



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
28.04.2021 Bulletin 2021/17

(51) Int Cl.:
E04B 1/348 ^(2006.01)
E04G 21/14 ^(2006.01) **E04D 13/08** ^(2006.01)

(21) Application number: **20202822.1**

(22) Date of filing: **20.10.2020**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(30) Priority: **25.10.2019 GB 201915545**

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(54) **RISER SYSTEM**

(57) Some examples of the stackable building module are manufactured with an integrated functionally operable riser system for transportation to its installation site. The integrated riser system functions at least as a drain which allows fluids to be passed through the riser system from the roof of the building module to a ground drainage system as soon as the building module is lowered in alignment either with a ground drainage system or a lower stackable building module so that a lower portion of the riser system is forced by the lowering of the building module to automatically engage with the ground drainage system or an upper portion of a lower building module.

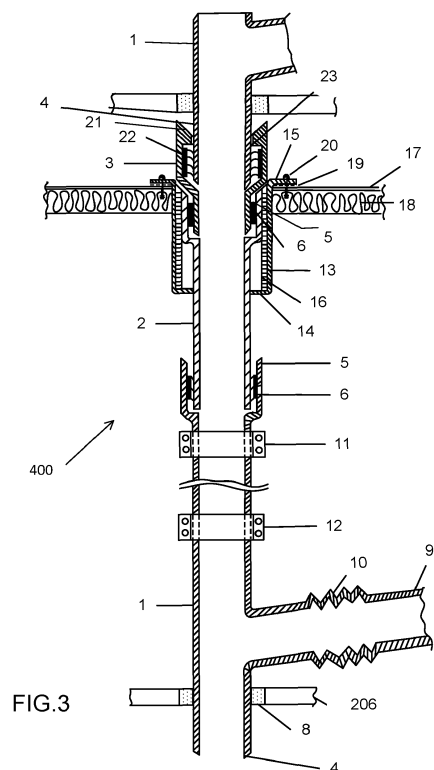


FIG.3

Description

[0001] The present disclosure relates to a riser system, to a riser coupler for the riser system, a building module including an integrated riser system and related aspects. In particular, 1 but not exclusively, a building module manufactured with an externally connectable integrated riser system is disclosed, where the riser system can be vertically extended by stacking building modules on top of each other is disclosed. In particular but not exclusively, examples of a riser system are disclosed which include a riser coupler for coupling riser systems of modular buildings. Some examples of the riser system provide, for example, a foul water riser system, which functions as a vertical drain spanning multiple-storeys of a multi-storey modular building structure formed by vertically stacking the stackable building modules. A test system for ensuring the integrity of the riser system is also disclosed. A roof-top guide for assisting in guiding fluids through the riser system to drain liquids from the roof of a modular building comprising one or more stacked building modules is also disclosed.

BACKGROUND

[0002] Modular building structures are well known, however, there is a rising demand for moving construction work of building structures which have been traditionally created on-site using traditional building materials and techniques into a factory environment.

[0003] Known modular buildings are generally constructed to typically comply with normal on-site construction tolerances, which at best are around say ± 5 mm. Whilst it is known for building modules manufactured in a modern factory to improve on these tolerances, unless the assembly methods are appropriate, the significant advantage from this improved manufacturing accuracy is often lost.

[0004] Multi-storey modular buildings create additional challenges, as tolerances for services are often tight. The treatment of a water connection or similar service connection such as a foul riser (also known as soil vent pipe or soil stack) is an example which illustrates how on-site construction techniques have traditionally failed to leverage the improved accuracy of off-site manufacturing techniques. Traditionally, as each storey of a multi-storey modular building is constructed by stacking modules which have riser pipework sections on top of each other, a vertical clearance has been left between a lower and an upper riser sections and the riser joint is completed after the module has been installed.

[0005] This methodology has several disadvantages, including but not limited to: i) that a greater workforce is required at site to complete the modules than might be needed otherwise; and ii) access to each riser section for installation imposes constraints where the riser is located within the module and within building structures which are formed using multiple modules per storey.

Conventional building design locates risers so that they are accessible from corridor cupboards which requires apertures to allow the services to penetrate through apartment and corridor walls which introduces further constraints and cost to manage environmental hazards such as fire, acoustics, and thermal performance. Another disadvantage is that if risers are located and accessible from within a module, some element(s) of the finish must be left incomplete in order to gain necessary access to complete installation.

[0006] Another disadvantage is experienced during the installation process of conventional building modules which are exposed to inclement weather such as rain, hail and snow during their installation. As traditionally such risers require making water-tight on site after a building module has been placed in position, the riser is not available for immediate use. This means that until the riser is made water-tight by installation of the appropriate joint or make-up piece, water must be prevented from entering the riser pipe. Conventional solutions include blocking the pipe so that rainwater that might otherwise enter the riser pipe is prevented from entering and/or diverting rainwater from the room of a building module away from the riser pipe, for example, by installing a temporary drainage system.

SUMMARY STATEMENTS

[0007] Examples of preferred aspects and embodiments of the invention are as set out in the accompanying independent and dependent claims.

[0008] This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter.

[0009] The disclosed technology seeks to exploit the accuracy of building modules made in a factory to enable a liquid-tight riser to be formed as building modules are stacked, so that the riser is made up by the action of stacking one module including a riser section on top of another module containing a riser section. Each module is provided with a section of riser which is configured to be immediately available to act as a drain as soon as it is installed.

[0010] A first aspect of the disclosed technology a stackable building module having an integrated functionally operable riser system. Preferably, the functionally operable riser system is an integrated externally connectable functionally operable riser system. The externally connectable riser system allows external connections to other externally connectable riser systems in other building modules and/or ground drainage systems. Preferably, the stackable building module manufactured with the integrated externally connectable functionally operable riser system. The external connections of the riser system enable the integrated functionally operable riser sys-

tem to be suitably connected directly to a coupler assembly connected to ground drainage system and/or indirectly to the ground drainage system by coupling to a coupler assembly at the roof level of a lower building module's riser system. The coupling is formed simply by lowering a building module in alignment with the lower coupler assembly after which the riser system can be used. Where a series of three or more modules are to be stacked, the integrity of the riser system which spans two modules can be tested using a riser test system as disclosed herein before the third or any further modules are stacked on top of the upmost lower module.

[0011] In some preferred example embodiments, the integrated riser system functions at least as a drain which allows fluids to be passed through the riser system from the roof of the building module.

[0012] In some preferred example embodiments, the fluids comprise at least rainwater which has fallen on the roof of the building module.

[0013] In some preferred example embodiments, the integrated functionally operably riser system comprises a riser portion having an upper coupling portion and a lower coupling portion.

[0014] In some preferred example embodiments, the upper coupling portion is configured to be capable of vertically engaging with a corresponding lower coupling portion of another building module.

[0015] In some preferred example embodiments, the lower coupling portion is configured to be capable of vertically engaging with a corresponding upper coupling portion of another building module.

[0016] In some preferred example embodiments, the lower coupling portion is configured to be capable of vertically engaging with a corresponding upper coupling portion of a ground drainage system.

[0017] In some preferred example embodiments, the stackable building module is configured to form a multi-storey building structure with at least one other building module according to the first aspect or any other suitable aspect or any suitable preferred embodiments of the first aspect or any other suitable aspect by being stacked on top of at least one of the at least one other building modules, wherein the functional operation of the riser system of each stacked building module is automatically extended vertically by the action of vertically stacking the building modules in alignment.

[0018] In some preferred example embodiments of the stackable building module, the building module is configured to form a multi-storey building structure with at least one other building module as claimed in any previous claim by being stacked under at least one of the at least one other building modules, wherein the functional operation of the riser system of each stacked building module is automatically extended vertically by the action of vertically stacking the building modules in alignment.

[0019] Another, second, example aspect of the disclosed technology comprises a modular building structure comprising a plurality of building modules as claimed

in any example embodiment.

[0020] Another, third, example aspect of the disclosed technology comprises a riser system operably formed by stacking a plurality of building modules as claimed in any example embodiment.

[0021] Another, fourth, example aspect of the disclosed technology comprises a riser system for modular building structures, the riser system comprising: at least one building module comprising at least a roof and floor, wherein each building module contains a riser pipework section of the riser system, the riser pipework section comprising a lower downpipe portion of the riser system pipework, the lower downpipe having a spigot section which protrudes through the floor of that building module, wherein the lower downpipe is connected at its upper end to an upper downpipe portion which allows liquids to access the riser system through the roof of that building module; and at least one riser coupler coupled to lower pipework, each riser coupler comprising: means to capture the spigot section of the riser system pipework of a building module; and means to guide the captured spigot into a connection with the lower pipework, wherein the riser coupler is configured to form a liquid-tight seal with the spigot as that building module is lowered into its resting position. The above features of the riser system of the fourth example aspect may be combined with the features of any of the other aspects, for example the riser system may comprise the integrated riser system of any of the first to third aspects.

[0022] In some preferred example embodiments of a riser system of the fourth aspect (or any other suitable aspects or preferred example embodiments of the other suitable aspects), the riser system is provided for a plurality of building modules which are lowered on top of each other to form a multi-storey building structure, and wherein at least one section of the lower pipework a riser couples to comprises a section of riser system pipework in another, lower building module.

[0023] In some preferred example embodiments of the riser system of the fourth or any other suitable aspect or preferred example embodiment of a suitable aspect, the lowering of each of the plurality of building module into its rest position over the lower pipework automatically creates a functional extended riser system allowing liquid to be cleared from the roof of the topmost building module to a ground pipework.

[0024] In some preferred example embodiments of the riser system of the fourth or any other suitable aspect or preferred example embodiment of a suitable aspect, the upper portion of the riser downpipe rises through a fire-stop.

[0025] In some preferred example embodiments of the riser system of the fourth or any other suitable aspect or preferred example embodiment of a suitable aspect, the axis of the spigot of the riser system pipework is configured to flex laterally from its true axis position. In some preferred example embodiments, this flex may be one of: up to 5mm, up to 8mm, or even in some embodiments,

up to 10mm from its true axis position.

[0026] Another, fifth, example aspect of the disclosed technology comprises a building module for use in a riser system according to the fourth or any other suitable aspect or preferred embodiment of the fourth or any other suitable aspect listed above, the building module comprising: a roof; a floor; riser pipework comprising a lower downpipe portion and an upper downpipe portion, wherein the lower portion includes a spigot section of downpipe which protrudes through the floor of the building module and is connected at its upper end within the building module to the upper downpipe portion, and wherein the upper downpipe portion is configured to allow liquids to flow off the roof of the building module down the riser system downpipe pipework.

[0027] Another, sixth, example aspect of the disclosed technology comprises a method of coupling two downpipes in a riser system, the method comprising: positioning a building module from which a portion of the first one of the downpipes protrudes through the floor of the building module such that the protruding portion is vertically aligned within a predetermined tolerance level with a corresponding recessed portion of the other one of the two downpipes; guiding the building module as it is lowered; capturing the protruding portion of the first downpipe to guide the protruding portion towards the recessed portion of the other downpipe; and automatically forming a sealed coupling between the two downpipes as the building module is guided into its lowered rest position.

[0028] In some preferred example embodiments of the method aspect or any other suitable aspect, the other downpipe is provided at ground level and the positioning of the modular building module comprises positioning the building module in a raised position above known alignment points provided at ground level.

[0029] In some preferred example embodiments of the method aspect or any other suitable aspect, the other downpipe is provided by another, lower, building module, and the positioning of the modular building module comprises positioning a first building module in a raised position above known alignment points on the roof of the other, lower, building module.

[0030] In some preferred example embodiments of the method aspect or any other suitable aspect, the guiding of the building module comprises lowering the first building module onto the known alignment points.

[0031] In some preferred example embodiments of the method aspect or any other suitable aspect, a riser coupler is engaged with the recessed portion of the other, lower, downpipe, the riser coupler comprising an inverted cone and seal assembly, and wherein the inverted cone captures the protruding portion of pipework to guide it as it is lowered towards the lower downpipe.

[0032] Another, seventh, aspect of the disclosed technology comprises apparatus comprising means for performing any one of the above method aspects or preferred embodiments of the method aspect.

[0033] In some preferred embodiments of the first as-

pect or the fifth aspect, the stackable building module is manufactured with the integrated functionally operable riser system. This allows a more completed building module to then be formed ready for transportation to its installation site.

[0034] Another, eighth, aspect of the disclosed technology relates to a riser test system for testing the integrity of the riser system. The riser test system preferably comprises: a bung positioning tool for positioning one or more inflatable bungs within a riser system downpipe such that a pair of inflated bungs form a sealed chamber along a section of the riser downpipe which spans a sealed joint in the riser system; means to inflate the bungs when positioned using the bung positioning tool; means to apply a fluid pressure increase in the sealed chamber; means to sense the fluid pressure in the sealed chamber; and means to monitor the fluid pressure in the sealed chamber. In some embodiments, the monitoring means comprise a computer and the means to sense the fluid pressure comprises a sensor configured to use a wireless data connection to send data indicating a pressure sensed within the sealed chamber to the pressure monitoring means. In some embodiments, the pressure monitoring means is configured to provide an audible alert if a pressure drop is detected. In some embodiments, the pressure monitoring means includes a suitable display and provides a visual alert if a pressure drop is detected. In some embodiments, the visual alert includes an indication of the position of the sealed chamber and/or the joint within the riser system where the pressure drop was/is being sensed.

[0035] The test system comprises a tool for positioning a plurality of inflatable bungs at a plurality of predefined positions determined by the configuration of the riser pipe joints in the downpipe section of a riser system, wherein by inflating the bungs, a sealed chamber is formed spanning a joint in a vertical riser downpipe. The tool further comprises a carrier pipe or rod or other suitable means along which the bungs can be positioned and/or are lowered into position within a riser system downpipe spanning an upper building module and a lower building module. The tool is lowered through the open end of the upper riser system in the roof of the upper building module (i.e. the portion into which a spigot extending from a lower riser portion of another building module enters as the building module is lowered). Each riser downpipe joint may be tested in sequence or, as the configuration of the riser downpipes is known through the manufacturing of the building modules with the riser system downpipe integrated within its infrastructure, more than one or all downpipe joints may be tested at the same time, providing the bungs can be inflated to provide a pressure sealed chamber(s) on each side of each joint. The carrier pipe may include vents, apertures, or comprise one or more separate conduit(s) to allow each pressure-sealed chamber to be suitably subjected to increasing pressure by pumping in a test fluid (preferably air, or another inert gas, or water) to test the integrity of the joint which the

adjacent bungs span. A sensor or other suitable pressure monitoring means is positioned within each sealed chamber formed by a pair of bungs within the downpipe. The pressure of the fluid (e.g. air) inside the sealed chamber increases as more fluid is pumped into the sealed chamber however, if there is a structure defect or the riser joint within the sealed which fails, and fluid escapes, the sensor(s) will register this as a drop in pressure.

[0036] The sensor(s) for each sealed chamber are suitably connected to a monitoring device, for example, by a wired connection (e.g. within the carrier pipeline) but preferably by a wireless connection (e.g. WiFi, Bluetooth). In embodiments where more than one joint is being pressure-tested at a time, to distinguish which sensor has detected the failure, the position of the pressure drop can be identified using some suitable data signature associated with the known sensor position. This allows for rapid testing of the riser system integrity as a multi-storey building module is constructed, as the joints between two riser portions and the riser system coupling assembly between two building modules can be quickly tested for their integrity from the roof of the upper building module before the next building module is lowered into position on the upper building module. In this manner, the functional operability of the riser system can be tested and confirmed as a building structure is built.

[0037] Another, ninth, aspect of the disclosed technology relates to a roof-top guide comprising at least one raised elongate element having an edge configured to assist in guiding fluids through the riser system to drain liquids from the roof of a modular building comprising one or more stacked building modules. Preferably another raised elongate element having a similar edge is provided such that the in use, the guide can be configured around the open aperture formed by the top of the riser system in the roof of a building module and provides a wide-mouthed channel which tapers towards the open aperture in the roof of the building module so that fluids can be more efficiently and quickly guided down into the riser system. Preferably the roof-top guide is v-shaped. Preferably the roof-top guide is formed of a material that can temporarily be attached to a building module roof. Preferably the roof-top guide is at least partially magnetic so as to be removably attachable to a metallic roof of a building module according to any of aspects or embodiments described herein. The above aspects and preferred embodiments disclosed relate to a stackable building module having an integrated functionally operable riser system. In some examples, the stackable building module is manufactured with the integrated functionally operable riser system. This allows the manufactured stackable building module having the integrated functionally operable riser system to be manufactured to have a form suitable for transportation to its installation site with a functionality operable riser system. Some examples of the integrated riser system function at least as a drain which allows fluids to be passed through the riser system from the roof of the building module to a ground drainage sys-

tem as soon as the building module is lowered in alignment either with a ground drainage system or a lower stackable building module so that a lower portion of the riser system is forced by the lowering of the building module to automatically engage with the ground drainage system or an upper portion of a lower building module

[0038] The features of the preferred aspects and embodiments of the invention as set out hereinbelow and in the accompanying may be combined with each other as appropriate, as would be apparent to a skilled person, and may be combined with any of the other examples described herein.

[0039] It will be apparent to anyone of ordinary skill in the art, that certain preferred features indicated above or in the accompanying claims as preferable in the context of one of the aspects of the disclosed technology are capable of being preferred features of one or more of the other aspects of the disclosed technology indicated above, but are not explicitly listed above under each such possible additional aspect for the sake of conciseness.

[0040] It will also be apparent to anyone of ordinary skill in the art, that certain preferred features indicated above or in the accompanying claims as preferable in the context of one of the aspects of the disclosed technology indicated above can be combined with other preferred features of that same aspect or combined with the preferred features of other ones of the preferred aspects of the disclosed technology. Such apparent combinations are again not explicitly listed above under each such possible additional aspect for the sake of conciseness.

[0041] Some examples of the stackable building module are manufactured with an integrated functionally operable riser system for transportation to its installation site. The integrated riser system function at least as a drain which allows fluids to be passed through the riser system from the roof of the building module to a ground drainage system as soon as the building module is lowered in alignment either with a ground drainage system or a lower stackable building module so that a lower portion of the riser system is forced by the lowering of the building module to automatically engage with the ground drainage system or an upper portion of a lower building module.

[0042] Examples of aspects and preferred embodiments of the technology disclosed are environmentally-friendly as relate to a riser system which is integrated into a building module in a controlled factory environment rather than being installed in the building module after the module has been delivered to a building site. This allows for the building module to be delivered and installed with the riser system available for immediate use, for example, to evacuate foul water and the like, from within/on the building module. This provides various environmental benefits, including the reduction/elimination of hazardous chemicals being used on site to form/seal the riser system in-situ, and a reduction in air and noise pollution as the majority of the building infrastructure is within a factory environment which cuts down on the

amount of dust and noise created at the building installation site.

[0043] It will also be apparent to anyone of ordinary skill in the art, that some of the preferred features indicated above as preferable in the context of one of the aspects of the disclosed technology indicated may replace one or more preferred features of other ones of the preferred aspects of the disclosed technology. Such apparent combinations are again not explicitly listed above under each such possible additional aspect for the sake of conciseness.

[0044] Other aspects and embodiments of the present invention will become apparent from the following detailed description, which, when taken in conjunction with the drawings, illustrate by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0045]

FIGs. 1A, 1B, 1C illustrate schematically various examples of modular building structures comprising building modules in which a riser system according to various example embodiments of the invention is integrated;

FIG. 2 illustrates schematically a cross-section through an example riser system servicing a multi-storey modular building structures such as that depicted in Figure 1C;

FIG. 3 is a schematic cross-sectional diagram showing in more detail an example embodiment of the riser system of FIG. 2;

FIG. 4 is a schematic diagram showing in more detail an upper portion of the example riser system of FIG. 3;

FIG. 5 is a schematic diagram showing in more detail a riser connector comprising a cone and seal assembly of the example riser system of FIG. 2;

FIGs. 6A and 6B comprise views of an example building module having an example of a roof drain provided by an example of an embodiment of the integrated riser system;

FIG. 7 shows steps in an example method of forming a riser system according to an embodiment of the invention; and

FIG. 8A shows an example test system for a riser system spanning a plurality of vertically connected building modules; and

FIG. 8B shows the example test system in more detail relative to the riser system of FIGs 2 and 3.

[0046] The accompanying drawings illustrate various examples. The skilled person will appreciate that the illustrated element boundaries (e.g., boxes, groups of boxes, or other shapes) in the drawings represent one example of the boundaries. It may be that in some examples, one element may be designed as multiple elements

or that multiple elements may be designed as one element. Common reference numerals are used throughout the figures, where appropriate, to indicate similar features.

DETAILED DESCRIPTION

[0047] The following description is made for the purpose of illustrating the general principles of the present invention and is not meant to limit the inventive concepts claimed herein. As will be apparent to anyone of ordinary skill in the art, one or more or all of the particular features described herein in the context of one embodiment are also present in some other embodiment(s) and/or can be used in combination with other described features in various possible combinations and permutations in some other embodiment(s). Unless otherwise specifically defined herein, all terms are to be given their broadest possible interpretation including meanings implied from the specification as well as meanings understood by those skilled in the art and/or as defined in dictionaries, treatises, etc. It must also be noted that, as used in the specification and the appended claims, the singular forms "a," "an" and "the" include plural referents unless otherwise specified. In the drawings, like elements have common numbering across the various Figures. One or more features of a particular embodiment may be omitted from the drawings and detailed description if their inclusion in the invention is apparent.

[0048] Some example embodiments of aspects relating to a riser system and a riser joint for use in the riser system and related aspects will now be described in some detail. Some example embodiments of aspects relating to building modules incorporating one or more portions of an example of the riser system which are integrated with the building modules as the building modules are manufactured, and examples of the riser joint used in the riser system, will also now be described in some detail. Some example embodiments of aspects relating to multi-storey modular building structure comprising a plurality of the example building modules will also now be described in some detail, including and a test system for testing the integrity of the riser system spanning a plurality of building modules as a building structure is built. One or more or all of the features of a described aspect are to be considered features of any other aspect referring to that aspect even if not explicitly disclosed in the context of that other aspect where it would be apparent to a person of ordinary skill in the art that such a feature could be implemented in the context of that other aspect.

[0049] Figure 1A of the accompanying drawings shows schematically a typical building module 100 comprising a roof 102, side walls 104, and floor 106. The structure of such a building module is typically a metal frame which provides structural stability and to which panels are attached to form the roof, walls and floor. In some embodiments a building structure which incorporates an inte-

grated riser system as disclosed herein is formed from a single building module 100 such as is shown by way of example in Figure 1A. In other embodiments, the building structure comprises a plurality of building modules, for example, an upper module such as is shown as building module 200 in Figure 1B, which also has a roof 202, side walls 204, and floor 206 (not shown in Figure 1B), which is positioned on top of the lower building module 100 on-site (as opposed to being a two-storey module constructed in a factory environment). Figure 1C shows a taller building structure comprising n storeys or floors in which the top-most floor comprises a building module 300, also having a roof 302, walls 304, and a floor 306. Some examples of building structures such as that shown in Figures 1A..1C include multiple building modules per storey, in which case depending on the number of modules per storey one or more or all of the vertical walls 304 is left open to be joined to one or more other building modules in the same storey to form a larger interior space.

[0050] FIG. 2 is a schematic cut-through of an example building module 200 in a building module located either at ground level (not shown) or immediately above another building module 100 (not show) and immediately below yet another building module 300, of which only the floor 306 is indicated in Figure 2.

[0051] An example of an integrated sectional riser system 400 according to an embodiment of the disclosed technology is shown on the left-hand side (lhs) of Figure 1 schematically as a vertical pipe or conduit section of the riser system. The riser system 400 passes down from the roof level 302 of the upper building module 300, down through the floor 306 of the upper building module and through the roof 202 of the building module 200 and on through the floor 206 of the building module 200 to either a suitable entry point to drain system in the ground or to another lower building module as mentioned above.

[0052] The section of the riser system 400 which passes through the building module 200 is shown in more detail on the right-hand side (rhs) of Figure 2. As shown, each section of the riser system comprises a lower riser system portion 1, an upper riser system portion 2, and a riser section coupler 3 comprising a cone 21 and seal 22 assembly for joining sections of riser attached to an upper building module 300 to the section of the riser system attached to the lower building module 200. The dashed area surrounding the upper portion 1 of the riser system 200 is shown in an expanded view and described later in Figure 4.

[0053] The lower portion 1 comprises a length of downpipe. The downpipe comprises a substantially vertically length of pipework that stops with an open end just above the bottom of the outside of floor 206 of the building module 200. All edges on the bottom edge of the downpipe of the lower portion 1 are suitably rounded or otherwise suitably configured so that entry into a lower opening is facilitated without catching or snagging. The pipe end of the downpipe is held accurately in position, but in a com-

pliant manner such that it may move up to 10mm in any radial direction under the application of a moderate force. This allows the downpipe to move responsive to any lateral forces as the building module is lowered into its resting position (for example, on the ground or on another building module). All pipework connected to the downpipe of the lower portion 1 must maintain this flexibility in the downpipe's ability to move radially and not lock off its movement and prevent this compliance. The lower portion 1 shown in Figure 1 extends upwards from the base of building module 200 as a straight length of pipe with an upward facing pipe socket 5 on the top.

[0054] The upper portion 2 of the riser system section of building module 200 is fitted by slotting it through a round hole in the roof 202 to locate into the mid-element upward facing pipe socket 5 of the lower section. The upper portion 2 of the riser system section itself has an upward facing pipe socket 5. The upper portion 2 contains a metal can 13 which houses a fire stop. The top of the metal can 13 is fitted with a thin flange 15 (see Figure 4 for more detail) . An annular gasket 19 is placed between the flange 15 and the upper surface of the roof 202 of the building module 200. Fixing means, for example, screws may be used to fix the flange 15 to the roof 202 to compress the gasket sufficiently to seal the roof and prevent unwanted ingress to the interior of the building module of substances like rainwater and the like during transportation and installation.

[0055] The riser section coupler 3 comprising the cone and seal assembly is preferably site-fitted. The site-fitted coupler 3 comprises a male pipe section for slotting into the top of the open section of the downpipe of the upper portion 2 and an upward facing cone 21 with integral seal 22. The seal 22 has multiple fins to ensure a fully effective liquid-tight seal is achieved using a relatively a short stroke (or depth of engagement) as upper building module 300 is lowered. The seal 22 is radially tolerant of misalignment which may occur as the upper building module 300 is lowered. The upward facing cone 21 is designed to push the incoming pipe from the building module 300 above towards the theoretical centre of the seal 22.

[0056] The example riser system shown in Figure 2 and also the examples of riser systems and riser joints described later below rely on building modules 100, 200, 300 being capable of being positioned in close alignment using a suitable tolerance control method to maintain alignment within less than 5mm and preferably equal or less than 1mm so that no damage occurs to the riser system and/or riser joints as the building modules are lowered in position on top of each other. Such levels of tolerance control are achievable using a suitable system of "cone" connectors to guide modules into position so that a module is automatically aligned as it is lowered on top of a lower module, with any additional lateral movement caused by their being more than one module per storey being adjusted if necessary using a suitable connector tie-plate mechanism.

[0057] Some example embodiments of the riser sys-

tem 400 shown in Figure 2 comprise a foul water riser system for the multi-storey building structure in which certain sections of the system are incorporated into each of the stacked building module 100, 200, 300 in a manner which allows the building modules 100, 200, 300 to include the sectional riser system elements as they constructed off-site in a factory environment. This allows a modular building structure to be quickly formed on-site by stacking the building modules 100, 200, 300 on top of each other.

[0058] The example embodiments of the sectional riser system 400 disclosed are configured to be useable without the need for further intervention after a building module 100 has been landed (regardless of whether it is landed on the ground floor if it is a ground floor module 100 or on another module 100, 200 if it is a top floor module 300 or an intervening floor module 200). This means that there is no need to restrict foul drain locations to service ducts and similar riser locations. It also means that the inside of building modules can be completed with the working riser system already in place, without further delay to complete the riser system or having to leave access for making the foul riser connection good on-site.

[0059] The example embodiments of the riser system 400 disclosed work by including a riser coupling component in the form of cone and seal assembly. The riser coupling element shown in the Figures includes an upward facing female cone 21 projecting out the top of a building module 100, 200, 300. A downward facing pipe 1 on the underside of the building module being installed locates cone 21 and as the building module is lowered into cone 21 it is sealed in situ. The height of the cone 21 and length of the downward facing end of pipe 1 are selected such that a building module 100 will have been already guided by a suitable cone connector system to reduce the level of tolerance to preferably 1mm or less (for example, such as is described in Annex 1) prior to the pipe end engaging in the cone 21. The rim of cone 21 has a tapered lead-in section with an outer diameter sufficiently large to provide a suitable 'capture' region at the top of the cone 21 which is greater than the tolerance deviation of the pipe end centreline of the protruding section of pipe extending below the upper building module 300 as this upper module 300 is guided downwards into its resting position on lower building module 200.

[0060] In some example embodiments of the riser coupling component, the coupling component including the upward facing female cone 21 is fitted off-site and integrated with the upper portion 2 of the riser system 400 within a building module 200. In other example embodiments the riser coupling component is manufactured as a component for fitting on-site and is not integrated with either building module 200, 300. One advantage obtained in embodiments where the riser coupling component including the upward facing female cone 21 is fitted on-site is the ability, prior to fitting the cone 21 on the top of the top portion 2 of the riser system 400, is that the top portion 2 ideally ends flush within or is slightly re-

cessed within the roof 202 of the building module 200. In some embodiments, a slight upstand around the flange 15 results from the assembly sequence but this presents a sufficiently low rim to still allow any accumulated fluids, debris or other materials (for example, such as rainwater and leaves) which accumulate on the roof of the building module to be swept towards and subsequently down the open end of the top portion of the foul riser pipe. In this way the volume of water and/or debris which ends up trapped between building modules 200, 300 as shown in Figure 2 can be minimised reducing the time taken to dry out the roof area of the lower building module and reduce the risk of unintended water damage due to rain-water for example accumulating and remaining on the roof after the upper building module 300 has been lowered into position. It is also possible in some embodiments to provide channels or grooves in the roof 202 of a building module 300 and/or to provide an optional guide to help direct water towards the open riser hole in the roof 202 of the module. Some examples of such a guide may be temporarily fixed to the roof, for example, magnetically. One example comprises a V-shaped kerb guide which magnetically fixed to the roof or temporarily adhered to the roof which guides water towards the drain formed by the open top portion of the riser system (i.e. the end of the riser system of a building module which is left open at the roof level which contains or receives the riser coupler and the riser spigot or stub of another building module as it is lowered down onto the building module from above).

[0061] The sectional structure of the riser system included in each building module also includes some means to control the spread of fire. If the compartmentation fire line between two vertically adjacent building modules 100, 200 runs at the level of the roof 202 of the lower building module 200, then as the upper portion 2 of the riser section runs through the fire line, a means of stopping the fire penetrating through the riser is provided in the upper portion 2.

[0062] Figure 3 of the accompanying drawings shows an example of the sectional riser system shown on the lhs of Figure 2 in more detail. In Figure 3, the example sectional riser system 400 is of a type which is typically configured to remove waste or foul water from within or from the roof 102, 202 302 of a residential or commercial building module 100, 200, 300, for example of the type which provides a habitable 3D volumetric space enclosed by at least two, but also possibly three and usually four walls. Examples of building structures formed from such building modules include, for example, residential premises such as blocks of flats or houses, or commercial buildings such as schools, hospitals, and offices and the like. The example sectional riser systems and example riser coupling systems or joints for joining sections of risers in such types of modular building structures include, for example, a foul water riser systems which provide a vertical drain for foul water and effluence for single- or multi-storey modular buildings which are formed from

stackable building modules.

[0063] An embodiment of a sectional riser system will now be disclosed with reference to Figure 3 of the drawings in the context of the riser system comprising foul riser stabbing system for allowing foul water and other liquids to be evacuated from a building module and/or any building modules located above or below the main riser section shown. The riser section shown in Figure 3, the comprises a lower riser assembly portion 1 which is located in the module 200 as shown in FIG. 2. The lower riser assembly portion of the section of module 2 is able to engage with a lower building module (for example, a building module 100). The upper riser assembly portion 2 is located in the building module 200 for engaging with the riser section of an upper building module 300. Located between the upper building module 300 and the lower building module 200 is the riser coupling assembly 3 which comprises the site-fitted cone 21 and seal 22 assembly

[0064] The terms "upper" and "lower portion" refers to the position of the portions in a riser section installed within a building module. The riser upper 2 and lower 1 portions of the riser section of a building module together with the riser coupler 3 are liquid-tight and in use are substantially vertical to allow liquid to drain vertically through each building module. Side branches which are flexibly connected to the vertical pipe sections in some embodiments of the riser system 400 provide lateral drainage within a building module. In most embodiments, the first and second pipe sections will be cylindrical so that rotation is allowed as a building module is lowered on another building module, i.e. so that the cylindrical spigot or end of the lower portion 1 of an upper module has a circular cross-section within a desired tolerance suitable for forming a watertight fit with the cone and seal assembly. However, although in the illustrated embodiment, each pipe section has a substantially uniform pipe diameter, other suitable cross-sectional profile shapes may be provided along some or all portions in some embodiments. For example, pipes/cones/seals which have squares, rectangles, and other polygon's may be formed within a building, with only the points of each riser section which needs to couple to another part of the riser system on site and allow for radial movement being substantially circular.

[0065] Returning now to Figure 3, a cross-sectional view is provided of a sectional riser system comprising a lower (downpipe) portion 1. The downpipe riser portion 1 has a tapered cut 4 at its lower end which forms a spigot for fitting the bottom of the down pipe portion 1 into an open connector socket, for example, of a riser coupling system located immediately below (not shown). The tapered cut slants outwards from the axis of the down-pipe portion 1 such that the innermost surface of the sidewall of the downpipe protrudes further than the outermost surface. At the distal (top) end of lower portion 1, a socket 5 is provided. The socket 5 shown is provided integrally with the pipe by expanding the diameter of the pipe along

a suitable length of the pipe to receive the lower end of the upper portion 2 of the riser section shown. In the embodiment shown, pipe socket connector 5 incorporates a suitable seal 6 so that the joint between the two pipe portions 1, 2 within the socket 5 is effectively watertight in some example embodiments.

[0066] The downpipe 1 of the lower portion of the section of riser section within a building module 200 passes through the module floor 206. To accommodate lateral movement as the building modules are lowered in position, some suitable resilient seal or ring is provided, for example, as shown in Figure 3, between the downpipe 1 and the module floor 206 is a compliant adjusting ring 8. This allows tapered cut 4 at the end of pipe 1 to be adjusted so that it is positionally correct in plan relative to the module datum system governing the position of the building modules on site.

[0067] In use, during site assembly of a building structure comprising one or more vertically stacked building modules 100,200 as each building module 200 is being positioned on top of another building module 100, the bottom end of the downpipe 1 of the lower portion of the upper module 200 needs to locate into the riser coupler system 3. In embodiments where the riser coupler system comprises a cone 21 and seal 22 assembly which is fitted on-site, either located at ground-level or at a higher building level for multi-storey building structures, once the coupler system has been fixed in place it cannot be adjusted, which causes all building plan tolerances to be have to be accommodated by the downpipe 1 of the lower portion of each sectional riser within a building module. The compliant adjusting ring 8 therefore provides only nominal resistance to sideways movement to ensure that strain on the downpipe is managed within appropriate levels and also to ensure the seals maintain their integrity. Preferably, in some example embodiments, the compliant adjusting ring 8 is pre-installed in a building module floor 7, as this allows for automatic drainage of surface water. but in some other example embodiments, the compliant adjusting ring 8 may be installed on site into a suitable aperture created in the building module floor where only the aperture is created in a factory environment so as to be precisely positioned within the building module. An advantage of having both the compliant adjusting ring 8 and the aperture manufactured and installed in a building module within a factory environment is that the manufacturing tolerances can be much better controlled, for example, to within 5mm or less.

[0068] Each section of riser system 400 within a building module is configured to suitably manage the amount of vertical and sideways movement, for example, by having enough flexibility provided to accommodate deviations in one or more dimensions from any desired modular building component manufacturing tolerance levels and/or strain as the building modules are installed. One way of doing this is to attach a side branch 9 to the vertical downpipe. As side branch 9 does not to restrain sideways movement of the downpipe 1 by providing one or more

of side branch bending, sliding joints or, as shown in Figure 3, providing a flexi-joint 10.

[0069] As end of pipe 1 locates into riser coupling assembly 3, there will be a vertically upwards force on the downpipe 1 of the lower portion of the riser section within the building module 200. This vertical movement is resisted, for example, as shown in Figure 3 by providing pipe clamps 11 and 12. Pipe clamp 11 is rigidly fixed to the module structure. Depending on the stiffness of downpipe 1 and how close pipe clamp 12 is needed near to the spigot of downpipe 1, some sideways flex may be provided to allow for some movement as a building module is lowered and guiding into position on top of another building module. If the downpipe 1 is stiff the location of the bottom of down pipe 1 may need to be preadjusted closer to its resting position when the building it is retained within has reached its resting position by adjusting the position of pipe clamp 12. In embodiments where the downpipe 1 is preadjusted sufficiently using the above method of moving clamp 12, further adjustment may not be required and in some embodiments, ring 8 may be omitted or replaced with a less flexible ring.

[0070] Various ways of allowing vertical down pipe 1 to accommodate sideways movement as two buildings are vertically stacked are possible and include the following: If the pipe is very stiff, as is the case with metal pipes, then pipe clamp 11 need to be fitted directly under socket connector 5. Pipe clamp 12 can be omitted. Sideways movement is achieved by give in compliant adjusting ring 8 and rotation at connector 5.

- a. If the pipe is flexible, as is the case with plastic pipes, then pipe clamp 12 needs to be set sufficiently high above the bottom of pipe 1 such that the pipe can flex.

[0071] The vertical position of the bottom of pipe 1 needs to be set as near to the bottom of the module as possible. A suitable level of clearance, for example, 5mm clearance, is recommended to allow some tolerance should a building module be placed directly on level ground and the spigot end of the downpipe 1 engage with a ground drainage system instead of with a riser section of another, lower, building module.

[0072] Turning now to Figure 4, which shows the upper portion 2 of Figure 3 in more detail, upper portion 2 comprises a short pipe section 2 having a connector socket 5 and a seal 6. Short pipe section 2 is attached to a cylindrical metal housing 13. Cylindrical metal housing 13 comprises an inward facing annular flange 14 along its bottom end and an outward facing annular flange 15 at the top. The metal housing 13 is filled with an expanding intumescent 16 which in the case of fire, expands to form a firestop.

[0073] A downpipe 2 located in the upper portion of a riser section within the building module 200 is inserted through a suitable aperture or hole in module roof 206. To prevent fire spreading through the roof, the roof layer

206 of the building module 200 is filled with fire protection material 18 as shown in Figure 4. The bottom end of short pipe 2 of the upper portion of the riser section is not shown in Figure 4, but, as Figure 3 shows, is inserted (or stabbed) into the socket 5 of the downpipe 1 of the lower portion of the riser section within building module 200. A gasket 19 is fitted to the underside of flange 15 such that it is sandwiched between flange 15 and roof 17. Once short pipe 2 is fully engaged in assembly 1 socket 5, the centre of downpipe 2 socket 5 is centred accurately at the roof level relative to the module datum system. This datum system allows the amount of tolerance to be kept to a minimum and reduces the amount of tolerance which may otherwise accumulate. Fixing means 20 such as screws can then be used to fix and compress gasket 19.

[0074] The downpipe 2 of the upper portion of the riser section within a building module is rigidly fixed to the top of the building module by the fixing 20. It is for this reason that some flexibility is provided by the pipe at the bottom of assembly 1 to cope with one or more the following possible issues:

- i. if an upper building module 300 is lowered out of position relative to a lower building module 200 and remains off-set from its intended as true aligned position after it has been fully lowered to its resting point, the flexibility of the sectional riser downpipes 1, 2 allow an off-set from the desired or true position no more than circa 2mm to be accommodated;
- ii. If the sectional riser upper portion pipe 2 is located off true at roof level on a building module relative to its true position against which any guidance mechanism fixed to the roof of the module is expecting, a flex of around 3mm may be accommodated.
- iii. If the lower end of a downpipe 1 of a lower portion of a riser section in a building module 100, 200, 300 is off its true position, the downpipe 1 of the module 100, 200, 300 can usually flex sufficiently to accommodate errors of up to 3mm as that building module is lowered on top of another building module/ground drain connector.

[0075] Collectively, this gives a maximum compliance in the order of 8mm for each section of a riser system which is fabricated as part of a building module 100, 200, 300.

[0076] Figure 4 also shows in more detail how an example fire line is maintained by the section of the riser system at the roof 202 of a building module 200. The example fire line shown in Figure 4 comprises a continuous steel plate 17 over the top of the module and an insulation batt 18. The steel plate is of a suitable thickness, for example, 1.5mm. In the event of a fire metal housing 13 heats up and as it is heated intumescent substance 16 expands and crushes the downpipe portion 2 to block off access through the riser downpipes 2, 3 to the module above (or below) and so prevents vertical fire spread. In some embodiments, to facilitate the collapse

of the walls of the down pipe 2 when intumescent material 16 expands, the downpipe is formed of an appropriate material such as plastic which will soften under heat. In some embodiments, however, such as where the riser section is made of steel or another material which is sufficiently resistant to any pressure exerted by the intumescent material 16, the intumescent material 16 will not be capable of collapsing the riser section. In embodiments where a steel riser pipe, or any riser pipe formed from similar fire-resistant materials which are also resistant to being crushed (whether by an intumescent material or other mechanism activated in the event of fire), are used, the properties of the riser pipe material must ensure the riser integrity through all storeys of the building is maintained in the event of fire so the riser pipe does not burn through to create a fire path across the fire line.

[0077] Figures 4 (and also Figure 5) shows a view of a riser coupling system 3 comprising a cone 21 within which a seal 22 is provided. Riser coupling system 3 is installed immediately prior to an upper module being lowered. The cone 21 has a lead-in taper 21. The bottom of the taper has an annulus 23. Housing 3 has an internal recess for locating seal 22. Whilst annulus 23 acts to centralise the stab or spigot 4 formed by the bottom portion of downpipe 1 which has extended below the floor 306 of the upper module 300, seal 22 needs to accommodate more radial movement than normal due to potential flexure of down pipe 1 (and accordingly pipe end 4) of the upper module 300. The seal 22 must also provide a watertight seal with a much shorter received pipe length than a normal seal would require. A variety of seal arrangements are possible to meet these requirements, but they are typically characterised by an increase in the number of seal lips and an increase in basic diameter to accommodate a greater radial movement. The capture of cone 21 needs to accommodate the compliance given above plus the additional radial clearance in the module cone system when the cones have just engaged. This is an additional 8mm giving a total capture requirement of 16mm which the cone 21 of the riser coupling system 3 must accommodate in order to be sure of successfully capturing the downpipe spigot portion 4 of a building module 3 as it is lowered into position so that water-tight seal is immediately formed.

[0078] Figures 6A and 6B show schematically how, prior to adding on-site a riser coupler 3, each building module 100 includes a roof surface 102 which automatically drains into the open upwards end of the downpipe 2 of the upper portion of the section of riser system integrated into the building module. As shown in Figure 4 and 6A, the open end of the section of the riser system formed by downpipe 2 and provides a socket 5 which is configured to receive the riser coupler 3 and to form a sealed joint using seal 6. The socket 5 is situated within a firestop provided by a metal container 13 which includes flange 15 which sits flush with the exterior surface of roof 102 of the building module 100. Figure 6A shows how the downpipe 1 of the upper portion of the section of the riser

system within building module 100 sits in socket 5 at the top of the downpipe 1 of the lower portion and also how downpipe 1 extends through the floor 106 of the building module to form a spigot or stab pipe section 4.

[0079] Figure 6B shows a plan view of the roof 102 of the building module and shows how within flange 15 is the open aperture of the top end of pipe 2 of the riser section located within the building module. Water and other debris can accordingly be guided towards the open end of pipe 2 of riser system and as the lower layers of the system are automatically made watertight as each building module is lowered into position, will escape into the local drainage system via the riser sections of the building module(s) below until reaching a ground level drain system. A roof-top guide for assisting in guiding fluids through the riser system to drain liquids from the roof of a modular building comprising one or more stacked building modules can be provided in the form of a v-shaped roof-top guide. Preferably, the roof-top guide is magnetic to attach in a removable manner to the top of a metallic roof on a building module of a type such as is disclosed herein which has an integrated operationally functional riser system.

[0080] In this manner, some example embodiments comprise a method of forming a water-tight riser system 400 in a multi-storey modular building structure such as is shown in Figure 7 of the accompanying drawings. The example method shown in Figure 7 comprises firstly positioning (step 500) a building module 100, 200, 300 over a suitable lower drain system connection point. As each building module 100, 200, 300 is stacked on top of lower building modules it must be positioned over a suitable lower drain system access point, for example, comprising a riser coupler 3 of the riser system 400 so that the stab or spigot 4 of downpipe 1 that extends below the floor of the building module engages in a watertight manner with the lower drain system. For example, such an access point may be provided by fitting a ground drain access point with a suitably dimensioned riser coupler system 3 prior to lowering a ground floor building module 100 into position at ground level so that as the ground floor building module 100 is lowered, its spigot 4 is lowered within the catchment region of the inverted cone 21 of the riser coupler 3. If the building module being lowered comprises instead an upper floor building module 200, 300 then as this is lowered into position its spigot or spur 4 is lowered within the catchment region of the inverted cone 21 of a riser coupler 3 located on the roof of a lower building module such as building module 100, 200. As each building module 100, 200, 300 is lowered into position it is appropriately guided (step 500) by the cones so that the spur or spigot extending from below its floor 102 falls within the catchment area of the inverted cone 21 of the riser coupler 3 beneath it, so that as the building module 100, 200, 300 comes to rest the spigot will have engaged with the riser coupler 3 sufficiently to form a liquid-tight seal, which automatically extends the functionality of the riser system 400 upwards through to the roof of the just

lowered module 100, 200, 300 (step 504).

[0081] Various features of the aspects of the riser system disclosed above enable a riser pipe system to be installed in a building structure. Although the aspects and embodiments described relate to riser systems for modular buildings, it will be appreciated that similar benefits can be obtained in other types of building structures where a blind joint riser system is to be installed. The riser systems disclosed for modular buildings can be constructed in sections where each section is integrated into the structure of a building module constructed off site. Each of the building modules' riser section of pipework 1,2 is connected to a lower point in the riser system by the action of lowering one building module onto another building module, advantageously with no further intervention being required. As the connected riser section of each building module is preferably configured to have a top-section which is suitably flush with the roof 102, 202, 302 of a building module it can be immediately used to remove rainwater from the roof surface before the next building module is lowered into position. A riser coupler system 3 comprising a receiving cone 21 and seal 22 system are preferably fitted on site to the roof 102 202, 302, of each module onto which another module is to be lowered. A preferred example of a riser coupler 3 allows a sealed connection to be formed with a guided vertical movement of the building module above of no more than 70mm and is able to accommodate lateral movement away from the intended "true" centre of the stab (or spigot) 4 being lowered to engage with cone 21. The amount of tolerance can, depending on materials and tensile strength of the materials used to form the riser, have a tolerance of up to 8mm from the "true" centre of the stab (and may be able accommodate up to 10mm in some embodiments).

[0082] In some embodiments, a guidance mechanism for stacking building modules having an integrated functionally operable riser system is provided using a cone connector guidance system. One example of such a cone-connector guidance system comprises a plurality of cones positioned on the top (roof) or base (below floor level) of a building module at locations which correspond to the locations of receiving connector inverted cones located on adjacent upper or lower building module (or appropriately located cones/inverted cones set up on ground works). By attaching the cones to the building modules off-site in a factory environment, lateral tolerances between adjacent building modules can be achieved which are at least less than 5mm, and even less than 2mm or 1mm. Another example of a guidance mechanism which can improve the level of conformity (and so reduce the need for a high level of tolerance) when lowering one building module having an integrated portion of a riser system on top of another building module having a similarly integrated portion of a riser system, of any of the examples described earlier where a stub or spigot protrudes from the top of the building module, is to provide the building module with an enlarged guiding

cone which is slightly taller than one or more other guidance cones. The enlarged cone matches the tolerance offset of the spigot and cone centreline. Due to the practical limitations on the height of the other guidance cones on a building module, however, the cone/seal system must have some specific aspects, for example, the spigot needs to be able to flex laterally by a sufficient amount to accommodate deviations from the centre line within the accumulated tolerance levels of the manufacturing tolerance position for the centre-line of the riser, the deformation caused by placing the building module under load as another building module is stacked or positioned on top of it, and any other tolerances required to accommodate deviations in the configuration of the cone connector elements (both male and female).

[0083] In some embodiments, a temporarily fixable guide, for example, a magnetic guide is attached to the roof of a building module around the location of the open end of the riser system. The guide is used to direct water as it is being 'brushed' off the module roof into the riser. In some embodiments, the guide is not magnetic but is attached and held in place on the roof of a building module by other suitable temporary fixing means, for example, by virtue of its weight, or by using a temporary adhesive etc.

[0084] The accommodation of riser misalignment through compliance and the control of tolerances is achieved by allowing the riser system to flex. In some embodiments, the spigot or stub 4 flexes laterally, for example, by up to 8mm from its true axis, to accommodate riser misalignment, however, in some examples, some compliance is also provided by the upper cone/seal system shown in FIG. 5. This needs to align axially initially to reduce the capture requirements of the cone. If the riser downpipe is formed of a stiff relatively inflexible material such as a metal of a certain thickness, then additional compliance can be provided using the riser fixings to the building module. However, in embodiments where the riser downpipe is formed of a sufficiently flexible material, the compliance comes from flexure of the downpipe itself ensuring that any lateral displacement remains within the required tolerance level.

[0085] A riser joint is created immediately as two building modules are stacked on top of each other, and in some embodiments of the invention, each riser joint is tested before the next building module is lowered into position over it. In such embodiments, as all riser joints below the current level will have already been tested, the riser downpipe can be used immediately. Access for testing the riser system which has been formed by stacking building modules on top of each other is from the roof of the topmost module, via the vertical riser downpipe opening.

[0086] Some examples of a test equipment for testing the functionality integrity of riser joints formed by stacking stackable building modules which are manufactured with functionally operable integrated riser systems will now be described with reference to Figures 8A and 8B of the

accompanying drawings.

[0087] In FIGs. 8A and 8B, an example of riser system test equipment is shown schematically in cross section. The riser system test equipment enables all riser joints to be individually tested. In the example shown in FIG. 8A and 8B, the riser test system is shown testing the riser system formed by two vertically stacked building modules, indicated as an upper building module and a lower building module. The upper and lower building modules comprise any suitable building module of a type as described herein which are manufactured with an integrated riser system having an upper riser portion 2 and lower riser portion 1.

[0088] FIG. 8A provides a schematic simplified view of the riser system of FIG. 8B, which shows in more detail the upper building module and the access point used by the test system located on the roof of the upper building module. As shown in FIG. 8A, one or more carrier pipes are inserted into the riser pipe which connect individually or collectively to four inflatable seal bladders used to test the riser system downpipe joint seals 6 and riser coupling seals 22 which are shown various points A, B, and C. By inflating the bungs and pressure sealing the pipe, if fluid is pumped into the pipe, the pressure of the fluid can be suitably monitored using any suitable pressure monitoring system known in the art as any leaks will reduce the pressure registered. Fluids which are used for testing may be liquids, such as water, but could be a gas, such as air or a similarly environmentally safe gaseous substance.

[0089] FIG. 8B shows the riser test system deployed in the context of the system as shown in FIGs. 2 and 3, where the riser system integrated into a building module comprises seals 6 which line each pipe socket connector 5 used to form a joint between two portions 1, 2 of the riser system downpipe. The pipe socket connector 5 seal 6 is provided to improve the likelihood that the joint between the two pipe portions 1, 2 within the socket 5 is effectively water-tight. Also shown in Fig. 8 is the seal 22 provided in the riser coupling assembly 3. Four bungs A, B, C, and D are also shown which are connected to a carrier pipe.

[0090] Bung (A) is shown located within the riser system before the joint formed by the end of the spigot or stub extending from the lower portion 1 of the riser system of the upper building module and the riser coupler 3 of the lower building module. Another bung B is located within the riser coupling assembly portion 3 pipe section before the joint with the upper portion of the riser system in the lower building module. Within the upper riser portion 2 and before the joint formed with the lower riser portion 3, another bung D is provided.

[0091] The riser test system uses the fact that the seal locations of the riser system which are tested on site are always within a fixed and relatively accurate dimension (say ± 5 mm) from the roof of the upper building module. In this example, the location of the coupler assembly allows a test system to use as little as four bungs (also

known as bladders) which are set at fixed intervals relative to the upper module roof to enable all the seals to be tested individually.

[0092] The test kit is inserted down the open downpipe and a carrier pipe is used to inflate each bladder in turn.

[0093] In embodiments where each building module includes the same (as in identical) portions of a riser system meaning the seals 6, 22 are located at the same positions along the riser downpipe, the same test kit can be used for each riser system within each building module by lowering the same kit down the riser pipe into position and inflating the seals. Pouring water down the pipe to an inflated bung will indicate if a seal located higher up the pipe has failed. In this way, by inflating bungs in sequence each of the seals 6, 6, and 22 can be tested for water-tightness. If there are any failures, then the test kit indicates which bung(s) were inflated and which were not, so the seal which was at fault can be identified. The bungs are located only along the downpipe only to pressure test the relevant seals of the joints along the downpipe. This allows higher pressures to be used as there is no need to pressure test any branch pipes as well which would take longer. It will be apparent that there are all sorts of permutations in how testing could be carried out in this manner, but importantly the incomplete riser is tested below the level of installation and once it has been confirmed by the test as being water-tight can be brought immediately into service.

[0094] The above examples of a riser test system accordingly enable the integrity of the riser system to be tested as a building is built. Some examples of the riser test system preferably comprise: a bung positioning tool for positioning one or more inflatable bungs within a riser system downpipe such that a pair of inflated bungs form a sealed chamber along a section of the riser downpipe which spans a sealed joint in the riser system; means to inflate the bungs when positioned using the bung positioning tool; means to apply a fluid pressure increase in the sealed chamber; means to sense the fluid pressure in the sealed chamber; and means to monitor the fluid pressure in the sealed chamber. In some embodiments, the monitoring means comprise a computer and the means to sense the fluid pressure comprises a sensor configured to use a wireless data connection to send data indicating a pressure sensed within the sealed chamber to the pressure monitoring means. In some embodiments, the pressure monitoring means is configured to provide an audible alert if a pressure drop is detected. In some embodiments, the pressure monitoring means includes a suitable display and provides a visual alert if a pressure drop is detected. In some embodiments, the visual alert includes an indication of the position of the sealed chamber and/or the joint within the riser system where the pressure drop was/is being sensed. The position is known as the configuration of the riser system will be known from the factory manufacture stage of the building module with the riser system. In some embodiments, as each type of internal riser system which is test-

ed will have had its lateral joints sealed at the factory stage by completing any internal connections required, a higher level of pressure can be applied to test the integrity of the vertical downpipe joints of the riser system.

[0095] Some examples of the test system comprises a tool for positioning a plurality inflatable bungs at a plurality of predefined positions determined by the configuration of the riser pipe joints in the downpipe section of a riser system, wherein by inflating the bungs, a sealed chamber is formed spanning a joint in a vertical riser downpipe. The tool further comprises a carrier pipe or rod or other suitable means along which the bungs can be positioned and/or are lowered into position within a riser system downpipe spanning an upper building module and a lower building module. The tool is lowered through the open end of the upper riser system in the roof of the upper building module (i.e. the portion into which a spigot extending from a lower riser portion of another building module enters as the building module is lowered). Each riser downpipe joint may be tested in sequence or, as the configuration of the riser downpipes is known through the manufacturing of the building modules with the riser system downpipe integrated within its infrastructure, more than one or all downpipe joints may be tested at the same time, providing the bungs can be inflated to provide a pressure sealed chamber(s) on each side of each joint. The carrier pipe may include vents, apertures, or comprise one or more separate conduit(s) to allow each pressure-sealed chamber to be suitably subjected to increasing pressure by pumping in a test fluid (preferably air, or another inert gas, or water) to test the integrity of the joint which the adjacent bungs span. A sensor or other suitable pressure monitoring means is positioned within each sealed chamber formed by a pair of bungs within the downpipe. The pressure of the fluid (e.g. air) inside the sealed chamber increases as more fluid is pumped into the sealed chamber however, if there is a structure defect or the riser joint within the sealed which fails, and fluid escapes, the sensor(s) will register this as a drop in pressure.

[0096] The sensor(s) for each sealed chamber are suitably connected to a monitoring device, for example, by a wired connection (e.g. within the carrier pipeline) but preferably by a wireless connection (e.g. WiFi, Bluetooth). In embodiments where more than one joint is being pressure-tested at a time, to distinguish which sensor has detected the failure, the position of the pressure drop can be identified using some suitable data signature associated with the known sensor position. This allows for rapid testing of the riser system integrity as a multi-storey building module is constructed, as the joints between two riser portions and the riser system coupling assembly between two building modules can be quickly tested for their integrity from the roof of the upper building module before the next building module is lowered into position on the upper building module. In this manner, the functional operability of the riser system can be tested and confirmed as a building structure is built using a testing

tool for a riser system having pre-defined joints at known predetermined positions which is integrated within a building module without the need to access the vertical portions of the riser system from any location other than the roof level of the building module. This allows the riser system spanning an upper module and a lower module to be tested as soon as each upper module is stacked on top of the lower module and before any further modules are stacked on top of the upper module. It will be understood that the benefits and advantages described above may relate to one embodiment or may relate to several embodiments. The embodiments are not limited to those that solve any or all of the stated problems or those that have any or all of the stated benefits and advantages.

[0097] In various examples there is a stackable building module having an integrated functionally operable riser system.

[0098] In an example, the stackable building module is such that, wherein the integrated riser system functions at least as a drain which allows fluids to be passed through the riser system from the roof of the building module.

[0099] In an example, the stackable building module of either of the preceding two paragraphs is such that wherein the functionally operable riser system is an integrated externally connectable functionally operable riser system, and wherein the stackable building module manufactured with the integrated externally connectable functionally operable riser system.

[0100] In examples, the stackable building module is such that, wherein the integrated riser system functions at least as a foul water drain which allows fluids to be passed from within the building module through the riser system.

[0101] In an example, the stackable building module, wherein the integrated functionally operable riser system comprising a riser portion having an upper coupling portion and a lower coupling portion.

[0102] In an example the stackable building module, wherein the upper coupling portion is configured to be capable of vertically engaging with a corresponding lower coupling portion of another building module as described above.

[0103] In an example the stackable building module described above is such that the lower coupling portion is configured to be capable of vertically engaging with a corresponding upper coupling portion of another building module as described above.

[0104] In an example, the stackable building module described above has the lower coupling portion configured to be capable of vertically engaging with a corresponding upper coupling portion of a ground drainage system.

[0105] In examples the stackable building module is configured to form a multi-storey building structure with at least one other building module as claimed in any previous claim by being stacked on top of at least one of the

at least one other building modules, wherein the functional operation of the riser system of each stacked building module is automatically extended vertically by the action of vertically stacking the building modules in alignment.

[0106] In examples the stackable building module described above, wherein the building module is configured to form a multi-storey building structure with at least one other building module as claimed in any previous claim by being stacked under at least one of the at least one other building modules, wherein the functional operation of the riser system of each stacked building module is automatically extended vertically by the action of vertically stacking the building modules in alignment.

[0107] In an example a modular building structure is provided comprising a plurality of building modules described in any of the paragraphs above.

[0108] In an example there is a riser system operably formed by stacking a plurality of building modules as described in any one or more paragraphs above.

[0109] In an example there is a riser system for modular building structures, the riser system comprising:

[0110] at least one building module comprising at least a roof and floor, wherein each building module contains a riser pipework section of the riser system, the riser pipework section comprising a lower downpipe portion of the riser system pipework, the lower downpipe having a spigot section which protrudes through the floor of that building module, wherein the lower downpipe is connected at its upper end to an upper downpipe portion which allows liquids to access the riser system from the roof of that building module; and

at least one riser coupler coupled to lower pipework, each riser coupler comprising: means to capture the spigot section of the riser system pipework of a building module; means to guide the captured spigot into a connection with the lower pipework, wherein the riser coupler is configured to form a liquid-tight seal with the spigot as that building module is lowered into its resting position.

[0111] In an example the riser system as described above, wherein the riser system is provided for a plurality of building modules which are lowered on top of each other to form a multi-storey building structure, and wherein at least one section of the lower pipework comprises a section of riser system pipework in another, lower building module.

[0112] In an example the riser system of the previous paragraph is provided, wherein the lowering of each of the plurality of building module into its rest position over the lower pipework automatically creates a functional extended riser system allowing liquid to be cleared from the roof of the topmost building module to a ground pipework.

[0113] In an example the riser system in any one of the previous four paragraphs is provided, wherein the upper portion of the riser downpipe rises through a fire-stop.

[0114] In an example the riser system in any one of the previous four paragraphs is provided, wherein the

axis of the spigot of the riser system pipework is configured to flex laterally from its true axis position.

[0115] In an example there is a building module for use in a riser system as described in any one of previous four paragraphs, the building module comprising:

a roof;

a floor;

riser pipework comprising a lower downpipe portion and an upper downpipe portion, wherein the lower portion includes a spigot section of downpipe which protrudes through the floor of the building module and is connected at its upper end within the building module to the upper downpipe portion, and wherein the upper downpipe portion is configured to allow liquids to flow off the roof of the building module down the riser system downpipe pipework.

[0116] In an example there is a method of coupling two downpipes in a riser system, the method comprising:

positioning a building module from which a portion of the first one of the downpipes protrudes through the floor of the building module such that the protruding portion is vertically aligned within a predetermined tolerance level with a corresponding recessed portion of the other one of the two downpipes; guiding the building module as it is lowered; capturing the protruding portion of the first downpipe to guide the protruding portion towards the recessed portion of the other downpipe; and automatically forming a sealed coupling between the two downpipes as the building module is guided into its lowered rest position.

[0117] In an example there is a method as described in the previous paragraph, wherein the other downpipe is provided at ground level and the positioning of the modular building module comprises positioning the building module in a raised position above known alignment points provided at ground level.

[0118] In an example there is a method as described in the previous paragraph but one, wherein the other downpipe is provided by another, lower, building module, and the positioning of the modular building module comprises positioning a first building module in a raised position above known alignment points on the roof of the other, lower, building module.

[0119] In an example there is a method as claimed in either of the previous two paragraphs, wherein the guiding of the building module comprises: lowering the first building module onto the known alignment points.

[0120] In an example there is a method as claimed in any one of the previous method paragraphs, wherein a riser coupler is engaged with the recessed portion of the other, lower, downpipe, the riser coupler comprising an inverted cone and seal assembly, and wherein the in-

verted cone captures the protruding portion of pipework to guide it as it is lowered towards the lower downpipe.

[0121] In an example there is apparatus comprising means for performing any one of the above method steps.

[0122] In an example there is a stackable building module as described above, wherein the building module is manufactured with the integrated functionally operable riser system.

[0123] Any reference to 'an' item refers to one or more of those items. The term 'comprising' is used herein to mean including the method blocks or elements identified, but that such blocks or elements do not comprise an exclusive list and an apparatus may contain additional blocks or elements and a method may contain additional operations or elements. Furthermore, the blocks, elements and operations are themselves not impliedly closed.

[0124] The steps of the methods described herein may be carried out in any suitable order, or simultaneously where appropriate. The arrows between boxes in the figures show one example sequence of method steps but are not intended to exclude other sequences or the performance of multiple steps in parallel. Additionally, individual blocks may be deleted from any of the methods without departing from the spirit and scope of the subject matter described herein. Aspects of any of the examples described above may be combined with aspects of any of the other examples described to form further examples without losing the effect sought. Where elements of the figures are shown connected by arrows, it will be appreciated that these arrows show just one example flow of communications (including data and control messages) between elements. The flow between elements may be in either direction or in both directions.

[0125] Where the description has explicitly disclosed in isolation some individual features, any apparent combination of two or more such features is considered also to be disclosed, to the extent that such features or combinations are apparent and capable of being carried out based on the present specification as a whole in the light of the common general knowledge of a person skilled in the art, irrespective of whether such features or combinations of features solve any problems disclosed herein. In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention.

Claims

1. A stackable building module having an integrated functionally operable riser system.
2. A stackable building module as claimed in claim 1, wherein the integrated riser system functions at least as:

a drain which allows fluids to be passed through

the riser system from the roof of the building module; and/or

a foul water drain which allows fluids to be passed from within the building module through the riser system.

3. A stackable building module as claimed in claim 1 or 2, wherein the functionally operable riser system is an integrated externally connectable functionally operable riser system, and wherein the stackable building module is manufactured with the integrated externally connectable functionally operable riser system.
4. A stackable building module as claimed in any previous claim, wherein the integrated functionally operable riser system comprising a riser portion having an upper coupling portion and a lower coupling portion.
5. A stackable building module as claimed in claim 4, wherein the upper coupling portion is configured to be capable of vertically engaging with a corresponding lower coupling portion of another building module as claimed in claim 4.
6. A stackable building module as claimed in claim 4 or 5, wherein the lower coupling portion is configured to be capable of vertically engaging with:
 - a corresponding upper coupling portion of another building module as claimed in claim 4 or 5; or
 - a corresponding upper coupling portion of a ground drainage system.
7. A stackable building module as claimed in any previous claim, wherein the building module is configured to form a multi-storey building structure with at least one other building module as claimed in any previous claim by being stacked on top of or under at least one of the at least one other building modules, wherein the functional operation of the riser system of each stacked building module is automatically extended vertically by the action of vertically stacking the building modules in alignment.
8. A modular building structure comprising a plurality of building modules as claimed in any previous claim.
9. A riser system operably formed by stacking a plurality of building modules as claimed in any previous claim.
10. A riser system for modular building structures, the riser system comprising:

at least one building module comprising at least

a roof and floor, wherein each building module contains a riser pipework section of the riser system, the riser pipework section comprising a lower downpipe portion of the riser system pipework, the lower downpipe having a spigot section which protrudes through the floor of that building module, wherein the lower downpipe is connected at its upper end to an upper downpipe portion which allows liquids to access the riser system from the roof of that building module; and at least one riser coupler coupled to lower pipework, each riser coupler comprising:

means to capture the spigot section of the riser system pipework of a building module; means to guide the captured spigot into a connection with the lower pipework, wherein the riser coupler is configured to form a liquid-tight seal with the spigot as that building module is lowered into its resting position.

11. A building module for use in a riser system as claimed in any one of previous claims 9 to 10, the building module comprising:

a roof;
a floor;
riser pipework comprising a lower downpipe portion and an upper downpipe portion, wherein the lower portion includes a spigot section of downpipe which protrudes through the floor of the building module and is connected at its upper end within the building module to the upper downpipe portion, and wherein the upper downpipe portion is configured to allow liquids to flow off the roof of the building module down the riser system downpipe pipework.

12. A method of coupling two downpipes in a riser system, the method comprising:

positioning a building module from which a portion of the first one of the downpipes protrudes through the floor of the building module such that the protruding portion is vertically aligned within a predetermined tolerance level with a corresponding recessed portion of the other one of the two downpipes;
guiding the building module as it is lowered;
capturing the protruding portion of the first downpipe to guide the protruding portion towards the recessed portion of the other downpipe; and
automatically forming a sealed coupling between the two downpipes as the building module is guided into its lowered rest position.

13. A method as claimed in claim 12, wherein the other

downpipe is provided:

at ground level and the positioning of the modular building module comprises positioning the building module in a raised position above known alignment points provided at ground level, or by another, lower, building module, and the positioning of the modular building module comprises positioning a first building module in a raised position above known alignment points on the roof of the other, lower, building module.

14. A method as claimed in any one of the previous method claims 12 to 13, wherein a riser coupler is engaged with the recessed portion of the other, lower, downpipe, the riser coupler comprising an inverted cone and seal assembly, and wherein the inverted cone captures the protruding portion of pipework to guide it as it is lowered towards the lower downpipe.
15. Apparatus comprising means for performing any one of the above method steps as claimed in claims 12 to 14.

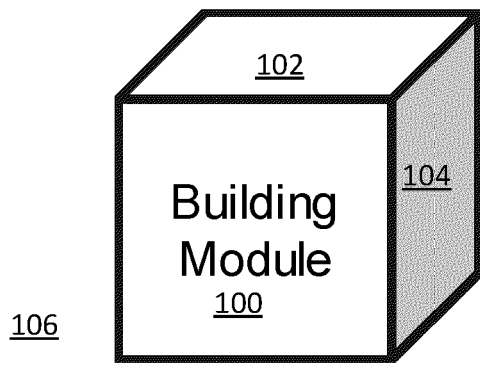


FIG. 1A

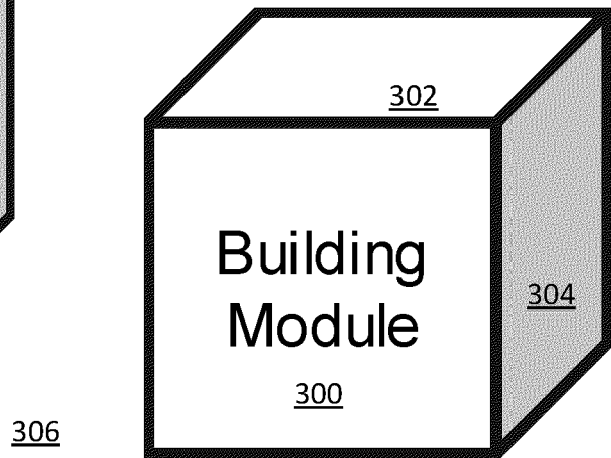


FIG. 1B

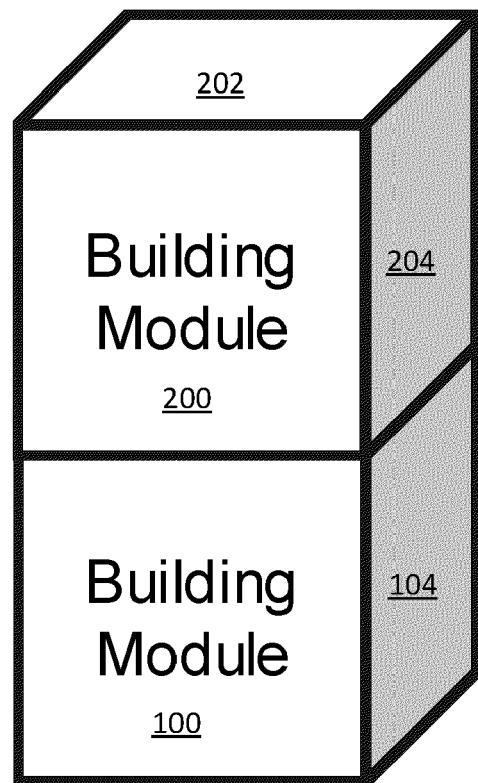
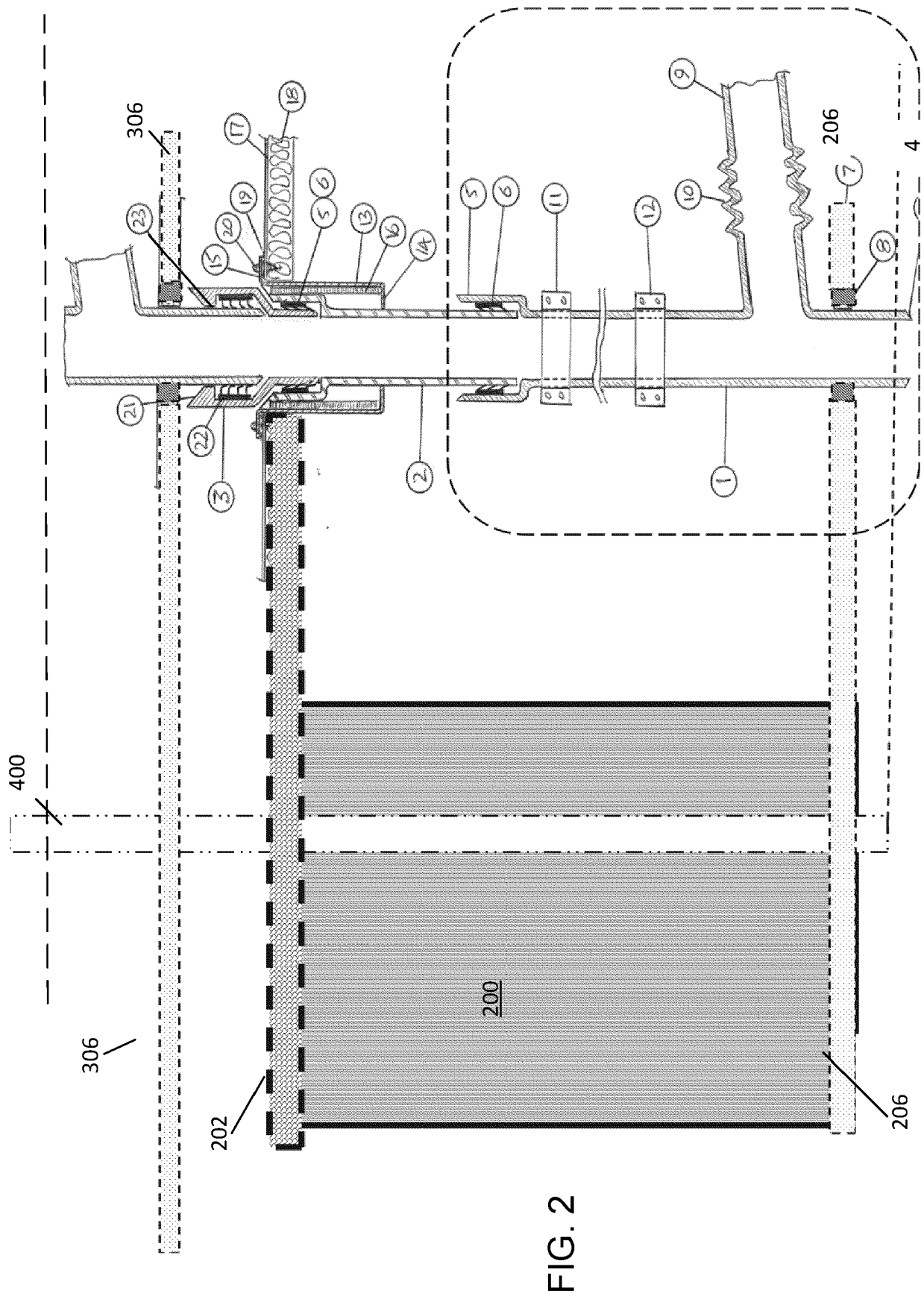
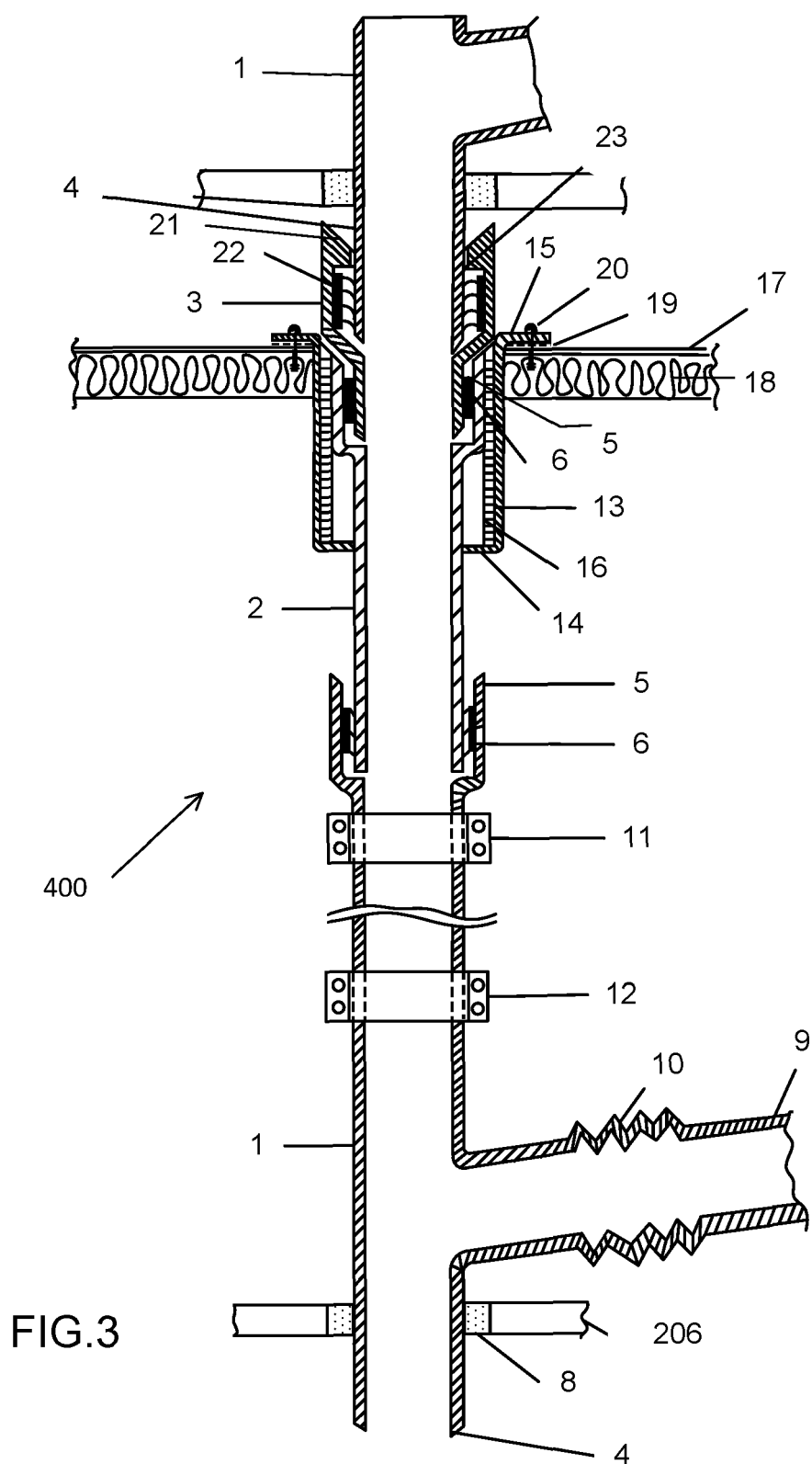
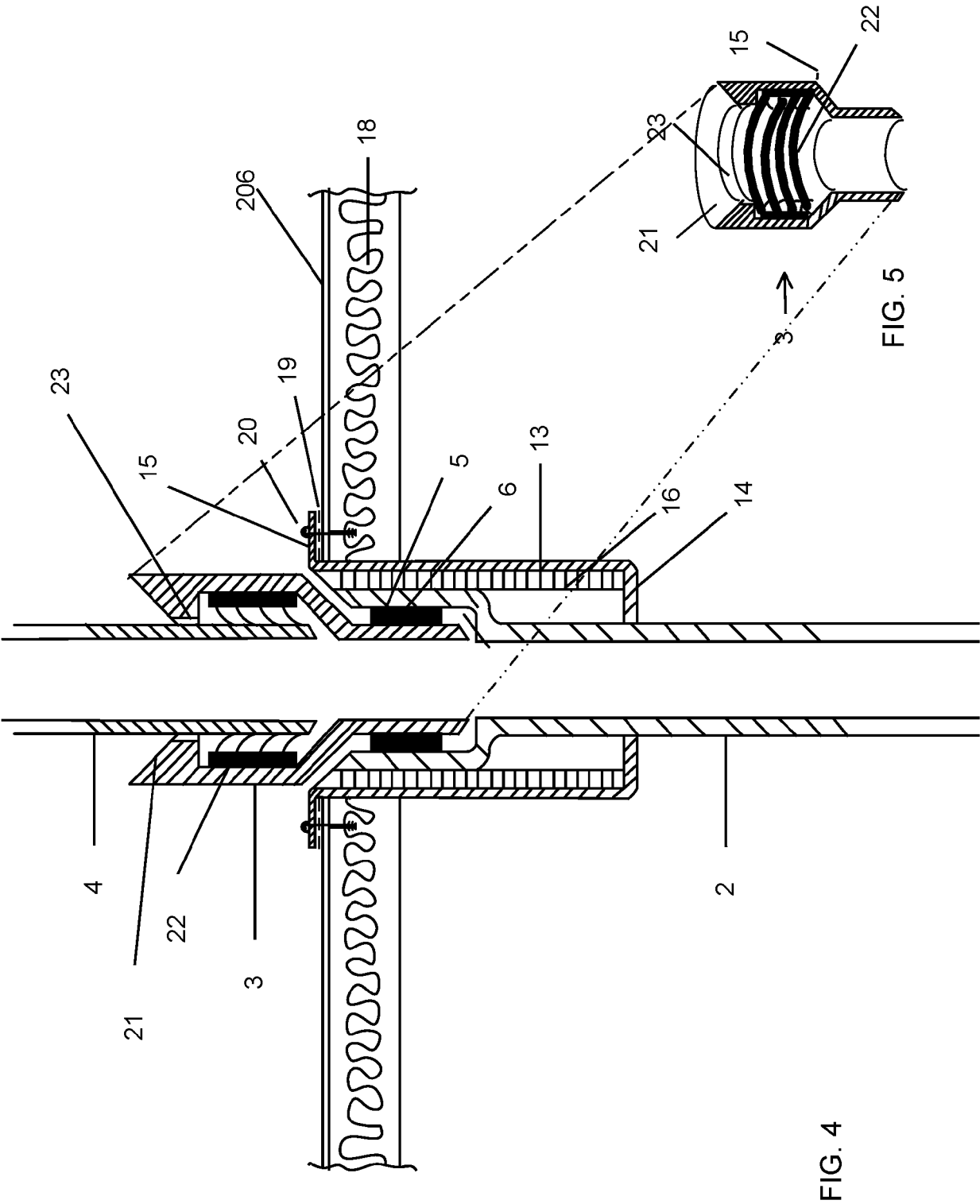


FIG. 1C







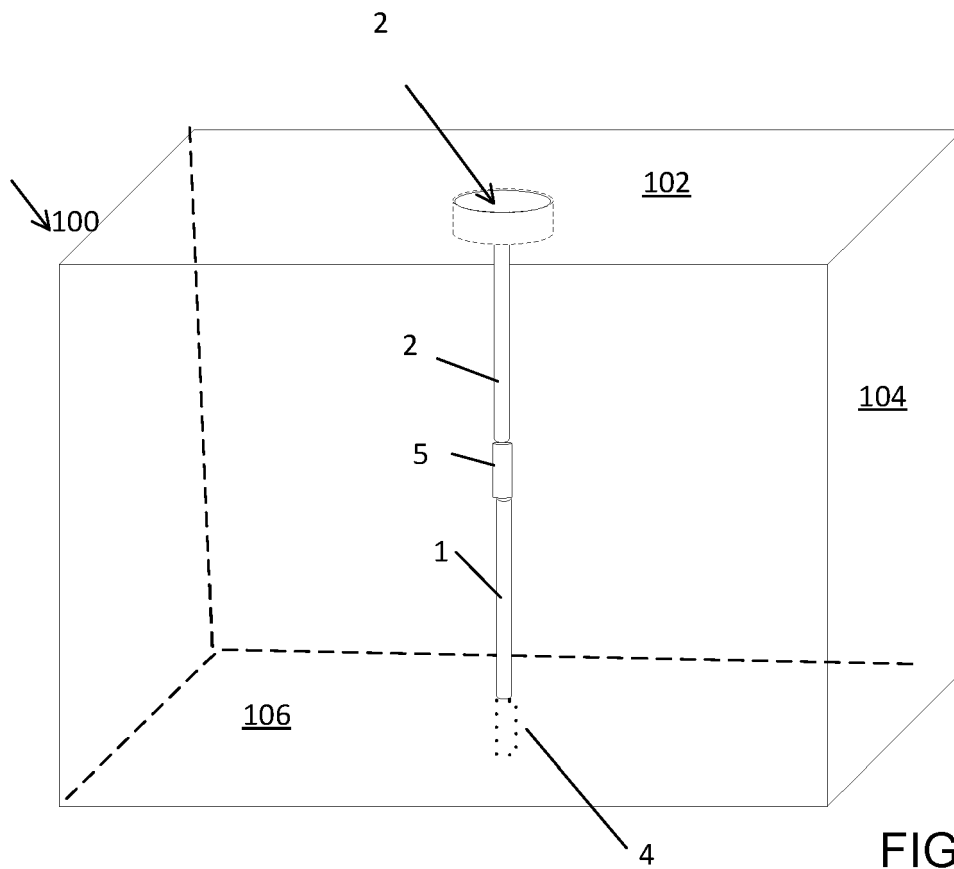


FIG. 6A

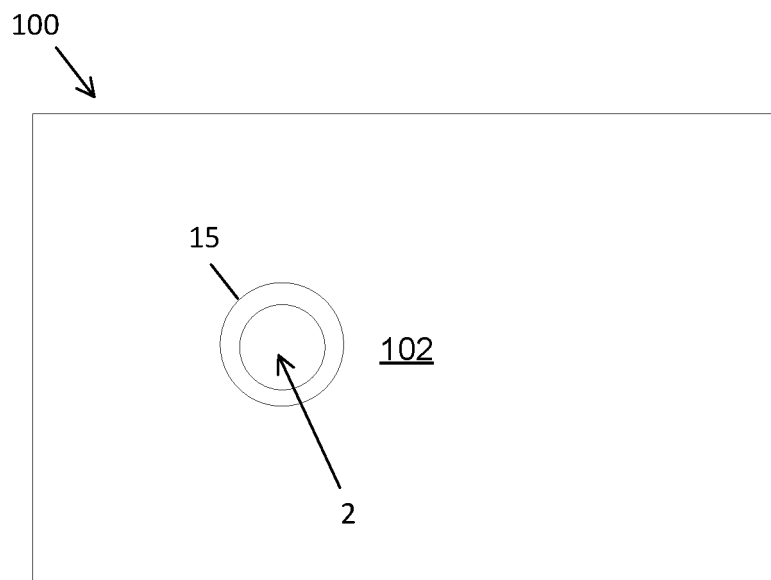


FIG. 6B

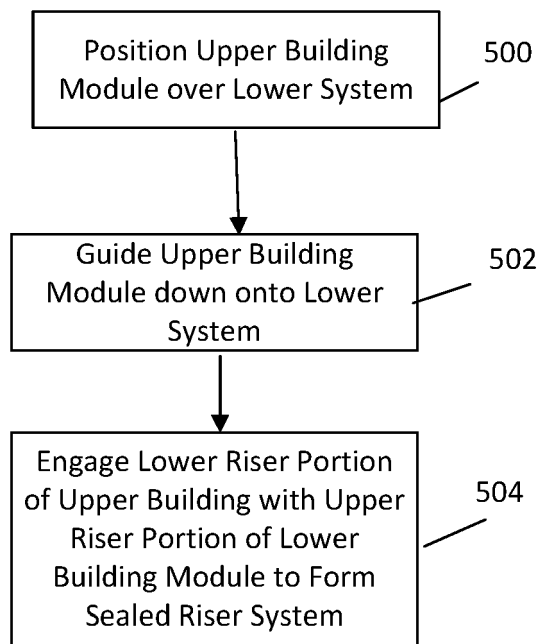


FIG. 7

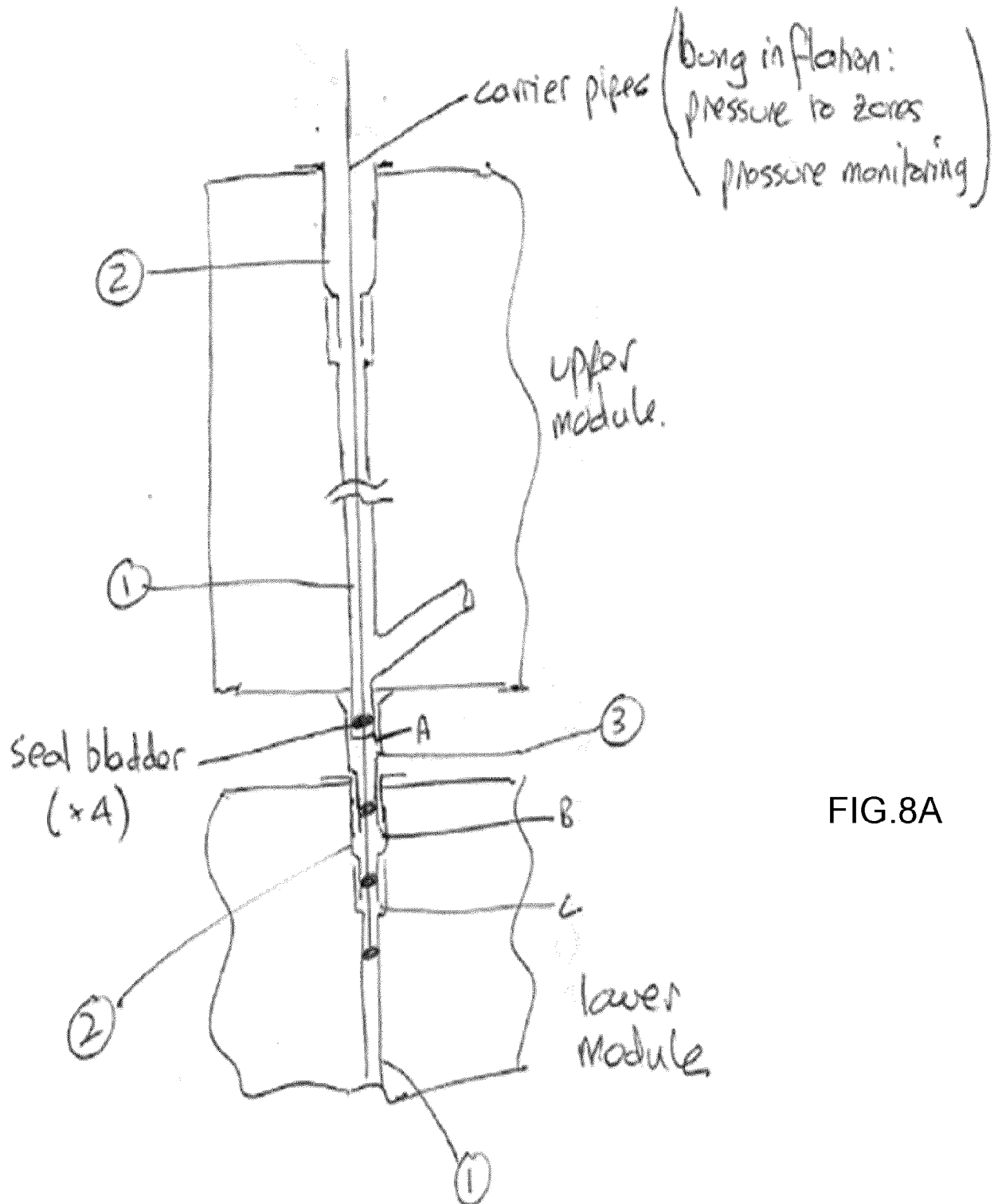


FIG.8A

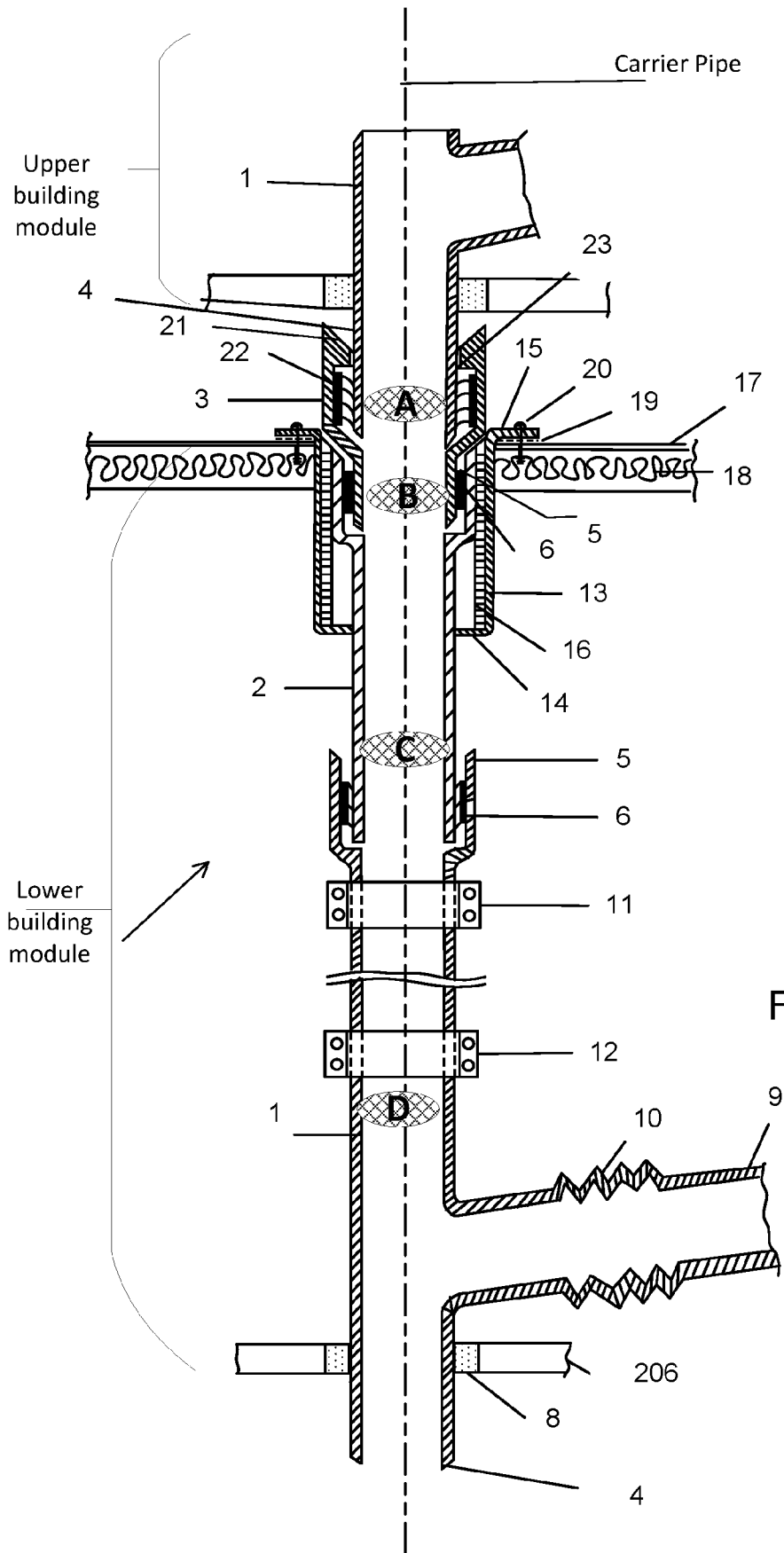


FIG.8B