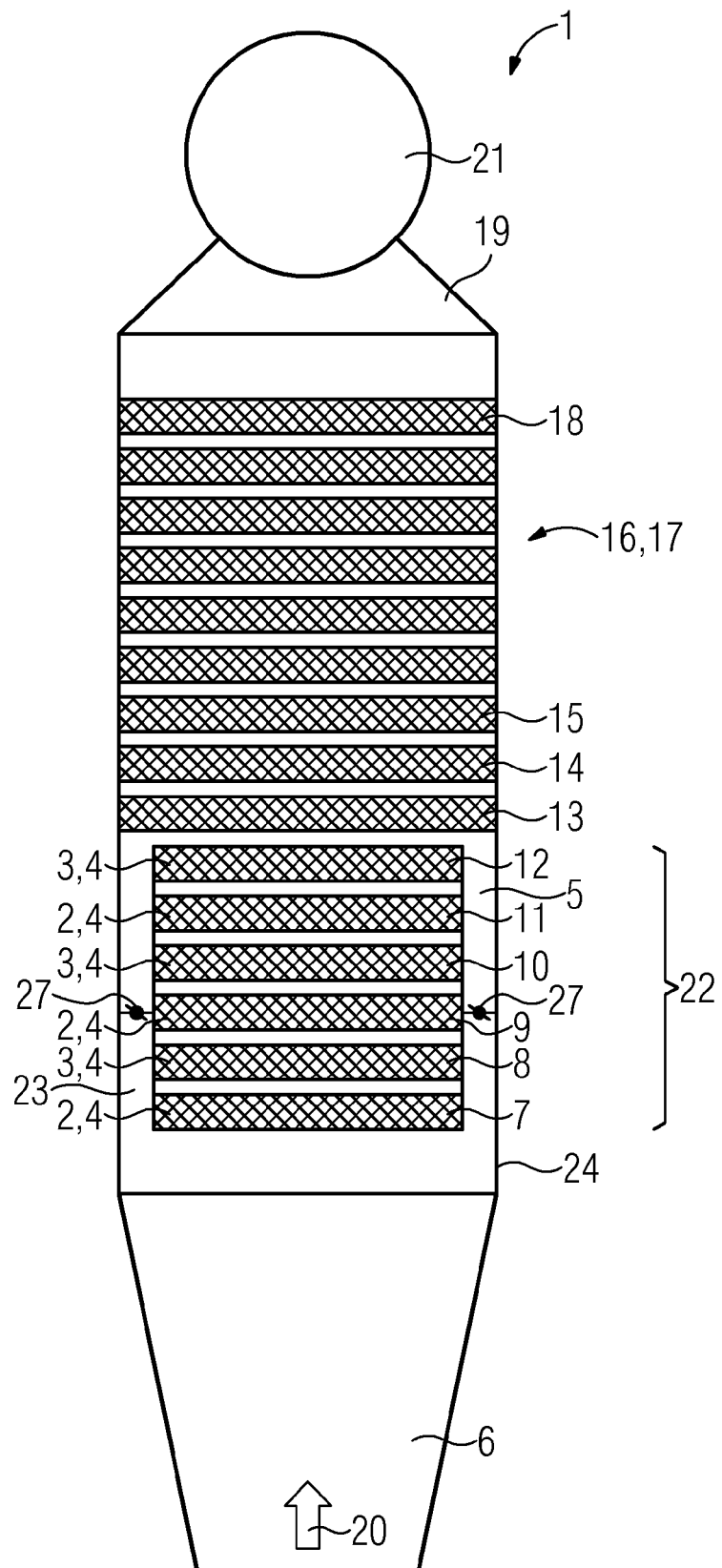


FIG 2

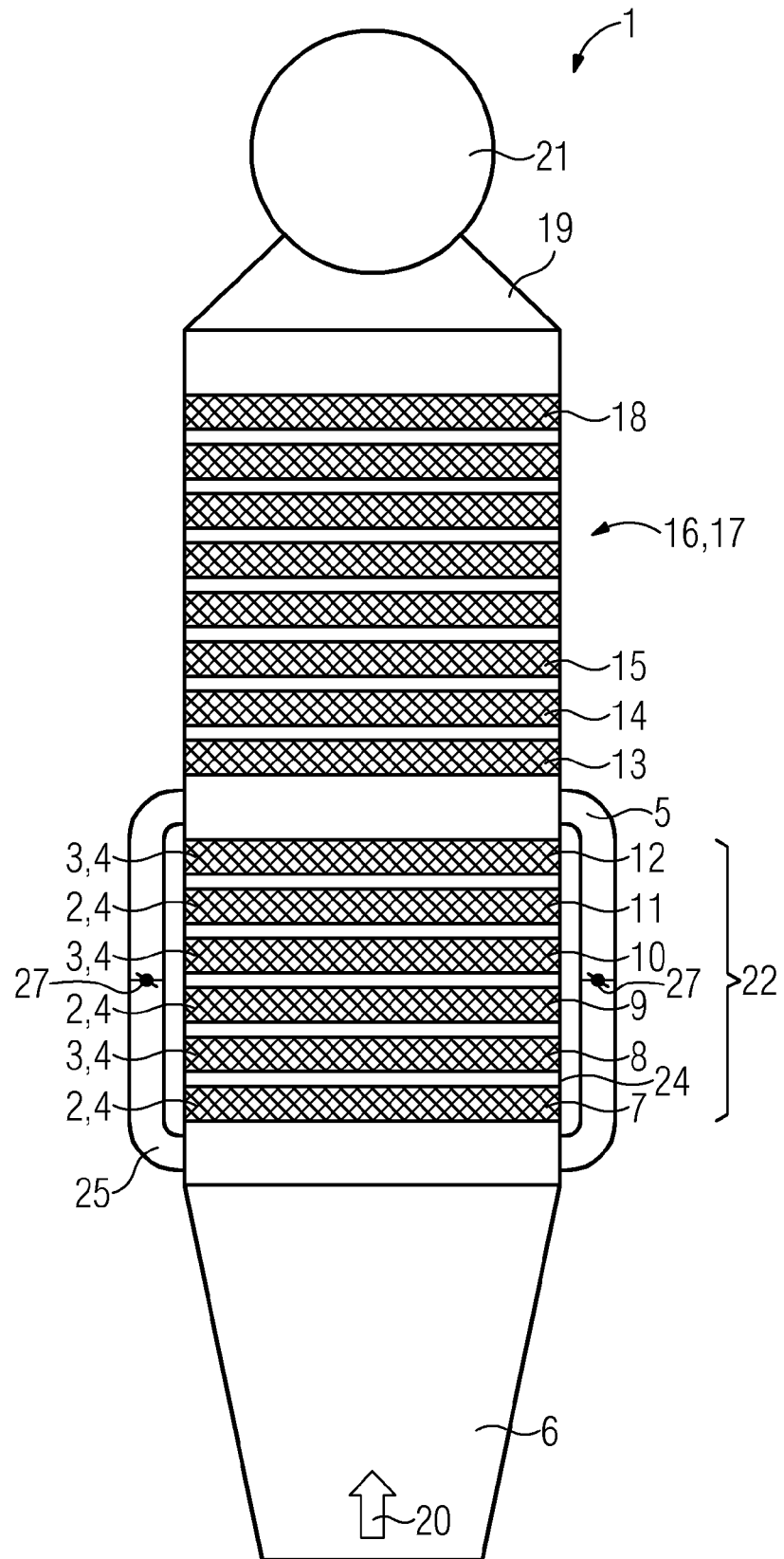


FIG 3

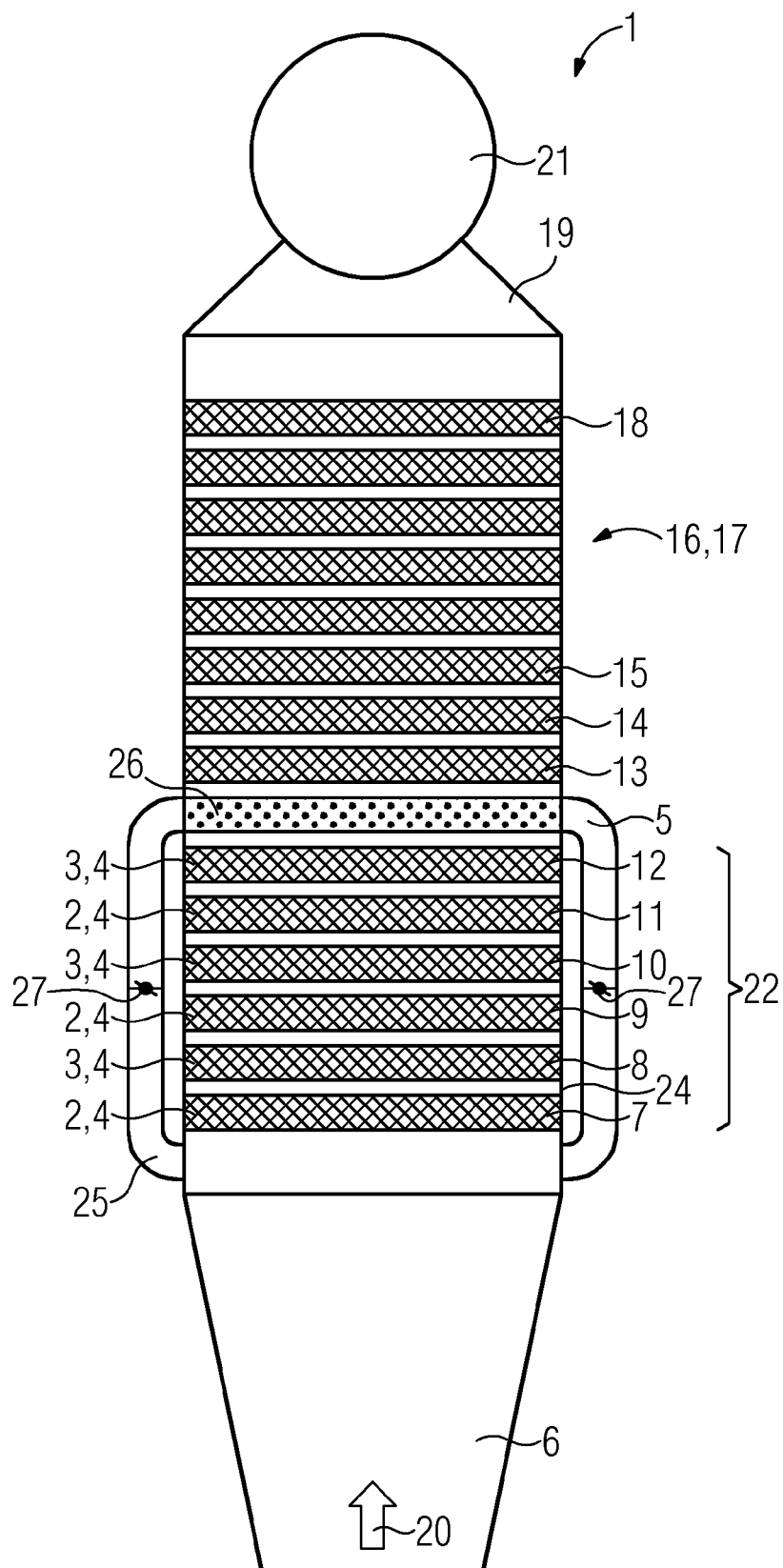


FIG 4

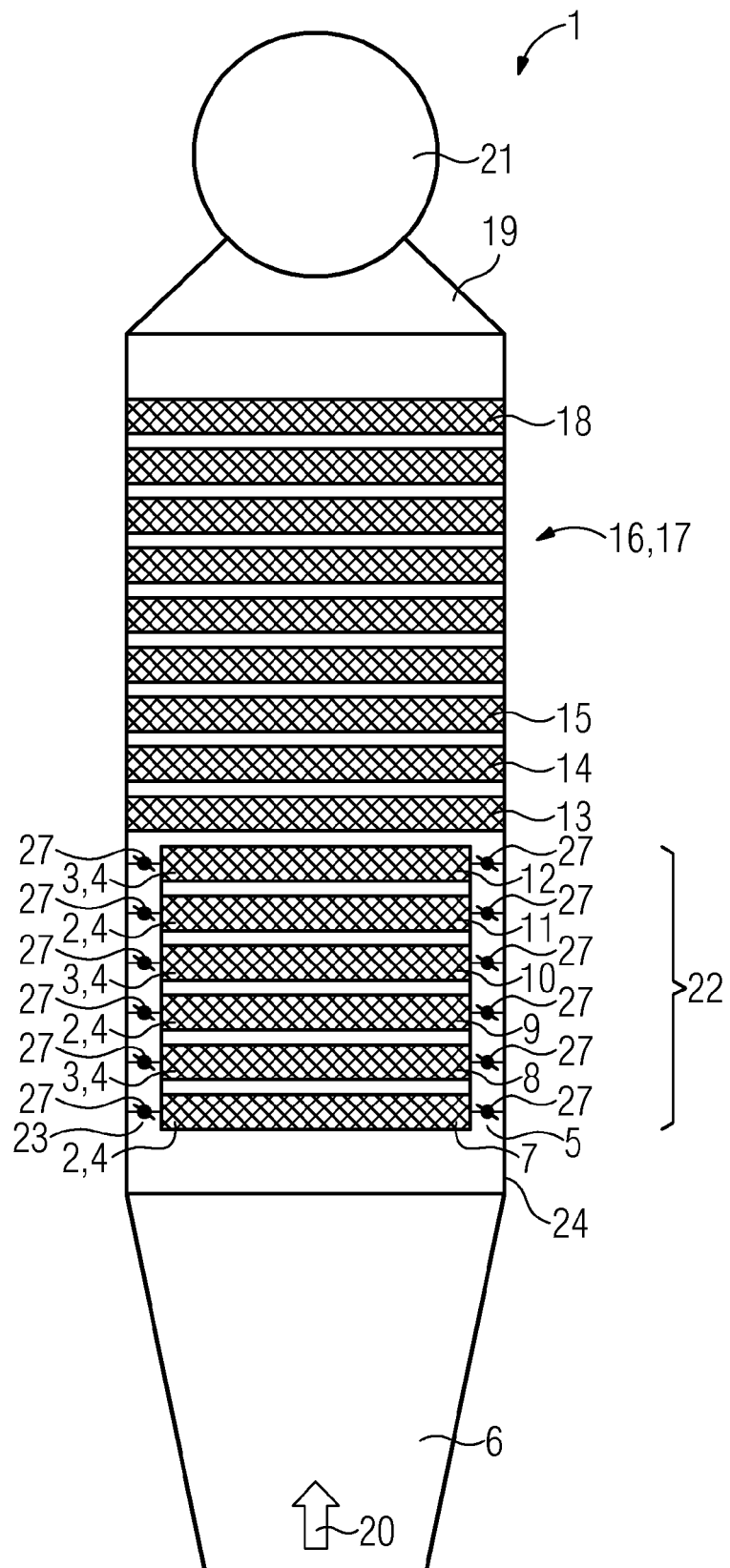


FIG 5

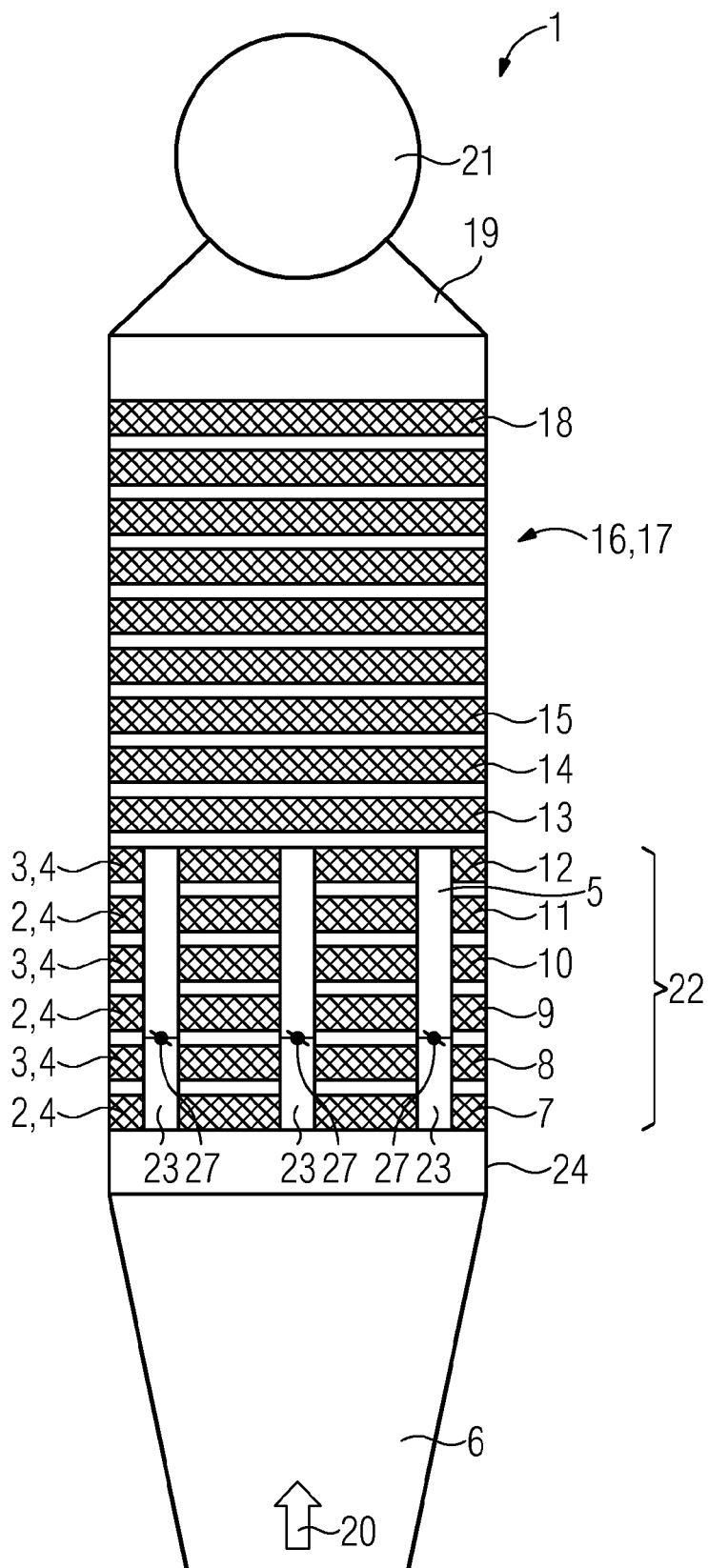


FIG 6

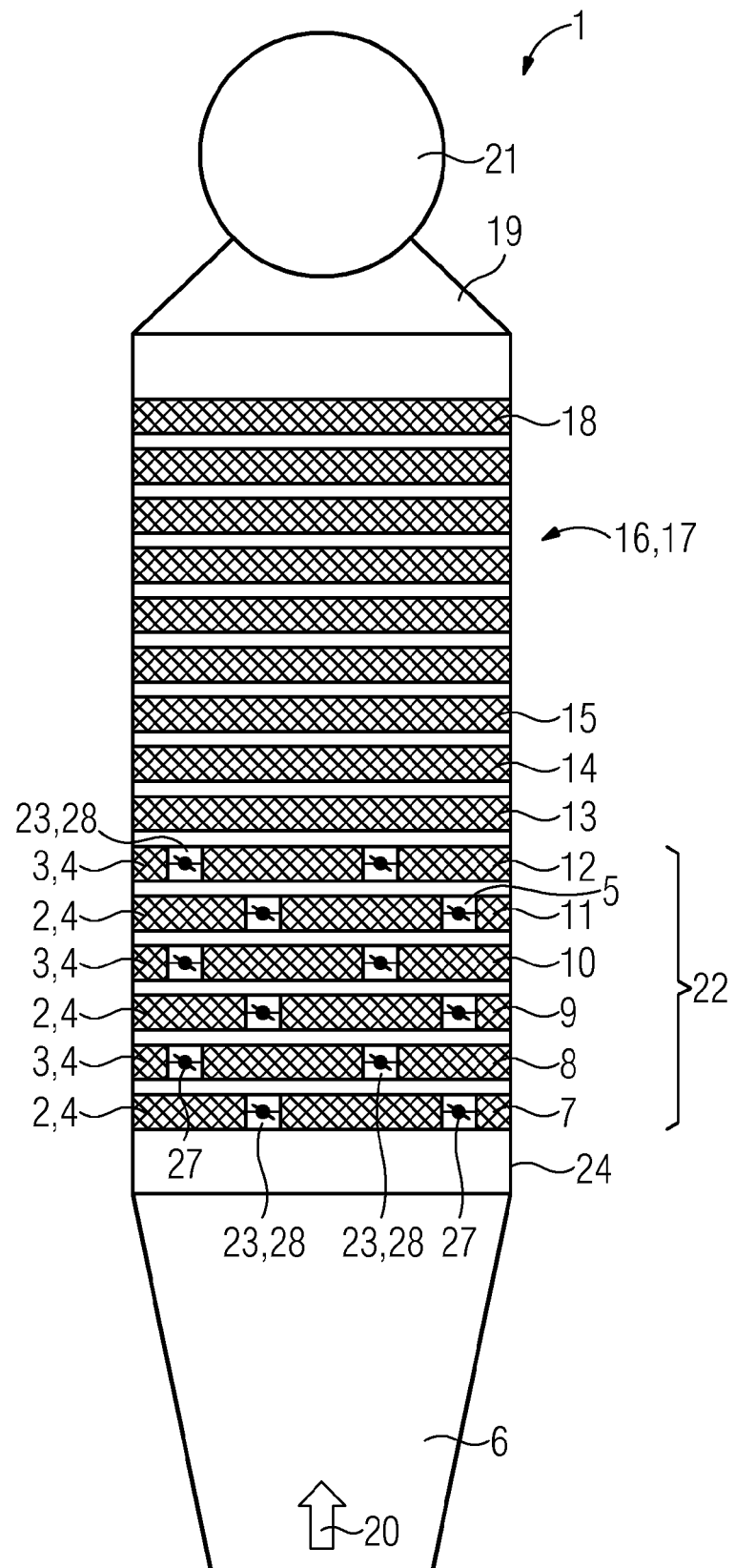


FIG 7

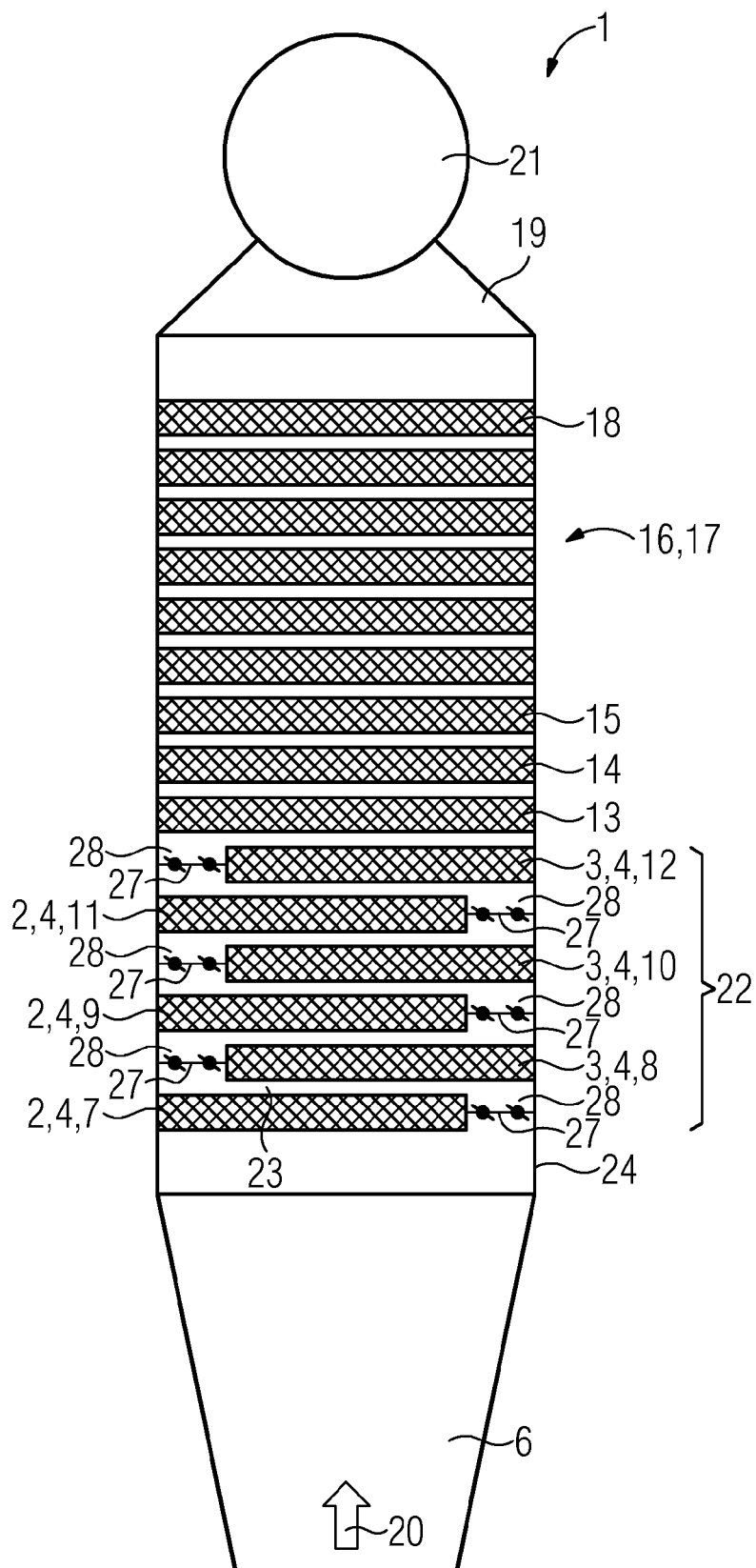


FIG 8

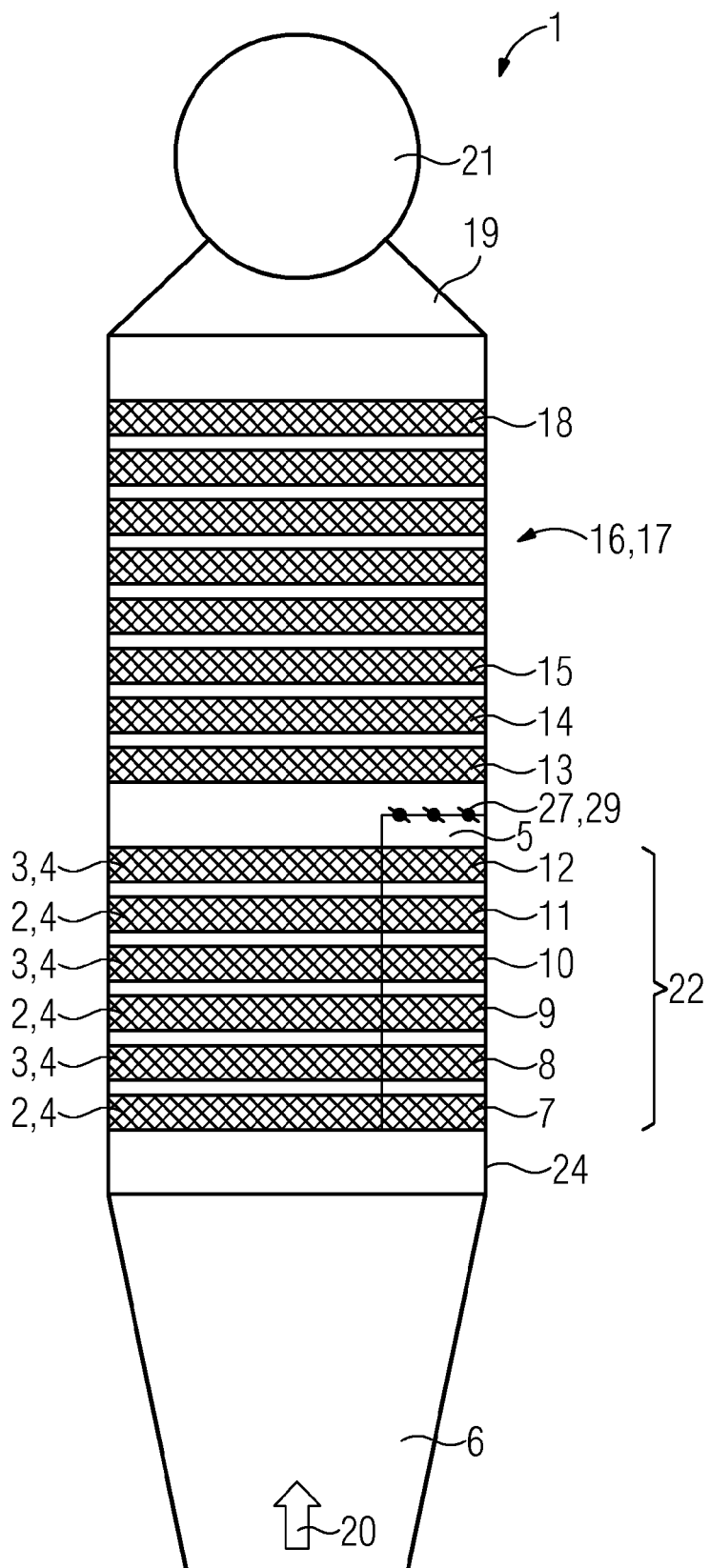


FIG 9

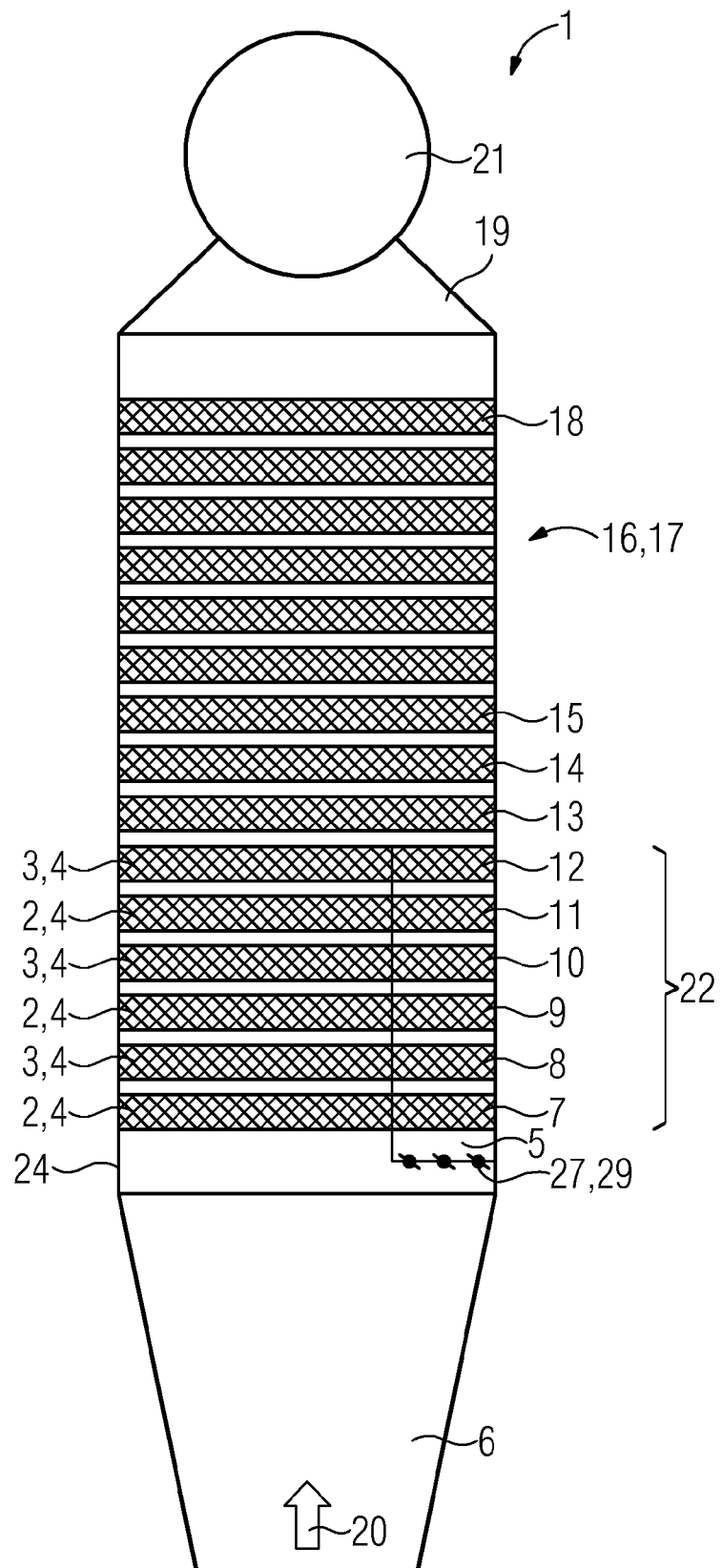
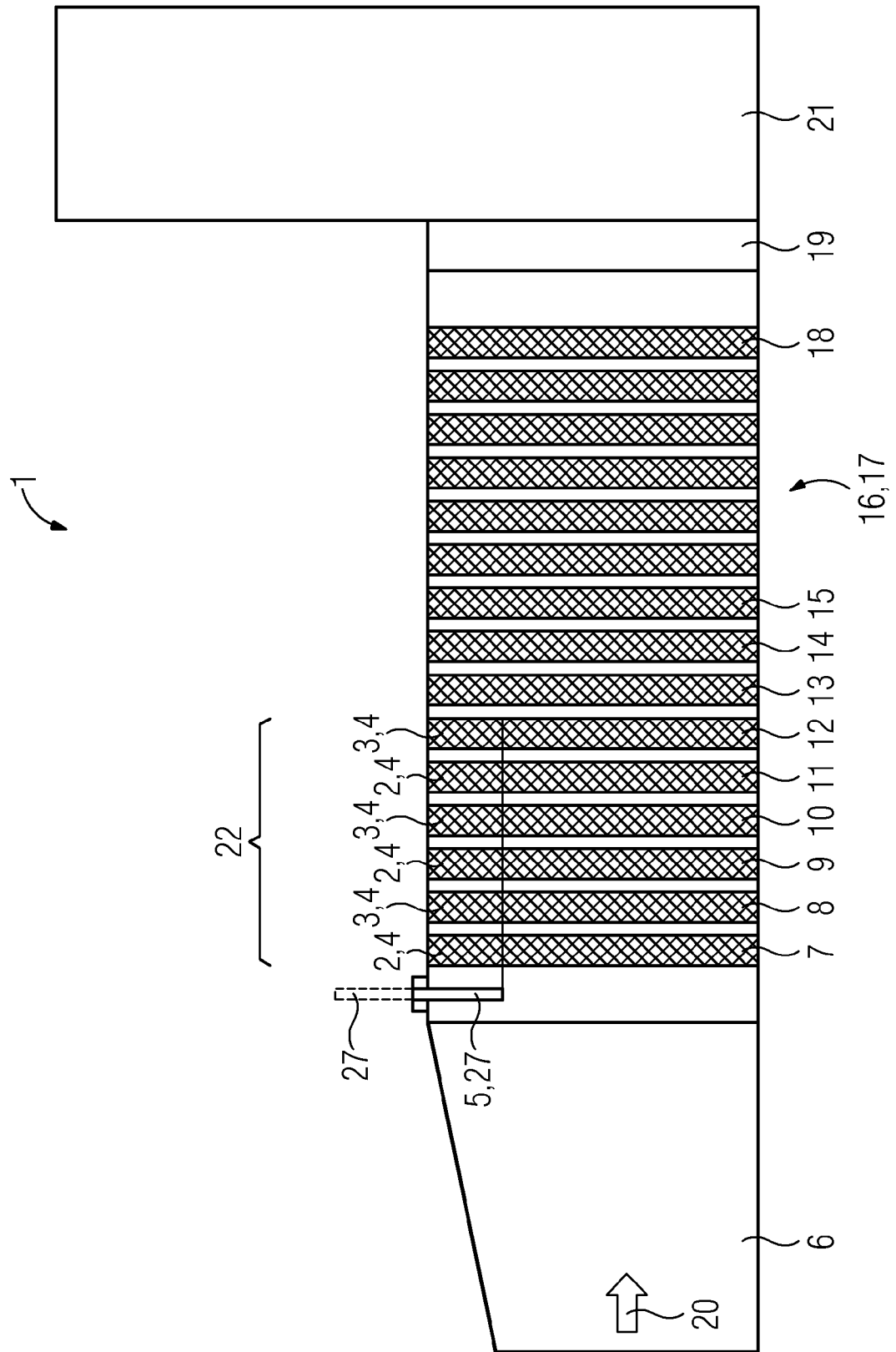


FIG 10





EUROPEAN SEARCH REPORT

Application Number
EP 17 18 1394

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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	US 2017/022847 A1 (YASHIKI TATSURO [JP] ET AL) 26 January 2017 (2017-01-26) * paragraphs [0060] - [0068]; figures 4-7b *	1-4,7, 9-16	INV. F22G5/04 F22G7/12
X	US 2013/098313 A1 (PANG RAYMOND [US]) 25 April 2013 (2013-04-25) * paragraphs [0024] - [0026]; figure 2 *	1-8, 14-16	
X	US 6 125 623 A (CLOYD SCOTT THORSTEN [US] ET AL) 3 October 2000 (2000-10-03) * column 5, line 8 - column 6, line 59; figure 3 *	1-3,10, 11,14-16	
X	JP H08 28808 A (BABCOCK HITACHI KK) 2 February 1996 (1996-02-02) * paragraph [0037]; figures 1,2 *	1-3, 14-16	
X	EP 0 807 785 A1 (ANSALDO ENERGIA SPA [IT]) 19 November 1997 (1997-11-19) * figure 1 *	1-3,10, 11,14-16	
A	JP H04 52401 A (OSAKA GAS CO LTD) 20 February 1992 (1992-02-20) * the whole document *	1-16	TECHNICAL FIELDS SEARCHED (IPC) F22G
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 17 January 2018	Examiner Röberg, Andreas
CATEGORY OF CITED DOCUMENTS 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 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 & : member of the same patent family, corresponding document			

EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 17 18 1394

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2017022847 A1	26-01-2017	CN 106368817 A	01-02-2017
		EP 3121393 A1	25-01-2017
		JP 2017025792 A	02-02-2017
		US 2017022847 A1	26-01-2017
US 2013098313 A1	25-04-2013	DE 102012109945 A1	25-04-2013
		FR 2981687 A1	26-04-2013
		RU 2012144424 A	27-04-2014
		US 2013098313 A1	25-04-2013
US 6125623 A	03-10-2000	CA 2288839 A1	10-09-1999
		EP 0980495 A1	23-02-2000
		JP 2002508059 A	12-03-2002
		KR 20010012195 A	15-02-2001
		US 6125623 A	03-10-2000
		WO 9945321 A1	10-09-1999
JP H0828808 A	02-02-1996	NONE	
EP 0807785 A1	19-11-1997	AT 196797 T	15-10-2000
		DE 69610551 D1	09-11-2000
		DE 69610551 T2	07-03-2002
		EP 0807785 A1	19-11-1997
JP H0452401 A	20-02-1992	NONE	