



HU000025161T2

(19) **HU****MAGYARORSZÁG**
Szellemi Tulajdon Nemzeti Hivatala(11) Lajstromszám: **E 025 161**(13) **T2****EURÓPAI SZABADALOM**
SZÖVEGÉNEK FORDÍTÁSA(21) Magyar ügyszám: **E 12 194042**(51) Int. Cl.: **F22B 37/20** (2006.01)(22) A bejelentés napja: **2012. 11. 23.****F28F 90/13** (2006.01)

(96) Az európai bejelentés bejelentési száma:

EP 20120194042

(97) Az európai bejelentés közzétételi adatai:

EP 2735791 A1 **2014. 05. 28.**

(97) Az európai szabadalom megadásának meghirdetési adatai:

EP 2735791 B1 **2015. 07. 29.**

(72) Feltaláló(k):

Caruzzi, Florent, 94250 Gentilly (FR)
Enault, Christian, 92260 Fontenay aux Roses (FR)
Quaranta, Alain, 91640 Fontenay Les Bris (FR)
Gurieć, Thierry, 78000 Versailles (FR)

(73) Jogosult(ak):

Alstom Technology Ltd, 5400 Baden (CH)

(74) Képviselő:

Szabó Zsolt, DANUBIA Szabadalmi és Jogi
Iroda Kft., Budapest

(54)

Fluidágyas hőcserélővel ellátott kazán

Az európai szabadalom ellen, megadásának az Európai Szabadalmi Közlönyben való meghirdetésétől számított kilenc hónapon belül, felszólalást lehet benyújtani az Európai Szabadalmi Hivatalnál. (Európai Szabadalmi Egyezmény 99. cikk(1))

A fordítást a szabadalmas az 1995. évi XXXIII. törvény 84/H. §-a szerint nyújtotta be. A fordítás tartalmi helyességét a Szellemi Tulajdon Nemzeti Hivatala nem vizsgálta.



(11) **EP 2 735 791 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention
of the grant of the patent:
29.07.2015 Bulletin 2015/31

(51) Int Cl.:
F22B 37/20 (2006.01) F28F 9/013 (2006.01)

(21) Application number: **12194042.3**

(22) Date of filing: **23.11.2012**

(54) **Boiler having a fluidized bed heat exchanger**

Kessel mit Flüssigbett-Wärmeaustauscher

Chaudière comprenant un échangeur de chaleur à lit fluidisé

(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**

(43) Date of publication of application:
28.05.2014 Bulletin 2014/22

(73) Proprietor: **ALSTOM Technology Ltd**
5400 Baden (CH)

(72) Inventors:
• **Caruzzi, Florent**
94250 Gentilly (FR)

- **Enault, Christian**
92260 Fontenay aux Roses (FR)
- **Quaranta, Alain**
91640 Fontenay Les Bris (FR)
- **Guriec, Thierry**
78000 Versailles (FR)

(74) Representative: **Alstom Technology Ltd**
CHTI Intellectual Property
Brown Boveri Strasse 7
5400 Baden (CH)

(56) References cited:
CH-A- 314 447 DE-A1- 4 032 973
US-A- 3 267 913 US-A- 4 827 723

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

[0001] The invention is related to a boiler, typically a circulating fluidized bed boiler (CFB), which comprises a fluidized bed heat exchanger. Circulating fluidized bed boilers include a reactor where the solid particles are fluidized and where chemical reactions and/or combustion reactions can take place. The circulating fluidized regime enhances the mixing of particles along with potential exothermic or endothermic chemical reactions.

[0002] The operating principle of a fluidized bed heat exchanger is relatively simple: hot solids are brought into a chamber, in which they are fluidized with air or re-circulated flue gas as a slowly bubbling fluidized bed. Heat exchanger elements, often in the form of tube coils following a boustrophedon path, are located inside this fluidized bed and are fed with a coolant fluid.

[0003] The tube coils have to be maintained by supports. It is known to use a sliding connection with supports allowing differential movements between the tubes and the supports. The drawback of this sliding connection is that gaps and wearing associated therewith may occur.

[0004] It is also known to use shims. However, this solution requires high construction skills to install all the different parts of the fluidized bed heat exchanger without gaps along with the difficulty to assess the good execution of the work afterwards.

[0005] US 3 267 913 discloses a boiler according to the pre-characterizing part of claim 1.

[0006] Thus, an object of the present invention is to provide a boiler having a fluidized bed heat exchanger as to solve the above-described problems.

[0007] The object mentioned above is accomplished by a boiler comprising a fluidized bed heat exchanger, as defined in claim 1.

[0008] In the boiler of the invention, every vertical supporting device comprises at least two vertical supports for fixing the tubes, typically at least two separate vertical supports.

[0009] Thus, the fixation of the tubes on the vertical supports prevents local vibrations and possible abrasions resulting therefrom. Using at least two supports by device makes it possible to split the amount of efforts.

[0010] The boustrophedon path of each tube comprises horizontal portions, two consecutive horizontal portions being linked together by a vertical portion thus forming a bend between the horizontal portions.

[0011] One supporting device can be located on the left side of the tube bundle and one supporting device can be located on the right side of the tube bundle.

[0012] The vertical supports are vertical tubes.

[0013] The tubes forming the vertical supports can be cooled or uncooled.

[0014] For at least one supporting device, two consecutive horizontal portions of each tube of the heat exchanger are not fixed to the same vertical support of the supporting device.

[0015] For each supporting device, two consecutive

horizontal portions of each tube of the heat exchanger are preferably not fixed to the same vertical support of the supporting device.

[0016] For each supporting device, each horizontal portion of each tube of the heat exchanger is preferably fixed to only one vertical support of the supporting device and, for each supporting device, two consecutive horizontal portions of each tube of the heat exchanger are preferably not fixed to the same vertical support of the supporting device.

[0017] The boiler can comprise a furnace in which combustion of solid particles is sustained and the fluidized bed heat exchanger can be placed outside the furnace.

[0018] Other features and advantages of the invention will become apparent from the following description of an embodiment of the invention given by way of a non-limiting example only, and with reference to the accompanying drawings, in which:

- Figure 1 is a diagram of a boiler according to the invention, and
- Figures 2 to 10 are partial view of the boiler showing the fluidized bed heat exchanger support system of the invention.

[0019] Figure 1 illustrates a boiler that includes a furnace 1 in which combustion of solid particles is sustained. The top of the furnace 1 is connected to a separator member 2 via an extraction duct 12 which conveys the flue gases and the recycled particles.

[0020] The separator member 2, e.g. a cyclone, delivers the gas to a flue duct 20 leading off from its top, and it delivers the particles to a recycling duct 23 which leads into an external dense fluidized bed 3 that is placed outside the furnace 1. The recycling duct 23 is generally provided with a siphon and with lagging. The external bed 3 is provided with a first heat exchanger 3A, and which, in this example, is in the form of a nest of tubes that zigzag in vertical planes, following a boustrophedon path, so that the long tube segments are preferably horizontal. The first heat exchanger 3A is fed with a coolant fluid, e.g. water, via an inlet 39. The outlet 30 of the heat exchanger 3A can be connected to a second heat exchanger 3B which can be located in the furnace 1.

[0021] The remainder of the description is dedicated to the support of the heat exchanger 3A. It is to be noted that the invention is not limited to external fluidized bed heat exchangers but can also be used with other fluidized bed heat exchangers.

[0022] As illustrated in Figure 2, and in Figure 3 in a perspective view, the heat exchanger 3A includes a plurality of tubes 7 (four tubes in this example) zigzagging in a vertical plane. The tubes 7 can be of a square or circular cross-section. The serpentine tubes 7 follow each a boustrophedon path. Boustrophedon is a kind of bi-directional text, mostly seen in ancient manuscripts and other inscriptions. Every other line of writing is flipped or reversed, with reversed letters. Rather than going left-

to-right as in modern English, or right-to-left as in Arabic and Hebrew, alternate lines in boustrophedon must be read in opposite directions. The name "boustrophedon" is taken from the Greek language. Its etymology is from bous, "ox" and strephein, "to turn", because the hand of the writer goes back and forth like an ox drawing a plough across a field and turning at the end of each row to return in the opposite direction (i.e., "as the ox ploughs"). In this way, the tubes path goes alternately from right to left and from left to right.

[0023] Two or more distinct supporting devices 41,42 separated by an empty space realize the support of the fluidized bed heat exchangers bundle tubes. One device 41 is located on the left side of the exchanger and the other device 42 is located on the right side of the exchanger. Each device 41,42 comprises at least two vertical supports 411,412;421,422 separated by an empty space and which are two close hanger tubes along with alternately welded interference clamps supports, which position can be adapted according to mechanical calculation results. The hanger tubes 411,412;421,422 may be cooled, as is the case in the High Temperature Superheater (HTS) bundles. Alternatively, the hanger tubes 411,412;421,422 may be uncooled, as is the case in the Intermediate Temperature Superheater (ITS) bundles.

[0024] Figure 4 illustrates the fixation points 6 between the tubes 7 and the vertical tubes 411,412,421,422.

[0025] As illustrated in Figure 5, the fixations 6 of the tubes 7 being represented by circles, for each supporting device 41,42, each horizontal portion of each exchanger tube 7 is fixed to only one vertical tube of the supporting device 41,42. This allows to decrease the bending stresses in the exchanger. Also for a decreasing of the bending stresses, as illustrated in Figure 6, for each supporting device 41,42, two consecutive horizontal portions of a tube 7 (i.e. an horizontal portion of the tube placed before one bend of the boustrophedon path and the horizontal portion placed after the bend) are preferably not fixed to the same vertical tube.

[0026] A first fixation embodiment which is consistent with these preferred conditions is shown on Figure 7. On the left side, the first supporting device 41 comprises two vertical supports 411,412, i.e. one left support 411 and one right support 412. In the same manner, on the right side, the second supporting device 42 comprises two vertical supports 421,422, i.e. one left support 421 and one right support 422. The tube bundle comprises five tubes 71 to 75. The tubes 71,72,73,74,75 follow a boustrophedon path including four bends A,B,C,D. Naturally, the number of tubes and the number of bends are given by way of example, and a person skilled in the art can choose a different number of tubes and bends.

[0027] If one considers tube 71 (i.e. a tube numbered N), this tube 71 is connected before the bend A to the right support 412 of the first supporting device 41 and after the bend A to the left support 411 of the first supporting device 41. After the bend A, the tube 71 is then connected before the bend B to the left support 421 of

the second supporting device 42 and after the bend B to the right support 422 of the second supporting device 42. The same connection mode is then repeated: the tube 71 is connected before the bend C to the right support 412 of the first supporting device 41 and after the bend C to the left support 411 of the first supporting device 41. The tube 71 is then connected before the bend D to the left support 421 of the second supporting device 42 and after the bend D to the right support 422 of the second supporting device 42.

[0028] The tubes 73 and 75 (i.e. tubes numbered N+2) are connected in the same way as for the tube 71 (a tube numbered N).

[0029] According to this first embodiment, the tubes 72 and 74 (i.e. tubes numbered N+1) are connected in the opposite way, i.e. a connection of a tube N to the right support 412 of the first supporting device 41 is replaced for a tube N+1 by a connection to the left support 411 of the first supporting device 41 and vice versa. In the same manner, a connection of a tube N to the right support 422 of the second supporting device 42 is replaced for a tube N+1 by a connection to the left support 421 of the second supporting device 41 and vice versa.

[0030] A second embodiment is shown on Figure 8. According to this embodiment, all the tubes 71 to 75 are connected before the bend A to the right support 412 of the first supporting device 41. Thus, all the tubes 71 to 75 are connected after the bend A to the left support 411 of the first supporting device 41. In the same manner, all the tubes 71 to 75 are connected before the bend B and after the bend A to the right support 422 of the second supporting device 42. Thus, all the tubes 71 to 75 are connected after the bend B to the left support 421 of the second supporting device 42.

[0031] Figures 9 and 10 show a third and a fourth embodiment, respectively. Thus, one skilled in the art is taught that various configurations can be carried out. These configurations are consistent with the two conditions illustrated in Figures 5 and 6, i.e. 1) for at least one supporting device, and preferably for both supporting devices, each horizontal portion of an exchanger tube is fixed to only one vertical tube of the supporting device, and 2) for each supporting device, and preferably for both supporting devices, two consecutive horizontal portions of an exchanger tube (i.e. an horizontal portion of the tube placed before one bend of the boustrophedon path and the horizontal portion placed after the bend) are fixed to a different vertical tube of the supporting device.

Claims

1. A boiler comprising a heat exchanger (3A) including a plurality of tubes (7) forming a tube bundle, each tube (7) following a vertical boustrophedon path, the tubes (7) being supported by at least two vertical supporting devices (41,42) placed on both sides of the tube bundle, wherein every vertical supporting

- device (41,42) comprises at least two vertical supports (411,412;421,422) for fixing the tubes (7), wherein the boustrophedon path of each tube (7) comprises horizontal portions, two consecutive horizontal portions being linked together by a vertical portion thus forming a bend between the horizontal portions, the vertical supports (411,412;421,422) are vertical tubes, each horizontal portion of each tube (7) of the heat exchanger (3A) is fixed to only one vertical support (411,412;421,422) of the supporting device (41,42), **characterized in that** the heat exchanger is a fluidized bed heat exchanger (3A), and for at least one supporting device (41,42) two consecutive horizontal portions of each tube (7) of the heat exchanger (3A) are not fixed to the same vertical support (411,412;421,422) of the supporting device (41,42).
2. A boiler according to claim 1, **characterized in that** one supporting device (41) is located on the left side of the tube bundle and **in that** one supporting device (42) is located on the right side of the tube bundle.
 3. A boiler according to claim 1, **characterized in that** the tubes forming the vertical supports (411,412;421,422) are cooled as uncooled.
 4. A boiler according to claim 1, **characterized in that**, for each supporting device (41,42), each horizontal portion of each tube (7) of the heat exchanger (3A) is fixed to only one vertical support (411,412;421,422) of the supporting device (41,42).
 5. A boiler according claim 1, **characterized in that**, for each supporting device (41,42), two consecutive horizontal portions of each tube (7) of the heat exchanger (3A) are not fixed to the same vertical support (411,412;421,422) of the supporting device (41,42).
 6. A boiler according to any of claim 1 to 5, **characterized in that**, for each supporting device (41,42), each horizontal portion of tube (7) of the heat exchanger (3A) is fixed to only one vertical support (411,412;421,422) of the supporting device (41,42) and **in that**, for each supporting device (41,42), two consecutive horizontal portions of each tube (7) of the heat exchanger (3A) are not fixed to the same vertical support (411,412;421,422) of the supporting device (41,42).
 7. A boiler according to any of claim 1 to 6, **characterized in that** the boiler comprises a furnace (1) in which combustion of solid particles is sustained and **in that** the fluidized bed heat exchanger (3A) is placed outside the furnace (1).

Patentansprüche

1. Kessel, umfassend einen Wärmetauscher (3A), der mehrere Rohre (7) aufweist, die ein Rohrbündel bilden, wobei jedes Rohr (7) einem vertikalen Boustrophedonweg folgt, wobei die Rohre (7) von mindestens zwei vertikalen Abstützvorrichtungen (41, 42) abgestützt werden, die auf beiden Seiten des Rohrbündels angeordnet sind, wobei jede vertikale Abstützvorrichtung (41, 42) mindestens zwei Stützen (411, 412; 421, 422) zum Fixieren der Rohre (7) umfasst, wobei der Boustrophedonweg jedes Rohrs (7) horizontale Abschnitte aufweist, wobei zwei aufeinander folgende horizontale Abschnitte durch einen vertikalen Abschnitt miteinander verbunden sind, und so eine Krümmung zwischen den horizontalen Abschnitten bildet, wobei die vertikalen Stützen (411, 412; 421, 422) vertikale Rohre sind, wobei der horizontale Abschnitt jedes Rohrs (7) des Wärmetauschers (3A) nur an einer vertikalen Stütze (411, 412; 421, 422) der Abstützvorrichtung (41, 42) fixiert ist, **dadurch gekennzeichnet, dass** der Wärmetauscher ein Flüssigbett-Wärmetauscher (3A) ist und dass mindestens eine Abstützvorrichtung (41, 42) zwei aufeinander folgende horizontale Abschnitte jedes Rohrs (7) des Wärmetauschers (3A) nicht an der gleichen vertikalen Stütze (411, 412; 421, 422) der Abstützvorrichtung (41, 42) fixiert sind.
2. Kessel nach Anspruch 1, **dadurch gekennzeichnet, dass** eine Abstützvorrichtung (41) auf der linken Seite des Rohrbündels angeordnet ist und dass eine Abstützvorrichtung (42) auf der rechten Seite des Rohrbündels angeordnet ist.
3. Kessel nach Anspruch 1, **dadurch gekennzeichnet, dass** die Rohre, welche die vertikalen Stützen (411, 412; 421, 422) bilden, gekühlt oder ungekühlt sind.
4. Kessel nach Anspruch 1, **dadurch gekennzeichnet, dass** für jede Abstützvorrichtung (41, 42) jeder horizontale Abschnitt jedes Rohrs (7) des Wärmetauschers (3A) nur an einer vertikalen Stütze (411, 412; 421, 422) der Abstützvorrichtung (41, 42) fixiert ist.
5. Kessel nach Anspruch 1, **dadurch gekennzeichnet, dass** für jede Abstützvorrichtung (41, 42) zwei aufeinander folgende horizontale Abschnitte jedes Rohrs (7) des Wärmetauschers (3A) nicht an der gleichen vertikalen Stütze (411, 412; 421, 422) der Abstützvorrichtung (41, 42) fixiert sind.
6. Kessel nach einem der Ansprüche 1 bis 5, **dadurch**

gekennzeichnet, dass für jede Abstützvorrichtung (41, 42) jeder horizontale Abschnitt des Rohrs (7) des Wärmetauschers (3A) an nur einer vertikalen Stütze (411, 412; 421, 422) der Abstützvorrichtung (41, 42) fixiert ist und dadurch dass für jede Abstützvorrichtung (41, 42) zwei aufeinander folgende horizontale Abschnitte jedes Rohrs (7) des Wärmetauschers (3A) nicht an der gleichen vertikalen Stütze (411, 412; 421, 422) der Abstützvorrichtung (41, 42) fixiert sind.

7. Kessel nach einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** der Kessel einen Ofen (1) umfasst, in dem die Verbrennung von Feststoffteilen unterstützt wird und dadurch, dass der Flüssigbett-Wärmetauscher (3A) außerhalb des Ofens (1) angeordnet ist.

Revendications

1. Chaudière comprenant un échangeur de chaleur (3A) comportant une pluralité de tubes (7) formant un faisceau de tubes, chaque tube (7) suivant un chemin de boustrophédon vertical, les tubes (7) étant supportés par au moins deux dispositifs de support verticaux (41, 42) placés des deux côtés du faisceau de tubes, dans laquelle chaque dispositif de support vertical (41, 42) comprend au moins deux supports verticaux (411, 412; 421, 422) pour fixer les tubes (7), dans laquelle:

le chemin de boustrophédon de chaque tube (7) comprend des parties horizontales, deux parties horizontales consécutives étant reliées l'une à l'autre par une partie verticale formant de ce fait une courbe entre les parties horizontales, les supports verticaux (411, 412; 421, 422) sont des tubes verticaux,

chaque partie horizontale de chaque tube (7) de l'échangeur de chaleur (3A) est fixée à un seul support vertical (411, 412; 421, 422) du dispositif de support (41, 42),

caractérisée en ce que l'échangeur de chaleur est un échangeur de chaleur à lit fluidisé (3A), et pour au moins un dispositif de support (41, 42), deux parties horizontales consécutives de chaque tube (7) de l'échangeur de chaleur (3A) ne sont pas fixées au même support vertical (411, 412; 421, 422) du dispositif de support (41, 42).

2. Chaudière selon la revendication 1, **caractérisée en ce qu'un** dispositif de support (41) est situé sur le côté gauche du faisceau de tubes et **en ce qu'un** dispositif de support (42) est situé sur le côté droit du faisceau de tubes.

3. Chaudière selon la revendication 1, **caractérisée en ce que** les tubes qui forment les supports verticaux (411, 412; 421, 422) sont refroidis ou non refroidis.

4. Chaudière selon la revendication 1, **caractérisée en ce que**, pour chaque dispositif de support (41, 42), chaque partie horizontale de chaque tube (7) de l'échangeur de chaleur (3A) est fixée à un seul support vertical (411, 412; 421, 422) du dispositif de support (41, 42).

5. Chaudière selon la revendication 1, **caractérisée en ce que**, pour chaque dispositif de support (41, 42), deux parties horizontales consécutives de chaque tube (7) de l'échangeur de chaleur (3A) ne sont pas fixées au même support vertical (411, 412; 421, 422) du dispositif de support (41, 42).

6. Chaudière selon l'une quelconque des revendications 1 à 5, **caractérisée en ce que** pour chaque dispositif de support (41, 42), chaque partie horizontale de tube (7) de l'échangeur de chaleur (3A) est fixée à un seul support vertical (411, 412; 421, 422) du dispositif de support (41, 42) et **en ce que**, pour chaque dispositif de support (41, 42), deux parties horizontales consécutives de chaque tube (7) de l'échangeur de chaleur (3A) ne sont pas fixées au même support vertical (411, 412; 421, 422) du dispositif de support (41, 42).

7. Chaudière selon l'une quelconque des revendications 1 à 6, **caractérisée en ce que** la chaudière comprend un four (1) dans lequel la combustion de particules solides est entretenue et **en ce que** l'échangeur de chaleur à lit fluidisé (3A) est placé à l'extérieur du four (1).

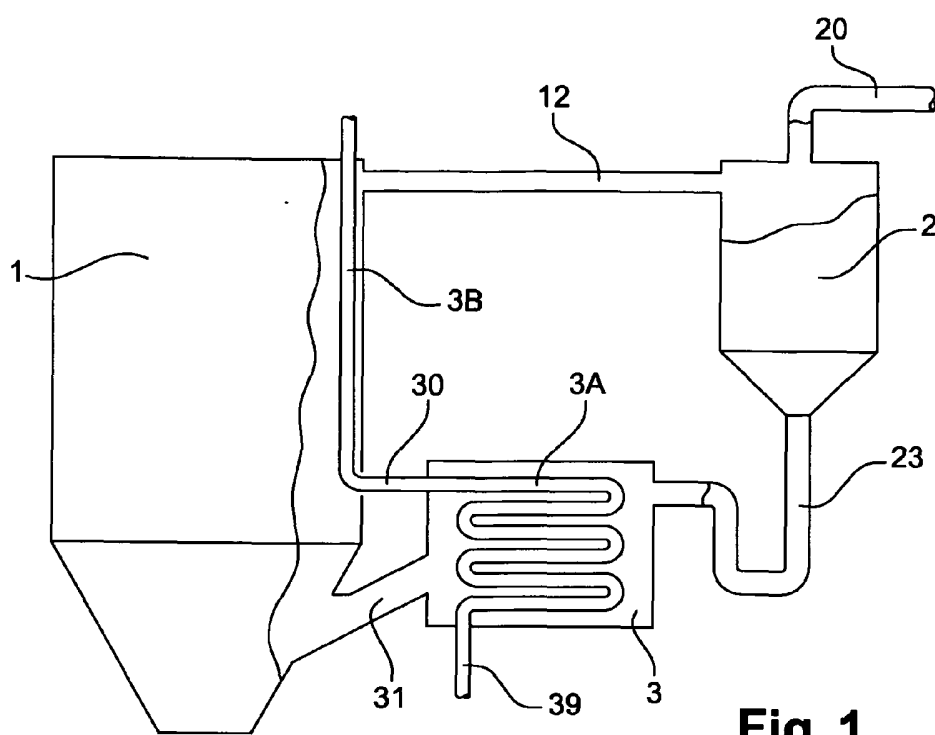


Fig. 1

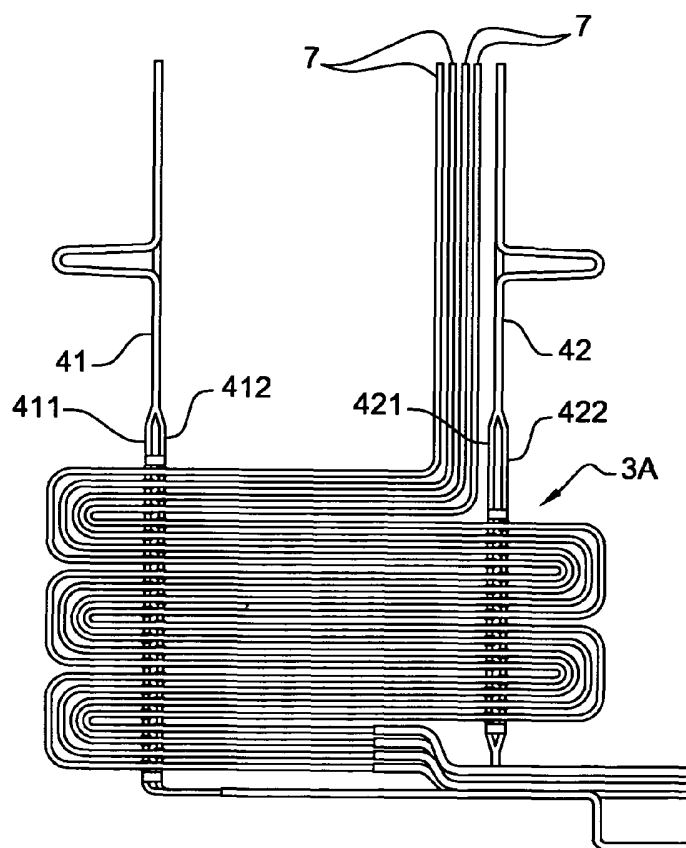
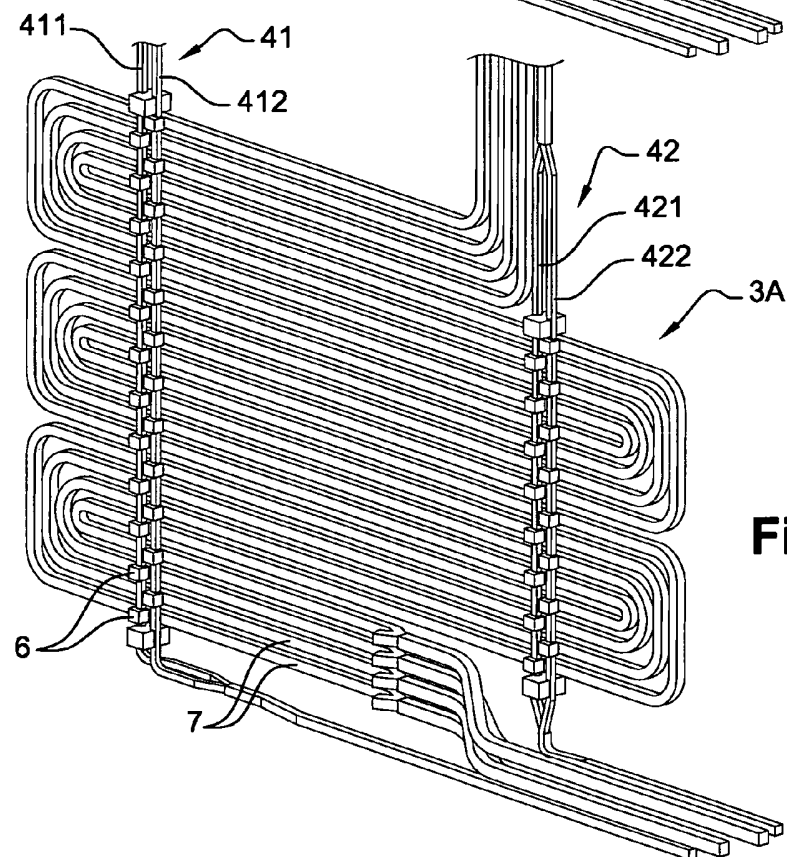
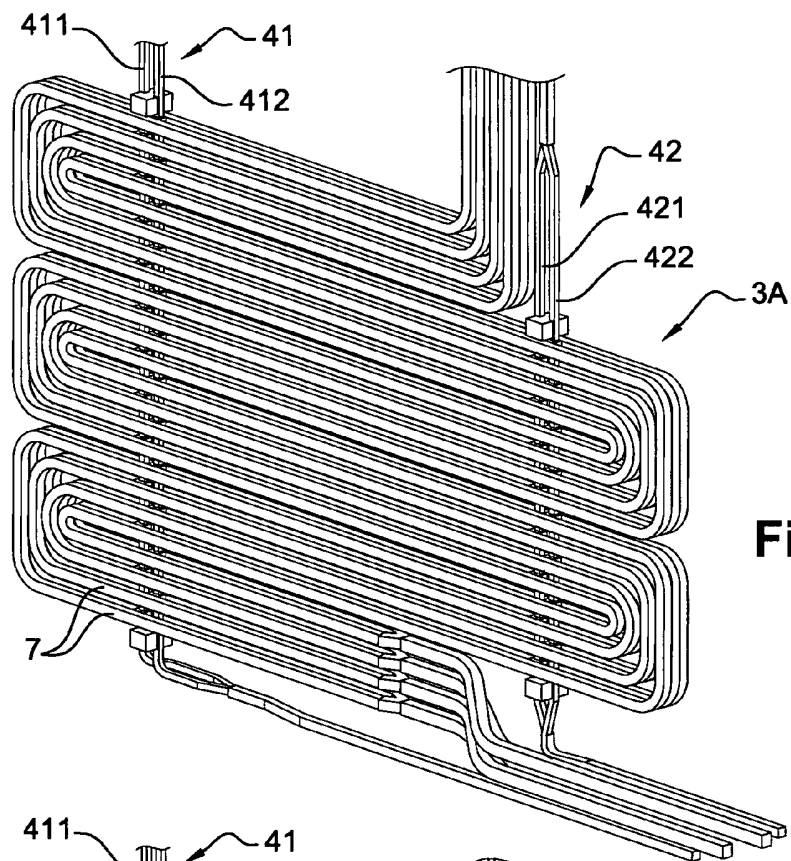


Fig. 2



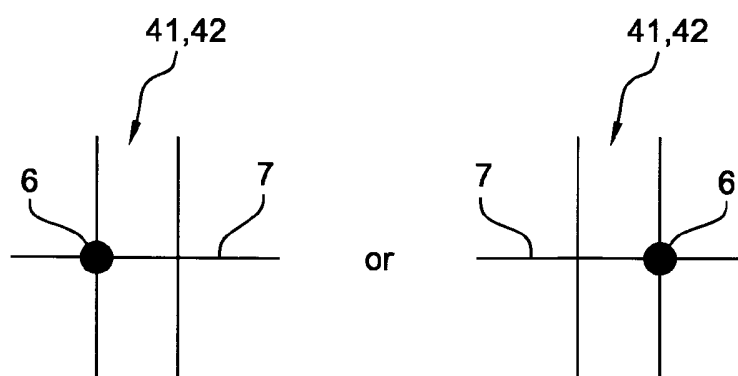


Fig. 5

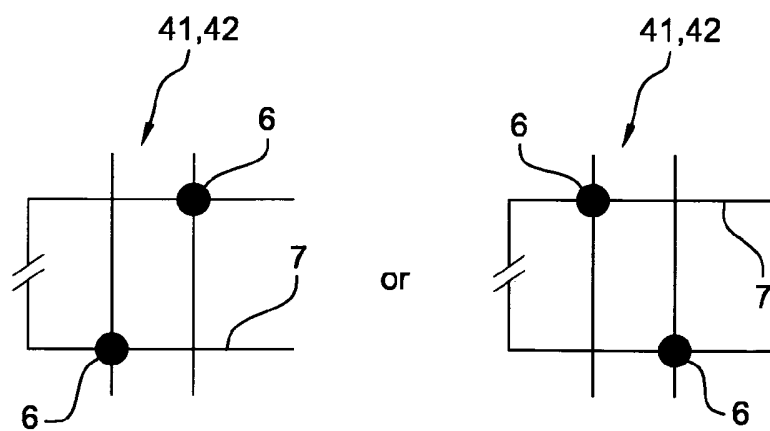
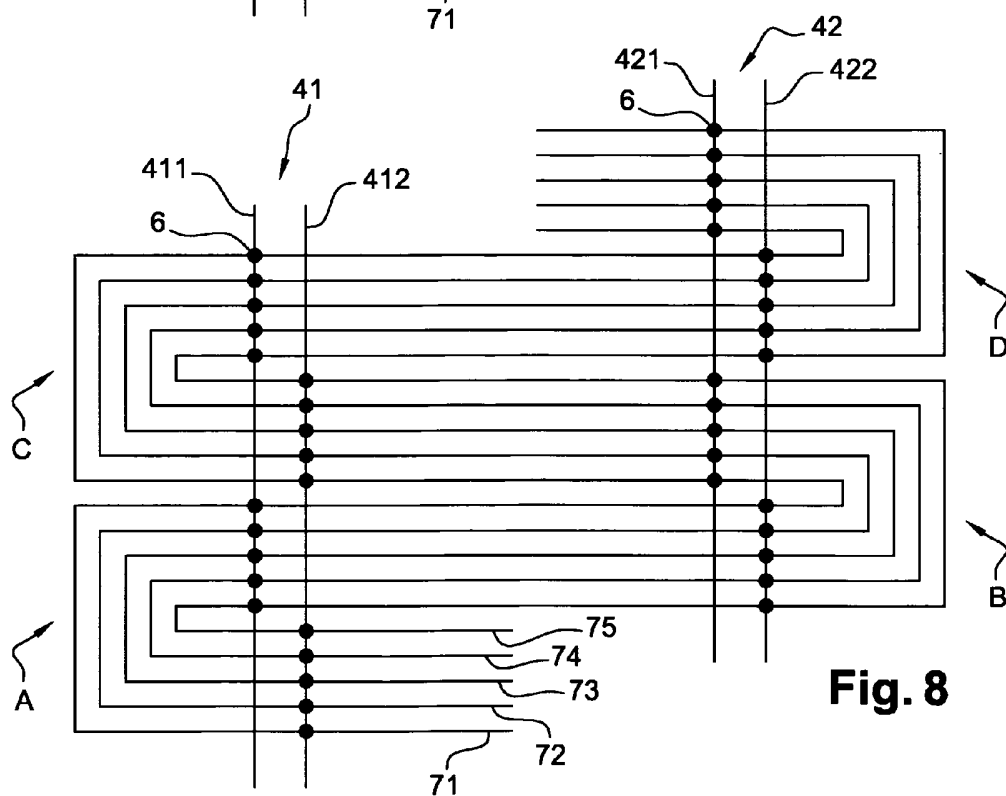
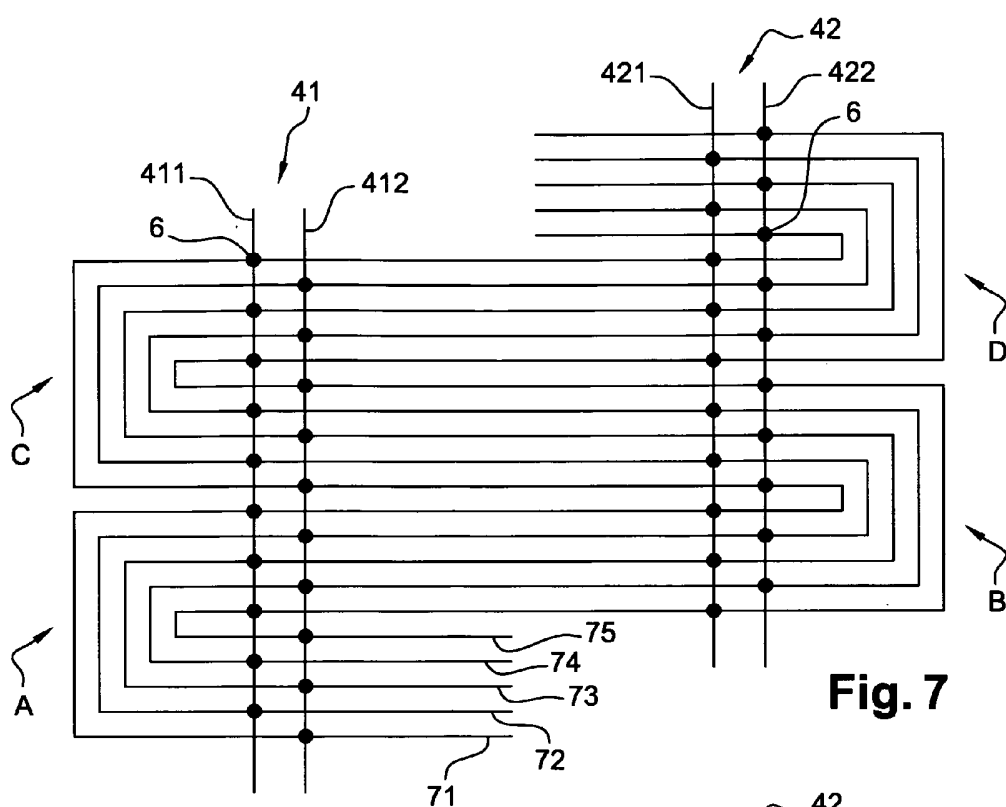
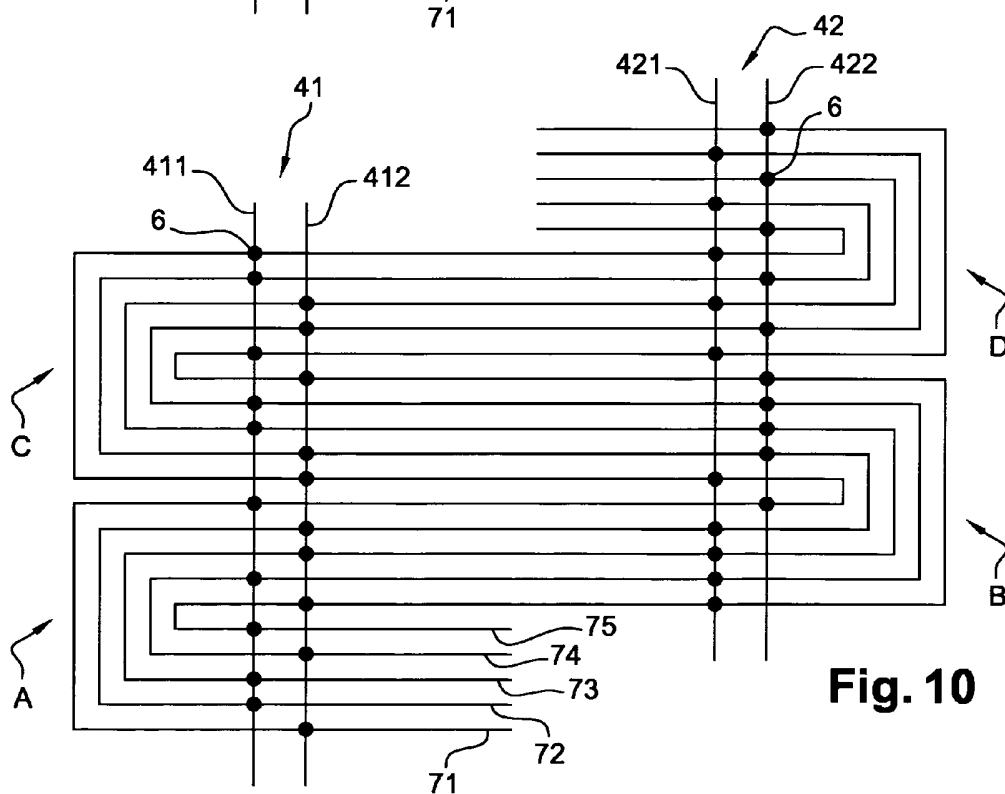
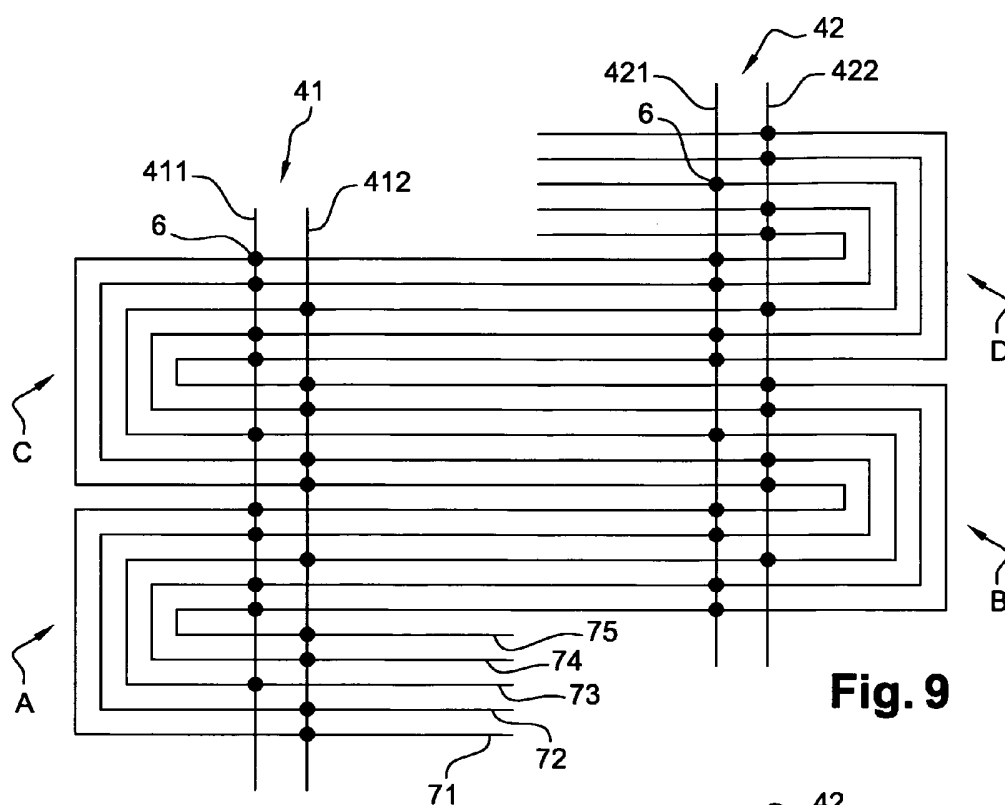


Fig. 6





REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 3267913 A [0005]

FLUIDÁGYAS HŐCSERÉLŐVEL ELLÁTOTT KAZÁN

Szabadalmi igénypontok

- 5 1. Kazán, melynek csököteget képező csöveket (7) magában foglaló hőcserélője (3A) van, valamennyi cső (7) függőleges busztrófedon pályát követ, a csöveket (7) a csököteg két oldalán elhelyezett legalább két függőleges tartószerkezet (41, 42) tartja, ahol a csövek (7) rögzítéséhez mindegyik függőleges tartószerkezetnek (41, 42) legalább két függőleges tartóeleme (411, 412; 421, 422) van,
- ahol
- 10 valamennyi cső (7) busztrófedon pályája vízszintes szakaszokat tartalmaz, két egymást követő vízszintes szakaszt egy függőleges szakasz kapcsol össze, így a vízszintes szakaszok között könyök képződik, a függőleges tartóelemek (411, 412; 421, 422) függőleges csövek,
- a hőcserélő (3A) valamennyi csövének (7) mindegyik vízszintes szakasza a tartószerkezet (41, 42) mindössze egyetlen függőleges tartóeleméhez (411, 412; 421, 422) van hozzáerősítve,
- 15 **azzal jellemezve**, hogy a hőcserélő fluidágyas hőcserélő (3A), továbbá a tartószerkezetek (41, 42) legalább egyikénél a hőcserélő (3A) mindegyik csövének (7) két egymást követő vízszintes szakasza a tartószerkezet (41, 42) nem ugyanazon tartóeleméhez (411, 412; 421, 422) van hozzáerősítve.
2. Az 1. igénypont szerinti kazán, **azzal jellemezve**, hogy egy tartószerkezet (41) a csököteg bal oldalán van elhelyezve, továbbá egy tartószerkezet (42) a csököteg jobb oldalán van elhelyezve.
- 20 3. Az 1. igénypont szerinti kazán, **azzal jellemezve**, hogy a függőleges tartóelemeket (411, 412; 421, 422) képező csövek hűtöttek vagy hűtés nélküliek.
4. Az 1. igénypont szerinti kazán, **azzal jellemezve**, hogy a hőcserélő (3A) mindegyik csövének (7) valamennyi vízszintes szakasza a tartószerkezetek (41, 42) mindegyike esetén mindössze a tartószerkezet (41, 42) egyetlen függőleges tartóeleméhez (411, 412; 421, 422) van hozzáerősítve.
- 25 5. Az 1. igénypont szerinti kazán, **azzal jellemezve**, hogy a hőcserélő (3A) mindegyik csövének (7) két egymást követő vízszintes szakasza egyetlen tartószerkezet (41, 42) esetén síncs a tartószerkezet (41, 42) ugyanazon tartóeleméhez (411, 412; 421, 422) hozzáerősítve.
6. Az 1-5. igénypontok bármelyike szerinti kazán, **azzal jellemezve**, hogy a hőcserélő (3A) csövének (7) valamennyi vízszintes szakasza valamennyi tartószerkezet (41, 42) esetén mindössze a tartószerkezet (41, 42) egyetlen függőleges tartóeleméhez (411, 412; 421, 422) van hozzáerősítve, továbbá a hőcserélő (3A) mindegyik csövének (7) két egymást követő vízszintes szakasza egyetlen tartószerkezet (41, 42) esetén síncs a tartószerkezet (41, 42) ugyanazon tartóeleméhez (411, 412; 421, 422) hozzáerősítve.
- 30 7. Az 1-6. igénypontok bármelyike szerinti kazán, **azzal jellemezve**, hogy a kazán tüzelőberendezést (1) tartalmaz, melyben szilárd szemcsék égetése zajlik, továbbá a fluidágyas hőcserélő (3A) a tüzelőberendezésen
- 35 (1) kívül van elhelyezve.