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(54) **A RESIDENTIAL HOUSING UNIT FORMED AS AN ISO CONTAINER**

(57) A residential housing unit formed as an ISO container having a longitudinal extension, a transverse extension and a height extension and having boundaries defining at least part of an inner volume of the ISO container, the residential housing unit comprising: a bottom defining a lower boundary of the ISO container; a top defining an upper boundary of the ISO container; at least one end part defining an end boundary of the ISO container; at least a first longitudinal side wall defining a side

boundary of the ISO container; where at least one of the boundaries of the ISO container comprises a multi-layered construction, where the multi-layered construction comprises: a first layer of steel having a first inner surface and a first outer surface; a second layer comprising concrete having a second inner surface and a second outer surface, wherein the second outer surface of the second layer faces the first inner surface of the first layer.

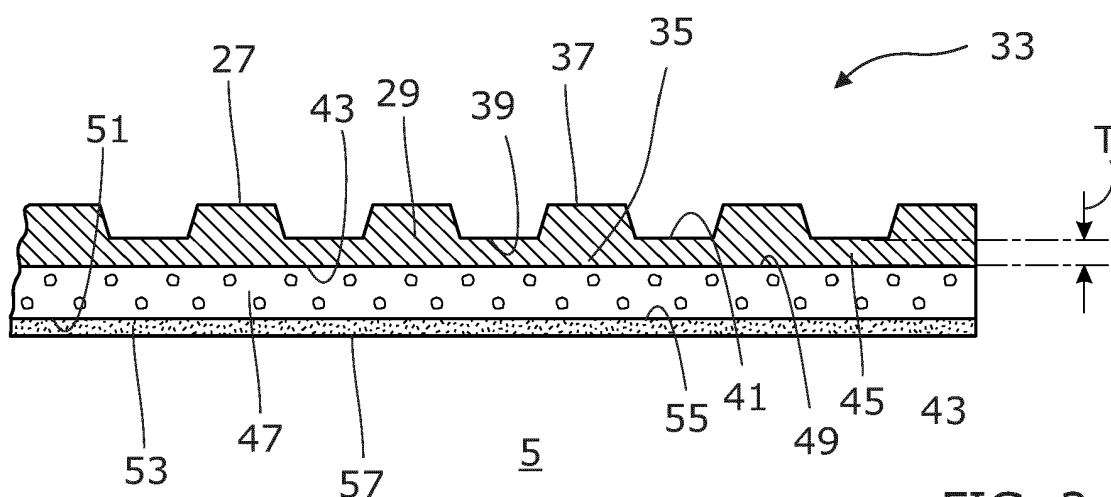


FIG. 3

Description

TECHNICAL FIELD

[0001] A residential housing unit formed as an ISO container having a longitudinal extension, a transverse extension and a height extension and having boundaries defining at least part of an inner volume of the ISO container.

BACKGROUND

[0002] Container residences or residential construction based on units having the same dimensions as ISO containers has been known for many years. By residential housing unit is meant a unit where people may take longer stay i.e. an apartment, a hotel room, an office, or a shop. When people take longer stay both safety and environmental issues need to be addressed. It has been attempted to use ISO containers for residential construction, because the mass production of containers makes them a cheap provision of a protected volume, which in some locations can be used directly for residences.

[0003] Furthermore, for their intended application, i.e. the carriage of goods, containers have a limited lifetime, which after use, however, does not make them unsuitable for other purposes where a protected volume is desired. Due to the considerable number of containers and their limited lifetime, used containers have also been very expensive to purchase.

[0004] Containers have thus been used for residences in a wide variety of ways throughout the world. In many regions of the world, there are very little or no real regulatory requirements for residences. This means that, as a point of departure, the predominant reason for a specific construction being made based on containers is either a specific desire for aesthetics and/or functionality, or that construction costs must be kept low. This has resulted in a wide range of creative uses for containers for residences. Such container units may assist city planners or municipalities to erect temporary or permanent housing options, that may be erected quickly in case of a pressing need for housing options in a specific location. The units may be prefabricated, or at least partly prefabricated, so that when the container units have been erected, there is minimal requirements for completion.

[0005] However, in some countries there are strict requirements for residential units, meaning that a wide range of factors affecting the construction must be taken into consideration during erection. These are factors such as insulation, fire protection, daylight, availability, indoor climate etc. Furthermore, there are e.g. specific regulations on the strength of the container unit, in order to ensure that a container unit is a safe living space for people. In addition, there are regulation concerning sound mitigation that also needs to be taken into account.

[0006] Solutions for such container units may eg. be seen in in DK 2018 70139 or EP application no.

20198423, which relate to a specific construction details that allow container units to fulfil governmental requirements with regards to e.g. strength and fire protection. However, when working with container units, that often are based on the steel constructions of a ISO container unit, there are a number of factors that can influence the fire protection of the unit, where conventional fire protection may include the introduction of fire retardant material such as plaster walls, thick layers of mineral wool, or other means, where the fire retardant material does not influence the strength of the ISO container in any significant way, but may primarily take up some of the internal volume of the ISO container, and thereby reduce the living space inside the container.

[0007] Thus, there is a need to improve the structure of an ISO container, where the strength of the container may be improved and also improving the fire resistance of the ISO container, without sacrificing a significant volume of living area inside the ISO container.

DESCRIPTION

[0008] In accordance with the invention there is provided a residential housing unit formed as an ISO container having a longitudinal extension, a transverse extension and a height extension and having boundaries defining at least part of an inner volume of the ISO container, the residential housing unit comprising: a bottom defining a lower boundary of the ISO container; a top defining an upper boundary of the ISO container; at least one end part defining an end boundary of the ISO container; at least a first longitudinal side wall defining a side boundary of the ISO container; where at least one of the boundaries of the ISO container comprises a multi-layered construction, where the multi-layered construction comprises: a first layer of steel having a first inner surface and a first outer surface; a second layer comprising concrete having a second inner surface and a second outer surface, wherein the second outer surface of the second layer faces the first inner surface of the first layer.

[0009] The residential housing units may be in the form of ISO containers, i.e. having outer dimensions that are in compliance with the ISO standard of containers. The containers may e.g. be 40-foot containers, where a plurality of containers may be used to create an apartment complex, using the ISO containers as separate units. Furthermore, a plurality of containers may be joined together, e.g. along its longitudinal extension, to create a housing unit that has an increased inner volume, compared to a single unit. Thus, if two units are joined together, the inner volume may be close to double the inner volume of a single unit. The same may be stated about three units, where the inner volume may be triple that of a single unit.

[0010] One residential housing unit, i.e. one ISO container sized unit, may have boundaries to all sides, where the sides, bottom, top and ends of the units may cut off the inner volume of the unit from the outside of the unit.

However, if a plurality of units are joined together, it may be understood that a boundary of the plurality of units may be seen as a boundary that borders or limits the inner volume of the housing unit from the outside. Thus, if two ISO containers are joined together along their longitudinal extension, the joint housing unit will have a first side wall and a second side wall, where the first side wall may be part of the first ISO container, while the second side wall may be part of the second ISO container. However, as the two units are joined together, the housing unit as a whole has an inner volume which may have side boundaries that are defined by opposing side walls of the adjoined ISO containers.

[0011] By providing residential housing units having a multi-layered construction having a first layer of steel and a second layer of concrete, it is possible to increase the strength and the structural integrity of the steel in the first layer, where the combined structural integrity of the multi-layered construction can fulfil the fire safety requirements set by e.g. a municipality or government agency for residential housing.

[0012] By providing a multi-layered structure, where the second layer is positioned in the inside of the steel layer, i.e. where the second layer faces the inner volume of the container, it is possible to maintain the outer dimensions of the ISO container when the residential housing is to be erected. Thus, the outer dimensions of the ISO container will not alter, even though a concrete layer has been positioned on the inner surface, which means that it is easier for construction workers to calculate and construct the framing, base, or any other structural elements that would require the ISO units to be used for e.g. a multi-storey housing construction.

[0013] In current housing units using ISO containers as housing units, the ISO containers may be provided with a steel skeleton inside the ISO container to maintain the structural integrity of the ISO container. However, by providing a housing unit in accordance with the current description, a boundary of the housing unit may be provided with a multi-layered structure, where the layer of concrete may replace some of the parts of the steel skeleton or all of the parts of a steel skeleton, and thereby improve the utilization of the inner volume of the ISO container for use as a living volume for residential housing. The boundary of the housing unit may in one embodiment may have a multi-layered construction where the inner surface of the concrete layer may define the inner volume of the housing unit.

[0014] It is not necessary that the first layer of the multi-layered construction is the outermost layer of the boundary. The outer surface of the steel layer may be painted, coated or applied with a layer which changes the aesthetic look of the steel layer. The steel layer may be undulated on the outer surface, where a further layer may be added on the outside create a straight or planar layer on the outside of the ISO container.

[0015] Within the understanding of the present invention, the term boundary may mean any two-dimensional

area that extends from one part of an ISO container to another part of an ISO container. The boundary may be a side wall, end wall, bottom or top of a ISO container. The boundary may include the joining of two boundaries, but should not be seen as beams, pillars or longitudinal members that may create the skeletal frame of the ISO container, e.g. where they are positioned in the edges of the container. A boundary may be seen as a two-dimensional area of the side wall, end part, top part and/or the bottom part of the ISO container.

[0016] Within the understanding of the present invention, the term inner surface or outer surface may be understood as a surface facing the inner volume of the ISO container or a surface facing the outside of the ISO container. The inner volume may comprise a central point, where the central point may be positioned centrally between the end points, the side walls and/or the bottom and the top of the ISO container. Thus, the inner surface of a layer may be seen as facing the central point, while the outer surface of a layer may be seen as facing away from the central point.

[0017] In one or more exemplary embodiments, the layer of concrete may be between 30 and 400 mm on the inner side of the first layer. In order to fulfil the requirements of the fire protection standard R60 in Denmark, the concrete layer may be between from 50 to 60 mm and thicker, to fulfil requirements regarding an exposure of fire from the outside.

[0018] In one or more exemplary embodiments the first layer may be the outermost layer of the ISO container, and/or where any subsequent layer is arranged in a direction facing an inner facing side of the boundary. This means that the first layer of steel, which may be seen as the outer layer of the ISO container may be maintained as the outermost layer of the residential housing unit, creating an exoskeleton of the residential housing, as the subsequent layers are added to the inside of the first layer, where the subsequent layers may increase the strength of the first layer and/or create a combined multi-layered boundary and/or may introduced functional attributes to the residential housing, such as insulation, vapour barriers or other suitable and/or desired functionalities of the layers.

[0019] In one or more exemplary embodiments the at least one boundaries may further comprise a third layer and/or a subsequent layer, where the third layer may comprise one or more of: insulation layer, vapor barrier layer, plaster layer, metal structure, electrical installation, radiant heating element, decorative layer. The third layer may be positioned on the inner surface of the second layer, where the outer surface of the third layer may face the inner surface of the second layer. The addition of a third layer may create a multi-layered construction comprising at least three layers, or when subsequent layers are added to the third layer, the multi-layered construction may comprise four or more layers.

[0020] The third layer may therefore add to the thickness of the multi-layered construction, where the third

layer may be added to add functionality to the ISO container. Thus, the third layer may be an insulation layer, which may ensure that thermal energy which is in the surrounding environment is prevented or slowed down from entering the inner volume of the housing unit. This may e.g. be the case when the surrounding environment is hotter or colder than the inner volume of the housing unit. Similarly the third layer may be a combination of functionalities, where e.g. electrical installations or metal structures may be included in the third layer. Thus the third layer may be an insulation layer as well as a decorative layer, vapour barrier or radiant heating.

[0021] In one or more exemplary embodiments the second layer may comprise a reinforcement structure. Concrete has a high compressive strength but may be lacking in shear and tensional strength. The reinforcement structure may e.g. be utilized to increase the shear strength and/or the tension strength of the concrete layer, in order to ensure that any form of deformation of the layer will not damage the concrete layer.

[0022] In one or more exemplary embodiments the reinforcement structure may be one or more of: reinforcing steel, reinforcing bar, steel fibres, glass fibres, synthetic fibres, natural fibres, or other types of known methods for increasing the structural integrity of the concrete layer.

[0023] The reinforcement structure may e.g. be rebar (short for reinforcing bar), known when used as reinforcing steel or reinforcement steel, and may be a steel bar or mesh of steel wires used as a tension device in reinforced concrete to strengthen and aid the concrete under tension. Concrete is strong under compression, but has weak tensile strength. The reinforcement structure may significantly increase the tensile strength of the structure. The surface of the reinforcement structure may be often provided with ribs, lugs or indentations to promote a better bond with the concrete and reduce the risk of slippage.

[0024] The reinforcement structure may be in the form of fibre-reinforced concrete (FRC) which is fibrous material that is introduced into the concrete increases its structural integrity. It contains short discrete fibres that are uniformly distributed and randomly oriented. Fibres include steel fibres, glass fibres, synthetic fibres and natural fibres - each of which lend varying properties to the concrete. In addition, the character of fibre-reinforced concrete may change with varying concretes, fibre materials, geometries, distribution, orientation, and densities.

[0025] In one or more exemplary embodiments the reinforcement structure in the second layer may be connected with the first layer and/or connected with the first inner surface of the first layer. When the concrete has been applied as the second layer, having the reinforcement structure being attached to the first layer, the reinforcement structure may be utilized to increase the retention between the first layer and the second layer, in addition to increasing the strength of the second layer.

[0026] In one or more exemplary embodiments the multi-layered construction may comprise at least 50% of

an area defined by at least two of the longitudinal extension, transverse extension or the height extension of the ISO container. The area defined by at least two of the longitudinal extension, transverse extension and the height extension may be seen as the area of the boundary, where e.g. the area of the side wall may be seen as product of the longitudinal extension and the height extension, and the area of the top or bottom boundaries may be seen as the product of the longitudinal extension and the transverse extension, and the area of the end parts may be seen as the product of the height extension and the transverse extension of the ISO container and/or the housing unit. The wall and/or the end parts may be provided with e.g. doors and/or windows, where the doors and the windows may reduce the area of the multi-layered boundary of the ISO container. Thus, it is to be understood that the multi-layered construction may be seen as the majority of a single boundary.

[0027] The concrete layer may extend from one peripheral edge of a boundary to an opposed peripheral edge of the boundary. Thus, the multi-layered construction may extend along most of the area of the boundary. When the ISO container has a structural reinforcement element such as a beam, pillar or longitudinal member, it may be understood that the multi-layered construction may extend from the border of the reinforcement element to a peripheral edge and/or an opposing reinforcement element.

[0028] Furthermore, the inner corners of an ISO container may also be provided with a multi-layered construction, where a structural reinforcement element may define the first layer and that a concrete layer is applied on the inner surface of the reinforcement element.

[0029] In one or more exemplary embodiments the second layer may comprise insulation. The insulation may be part of the second layer and/or the concrete of the second layer. By introducing insulation into the second layer, the need for a separate insulation layer may be reduced or eliminated, based on the building code requirements in a certain municipality and/or government. Thus, the second layer may provide a thermal insulation between the first layer and the inner volume of the container and/or housing unit.

[0030] In one or more exemplary embodiments the insulation may be mixed into the second layer and/or where the insulation may be cast into the second layer. The insulation may be mixed in particles into the second layer, where the insulation particles may be mixed into the fluid concrete prior to curing. The fluid concrete may be applied to the first layer, and upon curing the insulation particles may reduce the heat transfer from the outer surface of the second layer to the inner surface of the second layer. The insulation may further be cast into the second layer, where insulation may be introduced into fluid concrete, or fluid concrete introduced into parts defined by insulation. Thus, the insulation may be part of the second layer, and may reduce heat transfer across the second layer.

[0031] In one or more exemplary embodiments the boundary may comprise a through-going opening, where the opening may extend through the first and the second layer, and/or a subsequent layer. The through-going opening may be in the form of e.g. a window, a door, a venting opening, or any kind of opening that may be advantageous to a housing unit. The through-going opening may extend through the first layer, second layer and/or any subsequent layer on the boundary.

[0032] In one or more exemplary embodiments a peripheral region of the through-going opening may be reinforced. The through-going opening may create a reduction in the structural integrity of the boundary of the ISO container and/or the housing unit. Therefore, it may be necessary to add a structural element into the periphery of the opening to maintain or regain the structural integrity of the boundary. The reinforcement element may be positioned in a part of the periphery of the through-going opening or may be positioned in the entire periphery of the through-going opening. As an example, if a window has been cut or formed in the first and/or second layer of the boundary, it may be necessary to provide a reinforcement frame in the opening, in order to increase the structural integrity of the boundary, which might have been lost by the positioning of the opening. The reinforcement element may be in the form of a steel beam, or may further be in the form of a further multi-layered structure, where the multi-layered structure may be integral with the multi-layered structure of the boundary. Thus, the steel of the first layer may extend into the periphery of the opening, by e.g. an inward bending or inward flange and where a second layer of concrete may be applied to the inner surface of the flange to increase the structural integrity of the bending or the flange.

[0033] In one embodiment the second layer may comprise one or more flanges cast into the concrete material of the second layer. The flanges may extend in a direction inwards towards the inner volume of the housing unit/ISO container, and/or may extend from a top part of the unit towards and/or to a bottom part of the unit.

[0034] In accordance with the invention there is provided a method of manufacturing a residential housing unit, where the method comprises the steps of: providing an ISO container having: a bottom defining a lower boundary of the ISO container; a top defining an upper boundary of the ISO container; at least one end part defining an end boundary of the ISO container; at least a first longitudinal side wall defining a side boundary of the ISO container; where at least one of the boundaries has a first layer of steel having a first inner surface and a first outer surface; and providing a second layer comprising concrete where a second outer surface of the second layer faces the first inner surface of the first layer of steel. The method may be applied to manufacture a housing unit or a boundary as defined in the aforementioned or following disclosure.

[0035] The ISO container may be provided in the form of a prefabricated unit, where the ISO container compris-

es a first layer of steel in one or more boundaries, and where the ISO container may comprise constructional elements to improve the strength of the ISO container, compared to a normal ISO container. The inner surface of the first layer may be prepared so that a layer of concrete may be applied to the inner surface. The preparation may e.g. be in the form of a surface treatment to increase retention between the first layer and the second layer, or the preparation may be in the form of attaching a reinforcement structure to the inner surface or adjacent to the first surface. Then a layer of concrete may be applied to the inner surface of the first layer, where the layer may be applied in one or more iterations, where each iteration may increase the size, thickness and/or the volume of the layer, and where the layer of concrete may be allowed to set between each iteration.

[0036] In one example, the concrete layer may be sprayed on the inner surface of the first layer, while the first layer may be in a vertical position, where the concrete may be applied using Shotcrete or sprayed concrete, which may be seen as is concrete or mortar conveyed through a hose and pneumatically projected at high velocity onto the inner surface. The concrete may typically be reinforced by conventional steel rods, steel mesh, or fibres.

[0037] Shotcrete may usually be seen as an all-inclusive term for both the wet-mix and dry-mix versions. Shotcrete is placed and compacted/consolidated at the same time, due to the force with which it is ejected from the nozzle. It can be sprayed onto any type or shape of surface, including vertical or overhead areas.

[0038] In one or more exemplary embodiments the second layer may be provided using an open volume casting and/or a closed volume casting. An open volume casting may e.g. be seen where gravity and/or tackiness of the concrete will allow the concrete to stay in its wanted position, where at least part of the concrete layer is open into its surroundings. Such techniques are often used to make concrete slabs. Alternatively, the concrete layer may be formed by closed volume casting, where the volume of the concrete is closed to all sides, and the concrete may e.g. be introduced via an opening in a closed cast. Thus it is the cast that defines the moulding volume of the concrete. When the concrete has set or cured, parts of the cast may be removed to expose the cured concrete.

[0039] In one or more exemplary embodiments the second layer may be provided on the first inner surface of the first layer or steel by positioning the first layer of steel and/or the first inner surface in a horizontal position and pouring the concrete in a fluid state onto the horizontal first inner surface. This solution may be done by providing a prefabricated ISO container, and identify which part of the boundaries is supposed to receive a layer of concrete. When this has been identified, the ISO container may be rotated into a position where the selected boundary is positioned in a horizontal position, where the two-dimensional plane of the boundary may

be in a substantially horizontal position. When this has occurred, the inner surface of the first layer may be prepared for receipt of a layer of concrete, by e.g. cleaning or surface treating the surface, and where the concrete layer may be poured onto the horizontal inner surface of the first layer, where gravity is utilized to hold the concrete in its position on top of the first layer. When the second layer has cured, the ISO container may be returned to its correct position, or to another position, should a second boundary be destined for a second layer of concrete.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040] The following is an explanation of exemplary embodiments with reference to the drawings, in which

Fig. 1 shows a perspective view of a housing unit in accordance with the present disclosure,

Fig. 2 shows a top sectional view of a housing unit,

Fig. 3 shows a sectional view of one embodiment of a boundary of a housing unit,

Fig. 4 shows a sectional view of one embodiment of a boundary of a housing unit,

Fig. 5 shows a sectional view of one embodiment of a boundary of a housing unit,

Fig. 6 shows a sectional view of a corner of a housing unit, and

Fig. 7 shows a graph of a performed test of heat transfer through a boundary at different thicknesses of concrete, and

Fig. 8 shows a sectional view of the test setup seen in Fig. 7.

DETAILED DESCRIPTION

[0041] Various exemplary embodiments and details are described hereinafter, with reference to the figures when relevant. It should be noted that the figures may or may not be drawn to scale and that elements of similar structures or functions are represented by like reference numerals throughout the figures. It should also be noted that the figures are only intended to facilitate the description of the embodiments. They are not intended as an exhaustive description of the disclosure or as a limitation on the scope of the disclosure. In addition, an illustrated embodiment needs not have all the aspects or advantages shown. An aspect or an advantage described in conjunction with a particular embodiment is not necessarily limited to that embodiment and can be practiced in any other embodiments even if not so illustrated, or if not so explicitly described.

[0042] Fig. 1 shows a residential housing 1, constructed from an ISO container 3, where the ISO container has a longitudinal extension A, a transverse extension B and a height extension C. The housing 1 comprises a bottom 5 defining a lower boundary of the housing 1 or ISO container 3, a top 7 defining an upper boundary of the housing 1/ISO container 3, a first end part 9 and a second end part 11 defining an end boundary of the housing 1/ISO container 3, and a first side wall 13 and a second side wall 15 (not seen in this view) defining a side boundary of the ISO container. The boundaries 5, 7, 9, 11, 13, 15 of the ISO container 3 and/or the housing 1 define an inner volume 17 of the housing 1, where the inner volume 17 may be seen as a living space 19 when the housing 1, ISO container 3 is used for residential housing.

[0043] Fig. 2 shows a sectional view, taken along a longitudinal extension and seen from above, of an ISO container 3, where the ISO container comprises a first side wall 13 and a second side wall 15 defining the side boundaries of the ISO container 3. The first side wall 13 and the second side wall 15 have an inner side 21 and an outer side 23, where the inner side 21 faces a central point D of the ISO container 3. The first side wall 13 and/or the second side wall 15 may define a boundary to the ISO container 3 (housing unit 1), and may be in the form of a multi-layered construction 25, having at least a first layer 27 and a second layer 29, and is shown in more detail in Fig. 3-5. The ISO container further comprises a bottom 5, as well as a first end part 9 and a second end part 11.

[0044] Fig. 2 further shows that the ISO container 3 comprises a plurality of frame elements 31, where the frame elements 31 are used to increase the structural integrity of the ISO container 3. The frame elements 31 may be seen as pillars 31, where the pillars may extend from a bottom part 5 of the container 3 to a top part 7 (seen in Fig. 1) of the container 3, providing a structural stability at the end parts 9 and 11 of the ISO container 3.

[0045] In the container shown in Fig. 2, the access and the daylight may be provided from the end parts 9, 11 of the container. This type of container may have boundaries that are provided with a multi-layered construction 27, 29 in a uniform manner, where the multi-layered construction covers the entire side walls 13, 15 of the container. This means that the second layer 29, which may be a layer having concrete, provides increased structural stability to the container 3, whilst the concrete layer 29 may also protect an insulation layer (not shown) which may be positioned on the inner surface 21 of the side wall, from fire. As the purpose of the second layer 29 is not only to protect the insulation layer (not shown) but also to provide structural stability, the layer may have a thickness, which may be provided with one or more reinforcement mesh(es), where the total thickness of the wall and/or boundary may be around 30 mm - 120 mm, or even thicker in environments where this may be required, up to 400 mm. In one embodiment the second layer may comprise a two reinforcement meshes posi-

tioned e.g. 25 mm from each side of the second layer. The reinforcement mesh may be made of steel bars e.g. having a diameter of 4 - 16 mm or 5 - 14 mm or 6 - 12mm or 7 - 10mm.

[0046] The static principle may therefore be that a self-bearing second layer 29 of concrete is positioned on the inner side of the steel layer 27. This second layer 29 may support on the bottom 5 of at least a part of the container 3 or the full length of the container 3.

[0047] In one embodiment the second layer may be carried on support structures 31 that are positioned in the corners of the container 3. The support structure 31 may be an integrated part of the second layer 29 i.e. made from concrete or the support structure 31 may be a steel column. An example of a window construction may be seen in Fig. 6 which that may be used in such a container in the end parts 9, 11.

[0048] Fig. 3 - 5 show a sectional view of a boundary 33 of a ISO container 3 e.g. shown in Fig. 1 (which may e.g. be one or more of the boundaries 5, 7, 9, 11, 13, 15 of Fig. 1), where the boundary 33 may be on any outward facing part of the ISO container 3, or may as in this example be part of the side wall 13, 15, of the ISO container as seen in Fig. 2. The reference numbers shown in Fig. 3, 4 or 5 may be identical for identical parts, and elements discussed in one figure may also be applied in another figure.

[0049] Fig. 3 shows a boundary 33, where the boundary is in form of a multi-layered structure 35, where the boundary has a first layer 27 which may be seen as a steel layer, a second layer 29, which may be seen as a concrete layer. The first layer 27 has an outer surface 37 and an inner surface 39, while the second layer 29 has an outer surface 41 and an inner surface 43. The outer surface 41 of the second layer 29 may have the same form as the inner surface 39 of the first layer 27, as the second layer 29 may be moulded or cast onto the inner surface 39 of the first layer 27. The outer surface 41 of the second layer 29 bonds to the inner surface 39 of the first layer 27, when the concrete of the second layer 29 cures.

[0050] When the second layer 29 is cured, the second layer provides an increased structural integrity to the first layer 27, so that the multi-layered structure 35 may provide sufficient structural integrity to maintain the shape of the ISO container (which the boundary 33 is a part of) e.g. in the event of a fire.

[0051] The thickness T of the second layer 29 may be seen as a minimal thickness of the second layer 29, where thicker parts 43 of the second layer 29 may have increased thickness relative to thinner parts 45. The thickness of the second layer 29 may e.g. be influenced by the shape of the first layer 27, where in this example the steel of the first layer 27 has an undulated shape. The undulated shape may comprise a number of open trapezoid shapes. Testing of the thickness of the second layer 29 may be seen in Fig. 7 and the corresponding description.

[0052] In this example seen in Fig. 3, the multi-layered structure 35 may be provided with a third layer 47, which may be an insulation layer. The third layer 47 may comprise an inner surface 49 and an outer surface 51, where the outer surface 51 faces the inner surface 43 of the second layer 29. The third layer 47 may be applied to the boundary 33 to provide a reduction in heat transfer from the outer surface 37 of the first layer 27 in a direction towards the inner volume 5 of the housing unit. The insulation of the third layer 47 may be in the form of any kind of insulation suitable for a housing unit in accordance with the disclosure, where in this example the insulation may be PU or PIR foam insulation.

[0053] In this example seen in Fig. 3, the multi-layered structure 35 may be provided with a fourth layer 53, where the fourth layer may e.g. be in the form of a decorative layer, where the decorative layer may e.g. face the inner volume 5 of the housing and creates the aesthetic look of the inner walls of the housing. The fourth layer 53 may have an outer surface 55 and an inner surface 57, where the outer surface 55 may be in contact with the inner surface 51 of the third layer 47. The fourth layer may be a plaster layer or a Fermacell gypsum fibre board layer, which may both be an insulation layer, fire prohibiting layer and an aesthetically pleasing layer.

[0054] Fig. 4 shows a similar construction to that shown in Fig. 3, having a multi-layered structure 35 having four layers 27, 29, 47, 53. However, the difference may be seen where the second layer 29 has been provided with a reinforcement structure 59. The reinforcement structure may have connecting portions 61, where the connecting portion 61 are attached to the inner surface 39 of the first layer 27. The reinforcement structure 59 may be in the form of a steel mesh 63, which extends along the inner surface 39 of the first layer, and may be provided prior to the application of the second layer 29. The reinforcement structure 59 may increase the structural integrity of the second layer 29, by increasing the shear and tensional strength of the concrete layer 29, when the second layer 29 has been applied to the inner surface 39 of the first layer 27, and when the concrete has cured. It is to be understood that the reinforcement structure 59 may be applied to all embodiments.

[0055] Fig. 5 shows another embodiment of the boundary 33, where the first layer 27 is similar to that shown in Fig. 3 and 4. However, in this embodiment the second layer 29 may be provided with one or more concrete flanges 65, where the concrete flanges 65 may be formed in the casting process of the concrete layer 29. The concrete pillars 65 may extend from the top (7 in Fig. 1) of the container towards the bottom (5 of Fig. 1) of the container, where the pillars may increase the structural integrity of the second layer 29, and provide increased strength against bending of the first layer 27 and/or the second layer 29, and thereby provide increased protection should the container e.g. be affected by a force which may be in a direction which is in a transverse, vertical or horizontal direction, or a combination of the transverse,

vertical or horizontal directions. The inner surface 67 of the pillar 65 may extend into the inner volume 5 of the container, where a layer of insulation 47 may be provided between the flanges 65. The second layer 29 may have an increased thickness in the areas where the flange 65 has been formed in the concrete layer 29. The flanges 65 may extend from the second layer in various shapes i.e. having different cross-section shape e.g. cross-sectional shape in form of a square, rectangle, pyramid, trapezoid, curved or part of a circle.

[0056] Fig. 6 shows a sectional view of a corner 69 of a container (3 in Fig. 1) where the corner 69 is located in the area between a side wall 13 and an end part 9 of the container i.e. the area where the end part 9 and a side wall 13 meet. The end part 9 of the container may be provided with a window 71, where the corner 69 may be provided with an increased thickness of concrete in the second layer 29, to provide additional strength and may also in one embodiment accommodate the window 71. The end 73 of the second layer 29 may be formed in an L-shape, to provide a connecting part 75 for a window frame 77. Furthermore, the L-shape provide additional structural strength. The second layer 29 may be provided with a reinforcement structure 59, which increases the structural stability of the second layer 29 and in the corner 69, where the layers of the multi-layered structure 35 may be similar to that shown in Fig. 3-5 in the direction of the opposing end (11 seen in Fig. 1) of the container.

[0057] The window frame 77 may comprise a first part 81 and a second part 83 positioned on opposite sides of the window 71, to hold the window 71 in its correct position. The first part 81 and 83 may provide an increased structural integrity in the end part 9.

[0058] In the embodiment shown in Fig. 6, the boundary 33 may be provided with a further fire resisting part 85, in the form of lathes or C-shaped steel parts, where the fire resisting part 83 may increase the overall fire capabilities of the boundary 33 and in the vicinity of the end part 73 of the second layer and/or the boundary 33.

[0059] The boundary 33 may comprise a fifth layer 87 and a sixth layer 89, where the layers may provide different functionalities to the housing unit (1 seen in Fig. 1).

[0060] Fig. 7 shows a test setup of a multi-layered construction of a boundary 33, where the outer surface 37 of the first layer 27 faces an ISO-834 fire curve 93, where the boundary 33 faces a fire. The thickness X of the first layer is 2 mm and is made of steel. A second layer 29 is provided where the outer surface 41 of the second layer 29 faces the inner surface 39 of the first layer 27. For the test setup, the thickness Z of the second layer 29 has been varied from 30 mm to 80 mm, where the thickness is increased in 10 mm iterations. On the inner surface 43 of the second layer 29 a temperature probe 91 is positioned. The temperature probe may be positioned between the second layer 39 and a third layer 47, where the third layer may be an insulation layer.

[0061] In the test setup, the probe has been set to take measurements at various times, over a 30 minute test

run, where the results of the temperature measurements may be seen in Fig. 8. Here it is clear that the temperature increase at the inner surface of the second layer is decreased over time where the thickness of the concrete second layer is increased.

Test setup:

[0062] Simulations assume 1D-numerical heat transfer with ISO 834 exposure.

[0063] Material properties for steel and concrete taken from Eurocode 2 and Eurocode 3.

[0064] Temperature profiles are reported at the concrete and insulation interface.

[0065] Boundary condition on the un-exposed side is assumed to be perfectly insulated for conservative estimate.

[0066] For 10 min exposure, most concrete slabs show temperatures below 250 deg C mark.

[0067] For 30 min exposure, slabs of 60 mm or thick show attainment of temperatures below the 140 deg C mark.

[0068] The use of the terms "first", "second", "third" and "fourth", "primary", "secondary", "tertiary" etc. does not imply any particular order, but are included to identify individual elements. Moreover, the use of the terms "first", "second", "third" and "fourth", "primary", "secondary", "tertiary" etc. does not denote any order or importance, but rather the terms "first", "second", "third" and "fourth", "primary", "secondary", "tertiary" etc. are used to distinguish one element from another. Note that the words "first", "second", "third" and "fourth", "primary", "secondary", "tertiary" etc. are used here and elsewhere for labelling purposes only and are not intended to denote any specific spatial or temporal ordering.

[0069] Furthermore, the labelling of a first element does not imply the presence of a second element and vice versa.

[0070] It is to be noted that the word "comprising" does not necessarily exclude the presence of other elements or steps than those listed.

[0071] It is to be noted that the words "a" or "an" preceding an element do not exclude the presence of a plurality of such elements.

[0072] It should further be noted that any reference signs do not limit the scope of the claims.

[0073] Although features have been shown and described, it will be understood that they are not intended to limit the claimed invention, and it will be made obvious to those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the claimed invention. The specification and drawings are, accordingly, to be regarded in an illustrative rather than restrictive sense. The claimed invention is intended to cover all alternatives, modifications, and equivalents.

Claims

1. A residential housing unit formed as an ISO container having a longitudinal extension, a transverse extension and a height extension and having boundaries defining at least part of an inner volume of the ISO container, the residential housing unit comprising:

- a bottom defining a lower boundary of the ISO container;
- a top defining an upper boundary of the ISO container;
- at least one end part defining an end boundary of the ISO container;
- at least a first longitudinal side wall defining a side boundary of the ISO container;

where at least one of the boundaries of the ISO container comprises a multi-layered construction, where the multi-layered construction comprises:

- a first layer of steel having a first inner surface and a first outer surface;
- a second layer comprising concrete having a second inner surface and a second outer surface,

wherein the second outer surface of the second layer faces the first inner surface of the first layer.

2. A residential housing unit in accordance with claim 1, where the first layer is the outermost layer of the ISO container, and/or where any subsequent layer is arranged in a direction facing an inner facing side of the boundary.
3. A residential housing unit in accordance with any of the preceding claims, where the at least one boundaries further comprises a third layer and/or a subsequent layer, where the third layer may comprise one or more of: insulation layer, vapor barrier layer, plaster layer, metal structure, electrical installation, radiant heating element, decorative layer.
4. A residential housing unit in accordance with any of the preceding claims, wherein the second layer comprises a reinforcement structure.
5. A residential housing unit in accordance with claim 4, wherein the reinforcement structure may be one or more of: reinforcing steel, reinforcing bar, steel fibres, glass fibres, synthetic fibres, natural fibres, or other types of known methods for increasing the structural integrity of the concrete layer.
6. A residential housing unit in accordance with claim 4, wherein the reinforcement structure in the second

layer may be connected with the first layer and/or connected with the first inner surface of the first layer.

7. A residential housing unit in accordance with any of the preceding claims, wherein the at multi-layered construction comprises at least 50% of an area defined by at least two of the longitudinal extension, transverse extension or the height extension of the ISO container.
8. A residential housing unit in accordance with any of the preceding claims, wherein the second layer comprises insulation.
9. A residential housing unit in accordance with claim 7, wherein the insulation may be mixed into the second layer and/or where the insulation may be cast into the second layer.
10. A residential housing unit in accordance with any of the preceding claims, wherein the boundary comprises a through-going opening, where the opening extends through the first and the second layer, and/or a subsequent layer.
11. A residential housing unit in accordance with claim 7, wherein a peripheral region of the through-going opening is reinforced.
12. A residential housing unit in accordance with any of the preceding claims, where the at least one boundary is a first longitudinal side wall and/or an end part of the residential housing unit.
13. A method of manufacturing a residential housing unit, where the method comprises the steps of:

providing an ISO container having:

- a bottom defining a lower boundary of the ISO container;
- a top defining an upper boundary of the ISO container;
- at least one end part defining an end boundary of the ISO container;
- at least a first longitudinal side wall defining a side boundary of the ISO container;

where at least one of the boundaries has a first layer of steel having a first inner surface and a first outer surface; and providing a second layer comprising concrete where a second outer surface of the second layer faces the first inner surface of the first layer of steel.

14. A method of manufacturing a residential housing unit in accordance with claim 13, wherein the second layer is provided using an open volume casting and/or

a closed volume casting.

15. A method of manufacturing a residential housing unit in accordance with claim 13 or 14, wherein the second layer may be provided on the first inner surface of the first layer or steel by positioning the first layer of steel and/or the first inner surface in a horizontal position and pouring the concrete in a fluid state onto the horizontal first inner surface.

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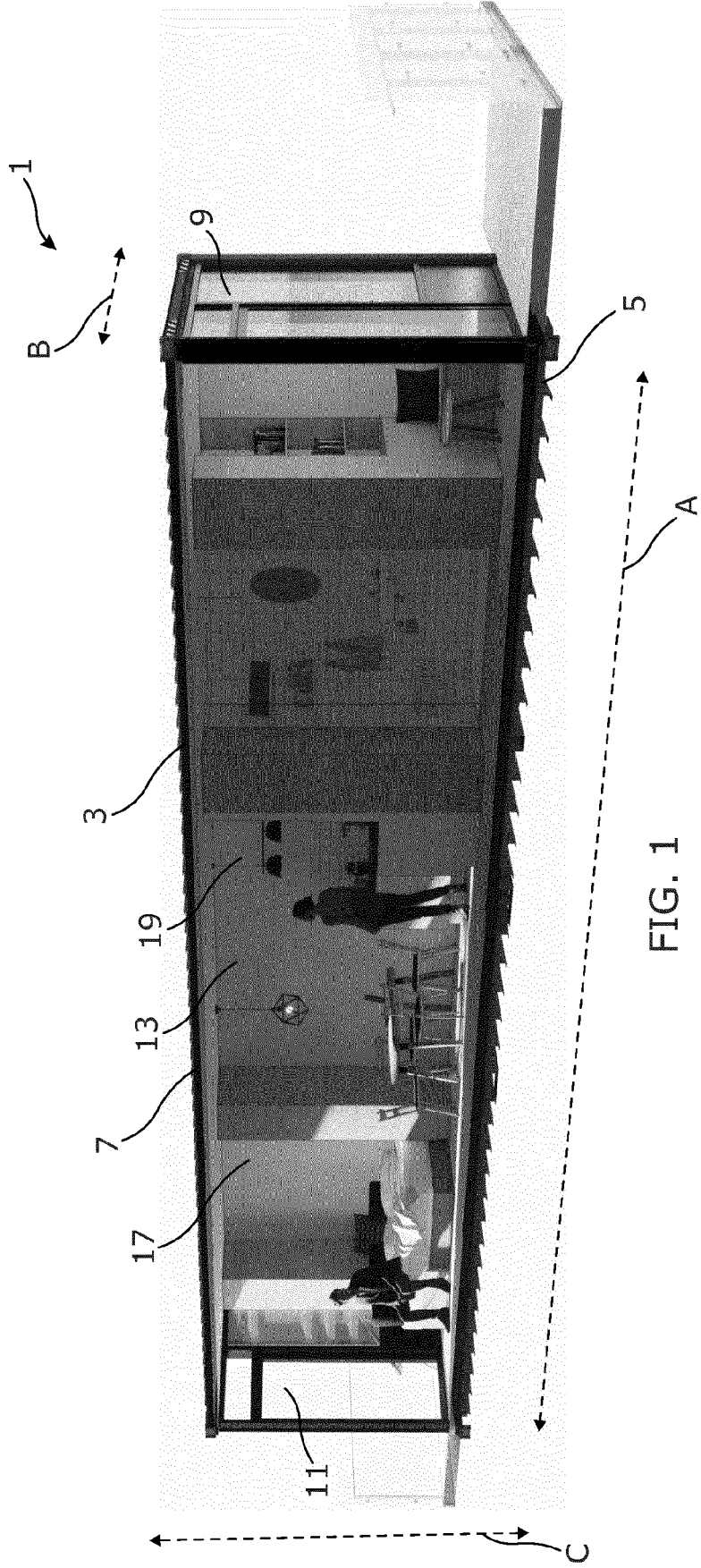


FIG. 1

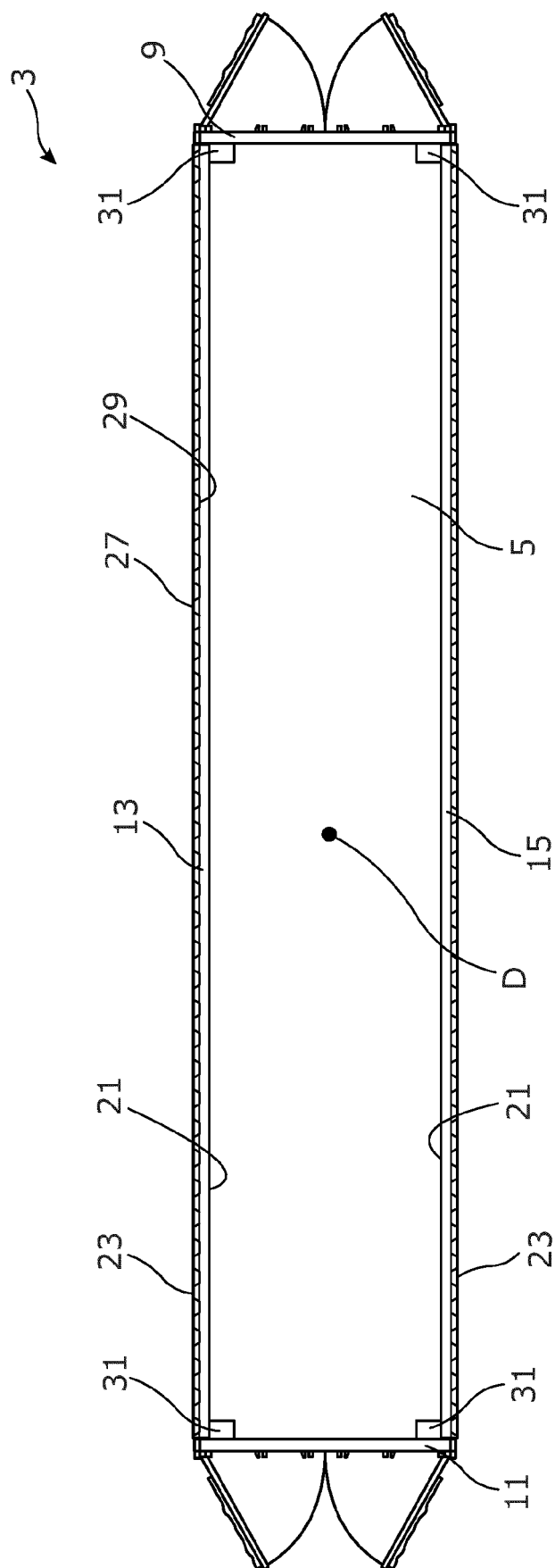


FIG. 2

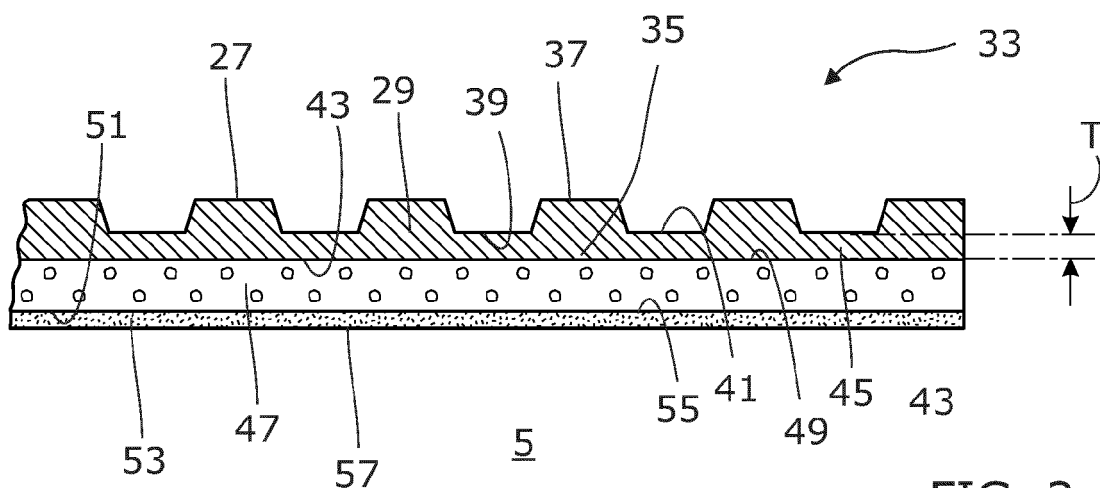


FIG. 3

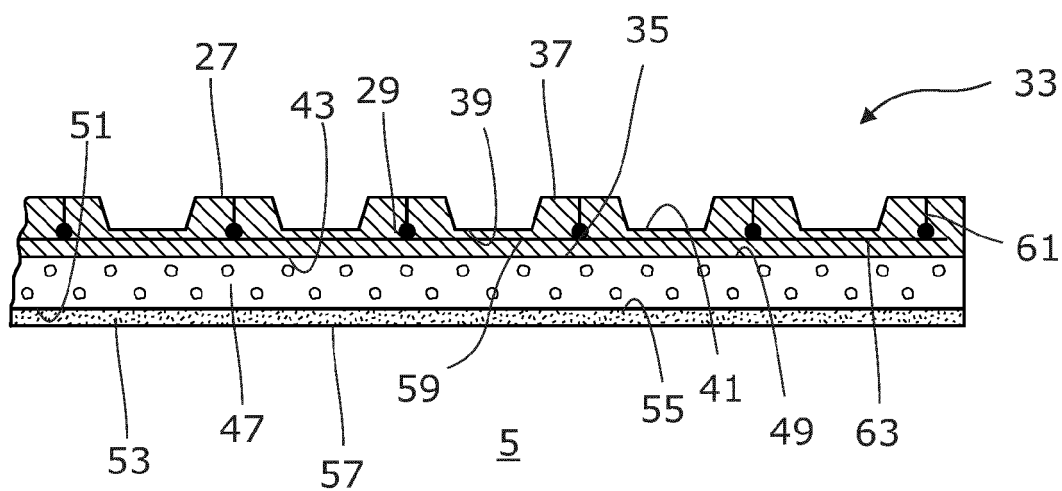


FIG. 4

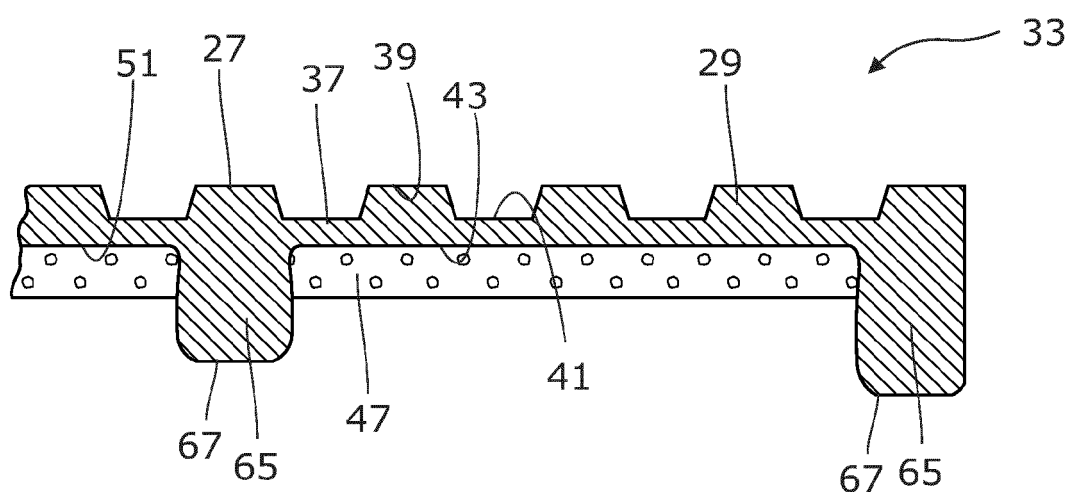


FIG. 5

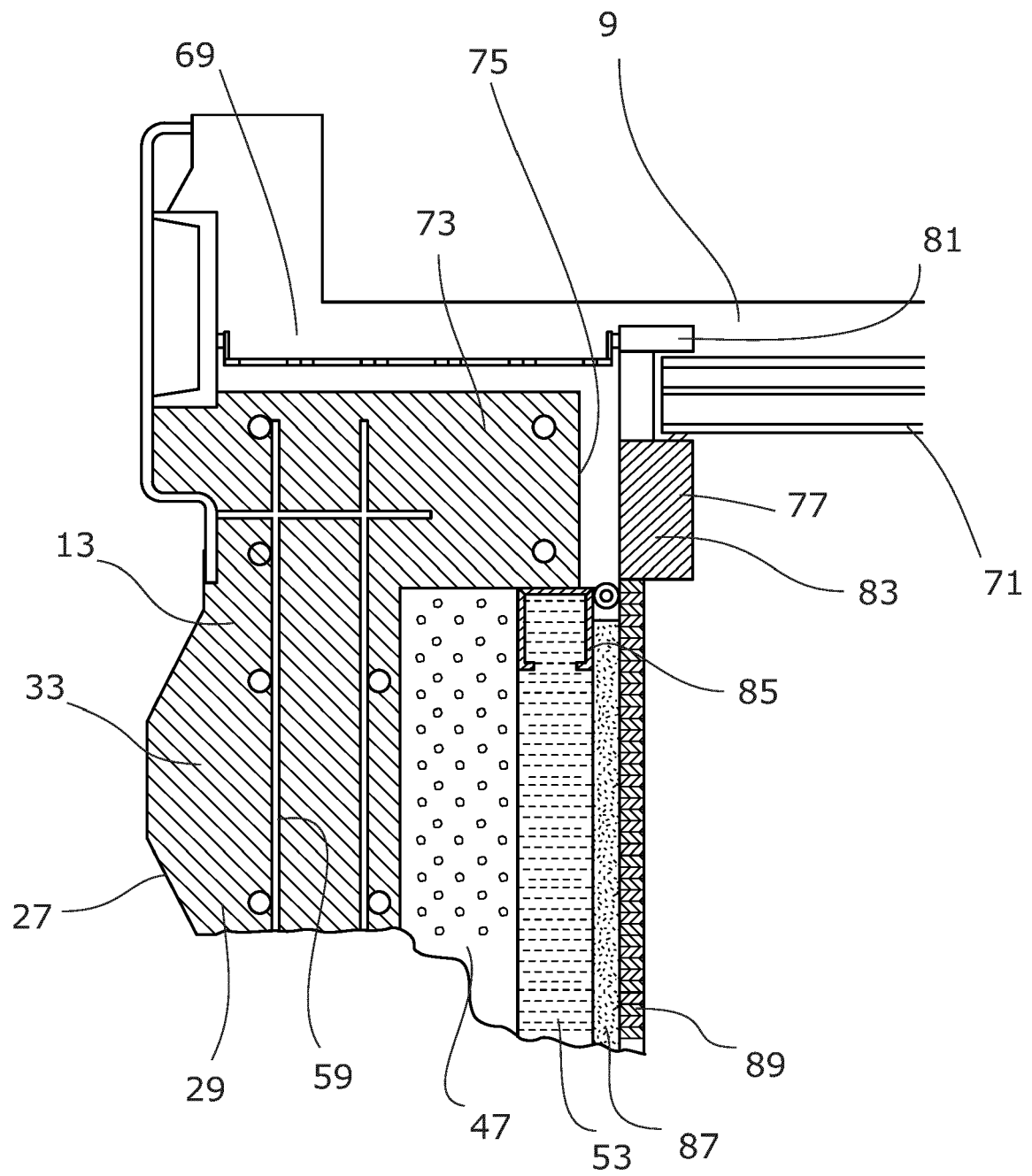


FIG. 6

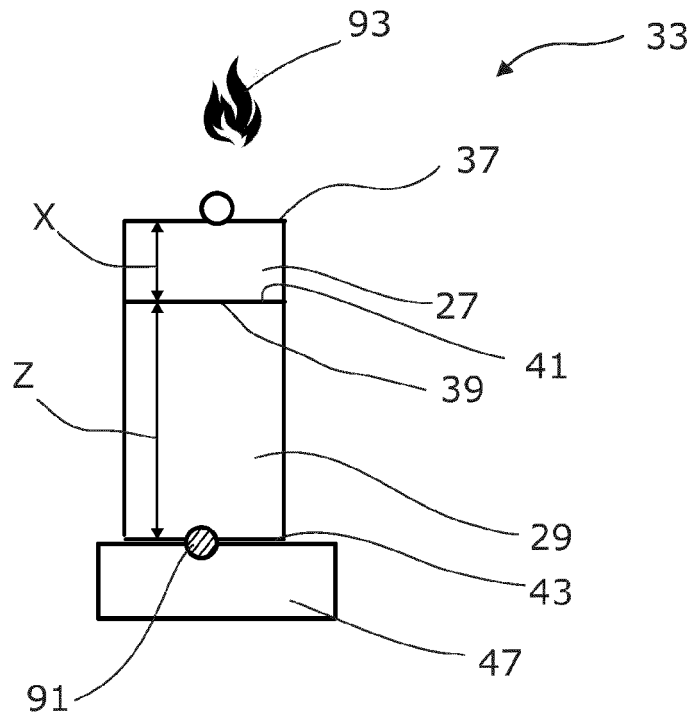


FIG. 7

Temperature Profile at Concrete - PU Insulation Interface

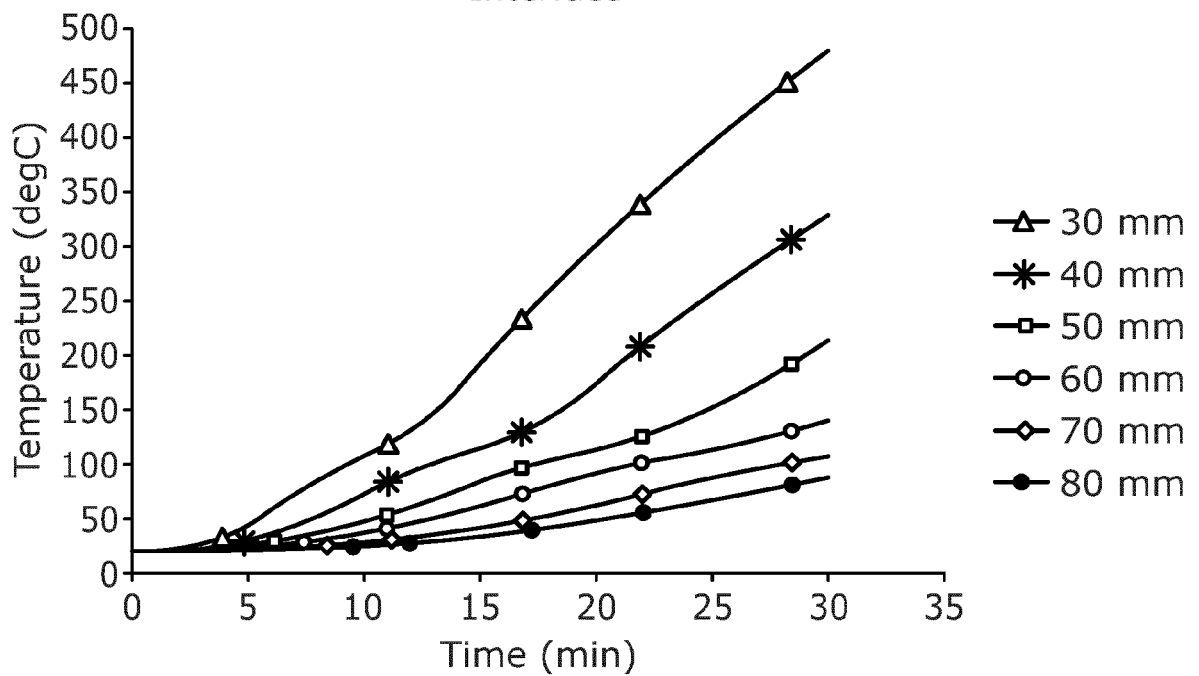


FIG. 8



EUROPEAN SEARCH REPORT

Application Number
EP 21 15 2586

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2015/121880 A1 (NBC SHELTER S R L [IT]) 20 August 2015 (2015-08-20) * page 1 - page 15; figures 1-6 * -----	1-15	INV. E04H1/02 E04H1/12
			TECHNICAL FIELDS SEARCHED (IPC)
			E04H
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 6 July 2021	Examiner Decker, Robert
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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06-07-2021

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WO 2015121880	A1	20-08-2015	NONE

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

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