(19) Europäisches Patentamt
European Patent Office
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(11) **EP 2 600 092 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
05.06.2013 Bulletin 2013/23

(51) Int Cl.:
F28D 7/16 *(2006.01)* ***F28F 9/22*** *(2006.01)*

(21) Application number: **11191611.0**

(22) Date of filing: **01.12.2011**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

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(54) **Vertical heat exchanger**

(57) The present invention relates to a vertical heat exchanger/evaporator (1) characterised in that the cylindrical shell (9) comprises a central cylindrical baffle (6) having closed ends, forming at each floor (7) a ringed space run through by the second fluid, the tubes (2) being arranged in circles in the shell (9) externally the central cylindrical baffle (6), with passages (8, 8', 8") designed between two contiguous floors (7), so that the second fluid alternately flows in reverse rotation in said two contiguous floors (7).

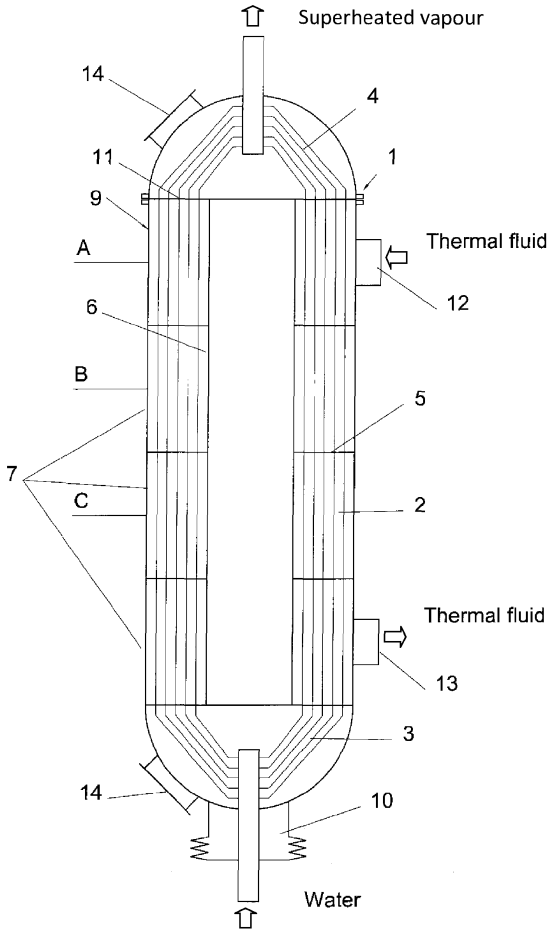

FIG.1

EP 2 600 092 A1

Description

Field of the invention

[0001] The present invention pertains to the technical field of once-through vertical heat exchangers/evaporators.

General background of the invention and prior art

[0002] It is known that, in a concentrated energy solar power plant (CSP), an intermediate thermal fluid is often used. The reason resides in the easiness of circulation of these fluids, working at high temperature, but at low pressure.

[0003] The solar radiation is directed and concentrated by means of parabolic or plane mirrors towards a heat exchanger containing the thermal fluid.

[0004] The circulation of the thermal fluid brings the heat back to a water/steam exchanger transforming the heat captured by the thermal fluid into a steam that can be used in a steam turbine.

[0005] The turbine is part of a classical steam cycle in a power plant and is coupled to a generator producing electric current.

[0006] The thermal fluid/water steam heat exchangers are mainly classified in two families:

- the boiler evaporator: a bundle of tubes is dipped into a boiler reservoir (or tank) and is run through by the thermal fluid. The water contained in the reservoir is thus heated and transformed into steam ;
- the bundle exchanger: the heating fluid is contained in a reservoir and water/steam runs through a bundle of tubes embedded in the reservoir.

[0007] In the first case, the evaporator is able to generate only saturated steam that has then to be superheated in a separate exchanger, which is also fed with thermal fluid.

[0008] In the second case, the water can be transformed into superheated steam, which can be directly used in a turbine, with only one passage: it is then referred to a mono-tubular or once-through boiler.

[0009] The bundle exchanger allows to work at high pressure, which guarantees a better yield, while allowing control of the cyclical thermal constraints.

[0010] In prior art Siemens AG developed a bundle exchanger, according to the once-through (or so-called Benson) technology, which is used in numerous classical power plants. But the heat exchanger of this conception shows disadvantages such as its cost and its almost impossibility of being maintained.

[0011] In a so-called "shell and tubes" heat exchanger/evaporator of prior art, a cylindrical shell houses a bundle of parallel tubes extending between two end manifolds or collectors so that a first fluid, generally water intended to be transformed into steam in the shell, can tightly pass through the pipes. For example, feed water is supplied to the lower ends of the pipes in the bundle of tubes through the lower collector. The steam is discharged from the upper end of the bundle of tubes through pipes sections into the upper collector. A second fluid (for example liquid sodium in document US 3,628,507) is supplied to the casing in its upper part through an upper inlet and, after flowing downwardly in counterflow relationship with the first liquid flowing in the pipe bundle, is discharged through an outlet located at the lower part of the shell.

[0012] To provide an improved heat exchange between the two fluids, the flow path of the second fluid is determined by intermediate baffles forming respective passages so that the second fluid flow changes its direction in passing from one passage to the next one. The baffles are under the form of partial circular segments or annular rings and disks, installed perpendicular to the longitudinal axis of the shell to provide a zigzag flow of the second fluid.

[0013] In order to improve the efficiency of the transfer rate, document WO 2009/148822 discloses baffles mounted in the shell to guide the fluid into a helical flow pattern, with different helix angles when the baffle is proximate the inlet and the outlet respectively.

[0014] Document US 2003/0116306 discloses a heat exchanger/evaporator very similar with a shell and tubes exchanger of prior art with tubes sheets, collectors, etc. for the first fluid and baffles perpendicular to the longitudinal direction of the casing for changing the direction of the second fluid. Moreover the tubes conveying the first fluid are provided with internal baffles converting the straight tube channel into two semi-circularly sectioned spiral channels. These channels define a spiralling flow path for the vapour generated in the heat exchange tube from the vapour-liquid mixture entering the tube.

[0015] Document CN 200993535 Y discloses a vertical steam-water heat exchanger designed to exhaust the incondensable gases accumulating in the upper region of the exchanger shell, causing circulation hindering and finally overheating and destruction of the heat exchange tubes. The exchanger shell is made of tube sheets or plates assembled to pass alternate baffle plates. A drawback of this configuration is that the heat exchange is reduced in the middle of the shell.

Aims of the invention

[0016] The present invention aims at avoiding the drawbacks of prior art.

[0017] More particularly, the invention aims at proposing a new kind of heat exchanger of the type bundle or one-through.

[0018] The invention also proposes an exchanger offering a lower cost and a maintenance rendered possible.

Summary of the invention

[0019] The present invention relates to a vertical heat exchanger/evaporator comprising a cylindrical shell housing a bundle of parallel vertical tubes in which, in use, is flowing a first fluid, said tubes extending between a lower end plate and an upper end plate, said lower end plate being fed with said first fluid by an inlet collector and said upper end plate delivering superheated steam of said first fluid at an outlet collector, said shell being provided respectively in its upper part with an inlet and in its lower part with an outlet for a second fluid, so that, in use, said second fluid is flowing downwardly in counterflow of the first fluid flowing in the tube bundle, said shell being provided with horizontal baffles dividing the enclosure in several floors vertically superimposed, characterised in that said shell also comprises a central cylindrical baffle having closed ends, forming at each floor a ringed space run through by the second fluid, said tubes being arranged in the shell externally the central cylindrical baffle, with passages designed between two contiguous floors, so that the second fluid alternately flows in reverse rotation in said two contiguous floors.

[0020] According to preferred embodiments of the invention, the vertical heat exchanger/evaporator also comprises one or a suitable combination of the following characteristics :

- the first fluid is a mixture of water and water steam ;
- said tubes are arranged in circles in the shell externally the central cylindrical baffle ;
- said tubes are provided with external fins arranged in a spiral ;
- the first fluid inlet collector is provided with an expansion joint so that to allow for differential expansion between the tubes and the shell ;
- the junction between the tubes and at least one collector comprises a flexibility lyre so that to allow differential expansion between the tubes of the bundle ;
- the collectors are provided with cavities allowing access for controlling, repairing or replacing any tube or assembly.

Short description of the drawings

[0021] FIG.1 schematically represents a longitudinal cross-sectional view of the heat exchanger according to the invention.

[0022] FIG.2 schematically represents three transverse cross-sectional views of the heat exchanger of FIG. 1.

Detailed description of the invention and preferred embodiments

[0023] The object of the invention is a heat exchanger, as depicted in FIG. 1, having reciprocating flow in which the tubes 2 of the heat exchanger 1 are run through by water/steam. The amount of tubes 2 depends on the flow of steam taken into consideration, on its pressure and on its chosen temperature. All the tubes 2, making a bundle, are installed in parallel, vertically, and are "once-through"-designed, between an inlet collector 3 and an outlet collector 4.

[0024] The tubes 2 are advantageously provided with transverse or longitudinal fins (not shown) arranged in a spiral in order to increase the surface of external exchange, which is in contact with the thermal fluid.

[0025] The whole bundle of tubes is contained in a vertical essentially cylindrical enclosure (or envelope or shell) 9, run through by the thermal fluid. A shape of the enclosure departing to some extent from the strictly cylindrical shape can also come within the scope of the invention.

[0026] The cylindrical enclosure comprises horizontal baffles 5, dividing the cylindrical enclosure in different floors 7. The baffles 5 each comprise an opening allowing the passage of the thermal fluid.

[0027] A cylindrical baffle 6 with a closed end is installed at the centre of the cylinder 9, thus forming a ring space which will be run through by the fluid.

[0028] The tubes 2 are preferably arranged in circles within the cylinder 9, except for two zones 8 (or 8', 8") which are dedicated to the passage of the fluid from one floor 7 to another (see FIG. 2).

[0029] The thermal fluid runs through the bundle of tubes 2 horizontally at each floor 7 with an essentially horizontal velocity vector, then goes to the next floor 7', 7'', 7''', etc. and, in reverse rotation, i.e. in alternately clockwise and counterclockwise rotation from one floor 7 to the next one, runs again through the bundle of tubes and so on.

[0030] The water inlet collector 3 comprises an expansion joint 10 in order to allow the differential expansion between the tubes of the bundle and the cylindrical enclosure 9. Furthermore, the junction (tubes) 11 between the collectors and the tubes of the bundle can comprise a lyre of flexibility (not shown) in order to allow for the possible differential expansion between the tubes.

[0031] The conception of the exchanger according to the present invention allows the use of tubes with fins (not shown), so that to optimize thermal exchange.

[0032] With access 14 to the bottom and top cavities in respective collectors 3, 4, all the tubes and all the welds are visible, accessible and can be controlled or maintained. By cutting a sleeve in a tube (not shown), it is possible to carry out an endoscopic inspection of the whole tube. By removing the higher bottom, it is possible to replace any tube.

List of reference symbols

[0033]

1. heat exchanger

2. tube
3. inlet collector
4. outlet collector
5. horizontal baffle
6. vertical cylindrical baffle with closed end
7. floor
8. passage zone between two floors
9. cylindrical shell
10. expansion join
11. junction between collector and tubes
12. thermal fluid inlet
13. thermal fluid outlet
14. collector access door

Claims

1. Vertical heat exchanger/evaporator (1) comprising a cylindrical shell (9) housing a bundle of parallel vertical tubes (2) in which, in use, is flowing a first fluid, said tubes extending between a lower end plate and an upper end plate, said lower end plate being fed with said first fluid by an inlet collector (3) and said upper end plate delivering superheated steam of said first fluid at an outlet collector (4), said shell (9) being provided respectively in its upper part with an inlet (12) and in its lower part with an outlet (13) for a second fluid, so that, in use, said second fluid is flowing downwardly in counterflow of the first fluid flowing in the tube bundle, said shell (9) being provided with horizontal baffles (5) dividing the enclosure in several floors (7) vertically superimposed, **characterised in that** said shell (9) also comprises a central cylindrical baffle (6) having closed ends, forming at each floor (7) a ringed space run through by the second fluid, said tubes (2) being arranged in the shell (9) externally the central cylindrical baffle (6), with passages (8, 8', 8") designed between two contiguous floors (7), so that the second fluid alternately flows in reverse rotation in said two contiguous floors (7).

2. Heat exchanger/evaporator (1) according to Claim 1, **characterised in that** the first fluid is a mixture of water and water steam.

3. Heat exchanger/evaporator (1) according to Claim 1, **characterised in that** said tubes (2) are arranged in circles in the shell (9) externally the central cylindrical baffle (6).

4. Heat exchanger/evaporator (1) according to Claim 1, **characterised in that** said tubes (2) are provided with external fins arranged in a spiral.

5. Heat exchanger/evaporator (1) according to Claim 1, **characterised in that** the first fluid inlet collector (3) is provided with an expansion joint (10) so that to allow for differential expansion between the tubes (2) and the shell (9).

6. Heat exchanger/evaporator (1) according to Claim 1, **characterised in that** the junction between the tubes (2) and at least one collector (3, 4) comprises a flexibility lyre so that to allow differential expansion between the tubes (2) of the bundle.

7. Heat exchanger/evaporator (1) according to Claim 1, **characterised in that** the collectors (3, 4) are provided with cavities allowing access (14) for controlling, repairing or replacing any tube or assembly.

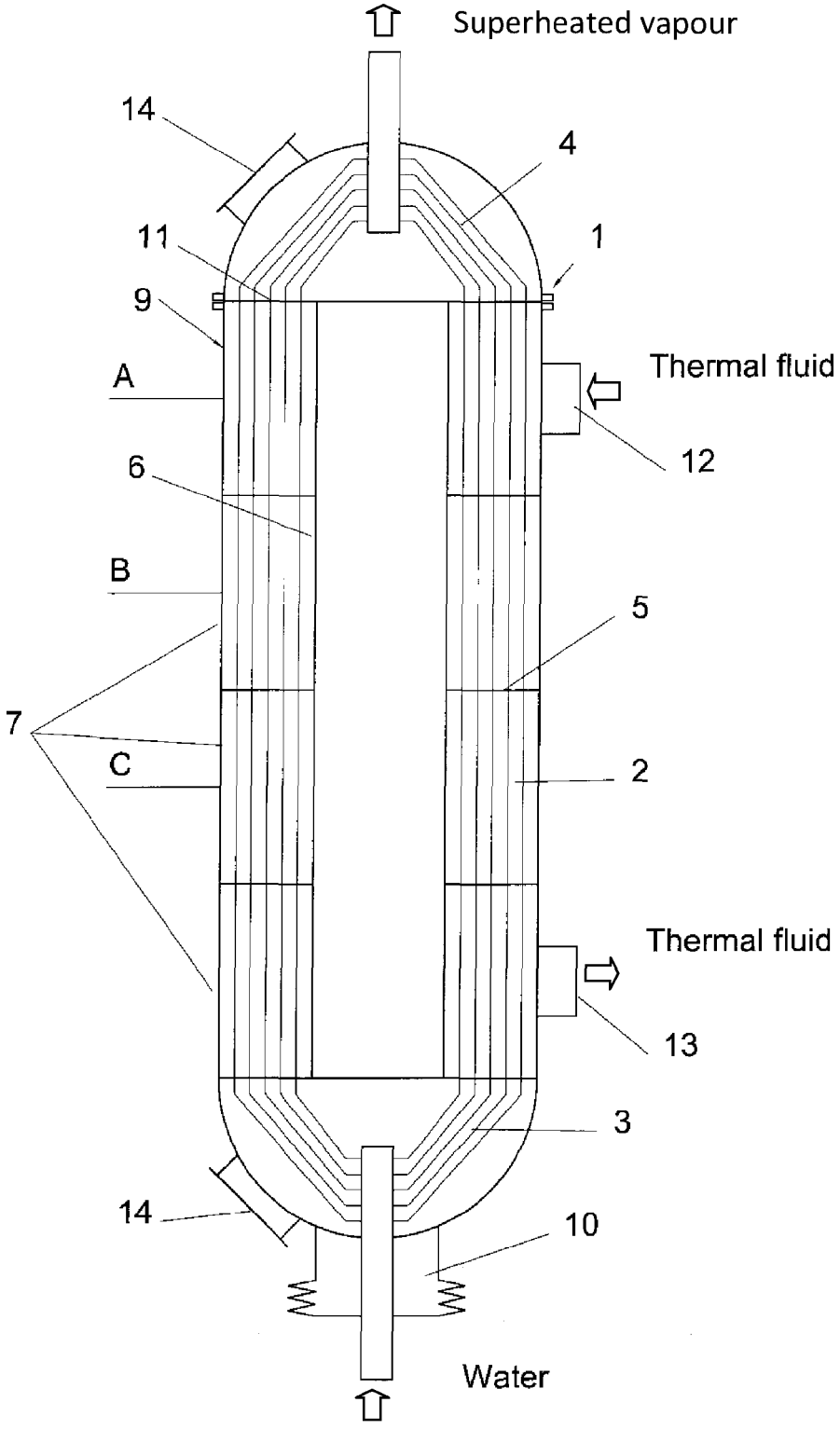
Superheated vapour
14
4
11
1
9
Thermal fluid
A
12
6
B
5
7
C
2
Thermal fluid
13
3
14
10
Water

FIG.1

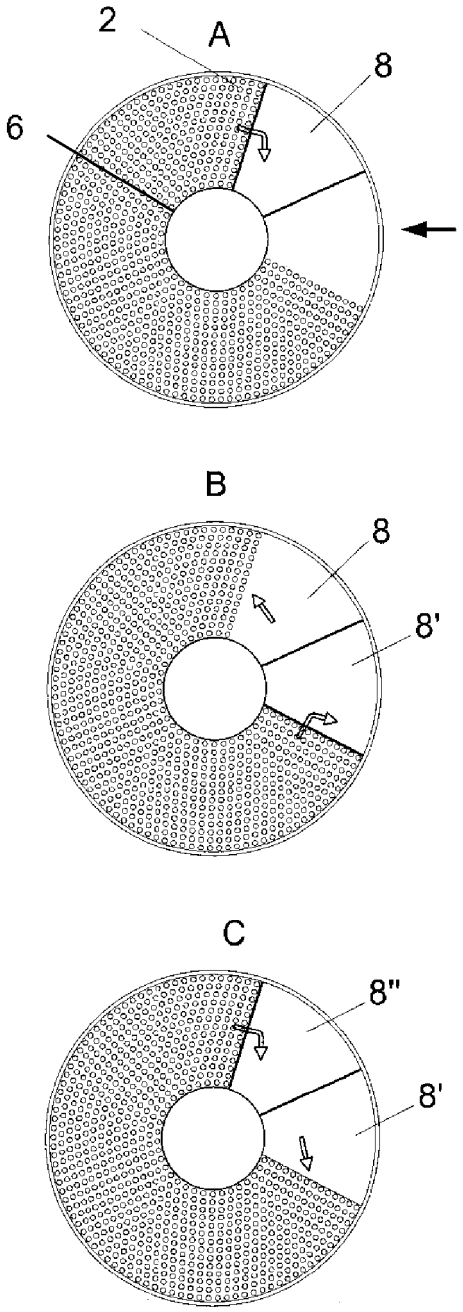

FIG.2

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EUROPEAN SEARCH REPORT

Application Number
EP 11 19 1611

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	GB 897 593 A (VER ECONOMISER WERKE G M B H) 30 May 1962 (1962-05-30) * figures 1-3 * * page 2, line 71 - line 79 * -----	1-3 4-7	INV. F28D7/16 F28F9/22
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Y	EP 0 246 486 A1 (STEIN INDUSTRIE [FR]) 25 November 1987 (1987-11-25) * figure 3 * -----	5	
Y	US 3 247 897 A (AMMON JOHANNES H) 26 April 1966 (1966-04-26) * figure 1 * * column 3, line 20 - line 33 * -----	6	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	7 May 2012	Fernandez Ambres, A

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
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E : earlier patent document, but published on, or after the filing date
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1 EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 11 19 1611

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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