(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 452 145 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
06.03.2019 Bulletin 2019/10

(21) Application number: **10728682.5**

(22) Date of filing: **06.07.2010**

(51) Int Cl.:
F28D 7/00 *(2006.01)* ***F28D 7/16*** *(2006.01)*
F28F 9/013 *(2006.01)* ***F28F 9/02*** *(2006.01)*

(86) International application number:
PCT/EP2010/059605

(87) International publication number:
WO 2011/003889 (13.01.2011 Gazette 2011/02)

(54) HEAT EXCHANGER

WÄRMETAUSCHER

ÉCHANGEUR DE CHALEUR

(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 SE SI SK SM TR

(30) Priority: **09.07.2009 EP 09165009**

(43) Date of publication of application:
16.05.2012 Bulletin 2012/20

(73) Proprietor: **AIR PRODUCTS AND CHEMICALS, INC.**
Allentown, Pennsylvania 18195 (US)

(72) Inventor: **VON KOSSAK-GLOWCZEWSKI, Thomas Paul**
51647 Gummersbach (DE)

(74) Representative: **Kador & Partner PartG mbB**
Corneliusstraße 15
80469 München (DE)

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EP 2 452 145 B1

Description

[0001] The present invention relates to a heat exchange device for cooling a gas, comprising a channel and one or more heat exchange surfaces disposed in the channel, supported by a support structure. The present invention relates, in particular, to a heat exchange device according to the preamble of claim 1 as disclosed in US 3,433,298.

[0002] Such heat exchangers are for example used in gasification processes for the production of synthetic gas, or syngas. In such a process, carbonaceous feedstock is partially oxidised in a reactor. Syngas leaving the reactor typically has a temperature of 1300-1600 °C. The hot syngas is quenched to temperatures between 100-700 °C and is then transported to a coiled heat exchanger, generally comprising a number of parallel coiled tubes.

[0003] Support structures are used to support the heat exchange surfaces within the channel formed by the channel wall. Differences in thermal expansion of the various parts complicate possible support constructions. Sliding bearings can be used, allowing some degree of freedom of movement, but such bearings are difficult to realize and less reliable under the circumstances in such reactors.

[0004] US 5,482,110 discloses a heat exchanger for cooling syngas from a partial combustion reactor comprising nested heat exchange surfaces carried by a support. Such a support structure may induce high local stress peaks.

[0005] It is an object of the present invention to provide a heat exchanger device with a robust support structure enabling reduction of loads caused by differences in thermal expansion by the various parts.

[0006] The object of the invention is achieved by a heat exchange device according to claim 1.

[0007] The heat exchange surfaces can rest on the support structure, or the heat exchange surfaces can hang down from the support structure. The one or more heat exchange surfaces can be connected to the support structure, e.g., by welding joints. The support structure can be joined to the channel wall, or to a load bearing structure within the channel wall.

[0008] The device can for instance have a number of nested heat exchange surfaces of a closed geometry, e.g., of a cylindrical geometry, as is disclosed in US 5,482,110. The heat exchange surfaces can be coaxially arranged or nested within the channel wall, which will typically be cylindrical. Optionally, the support structure can support a series of two or more bundles of nested heat exchange surfaces.

[0009] Generally, the fluid heat exchange medium is water, although any other type of aqueous or non-aqueous coolant can be used if so desired.

[0010] The support structure can comprise a plurality of embedded parallel inner channels each being in open connection with one of the flow paths in the heat exchange surfaces. To equalize thermal expansion, the inner channels are preferably evenly distributed and equidistantly arranged. To this end, the inner channels may meander through the arm parts of the support structure. Since meandering inner channels are difficult to manufacture, the arm parts may be built of a number of sections each embedding parallel and equidistant inner channels making a single turn, e.g., of about 90 degrees. For example, each arm of the support structure may comprise:

- a first lower arm part with equidistantly arranged parallel flow paths with a first part extending upwardly to a first corner and a second section extending from the first corner in the direction of the crossing section;
- a second lower arm part with equidistantly arranged parallel flow paths having a first section in line with the second section of the respective flow paths in the first part extending to a second corner, and a second section extending upwardly from the second corner;
- an upper arm part with equidistantly arranged parallel flow paths having a first vertical section in line with the second section of the respective flow paths in the second lower arm part and extending upwardly to a third corner, and a horizontal second section extending from the third corner away from the crossing section.

[0011] The heat distribution with this configuration is such that differences in thermal expansion of the connected parts do not result in high mechanical stress loads.

[0012] The arms of the support structure can for example be formed as blocks or plates embedding inner channels operatively connected to the tubular parts. Alternatively, one or more of the arms of the support structure can wholly or partly be composed of tubular parts, optionally in combination with blocks or plates embedding inner channels operatively connected to the tubular parts.

[0013] If a larger number of heat exchange surfaces, or heat exchange surfaces of a higher weight, are to be supported, the height of the support structure can be increased. This way, the support structure can be made stronger without increasing the thickness of the support structure arms, which could result in undesirable high wall temperatures of the support structure.

[0014] The thickness of the arms of the support structure should be sufficient to give the support structure the required carrying capacity. Generally, a wall thickness of 5-20 mm at both sides of an inner channel balances sufficient strength with good heat dissipation capacity.

[0015] Particularly for the cooling of deposit-forming gases from pressure-loaded pyrolysis and gasification reactors it is desirable that the heat exchange surfaces are cleaned by rapping devices which can regularly be actuated during operation of the reactor. With the aid of, e.g., pneumatically operated rapping devices the individual heat exchange surfaces are accelerated to such an extent, that soot deposits and fouling are effectively removed. Cleaning by rapping can be done particularly effectively if all tubes of one heat exchange surface unit are rigidly connected to one constructive gastight unit, e.g., by constructing the heat exchange surfaces as a tube-stay-tube or fin-tube construction.

[0016] The heat exchange surfaces can be assembled as a plurality of nested heat exchange surfaces of a closed geometry whereby the inner heat exchange surface has a greater constructive height than the adjacent outer heat exchange surface so that each heat exchange surface can be rapped from the exterior without the need for penetrating any other heat exchange surfaces. Optionally, one or more deflectors arranged within the inner heat exchange surface of the nested set may be used to guide the hot gas flow towards the heat exchange surfaces, in order to cool all of the gas evenly.

[0017] The heat exchange device according to the present invention can for example be a section of a partial combustion reactor for the production of synthetic gas.

[0018] The invention is further explained under reference to the accompanying drawings. In the drawings:

- Figure 1A: shows a longitudinal cross section of a heat exchange device according to the present invention;
- Figure 1B: shows the device of Figure 1A in cross section;
- Figure 2A: shows in side view a support structure of the device of Figure 1;
- Figure 2B: shows a plan view of the support structure of Figure 2A;
- Figure 3: shows in side view of a second possible embodiment of a support structure according to the invention;
- Figure 4: shows a longitudinal cross section of a further possible embodiment of a heat exchange device according to the present invention.

[0019] Figure 1A shows in longitudinal cross section a heat exchange section 1 of a partial combustion reactor for the production of syngas. The section 1 comprises a cylindrical outer wall 2. The outer wall 2 encloses a concentrically arranged inner channel wall or membrane 3 built of parallel tubular pipe lines, schematically represented in the drawing by centrelines. The tubular pipe lines of the inner channel wall 3 are welded together - e.g., directly or via fins - to form a gastight wall. A cooling medium, such as water flows through the pipe lines of the channel wall 3.

[0020] The inner channel wall 3 encloses a set of four schematically represented nested coaxial heat exchange surfaces 5a, 5b, 5c, and 5d. In practice, two or more may be used-for example heat exchange surfaces 5a and 5b. Like the inner channel wall 3, the heat exchange surfaces 5a - d are built of parallel tubular lines. Optionally, the tubular lines of the heat exchange surfaces 5a - d can be helically wound.

[0021] The inner channel wall or membrane 3 defines a central channel 4a for hot gas flowing downwards along the heat exchange surfaces 5a - d towards a discharge. At the lower end of the inner channel wall 3, the cooled gas can enter the annular space 4b between the inner channel wall 3 and the outer wall 2. Coolant flowing through the pipe lines of inner channel wall 3 isolates the cool gas in the annular channel 4b from the hot gas in the central channel 4a.

[0022] The lower end 6 of each inner heat exchange surface 5b - d extends past the lower end 6 of the adjacent outer heat exchange surface 5a - c, respectively. This way, each individual heat exchange surface 5a - d can be cleaned individually by using rapper devices (not shown).

[0023] Four or more equidistantly arranged coolant discharge lines 7 are provided between the inner channel wall 3 and the outer channel wall 2, as schematically shown in Figure 1B. Referring back to Figure 1A, the discharge end 8 of the lines 7 passes the outer wall 2 to form a connection to a coolant discharge. In line with the discharge lines 7, and at a distance below these discharge lines 7, are four supply lines 9. The upper ends 10 of the supply lines 9 pass through the outer wall 2 to form a connection to a coolant supply. Coolant feed lines 16 connect the supply lines 9 to the heat exchange surfaces 5a - d. The arrangement of the supply lines and discharge lines can also be reversed depending on the cooling media.

[0024] A horizontal support cross 20 has four arms 21 extending from a central crossing 22 to a corresponding coolant discharge line 7. The support cross 20 is shown in more detail in Figures 2A and 2B. Parallel inner channels 23 run through the arms 21, each inner channel 23 being in open connection with the flow paths in the heat exchange surfaces 5a - d. The inner channels 23 are evenly distributed over the corresponding arm 21. The top side of each of the heat exchange surfaces 5a - d comprises two vertical line sections 19, axially symmetrically arranged, extending vertically towards the support cross 20, where they are connected to the embedded inner channels 23, as shown in Figure 1A.

[0025] Each arm 21 comprises a first and a second lower arm part 24, 25 respectively, and an upper arm part 26. In the first lower arm part 24, equidistantly arranged parallel flow paths 27 have a first part 27a extending upwardly to a first corner 27b and a second section 27c extending in the direction of the crossing section 22.

[0026] In the second lower arm part 25 are embedded equidistantly arranged parallel flow paths 28. Two of the four second lower arm parts 25 form a single block, while the other two are formed as separate parts at opposite sides of the block and under right angles with it and are welded to a central section of the block to form a cross, as shown in Figure 2B. Referring back to Figure 2A, the flow paths 28 in the second lower arm parts 25 have a first horizontal section 28a in line with the respective flow paths 27c in the first part 24 extending to a second corner 28b, and a second section 28c extending upwardly from the second corner 28b.

[0027] In the upper arm part 26 are embedded equidistantly arranged parallel flow paths 29. Two of the four upper arm parts 26 form a block, while the other two upper arm parts 26 are formed as separate parts and are welded to the central section of the block to form a cross. The flow paths 29 in the upper arm parts 26 have a first vertical section 29a in line with the respective flow paths 28 in the second lower arm part 25 extending upwardly to a third corner 29b, and a second section 29c extending from the third corner 29b away from the crossing section 22.

[0028] Opposite to the side forming the crossing section 22, the upper arm parts 26 are joined to an extension part 30. These extension parts 30 are rectangular parts with equidistantly arranged inner channels 31 embedded in line with the horizontal channel sections 28c in the upper arm parts 26.

[0029] In this configuration, all parts of the support cross 20 are evenly cooled by the evenly distributed inner channels 27, 28, 29, 31 in arm parts 24, 25, 26, 30. As a result, the risk of mechanical stresses induced by differences in thermal expansion is substantially reduced.

[0030] The outer ends of inner channels 27, 28, 29, 31 in arm parts 24, 25, 26, 30 are surrounded by circular rims 35. The arm parts 24, 25, 26, 30 are welded together at these circular rims to form leaktight joints.

[0031] Blocks 32 (see Fig. 2B) are attached to both sides of the extension part 30. The blocks 32 are in line with the inner channel wall 3 and have the same curvature. The blocks 32 are provided with inner channels 33 which are operatively connected to the tubular lines 4 in the channel wall 3.

[0032] Figure 3 shows in side view an alternative support cross 40 for a heat exchanger according to the present invention. The support cross comprises four arms 41 of equal length forming a cross with a centre part 42. Each arm 41 is made of four sections: a lower main section 43, a lower central section 44, an upper centre section 45 and an upper main section 46.

[0033] Inner channels 47a and 47b are embedded in the lower main section 43 with a vertically extending channel section 47a at the lower side of the lower main section 43 and a horizontally extending channel section 47b, extending to a lateral side of the lower main section 43. Three of the channel sections 47b extend towards the adjacent lower central section 44. The upper one of channels sections 47b has its upper longitudinal half formed as a pipeline in a rectangular cut-out 48 in the lower main section 43.

[0034] Inner channels 49a and 49b are embedded in the lower central section 44, having horizontal channel sections 49a connected at one end to the channel sections 47b in the lower main section 43, and to vertical channel sections 49b at their other end. The lower central section 44 is mirrored by the upper central section 45, which embeds inner channels 50a and 50b, with vertical sections 50a in line with the vertical inner channels sections 49b in lower central section 44. Horizontal channels sections 50b lead from the vertical channel sections 50a to the side of the upper central section 45 opposite the centre 22.

[0035] The upper main section 46 is made of three horizontal parallel pipe lines 51 operatively connected to the horizontal channel sections 50b in upper central section 45. The pipe lines 51 lead to an extension block 52 with three inner channels 53 connected to the pipe lines 51.

[0036] The outer ends of inner channels in arm parts 43, 44, 45 and the pipe lines 51 of upper main section 46 are surrounded by circular rims 54. The arm parts are welded together at these circular rims 54 to form leaktight joints.

[0037] Figure 4 shows a heat exchange device 60 similar to the heat exchange device of Figure 1A and 1B. The same reference numbers are used for parts that are the same in both embodiments. The heat exchange device in Figure 4 comprises two bundles 61, 62 in line above one another of four nested heat exchange surfaces 61a - d, 62a - d. Because of the double weight that has to be supported a support cross 63 is used which is thicker than the support cross 20 in Figure 1A.

Claims

1. A heat exchange device (1) comprising:

   - a channel wall (3) defining a flow channel;
   - one or more heat exchange surfaces (5a - d), each embedding one or more flow paths for a fluid heat exchange medium, and comprising supply and discharge connections (7, 9) for the supply and discharge of the fluid heat exchange medium;
   - a support structure (20) for supporting the heat exchange surfaces (5a - d) within the flow channel;

   the heat exchange device being **characterized in that** the support structure (20) comprises four arms (21) extending under right angles from a central crossing (22) to the channel wall (2) to form a cross; wherein at least a part of the arms (21) comprises inner channels (23) each being in open connection with one of the flow paths in the heat exchange surfaces (5a - d).

2. A heat exchange device according to claim 1 wherein the inner channels (23) are parallel and equidistant and evenly distributed over the corresponding arm (21).

3. A heat exchange device according to claim 2 wherein

the inner channels (23) meander through the arms (21).

4. A heat exchange device according to claim 3 wherein the arms (21) are built of two or more arm parts (24, 25, 26), wherein at least a part of the arm parts embed parallel and equidistant inner channel sections making a single turn.

5. A heat exchange device according to claim 4 wherein each arm (21) comprises:

- a first lower arm part (24) with equidistantly arranged parallel flow paths (27) with a first section (27a) extending upwardly to a first corner (27b) and a second section (27c) extending in the direction of the crossing section (22);
- a second lower arm part (25) with equidistantly arranged parallel flow paths (28) having a first section (28a) in line with the second sections (27c) of the respective flow paths (27) in the first lower arm part (24), wherein the first sections (28a) extend to a second corner (28b), and second section (28c) extend upwardly from the second corner (28b);
- an upper arm part (26) with equidistantly arranged parallel flow paths (29) having a first vertical section (29a) in line with the second sections (28c) of the respective flow paths (28) in the second lower arm parts (25), wherein the first sections (29a) extending upwardly to a third corner (29b), and wherein second sections (29c) extend from the third corner (29b) away from the crossing section (22).

6. A heat exchange device according to any one of the preceding claims wherein the device (1) comprises two or more coaxially nested heat exchange surfaces (5a - b) of a closed geometry.

7. A heat exchange device according to any one of the preceding claims wherein one or more of the arms of the support structure is at least partly built of tubular parts, optionally in combination with blocks or plates embedding inner channels operatively connected to the tubular parts.

8. A partial combustion reactor for the production of synthetic gas, wherein the reactor comprises at least one section with a heat exchange device (1) according to any one of the preceding claims.

Patentansprüche

1. Wärmetauschvorrichtung (1), umfassend:

- eine Kanalwand (3), die einen Strömungskanal definiert;
- eine oder mehrere Wärmetauschoberflächen (5a - d), die jeweils einen oder mehrere Strömungswege für ein fluides Wärmetauschermedium einbetten und die Zuführ- und Abführverbindungen (7, 9) für die Zuführung und Abführung des fluiden Wärmetauschermediums umfassen;
- eine Stützstruktur (20) zum Stützen der Wärmetauscheroberflächen (5a - d) innerhalb des Strömungskanals;

wobei die Wärmetauschervorrichtung **dadurch gekennzeichnet ist, dass** die Stützstruktur (20) vier Arme (21) umfasst, die sich unter rechten Winkeln von einer zentralen Schnittstelle (22) zur Kanalwand (2) erstrecken, um ein Kreuz auszubilden;
wobei mindestens ein Teil der Arme (21) Innenkanäle (23) umfasst, die jeweils mit einem der Strömungswege in den Wärmetauscheroberflächen (5a - d) in einer offenen Verbindung stehen.

2. Wärmetauschvorrichtung nach Anspruch 1, wobei die Innenkanäle (23) parallel und gleichabständig und über den entsprechenden Arm (21) gleichmäßig verteilt sind.

3. Wärmetauschvorrichtung nach Anspruch 2, wobei die Innenkanäle (23) durch die Arme (21) mäandern.

4. Wärmetauschvorrichtung nach Anspruch 3, wobei die Arme (21) aus zwei oder mehreren Armteilen (24, 25, 26) gebildet sind, wobei mindestens ein Teil der Armteile parallele und gleichabständige Innenkanalabschnitte einbettet, die eine einzige Biegung machen.

5. Wärmetauschvorrichtung nach Anspruch 4, wobei jeder Arm (21) das Folgende umfasst:

- einen ersten unteren Armteil (24) mit gleichabständig angeordneten parallelen Strömungswegen (27) mit einem ersten Abschnitt (27a), der sich zu einer ersten Ecke (27b) nach oben erstreckt, und einem zweiten Abschnitt (27c), der sich in der Richtung des Schnittpunktabschnitts (22) erstreckt;
- einen zweiten unteren Armteil (25) mit gleichabständig angeordneten parallelen Strömungswegen (28), der einen ersten Abschnitt (28a) in einer Richtung mit den zweiten Abschnitten (27c) der entsprechenden Strömungswege (27) in dem ersten unteren Armteil (24) aufweist, wobei sich die ersten Abschnitte (28a) zu einer zweiten Ecke (28b) erstrecken und wobei sich ein zweiter Abschnitt (28c) von der zweiten Ecke (28b) nach oben erstreckt;
- einen oberen Armteil (26) mit gleichabständig

angeordneten parallelen Strömungswegen (29), der einen ersten vertikalen Abschnitt (29a) in einer Richtung mit den zweiten Abschnitten (28c) der entsprechenden Strömungswege (28) in den zweiten unteren Armteilen (25) aufweist, wobei sich die ersten Abschnitte (29a) zu einer dritten Ecke (29b) nach oben erstrecken und wobei sich zweite Abschnitte (29c) von der dritten Ecke (29b) weg von dem Schnittpunktabschnitt (22) erstrecken.

6. Wärmetauschvorrichtung nach einem der vorhergehenden Ansprüche, wobei die Vorrichtung (1) zwei oder mehrere koaxial geschachtelte Wärmetauscheroberflächen (5a - b) mit einer geschlossenen Geometrie umfasst.

7. Wärmetauschvorrichtung nach einem der vorhergehenden Ansprüche, wobei einer oder mehrere der Arme der Stützstruktur zumindest teilweise aus röhrenförmigen Teilen gebildet sind, optional in Kombination mit Blöcken oder Platten, die Innenkanäle einbetten, welche mit den röhrenförmigen Teilen wirksam verbunden sind.

8. Teilverbrennungsreaktor für die Herstellung von einem synthetischen Gas, wobei der Reaktor mindestens einen Abschnitt mit einer Wärmetauschvorrichtung (1) nach einem der vorhergehenden Ansprüche.

Revendications

1. Dispositif d'échange de chaleur (1) comprenant :

une paroi de canal (3) définissant un canal d'écoulement ;
une ou plusieurs surfaces d'échange de chaleur (5a-d), chacune comprenant une ou plusieurs trajectoires d'écoulement pour un milieu caloporteur fluide, et comprenant des raccordements d'alimentation et d'évacuation (7, 9) pour l'alimentation et l'évacuation du milieu caloporteur fluide ;
une structure de support (20) pour supporter les surfaces d'échange de chaleur (5a-d) à l'intérieur du canal d'écoulement ; le dispositif d'échange de chaleur étant **caractérisé en ce que** :

la structure de support (20) comprend quatre bras (21) s'étendant en angle droit à partir d'une traversée centrale (22) jusqu'à la paroi de canal (2) afin de former une croix ; dans lequel au moins une partie des bras (21) comprend des canaux internes (23), chacun étant en raccordement ouvert avec l'une des trajectoires d'écoulement dans les surfaces d'échange de chaleur (5a-d).

2. Dispositif d'échange de chaleur selon la revendication 1, dans lequel les canaux internes (23) sont parallèles et équidistants et régulièrement répartis sur le bras (21) correspondant.

3. Dispositif d'échange de chaleur selon la revendication 2, dans lequel les canaux internes (23) décrivent des méandres à travers les bras (21).

4. Dispositif d'échange de chaleur selon la revendication 3, dans lequel les bras (21) sont composés de deux parties de bras (24, 25, 26) ou plus, dans lequel au moins une partie des parties de bras intègre des sections de canal interne parallèles et équidistantes faisant un seul tour.

5. Dispositif d'échange de chaleur selon la revendication 4, dans lequel chaque bras (21) comprend :

une première partie de bras inférieure (24) avec des trajectoires d'écoulement (27) parallèles agencées de manière équidistante avec une première section (27a) s'étendant vers le haut à partir d'un premier coin (27b) et une seconde section (27c) s'étendant dans la direction de la section transversale (22) ;
une seconde partie de bras inférieure (25) avec des trajectoires d'écoulement parallèles (28) agencées de manière équidistante ayant une première section (28a) alignée avec les secondes sections (27c) des trajectoires d'écoulement (27) respectives dans la première partie de bras inférieure (24), dans lequel les premières sections (28a) s'étendent vers un deuxième coin (28b), et les secondes sections (28c) s'étendent vers le haut à partir du deuxième coin (28b) ;
une partie de bras supérieure (26) avec des trajectoires d'écoulement (29) parallèles agencées de manière équidistante ayant une première section verticale (29a) alignée avec les secondes sections (28c) des trajectoires d'écoulement (28) respectives dans les secondes parties de bras inférieures (25), dans lequel les premières sections (29a) s'étendent vers le haut vers un troisième coin (29b), et dans lequel les secondes sections (29c) s'étendent à partir du troisième coin (29b) à distance de la section transversale (22).

6. Dispositif d'échange de chaleur selon l'une quelconque des revendications précédentes, dans lequel le dispositif (1) comprend deux surfaces d'échange de chaleur (5a-b) ou plus formant une géométrie fermée et emboîtées de manière coaxiale.

7. Dispositif d'échange de chaleur selon l'une quelconque des revendications précédentes, dans lequel un ou plusieurs des bras de la structure de support sont partiellement composés avec des parties tubulaires, facultativement en combinaison avec des blocs ou des plaques intégrant des canaux internes raccordés de manière opérationnelle aux parties tubulaires.

8. Réacteur de combustion partielle pour la production de gaz de synthèse, lequel réacteur comprend une section avec un dispositif d'échange de chaleur (1) selon l'une quelconque des revendications précédentes.

Fig.1A

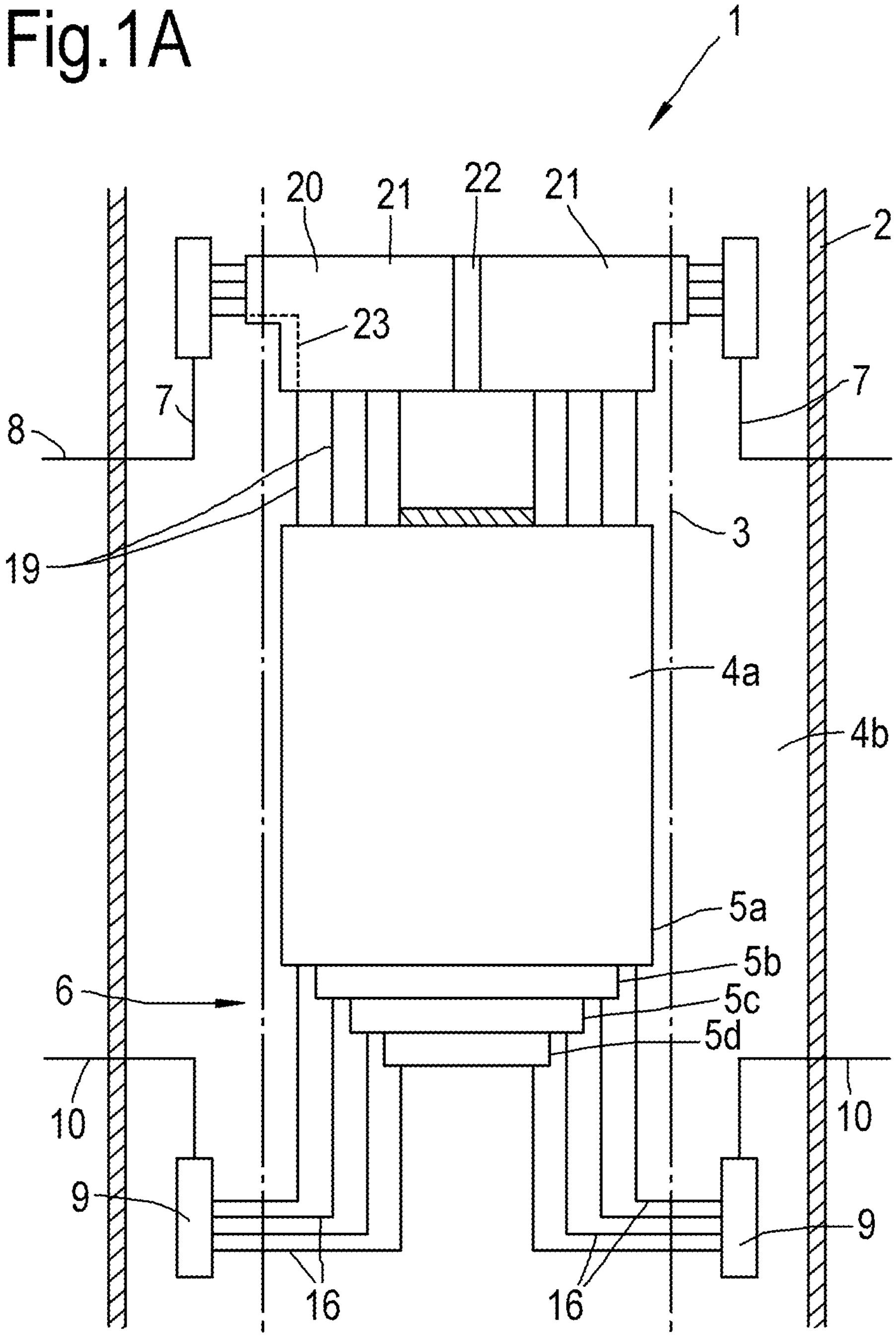

Fig.1B

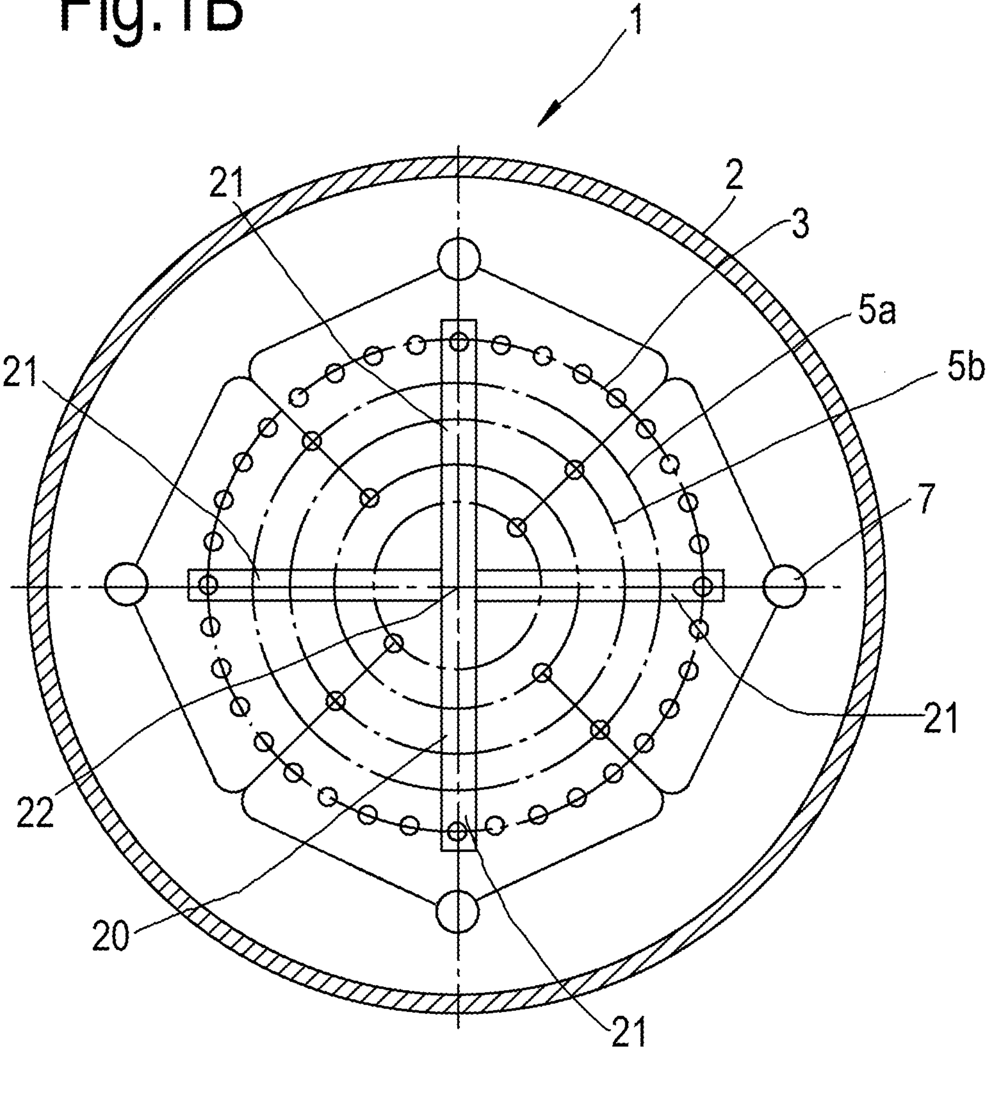

Fig.2A

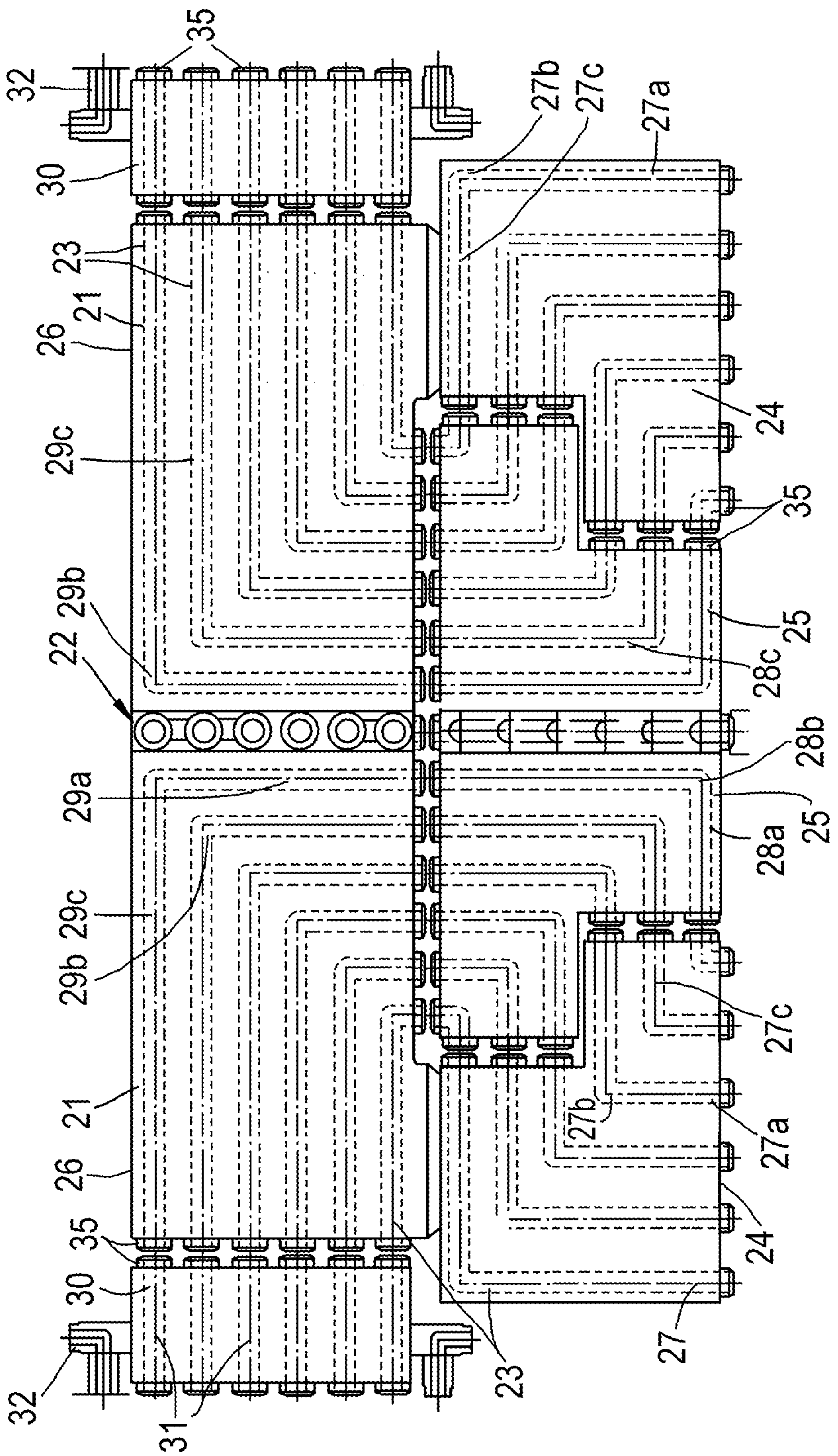
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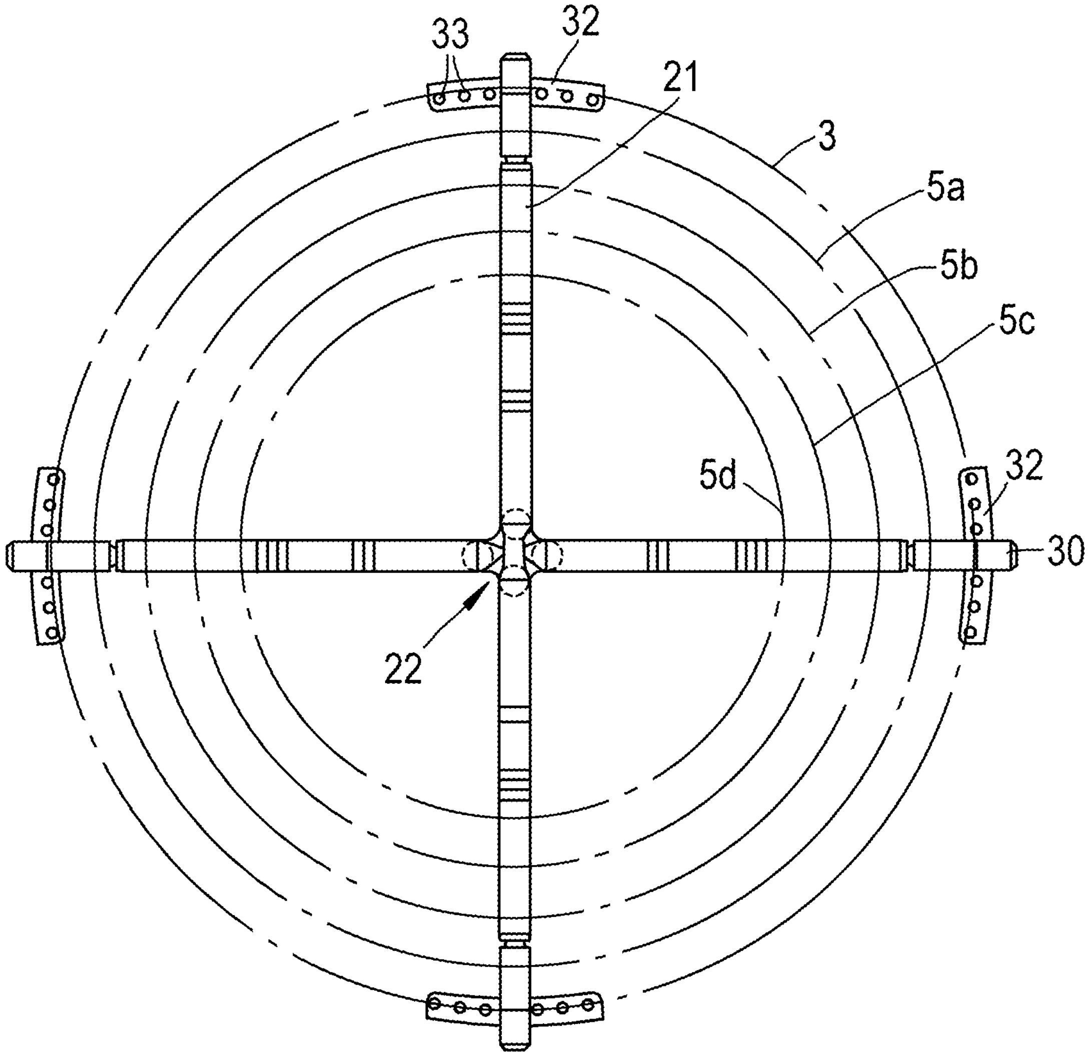
Fig.2B



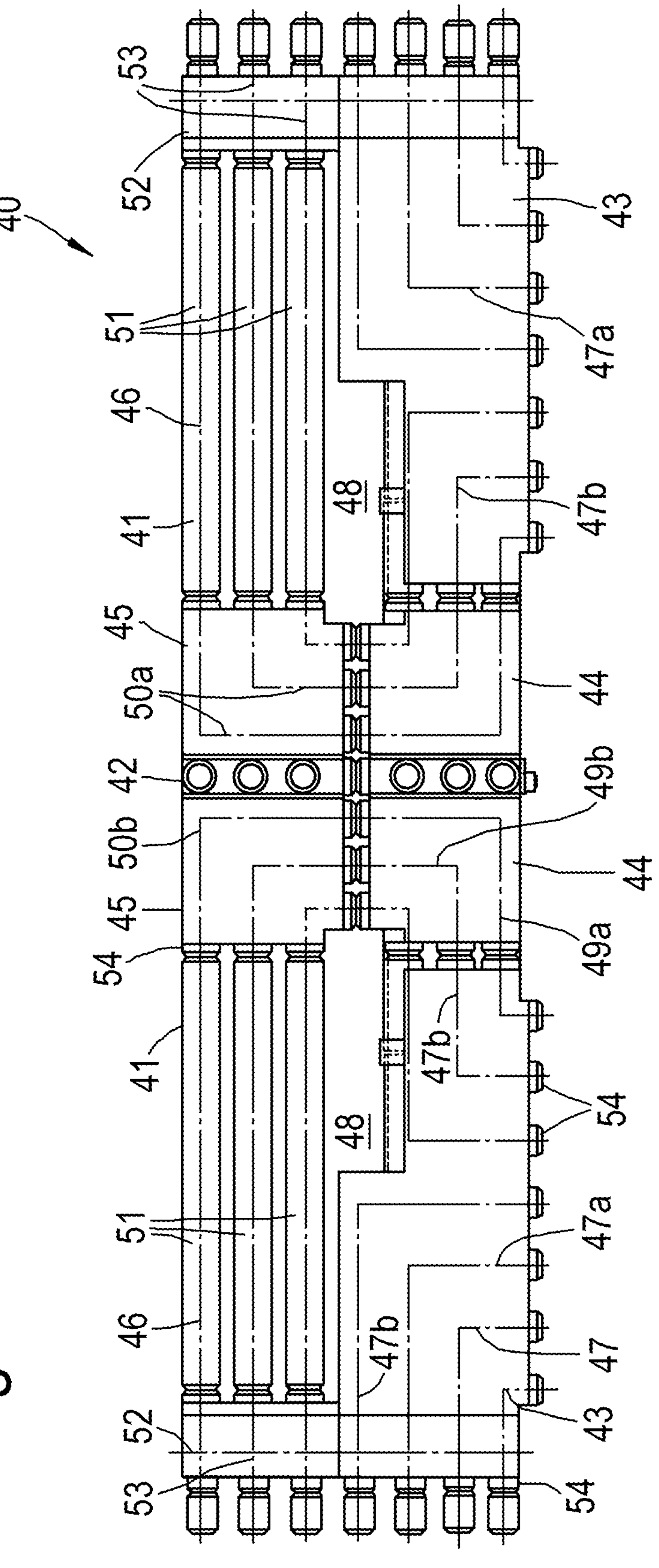

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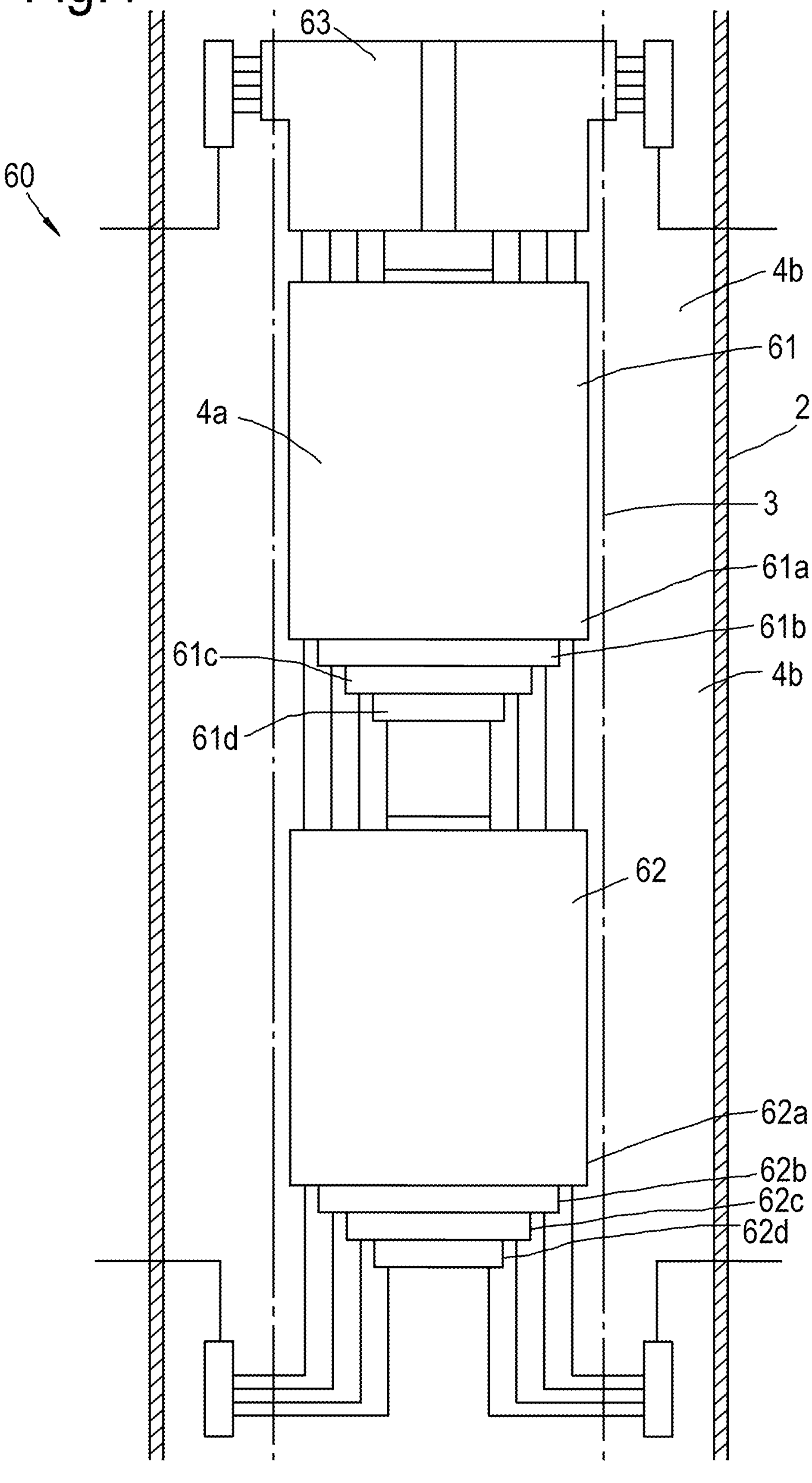
Fig.3

Fig.4



REFERENCES CITED IN THE DESCRIPTION

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