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(54) **HEAT EXCHANGE DEVICE FOR ENERGY RECOVERY FROM COMBUSTION FUMES**

WÄRMEAUSTAUSCHVORRICHTUNG ZUR ENERGIERÜCKGEWINNUNG AUS
VERBRENNUNGSDÄMPFEN

DISPOSITIF D'ÉCHANGE DE CHALEUR POUR LA RÉCUPÉRATION D'ÉNERGIE À PARTIR DE
FUMÉES DE COMBUSTION

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Description

[0001] The present invention relates to a heat exchange device for energy recovery (heat) from combustion fumes and more generally from fluids in the gaseous state having an adequate temperature.

[0002] In particular, the present invention relates to a heat exchange device for fumes coming from boilers, steam generators, industrial ovens (and, more generally, from processes in which an effluent in the gaseous state is available for heat exchange) and allows recovery of a part of the heat associated with said fumes which, passing through said device, transfer heat to a second fluid (heat transfer fluid or secondary fluid) which may be in the liquid state and/or two-phase state (liquid and vapor).

[0003] The transfer of heat from the fumes to the secondary fluid allows the temperature to be increased and, at the same time, the temperature of the fumes to be lowered before they are emitted into the atmosphere.

[0004] It is known that heat exchange devices of this type are installed between a boiler and the relative flue and, more generally, on a chimney, and they are able to intercept a part of the energy associated with the gaseous effluent, recover it and reuse it.

[0005] It is known that condensing boilers recover a latent part of the heat contained in the water vapour present in the fumes expelled through the flue. In fact, this technology allows the fumes to be cooled until condensing (partially or totally) the water vapor contained therein and changing it to the liquid state, with an energy recovery (further the contribution with respect to the sensible heat) which is used for preheating the water returning to the system.

[0006] Patent document WO2015004591 describes an apparatus of this type comprising a parallelepiped body having an inlet for the fumes on a face of the parallelepiped, which inside comprises a horizontal heat exchanger and a device for purification of the fumes connected in cascade with each other and an outlet connected to a flue, positioned on the opposite face of the parallelepiped.

[0007] The heat exchanger comprises a plurality of plates, each with a surface with a substantially rectangular shape oriented in the same direction as the fumes. Each plate is obtained by two sheets joined together by welding and then subjected to bulging according to a known technique for obtaining channels designed for the passage of the heat transfer fluid; the plurality of plates, enclosed in the parallelepiped body, is lapped externally by the passage of the fumes, thereby creating the heat exchange between the two spaces.

[0008] The heat exchanger of the above-mentioned patent document WO2015004591 has an inlet duct for the heat transfer fluid located on a surface of the parallelepiped and an outlet duct for the fluid located on the opposite surface of the parallelepiped.

[0009] This apparatus is modular in the sense that several parallelepiped bodies may be placed alongside each

other.

[0010] The Applicant has noted that the apparatus is constrained to a single positioning, wherein the inlet and outlet of the fumes are located on opposite faces of the same parallelepiped allowing an exclusively linear path for the fumes also due to the presence of the module for purification of the fumes located in cascade with the heat exchanger; the heat transfer fluid is introduced on one face and extracted from the opposite face of the parallelepiped.

[0011] The aim of this invention is to overcome the above-mentioned limitations by proposing a heat exchanger device which is modular and versatile in its installation, in which the inlet and outlet of the fumes can be positioned in various ways.

[0012] An aspect of the present invention concerns a heat exchange device for fumes (gaseous) having the characteristics of the accompanying claim 1.

[0013] The characteristics and the advantages of the device according to the present invention will become more clear from the following detailed descriptions of nonlimiting example embodiments of it, with reference to the accompanying drawings, which schematically illustrate embodiments of the invention and in particular:

- Figure 1a illustrates an operational/installation diagram of the device according to the present invention;
- Figure 2 illustrates an exploded view of the device according to the present invention;
- Figure 3a illustrates a first embodiment of the device according to the present invention;
- Figure 3b illustrates a second embodiment of the device according to the present invention;
- Figure 4 illustrates a third embodiment of the device according to the present invention;
- Figure 5a illustrates a fourth embodiment of the device according to the present invention;
- Figure 5b illustrates a fifth embodiment of the device according to the present invention;
- Figure 6a illustrates a sixth embodiment of the device according to the present invention;
- Figure 6b illustrates a seventh embodiment of the device according to the present invention;
- Figure 7 illustrates a detail of the tubes for connection of the plates to the inlet (or outlet) duct for the heat transfer fluid of the device according to the present invention;
- Figure 8a illustrates a heat transfer plate of the device according to the present invention;
- Figures 8b and 8c illustrate the particular arrangement of adjacent plates (valid for all the plates) of the device according to the present invention;
- Figure 8d illustrates a heat transfer plate of the device according to the present invention with a detail highlighted and enlarged;
- Figure 9 illustrates an eighth embodiment of the device according to the present invention;

- Figure 10 illustrates a ninth embodiment of the device according to the present invention.
- Figures 11a-c illustrate, respectively, a front, side and perspective view of a bracket for connecting the plates of the inlet and outlet ducts of the device according to the present invention.

[0014] The device according to the present invention comprises at least one heat exchange module 2 including a plurality of plates 3 each formed by two joined sheets, for example by welding and bulged in order to form inner channels 34 designed for the passage of the heat transfer fluid. This module 2 has at least one inlet duct 4 and one outlet duct 5 for the fluid, connected to the channels 34 of the plates through the tubes 35-36. The plurality of plates, enclosed in the parallelepiped body, is lapped externally by the passage of the fumes, thereby creating the heat exchange between the two spaces.

[0015] The device is formed by a box-shaped body, in which is inserted the module, having at least one inlet opening for the fumes 6, 6', 8', which can be operated selectively, located on one of the four faces perpendicular to the plane of parallelism of the plates and at least one outlet opening for the fumes which can also be operated selectively 7 or 7' positioned on any one of the remaining faces in such a way as to form predetermined paths for the fumes inside the module.

[0016] The box-shaped body comprises openable partitions which facilitate the cleaning and inspection operations of the module comprising the plates.

[0017] The arrangement and the selective operation of the above-mentioned inlet and outlet openings allows various paths of the fumes to be made and, therefore, as many embodiments of the invention.

[0018] For example, the inlet opening in some embodiments may be single. In other embodiments, it can be double, positioned on opposite faces, between the four faces perpendicular to the plane of parallelism of the plates, whilst the single outlet 7 can be positioned on one of the two remaining faces in such a way as to form paths of the fumes which can be selected inside the module.

[0019] In particular, Figures 3a to 6b, 9 and 10 illustrate nine embodiments of the invention.

[0020] In particular, Figure 3a shows an L-shaped path in which the inlet opening 6' is on a vertical side of the box-shaped body and the outlet opening 7 of the fumes is positioned on the top of the box-shaped body.

[0021] Also in the case of Figure 3b, the path is an L-shaped path in which the inlet opening 6' is on a vertical side of the box-shaped body but the outlet opening 7 of the fumes is positioned on the bottom of the box-shaped body.

[0022] For example, a path which is visible in Figure 5a is a vertical rectilinear path, in which the inlet and outlet openings of the fumes are positioned on the lower and upper base of the box-shaped body.

[0023] The path in Figure 5b is also vertical rectilinear, but the inlet and outlet openings of the fumes made in

the box-shaped body are inverted relative to the case of Figure 5a.

[0024] The positioning of the openings in Figure 4 is analogous to that of Figures 5a and 5b but the box-shaped body is orthogonally-oriented to that shown in Figures 5a e 5b and the path of the fumes is horizontal.

[0025] A further path which can be seen in Figures 6a and 6b is a Z-shaped path in which the inlet opening 6' is on a vertical side of the box-shaped body and the outlet opening 7' of the fumes is positioned on the opposite vertical side of the box-shaped body.

[0026] The path of the fumes shown in Figures 9 and 10 is T-shaped with the two inlet openings on the opposite vertical sides 6' and 8' and the outlet opening 7 is positioned on the top (Figure 9) or on the lower base of the box-shaped body (Figure 10).

[0027] The device according to the present invention is modular in the sense that several devices can be positioned both in cascade and parallel to each other. Moreover, several embodiments can be combined together to allow systems to be constructed which can be positioned in spaces that are sometimes even restricted.

[0028] Each plate 3 is made using a pair of sheets 31 and 32 joined together by junction points 33 and closure of the flaps along the edges of the sheets (for example by welding), and subsequent mechanical, pneumatic or hydraulic deformation to distance the two sheets at the points not joined (welded) in order to form spaces/channels 34 inside the plate for the passage of the heat transfer fluid.

[0029] Each plate also comprises at least one tube 35 for introduction of the fluid and at least one tube 36 for extraction of the fluid, preferably positioned close to opposite corners of the plate.

[0030] Even though the plates 33 are in construction terms all identical to each other and as such geometrically congruent, they are assembled in the plurality 3 parallel to each other but, at the same time, asymmetrically, so that each of them is rotated by 180° relative to the axis perpendicular to the plane of parallelism of the plates, with respect to the contiguous plate(s). The purpose of this parallel-asymmetric configuration of the plates is to increase the turbulence of the gaseous fluid which passes through the device, with the convex parts of a plate being located in correspondence with concave parts of the contiguous plates (Figure 8b and 8c). The inlet 35 and outlet 36 tubes of the thermal vector are positioned at different distances (x and y) from the edges (of the plate) contiguous and parallel to the respective tubes 35 and 36, so that following the rotated positioning of two contiguous plates, the same connection tubes are staggered (Figure 8d) on the duct allowing the plates to be positioned at a close distance: that is, only in this way can the spacing between two contiguous plates be less than the diameter of the tubes 35 and 36.

[0031] In particular, the side by side arrangement of two adjacent plates is such as to make the "bulging" parts of the channels 34 of a plate correspond with the "re-

cessed" parts of the adjacent plates at the junction points 33 (Figure 8c).

[0032] In this way, the space between the two plates, which constitutes the path of the fumes, is an undulated path as can be seen in Figures 8b, 8c.

[0033] The positioning of the tubes 35 or 36 for connection of the plates to the input 4 (or output 5) ducts of the heat exchanger is achieved by means of a bracket 9 which has the purpose of compensating for the various thermal expansions to which the plurality of plates 3 are subjected, which are colder because they are crossed by the heat transfer fluid, and the box-shaped body which is at a higher temperature because it is crossed by the hot fumes. The bracket is "omega" shaped with the two arms 91, 92 constrained to the box-shaped body, whilst the tubes 35 or 36 are inserted in openings 93 made in the central part of the bracket. The central portion of the omega is then connected with the hydraulic inlet 4 or outlet 5 duct. The bracket 9 therefore allows a minimum distance z to be maintained between the edges of the plurality of plates 3 and the box-shaped body, thereby giving a greater compactness and efficiency of the heat exchange, but simultaneously guaranteeing a greater length z' of the tubes 35 and 36 designed for the absorption of the various thermal expansions between the plates and the box-shaped body.

[0034] The versatility and the modularity of the device according to the present invention allows a fuel saving of up to 15%, compared with the 3-5% of the most common applications. In fact, it transforms the traditional boilers, even the oldest ones, into condensing boilers, recovering also the latent heat of condensation as well as the sensible heat. Moreover, the device according to the present invention neither slows down or obstructs in any way the normal transit of the fumes towards the flue thanks to the smooth geometry of the plates and the absence of roughness.

[0035] However, this geometry determines a turbulence of the fumes such as to allow a high heat transfer. Thanks to the heat exchange efficiency, the device has smaller dimensions than known devices, which therefore allows the installation even in restricted spaces.

[0036] The maintenance is simplified, fast and economic thanks to the partitions which can be easily removed which make the plates completely accessible. This cleaning is possible without having to dismantle the unit from the system or disassembling the plates.

[0037] Lastly, the gently undulating shape of the plates, without roughness, fins or anything else allows the device to remain clean of the scale carried by the fumes.

Claims

1. Heat exchange device for transferring heat from fluids in the gaseous state to fluids in the liquid and/or vapor state and comprising at least one heat-exchange module (2) including a plurality of superim-

posed plates (3), each formed by two sheets (31,32) joined at points of junction (33) and deformed to obtain channels (34) adapted to accommodate a heat transfer fluid and paths for the passage of the fumes, externally to the plates, in thermal contact with each other, such module having at least one inlet duct (4) and an outlet duct (5) for the heat transfer fluid, a box-shaped body in which such module is inserted having at least one inlet opening (6,6',8') and at least one outlet opening (7, 7'), wherein

- the plates (3) are side by side according to a staggered design and are assembled in the plurality parallel to each other but asymmetrically, so that each of them is rotated by 180° with respect to the axis perpendicular to the plane of parallelism between the plates themselves, with respect to the contiguous plate, the side by side arrangement of two adjacent plates (3) being such as to make the bulging parts of the channels (34) of a plate (3) correspond with the recessed parts of the adjacent plates (3) at the junction points (33), so that the space between two plates, which constitutes the fume path, is an undulated path,
- each plate comprises at least one inlet tube (35) for the fluid and at least one extraction tube (36) for the fluid itself positioned in proximity to opposite corners of the plate,

characterized in that

the at least one inlet opening (6, 6', 8') is located on one of the four faces perpendicular to the plane of parallelism of the plates (3) and the at least one outlet opening (7,7') is located on at least one of the remaining faces, both the inlet opening (6, 6', 8') and the outlet opening (7,7') being selectively operable,

- the connection of the tubes (35,36) for connecting the plates to the inlet and outlet ducts (4,5) of the exchanger in its entirety is obtained by means of a substantially omega-shaped bracket (9), with the two arms (91,92) constrained to the box-shaped body, while the tubes (35 or 36) are inserted in openings (93) obtained in the central part of the bracket itself.

2. Heat exchange device according to claim 1, wherein the inlet opening is a double opening (6',8') placed on opposite faces of the four faces perpendicular to the plane of parallelism of the plates, while the outlet is a single opening (7) and can be positioned on one of the two remaining faces.
3. Heat exchange device according to claim 2, wherein the path of the fumes is shaped as a "T" with the two inlet openings on opposite vertical sides (6' and 8')

and the outlet (7) positioned on the top of the box-shaped body.

4. Heat exchange device according to claim 2, wherein the path of the fumes is shaped as a "T" with the two inlet openings on opposite vertical sides (6' and 8') and the outlet (7) positioned on the lower base of the box-shaped body. 5
5. Heat exchange device according to claim 1, wherein a path of the fumes is vertical rectilinear, in which the inlet (6) and outlet (7) openings of the fumes are positioned on an upper and lower base of the box-shaped body. 10
6. Heat exchange device according to claim 1, wherein the path of the fumes is "L"-shaped, in which the inlet opening (6') is on a vertical side of the box-shaped body and the outlet opening (7) for the fumes is positioned on the top of the box-shaped body. 15
7. Heat exchange device according to claim 1, wherein the path of the fumes is "Z"-shaped, in which the inlet opening (6') is on a vertical side of the box-shaped body and the outlet opening (7') of the fumes is positioned on the opposite vertical side of the box-shaped body. 20
8. Heat exchange device according to claim 1, wherein the inlet (35) and outlet (36) tubes of the thermal vector are positioned at different distances (x and y) from the edges of the plate so that following the rotated positioning of two contiguous plates, the same connection tubes are staggered on the collector. 25
9. Heat exchange device according to claim 8, wherein the spacing between two contiguous plates can be smaller than the diameter of the tubes (35 and 36). 30
10. Heat exchange device according to claim 1, wherein such box-shaped body comprises openable partitions that facilitate the cleaning and inspection operations of the module comprising the plates. 35

Patentansprüche

1. Wärmeaustauschvorrichtung zum Übertragen von Wärme von Fluiden im gasförmigen Zustand auf Fluide im flüssigen und/oder Dampfzustand und das mindestens ein Wärmetauschermodul (2), einschließlich einer Vielzahl von übereinandergelagerten Platten (3), von denen jede aus zwei Blechen (31,32) besteht, die an Verbindungspunkten (33) miteinander verbunden sind, und die deformiert sind, um Kanäle (34), die ausgelegt sind, ein Wärmetauscherfluid zu enthalten, und Pfade für die Strömung der Dämpfe außerhalb der Platten in thermischem 50

Kontakt miteinander zu erhalten, wobei ein solches Modul mindestens einen Einlasskanal (4) und einen Auslasskanal (5) für das Wärmetauscherfluid, einen kastenförmigen Körper aufweist, in den ein solches Modul eingeführt ist, der mindestens eine Einlassöffnung (6, 6', 8') und mindestens eine Auslassöffnung (7, 7') umfasst, wobei

» die Platten (3) nebeneinander in einer versetzten Anordnung positioniert und in der Vielzahl parallel zueinander, jedoch asymmetrisch angeordnet sind, so dass jede davon, bezogen auf die Achse, die normal zur Parallelismus-Ebene zwischen den Platten selbst steht, in Hinblick auf die benachbarte Platte, um 180° gedreht ist, wobei die Anordnung von zwei benachbarten Platten (3) nebeneinander so ausgeführt ist, dass die hervortretenden Teile der Kanäle (34) einer Platte (3) in die vertieften Teile der benachbarten Platten (3) an den Verbindungspunkten (33) passen, so dass der Raum zwischen zwei Platten, der den Dampfpfad darstellt, ein wellenförmiger Pfad ist,

» jede Platte mindestens ein Zufuhrrohr (35) für das Fluid und mindestens ein Gewinnungsrohr (36) für das Fluid selbst umfasst, die in der Nähe von gegenüberliegenden Ecken der Platte positioniert sind, **dadurch gekennzeichnet, dass** sich die mindestens eine Einlassöffnung (6, 6', 8') auf einer der vier Flächen, normal zur Parallelismus-Ebene der Platten (3), befindet und sich die mindestens eine Auslassöffnung (7, 7') auf mindestens einer der übrigen Flächen befindet, wobei sowohl die Einlassöffnung (6, 6', 8') als auch die Auslassöffnung (7, 7') selektiv betätigbar sind,

» die Verbindung der Rohre (35, 36) zum Verbinden der Platten mit dem Einlass- und dem Auslasskanal (4, 5) des Tauschers insgesamt mittels einer im Wesentlichen Omega-förmigen Klammer (9) mit zwei Armen (91, 92) erhalten wird, die an dem kastenförmigen Körper fixiert sind, während die Rohre (35 oder 36) in Öffnungen (93), die im Mittelteil der Klammer selbst erhalten werden, eingeführt sind. 45

2. Wärmeaustauschvorrichtung nach Anspruch 1, wobei die Einlassöffnung eine Doppelöffnung (6', 8') ist, die auf gegenüberliegenden Flächen der vier Flächen, normal zur Parallelismus-Ebene der Platten, positioniert ist, während der Auslass eine Einzelöffnung (7) ist und auf einer der beiden übrigen Flächen positioniert werden kann.
3. Wärmeaustauschvorrichtung nach Anspruch 2, wobei der Pfad der Dämpfe eine "T"-Form aufweist, wobei sich die zwei Einlassöffnungen auf gegenüber-

liegenden vertikalen Seiten (6' und 8') befinden und der Auslass (7) auf dem kastenförmigen Körper positioniert ist.

4. Wärmeaustauschvorrichtung nach Anspruch 2, wobei der Pfad der Dämpfe eine "T"-Form aufweist, wobei sich die zwei Einlassöffnungen auf gegenüberliegenden vertikalen Seiten (6' und 8') befinden und der Auslass (7) auf der unteren Basis des kastenförmigen Körpers positioniert ist. 5
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5. Wärmeaustauschvorrichtung nach Anspruch 1, wobei ein Pfad der Dämpfe vertikal geradlinig ist, in dem die Einlass- (6) und die Auslass- (7) Öffnungen der Dämpfe auf einer unteren und oberen Basis des kastenförmigen Körpers positioniert sind. 15
6. Wärmeaustauschvorrichtung nach Anspruch 1, wobei der Pfad der Dämpfe eine "L"-Form aufweist, in der sich die Einlassöffnung (6') auf einer vertikalen Seite des kastenförmigen Körpers befindet und die Auslassöffnung (7) für die Dämpfe auf dem kastenförmigen Körper positioniert ist. 20
7. Wärmeaustauschvorrichtung nach Anspruch 1, wobei der Pfad der Dämpfe eine "Z"-Form aufweist, in der sich die Einlassöffnung (6') auf einer vertikalen Seite des kastenförmigen Körpers befindet und die Auslassöffnung (7) der Dämpfe auf der gegenüberliegenden vertikalen Seite des kastenförmigen Körpers positioniert ist. 25
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8. Wärmeaustauschvorrichtung nach Anspruch 1, wobei das Einlass- (35) und das Auslass- (36) Rohr des thermischen Vektors in unterschiedlichen Abständen (x und y) von den Rändern der Platte positioniert sind, so dass dieselben Verbindungsrohre gemäß der gedrehten Positionierung zweier benachbarter Platten versetzt auf dem Kollektor angeordnet sind. 35
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9. Wärmeaustauschvorrichtung nach Anspruch 8, wobei der Abstand zwischen zwei benachbarten Platten kleiner sein kann als der Durchmesser der Rohre (35 und 36). 45
10. Wärmeaustauschvorrichtung nach Anspruch 1, wobei ein solcher kastenförmiger Körper öffnungsfähige Abtrennungen umfasst, die Reinigungs- und Prüfungsvorgänge des die Platten umfassenden Moduls erleichtern. 50

Revendications

1. Dispositif d'échange de chaleur pour transférer de la chaleur de fluides à l'état gazeux à des fluides à l'état liquide et/ou de vapeur et comprenant au moins un module d'échange de chaleur (2) incluant une 55

pluralité de plaques superposées (3), chacune formée par deux feuilles (31, 32) jointes à des points de jonction (33) et déformées pour obtenir des canaux (34) adaptés pour recevoir un fluide de transfert de chaleur et des trajectoires pour le passage des fumées, de manière externe aux plaques, en contact thermique les unes avec les autres, un tel module ayant au moins un conduit d'entrée (4) et un conduit de sortie (5) pour le fluide de transfert de chaleur, un corps en forme de boîte dans lequel un tel module est inséré ayant au moins une ouverture d'entrée (6, 6', 8') et au moins une ouverture de sortie (7, 7'), dans lequel

- les plaques (3) sont côte à côte selon une conception en quinconce et sont assemblées dans la pluralité parallèlement les unes aux autres mais de manière asymétrique, de sorte que chacune d'elles est tournée de 180° par rapport à l'axe perpendiculaire au plan de parallélisme entre les plaques elles-mêmes, par rapport à la plaque contiguë, l'agencement côte à côte de deux plaques adjacentes (3) étant tel qu'il amène les parties bombées des canaux (34) d'une plaque (3) à correspondre aux parties en retrait des plaques adjacentes (3) aux points de jonction (33), de sorte que l'espace entre deux plaques, qui constitue la trajectoire des fumées, est une trajectoire ondulée,
- chaque plaque comprend au moins un tube d'entrée (35) pour le fluide et au moins un tube d'extraction (36) pour le fluide lui-même positionnés à proximité de coins opposés de la plaque,

caractérisé en ce que

l'au moins une ouverture d'entrée (6, 6', 8') est située sur l'une des quatre faces perpendiculaires au plan de parallélisme des plaques (3) et l'au moins une ouverture de sortie (7, 7') est située sur au moins l'une des faces restantes, à la fois l'ouverture d'entrée (6, 6', 8') et l'ouverture de sortie (7, 7') étant sélectivement utilisables,

- le raccordement des tubes (35, 36) pour raccorder les plaques aux conduits d'entrée et de sortie (4, 5) de l'échangeur dans sa totalité est obtenu au moyen d'un support sensiblement en forme d'oméga (9), avec les deux bras (91, 92) contraints au corps en forme de boîte, tandis que les tubes (35 ou 36) sont insérés dans des ouvertures (93) obtenues dans la partie centrale du support lui-même.

2. Dispositif d'échange de chaleur selon la revendication 1, dans lequel l'ouverture d'entrée est une ouverture double (6', 8') placée sur des faces opposées

des quatre faces perpendiculaires au plan de parallélisme des plaques, tandis que la sortie est une ouverture simple (7) et peut être positionnée sur l'une des deux faces restantes.

comprenant les plaques.

3. Dispositif d'échange de chaleur selon la revendication 2, dans lequel la trajectoire des fumées est en forme de « T » avec les deux ouvertures d'entrée sur des côtés verticaux opposés (6' et 8') et la sortie (7) positionnée sur le haut du corps en forme de boîte.

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4. Dispositif d'échange de chaleur selon la revendication 2, dans lequel la trajectoire des fumées est en forme de « T » avec les deux ouvertures d'entrée sur des côtés verticaux opposés (6' et 8') et la sortie (7) positionnée sur la base inférieure du corps en forme de boîte.

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5. Dispositif d'échange de chaleur selon la revendication 1, dans lequel une trajectoire des fumées est rectiligne verticale, dans laquelle les ouvertures d'entrée (6) et de sortie (7) des fumées sont positionnées sur une base supérieure et inférieure du corps en forme de boîte.

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6. Dispositif d'échange de chaleur selon la revendication 1, dans lequel la trajectoire des fumées est en forme de « L », dans laquelle l'ouverture d'entrée (6') est sur un côté vertical du corps en forme de boîte et l'ouverture de sortie (7) pour les fumées est positionnée sur le haut du corps en forme de boîte.

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7. Dispositif d'échange de chaleur selon la revendication 1, dans lequel la trajectoire des fumées est en forme de « Z », dans laquelle l'ouverture d'entrée (6') est sur un côté vertical du corps en forme de boîte et l'ouverture de sortie (7) des fumées est positionnée sur le côté vertical opposé du corps en forme de boîte.

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8. Dispositif d'échange de chaleur selon la revendication 1, dans lequel les tubes d'entrée (35) et de sortie (36) du vecteur thermique sont positionnés à différentes distances (x et y) des bords de la plaque de sorte qu'à la suite du positionnement pivoté de deux plaques contiguës, les mêmes tubes de connexion sont en quinconce sur le collecteur.

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9. Dispositif d'échange de chaleur selon la revendication 8, dans lequel l'espacement entre deux plaques contiguës peut être inférieur au diamètre des tubes (35 et 36).

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10. Dispositif d'échange de chaleur selon la revendication 1, dans lequel un tel corps en forme de boîte comprend des cloisons ouvrables qui facilitent les opérations de nettoyage et d'inspection du module

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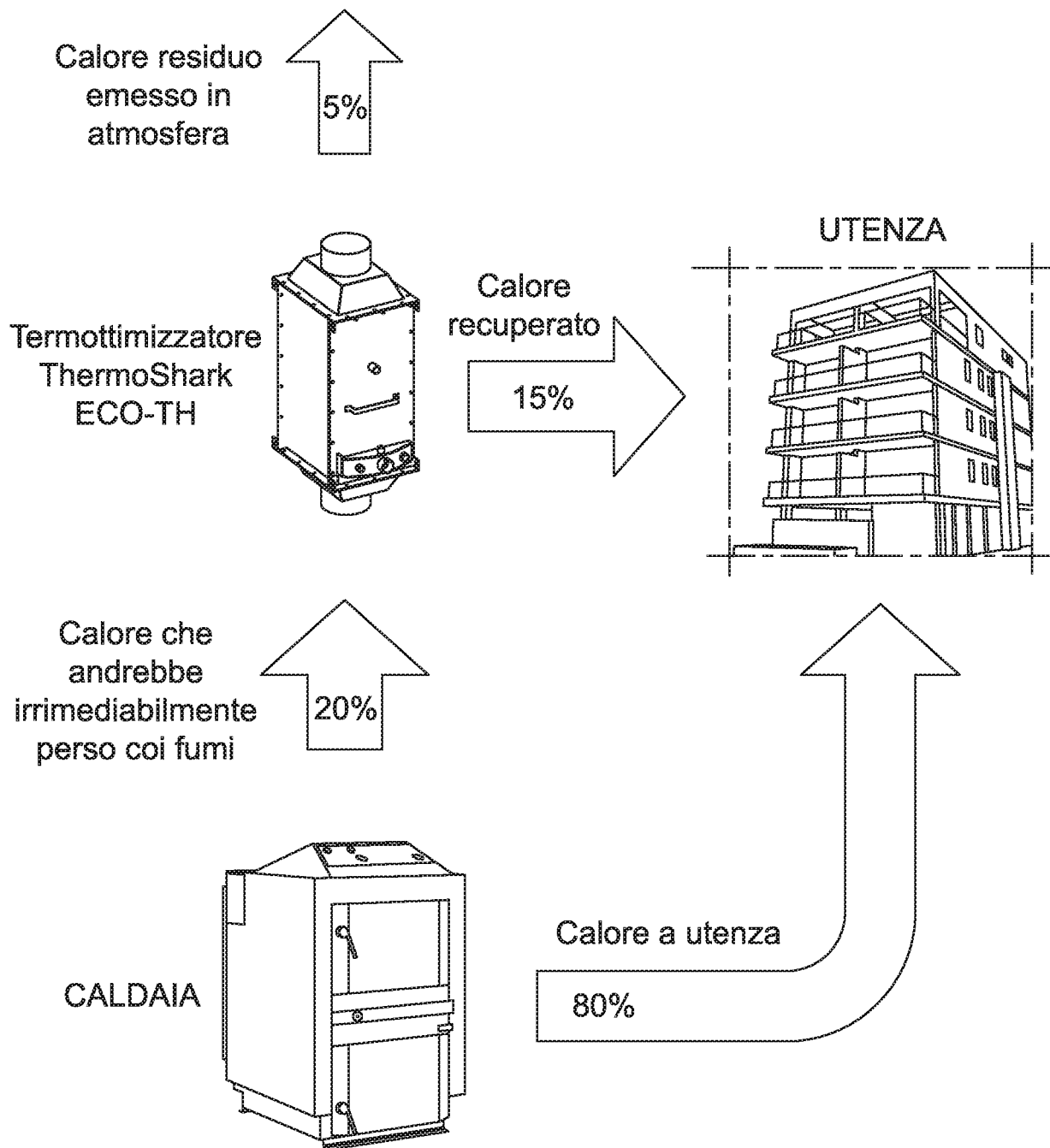


Fig. 1a

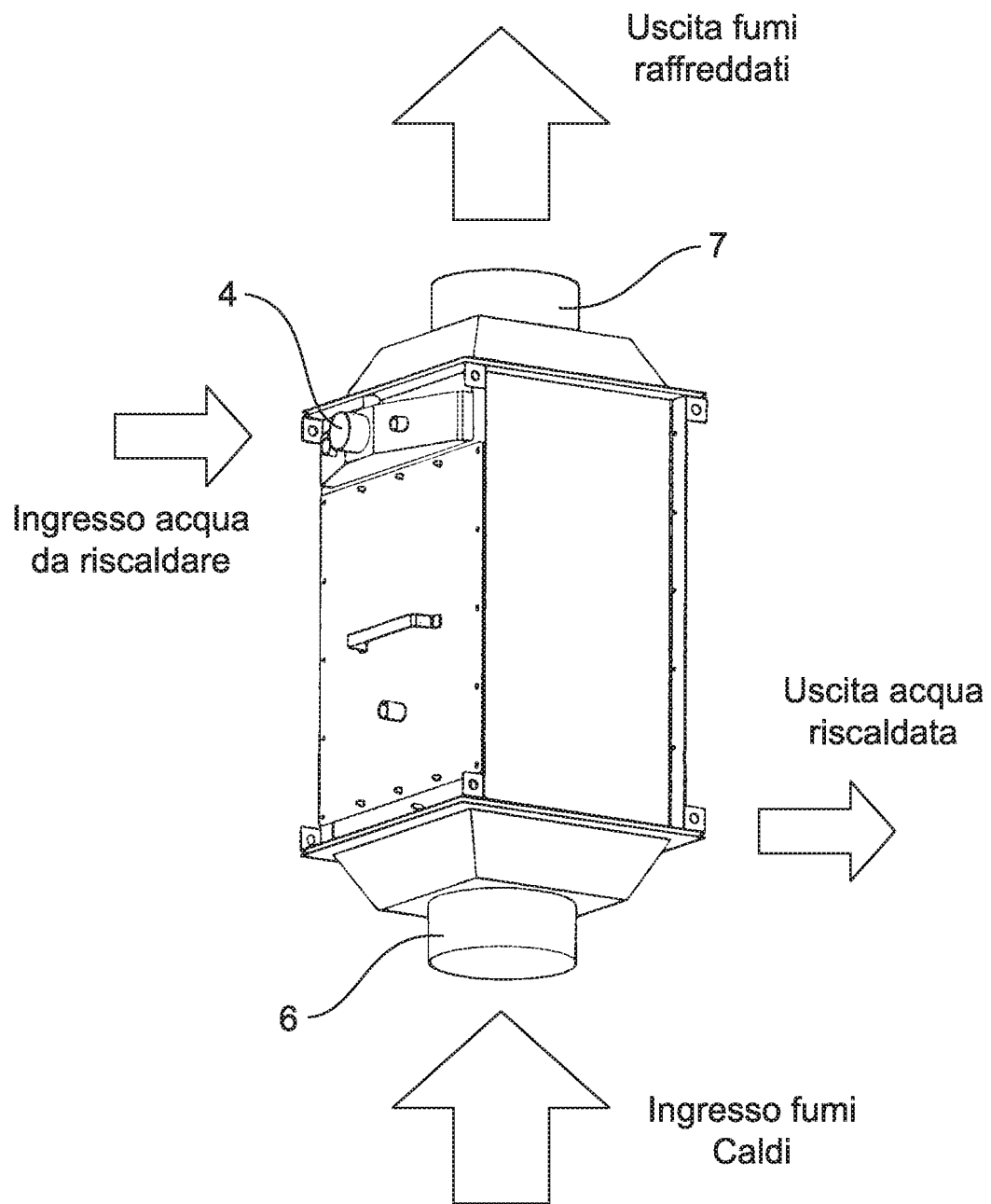


Fig. 1b

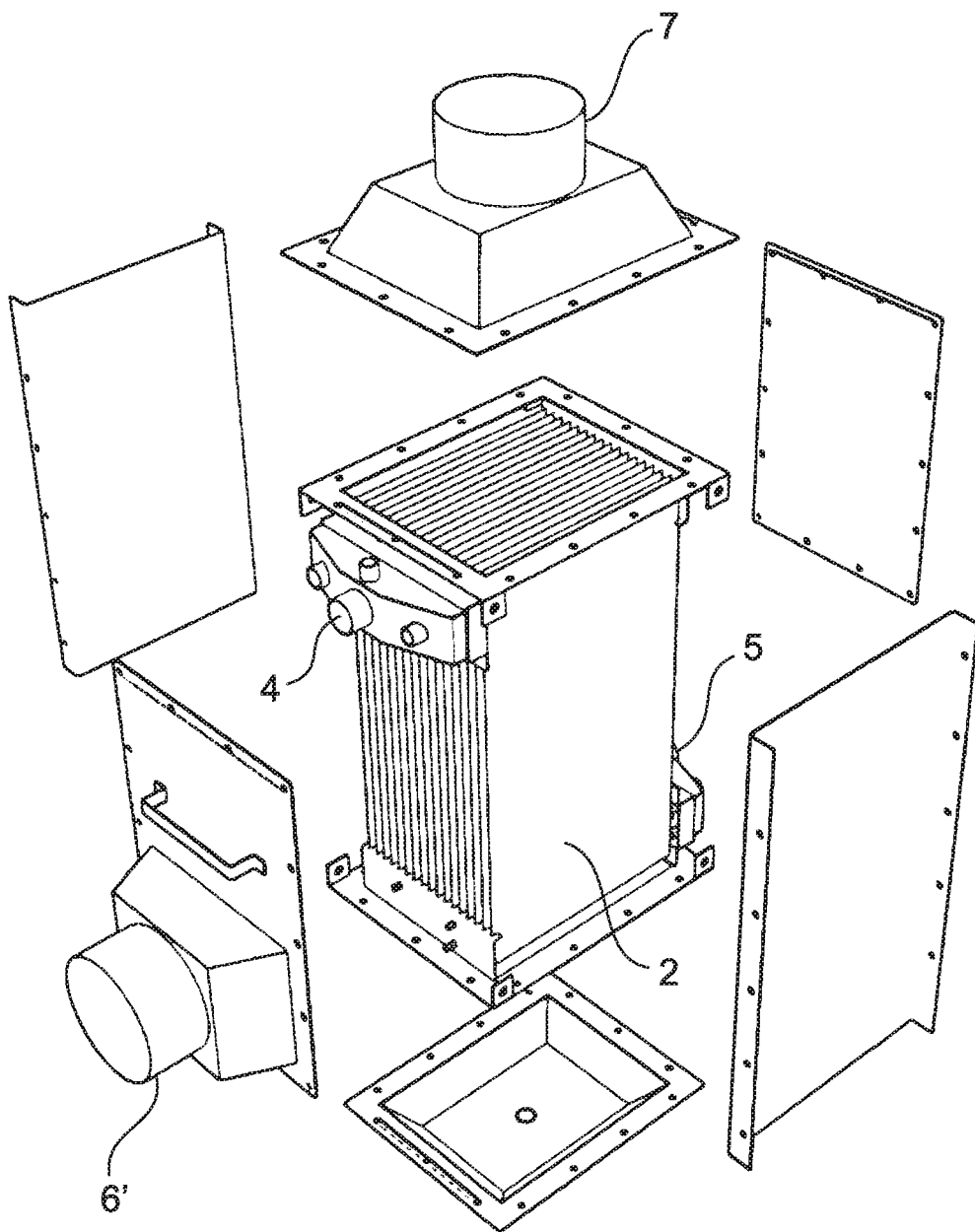


Fig. 2

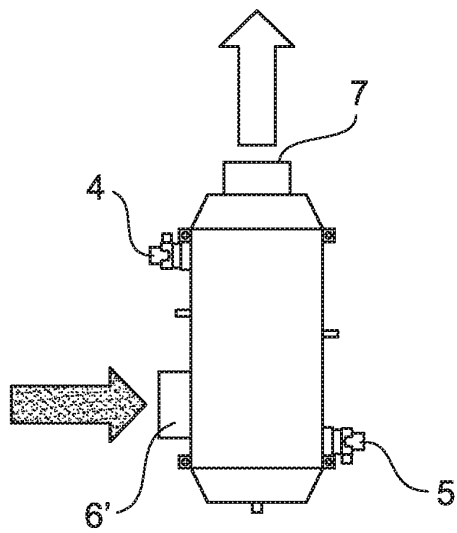


Fig. 3a

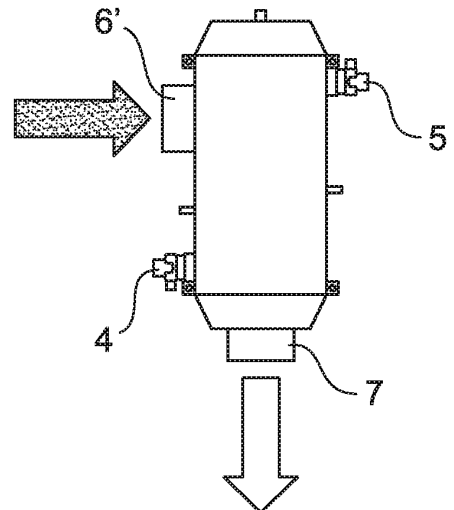


Fig. 3b

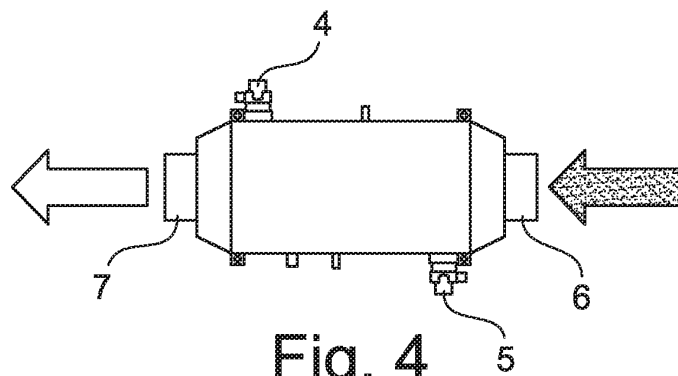


Fig. 4

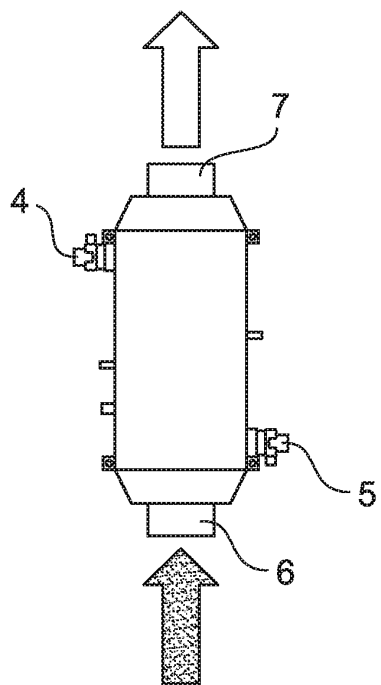


Fig. 5a

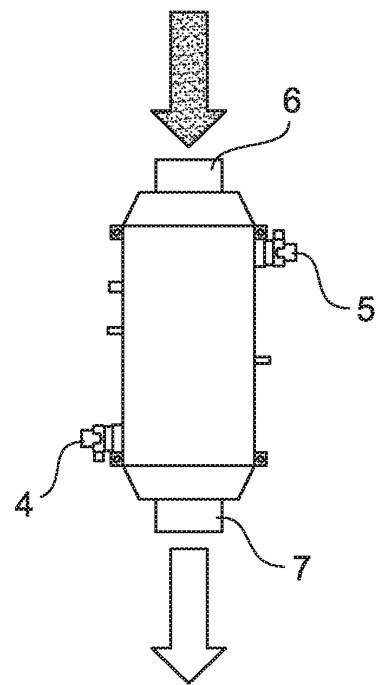


Fig. 5b

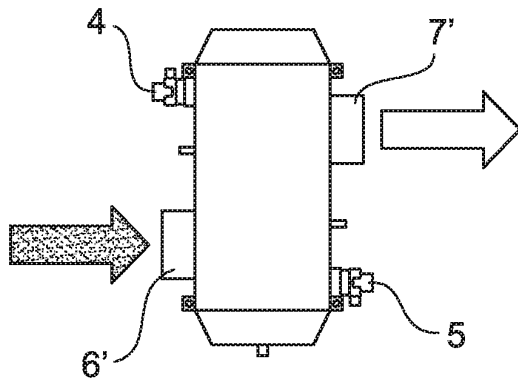


Fig. 6a

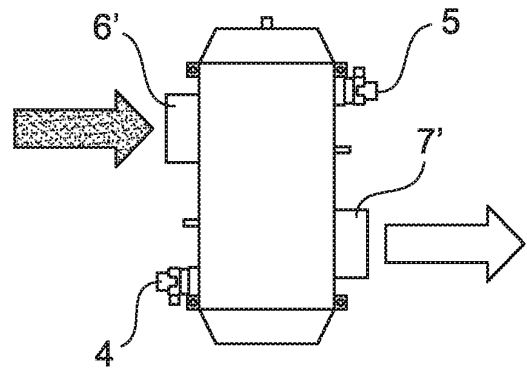


Fig. 6b

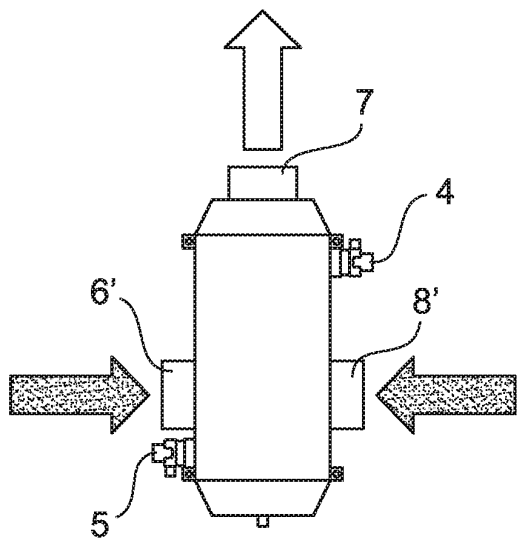


Fig. 9

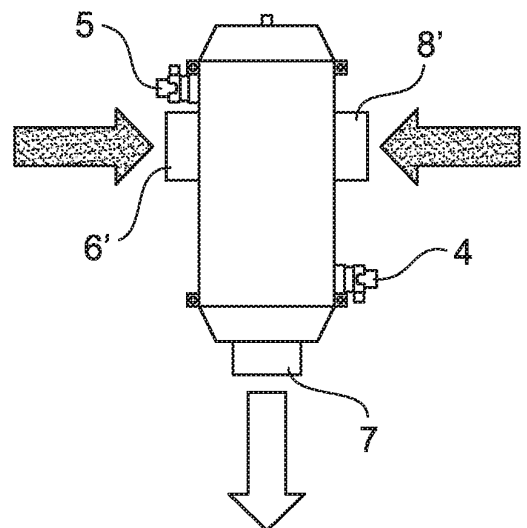


Fig. 10

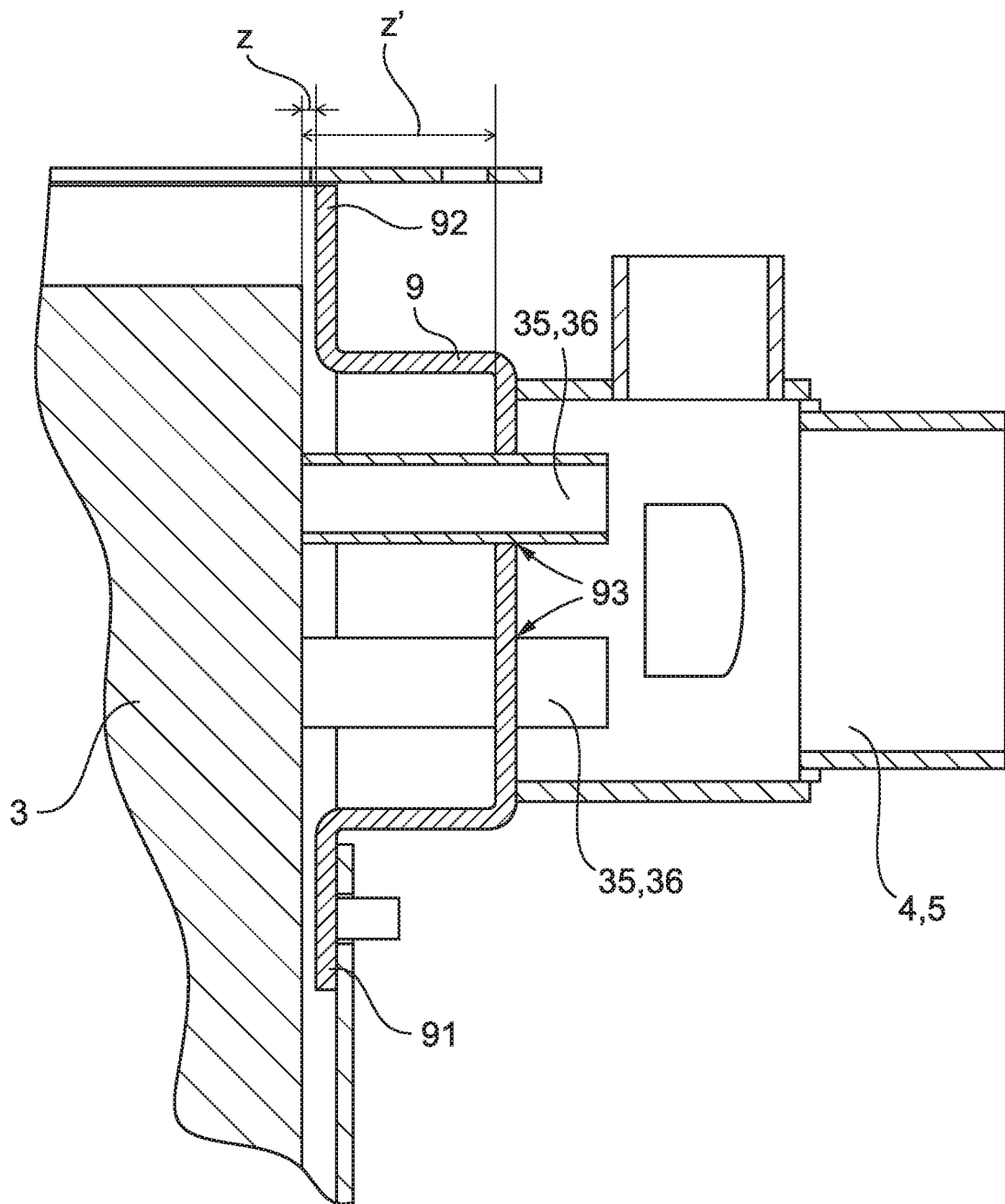


Fig. 7

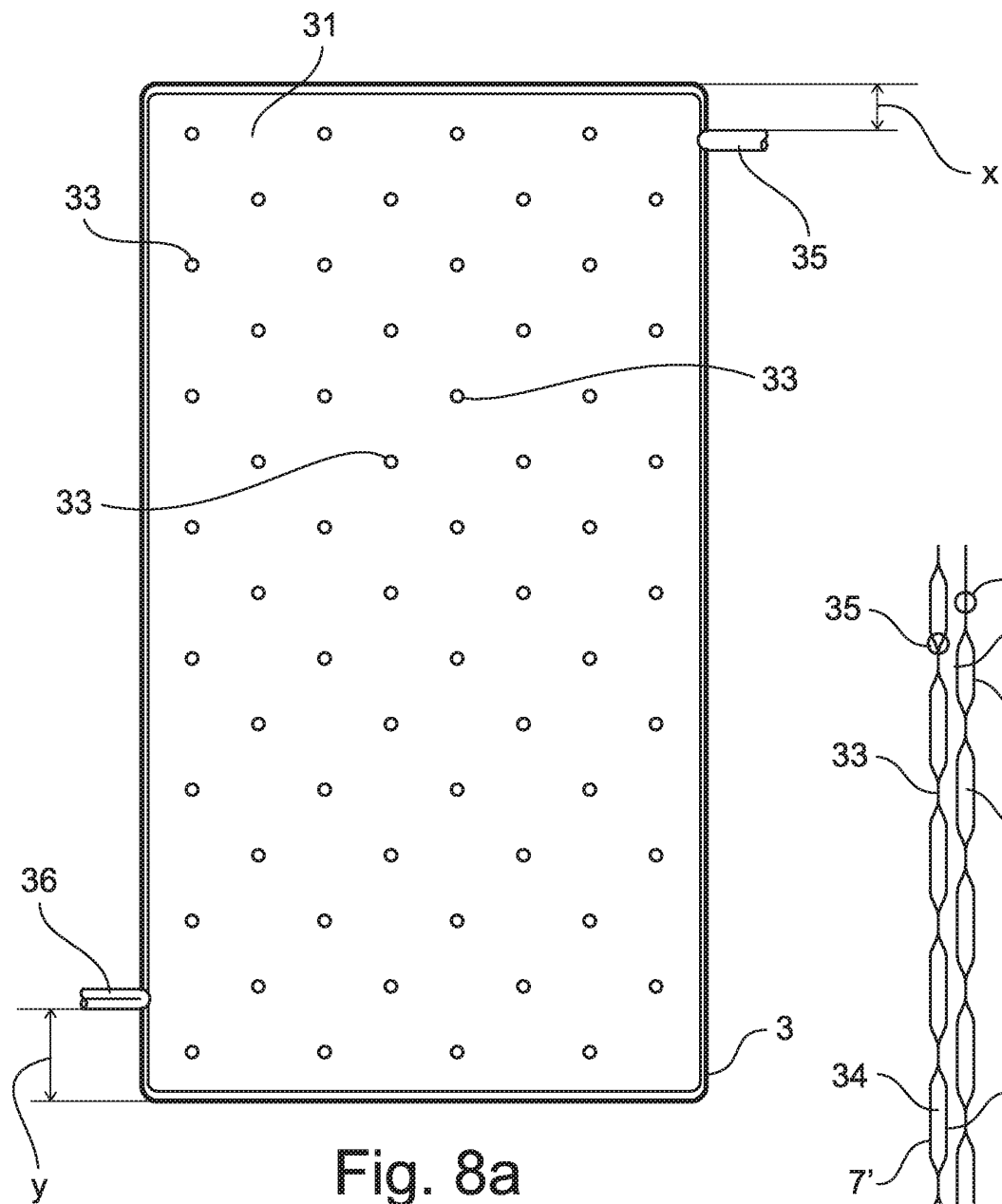


Fig. 8a

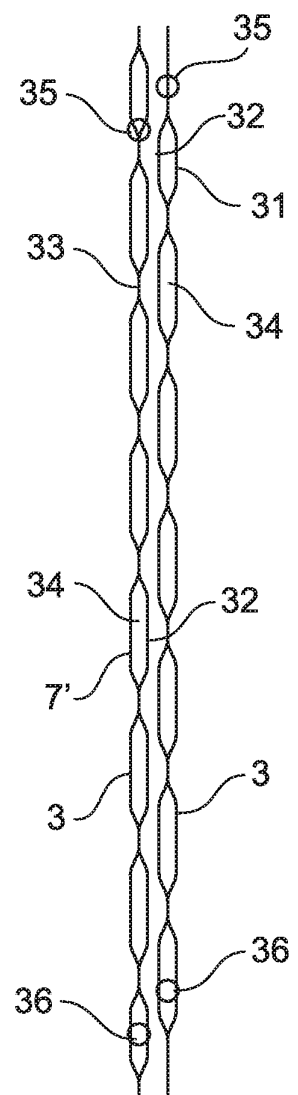


Fig. 8b

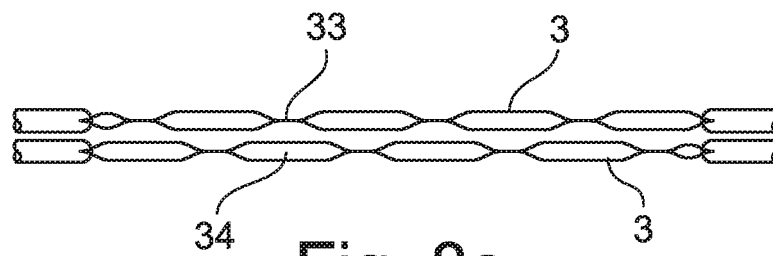


Fig. 8c

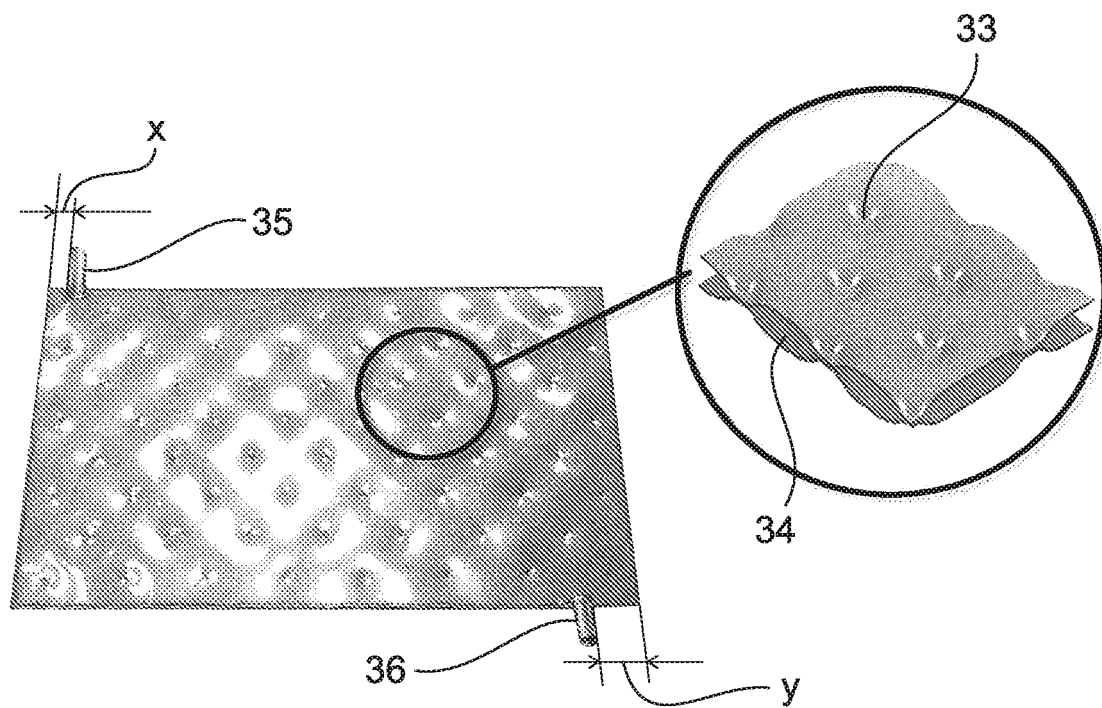


Fig. 8d

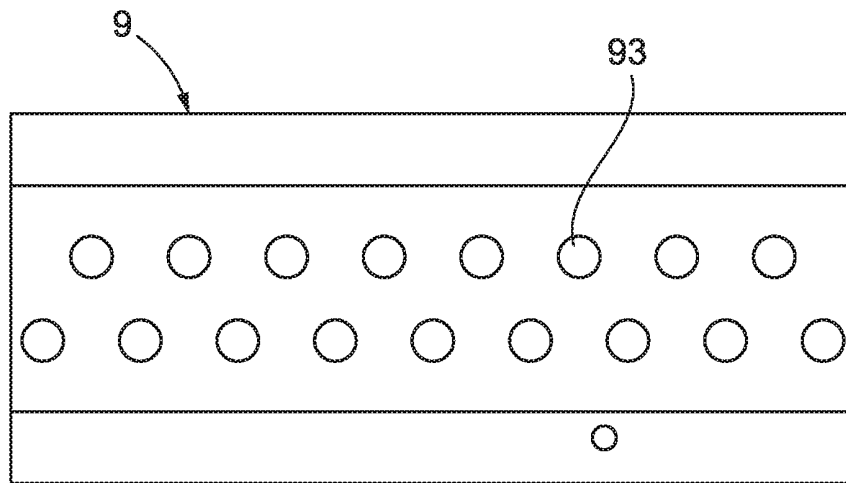


Fig. 11a

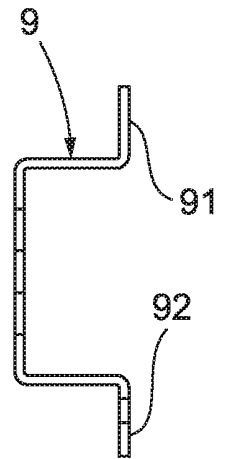


Fig. 11b

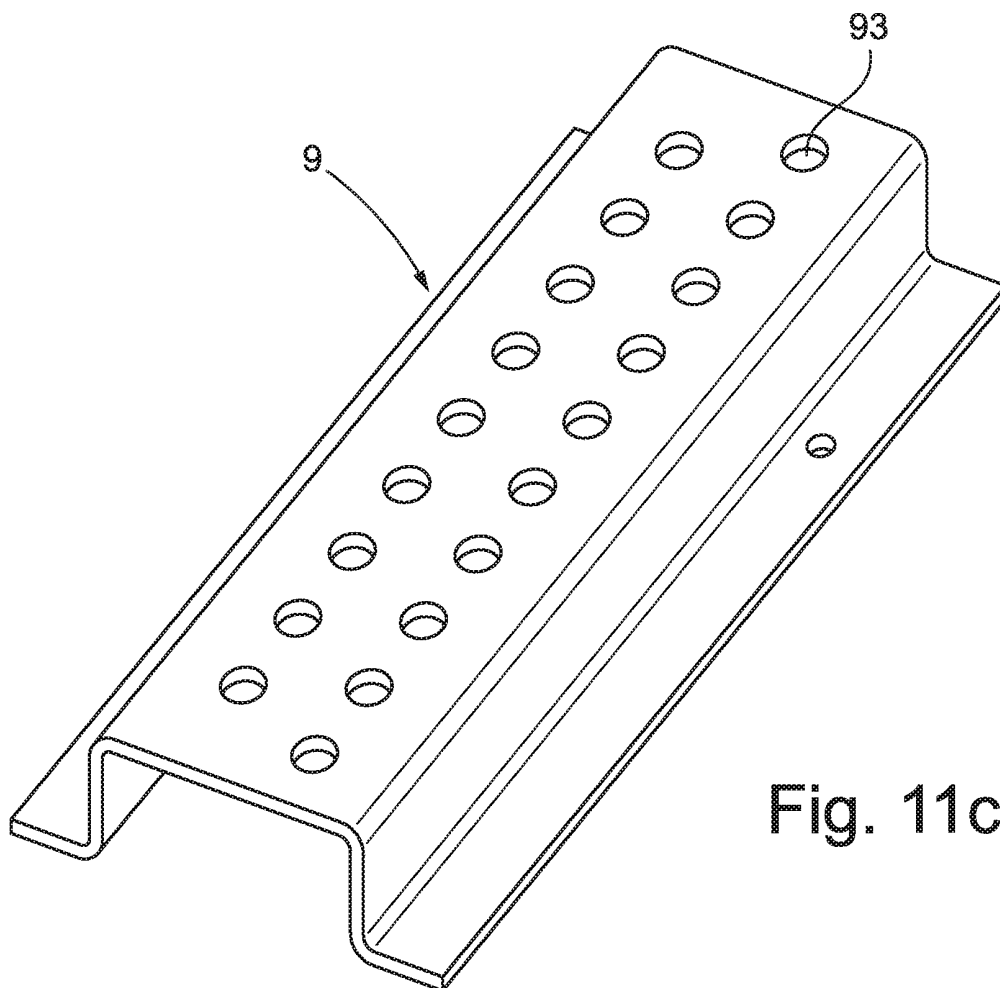


Fig. 11c

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2015004591 A [0006] [0008]