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(54) **MODULAR FURNACE FOR THE HEAT TREATMENT OF ARTICLES**

(57) A modular furnace (100) is described for the heat treatment of an article, in particular for the post weld heat treatment (PWHT, stress relieving, solution annealing, tempering, normalization) intended for use, for example, in a chemical or oil or energy production plant, or in heavy industry, comprising a plurality of prefabricated modules (10) intended to be assembled in order to form the modular furnace (100) around or in the vicinity of the article, avoiding displacement of the article on wheels, each of the plurality of prefabricated modules (10) comprising at least one side-wall (10a) and an insulating panel (2) intended to remain on the inside of the modular furnace (100), at least one module (5) of the plurality of prefabricated modules (10) comprising at least two integrated sidewalls (3, 4) extending relative to each other at a predefined angular distance and being provided with a supporting base (3a, 4a) from which the at least two integrated sidewalls (3, 4) vertically extend, each module of the plurality of prefabricated modules (10) comprising connecting means (6) for realizing the structural connection with one or more adjacent modules (10), and said plurality of modules (10) being connected together to form at least one closed loop (50) which starts from one of said at least two sidewalls (3, 4) and terminates in the other one of said at least two sidewalls (3, 4), at least one of said prefabricated modules (60), also known as roof (60), being structurally connected on top of the loop (50), thus defining a closed space for receiving the article.

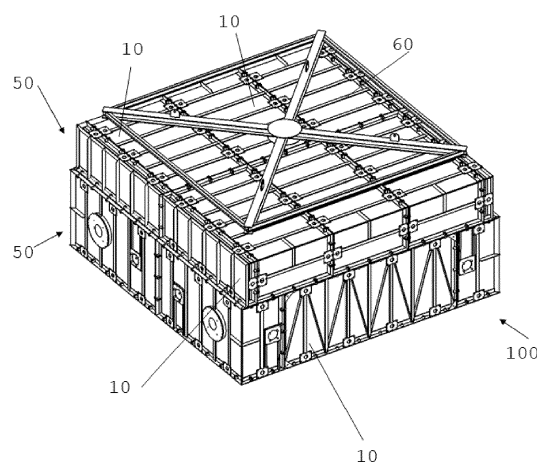


Fig. 1

Description

Field of application

[0001] The present invention relates to a modular furnace for the heat treatment of articles, e.g. heavy structural work, piping, tanks, columns, heat exchangers, pressure vessels, in particular for post weld heat treatments of large-size articles intended, for example, for use in chemical, oil and energy production plants, in heavy industry, etc.

[0002] The present invention also relates to a method for the heat treatment of articles using the modular furnace of the type mentioned above.

Prior art

[0003] Furnaces are known for the heat treatment of large-size articles, e.g. articles for the heavy structural work, energy, chemical or oil and gas industries.

[0004] Due to their large size, these articles are normally assembled on site or at remote temporary sites by assembling several smaller components, individually produced elsewhere and transported for assembly on site, where the article is then used.

[0005] The assembly normally involves welding procedures of the individual components, which thus implies heat treatment (PWHT, stress relieving, solution annealing, etc.) for the improvement of the microstructure of the article, especially in the weld areas and adjacent areas, for the diffusion of hydrogen in the welds, for the reduction of stress concentration sites, which are created during the welding procedures (stress relieving). This involves, for example, performing the heat treatment on a fixed-plate heat exchanger made of carbon steel, low-alloy or alloy steels, or performing the treatment on pressure vessels, such as columns and reactors of considerable length (more than 30 metres), for example made of carbon steel or "creep" steels such as P11, P22, P91, P92, etc...

[0006] Heat treatments can also be aimed, in some cases, at the solution annealing and stabilisation of austenitic and duplex steels on components intended for refineries, chemical and petrochemical plants, or the solution annealing and stress relieving of nickel alloy components, for the hardening (quenching and tempering) of alloy/low alloy steels (grade 11, grade 22, grade 91, grade 92), or the annealing of steels intended for chemical, petrochemical and energy production plants.

[0007] The thermal heating must be uniform over the entire geometry of the article to ensure a uniform reaction of the assembled materials to the component's operating stresses, whether mechanical or corrosive. This requires the use of furnaces of considerable dimensions, like the treated components, which are also normally built on site and developed all around the article.

[0008] Given the size of the article to be treated, heat treatment furnaces according to the prior art cannot be

transported, especially on wheels. As a rule, the furnace is therefore improvised on site and adapted as necessary. For example, the furnace consists of piers of a predetermined height, corresponding to the maximum height of the article, cross-pieces of a predetermined length and width, corresponding to the maximum length and width of the article, and walls supported by the piers and spaced by the cross-pieces.

[0009] However, such furnaces suffer from some important limitations.

[0010] First of all, they are specifically suited to a single article and cannot easily be reused. In addition, the furnaces require significant construction efforts, the greater the size of the furnace, thus having to transport, and then lift, position and fix together piers, cross-pieces and walls of several tens of metres. In particular, lifting and positioning a pier or wall vertically, and holding it in that position for subsequent fastening of the parts is far from straightforward, and can lead to defects as a result of unpredictable misalignment of the parts during fastening.

[0011] As a consequence of these defects, but also of structural limitations of the aforesaid components, the temperatures that can be reached inside the furnace during heat treatment are limited to 650 °C, as a result of thermal losses occurring at the joints between the walls, thermal losses due to the low insulation thicknesses used to limit the weight of the walls, and also structural difficulties arising from the need to support the walls themselves. The effect of thermal losses cannot guarantee any process quality due to the lack of temperature uniformity in the furnace, and the higher operating temperatures (above 635 °C) lead to structural deformations of the slender support structures.

[0012] Last but not least, the use of modern construction materials for pressure vessels and increasingly high-performance structures means that the article must also be subjected to rapid cooling steps that even require its immediate removal from the furnace at high temperature. However, this is complicated both by the size and weight of the article being treated, and by the size, geometry and weight of the furnace used, as well as the time required for its displacement on site.

[0013] CN212806531 is an example of a modular furnace.

[0014] The technical problem at the basis of the present invention is to devise a mobile modular plant for the heat treatment of large articles, e.g. for the heavy structural work, energy, chemical or oil and gas sectors, which is capable of solving all the above-mentioned drawbacks, in particular, suitable to develop and withstand an operating temperature of up to 1250 °C, to accommodate the article regardless of its dimensions and geometry, to facilitate its displacement in relation to possible cooling or heating cycles, as well as being easily heatable, and reusable for the heat treatment of other articles.

Summary of the invention

[0015] The idea underlying the present invention is to realise a dismountable modular plant or furnace for the heat treatment of large articles, for example articles for the heavy structural work, energy, chemical or oil and gas sectors, having at least one self-supporting module structurally connected to a plurality of other modules intended to be close in a loop with the self-supporting module, and to enclose the article, as well as a module intended to remain on top of the article, preferably a plurality of prefabricated and pre-assembled modules intended to remain on top of the article, removably.

[0016] The technical problem underlying the present invention is solved by a modular furnace for a heat treatment according to claim 1 and a heat treatment according to claim 11.

[0017] Preferred embodiments of the modular furnace and of the heat treatment according to the present invention are given by claims 2-10 and 12, respectively.

[0018] Further features and advantages of the modular furnace and heat treatment according to the present invention are provided in the following description with reference to the accompanying drawings, which are given for illustrative purposes only and do not limit the scope of protection of the invention.

Brief description of the accompanying figures

[0019]

Figure 1 is a perspective view of a modular furnace for the heat treatment of articles according to the present invention.

Figure 2 is a perspective view of a self-supporting prefabricated module of the modular furnace for the heat treatment of articles of Figure 1.

Figure 3 is another perspective view of a self-supporting prefabricated module of the modular furnace for the heat treatment of articles of Figure 1.

Figure 4 is a perspective view of a detail of a prefabricated module of the modular furnace for the heat treatment of articles of Figure 1.

Figure 5 is a perspective view of another detail of a prefabricated module of the modular furnace for the heat treatment of articles of Figure 1.

Figure 6 is a perspective view of another detail of a prefabricated module of the modular furnace - combustion module - for the heat treatment of articles of Figure 1.

Figure 7 is a perspective view of a plurality of modules according to the present invention, arranged for

transport.

Description of the drawings

[0020] With reference to Figure 1, a modular furnace 100 is shown according to a possible embodiment of the present invention, provided for illustrative purposes. The modular furnace 100 is intended for use in the heat treatment of large articles, e.g. articles for the heavy structural work, energy, chemical or oil and gas industries, and in particular articles assembled on site by assembling multiple components, produced elsewhere and transported for assembly on site, where the article is then used without further displacements, in consideration of the size and weight of the article.

[0021] The assembly of components, whether structural work, heat exchangers, tanks, reactors, equipment for the energy sector, industry, the chemical and petrochemical industries, may involve welding processes, and heat treatment therefore becomes necessary for the improvement of the microstructure of the article, the metallurgy of the material adjacent to the weld, and the diffusion of hydrogen in the weld. By way of example only, the heat treatment using the modular furnace 100 can be applied to a fixed-plate heat exchanger made of carbon steel, and/or low-alloy and/or alloy steels, to reduce, among other things, stress concentration sites, i.e., relieving the stress created during welding, which are especially deleterious for articles subject to so-called "stress corrosion cracking", i.e., a degradation effect due to the combined action of corrosion and the application of a constant load.

[0022] However, the aforementioned heat treatment does not in itself limit the scope of application of the modular furnace, as it can also be used for treatment on pressure vessels, columns and reactors with a length of up to 30 metres, in carbon steel or alloy steels, or for solution annealing and stabilisation of austenitic and duplex steels on components for refineries, chemical and petrochemical plants, or for solution annealing and stress relieving of nickel alloy components, for the normalisation of low alloy steels (grade 11, grade 22, grade 91, grade 92), or the annealing of steels for chemical, petrochemical and energy production plants.

[0023] The result of the heat treatment on the article must be uniform to ensure uniform strength and response of materials and welds to operating stresses. The modular furnace must be large enough to accommodate the entire article, thus it is built on site and developed all around the article. In fact, the modular furnace is not transportable, especially on wheels, due to its considerable size.

[0024] According to the present invention, the modular furnace 100 for the heat treatment of the article, in particular for the post-weld heat treatment of the article, comprises

a plurality of prefabricated modules 10 (as for example shown in fig. 1) intended to be assembled in order to form

the modular furnace 100 around or in the vicinity of the article, avoiding displacement of the article on wheels, each of the plurality of prefabricated modules 10 comprising at least one sidewall 10a (as for example shown in fig. 4) and an insulating panel 2 intended to remain on the inside of the modular furnace 100 (again as for example shown in fig. 4).

[0025] In the example of figure 4, the prefabricated module 10 has a sidewall 10a which substantially extends in two directions X, Y, like the insulating panel 2, which is superimposed on the sidewall 10a (without taking into account the thickness of the insulating panel 2 and the sidewall 10a which extend in the third direction Z, which is, however, negligible compared to the extension of the insulating panel 2 and the sidewall 10a in the other two directions X, Y).

[0026] Such a geometry of the prefabricated module 10 is, however, not restrictive. On the contrary, prefabricated modules with different geometries, hereafter referred to with reference number 5, are provided for the main purpose of connoting the different geometry of the prefabricated module 5. In particular, at least one module 5 of the plurality of prefabricated modules comprises at least two sidewalls 3, 4 extending relative to each other at a predefined angular distance.

[0027] In other words, whereas the prefabricated module 10 has a sidewall 10a which extends substantially in two directions X, Y, as well as the insulating panel 2 which is superimposed thereon, the prefabricated module 5 has two sidewalls 3, 4 which each extend in two directions (e.g. the sidewall 3 in the X and Y direction and the sidewall 4 in the Z and Y direction), as well as the respective insulating panels 2 superimposed on them, but which are arranged relative to each other at a predefined angular distance, forming, for example, a prefabricated module 5 with an L section.

[0028] Of course, as already observed for the prefabricated module 10, also the sidewalls 3, 4 (and insulating panels 2) of the prefabricated module 5 have a thickness that extends in a third direction (in the example given above, in the Z direction for the sidewall 3 and in the X direction for the sidewall 4, however, to a negligible extent compared to the extension of the insulating panel 2 and sidewalls 3, 4 in the respective two directions).

[0029] The sidewalls 3, 4 of the prefabricated module 5 are preferably prefabricated and integrated, so that the prefabricated module 5 can be immediately laid in a self-supporting manner.

[0030] The prefabricated module 5 is therefore equipped with a base 3a, 4a from which the sidewalls 3, 4 extend vertically (e.g. in the Z direction). The base 3a, 4a therefore has a surface area that allows the prefabricated module 5 to be maintained independently on the ground. Of course, if the prefabricated module 5 is turned upside down, the surface formerly known as the "base" is facing upwards and can therefore be used to support other modules at the base.

[0031] In particular, the prefabricated module 5 is pref-

erably provided with a surface at the base 3a, 4a and a corresponding surface opposite the base, e.g. the head surface. The surfaces are the same. The module 5 is thus reversible or tiltable (it can be laid on either surface indifferently).

[0032] Each module of the plurality of prefabricated modules 10 comprises connecting means 6 which realize the structural connection with one or more adjacent modules 10, and the plurality of modules 10 are connected together to form at least one closed loop 50 which starts from one of the at least two sidewalls 3, 4 and terminates in the other one of the at least two sidewalls 3, 4.

[0033] The expression "closed loop" is used to indicate a closed structure, in particular a structure closed in on itself.

[0034] The expression "closed loop" is not representative of a circular or curved shape or one without corners. In fact, the closed structure may include corners. For example, the closed structure may have a quadrangular, rectangular or square plan and a parallelepiped shape.

[0035] In other words, the expression "closed loop" is adopted to indicate the characteristic whereby the plurality of modules are structurally connected, one after the other, to give rise to a structure that closes in on itself, forming, for example, a closed quadrangular or rectangular loop.

[0036] The closed structure, like a closed loop, delimits a perimeter, along which the prefabricated modules are located.

[0037] The closed structure, like a closed loop, is closed perimetrically but accessible from above.

[0038] Hence, multiple (perimetrically) closed structures always delimit a vertically extended (perimetrically) enclosed structure, which is still accessible from above. For example, the closed structure forms the furnace chamber with a vertical box body.

[0039] At the upper end, a panel (or roof) is applied above the closed structure so that the closed structure is no longer vertically accessible, but instead forms the closed chamber of the furnace.

[0040] At least one of the prefabricated modules 60, also known as roof 60, is structurally connected on top of loop 50, thus defining a closed space for receiving the article. In one embodiment, the roof consists of prefabricated modules of a different geometry or size from the previously mentioned prefabricated modules 10, 5. In particular, it was observed that a module thickness of 300 mm or less for the roof is preferable to the greater thicknesses normally adopted for the side walls of the furnace (prefabricated modules 5 or 10). Similarly, it has been observed that a linear extension of the modules forming the roof of 3600 mm or less is preferable to larger extensions normally adopted for the side walls of the furnace (prefabricated modules 5 or 10). These parameters are adopted to optimize the weight of the roof and the thermal insulation of the furnace.

[0041] Figure 2 schematically depicts a module 5 of the plurality of prefabricated modules in an embodiment

in which the module 5 extends by a shorter distance than the module 5 of Figure 3. The two integrated sidewalls 3, 4 extend relative to each other at an angular distance of 90°. The base 3a, 4a of each sidewall 3, 4 forms a support from which the sidewalls 3, 4 extend vertically. The module therefore has an L-shaped plan and is self-supporting as it does not require supports or equipment (cranes or props) to remain upright, unlike modules (according to the known art) extending in only one direction.

[0042] A plurality of self-supporting prefabricated modules 5, e.g. arranged as schematically depicted in Figure 7, can be transported on site to make the self-supporting corner parts of the modular furnace 100. Between said self-supporting corner parts, linear side walls of the modular furnace extend, or individual planes of such walls that extend over several vertical planes of modules 10, also called simple modules 10.

[0043] For example, the simple modules 10 are depicted in Figure 7. These simple modules 10 are in the form of a substantially flat panel with a substantially linear supporting surface, and are intended for connection with other adjacent simple modules 10, however, starting and terminating in a self-supporting prefabricated module 5. In particular, the self-supporting prefabricated module 5 can also support the module 10 or the associated simple modules 10 one after the other.

[0044] Preferably, the assembly of the modular furnace 100

- starts from a self-supporting prefabricated module 5 with or without provision for housing the combustion system, which is laid on the ground on its L-shaped supporting surface (or on a different shaped section of module 5, determined by the extension in predetermined angular distance of the sidewalls 3, 4),

continues with the connection of one of the sidewalls 3 to a first simple module 10 that extends the modular furnace along the direction of the first sidewall 3, and then with

the connection of one of the simple modules 10 (with or without provision for housing the combustion system) to another of the self-supporting prefabricated modules 5, which allows the modular furnace to extend in a direction parallel to the direction of the second sidewall 4.

[0045] Further simple modules 10 are then applied starting from the second of the self-supporting prefabricated modules 5, until the application of a third self-supporting prefabricated module 5, which allows the modular furnace to continue to extend in a direction parallel to the direction of the first sidewall 3.

[0046] A fourth self-supporting prefabricated module 5 is then applied to close the modular furnace 10 in a loop, together with other associated simple modules 10, at the first self-supporting prefabricated module 5.

[0047] Each module of the plurality of prefabricated modules 10 comprises connecting means 6, preferably quick connect, which realize the structural connection

with one or more adjacent simple modules 10.

[0048] As mentioned, the plurality of modules 10 are connected to form at least one closed loop 50 (fig. 1) starting at one of the at least two sidewalls 3, 4, and terminating at the other of the at least two sidewalls 3, 4.

[0049] The roof 60 is shown, for example, in Figure 1. The roof 60 can comprise several prefabricated, pre-assembled modules. In other words, the roof 60 can be assembled before being mounted on the loop 50.

[0050] The vertical extension of the modular furnace 100 is on superimposed loops 50.

[0051] In the embodiment of Figure 1, the surface area of the modules 10 forming the base loop, i.e. the one in contact with the ground, is greater than the surface area of the modules 10 forming the loop above the base loop. Such sizing facilitates the installation of the upper loops. Preferably, the area of the simple modules 10 of an upper loop is less than the area of the simple modules 10 of the lower loop. An upper loop preferably comprises self-supporting prefabricated modules 5, possibly smaller than the self-supporting prefabricated modules 5 of the lower floor. However, there are embodiments in which an upper loop is formed only by simple modules 10.

[0052] A plurality of closed loops 50 are superimposed on each other. Each closed loop 50 is structurally connected to an upper closed loop 50 or to the roof 60 by means of structural connecting means 6.

[0053] Structural connecting means 6 are, therefore, used both for the structural connection of the modules 5, 10 of a loop and for the structural connection between loops. Figure 6 and Figure 8 depict the connecting means 6 according to an embodiment, and in particular a quick-release nut (Fig. 8) intended to partially and immovably enter a seat or bushing located on a side profile of a first module 5, 6 and intended to enter, on the other side, in a removable manner, a seat or bushing located on the side profile of a second module 5, 6 intended for connection with the first module.

[0054] In one embodiment, the insulating panel 2 is made of ceramic fibre.

[0055] The applicant came up with a particularly advantageous geometry for the insulating panel. The sidewalls of the modules 5, 10, in particular, have the perimeter surfaces of the insulating panel 2 projecting by a predefined amount S. For example, the projection is between 5 and 10 mm.

[0056] Such geometry improves the insulation and thermal connection of the modular furnace. In fact, due to the projection of the insulating panel, the vertical and horizontal superposition of the sides of two modules 5, 10 results in direct contact between the surfaces of the insulating panels 2. Furthermore, the weight of an upper module 5, 10 compresses the corresponding insulating panel 2 against the insulating panel of a lower module 5, 10, preventing air infiltration, and thus increasing the thermal insulation of the modular furnace 100. Even more preferably, the projection is between 1 and 3 mm and, in use, the weight of the upper module 5, 10 compresses

the corresponding insulating panel 2 against the insulating panel of the lower module 5, 10 to the point of partially deforming the insulating panel 2 and bringing the remaining structure of the module 5, 10 into contact.

[0057] This structure is metallic. Basically, the module 5, 10 is equipped with a metallic mounting body, provided with structural connecting means 6, in the form of a slab, above which the insulating panel 2 is mounted. The panel 2 completely covers the metal mounting body, and projects a few millimetres from it.

[0058] These measures are also adopted for the roof modules. Specifically, each of the roof modules comprises a plate (functionally corresponding to the sidewall 10a of the module 10) and is connected to an insulating panel 2, e.g. made of ceramic fibre. The geometry and size of the insulating panel 2 is such that it projects to a predetermined extent from the plate. For example, the projection is between 5 and 10 mm. Such geometry improves the insulation and thermal connection of the modular furnace roof. The projection of a first insulating panel 2 from the plate allows direct contact of the first insulating panel with a second insulating panel of another plate. In addition, the projection of a perimeter insulating panel 2 of the roof, located at the side walls of the furnace, relative to the respective plate, allows a direct contact of the perimeter insulating panel 2 with an insulating panel 2 of a sidewall 3, 4, or 10a of the prefabricated modules 5 or 10. Furthermore, the weight of a roof module compresses the insulating panel 2 against the insulating panel of a module 5, 10, again preventing infiltration or loss of air and heat, and thus increasing the thermal insulation of the modular furnace 100. Again, preferably, the projection is between 1 and 3 mm and, in use, the weight of the roof module compresses the corresponding insulating panel 2 against the insulating panel 2 of the lower module 5, 10 to the point of partially deforming the insulating panel 2 and bringing the remaining structure of the module 5, 10 into contact with the roof module plate, which is preferably metallic. The roof 60 is preferably provided with a re-closable undefined area opening. The re-closable opening allows the insertion and extraction of the article even during article treatment cycles. In one embodiment, the opening can also be the same size as the top loop of the modular furnace. Therefore, the removal of the article does not require side doors. Figure 9 schematically depicts a modular furnace with an opening on the roof 60 and a closure 70 of the opening. The article 2000 is inserted and extracted from the opening on the roof.

[0059] A base (not shown) can be formed on the bottom of the modular furnace 100 by means of a plurality of prefabricated modules 10. The base is located underneath the lower loop 50 of the modular furnace 100, and is preferably removable to provide access to, for example, an underlying cooling tank.

[0060] One or more prefabricated modules comprises a connection point for a heating means, preferably a burner, intended to introduce heat from the outside of the

modular furnace, e.g. for combustion of natural gas or LPG or mixtures of natural gas and hydrogen. The connection point is preferably located on a lower loop, but there is nothing to prevent heating units also being installed on an upper loop, at higher heights.

[0061] The modules 5, 10 are also provided with anchor plates, as shown in figure 5. Anchor plates can serve a variety of purposes, including, for example, the attachment of accessories such as safety walkways, balconies or supports for overhead combustion systems, or safety devices to secure the module to the ground and prevent it from moving even in strong winds. Basically, the plates are fixed to the outer surface of the module, e.g. at an upper and a lower side of the module, possibly also at intermediate positions along the vertical between the two sides. The plates can be provided with multiple holes, e.g. four holes at the corners of a square plate, and a central hole with a larger diameter than the other holes. Multiple plates are located on the upper and lower sides. An attachment part of the accessory can be accommodated in the larger diameter hole and fastening means of the accessory can abut in the smaller diameter holes of the plate and respective holes of the accessory.

[0062] The method for the heat treatment of an article according to the present invention, e.g. a structural article, a pipeline, a heat exchanger, in particular a post-weld heat treatment (PWHT) of a large article intended for use, for example, in a chemical or oil plant, comprising the steps of:

assembling a plurality of prefabricated modules 10 on-site, around or in the vicinity of the article, each of the plurality of prefabricated modules 10 comprising at least one sidewall 10a and an insulating panel 2 intended to remain on the inside of the modular furnace 100 during the heat treatment,

the assembling step comprising, initially, placing in position at least one module 5 of the plurality of prefabricated modules 10 comprising at least two integrated sidewalls 3, 4 extending relative to each other at a predefined angular distance and being provided with a supporting base 3a, 4a from which the sidewalls 3, 4 vertically extend,

forming the remainder of the modular furnace starting with said at least one module, by means of structural connection of further modules of the plurality of prefabricated modules 10, connecting means 6 being provided for performing the structural connection together with one or more adjacent modules 10,

the plurality of modules (10) is connected together to form at least one closed loop 50 which starts from one of the at least two integrated sidewalls 3, 4 and terminates in the other one of said at least two integrated sidewalls 3, 4,

closing the loop 50 by means of at least one of the prefabricated modules 60, also known as roof 60, the roof 50 being structurally connected on top of the loop 50, thus defining a closed receiving space for heat treatment of the article.

[0063] The article can be inserted into the modular furnace by means of a closable opening on the roof 60 or by means of an opening obtained through the complete removal of the roof 60 and series of loops 50. Preferably, the re-closable opening is closed by an integral lid 60 or subsets which can be mounted on the article, and the step of inserting the article through the opening also performs the simultaneous closure of the modular furnace.

Claims

1. Modular furnace (100) for the heat treatment of structural articles, piping, heat exchangers, or for the post weld heat treatment (PWHT) of large-size articles, comprising

a plurality of prefabricated modules (10) intended to be assembled in order to form the modular furnace (100) around or in the vicinity of the article, avoiding displacement of the article on wheels, each of the plurality of prefabricated modules (10) comprising at least one sidewall (10a) and an insulating panel (2) intended to remain on the inside of the modular furnace (100), at least one module (5) of the plurality of prefabricated modules (10) comprising at least two integrated sidewalls (3, 4) extending relative to each other at a predefined angular distance and being provided with a supporting base (3a, 4a) from which the at least two integrated sidewalls (3, 4) vertically extend, each module of the plurality of prefabricated modules (10) comprising connecting means (6) for realizing the structural connection with one or more adjacent modules (10), and said plurality of modules (10) being connected together to form at least one closed structure (50) which starts from one of said at least two sidewalls (3, 4) and terminates in the other one of said at least two sidewalls (3, 4), at least one of said prefabricated modules (60), also said roof (60), being structurally connected on top of the at least one closed structure (50), thus defining a closed space for receiving the article, **characterized by** comprising a plurality of symmetrical or asymmetrical closed structure (50) arranged on top of each other, each closed structure (50) being structurally connected together with a closed structure (50) arranged on top of that, or with the roof (60), by means of the structural connecting means (6).

2. Modular furnace according to claim 1, **characterized in that** four modules (5) each comprising two integrated sidewalls (3, 4) extending relative to each other at an angular distance of 90° are arranged at the corners of the at least one closed structure (50), said structure having a quadrangular or rectangular shape.
3. Modular furnace according to claim 1, **characterized in that** the roof (60) comprises a plurality of preassembled prefabricated modules (10).
4. Modular furnace according to claim 1, **characterized in that** the insulating panel (2) is made of ceramic fibre.
5. Modular furnace according to claim 4, **characterized in that** the sidewall of a module (10) has a surface area smaller than a surface of the insulating panel (2), and the insulating panel (2) projects by a predefined amount (S) ranging between 1 and 10 mm from at least one side of the sidewall of the module (10).
6. Modular furnace according to claim 1, **characterized in that** the roof (6) is provided with a re-closable opening for inserting and extracting the article.
7. Modular furnace according to claim 1, **characterized in that** the roof (60) is removable integrally from an uppermost closed structure (50) among said plurality of closed structure (50).
8. Modular furnace according to claim 1, **characterized in that** the closed structure (50) does not have doors for inserting the article.
9. Modular furnace according to claim 1, **characterized by** comprising a base formed by a plurality of prefabricated modules, situated underneath the structure (50), said base being removable in order to provide access to an underlying cooling tank or empty chamber.
10. Modular furnace according to claim 1, **characterized in that** at least one of the prefabricated modules comprises a connection point for a heating means, preferably a burner, intended to introduce heat from the outside of the modular furnace, for combustion of natural gas or LPG or mixtures of natural gas and hydrogen, said connection point being on a closed structure (50) of said at least one structure (50).
11. Method for heat treatment of structural articles, piping, heat exchangers, or for post weld heat treatment (PWHT) of large-size articles, comprising the following steps:

assembling a plurality of prefabricated modules (10) on-site, around or in the vicinity of the article, each of the plurality of prefabricated modules (10) comprising at least one sidewall (10a) and an insulating panel (2) intended to remain on the inside of the modular furnace (100) during the heat treatment; 5

said assembling step comprising, initially, placing in position at least one module (5) of the plurality of prefabricated modules (10) comprising at least two integrated sidewalls (3, 4) extending relative to each other at a predefined angular distance and being provided with a supporting base (3a, 4a) from which the sidewalls (3, 4) vertically extend; 10 15

forming the remainder of the modular furnace starting with said at least one module (5), by means of structural connection of further modules of the plurality of prefabricated modules (10), connecting means (6) being provided for performing the structural connection together with one or more adjacent modules (10); 20

said plurality of modules (10) being connected together to form at least one closed structure (5) which starts from one of said at least two integrated sidewalls (3, 4) and terminates in the other one of said at least two integrated sidewalls (3, 4); 25

closing the structure (50) by means of at least one of said prefabricated modules (60), also said roof (60), the roof (60) being structurally connected on top of the closed structure (50), thus defining a closed receiving space for heat treatment of the article, **characterized by** inserting the article into the modular furnace via a re-closable opening on the roof (60) or via an opening obtained by means of integral removal of the roof (60) of the closed structure (50). 30 35

12. Heat treatment method according to claim 11, **characterized in that** said re-closable opening is closed by a lid which can be mounted on the article and **in that** the step of inserting the article through the opening also performs closure of the modular furnace. 40 45

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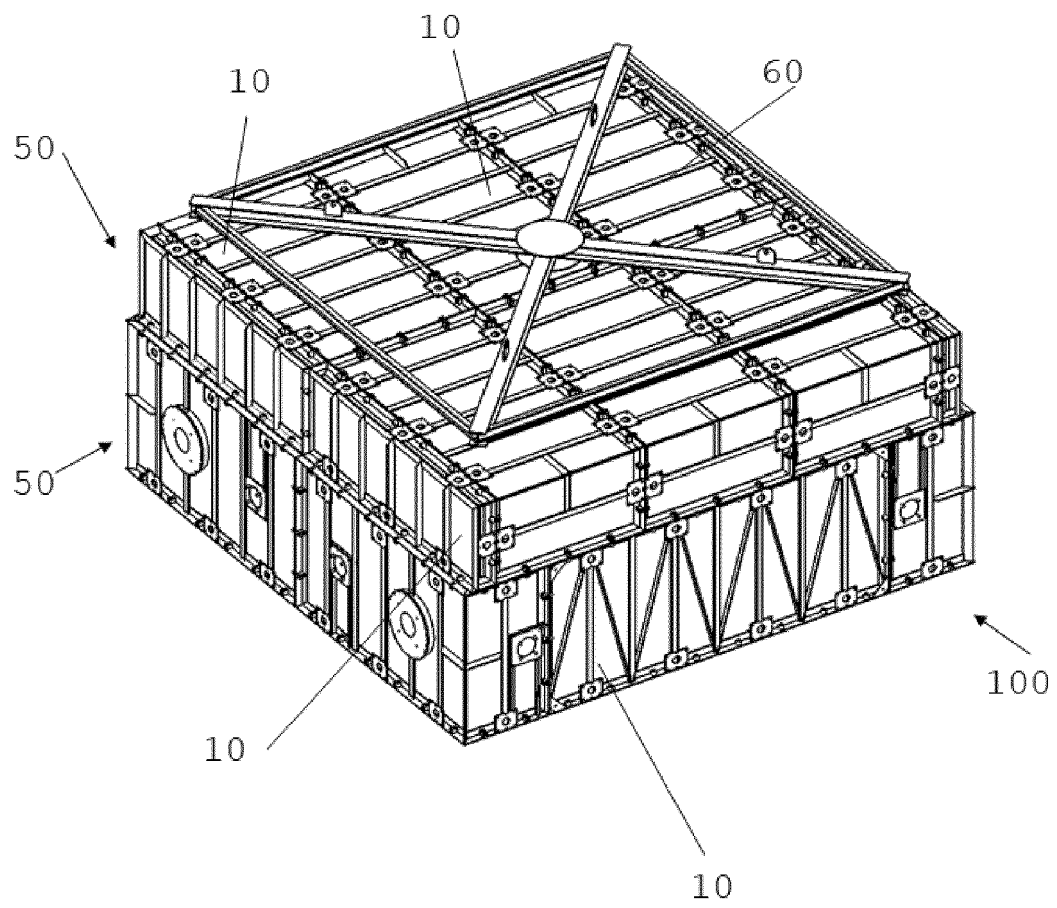


Fig. 1

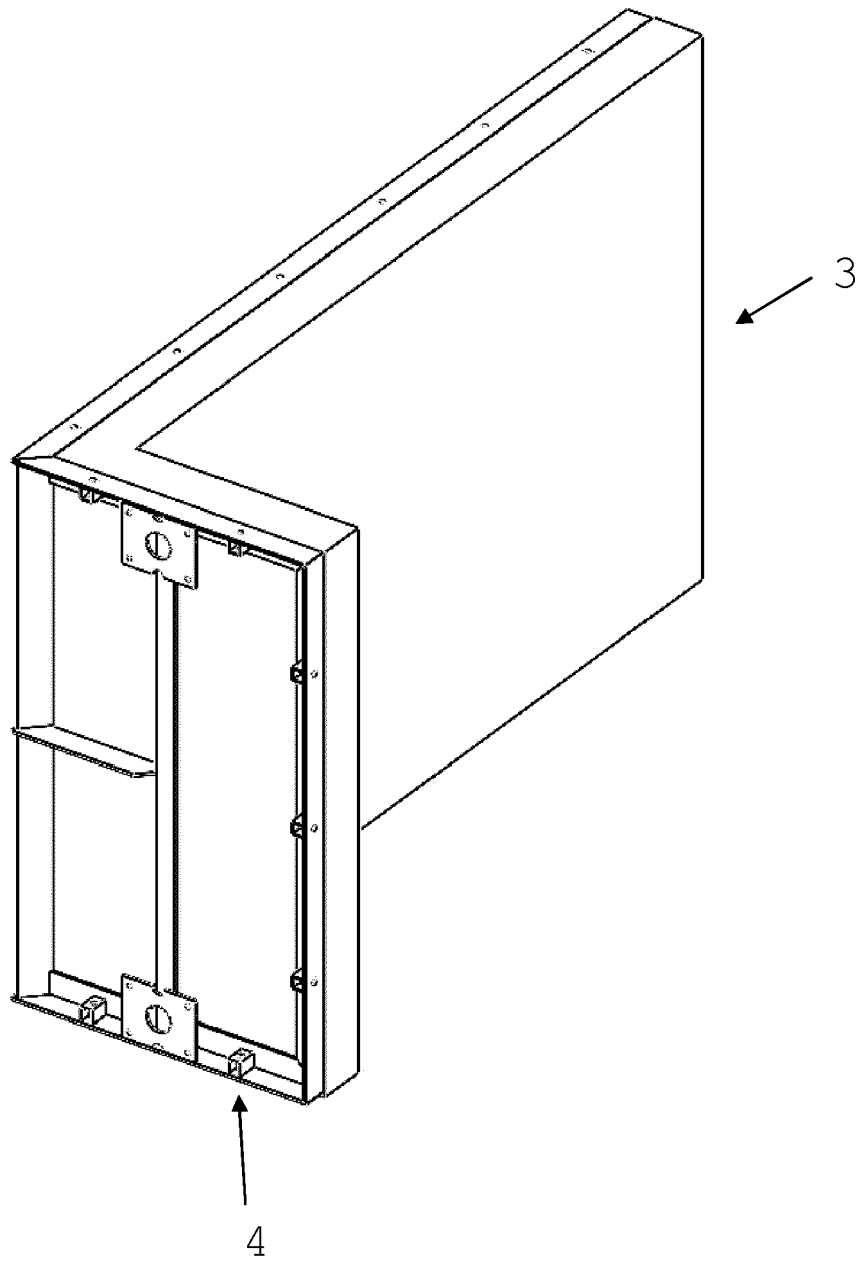


Fig. 2

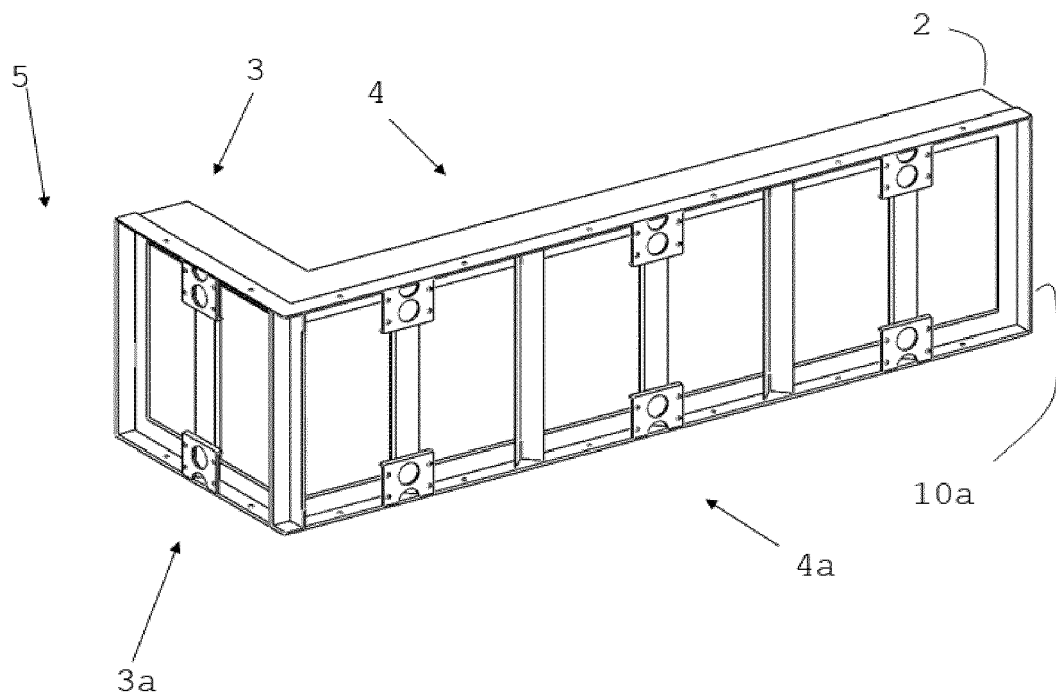
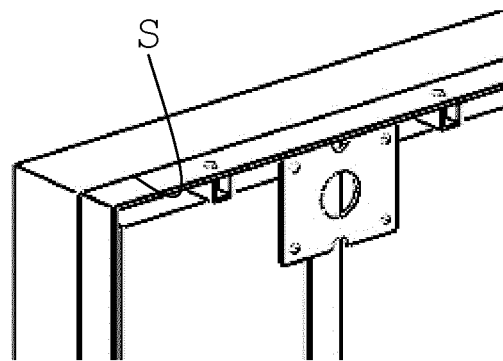
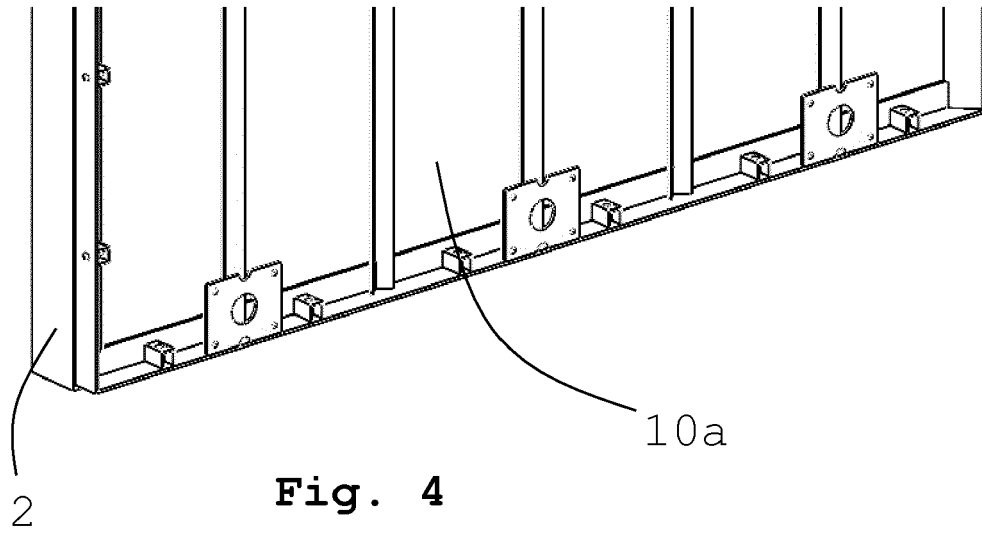


Fig. 3



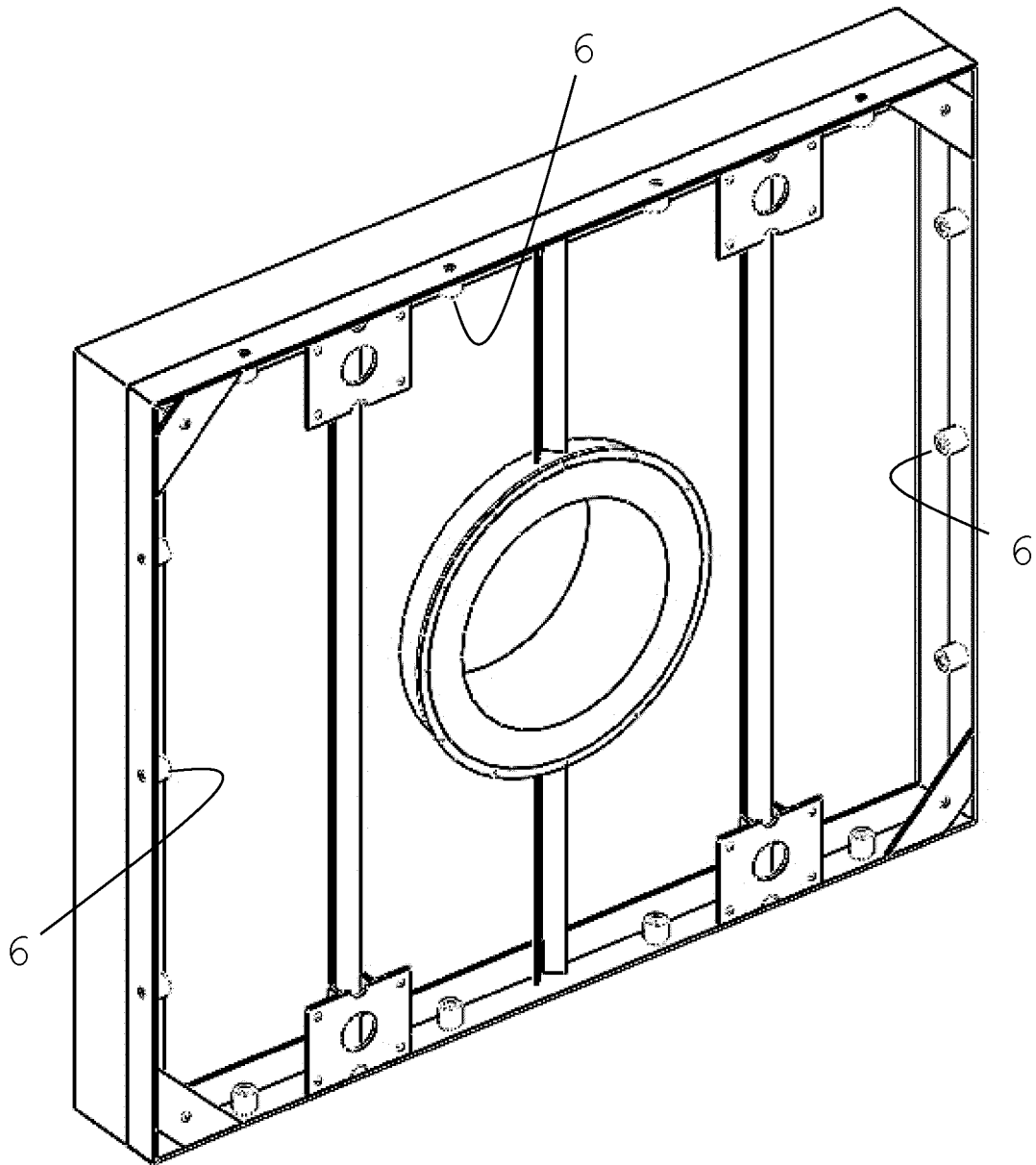


Fig. 6

Fig. 7

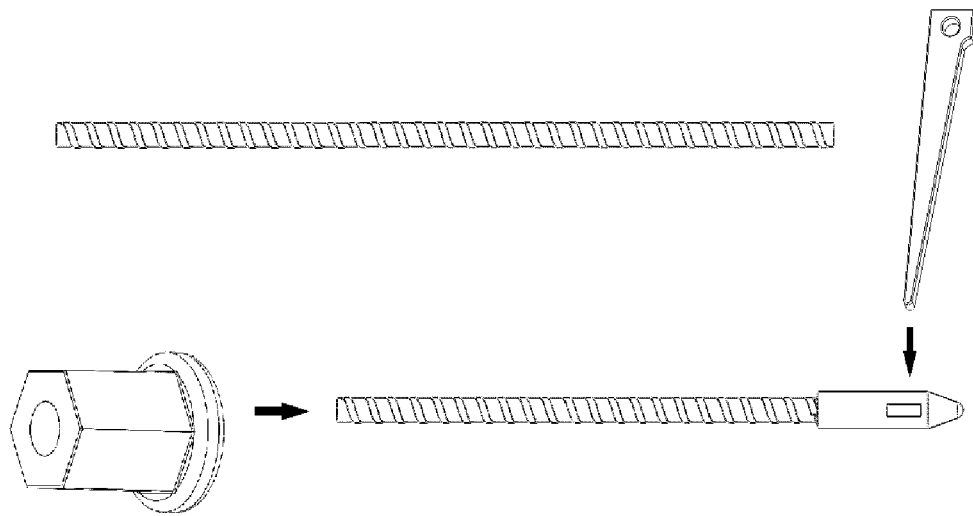
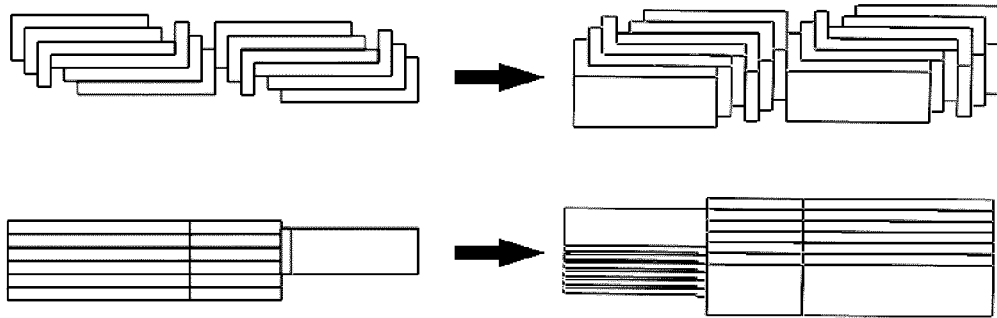


Fig. 8

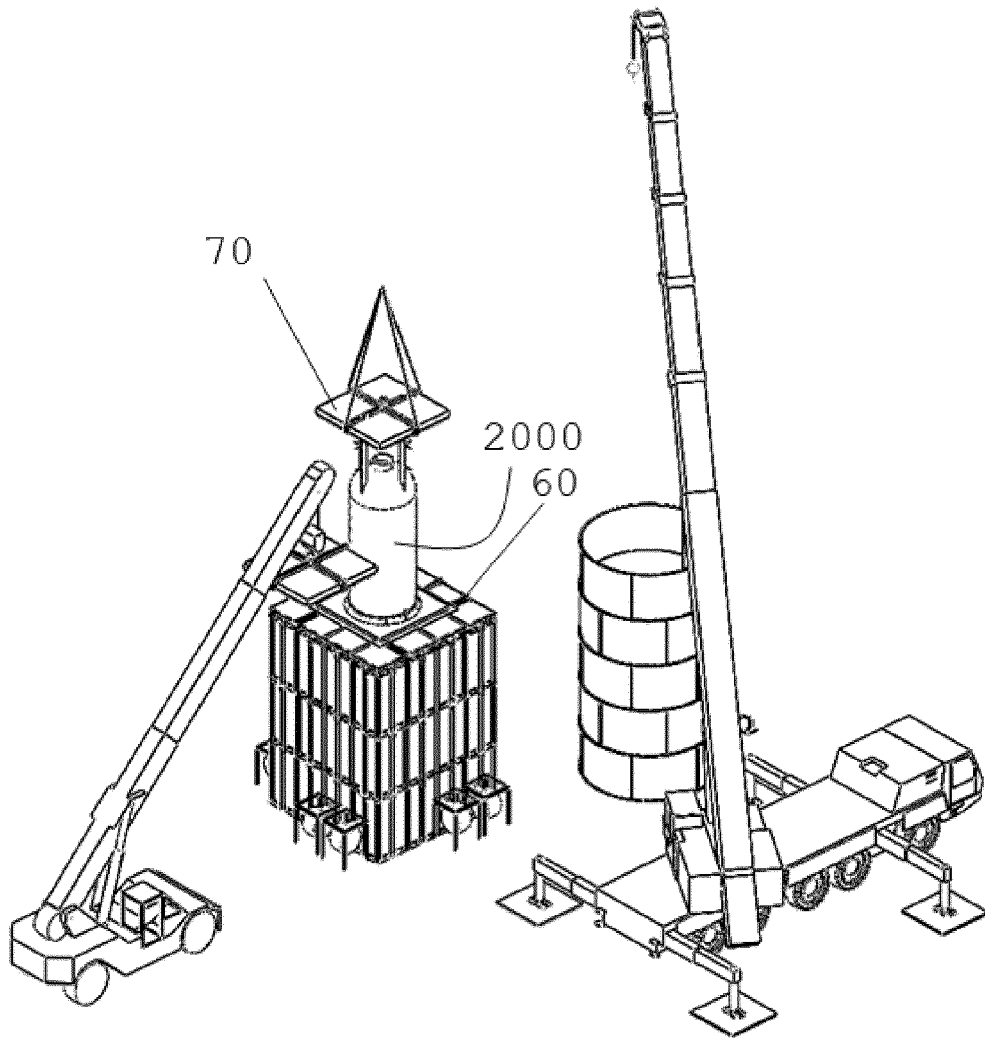


Fig. 9



EUROPEAN SEARCH REPORT

Application Number

EP 22 18 6528

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Place of search Munich		Date of completion of the search 26 January 2023	Examiner Gavriliu, Alexandru
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