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(54) **Single and multi-pressure condensation system**

(57) The invention relates to a condenser system comprising a condenser (10) with an extraction system. The vent system adapted for variable non-condensable

loading by comprising an adjustable ejector (20) for adjustably reducing a pressure ratio between different regions of the condenser (10).

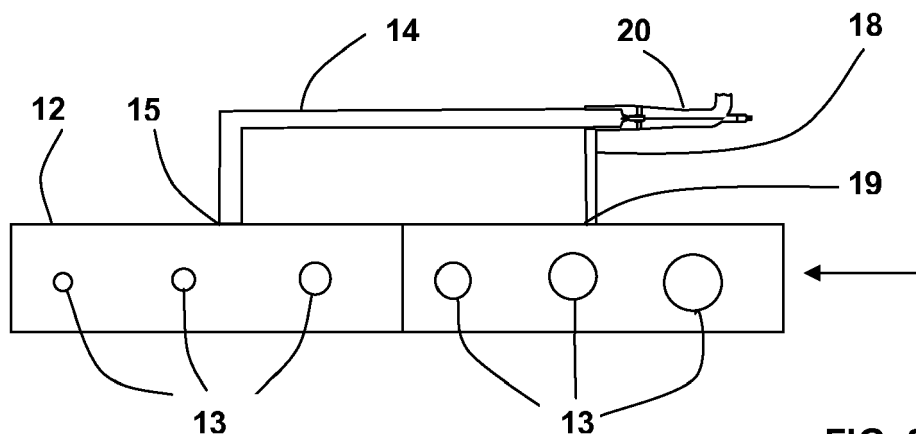


FIG. 2

Description

TECHNICAL FIELD

[0001] The present disclosure relates generally to single pressure and multi-pressure condensation systems for condensing steam exhausted from low pressure steam turbines and more specifically to extraction system for extracting non-condensable gases from such condensing system.

BACKGROUND INFORMATION

[0002] In a steam turbine power plant, a steam condenser has a function to condense exhausted steam from a steam turbine and collect condensed water thereof. In general, a steam condenser has a body connected to a steam exhaust port of the steam turbine. The body includes a heat transfer region that comprises an array of heat transfer tubes through which a cooling medium, such as water is directed.

[0003] Steam exhausted from the steam turbine flows down into the body of the steam condenser here it contacts the tube array. The steam is first cooled by the cooling medium flowing through the heat transfer tubes, and then condensed. While being condensed, at the condensing surface of the tubes, the temperature of steam is at its saturation temperature at its corresponding partial pressure of steam.

[0004] The lowering of the partial pressure of steam the lower the saturated temperature, and as a result the lower the temperature driving force between the steam and cooling water. As a result the greater degree of condensation the less efficient the localised condenser performance becomes. Besides the degree of condensation, which is affected by cooling water temperature as it increases along the length of the tube, the amount of non-condensables is an additional factor that may decrease steam partial pressure and therefore is another factor that has a detrimental effect on condenser performance. These non-condensables typically result for unavoidable air leakage, non-condensable gases generated by physicochemical treatments, or radiolytic generated gases in condensers associated with boiling water nuclear reactors, as well as changing condenser controls and thermal load variations. To overcome this problem caused by non-condensable various extraction process have been configured.

[0005] EP 2 010 852 discusses one solution that utilizes a plurality of vents lanes to extract gas from various regions of the condenser and direct them to an air cooling zone where non-condensables are discharged with the assistance of a suction pump or ejector connect to the exit of the air cooling zone. While it is advantageous to remove non-condensables, excessive extraction can result in decreased net plant efficiency.

[0006] As cooling water flows through the condenser its temperature increases as it gains latent heat from con-

densing steam. As a result the temperature, driving force is greatest at the cooling water entry end of the condenser and decreases along the length of the cooling tubes. As a result, condensation and thus non-condensable concentrations vary not only in the steam flow direction, but also across the length of the cooling tubes. Particularly where baffles are located along the length of the cooling tubes a further pressure gradient may be created by the differing condensate rates. To adjust the rate of extraction of the non-condensable system based on regional conditions of the condenser, orifice or varying size may be place in inlets of the extraction system.

[0007] In a multi-pressure condenser, DE 199 49 761 B4 discusses another method that involves a manifold with inlets located in strategic locations in the condenser that are joined by a manifold in which an ejector is located. By using pressure differences in the condenser to drive the ejectors, extraction can be designed to consider the different pressure regions of the condenser.

[0008] As steam load, cooling water temperature, and non-condensate concentration in the steam feed to the condenser vary the optimum extraction rate of non-condensables in difference zones of the condenser may also vary. For extractions systems that comprise fixed orifices or ejector sizes, such systems are not easily adaptable and so it may be difficult to optimise extraction across the condenser along the length of the condenser tube bundle. There is therefore a need to provide an easily adjustable system that can vary extraction across the condenser in response to varying condenser operating conditions.

SUMMARY

[0009] A single- and multi-pressure condensation system is disclosed that can be adapted to compensate for varying non-condensable concentration at different extraction pressures.

[0010] The disclosure attempts to address this problem by means of the subject matter of the independent claims. Advantageous embodiments are given in the dependent claims.

[0011] The disclosure is based on the general idea of adapting a multi-pressure condenser system with an adjustable ejector that is configured to enable the control of relative pressure in different pressure sections of the condenser which may resulting in a local pressure change of 5-10 mbar.

[0012] The situation is similar for single pressure condensers with high cooling water temperature rise, particularly those with two or more passes in steam room. The removing of non-condensables with a single evacuation system is in such cases is close to impossible without staggering of suction ducts.

[0013] One general aspect includes a condenser with a condensing steam flow path. The condenser also includes a plurality of cooling tubes, extending transversely to the steam flow path, for containing and directing a cool-

ing water flow and an extraction system. The extraction system including a first extraction line with a first inlet, a second extraction line, with a second inlet located in a region of the condenser that, in operation, is configured to be at a lower pressure than a region of the first inlet an adjustable ejector. The adjustable ejector includes nozzle having an opening connected to the first extraction line and adapted to so as enable fluid extracted through the first extraction line to be used as a motive fluid for the adjustable ejector. The condenser also includes a suction inlet connected to the second extraction line so as to enable evacuation of the second extraction line by the adjustable ejector. In this way, steam from the high pressure region of the condenser can be used as the motive force for the adjustable ejector. The adjustable ejector can therefore be understood to be a device for pressure reduction and at the same time, as vacuum booster. The condenser further includes a flow means for varying a flow rate of the motive fluid.

[0014] The proposed solution can be applied to single pressure condensers with large cooling water temperature rise, such as multi-pass condensers, as the problems caused by non-condensables in single pressure condensers is similar to that of multi-pressure condensers.

[0015] Further aspects may include one or more of the following features. The second inlet of the second extraction lines displaced from the first inlet of the first extraction line in a direction of extension of one of the cooling tubes. The adjustable ejector includes a needle with a first end having a variable diameter in a longitudinal direction extending from the first end. The condenser may also include an actuator that is connected to the needle and adapted to adjustably displace the needle in the nozzle opening such that the variable diameter of the needle varies an area of the nozzle opening thereby varying the flow of the motive fluid. The condenser in which the variable diameter is a portion of the needle that has an increasing diameter in the direction extending away from the first end along at least a partial longitudinal length of the needle. The condenser is a multi-pressure condenser.

[0016] It is a further object of the invention to overcome or at least ameliorate the disadvantages and shortcomings of the prior art or provide a useful alternative.

[0017] Other aspects and advantages of the present disclosure will become apparent from the following description, taken in connection with the accompanying drawings which by way of example illustrate exemplary embodiments of the present invention

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] By way of example, an embodiment of the present disclosure is described more fully hereinafter with reference to the accompanying drawings, in which:

Figure 1 is an end view of a condenser with an ex-

traction system

Figure 2 is a side view of an extraction system according to an exemplary embodiment of the disclosure;

Figure 3 is a sectional view an adjustable ejector of the extraction system of Fig. 2.

Figure 4 is a sectional view of a single pressure single pass condenser with an extraction system of Fig. 2; and

Figure 5 is a schematic of a single pressure two pass condenser with the extraction system of Fig. 2

DETAILED DESCRIPTION

[0019] Exemplary embodiments of the present disclosure are now described with references to the drawings, wherein like reference numerals are used to refer to like elements throughout. In the following description, for purposes of explanation, numerous specific details are set forth to provide a thorough understanding of the disclosure. However, the present disclosure may be practiced without these specific details, and is not limited to the exemplary embodiment disclosed herein.

[0020] Fig. 1 shows a condenser 10 with a plurality of cooling tubes 11 that extend transversely to a steam flow path. An extraction duct 12 for extracting non-condensables is located next adjacent the plurality of cooling tubes 11 along the direction of extension of one of the cooling tubes 11 of the plurality of cooling tubes 11. That is, the extraction duct 12 extends in across the condenser 10 which is transverse the steam flow path through the condenser 10

[0021] In an exemplary embodiment shown in Fig. 2 the extraction duct 12 comprises a series of orifices 13 of different sizes, a high pressure extraction line 14, a low pressure extraction line 18 and an adjustable ejector 20.

[0022] The different sizes of the orifices 13 enable course control of the relative extraction at different points of the condenser 10 that cannot be adjusted based on operating conditions. An

[0023] In another not shown exemplary embodiment, inlets 15, 19 of the extraction lines 14, 18 are directly connected to different pressure regions of the condenser 10.

[0024] In an exemplary embodiment shown in Fig. 2 an inlet 15 of the high pressure extraction line 14 and an inlet 19 of the low pressure extraction line 18 connect different regions of the extraction duct 12 to the adjustable ejector 20. In another not shown exemplary embodiment the inlet 15 of the high pressure extraction line 14 and inlet 19 of the low pressure extraction line 18 are connected directly to different pressure regions of the condenser 10. In this way, the adjustable ejector 20 is

fluidly located between different pressure regions of the condenser 10 so as to enable the adjustable ejector 20 to preferentially extract gas from one regions of the condenser as compared to another region of the condenser 10.

[0025] In an exemplary embodiment shown in Fig. 2, the adjustable ejector 20 is an adjustable ejector 20 with a nozzle 26 and suction inlet 24. In order to preferentially reduce the pressure, or at least vary the extraction rate in different regions of the condenser 10, the adjustable ejector 20 the nozzle 26 is connected to the high pressure extraction line 14 while the suction inlet 24 is connected to the low pressure extraction line 18. In this way, extracted gas from the condenser 10 passing through the high pressure extraction line 14 and then through the nozzle 26 so that the gas can be used as the motive fluid for the adjustable ejector 20 to provide suction in the low pressure extraction line 18.

[0026] In an exemplary embodiment, the adjustable ejector 20 is configured as a adjustable ejector 20 by comprising a nozzle 26 having an opening 28 with an opening area and a needle 30 with a first end 31 having a variable diameter in a longitudinal direction extending from the first end 31, as shown in Fig. 3. The needle 30 is connected to an actuator 34 to enable the needle 30 to be displaced so that a first end 31 of the needle 30 adjustably enters the opening area of the nozzle 26. To enable controllable pressure reduction the diameter of the needle 30 increases in the longitudinal direction away from the first end 31 such that the further the needle 30 is inserted in the nozzle opening 28 the smaller the effective opening area. In an exemplary embodiment shown in Fig. 3 the variable diameter of the needle 30 extends part way along the longitudinal length 32 of the needle 30 so as to vary the opening area of the nozzle 26 thereby enabling the adjustable ejector to operate as an adjustable ejector 20. The nozzle area reduction allows to achieve different steam-mixture speeds at end of the expansion section of the adjustable ejector 20, ensuring that the speed remains below the sound velocity at the given downstream conditions, thus ensuring that the adjustable ejector 20 operates at subcritical conditions.

[0027] In an exemplary embodiment shown in Fig. 4, an extraction system is applied to a single pressure single pass condenser 10 with support baffles. A high pressure extraction line 14 and low pressure extraction line 18 are connected at one end to an extraction duct 12 and at another end to an adjustable ejector 20.

[0028] In an exemplary embodiment shown in Fig. 5, an extraction system is applied to a single pressure two pass condenser 10. A high pressure extraction line 14 is connected to higher pressure regions of condenser 10 corresponding to the return cooling water flow path having a high cooling water temperature which reduces in lower condensation rates. A low pressure extraction line 18 is connected to lower pressure regions corresponding to the cooling water inlet having a low cooling water tem-

perature and thus higher condensation rates.

[0029] Although the disclosure has been herein shown and described in what is conceived to be the most practical exemplary embodiment, the present disclosure can be embodied in other specific forms. The presently disclosed embodiments are therefore considered in all respects to be illustrative and not restricted. The scope of the disclosure is indicated by the appended claims rather than the foregoing description and all changes that come within the meaning and range and equivalences thereof are intended to be embraced therein.

REFERENCE NUMBERS

[0030]

10	Condenser
11	Cooling tubes
12	Extraction duct
13	Orifice
14	High pressure extraction line
15	Inlet (high pressure extraction line)
18	Low pressure extraction line
19	Inlet (low pressure extraction line)
20	Adjustable ejector
24	Suction inlet
26	Nozzle
28	Nozzle opening
30	Needle
31	End
32	Longitudinal length
34	Actuator

Claims

1. A condenser (10) with a condensing steam flow path, comprising;
a plurality of cooling tubes (11), extending transversely to the steam flow path, for containing and directing a cooling water flow; and
an extraction system comprising:

a first extraction line (14), with a first inlet (15);
a second extraction line (18), with a second inlet (19) located in a region of the condenser (10) that, in operation is configured to be at a lower pressure than the first inlet (15);
an adjustable ejector (20) with:

a nozzle (26), having an opening (28), connected to the first extraction line (14) and adapted to enable fluid extracted through the first extraction line (14) to be used as a motive fluid for the adjustable ejector (20); and

a suction inlet (24) connected to the second extraction line (18) so as to enable evacu-

ation of the second extraction line (18) by
the

adjustable ejector (20).

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characterised by the adjustable ejector (20) having
a flow means (30) to vary a flow of the motive fluid.

2. The condenser 10 of claim 1 wherein the second inlet (19) is displaced from the first inlet (15) in a direction of extension of one of the cooling tubes (11). 10
3. The condenser (10) of claim 1 or 2 wherein the flow means (30) comprises
a needle (30) with a first end (31) having a variable diameter in a longitudinal direction extending from the first end (31); and 15
an actuator (34), connected to the needle (30), adapted to adjustably displace the needle (30) in the nozzle opening (28) such that the variable diameter of the needle (30) varies an area of the nozzle opening (28) thereby varying the flow of the motive fluid. 20
4. The condenser (10) of claim 3 wherein the variable diameter is a portion of the needle (30) that has an increasing diameter extending away from the first end (31) along at least a partial longitudinal length (32) of the needle (30). 25
5. The condenser of any one of claims 1 to 4 wherein the condenser (10) is a single-pass condenser (10). 30
6. The condenser of any one of claims 1 to 4 wherein the condenser (10) is a multi-pass condenser (10). 35
7. The condenser of any one of claims 1 to 6 wherein the condenser (10) is a single-pressure condenser (10).
8. The condenser of any one of claims 1 to 6 wherein the condenser (10) is a multi-pressure condenser (10). 40

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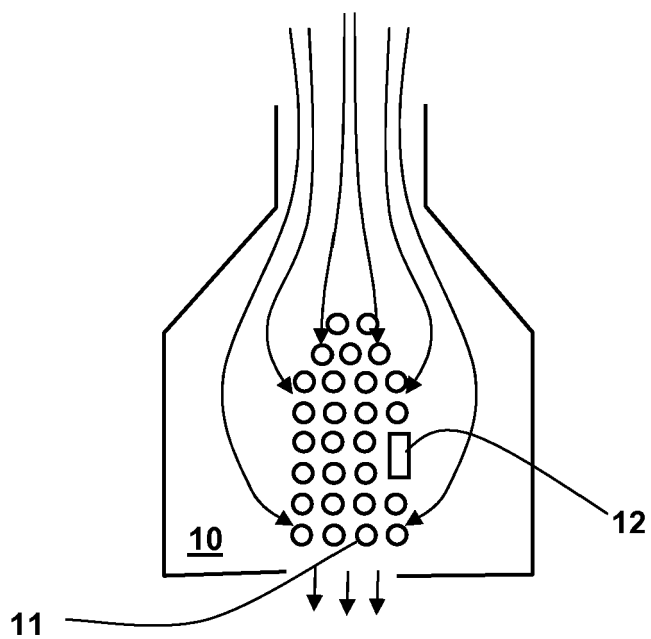


FIG. 1

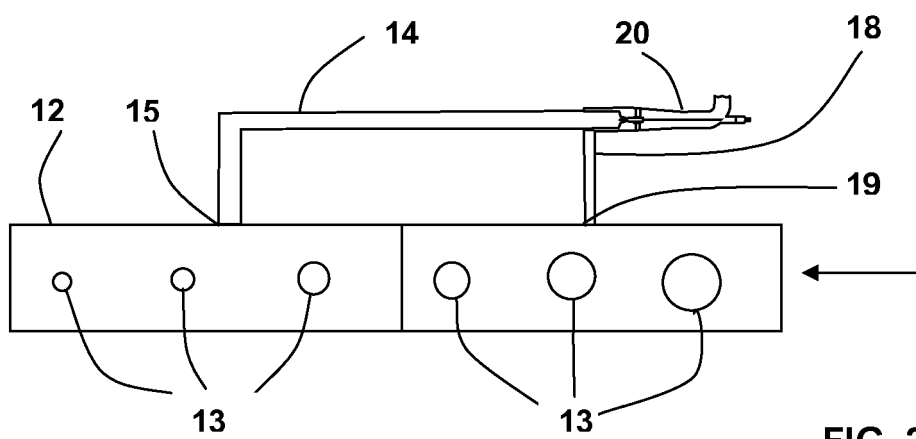


FIG. 2

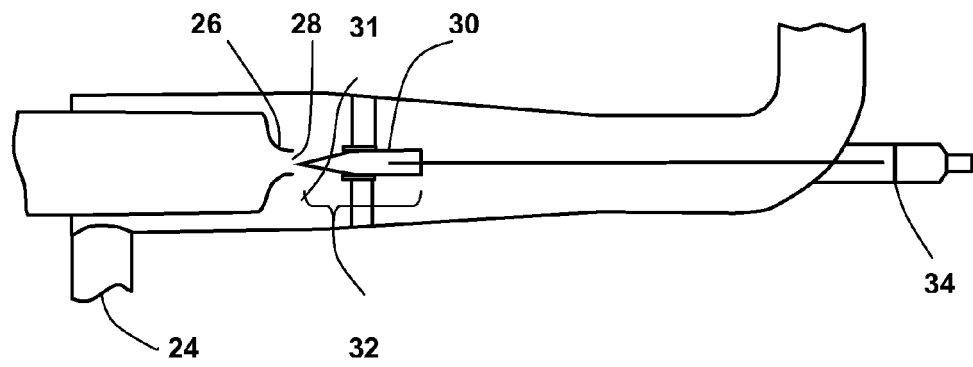


FIG. 3

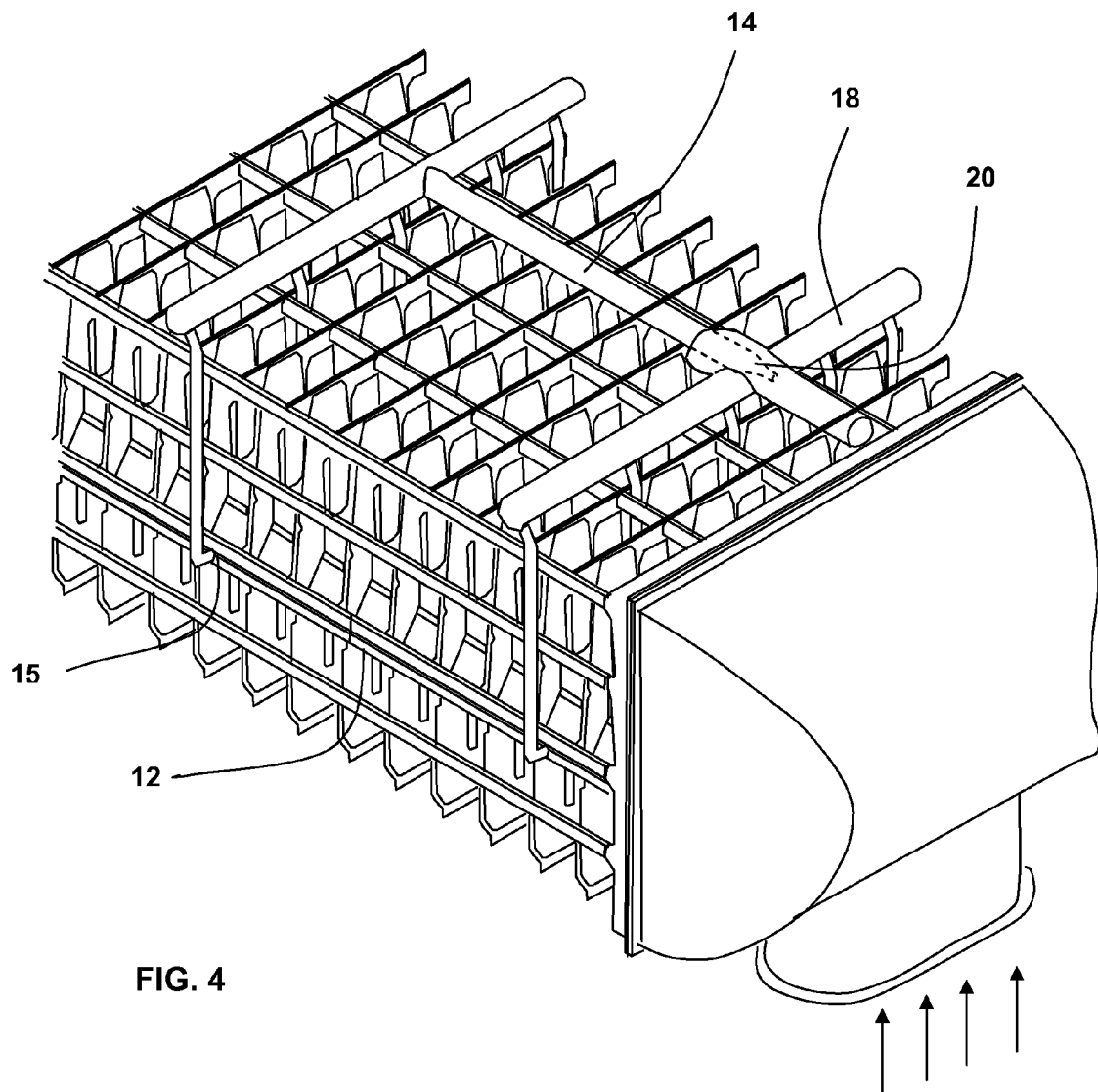


FIG. 4

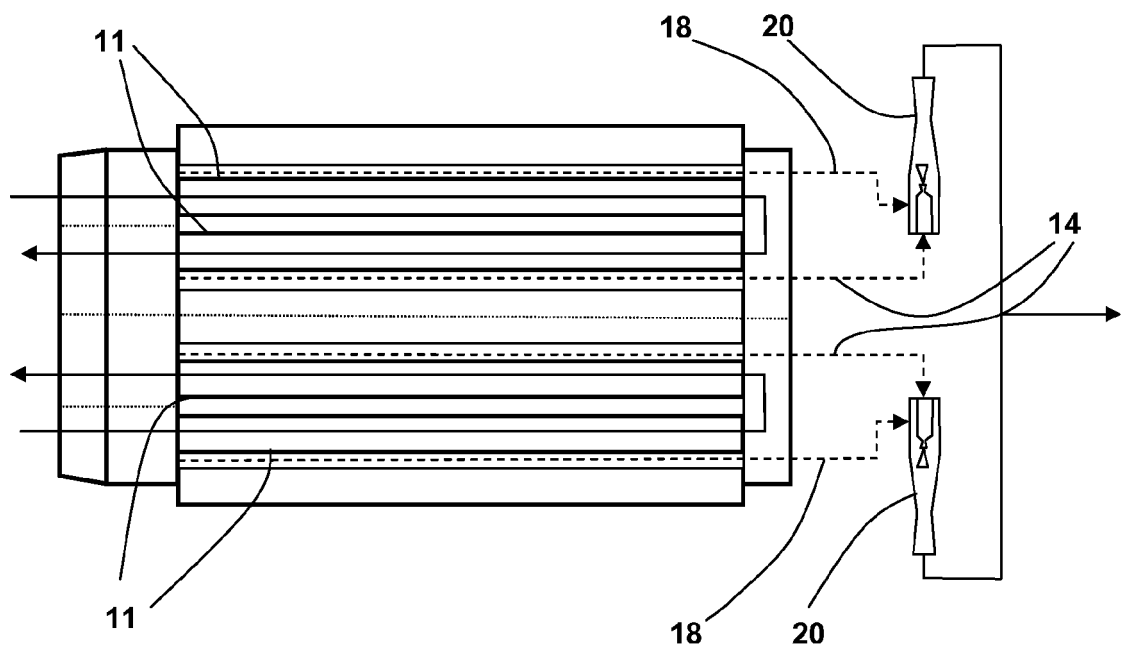


FIG. 5



EUROPEAN SEARCH REPORT

Application Number
EP 14 18 7017

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 10 March 2015	Examiner Martínez Rico, Celia
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 03/02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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