

(19)



(11)

EP 3 722 551 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

14.10.2020 Bulletin 2020/42

(51) Int Cl.:

E21B 15/00 (2006.01)

E21B 41/00 (2006.01)

B63B 35/44 (2006.01)

(21) Application number: **19168713.6**

(22) Date of filing: **11.04.2019**

(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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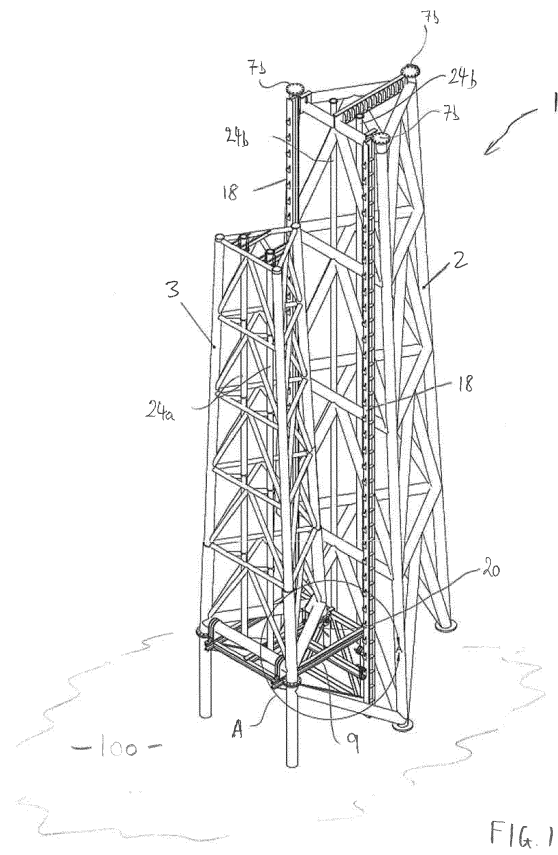
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(54) **IMPROVEMENTS RELATING TO PROVIDING ELONGATE STRUCTURES, IN PARTICULAR FLARE OR VENT TOWERS ON VESSELS**

(57) Apparatus in various embodiments has first and second tower sections for providing a flare or vent tower for flaring or venting gas, the second tower section being arranged to be configurable with respect to the first tower section between a lowered configuration and an erected configuration, and an actuation system to raise or lower the second tower section with respect to the first tower section to position the second tower section in the erected or the lowered configuration.



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Description

Technical field

[0001] The present invention relates in particular to the provision of elongate structures as may typically be installed on a vessel or platform, e.g. floating, production, storage and offloading vessels (FPSOs), oil and gas production ships, floating platforms or rigs, etc. In various examples, such elongate structures may be in the form of flare or vent towers such as used for discharging discharge gas from an oil or gas production process. Other examples of elongate structures include flare or vent arms, or derricks.

Background

[0002] In industrial processes such as the exploration and production of oil and gas, large-scale elongate structures are commonly utilised. In many cases, the production of oil and gas takes place with the assistance of floating platforms or vessels which are brought to an offshore site to recover oil and gas from a wellbore which extends into a subterranean reservoir below the seabed. Such a vessel or platform, e.g. an FPSO, may typically be provided with a flare or vent disposal system including a flare or vent tower which extends to significant height above deck. A derrick may also be installed on the vessel or platform for supporting drilling or production equipment to be engaged in operations in the well.

[0003] Generally speaking, a flare or vent disposal system collects and discharges gas from atmospheric or pressurized process components to the atmosphere to safe locations for final release during normal operations and abnormal conditions (emergency relief). In vent systems, the gas exiting the system is dispersed in the atmosphere. Flare systems generally have a pilot or ignition device that ignites the gas exiting the system because the discharge may be either continuous or intermittent. Gas-disposal systems for tanks operating near atmospheric pressure are often called atmospheric vents or flares, and gas-disposal systems for pressure vessels are called pressure vents or flares. A flare or vent system from a pressurized source may include a control valve, collection piping, flashback protection, and a gas outlet. A scrubbing vessel should be provided to remove liquid hydrocarbons.

[0004] Because FPSOs typically have to process very large quantities of high-pressure gas, the relief systems and, therefore the flare systems, must usually be designed to handle extremely large quantities of gas quickly. By nature, flares normally have to be located very close to production equipment and the FPSO, but preferably as far away from personnel and living quarters as possible. Maximum emergency-flare design is based on emergency shut in of the production manifold and quick depressurization of the system. Maximum continuous-flare design is based on loss of produced-gas transport,

single compression shutdown, gas-turbine shutdown, etc. Typical flare mountings on an offshore platform are angled boom mounting or vertical towers.

[0005] The height is generally based on the radiant-heat intensity generated by the flame. The stack should be located so that radiation releases from both emergency and long-term releases are acceptable and so that hydrocarbon and H₂S dispersion is adequate if the flame is extinguished. The stack also should be structurally sound and withstand wind, vessel motions, and other miscellaneous loadings. This commonly leads to the flare tower being a tall and relatively heavy structure. Flare or vent tubing extends along the tower to communicate the gas to the flame or vent outlet.

[0006] The construction of the FPSO could commonly be built in an area where the transit voyage to the operational site would set limitations on the total height to allow passage below bridges, such as the Mubarak Peace Bridge (Suez canal bridge) with a 60 meters' clearance, the Centennial Bridge (Panama Canal bridge) with an 80-meter clearance, Niterói Bridge (Brazil) with a 60-meter clearance, etc. Commonly, the necessary flare towers on FPSOs will exceed this clearance. To address this difficulty, the conventional practice is to move the FPSO to another yard and then install the flare towers at a later stage at another location/yard from where the FPSO can then transit to the operational site, e.g. well site without obstacle. Furthermore, due to the large weight and height of the flare tower, special lifting facilities will normally be needed for installing this on the FPSO. These lifting facilities normally need to be pre-ordered for a specific date, a long time prior to the FPSO arrival at location for flare tower installation, and conventionally a mobilization rate is charged in addition to a day rate for the special lifting facility. If the FPSO project is delayed, a standby rate of the lifting device could be significant. Cancelling or rescheduling of the lifting devices normally also costly depended on contract terms, market, and location. The availability of these lifting devices could also be critical and challenge the whole start up schedule of the FPSO.

[0007] The transit voyage to the location of operation could also be governing for the design of the flare tower, as the metocean condition along the transit route could imply much worse accelerations, wind loads, etc. on the flare tower than in the field of operation. The flare tower can be especially vulnerable to these increased loads due to the share height of the centre of gravity, which would normally result increase the steel weight of the flare tower and reinforcements in the hull. Similar considerations apply to other elongate structures on FPSO vessels, platforms, or the like.

[0008] At least one aim of the invention is to obviate or at least mitigate one or more drawbacks of prior art solutions.

Summary of the invention

[0009] According to a first aspect of the invention, there is provided apparatus comprising first and second tower sections for providing a flare or vent tower for flaring or venting gas, the second tower section being arranged to be configurable with respect to the first tower section between a lowered configuration and an erected configuration; and an actuation system to raise or lower the second tower section with respect to the first tower section to position the second tower section in the erected or the lowered configuration.

[0010] When in the erected configuration, the second tower section can reach a certain height beyond the first tower section. When in the lowered configuration, the height that the second tower section can reach can be reduced or the second tower section can be arranged so that it does not reach any height beyond that of the first tower section. In this way, the apparatus can be installed on a vessel and the vessel can advantageously transit under low clearance bridges in the lowered configuration.

[0011] At a desired site for operation of the flare or vent tower, the second tower section can be raised and positioned in the erected configuration. In the erected configuration, the second tower section can reach to its full height beyond an end of the first tower section, as may be determined at least partially by the length of the second tower section. By raising the second tower section, the amount by which the second tower section may extend from the end of the first tower section and/or the height attained by the second tower section can be increased. The actuation system can be configured to move the second tower section in a constrained or guided movement pattern or trajectory between the lowered and the erected configurations, and conveniently actuated, e.g. through vessel systems, to initiate and/or control the movement between the lowered and the erected configurations. For example, the actuation system may be operable in response to receiving a signal communicated from a computer device. The first and second tower sections may be movably coupled during the movement therebetween.

[0012] The apparatus may include guide means capable of guiding the movement of the second tower section relative to the first section between the lowered configuration and the erected configuration, e.g. as the second tower section is advanced longitudinally along the first tower section. More specifically, the first tower section may have or be provided with at least one guide arrangement for guiding the second tower section during movement between the lowered configuration and the erected configuration.

[0013] The guide arrangement which may comprise e.g. a sleeve, slot, or recess, or the like, which may provide a channel for receiving a part of the second tower section. The guide arrangement may be arranged to allow movement of the second tower longitudinally along the first tower section and prevent or restrict undesired

movement of the second tower section transverse to the longitudinal direction.

[0014] The guide means may comprise one or more guide rails arranged to extend along the first tower section. The apparatus may further comprise at least one support for supporting the second tower section, wherein the support may be movable along the guide rail(s), relative to the first tower section. Thus, by movement of the support along the guide rail(s), the second tower may be moved correspondingly. The apparatus and/or actuation system may comprise an assembly (e.g. lifting/lowering/skidding assembly) including the support for the second tower section. The guide rail(s) may be disposed on outside of a frame of the first tower section.

[0015] The guide means may comprise a configuration of an elongate frame of the first section arranged to receive or be received in an elongate frame of the second tower section, e.g. in a nested or telescopic arrangement. The frames may then have a geometric fit whereby the frames may be arranged to permit relative movement longitudinally but substantially prevent or restrict movement transverse to the longitudinal direction. For example, the frames may have corners which align one within the other in a tight fit, such that the one frame cannot rotate to any significant degree when arranged within the other frame. The first frame may in such an example have one or more surfaces against which for example a part of the frame of the second tower section may bear, e.g. slidably or the like, for guiding the second tower section longitudinally.

[0016] The second tower section may be supported on the first tower section, wholly or partially, during the movement of the second tower section relative to the first tower section between the lowered configuration and the erected configuration.

[0017] The second tower section may be coupled to and/or supported on the first tower section via at least one part of the actuation system, e.g. an assembly (e.g. lifting or jacking assembly) and/or mechanism of the actuation system, or one or more components of such an assembly and/or mechanism, such component(s) e.g. pinions, rack, rail, brackets, jacking points, hydraulic extender, etc.

[0018] The actuation system may comprise at least one rack and pinion mechanism.

[0019] The rack and pinion mechanism may comprise at least one pinion arranged on the first tower section and at least one rack to be engaged by the pinion. The rack may be arranged on or connected to the second tower section, thus may form a unitary structure therewith. The second tower section may comprise an elongate frame comprising longitudinal support members or chords and the rack arranged on or connected to the second tower section may be mounted along at least one of the longitudinal support members or chords, e.g. integrated therewith.

[0020] The rack and pinion mechanism may comprise at least one pinion arranged on the second tower section,

and/or on a mover assembly (e.g. lifting assembly) to which the second tower section may be fastened, and at least one rack to be engaged by the pinion. The rack may be arranged on the first tower section or may be connected to the first tower section, and thus may form a unitary structure therewith. The first tower section may comprise an elongate frame comprising longitudinal support members or chords and the rack arranged on or connected to the first tower section may be arranged along at least one of the longitudinal support members or chords, e.g. integrated therewith.

[0021] The actuation system may comprise at least one jacking mechanism.

[0022] The jacking mechanism may comprise at least one hydraulic actuator. The jacking mechanism may further comprise at least one set of formations engagable by operation of the actuator, e.g. brackets, jacking points, engagers or the like for supporting a jacking distributed along the first or second tower section, e.g. along a rail, chord, etc., thereof.

[0023] The actuator, e.g. a linearly extendable or retractable actuator, e.g. a hydraulic or electric actuator, may be connected to at least one engager and may operate in repeated strokes to position the engager against engaging formation(s) progressively further along the set of formations.

[0024] The actuation system may include a mover which may be movably coupled to the first tower section for travelling longitudinally along the first tower section for moving the second tower section between the lowered configuration and the erected configuration. An end, e.g. a lower end in use, of the second tower section may be supported upon and fastened to the mover for advancement along the first tower. The mover may thus be adapted to support the second tower section.

[0025] The mover may be movably coupled to the first tower section via at least one longitudinally extending rail or support member, which may be for instance at least one guide rail. In examples in which the actuation system comprises at least one rack and pinion, the mover may be movable coupled to the first tower section via a rack. In such examples, the apparatus may also include one or more guide rail(s), which may have surfaces arranged for restricting / preventing undesired transverse displacement of the mover with respect to the first tower section.

[0026] The mover may include the actuator. When in contact against the engaging formations, in use, leverage may be provided for the actuator to act against to jack the mover along the assembly. The mover may in use therefore climb upward along the set of formations, "step-wise", by operation of the actuator jacking.

[0027] The first tower section may include at least one flare or vent pipe for communicating flare or vent gas. The second tower section may include at least one flare or vent pipe for communicating flare or vent gas. The first tower section may comprise an elongate frame and the flare or vent pipe of the first tower section may extend along the frame. The second tower section may comprise

an elongate frame and the flare or vent pipe of the second tower section may extend along the frame. In the erected configuration, an end of the flare or vent pipe of the second tower section may be alignable with an end of the flare or vent pipe of the first tower section for connecting the ends. When the ends are connected, flare or vent gas may be communicated through the connected pipes, e.g. to an outlet to atmosphere, and/or ignition point.

[0028] The second tower section or the first tower section may include at least one adjuster for adjusting the position of the vent or flare pipe of the second or first tower section. The vent or flare pipe may be adjusted relative to the elongate frame of the first or second tower section. The vent or flare pipe may be supported on the frame, e.g. via a clamp, other fixture, and/or via the adjuster. The adjuster may be operable to adjust the position of the vent or flare pipe longitudinally along, or rotationally about the longitudinal axis, relative to the frame about a longitudinal axis of the tower section. The adjuster may in some examples be adapted to adjust the position of the end of the flare or vent tubing azimuthally about the longitudinal axis of the tower section. By adjustment of the flare or vent pipe, the connecting end of the pipe of the first or second tower section may be aligned with the connecting end of the flare or vent pipe of the other of the first and second tower sections. By doing so, this may allow the ends of the sections of tubing to be coupled together in the erected configuration.

[0029] The actuation system may comprise at least one actuator, which may comprise a cylinder or housing from which an arm may extend or retract. The cylinder may be a hydraulic cylinder. The actuator may be a hydraulic and/or electrical actuator. The actuator may preferably be a linear actuator, thus extension or retraction may be linear. The actuator may be operable for driving or controlling movement of the second tower section relative to the first tower section between the lowered and the erected configuration. The actuator may be extendable or retractable, one end coupled to the first tower section and the other end coupled to the second tower section, for raising or lowering the second tower section with respect to the first tower section.

[0030] The actuation system may comprise at least one "longitudinal" actuator for urging the second tower section longitudinally along the first tower section or urging the mover longitudinally along the first tower section, e.g. when the second tower section is attached to the mover. The actuation system may further comprise at least one transverse "actuator" for urging the second tower section transversely to the longitudinal direction. The longitudinal actuator is extendable or retractable, preferably linearly, in the longitudinal direction. The transverse actuator is extendable or retractable, preferably linearly, in the transverse direction.

[0031] The actuation system may include the mover, e.g. a lifting assembly or lifting and skidding assembly, which may be movable longitudinally along the first tower section. The mover may include the longitudinal actuator

and the transverse actuator. The longitudinal actuator may be configured to be supported on the first tower section and urge the second tower section along the first tower section, e.g. one end of the actuator may be supported on the first tower section or associated formations and the other end of the actuator may engage the second tower section or the mover to which the second tower section may be fastened.

[0032] The transverse actuator may be configured to be supported on the mover or on the first tower section and may urge the second tower section or part of the mover in the transverse direction. One end of the transverse actuator may be connected to a first part of the mover (e.g. main frame or rail) and the other end of the transverse actuator may be connected to the second tower section or a second part of the mover (e.g. skidding frame) to which the second tower section may be fastened for transverse movement. At least one end of the transverse actuator may be releasably connectable e.g. by a clamp, locking pin, or the like, to allow for repositioning the end and repeated (preferably linear) extension or retraction strokes for advancing the second tower section or second part of the mover (relative to the first part of the mover) in the transverse direction.

[0033] The first and second tower sections may be arranged telescopically. In this way, the second tower section may be telescopically movable with respect to first tower section between the lowered configuration and the erected configuration. The lowered configuration may thus be a telescopically retracted configuration. The erected configuration may thus be a telescopically extended configuration.

[0034] The second tower section may be pivotally movable relative to the first tower section. The second tower section may be coupled to and/or supported upon the first tower section by at least one hinge. In this way, the hinge may comprise a pivot for accommodating the rotational movement between the first and second tower sections. The hinge may be positioned between an upper end of the first tower section and a lower end of the second tower section. The second section may be foldably movable between the lowered configuration and the erected configuration. In the lowered configuration, the second tower section may be arranged relative to the first tower section in upside-down relationship.

[0035] In the lowered configuration, the first and second tower sections may be arranged side-by-side. In the erected configuration, the second tower section may extend beyond the second end of the first tower section.

[0036] Each tower section has first and second ends. The first, lower end of the first tower section may be arranged fixedly connected to structure, e.g. deck, floor, or mounting. In the erected configuration, the second tower section may extend beyond the second, upper end of the first tower section.

[0037] The second tower section may be movable in at least one phase of movement longitudinally along the first tower section and in at least one phase of movement

transverse to the longitudinal direction, e.g. laterally, in use.

[0038] The first and second tower sections may each typically comprise an elongate frame, and the elongate frame may comprise one more longitudinal chords or support members, which may preferably extend from one end of the frame to the other. The chords or support members may define corners of the frame. A transverse cross-sectional shape of the frame may be polygonal, e.g. triangular, or square, and the chords or supports may be positioned in the corners of the polygonal section.

[0039] In the erected configuration, the first and second sections may be arranged to be connected or fastened together for fixing the first and second sections in position for operation of the flare or vent tower. The first tower section may comprise an elongate frame comprising longitudinal chords or support members. The second tower section may comprise an elongate frame comprising longitudinal chords or support members. In the erected configuration, the longitudinal chords or support members in the respective frames of the first and second tower sections may be arranged in alignment. An end of at least one longitudinal chord or support member of the second section may be aligned with and connected to an end of a corresponding chord or support member of the second tower section. The ends of the chords or support members to be connected may have radial flanges, and flange connections may be made up between the flanges to connect the ends, for fastening the first and second tower sections together. The connection(s) between chords or support members of the respective first and second tower sections may secure the first tower section in fixed position to the second tower section.

[0040] The erected configuration may be a deployed configuration, and the lowered configuration may be a withdrawn configuration. In this sense, the actuation system may operate to move the second tower section relative to the first tower section to position the second tower section in the deployed configuration or the withdrawn configuration.

[0041] According to a second aspect of the invention, there is provided a vessel or platform including the apparatus according to the first aspect of the invention. The first tower section may be fixed to a structure of the vessel, e.g. a deck. The first tower section may project upward from the structure of the vessel. The second tower section, in the erected configuration, may be arranged to extend upward from a projecting end of the first tower section. The first tower section may thus be a lower tower section, and the second tower section may be an upper tower section.

[0042] The vessel may be an FPSO vessel. The flare tower may support flare or vent tubing for communicating gas to a vent or flare outlet on the tower. A first section of the tubing may be supported by the first tower section, and a second section of the tubing may be supported by the second tower section. In the erected configuration, the first and second sections of tubing are arranged to

align connecting ends of the first and second sections of the tubing such that upon making up a connection between the connecting ends, the first and second sections of tubing may be coupled together for communicating the gas to be vented or flared through the connected sections of the tubing. The sections of the tubing may be connected through pipework or other conduits to a source of gas. The gas may be discharged from an oil or gas exploration or production activity, e.g. the production and recovery of oil and gas from a subterranean reservoir.

[0043] According to a third aspect of the invention, there is provided a method of using the apparatus according to the first aspect of the invention on a vessel, the method comprising: providing the apparatus in the lowered configuration; and raising the second tower section relative to the first tower section to position the second tower section in the erected configuration.

[0044] The method may further comprise: sailing the vessel underneath a bridge in the lowered configuration; and performing the raising step after passing underneath the bridge. The method may further comprise, in the erected configuration, operating the flare tower to vent or flare gas from at least one outlet near a far end of the tower. The method may further comprise supplying gas to be flared or vented through tubing along the flare tower to the outlet, e.g. discharge gas from an oil or gas exploration or production activity. The tubing may be supported on the tower and may extend along the tower between a lower end and an upper end of the tower.

[0045] According to a fourth aspect of the invention, there is provided apparatus comprising first and second arm sections for providing a flare or vent arm for flaring or venting gas, the second arm section being arranged to be configurable with respect to the first arm section between a withdrawn configuration and a deployed configuration; and an actuation system to move the second arm section with respect to the first arm section to position the second arm section in the deployed configuration or the withdrawn configuration.

[0046] The first and second arms sections may typically be elongated sections, whereby in the deployed configuration, the second arm section may be arranged to extend beyond an end of the first arm section. In the deployed configuration, the second arm section is arranged to be coupled to the first arm section to fasten the second arm section fixedly to the first arm section. The first arm section may comprise a section of flare or vent tubing and the second arm section may comprise a section of flare or vent tubing to be coupled to the section of flare or vent tubing of the first arm section. The section of flare or vent tubing may be arranged to be supported upon and/or extend along the respective arm sections.

[0047] The apparatus may be provided on a vessel or a platform. The first arm section may be connected to a structure of the vessel and project from the structure of the vessel. In the deployed configuration, the second arm section may reach over a side of the vessel. In the withdrawn configuration, the reach of the second arm section

may be reduced compared with the deployed configuration. Advantageously, the vessel may travel or transit through a small-width canal, channel, or lock, when in the withdrawn configuration.

[0048] According to a fifth aspect of the invention, there is provided apparatus comprising first and second tower sections for providing a flare or vent tower for flaring or venting gas, the second tower section being arranged to be configurable with respect to the first tower section between a withdrawn configuration and a deployed configuration; and an actuation system to move the second tower section with respect to the first tower section to position the second tower section in the deployed configuration or the withdrawn configuration. According to a sixth aspect of the invention, there is provided apparatus comprising first and second longitudinal sections for providing an elongate structure e.g. for an oil and gas production or exploration process, the second longitudinal section being arranged to be configurable with respect to the first longitudinal section between a withdrawn configuration and a deployed configuration; and an actuation system to move the second longitudinal section with respect to the first longitudinal section to position the second longitudinal section in the deployed configuration or the withdrawn configuration.

[0049] The elongate structure may be a flare or vent tower, flare or vent boom or arm, a derrick, or the like. The first and second longitudinal sections may be first and second tower sections, respectively. The actuation system may raise the second longitudinal section with respect to the first longitudinal section.

[0050] According to a seventh aspect of the invention, there is provided apparatus comprising first and second derrick sections for providing a derrick for supporting wellbore operations equipment, the second derrick section being arranged to be configurable with respect to the first derrick section between a lowered configuration and an erected configuration; and an actuation system to raise or lower the second derrick section with respect to the first derrick section to position the second derrick section in the erected or the lowered configuration.

[0051] According to an eighth aspect of the invention, there is provided a vessel or platform including the apparatus in accordance with any of the fourth to sixth aspects of the invention.

[0052] The apparatus may be substantially as described herein with reference to any one or more of the examples and/or drawings. Any of the aspects of the invention may include further features as described in relation to any other aspect, anywhere herein.

[0053] The various aspects of the invention and embodiments thereof can provide various advantages as will be apparent from the specification throughout.

55 Drawings

[0054] There will now be described, by way of example only, embodiments of the invention with reference to the

accompanying drawings, in which:

- Figure 1 is a perspective representation of apparatus for forming a flare tower, the upper section of the tower to be formed, arranged in a lowered, parked configuration;
- Figure 2 is a perspective representation of the apparatus of Figure 1 after elevating the upper section;
- Figure 3 is a perspective representation of the apparatus of Figures 1 and 2 during lateral skidding of the elevated upper section of Figure 2;
- Figure 4 is a perspective representation of the apparatus of Figures 1 to 3 where the upper section is positioned in an erected configuration, after having been skidded laterally to position the upper section above the lower section of the tower;
- Figure 5 is a perspective representation of the apparatus of Figures 1 to 4, the lifting frame parked near the base of the tower;
- Figure 6A is a close-up view of the arrangement of the lift and skid assembly of the apparatus of Figures 1 to 5, of the circled area A of Figure 1;
- Figure 6B is a close-up view of a main frame of the lift and skid assembly of the apparatus of Figures 1 to 5;
- Figure 7 is a perspective representation of another apparatus for a flare tower, the upper section of the tower to be formed being arranged in a parked configuration, offset from the lower section, the lift and skid assembly having a rack and pinion mechanism for elevating the upper section;
- Figure 8 is a perspective representation of the apparatus of Figure 7 after elevating the upper section;
- Figure 9 is a perspective representation of the apparatus of Figures 7 and 8 during lateral skidding of the elevated upper section of Figure 8;
- Figure 10 is a perspective representation of the apparatus of Figures 7 to 9 where the upper section is positioned in an erected configuration, after having been skidded laterally into position above the lower section of the tower;
- Figure 11 is a perspective representation of the apparatus of Figures 7 to 10, the lifting frame is returned to a parked position near the base of the tower;
- Figure 12 is a close-up view of the arrangement of the lift and skid assembly of the apparatus of Figures 1 to 5, of the circled area B of Figure 7;

- Figure 13A is a top view of the apparatus of during the lateral skidding as depicted in Figure 3 and 9;
- Figure 13B is a side sectional representation in close up of the apparatus including the lower end of the upper section and the upper end of the lower section of the tower to be formed, during the lateral skidding of the upper section as depicted Figures 3, 9, and 13B;
- Figure 14A is a side representation of the upper section of the tower of the apparatus of Figures 1 to 13B;
- Figure 14B is a close-up representation along the line G-G in Figure 14A showing details of the vertical adjustment mechanism for the flare or vent pipes;
- Figure 15A is a perspective representation of another apparatus for a flare tower, in parked configuration, where the upper section of the tower to be formed is hinge coupled to the lower section and parked in upside down configuration;
- Figure 15B is a close-up representation of detail within the circled area A of Figure 15A;
- Figure 16A is a perspective representation of the apparatus of Figure 15A, partially erected;
- Figure 16B is a close-up representation of detail within the circled area B of Figure 16A;
- Figure 17A is a perspective representation of the apparatus of Figure 15A, partially erected and after connecting a pull cylinder for pulling the upper section about a pivot to position the upper section in the erected configuration;
- Figure 17B is a close-up representation of detail within the circled area C of Figure 17A;
- Figure 18 is a perspective representation of the apparatus, the upper section fully erected in the erected configuration for forming the flare or vent tower;
- Figure 19A is a perspective representation of apparatus for forming a tilted flare or vent tower using tension mechanism, the upper section lowered;
- Figure 19B is a perspective view of the apparatus of Figure 19A after tensioning and the upper section is fully erected in alignment with the lower section to form the tilted tower;
- Figure 20A is a side view of the apparatus of Figures 19A and 19B with lowered and erected positions of the upper section of the tilted tower superimposed;
- Figure 20B is a close-up representation of detail within the circled area A of Figure 20A;
- Figure 21A is a perspective representation of apparatus for forming a flare tower, in a parked configuration, where the upper and lower

sections of the tower to be formed are arranged to be telescopically extendable and the upper section is lowered;

Figure 21B is a close-up representation of detail within the circled area A of Figure 21A;

Figure 22A is a perspective representation of the apparatus of Figure 21A where the upper section of the tower is extended, and in fully erected configuration;

Figure 22B is a close-up representation of detail within the circled area B of Figure 22A;

Figure 23A is a perspective representation of another apparatus for forming a flare tower, in a parked configuration, where the upper and lower sections of the tower to be formed are arranged to be telescopically extendable, the lifting assembly utilises a centred jacking mechanism;

Figure 23B is a close-up representation of detail within the circled area A of Figure 23A;

Figure 24A is a perspective representation of the apparatus of Figure 24A, the upper section of the tower extending from the end of the lower section in an erected configuration;

Figure 24B is a close-up representation of detail within the circled area B of Figure 24A;

Figure 25A is a perspective representation of another apparatus for forming a flare tower, in a lowered configuration, where the upper and lower sections of the tower to be formed are arranged to be telescopically extendable, the lifting assembly utilises corner jacking mechanisms;

Figure 25B is a close-up representation of detail within the circled area A of Figure 25A;

Figure 26A is a perspective representation of the apparatus of Figure 25A in an erected configuration, the upper section of the tower extending from the end of the lower section;

Figure 26B is a close-up representation of detail within the circled area B of Figure 26A;

Figure 27A is a perspective side view of one of the jacking mechanisms of the apparatus of Figures 25A and 26A;

Figure 27B is an underside perspective view of the jacking mechanism of Figure 27A;

Figure 28A is side sectional view of part of the apparatus of Figure 25A during use of the jacking mechanism in an initial step of a jacking sequence, the jacking frame in a first position;

Figure 28B is a smaller scale top view of the apparatus of Figure 28A;

Figure 29A is side sectional view of part of the apparatus during use of the jacking mechanism in a further step of the jacking sequence, the jacking frame in a second po-

sition;

Figure 29B is a smaller scale top view of the apparatus of Figure 29A;

Figure 30A is side sectional view of part of the apparatus during use of the jacking mechanism in a yet further step of the jacking sequence, the jacking frame in a third position;

Figure 30B is a smaller scale top view of the apparatus of Figure 30A;

Figure 31A is side sectional view of part of the apparatus during use of the jacking mechanism in a yet further step of the jacking sequence, the jacking frame back in the first position, but the upper section elevated relative to the lower section of the tower; and

Figure 31 B is a smaller scale top view of the apparatus of Figure 31A.

Specific description

[0055] Referring to Figure 1, apparatus 1 includes first and second tower sections 2, 3 for forming a flare or vent tower. The apparatus 1 is arranged on a deck 100 of a vessel. The first and second tower sections 2, 3 can be configured with respect to one another so as to obtain an erected configuration in which the second tower section extends upward beyond an end of the first tower section. To do so, the second tower section 3 is actually movable with respect to the first tower section 2 from a lowered (or withdrawn) configuration as shown in Figure 1 and an erected (or deployed) configuration as shown for example in Figure 4. In the erected configuration, the first and second tower sections are coupled together for operational use of the flare or vent tower. Various actuation systems can be used to lift the second tower section relative to the first tower section and move it into position in the erected configuration such that it extends upward from the end of the first tower section. In the following, some examples of possible actuation systems are described. It will be appreciated that any suitable actuation system may be used to raise the second tower section and position it in the erected position, including ones not explicitly mentioned herein.

[0056] As can be appreciated, the flare or vent tower can be formed through raising the second, upper tower section between a lowered configuration and an erected configuration wherein in the erected configuration the raised second section is positioned so that it can be coupled to the first section and extend upward beyond the end of the first, lower tower section. A sectionalised flare or vent tower solution where sections can be actuated to be lowered from and later raised by the actuation system into the erected configuration for operation can facilitate passage of the vessel below bridges and reduce transit loads and/or bending moments. Thus, transit to a site through canals or below bridges can be made more easily

possible.

[0057] In addition, lifting requirements may be reduced due to reduced height of the apparatus in the lowered configuration compared with for example prior art installations of full-height flare towers. Increased freedom of scheduling and convenience can be obtained due to reduced lifting requirements from external lifting devices by incorporation of the lifting facilities in the apparatus on board the vessel. Repeat transits may be made simpler/easier. The tower can easily be erected when in operational location and may be erected independent of external lifting facilities availability at the operation location, through using the actuation system on board the vessel. By transiting in the lowered configuration, the structure of the apparatus may better cope with loads from environmental forces upon transit and may experience lower transit loads than in prior art solutions. The typical height reached by the flare tower on a vessel in the erected configuration may be in the region of 80 to 140 m above the water line.

Offset tower examples

[0058] Figure 1 shows the configuration of the apparatus 1 where the upper tower section 3 (the second tower section) is lowered and parked in a position close to deck elevation. The main parts of the apparatus 1 comprise the lower tower section 2, the upper tower section 3, a vertical lifting assembly 9 and a horizontal skidding assembly 20. The upper tower section 3 is movable relative to the lower tower section 2 to position the upper tower section in the erected configuration, by way of the vertical and horizontal lifting assemblies 9, 20. The lower tower section 2 is bolted or welded onto its foundation on the facility, e.g. in this case connecting to the deck 100 of the vessel, to ensure proper fixation of the flare tower to the vessel in all operational conditions. Guide rails 18 are mounted on, or close to, two of the main longitudinal support members or chords 71 of the lower tower section 2 to support the vertical lifting assembly 9. The upper tower section 3 is supported by the vertical lifting assembly 9, with an additional sea fastening to deck through the sea fastening point 5. Flare or vent pipes 24 (tubing) are supported upon and extend vertically along the frame 80 of the upper flare tower section 3 and are slightly elevated in the frame. The elevation of the flare or vent pipes 24 is determined and adjustable through pipe clamps 26 on the upper tower section 3 and which grip onto the vertical flare or vent pipes 24 to keep them in position along the upper tower section 3. The pipe clamps 26 can be used to fine-adjust the vertical alignment of the flare or vent pipes to clear the flare or vent pipes 24 in the lower tower section 2 before making up a connection between connecting ends of the two tower sections 2, 3.

[0059] In Figure 2, the upper tower section is in an elevated position, but laterally offset from the lower tower section 2. The upper tower 3 is lifted by the vertical lifting assembly 9 after the sea fastening 5 has been removed.

The vertical lifting assembly 9 supports the upper tower section 3 through the guide rails 18. The vertical lifting assembly 9 is supported on (and coupled to) the guide rails 18 and/or the lower tower section 2, throughout the lifting. The lifting assembly 9 provides the necessary lifting capability to elevate the upper tower section into position. The manner of operation of the lifting assembly 9 is described in further detail below.

[0060] Figure 3 shows the upper tower section 3 in elevated position being skidded horizontally from offset position towards the fully installed position on top of the lower flare tower section 2 using the horizontal skidding assembly 20. The manner of operation of the skidding assembly 20 is described in further detail of below.

[0061] Figure 4 shows the upper tower section 3 in the erected configuration, fully skidded into position on top of the lower tower section 2 until stopped by the skidding stopper 8. Lower ends of longitudinal support members 81 of the frame 80 of the upper tower section 3 are each provided with a mounting flange 7a. The upper ends of the longitudinal support members 71 of the frame 70 of the lower tower section 2 are each provided with a mounting flange 7b.

[0062] The ends of the support members 71 and 81 are aligned, and the mounting flanges 7a of the upper tower section are connected respectively to the mounting flanges 7b of the lower tower section to form connected pairs of flanges 7a, 7b, the connections being made up to fasten the lower tower section 2 and upper tower section 3 together. The

[0063] In Figure 5, the flare or vent tower is formed, the upper tower section positioned in the erected configuration. The connections between flare or vent pipes 24a in the upper tower section 3 and corresponding flare or vent pipes 24b in the lower tower section 2 have been made up after adjusting the vertical alignment of the pipes before connection using the vertical pipe clamps 26.

[0064] After use, e.g. after fastening the upper and lower tower sections 2, 3 together by the mounting flanges 7a, 7b, the horizontal skidding assembly is decoupled from the upper tower section 3, and is retracted into the structure of the vertical lifting assembly 9, allowing the vertical lifting assembly 9 together with the skidding assembly 20 to be lowered along the first tower section 2 back toward a lowered position. In Figure 5, the vertical lifting assembly 9 is parked in the lowest position together with the horizontal skidding assembly 20.

[0065] Turning now to consider Figures 6A and 6B, the vertical lifting assembly 9 has a main lifting frame 11, main frame locking bolts 13, a lower jacking beam with lifting beam locking bolts 16 and a lifting beam 15, and a lifting cylinder 14. The main lifting frame 11 in effect transfers lateral loads to the guide rails 18 through four lateral guiding nodes 17. The frame 11 is arranged to fit between the guide rails, the guiding nodes 17 arranged to face and make contact with guide surfaces of the guide rails 18, e.g. in a sliding or rolling arrangement. Thus, the guiding nodes 17 can be configured to have a roller ar-

rangement or low friction glider arrangement. A main frame locking bolt 13 is connected to a hydraulic cylinder and used to secure and transfer vertical loads between the main lifting frame 11 and guide rails 18 on both sides. The locking bolt 13 is operable to be retracted or extended from the cylinder. When the locking bolt 13 is extended and while the main frame 11 is locked to the guide rails 18 by the main frame locking bolts 13, the lifting beam 15 can be operated using the cylinder 14, and moved to another position on the guide rails 18. The lifting beam locking bolts 16 are connected to cylinders so as to be extendable or retractable. When the locking bolts 16 are extended, the lifting beam 15 is locked into and hung off in the hang-off brackets 19 of the guide rails 18 by means of the locking bolts 16 which engage the brackets 19. Vertical load is transferred to the lifting beam 15 by the lifting cylinder 14 which lifts or lowers the main lifting frame 11, with leverage obtained through the engagement of the lifting beam locking bolts 16 against the hang off brackets 19. After a small elevation of the main lifting frame 11 has been gained, the main lifting frame locking bolts 13 can be retracted to allow them to clear the next set of hang off brackets 19 along the guide rails 18. When the brackets are cleared, the main lifting frame locking bolts 13 can be extended and supported in the hang off brackets, at the new elevation, through retraction of the lifting cylinder 14. Using this mechanism allows step-by-step lifting or lowering of the vertical lifting assembly along the guide rails 18.

[0066] For instance, in order to advance the lifting assembly upward along the guide rails 18, the main frame 11 is jacked upward by the lifting cylinder 14 with the lifting beam locking bolts 16 engaged in the hang off brackets 19. During upward jacking, the main frame locking bolts 13 are retracted to clear overlying hang-off brackets. The main frame locking bolts 13 are then re-engaged in another pair of the hang off brackets 19 higher up. The lifting beam 15 is then drawn upward by retraction of the lifting cylinder 14, the weight transferred onto the main frame locking bolts 13 from which the frame 11 is hung off. As the lifting beam 15 is drawn upward, the lifting beam locking bolts 16 are retracted and then extended to be applied in another pair of the hang off brackets 19 higher up along the guide rails 18, where once again the lifting cylinder 14 can be applied to jack the main frame 11 further upward. The reverse sequence would apply for lowering.

[0067] In use, the upper tower section 3 is supported on the main frame 11 of the lifting assembly 9, e.g. on the skidding beams 12. Thus, by lifting or lowering the lifting assembly and/or main frame 11 along the first tower section, the second tower section is lifted or lowered correspondingly. The lifting assembly climbs the tower along the guide rails 18 through operation of the jacking cylinders 14. The upper section is moved along the guide rails 18 toward the elevated position.

[0068] With reference to Figures 7 to 12, an alternative lifting assembly 9 uses a rack and pinion mechanism,

replacing the lifting beam 15, lifting cylinder 14, lifting beam locking bolts 16 and most of the hang-off brackets 19. All other functions are as described in relation to the apparatus 1 of Figures 1 to 6. The lifting assembly 9 in this example includes a pinions and drive mechanism 28 which engages with a rack 27. The rack 27 extends along the full length of the frame 70 of the lower flare tower section 2, in this case positioned centrally between the guide rails 18. The pinions and drive mechanism 18 is mounted in the main lifting frame 11. Pinions in the mechanism 28 rotate along both sides of the rack and are driven e.g. by a hydraulic or electrical motor through a gear box. The motor or gearbox has an internal break system to secure the load when the motor is not engaged or failure of non-critical parts of the pinions and drive mechanism 28. A pair of top and bottom hang-off brackets 19 is provided at upper and lower ends respectively of the guide rails 18, for supporting the main lifting frame 11 of the assembly 9 in "parked" locations, e.g. a lower "parking" location for refastening the upper tower in the lowered configuration or an upper "parking" location from which the upper tower section 3 can be skidded horizontally into the erected configuration. In this example therefore, the upper tower section 3 can be supported on a support of the lifting assembly 9 be moved upward along the tower by actuating the pinions which engage and drive the lifting assembly 9 along the rack 27.

[0069] With reference to Figures 13A and 13B the horizontal skidding assembly 20 is described in further detail.

The horizontal skidding assembly 20 is used for skidding the upper tower section 3 from an elevated position, offset from the first tower section 2, as shown in in Figures 3 and 9 laterally into position above the lower section 2. The horizontal skidding assembly 20 thus assists to position the upper, second tower section 3 in the erected configuration. The lower tower section 2 has tower skidding rails 6 arranged at an upper end of the lower tower section. The lifting frame skidding rails 12 and the tower skidding rails 6 are arranged at the same elevation to allow skidding of the upper tower section 3 laterally onto the top of the lower tower section 2 using the horizontal skidding assembly 20. The upper flare tower section 3 is guided along and secured to the abovementioned horizontal skidding rails 6, 12 by the tower skidding clamps 4. The horizontal skidding assembly 20 comprises a cylinder rail clamp 21 and horizontal skidding cylinder 22. When the cylinder rail clamp 21 is activated, the horizontal skidding assembly 20 is clamped onto the skidding rail allowing the horizontal skidding cylinder 22 to push or pull the upper flare tower section 3 horizontally. It can be appreciated that the cylinder rail clamp 21 connects the skidding cylinder 22 to the horizontal skidding rail so that by extending an arm from the skidding cylinder 22 engaging the skidding clamps 4, obtaining leverage from the connection to the rail, the cylinder is operable move the upper tower section 3 laterally. Freeing the cylinder rail clamp 21 and retracting the horizontal skidding cylinder 22 enables further horizontal skidding. Thus, after

completing one stroke of the cylinder arm, the cylinder rail clamp 21 can be disengaged and the cylinder arm returned to a start position for another stroke, the clamp reengaged to grip the skidding rails 12, and the skidding cylinder 22 operated again to move the upper tower section 3 further laterally toward its end position. A skidding stopper 8 is arranged to stop the movement of the upper tower section 3 in correct horizontal alignment between the with the lower tower section 2 in the erected configuration. When aligned, the mounting flanges 7a, 7b can be connected to connect the frames 70, 80 of the lower and upper tower sections together. Following that, connections between sections of the flare or vent pipes 24a in the upper tower section 3 are made with corresponding sections of the flare or vent pipes 24b in the lower tower section 2. Similar, connections are made between connectors of electrical line sections (not shown) for lights and instruments between respective upper and lower tower sections 2, 3. The tower skidding clamps 4 are disengaged from the upper tower section 3 and the horizontal skidding assembly 20 is retracted back onto the vertical lifting assembly 9 using the skidding cylinder 22. The vertical lifting assembly 9 can be lowered back to a lower parking position. Reversing the above steps allows withdrawal and lowering of the upper flare tower section 3 from the erected configuration to the lowered configuration.

[0070] It can be appreciated that the horizontal movement could in other examples be implemented by deploying pinions to engage a horizontal rack instead of the solution of using a horizontal skidding cylinder.

[0071] In Figures 14A and 14B, the mechanism for vertical adjustment the flare or vent pipes can be seen in further detail. The adjustment is typically made to position the flare or vent pipes 24a relative to the frame structure 80 of the upper tower section 3 to provide clearance to the ends of the vent or flare pipes 24b in the lower flare tower section 2 during horizontal skidding of the upper flare tower section 3 assembly, before connection of the respective pairs of flare or vent pipes 24a, 24b of the first and second tower sections. The flare or vent pipe 24a has a flare or vent sleeve 29 as part of the pipe. Sleeve brackets 31 are clamped around two rods on each side of the flare or vent sleeve 29. The adjuster comprises threaded rods 32 or bolts which support the sleeve brackets 31 of the vent or flare pipe 24a on the frame 80 of the upper tower section 3 with help of nuts 30 which are mounted on the rod 32 or bolt. The flare or vent pipes 24a can be vertically adjusted relative to the frame 80 in this example by adjusting the nuts 30 in conjunction with support structure in the upper flare tower section 3. By vertical adjustment of the pipe 24a, the lower connecting end 241a of the pipe 24a can be positioned to align with a corresponding upper connecting end 241b of a pipe 24b supported in the lower tower section 2, in order to allow the ends 241a, 241b to be connected together. The ends 241a, 241b may be connected e.g. by flanges and bolts, clamps, or another other suitable means, for con-

necting the pipes 24a, 24b for conveying gas in fluid tight fashion through the interior of the connected pipes 24a, 24b to a vent outlet and/or flare exit point to atmosphere higher in the tower.

Hinged tower examples

[0072] Referring now to Figures 15A and 15B, the apparatus 48 has a hinged arrangement, where the second, upper tower section 34 is movably coupled to the first, lower tower section 33 by a hinge. The upper tower section 34 can therefore be actuated to rotate pivotably about the hinge with respect to the lower tower section 33 from a lowered, withdrawn configuration to an erected, deployed configuration.

[0073] The upper tower sections 34 is arranged in the lowered, parked configuration. In this configuration, the upper tower section 34 is arranged in upside-down orientation, supported by the lower tower section 33 through the lower flare tower hinge member 46 and the upper flare tower hinge member 47. In the parked configuration, the upper flare tower section 34 can be sea fastened laterally in the parking bracket 35 on the lower flare tower section 33.

[0074] In Figures 16A and 16B, the upper tower section 34 has been moved to a partially erected configuration. Actuation for moving the upper tower section 34 takes place in this example using actuators in the form of hydraulic push cylinders 36. The push cylinders 36 are activated to push and rotate the upper tower section 34 around the hinge formed by hinge members 46, 47. The push cylinder 36 is mounted to and guided by a guide bracket 37 on the upper tower section 34 at one end. The push cylinder 36 is further mounted to a mounting 49 on the lower tower section 33 at its other end. The guide bracket 37 interfaces with the upper tower 34 via a mounting 38 and a notch in the guide bracket 37. This limits the lateral loads in the guide bracket 37 and allows the cylinder 36 and bracket 37 to be disconnected from the upper tower section 34, e.g. after use.

[0075] In Figures 17A and 17B, a pull cylinder 40 (actuator) is additionally connected. The pull cylinder 40 is extended and mounted in and guided by a pull cylinder guide 41. The pull cylinder 40 is locked into an upper a pull cylinder interface 42 on the upper tower section 34 by a locking bolt 45. The locking bolt 45 is extended from its own cylinder. The connected pull cylinder 40 can now be retracted to continue the rotation and erection of the upper flare tower section 34. When the pull cylinder 40 is close to being fully retracted the guide pin 43 protruding from an end of the lower tower section 33 engages with a corresponding recess in the upper tower section 34, which ensures a proper alignment of the mounting flanges 7a, 7b of the upper and lower tower sections 33, 34 which are to be coupled. In use, the upper tower section 34 is moved initially by activating the push cylinder 36 so that it extends and rotates the upper tower section 34 about the hinge. The far end of the pull cylinder 40 is

connected to the upper tower section 34 in the partially erected configuration and is activated so that it retracts and pulls the upper tower section 34 to continue the rotation about the hinge. The cylinders 34 and/or 40 operate to control the movement and landing of the upper section onto an end of the lower tower section 33 to position it in the erected configuration.

[0076] Figure 18 shows the erected configuration after raising and rotating the second tower section 34 into the right way up orientation using the actuation system. The connections of each of the three pairs of mounting flanges 7a, 7b have been made up between the lower tower section 33 and the upper tower section 34. Upper and lower flare or vent pipes 24a, 24b have also been connected for communicating vent or flare gas through the connected pipes 24a, 24b along the tower. The push cylinder 34 is retracted.

[0077] Another example is depicted in Figures 19A and 19B where the flare or vent tower to be formed, in erected configuration, is tilted slightly with respect to the deck 100 of the vessel e.g. an FPSO. Figure 20A shows the arrangement of the first and second tower sections 33, 34 in the lowered configuration and the erected configuration superimposed, and Figure 20B shows particular detail of a tensioning device 75. In this example, the erected flare tower is partly supported by a tension mechanism which also serves as the actuation system for raising the second, upper tower section 34 relative to the first, lower tower section 33. To this end, a lever arm is formed on the upper tower section 34. The tensioning mechanism is provided through an upper tension wire 74 and a rod 73 near a lower end on the upper tower section 34. Further, the mechanism includes a lower tension wire 73 and lower rod 77 on the lower tower section 33. The lower tension wire 72 is connected to the rod 73 on the upper tower section 34 and connected to a tension device 75 e.g. on deck. Using the lever arm provided by the rods 73, 77 tension can be applied to the wires to facilitate rotating the upper tower section 34 about the hinge connection into the erected configuration.

[0078] When tension is released in the wires, the upper tower section 34 is lowered around the hinge and the overall height is decreased. The flare tower can be erected again by tensioning the wires again. When fully erected, the correct preload can be set through the lower tension rod, wire 72 and tensioning device 75.

[0079] When fully erected the upper tower section 34 and lower tower section 33 are arranged to be fastened together by making up aligned mounting flanges 7a, 7b.

[0080] In various examples, other mechanisms for tensioning the wires could be implemented using a single cylinder, cylinder jacks, winch, threaded rods or similar, or combinations thereof. For instance, it can be appreciated that a cylinder operating to extend the rod 73, 77 could produce tension in wire lengths 72, 74 to move the upper tower section 34 relative to the lower tower section 33 toward the erected configuration.

Telescopic tower examples

[0081] With reference to Figures 21A and 21B and Figures 22A and 22B, the first and second tower sections 51, 52 are arranged telescopically to allow the upper tower section 52 to extend from the lowered configuration to the erected configuration. As can be seen, Figure 21A shows the upper tower section 52 in the lowered configuration, whereas Figure 22A shows the upper tower section 52 in the erected configuration.

[0082] The flare tower is erected by means of a rack and pinion solution. More specifically, the apparatus 50 includes an actuation system in the form of a pinions and drive mechanism 28 which is mounted in the lower tower section 51. The upper tower section 52 comprises three or more main vertical jacking chords 54 which extend vertically. The rack is integrated vertically along the longitudinal jacking chords 54 of the frame 180 of upper tower section 52.

[0083] The pinions and drive mechanism 28 is supported in each of the three corners of an upper end of the frame 170 of the lower tower section 51. The upper tower section 52 is nested within the frame 170 of the lower tower section 51. The pinions of each mechanism 28 are arranged to interact with the rack of the corresponding jacking chord 54 of the upper tower section 52. The upper tower section 52 is laterally supported in each corner by way of a guiding arrangement 59 on the frame of the lower tower section 51. The guiding arrangement 59 supports the upper tower section 52 in the lateral directions perpendicular to the vertical jacking chord 54.

[0084] Figure 22A shows the self-erecting flare tower 50 in fully erected configuration. The pinions and drive mechanism 28 has interacted with the jacking chords 54 in each corner lifting the upper tower section 52 to its fully erected position. In the erected configuration, the mounting bolts 58 can be installed manually or be pre-installed and extended by a hydraulic cylinder or the like. The pinions and drive mechanism 28 is typically disengaged from the rack after installation of the mounting bolts 58 to avoid transferring operational loads through the mechanism.

[0085] As can be appreciated, in use, the pinions are driven by motors and engage the rack so as to urge the upper section telescopically upward from the lowered configuration toward the erected configuration. The lower tower section 51 supports the vertical load of the upper tower section 52, at least during lifting or lowering, through the engagement and coupling between the upper and lower sections via the pinions and rack. In the erected configuration, mounting bolts 58 may be inserted to secure and fasten upper tower section 52 to the lower tower section 51.

[0086] Turning now to Figures 23A and 23B and Figures 24A and 24B the actuation system in another example of telescopically arranged first and second tower section uses a centred rack 61. In Figure 23A, the upper tower section 52 of the apparatus 50 is exemplified in a

parked/lowered configuration. Stopper flanges 60, which are parts of the upper tower section 52, are hung off towards the upper guiding arrangement 59 so that no load is transferred to the pinions and drive mechanism 28. The vertically extending rack 61 is mounted centrally between the main vertical longitudinal chords 171 on the lower tower section 51. The flare or vent pipes 24 are mounted to the respective lower and upper tower sections 51, 52 as described in other examples above.

[0087] With reference to Figures 24A and 24B, the vertical erection and extension of the upper tower section 52 is performed by actuating the pinions and drive mechanism 28 which in turn interacts with the centred vertical racks 61. The pinions and drive mechanism 28 in this example is mounted on the upper tower section 52 at or near a lower end of the upper tower section 52. The upper tower section 52 is laterally supported by the guiding arrangement 59 on the lower tower section 51 which provides a low friction guide between the lower tower section 51 and the longitudinal chords 181 of the frame 180 of the upper tower section 52. Typically, polymer surfaces or similar may be used to provide the low friction contact performance. When fully erected, as seen in Figure 24A, a mounting bolt 58 can be installed to connect, fixedly with respect to one another, the lower tower mounting bracket 57 and the upper tower mounting bracket 53. In the erected configuration, the mounting bolts 58 can be installed manually or be pre-installed and extended by a hydraulic cylinder. The connection between flare or vent pipes 24a of the upper tower section 52 and flare or vent pipes 24b of the lower tower section 51 can be made up either using a spool piece or by fine alignment and adjustment of the vent or flare pipe 24a, 24b relative to the frame 170, 180 of either the lower or upper tower section 51, 52 after erection, and connecting by bolts and flanges, clamps, or the like.

[0088] The pinions and drive mechanism 28 is not described in detail herein, but it will be appreciated that it may comprise a motor or the like to turn the pinion which when in engagement with the rack travels along the rack up or down along it. The drive mechanism may need sufficient dimensions and power to withstand and lift the load of the upper tower section into elevated configurations relative to the lower tower section. In the representations of the drawings, the rack is not shown in the full length of the jacking chord 54, although in practice this may typically be the case.

[0089] With reference to Figures 25A and 25B, the upper tower section 52 of the apparatus 50 is in parked/lowered configuration. The actuation system in this example comprises a hydraulic jacking assembly 62 to provide lifting.

[0090] The hydraulic jacking assemblies 62 are supported at the upper end of the lower tower section 51 in each of the corners of the frame 170 of the lower tower section 51. In the parked configuration, the upper tower section 52 is vertically supported by the hydraulic jacking assembly 62 through interaction with the jacking points

63 in the upper tower section 52. Multiple jacking points 63 are arranged along the corner main longitudinal chords 181 of the upper tower section 52. Lateral support is provided through the guiding arrangement 59 mounted in the lower tower section 51, the guiding arrangement 59 interacts with the upper tower section 52 as it is moved upward or downward relative to the first, lower tower section 51. A longitudinal member of the upper flare tower, e.g. chord or column of frame 180, is received slidably in a channel of the guiding arrangement 59 of the lower tower section 51. Typically, low friction performance is obtained by use of polymer surfaces or similar in the channel of the guiding arrangement. A longitudinal spacing is made in the sleeve to allow the jacking points 63 which protrude radially from the longitudinal chord 181 of the frame to slide vertically in the spacing past the upper guiding arrangement 59. The spacing is arranged so as to provide lateral guiding, perpendicular to the jacking points 63. Lateral guidance parallel to and/or along the jacking points 63 is provided between the main longitudinal chords 181 in the upper telescopic flare tower 52 and the upper guiding arrangement 59.

[0091] In Figures 26A and 26B, the erected configuration can be seen. The vertical lifting of the upper tower section 52 has taken place through use of a hydraulic jacking assembly 62. Fixation points in each corner provided by the mounting bolts 58 secures the upper tower section 52 to the lower tower section 51. Connections between the flare or vent pipes 24a in the upper tower section 51 and flare or vent pipes 24b of the lower tower section can be made up either using a spool piece or by fine adjustment and alignment after erection, as described in various examples above. The adjustment can be performed to position the connecting ends of the pipes in respective sections in alignment for making up the connection therebetween. In various examples, adjustment can be rotational about a long axis of the tower section and/or longitudinal/vertical.

[0092] The hydraulic jacking assembly 62 is seen in further detail in Figures 27A and 27B. The hydraulic jacking assembly 62 comprises a jacking frame 64, jacking guides 65, vertical jacking cylinders 66, an upper hang off bolt 67, a lower hang off bracket 68, a tilt cylinder 70, and a jack foundation 71.

[0093] Figures 28A and 28B, 29A and 29B, 30A and 30B and 31A and 31B show the sequence of utilizing the hydraulic jacking assembly 62 to lift the upper tower section 52 along the lower tower section 51 to position it in the erected configuration.

[0094] In part one of the sequence, the upper tower section 52 is hung off from a lower hang off bracket 68 of the jacking points 63 of the upper tower section 52. The jacking frame 64 is tilted using the tilt cylinder 70 to allow the upper hang-off bolt 67 to clear the above lying jacking points 63 when the vertical jacking cylinder 66 is retracted. The jacking frame 64 is tilted around the centre line of the bottom mounting of the vertical lifting cylinders 66, against the jack foundation 71. The vertical jacking

cylinders 66 are also tilted as they are interconnected to the jacking frame 64 through the upper hang-off bolt 67 and jacking guides 65.

[0095] In part two of the sequence, the jacking frame 64 is tilted using the tilt cylinder 70 to locate the upper hang-off bolt 67 to be below the jacking point 63p ready for engagement with the jacking point 63p.

[0096] In part three of the sequence, the vertical jacking cylinders 66 extend and lift the upper tower section 52. The lower hang off bracket 68 has been retracted using the lower hang off cylinder 69 to clear the jacking points 63.

[0097] In part four of the sequence, vertical jacking cylinder is returned to the same position as seen in part one, except that the upper tower section 52 has moved been upward. To move from step three to step four in the sequence, the lower hang off bracket 68 has been extended below one of the jacking points 63 once again to support the upper tower section 52 in position, allowing the vertical jacking cylinders 66 to be retracted and positioned to engage a lower one of the jacking points 63 in a further jacking cycle. As seen in Figure 31A, the vertical jacking cylinders 66 have been fully retracted together with the tilt cylinder 70 and the load has been transferred to the lower hang off bracket 68. By repeating the steps in the sequence, the upper tower section 52 continues to climb toward the fully elevated configuration. Reversing the sequence lowers the upper tower section 52 relative to the lower tower section 51 toward the lowered configuration.

[0098] By operating the jacking assemblies, the lower tower section is translated telescopically from the lowered configuration to the erected configuration.

[0099] The hydraulic jacking assembly 62 and jacking points 63 could also be used as substitutes for the pinions and drive mechanism 28 and the centred jacking rack 61 in variants of the examples described above.

[0100] An alternative to the mounting between the upper tower section and the lower tower section by mounting bolts can be obtained by flanges and bolts, or welding.

[0101] An access route for personnel, though not illustrated, is made available to the top of the erected flare tower. The access route is provided on an outside the lower tower section 51 and on an inside of the upper tower section 52.

[0102] The self-erecting flare tower have the function to allow passage below bridges in e.g. Mubarak Peace Bridge, Niterói Bridge, etc. This allows for a flexible transit route and improved project schedule, in addition to potentially reducing the transit loads from a pre-installed flare tower.

[0103] Although examples herein refer to tower sections for a flare or vent tower, it will be appreciated that an arm extending laterally, e.g. over a side of the vessel, may be formed in similar manner. In the example of the arm, the tensioning system may be employed to lever a distal arm section with respect to a proximal arm section to position the distal arm section in a deployed configuration where the distal arm section extends laterally be-

yond an end of the proximal arm section. A telescopic arrangement of the arm sections could be employed, such that the distal arm section is extended with respect to the proximal arm section to position it in the deployed configuration. Hydraulic jacking or rack and pinion mechanisms such as those deployed in relation to the tower sections in the above examples may be employed similarly for deploying and extending the lateral extent of the distal section.

[0104] Furthermore, although examples herein refer to tower sections or arm sections for flaring or venting, it will be appreciated that a derrick extending from a structure of a vessel, or offshore rig or platform for supporting well operations equipment may be formed in similar manner. In the example of the derrick, any of the actuation mechanisms as described above may be employed to raise or lower an upper derrick section relative to a lower derrick section to position the upper derrick section in a lowered configuration or erected configuration.

[0105] References to cylinder herein refer typically to hydraulic cylinders with arms which are extendable or retractable (e.g. by pistons) by application of hydraulic fluid. Any such reference, may be taken to non-hydraulic actuators such as electrically operated actuators or extenders which may in similar manner have an arm which is extendable or retractable to obtain varying degrees of linear extension.

Claims

1. Apparatus comprising first and second tower sections for providing a flare or vent tower for flaring or venting gas, the second tower section being arranged to be configurable with respect to the first tower section between a lowered configuration and an erected configuration; and an actuation system to raise or lower the second tower section with respect to the first tower section to position the second tower section in the erected or the lowered configuration.
2. Apparatus as claimed in claim 1, wherein the second tower section is movably coupled to the first tower section.
3. Apparatus as claimed in claim 1 or 2, wherein the second tower section is supported on the first tower section, wholly or partially.
4. Apparatus as claimed in claim 1, wherein the second tower system is coupled to and supported on the first tower section via at least one part of the actuation system
5. Apparatus as claimed in any preceding claim, further comprising guide means for guiding or constraining movability of the second section relative to the first

section between the lowered configuration and the erected configuration.

6. Apparatus as claimed in any preceding claim, wherein the actuation system comprises at least one actuator which is extendable or retractable, for raising or lowering the second tower section with respect to the first tower section. 5
7. Apparatus as claimed in claim 6, wherein the actuator comprises at least one longitudinal actuator configured to urge the second tower section longitudinally along the first tower section. 10
8. Apparatus as claimed in claim 6 or 7, wherein the actuator comprises at least one transverse actuator configured to urge the second tower section relative to the first tower section in a transverse direction. 15
9. Apparatus as claimed in any of claims 6 to 8, wherein the actuation system further comprises a mover which is arranged to travel longitudinally along the first tower section, the second tower section being coupled to the mover, the mover including the at least one actuator to raise or lower the mover longitudinally along the first tower section. 20 25
10. Apparatus as claimed in any preceding claim, wherein the actuation system comprises at least one rack and pinion mechanism for raising or lowering the second tower section with respect to the first tower section. 30
11. Apparatus as claimed in any preceding claim, wherein the actuation system comprises at least one jacking mechanism using at least one actuator for raising or lowering the second tower section with respect to the first tower section. 35
12. Apparatus as claimed in any preceding claim, wherein in the lowered configuration, the second tower section is offset to one side of the first tower section, in side-by-side relationship, and in the erected configuration, the second tower section is positioned end to end on the first tower section. 40 45
13. Apparatus as claimed in claim 11, wherein the actuation system comprises:
a lifting assembly for translating the second tower section in a first, longitudinal direction along the first tower section between the lowered configuration and an intermediate, elevated configuration in which the second tower is offset to one side of the first tower section; and 50
a skidding assembly for translating the second tower section in a second, transverse direction between the intermediate, elevated configura- 55

tion and the erected configuration.

14. Apparatus as claimed in any of claims 1 to 11, wherein the first and second tower sections are arranged telescopically, the second tower section being telescopically raised or lowered with respect to the first tower section.
15. Apparatus as claimed in any of claims 1 to 7, wherein the second tower section may be pivotally movable relative to the first tower section, and the second tower section is coupled to the first tower section by at least one hinge for accommodating rotational the movement between the first and second tower sections.
16. Apparatus as claimed in claim 15, wherein the actuation system comprises a tensioning and/or lever arm mechanism.
17. Apparatus as claimed in any preceding claim, wherein the first and second tower sections each comprise an elongate frame, and the first tower section includes at least one flare or vent pipe and the second tower section includes at least one flare or vent pipe, flare or vent pipes extending along the respective frames, wherein in the erected configuration an end of the flare or vent pipe of the second tower section is alignable with an end of the flare or vent pipe of the first tower section for connecting the ends, for communicating flare or vent gas through the connected pipes.
18. Apparatus as claimed in claim 17, wherein the first or second tower section has at least one adjuster for adjusting the position of the vent or flare pipe of the second or first tower section relative to the frame of the first or second section for facilitating aligning the ends of the pipes in the erected configuration.
19. Apparatus as claimed in any preceding claim, wherein in the erected configuration, the first and second sections are arranged to be connected or fastened together for fixing the first tower section to the second tower section for operation of the flare or vent tower.
20. Apparatus as claimed in any preceding claim, wherein the first tower section comprises an elongate frame comprising longitudinal chords, and the second tower section comprises an elongate frame comprising longitudinal chords, and in the erected configuration, the chords in the respective frames of the first and second sections may be arranged in alignment, and ends of the chords of the first tower section are connected to ends of the aligned chords of the second tower section.
21. Apparatus comprising first and second longitudinal

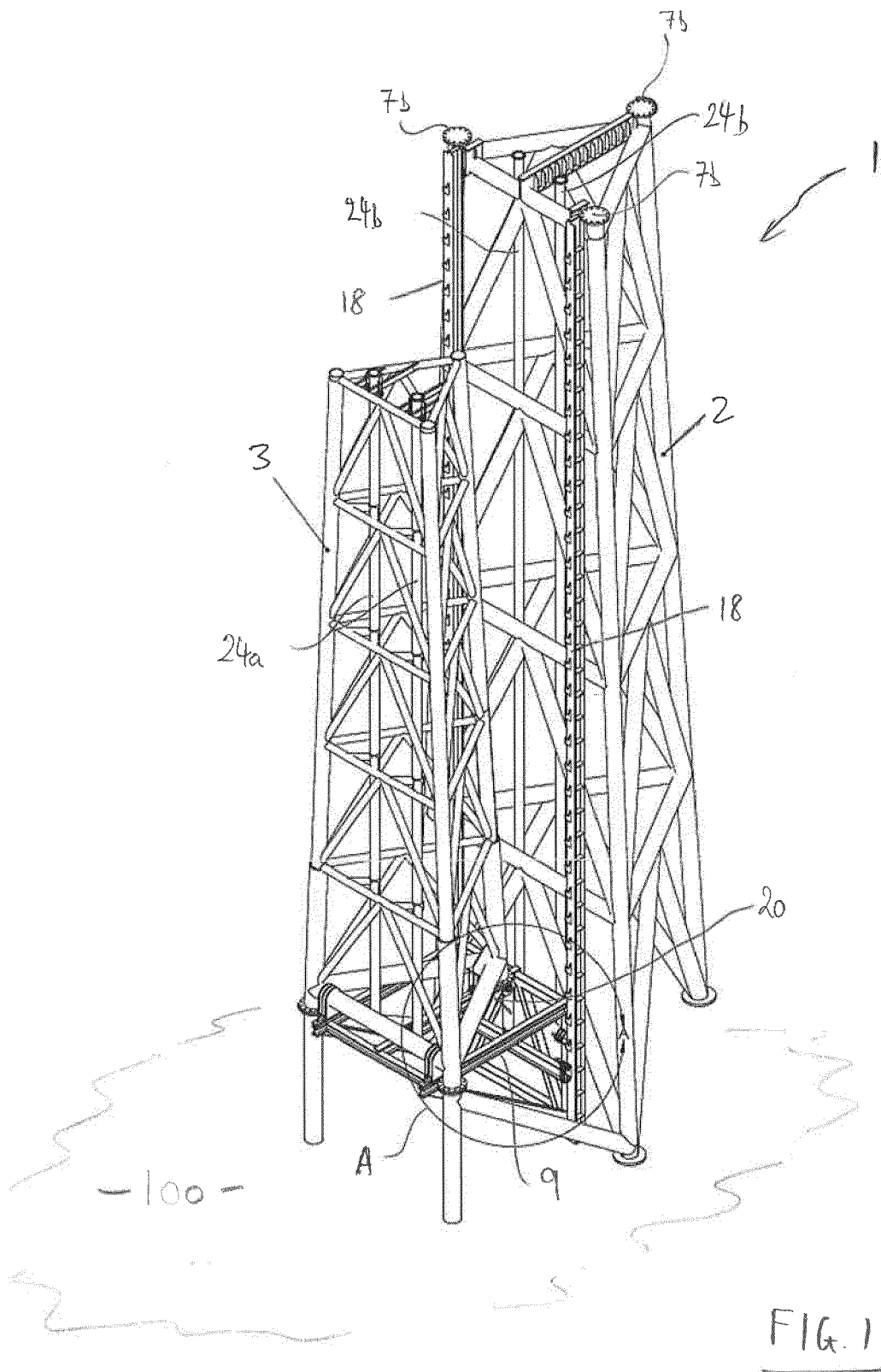
sections for providing an elongate structure for an oil and gas production or exploration process, the second longitudinal section being arranged to be configurable with respect to the first longitudinal section between a withdrawn configuration and a deployed configuration; and an actuation system to move the second longitudinal section with respect to the first longitudinal section to position the second longitudinal section in the deployed configuration or the withdrawn configuration.

22. Apparatus comprising first and second arm sections for providing a flare or vent arm for flaring or venting gas, the second arm section being arranged to be configurable with respect to the first arm section between a withdrawn configuration and a deployed configuration; and an actuation system to move the second arm section with respect to the first arm section to position the second arm section in the deployed configuration or the withdrawn configuration.
23. Apparatus comprising first and second derrick sections for providing a derrick for supporting wellbore operations equipment, the second derrick section being arranged to be configurable with respect to the first derrick section between a lowered configuration and an erected configuration; and an actuation system to raise or lower the second derrick section with respect to the first derrick section to position the second derrick section in the erected or the lowered configuration.
24. A vessel, floating platform, or rig, which includes the apparatus according to any preceding claim.
25. A method of using the apparatus according to any of claims 1 to 20, the method comprising: providing the second tower section in the lowered configuration; and raising the second tower section relative to the first tower section to position the second tower section in the erected configuration.

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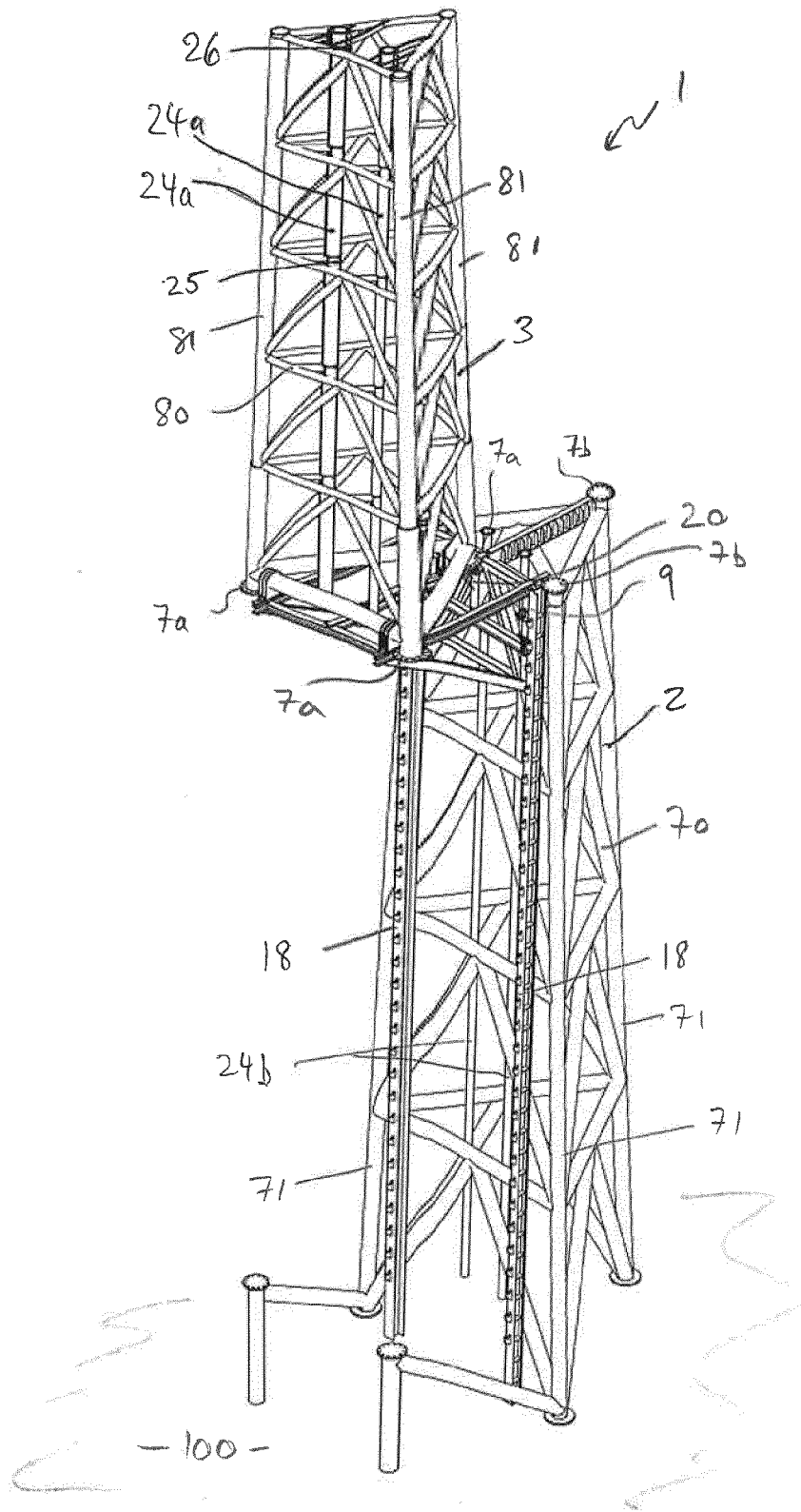
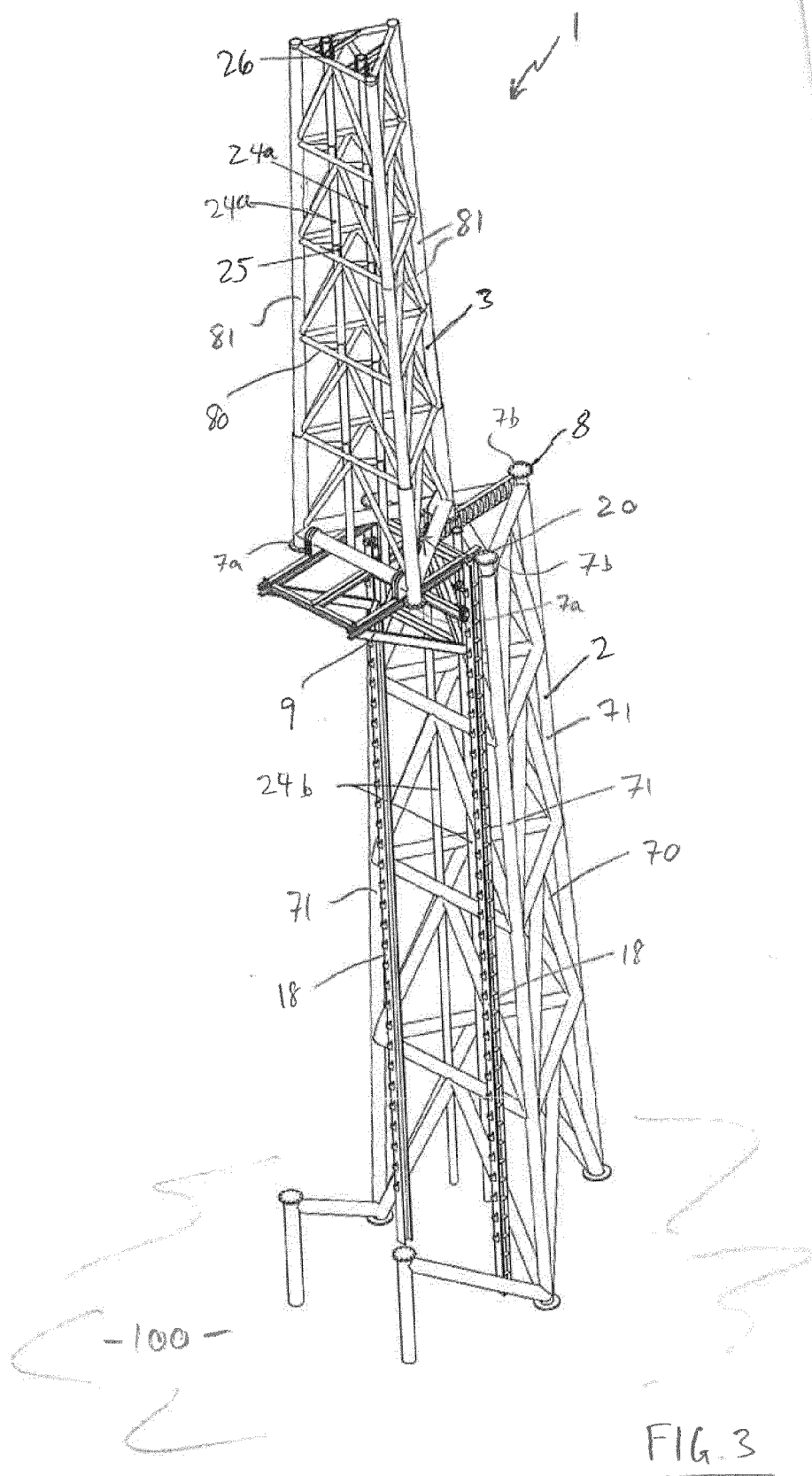


FIG. 2



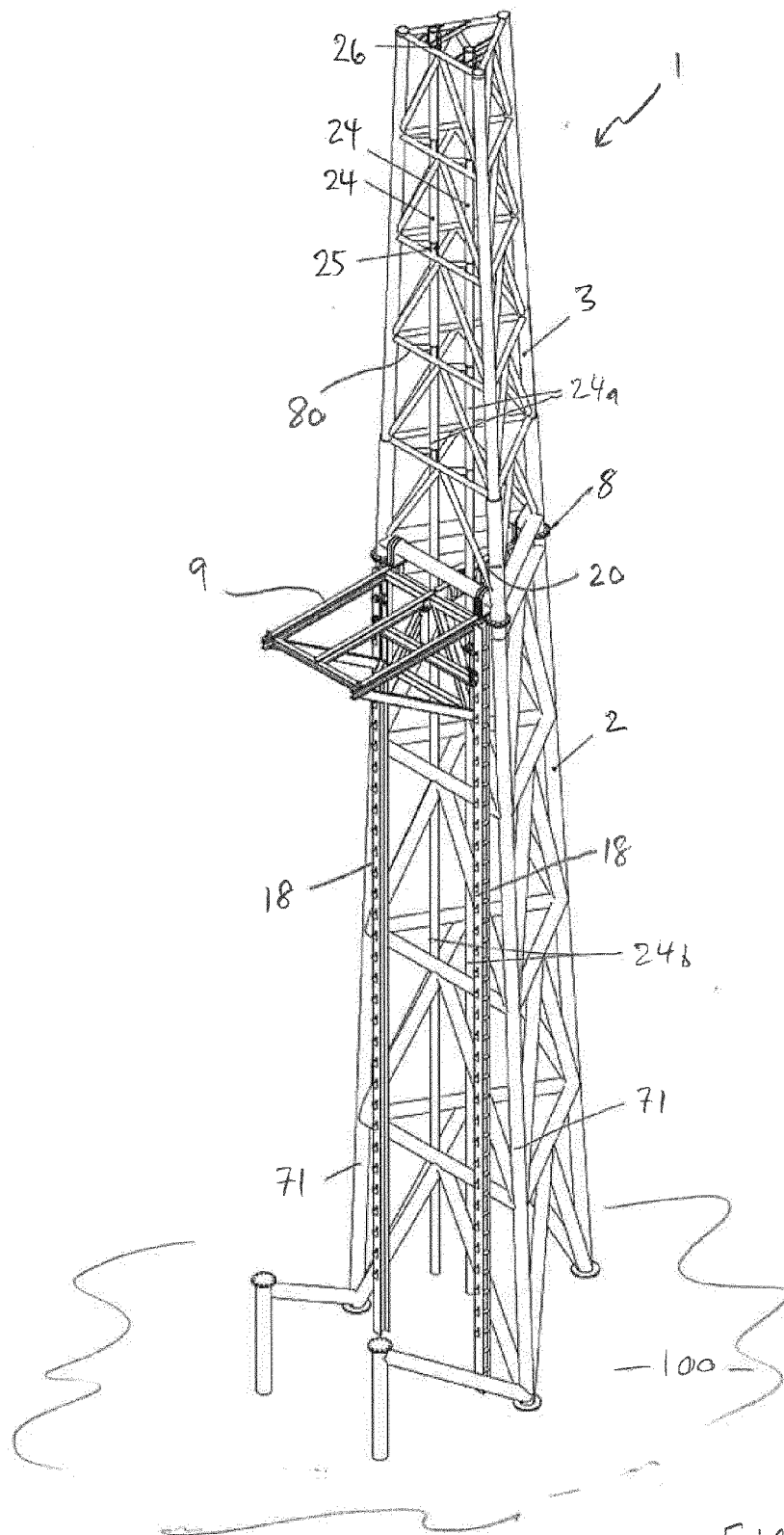
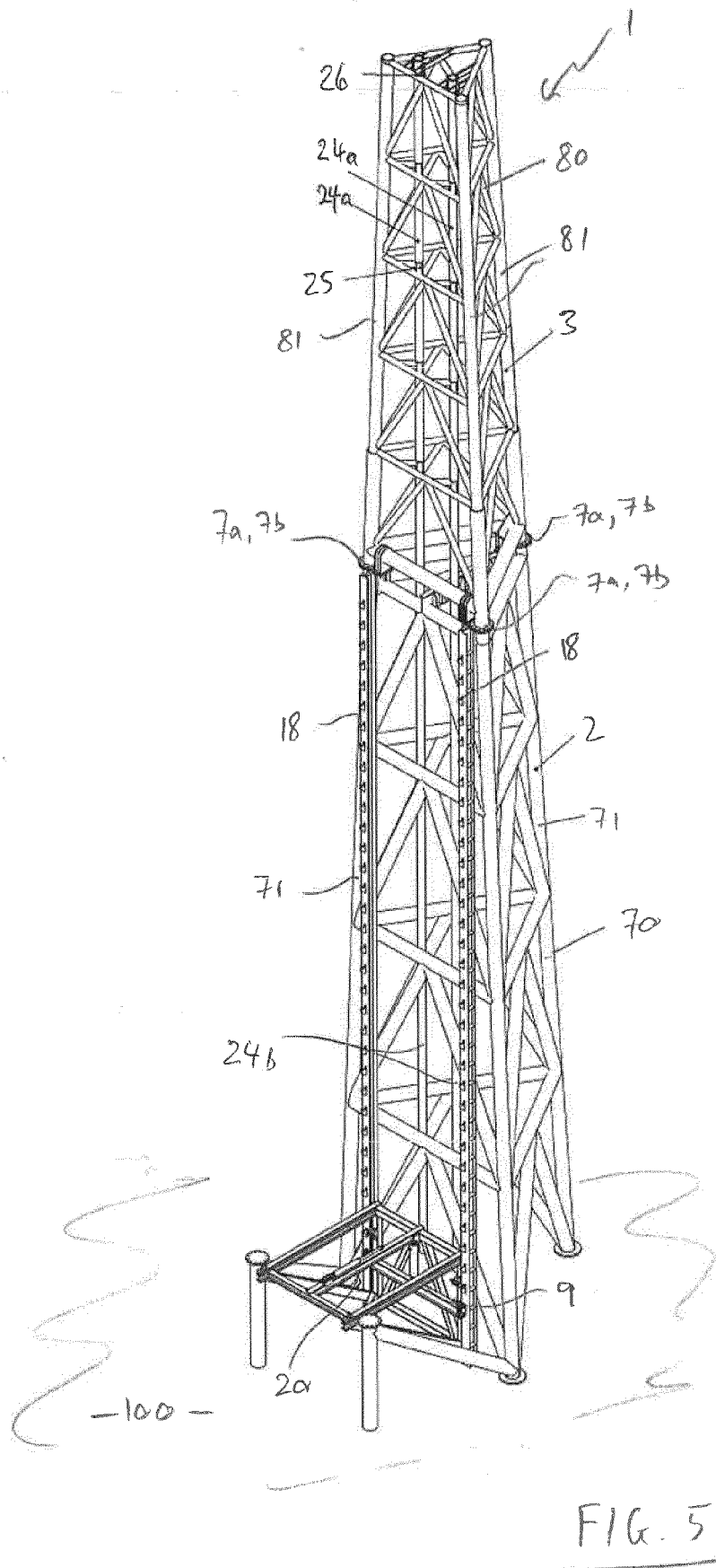


FIG. 4



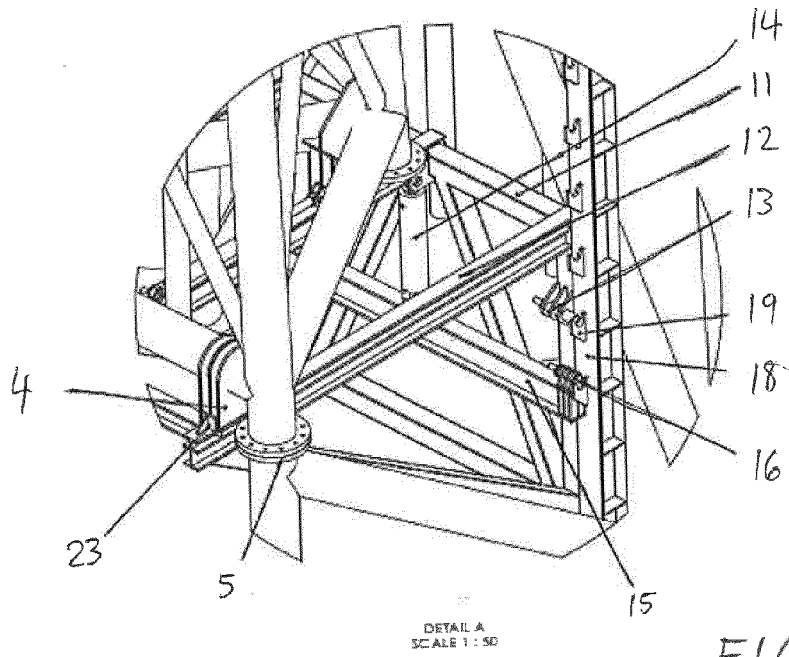


FIG. 6A

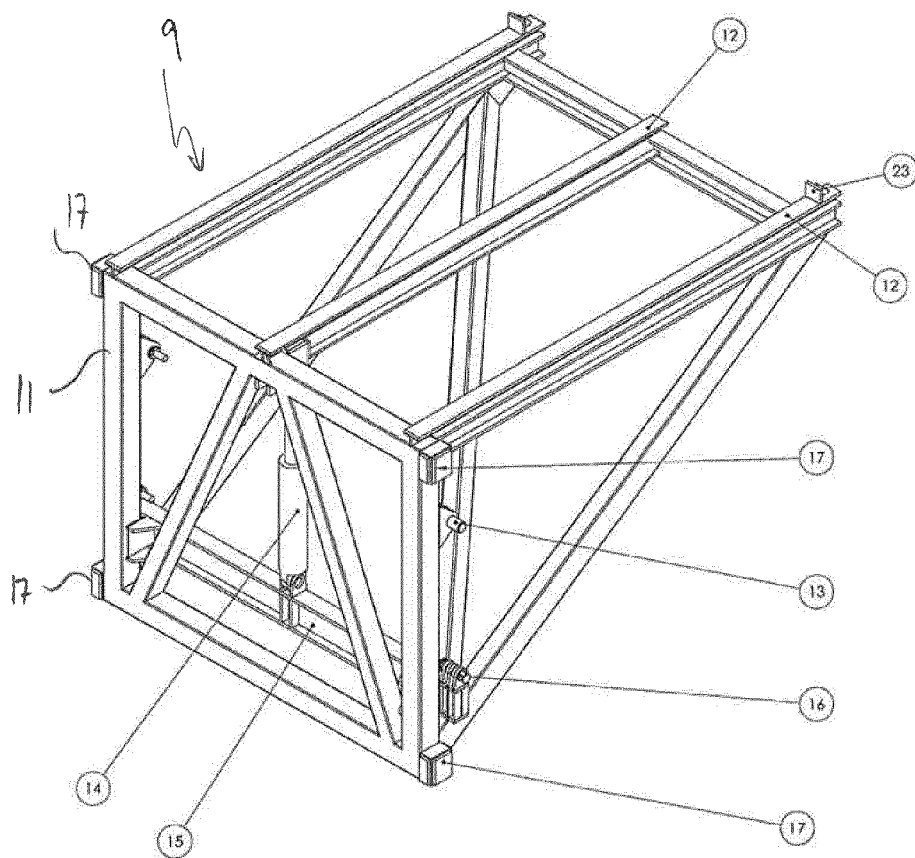
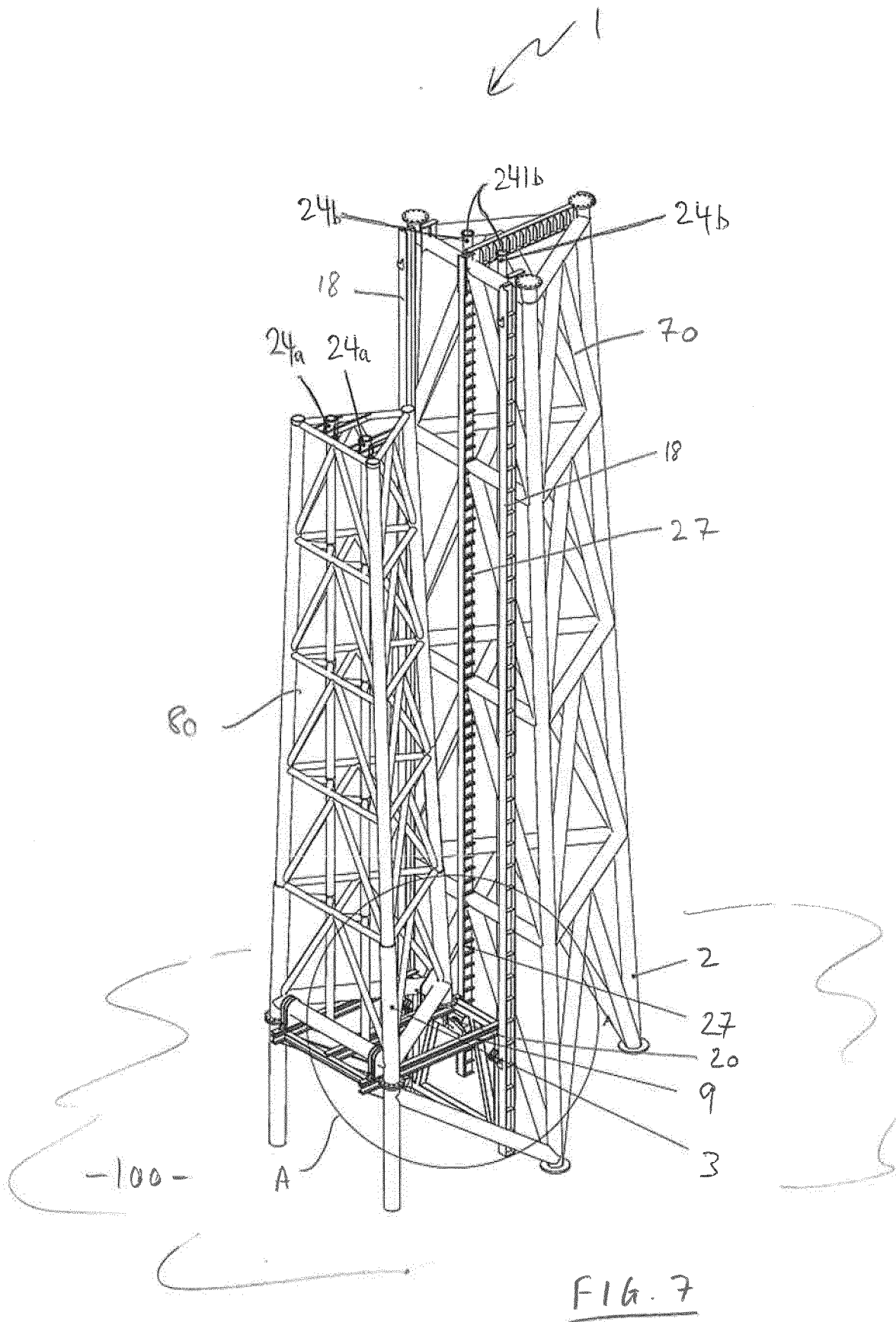
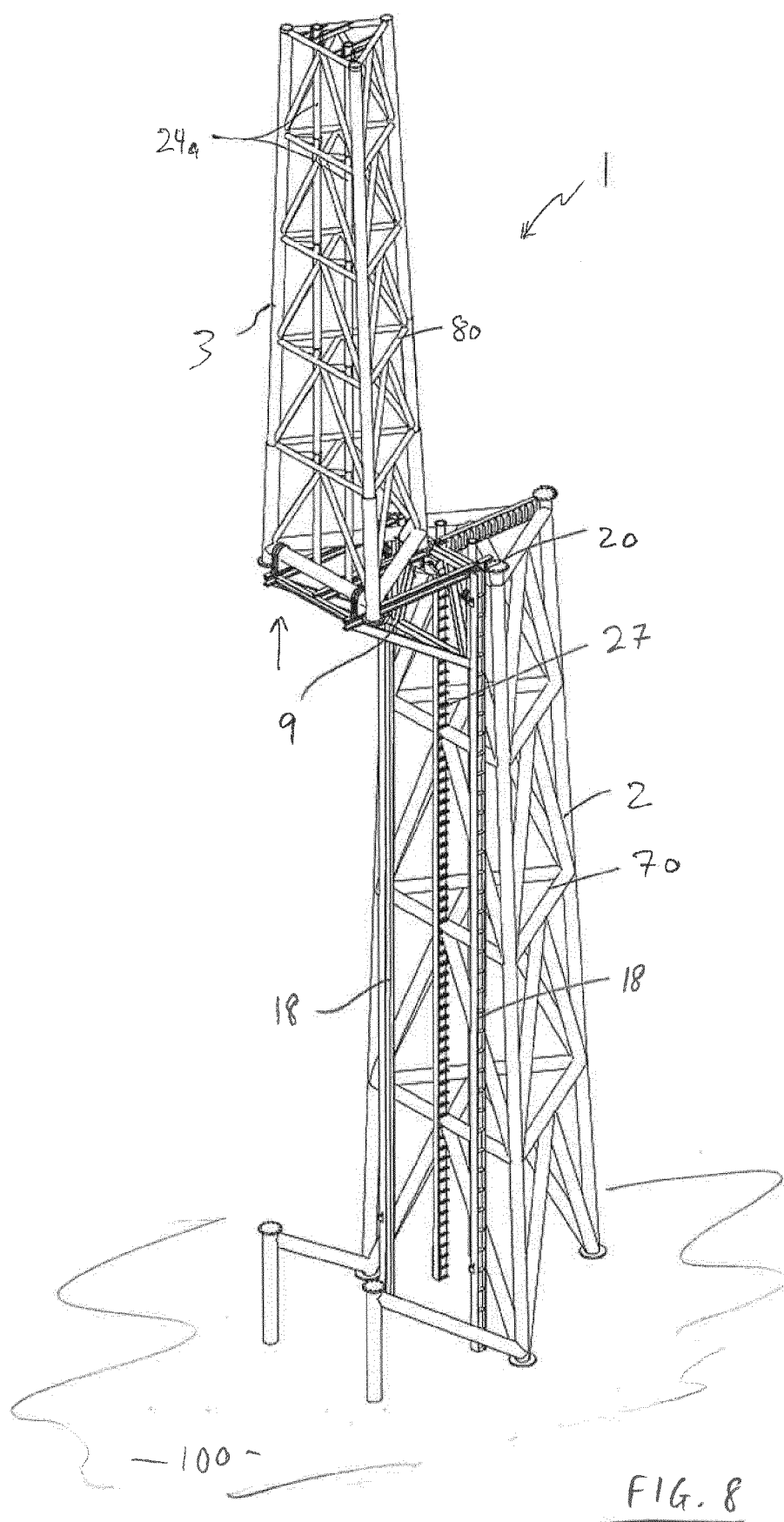
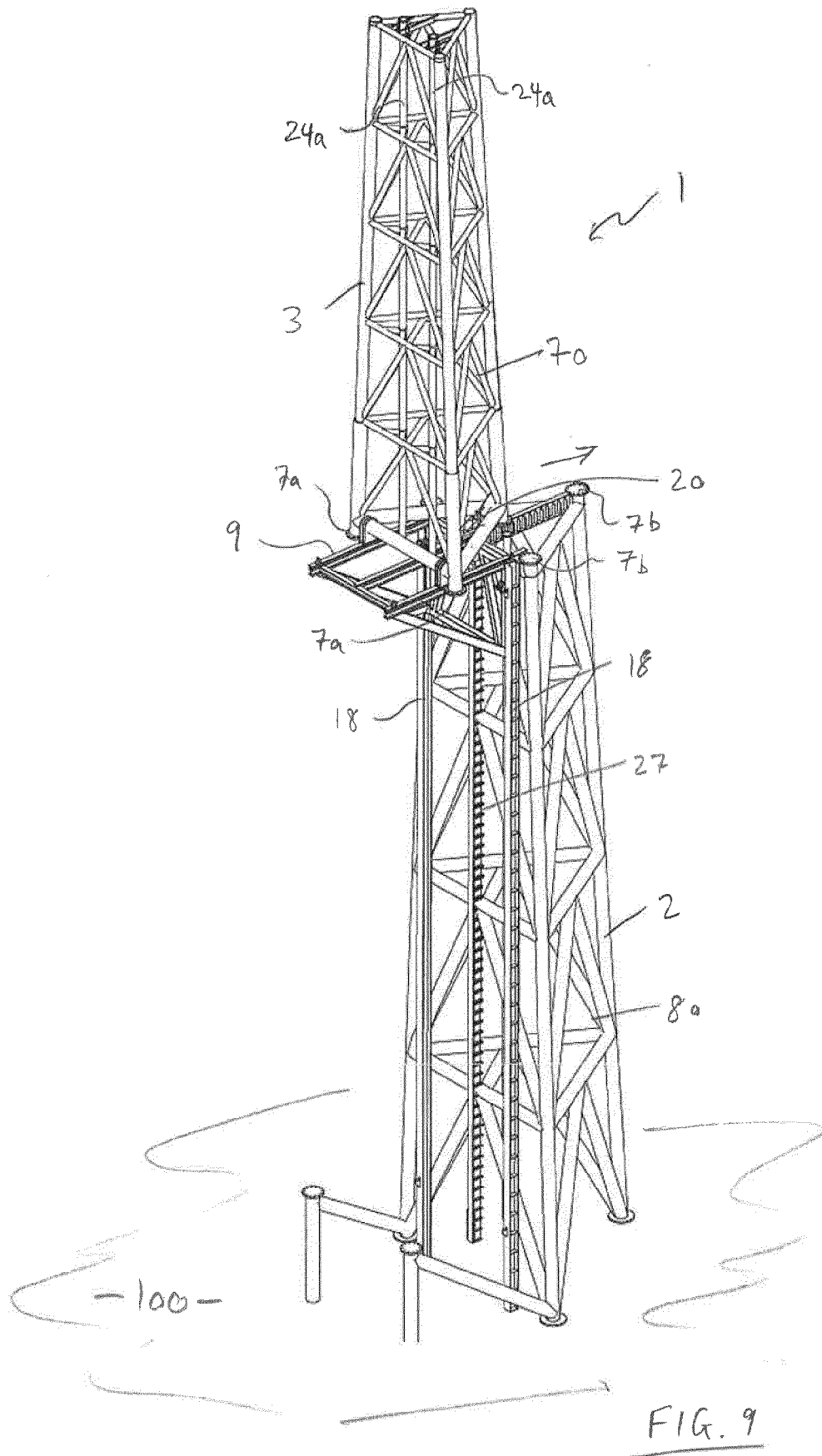
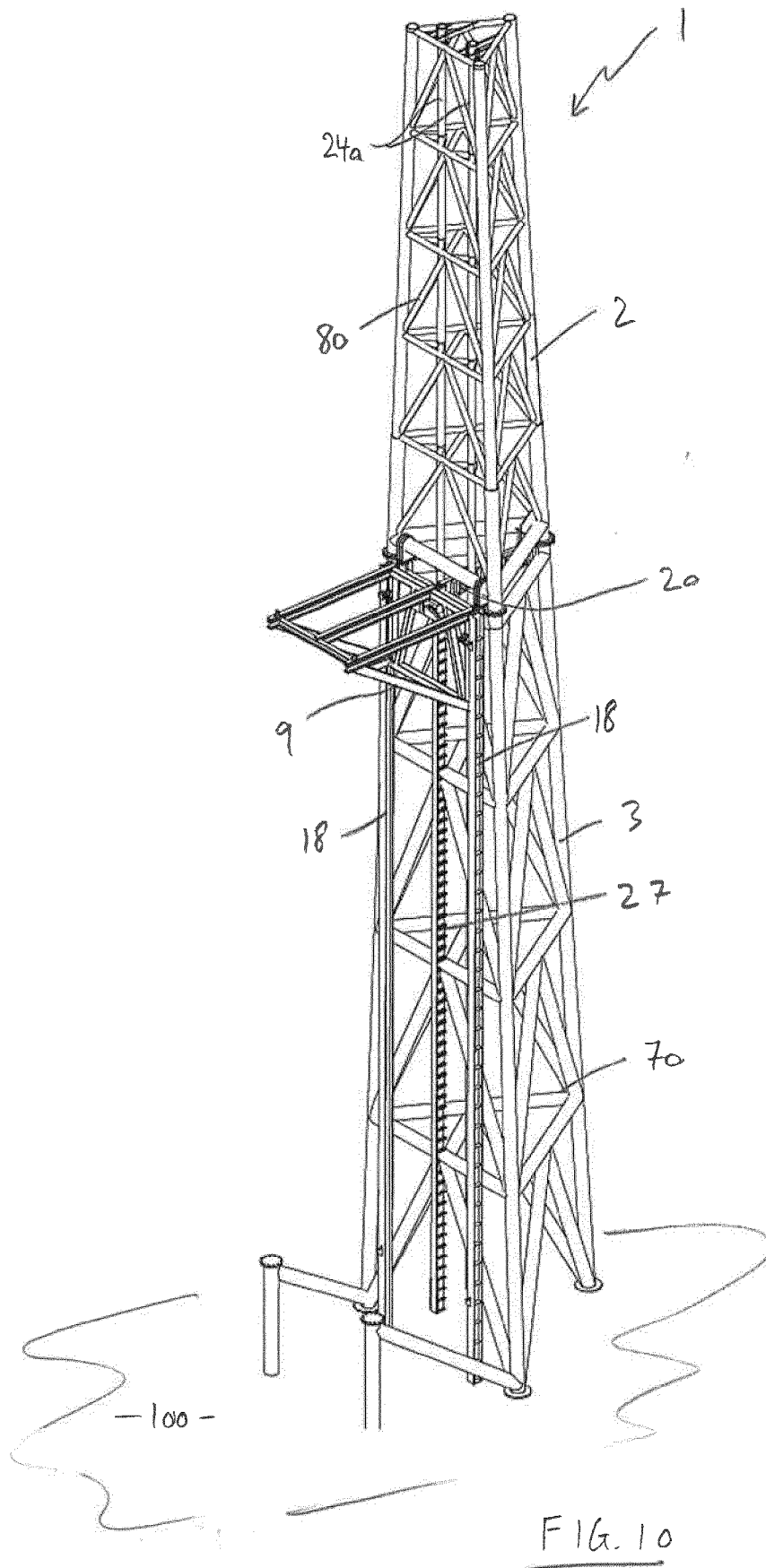


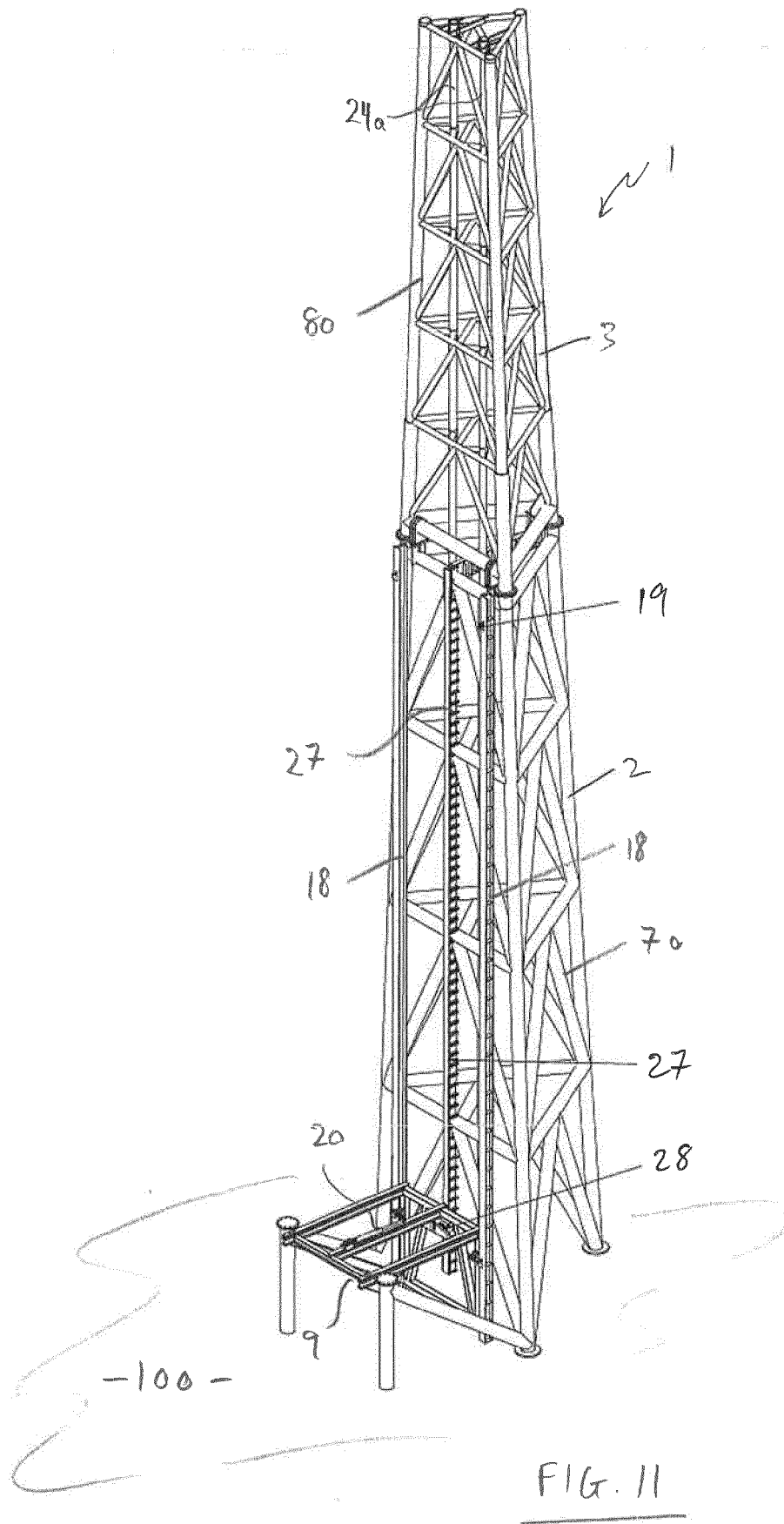
FIG. 6B











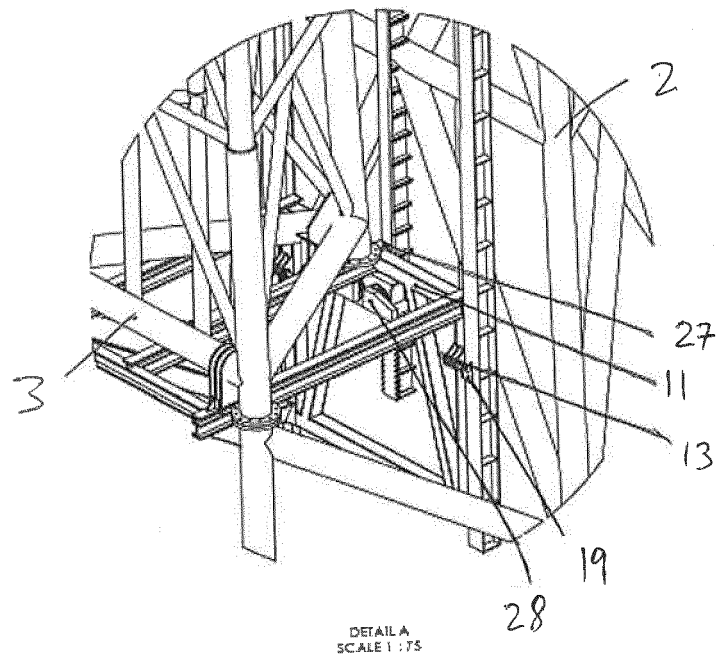
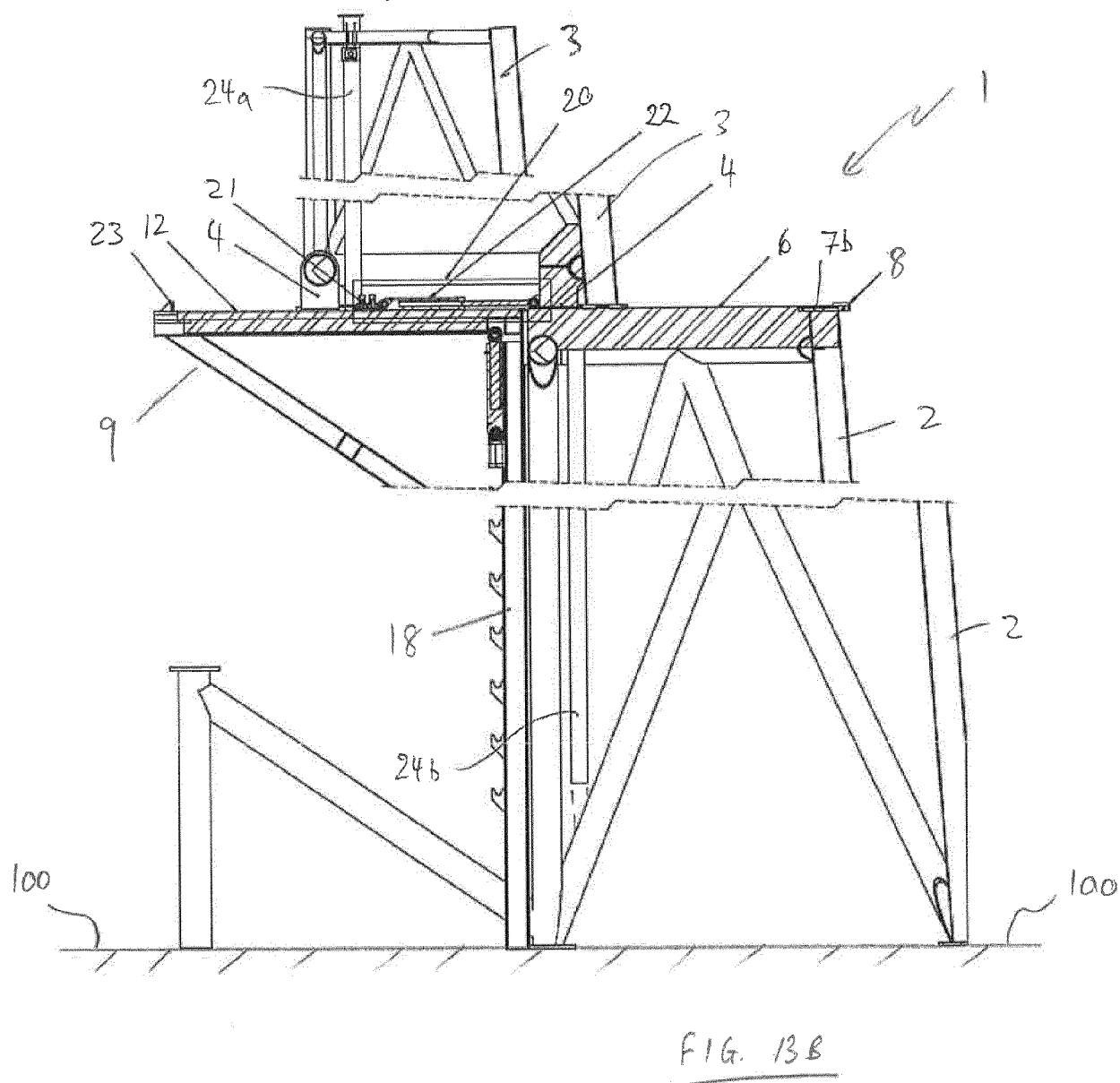
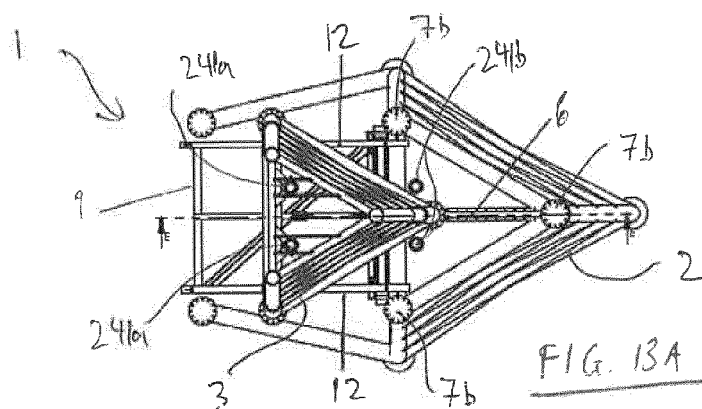
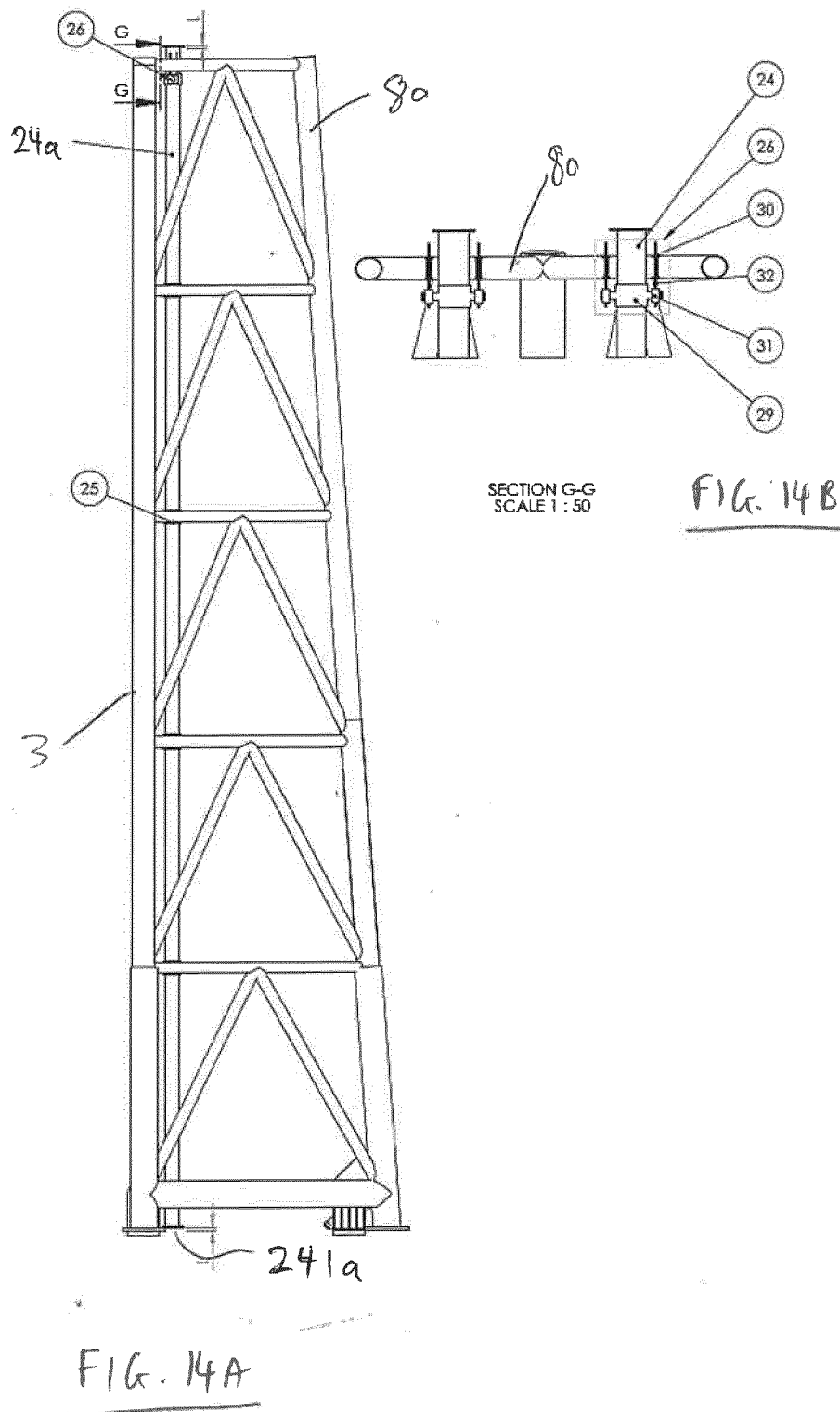


FIG. 12





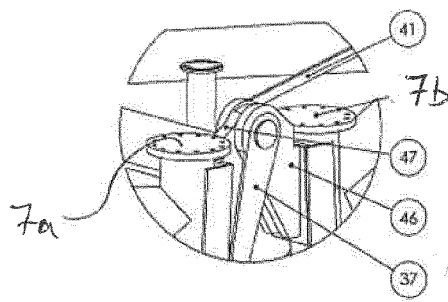


FIG. 15B

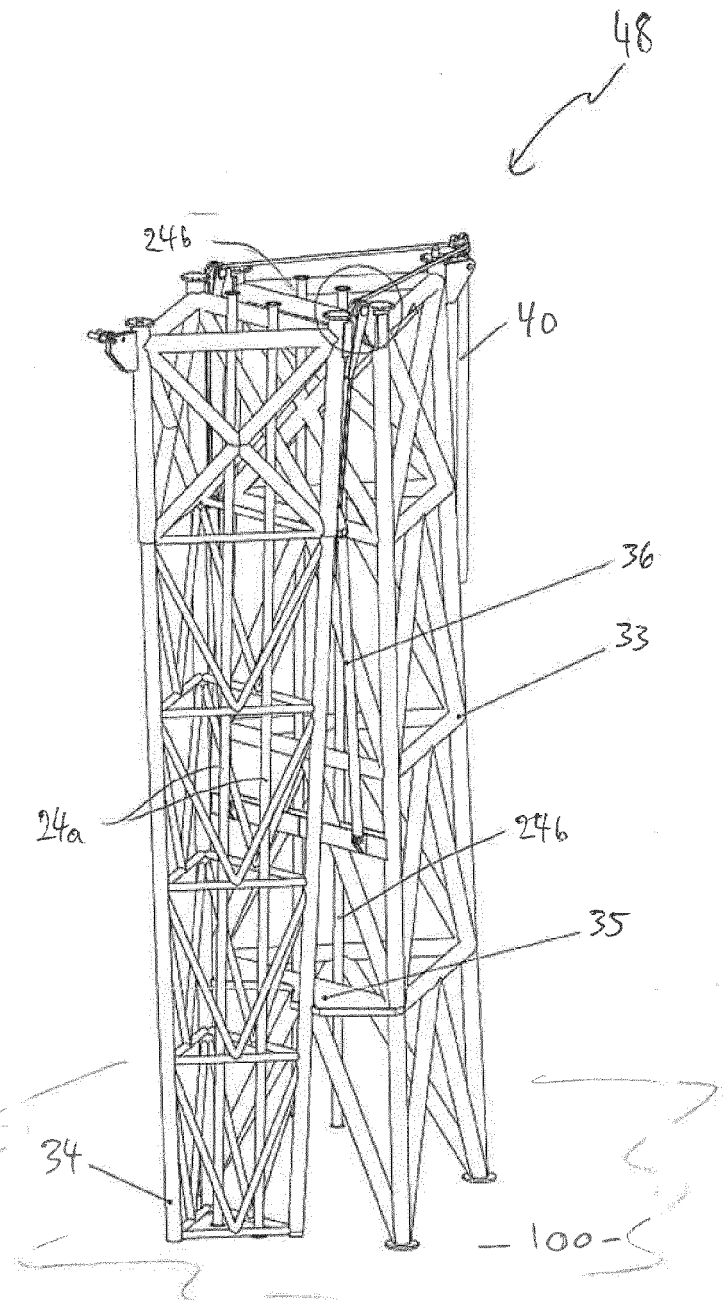
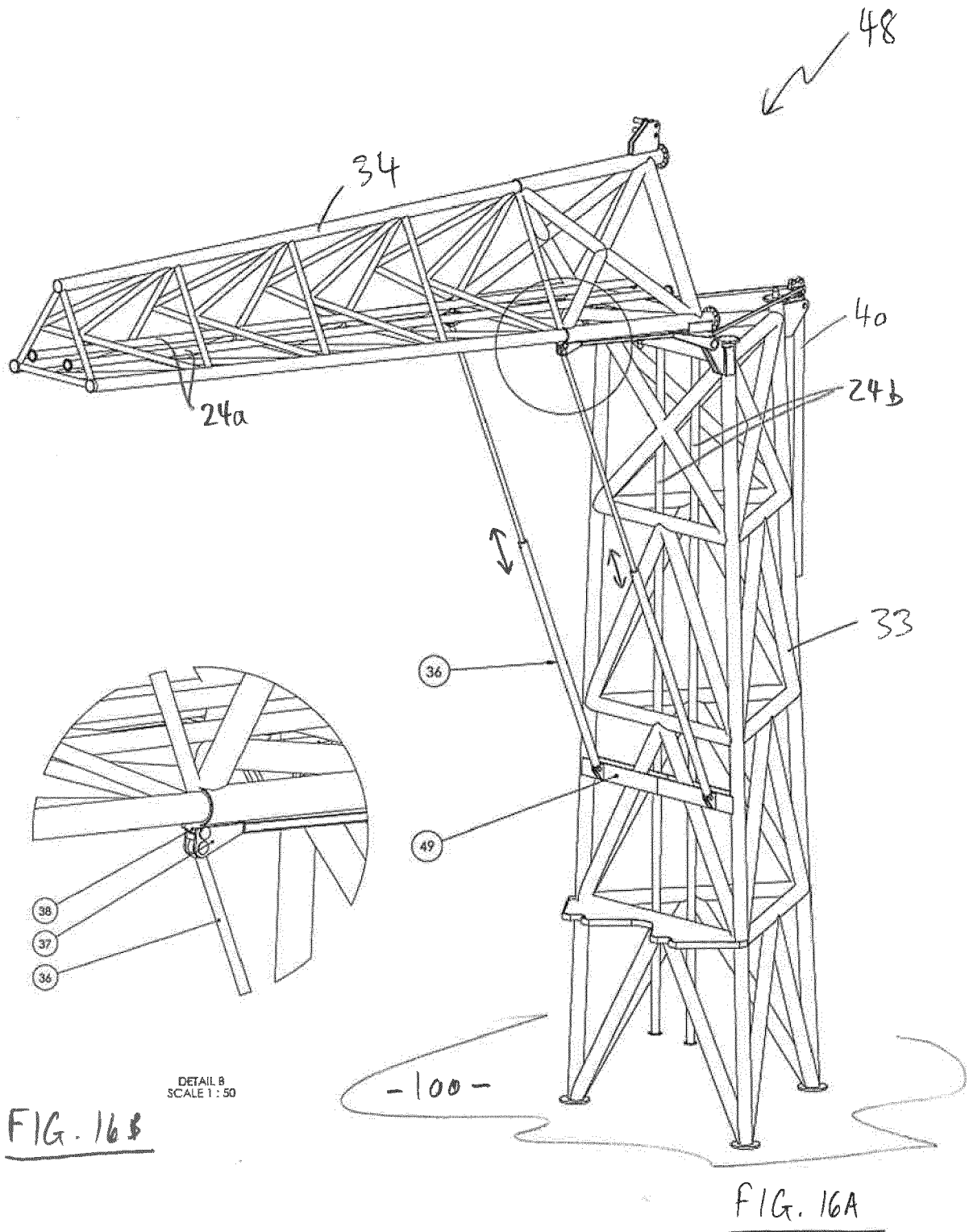


FIG. 15A



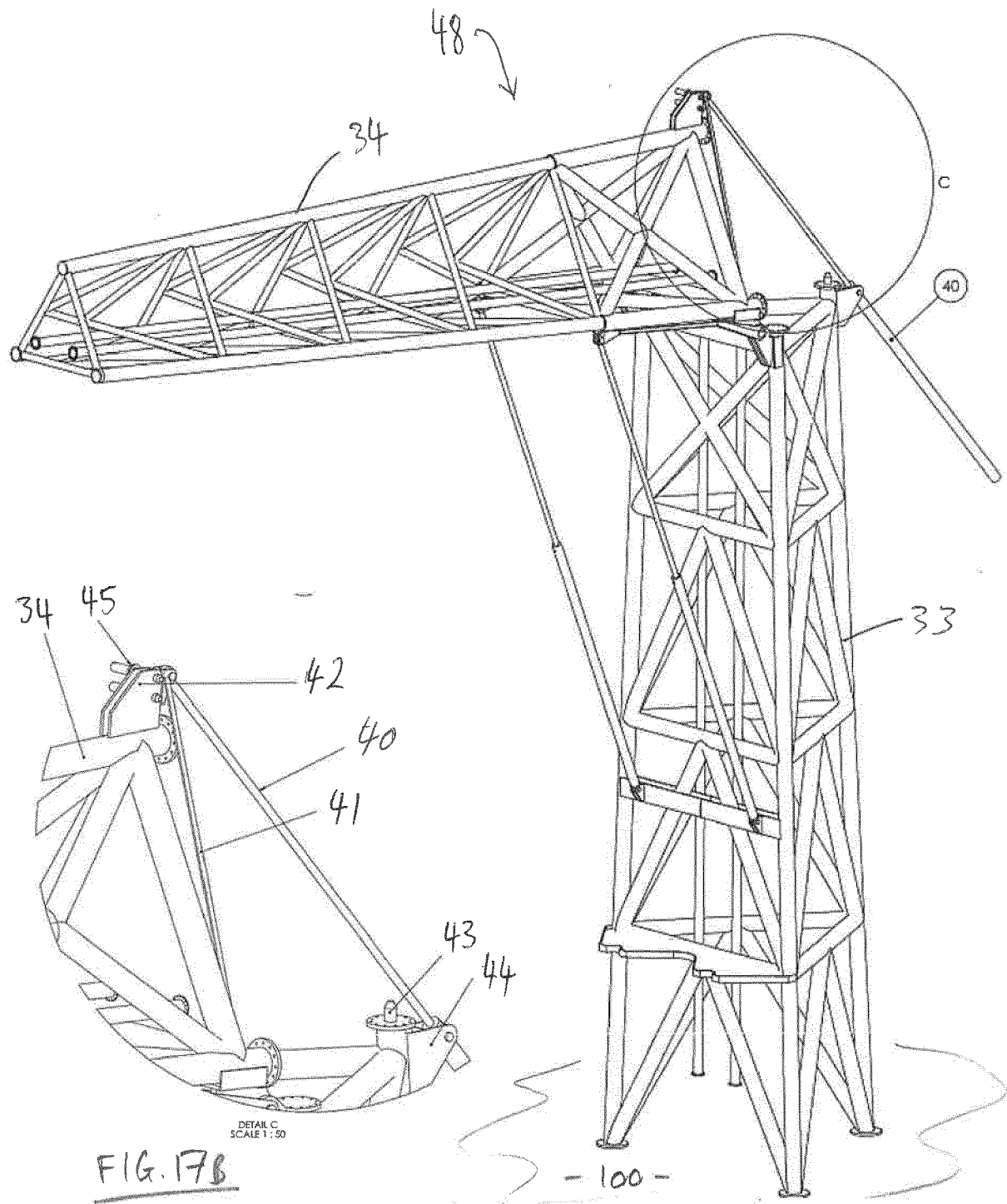


FIG. 17B

FIG. 17A

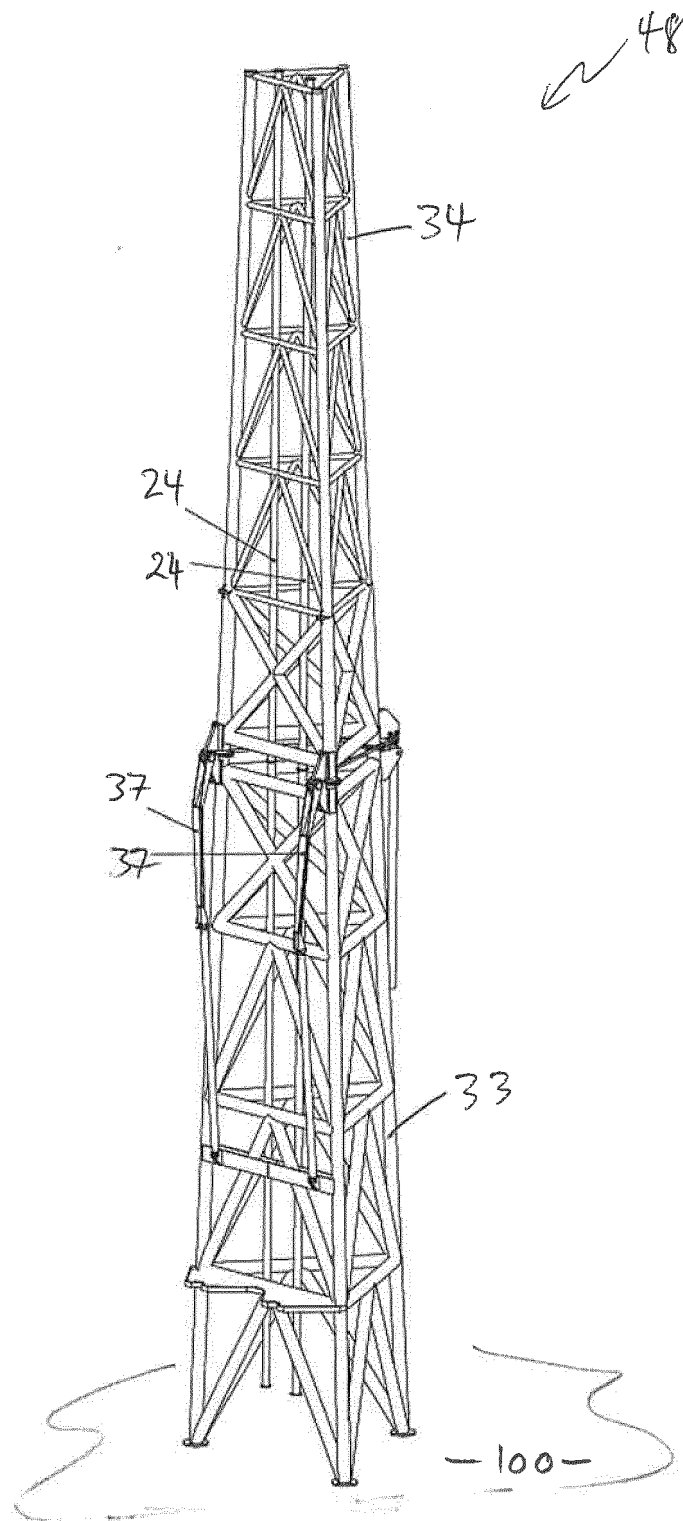
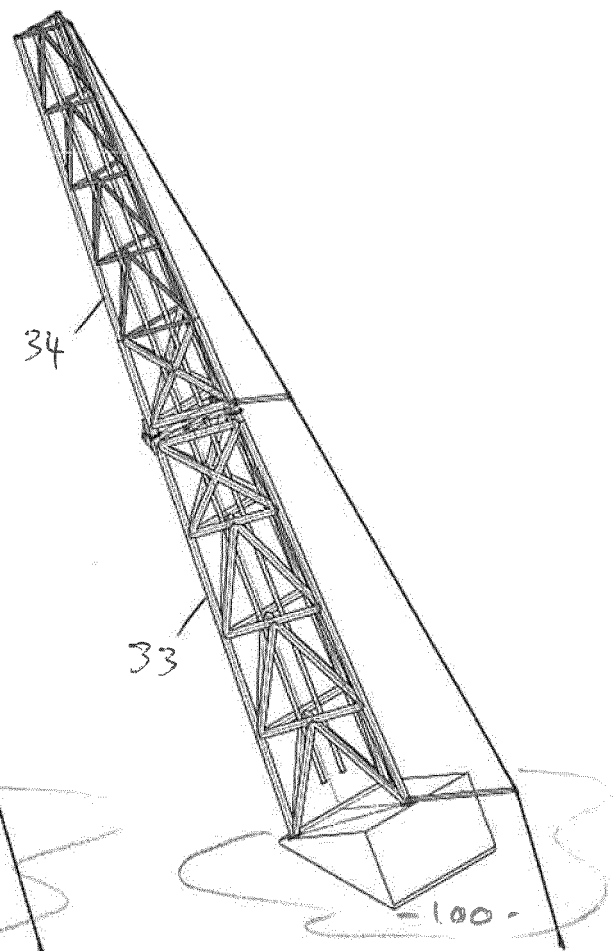
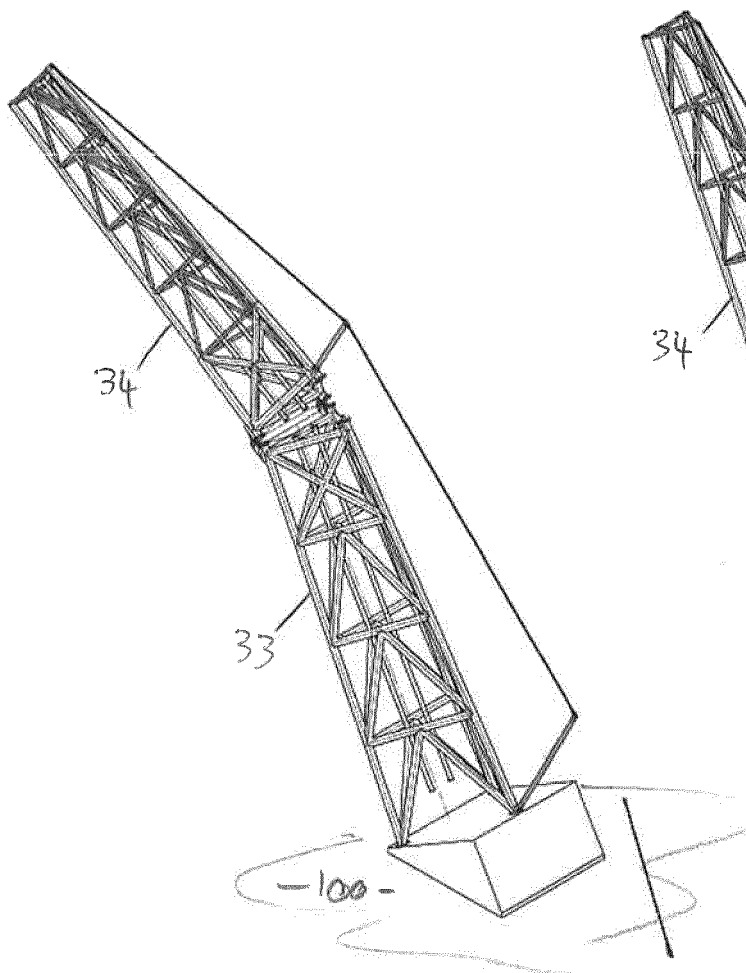


FIG. 18



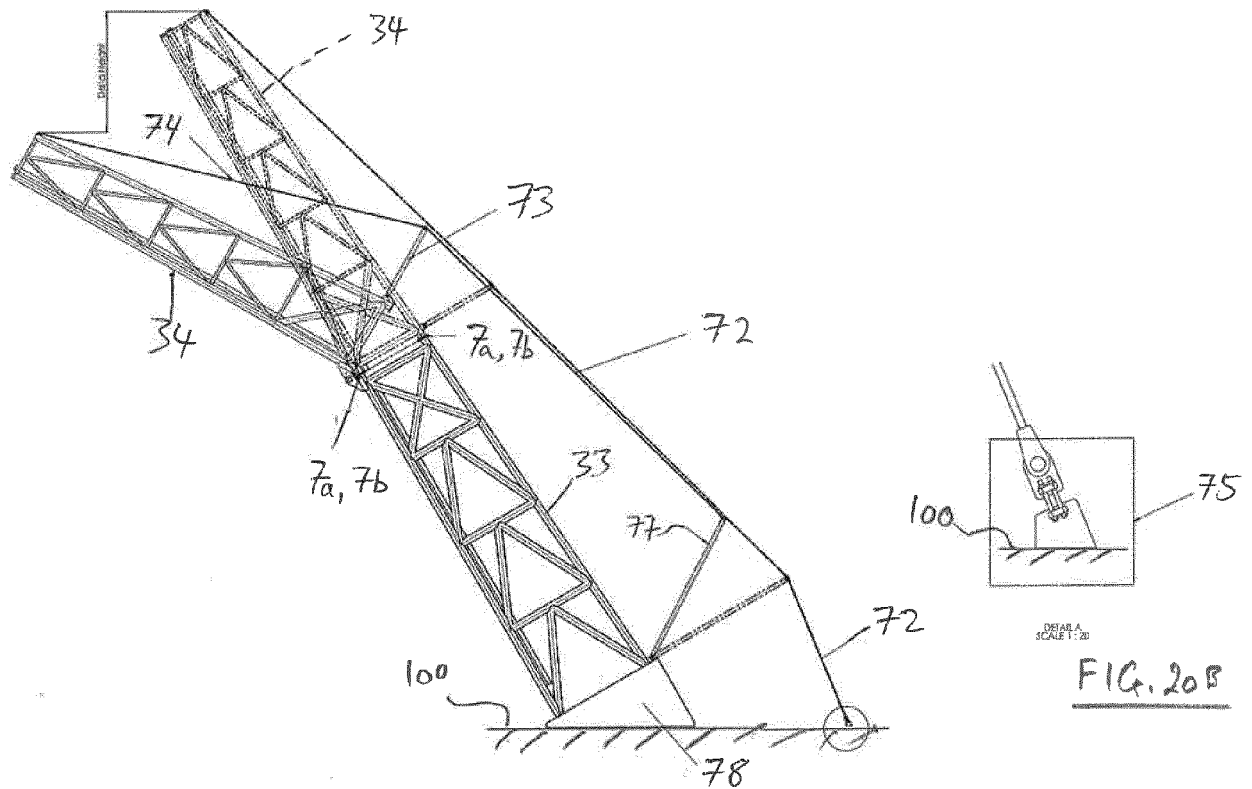
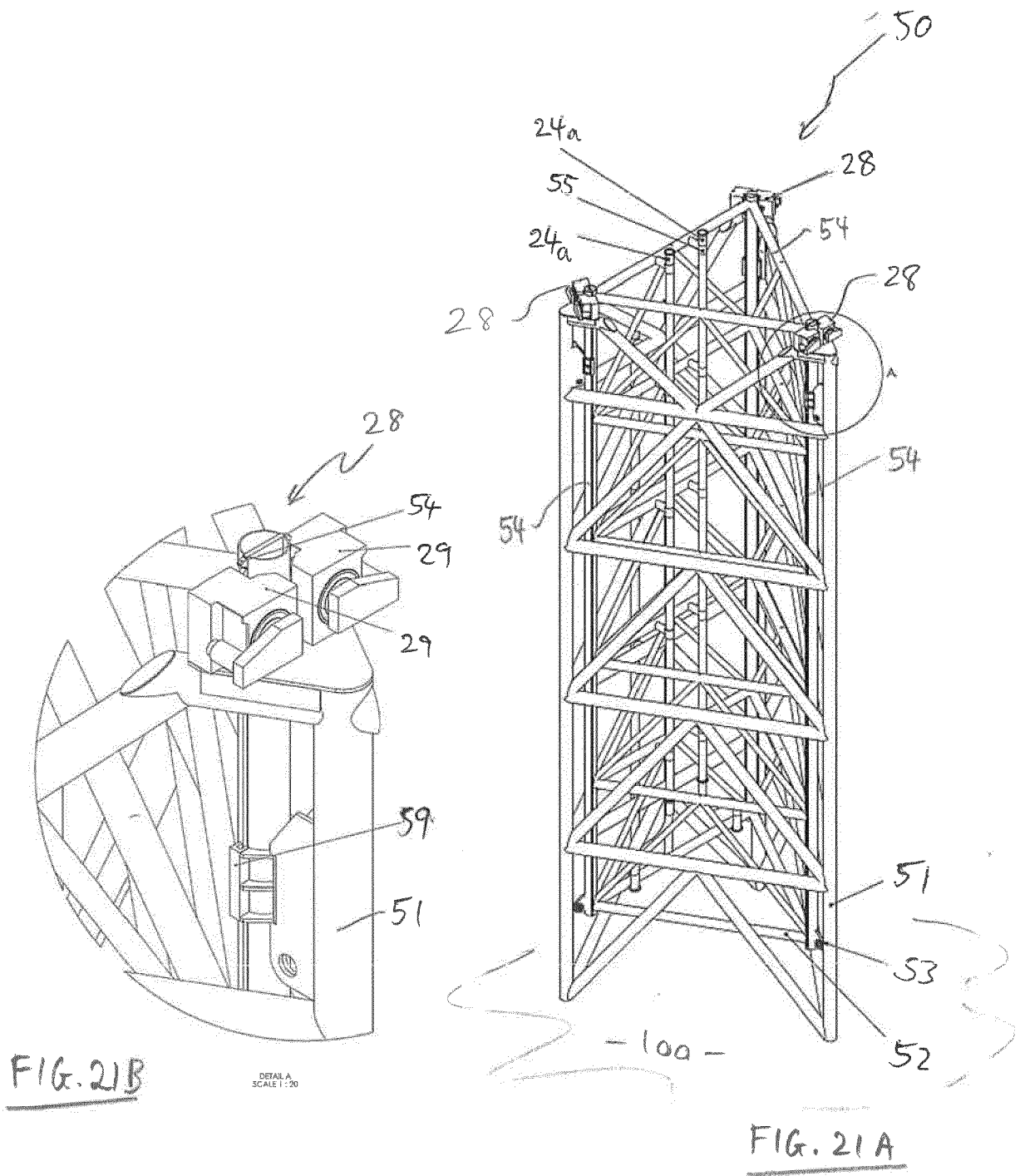
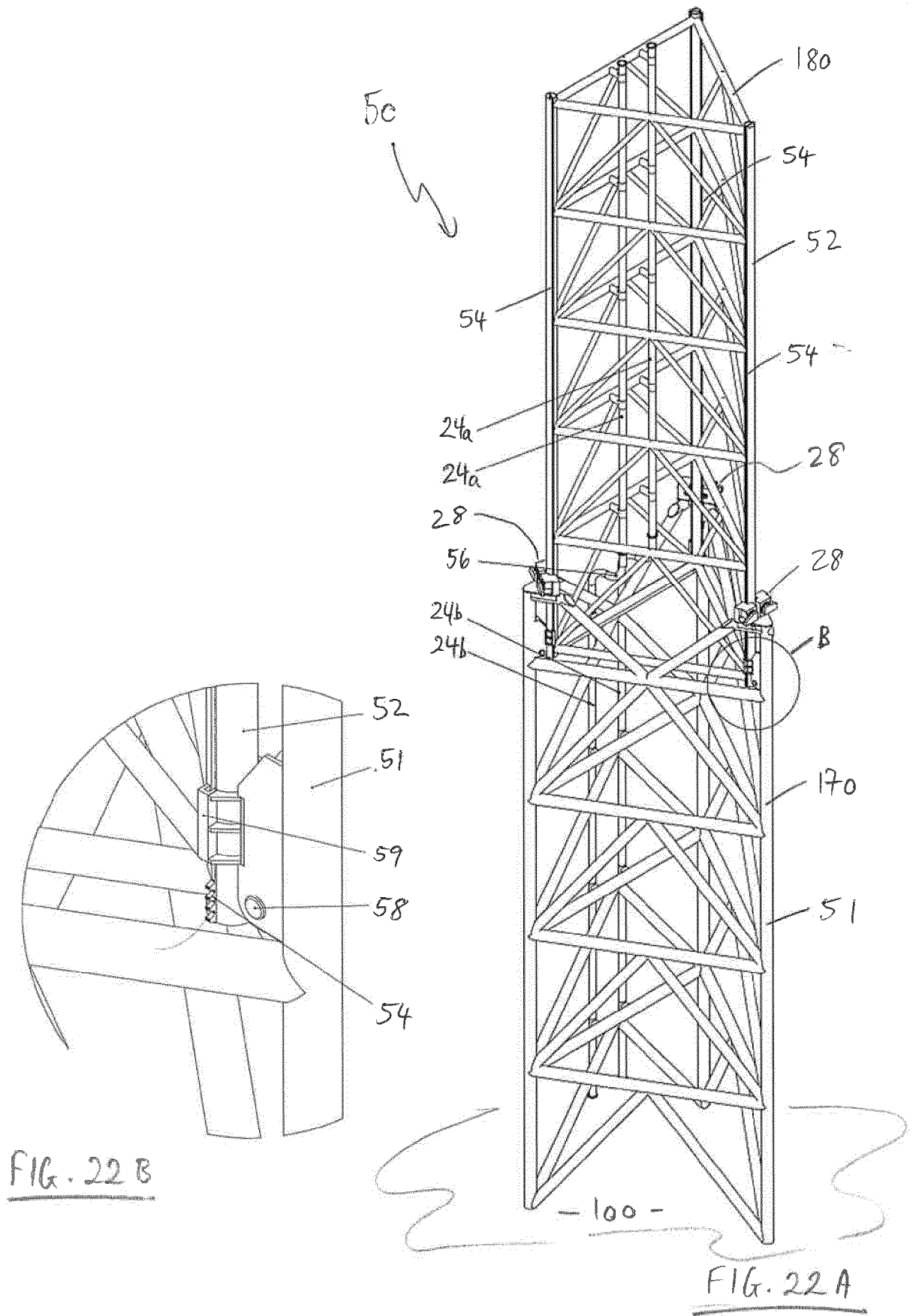


FIG. 20A

FIG. 20B





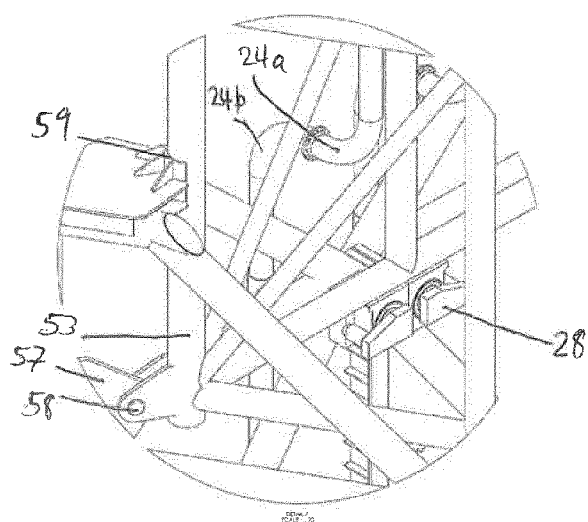


FIG. 24B

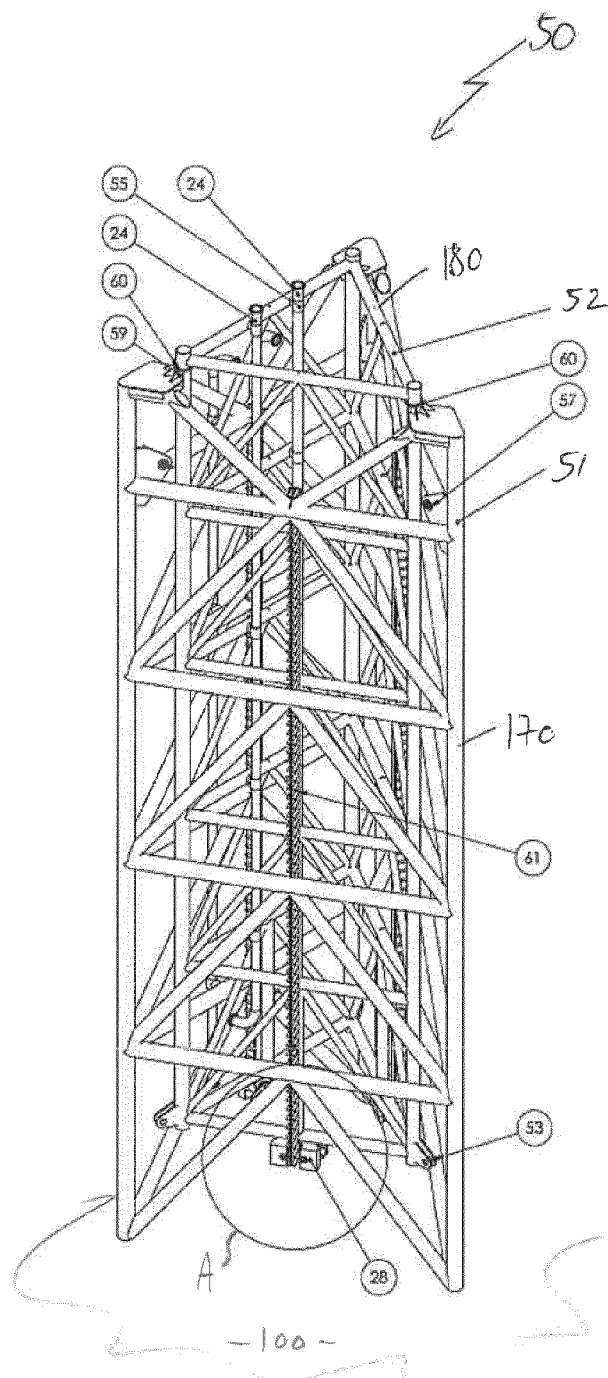
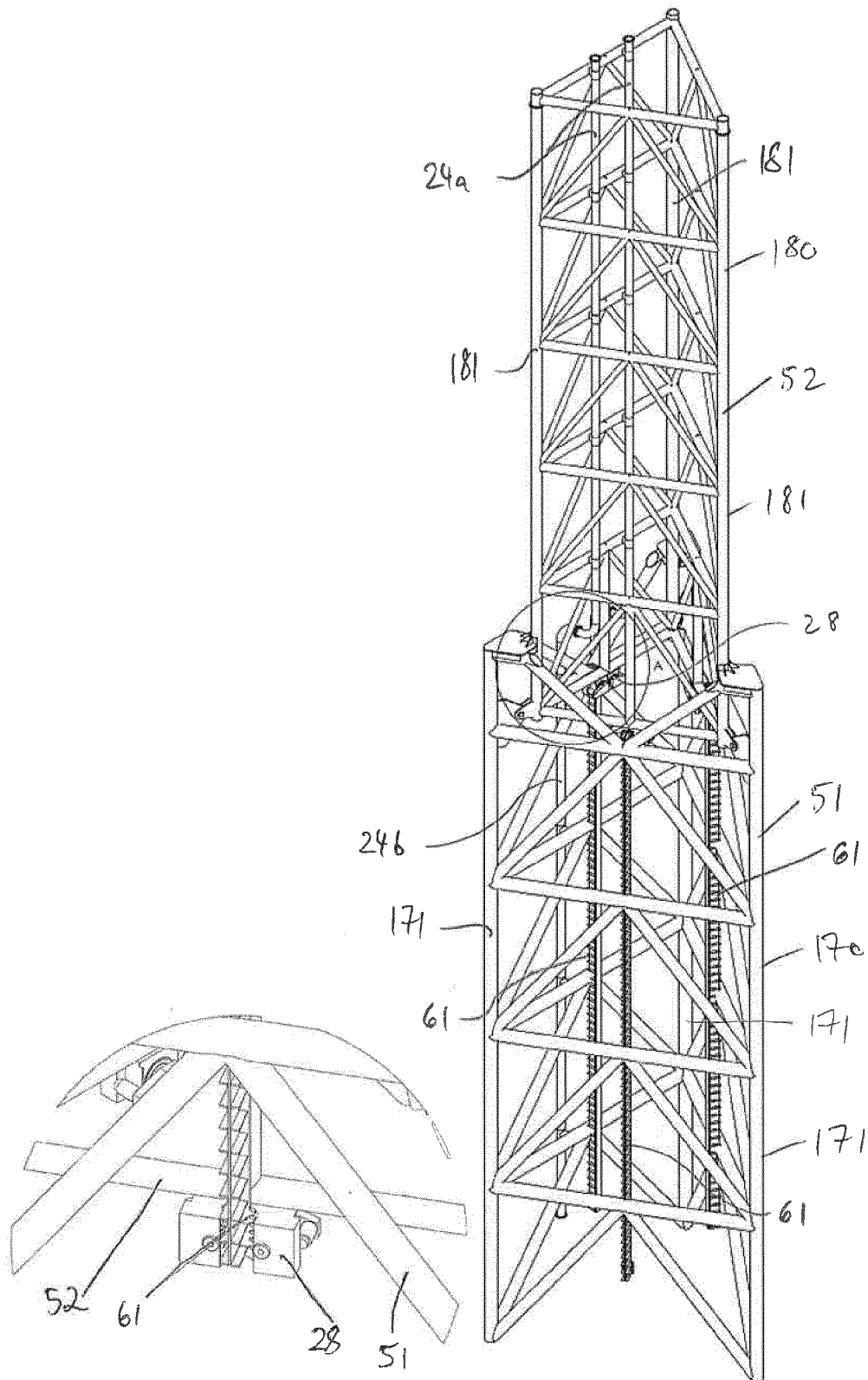


FIG. 23A



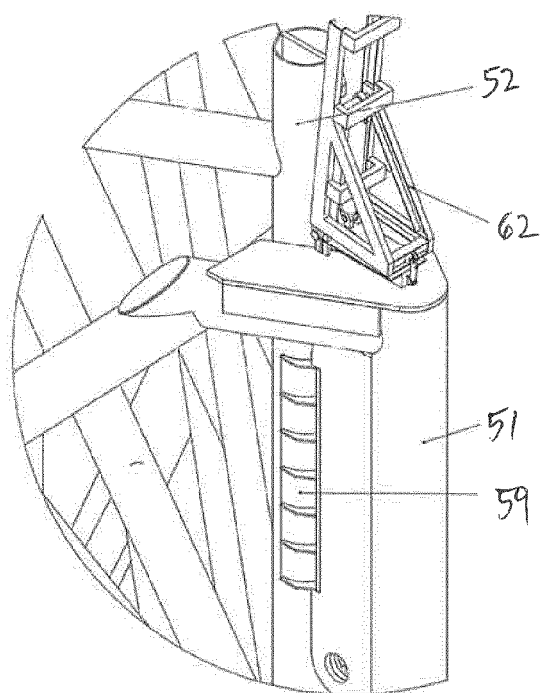


FIG. 25B

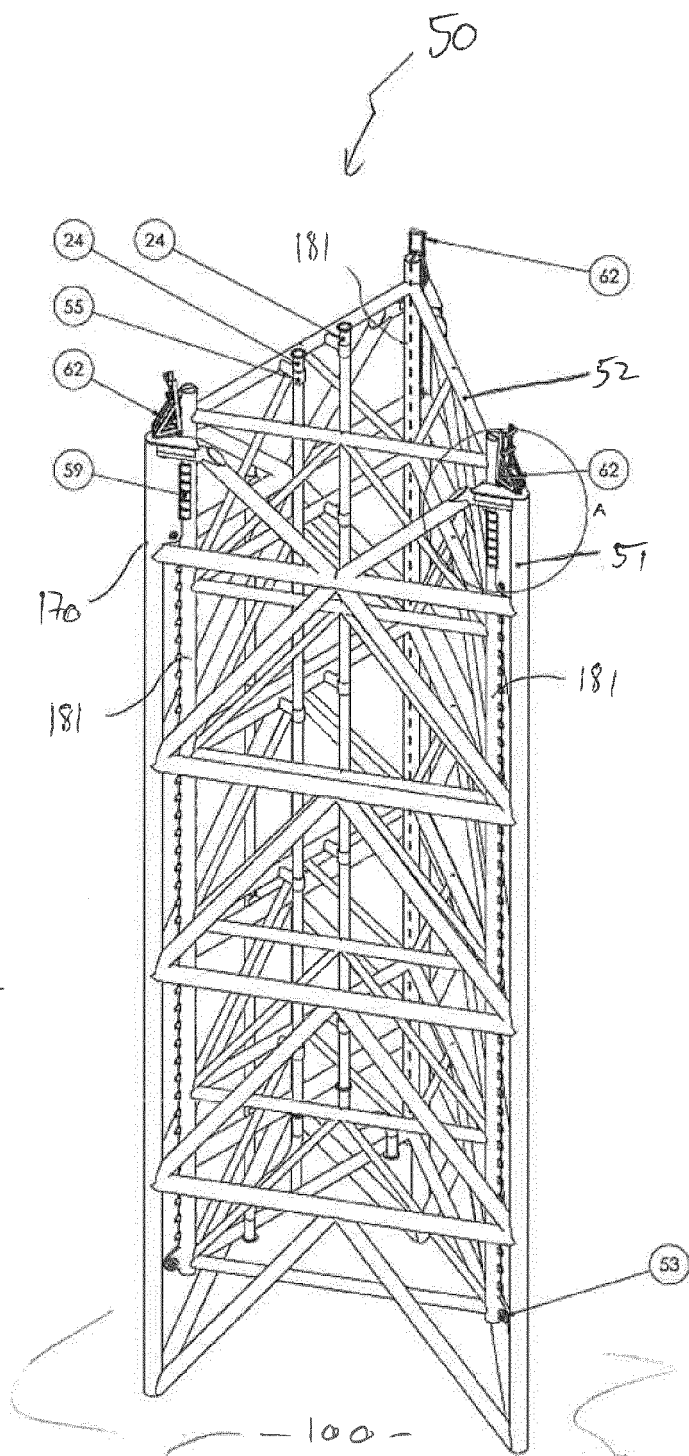
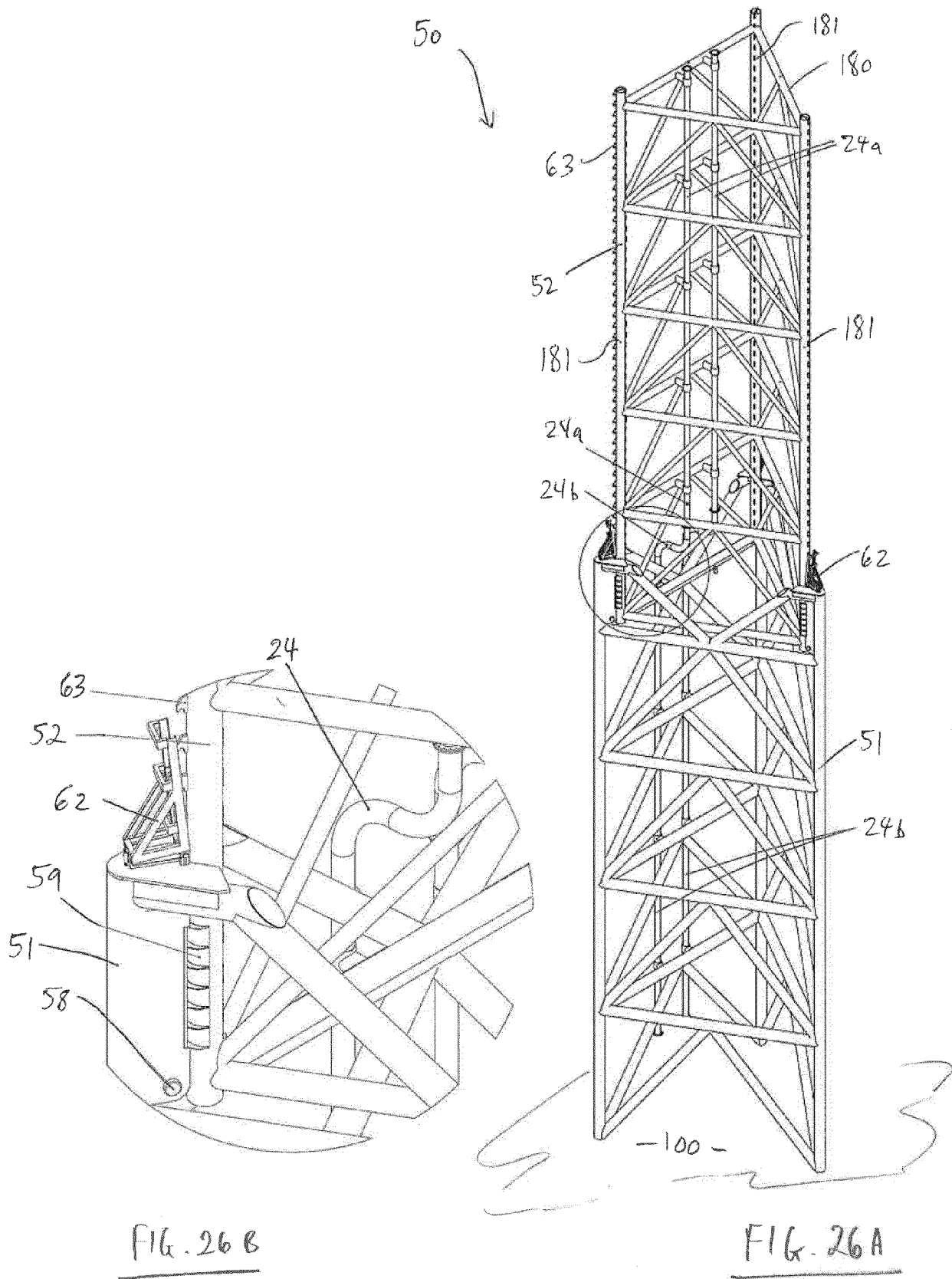
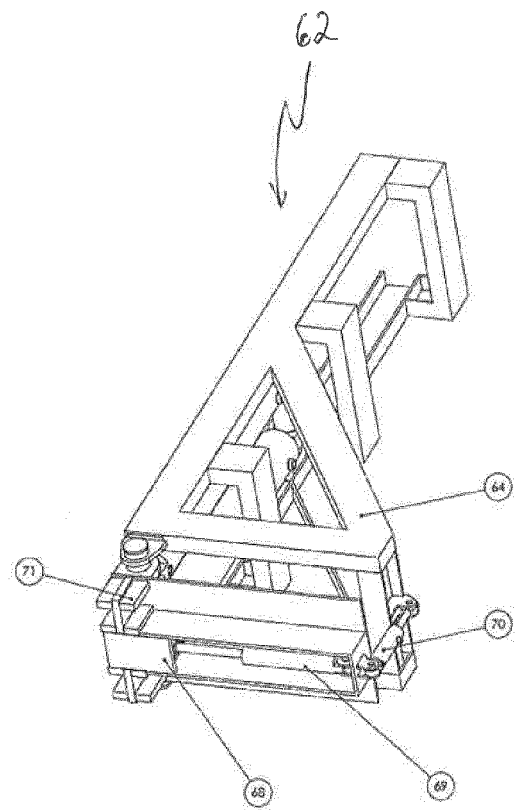
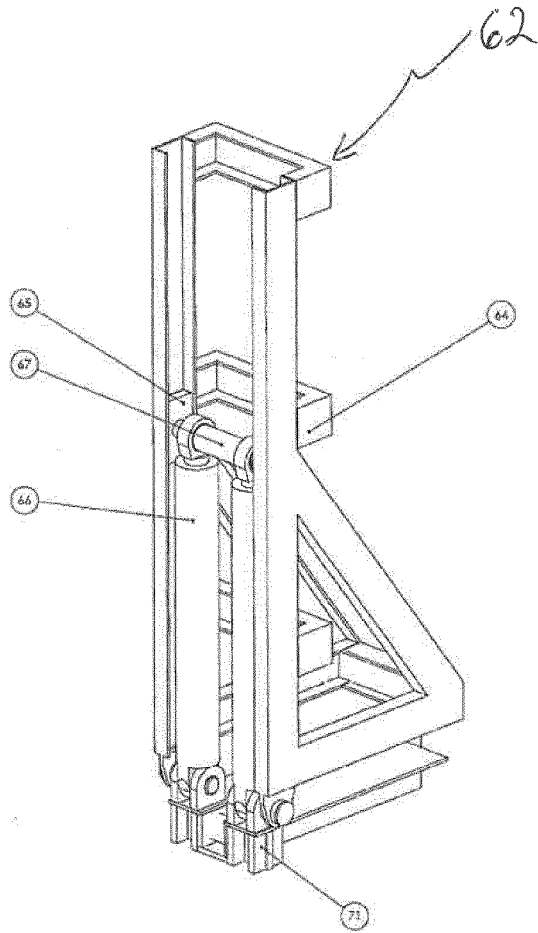


FIG. 25A





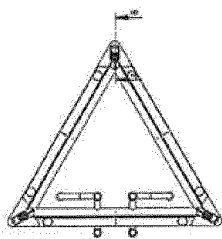


FIG. 28B

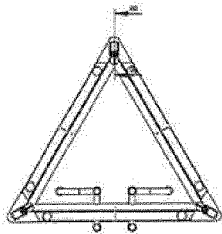


FIG. 29B

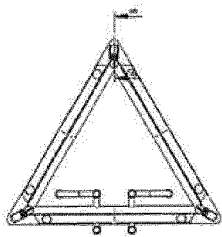


FIG. 30B

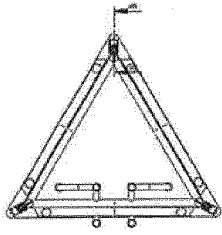
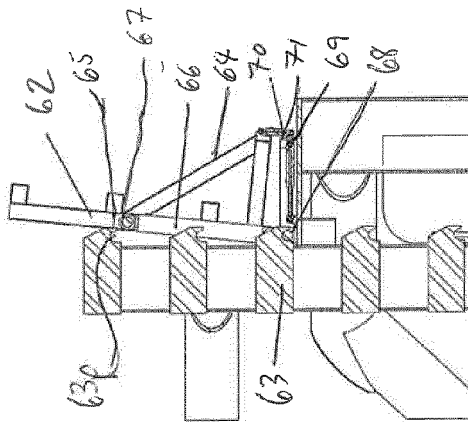
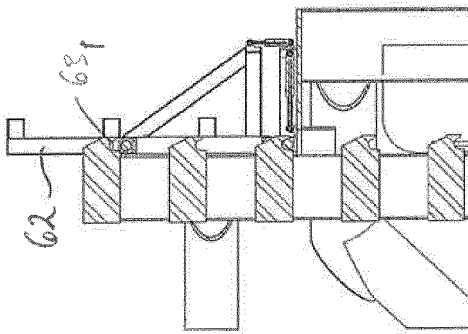


FIG. 31B



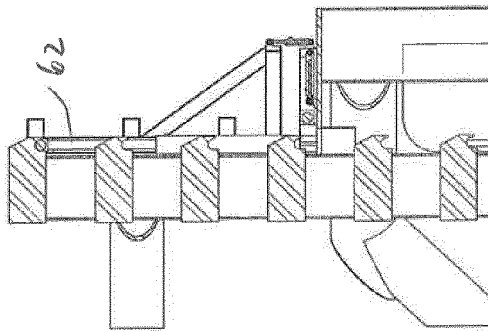
Pos. 1

FIG. 28A



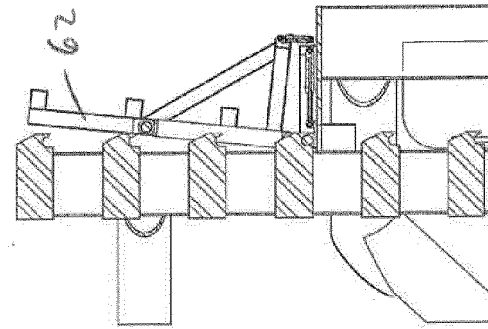
Pos. 2

FIG. 29A



Pos. 3

FIG. 30A



Pos. 1

FIG. 31A



EUROPEAN SEARCH REPORT

Application Number
EP 19 16 8713

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EPO FORM 1503 03.82 (P04C01)

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A	US 4 590 720 A (REED LOWELL M [US]) 27 May 1986 (1986-05-27) * column 6, line 21 - line 40; figures 5,6 *	1-25	
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A	CN 107 725 000 A (CHINA NAT OFFSHORE OIL CORP) 23 February 2018 (2018-02-23) * abstract; figures 1,2 *	1-25	
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Place of search Munich		Date of completion of the search 18 October 2019	Examiner Strømme, Henrik
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82