Innovation, Sciences et Développement économique Canada
Office de la Propriété Intellectuelle du Canada

Innovation, Science and Economic Development Canada
Canadian Intellectual Property Office

CA 3040825 A1 2018/04/26

(21) 3 040 825

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) Date de dépôt PCT/PCT Filing Date: 2017/10/18
(87) Date publication PCT/PCT Publication Date: 2018/04/26
(85) Entrée phase nationale/National Entry: 2019/04/16
(86) N° demande PCT/PCT Application No.: IL 2017/051145
(87) N° publication PCT/PCT Publication No.: 2018/073820
(30) Priorité/Priority: 2016/10/18 (IL248383)
(51) Cl.Int./Int.Cl. *A01K 61/00* (2017.01), *A01K 61/55* (2017.01), *A01K 61/60* (2017.01)
(71) Demandeur/Applicant:
SEA CONTROL HOLDINGS LTD., IL
(72) Inventeur/Inventor:
BROSH, SHAY, IL
(74) Agent: FASKEN MARTINEAU DUMOULIN LLP

(54) Titre : SYSTEME D'AQUACULTURE EN HAUTE MER
(54) Title: OPEN-SEA AQUACULTURE SYSTEM

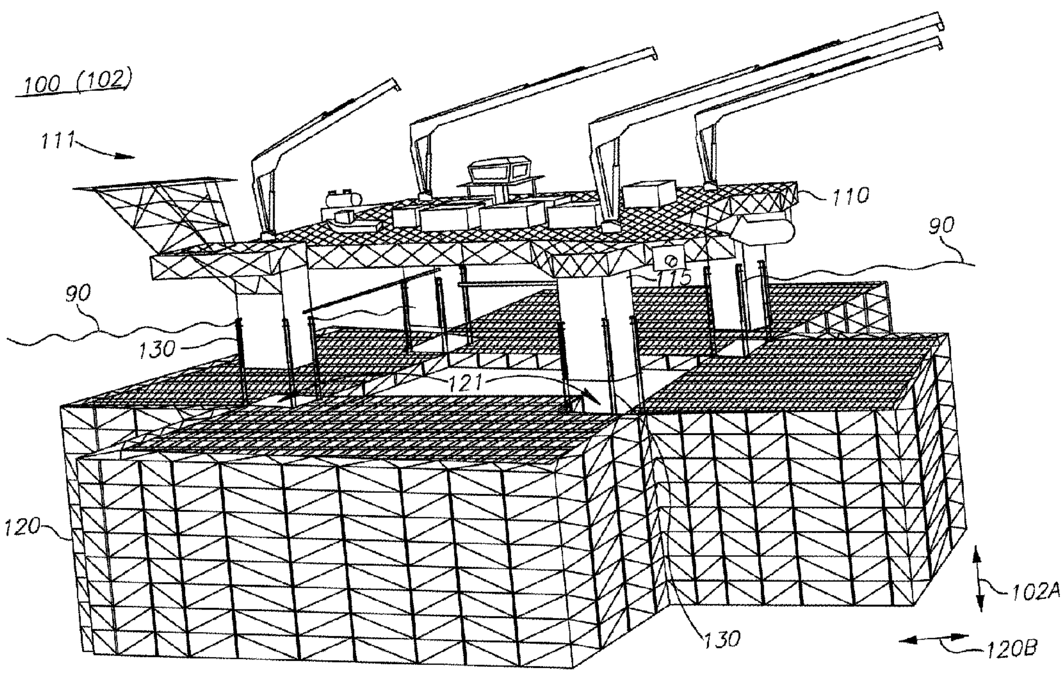


Figure 1B

(57) Abrégé/Abstract:
Open-sea aquaculture systems and methods are provided, which employ a semisubmersible platform with vertical columns, having storage and maintenance facilities for supporting aquaculture. Systems comprise a rigid assembly of aquaculture cages, with vertical cavities having forms configured to receive the corresponding vertical columns of the semisubmersible platform. The rigid assembly is mechanically connected to the semisubmersible platform in operational positions: (i) a raised position in which the rigid assembly encloses the corresponding vertical columns in the vertical cavities to limit a horizontal movement of the rigid assembly, and (ii) a lowered position in which the rigid assembly is below the corresponding vertical columns. Systems further comprise a control unit configured to control the mechanical position control mechanism to lower the rigid assembly upon occurrence of specified rough sea conditions, or whenever needed, and to raise the rigid assembly upon specified conditions.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
26 April 2018 (26.04.2018)

(10) **International Publication Number**
WO 2018/073820 A1

(51) **International Patent Classification:**
A01K 61/00 (2017.01) *A01K 61/55* (2017.01)
A01K 61/60 (2017.01)

(21) **International Application Number:** PCT/IL2017/051145

(22) **International Filing Date:** 18 October 2017 (18.10.2017)

(25) **Filing Language:** English

(26) **Publication Language:** English

(30) **Priority Data:**
248383 18 October 2016 (18.10.2016) IL

(71) **Applicant: SEA CONTROL HOLDINGS LTD.** [IL/IL]; 4 Hagidonim Street, 3094104 Zikhron Ya'akov (IL).

(72) **Inventor: BROSH, Shay**; 4 Hagidonim Street, 3094104 Zikhron Ya'akov (IL).

(74) **Agent: TAL, Ophir** et al.; PEARL COHEN ZEDEK LATZER BARATZ, Azrieli Sarona Tower, P.O. Box 7198, 6107121 Tel Aviv (IL).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(54) **Title:** OPEN-SEA AQUACULTURE SYSTEM

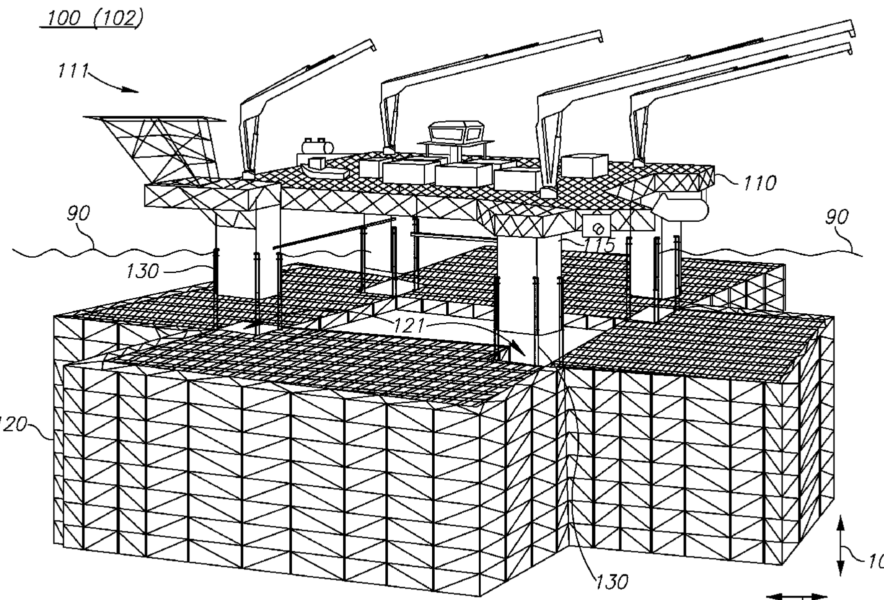


Figure 1B

(57) **Abstract:** Open-sea aquaculture systems and methods are provided, which employ a semisubmersible platform with vertical columns, having storage and maintenance facilities for supporting aquaculture. Systems comprise a rigid assembly of aquaculture cages, with vertical cavities having forms configured to receive the corresponding vertical columns of the semisubmersible platform. The rigid assembly is mechanically connected to the semisubmersible platform in operational positions: (i) a raised position in which the rigid assembly encloses the corresponding vertical columns in the vertical cavities to limit a horizontal movement of the rigid assembly, and (ii) a lowered position in which the rigid assembly is below the corresponding vertical columns. Systems further comprise a control unit configured to control the mechanical position control mechanism to lower the rigid assembly upon occurrence of specified rough sea conditions, or whenever needed, and to raise the rigid assembly upon specified conditions.

WO 2018/073820 A1

[Continued on next page]

WO 2018/073820 A1

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

OPEN-SEA AQUACULTURE SYSTEM

BACKGROUND OF THE INVENTION

1. TECHNICAL FIELD

[0001] The present invention relates to the field of aquaculture, and more particularly, to offshore aquaculture.

2. DISCUSSION OF RELATED ART

[0002] Offshore aquaculture is experiencing an expansion but has to cope with rougher sea conditions than the more traditional near-shore aquaculture.

[0003] U.K. Patent No. GB 2,501,879 which is incorporated herein by reference in its entirety, discloses an offshore aquaculture system based on a semisubmersible platform having storage and maintenance facilities for supporting aquaculture with an attached framework, to which net covered rigid aquaculture cages are movably connected and controllably positioned according to sea conditions. The cages may be lowered or raised with respect to the framework to protect the aquaculture products, and all maintenance and feeding is carried out by crew onboard the platform.

SUMMARY OF THE INVENTION

[0004] The following is a simplified summary providing an initial understanding of the invention. The summary does not necessarily identify key elements nor limit the scope of the invention, but merely serves as an introduction to the following description.

[0005] One aspect of the present invention provides an open-sea aquaculture system comprising: a semisubmersible platform having storage and maintenance facilities for supporting aquaculture, the semisubmersible platform comprising a plurality of vertical columns, a rigid assembly of aquaculture cages, the rigid assembly comprising a plurality of vertical cavities having forms configured to receive corresponding vertical columns of the semisubmersible platform, a mechanical position control mechanism configured to connect, mechanically, the rigid assembly to the semisubmersible platform and control a relative position therebetween to provide at least two operational positions: (i) a raised position in which the rigid assembly encloses the corresponding vertical columns in the vertical cavities to limit a horizontal movement of the rigid assembly, and (ii) a lowered position in which the rigid assembly is below the corresponding vertical columns, and a control unit configured to control the mechanical position control mechanism to move the rigid assembly from the raised to the lowered position upon occurrence of specified rough sea conditions, or whenever needed, and to move the rigid assembly from the lowered to the raised position upon specified conditions.

[0006] These, additional, and/or other aspects and/or advantages of the present invention are set forth in the detailed description which follows; possibly inferable from the detailed description; and/or learnable by practice of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] For a better understanding of embodiments of the invention and to show how the same may be carried into effect, reference will now be made, purely by way of example, to the accompanying drawings in which like numerals designate corresponding elements or sections throughout.

[0008] In the accompanying drawings:

[0009] Figures 1A-1G are high level schematic illustrations of an open-sea aquaculture system, according to some embodiments of the invention.

[0010] Figure 2A is a high level schematic block diagram of the open-sea aquaculture system, according to some embodiments of the invention.

[0011] Figures 2B and 2C are a high level schematic illustration of positions and possible movements of the open-sea aquaculture system, according to some embodiments of the invention.

[0012] Figures 3A-3O are high level schematic illustrations of mechanical position control mechanisms in the open-sea aquaculture system, according to some embodiments of the invention.

[0013] Figures 4A-4D are high level schematic illustrations of cage configurations in the rigid cage assembly, according to some embodiments of the invention

[0014] Figure 5 is a high level schematic illustration of a movable cage floor, used for fish handling in the open-sea aquaculture system, according to some embodiments of the invention.

[0015] Figure 6 is a high level flowchart illustrating an open-sea aquaculture method, according to some embodiments of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0016] In the following description, various aspects of the present invention are described. For purposes of explanation, specific configurations and details are set forth in order to provide a thorough understanding of the present invention. However, it will also be apparent to one skilled in the art that the present invention may be practiced without the specific details presented herein. Furthermore, well known features may have been omitted or simplified in order not to obscure the present invention. With specific reference to the drawings, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the present invention only, and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

[0017] Before at least one embodiment of the invention is explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention is applicable to other embodiments that may be practiced or carried out in various ways as well as to combinations of the disclosed embodiments. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and should not be regarded as limiting.

[0018] Unless specifically stated otherwise, as apparent from the following discussions, it is appreciated that throughout the specification discussions utilizing terms such as "processing", "computing", "calculating", "determining", “enhancing” or the like, refer to the action and/or processes of a computer or computing system, or similar electronic computing device, that manipulates and/or transforms data represented as physical, such as electronic, quantities within the computing system's registers and/or memories into other data similarly represented as physical quantities within the computing system's memories, registers or other such information storage, transmission or display devices. Any of the disclosed modules or units may be at least partially implemented by a computer processor.

[0019] **Figures 1A-1G** are high level schematic illustrations of an open-sea aquaculture system **100**, according to some embodiments of the invention. **Figures 1A** and **1B** are perspective view, **Figures 1C** and **1D** are side views, **Figure 1E** is a top view and **Figures 1F** and **1G** schematically illustrate columns and cages of system **100**, **Figure 1F** in a top view of a horizontal cross section below the sea level and **Figure 1G** in a perspective view. Elements from **Figures 1A-1G** may be combined in any operable combination, and the illustration of certain elements in certain figures and not in others merely serves an explanatory purpose and is non-limiting. **Figure 2A** is a high level schematic block diagram of open-sea aquaculture system **100**, according to some embodiments of the invention, and **Figures 2B** and **2C** are high level schematic illustrations of positions and possible movements of open-sea aquaculture system **100**, according to some embodiments of the invention.

[0020] Open-sea aquaculture system **100** is configured to operate at a large distance from the shore and to enable a continuous operation of aquaculture at open-sea. Open-sea aquaculture system **100** comprises a semisubmersible platform **110**, buoyant by its vertical columns **115** which are partly below ocean surface **90** (vertical columns **115** may be constructed as watertight pontoons). Semisubmersible platform **100** comprises an operating deck **111** having storage and maintenance facilities for supporting aquaculture and a plurality of vertical columns **115**. Operating deck **111** is located stably high above (**116**) sea level **90** and is not or almost not affected by wave action under rough sea conditions. Open-sea aquaculture system **100** is configured to withstand long operation periods at sea.

[0021] Open-sea aquaculture system **100** further comprises a rigid assembly **120** of aquaculture cages **120A**, **120B**, etc. (see **Figures 4A**, **4D**). Rigid assembly **120** may comprise at least part of buoyancy mechanisms **127** or be independent therefrom. Rigid assembly **120** comprises a plurality of vertical cavities **121** (see e.g., **Figures 1A**, **1F, 3A**) having forms configured to receive corresponding vertical columns **115** of semisubmersible platform **110**. It is noted that vertical columns **115** are understood as any structural element of semisubmersible platform **110** which crosses water level **90** and receives rigid cage assembly **120**.

[0022] The dimensions and forms of rigid assembly **120** of aquaculture cages **120A**, **120B**, etc. are not limiting, in particular, rigid assembly **120** may extend far beyond the area of semisubmersible platform **110** to support a large number of cages, and may reach depths of several tens of meters. The cages themselves may be higher than wide, may be wider than high or may have similar height and width. The cages may be adapted to various types of aquaculture, e.g. fish, clams, ornamentals etc. The cages may be covered with nets (not shown) to maintain the cultured organisms within the cages. As shown in **Figure 1E**, rigid cage assembly **120** may extend beyond the sides of platform **100** and extend horizontally and vertically according to required cage volumes. Rigid cage assembly **120** may enclose any water level crossing structures of platform **110**, which are generally related here in a non-limiting manner as being vertical columns.

[0023] Buoyancy mechanisms **127** (e.g., floats or other buoyancy mechanism such as inflatable tubes, containers or other elements which may change their buoyancy under control of control unit **160**) may be connected to rigid cage assembly **120** at various position, providing buoyancy for rigid cage assembly **120** and control over the buoyancy of rigid cage assembly **120**, especially during raising and lowering rigid cage assembly **120**.

[0024] Open-sea aquaculture system **100** comprises mechanical position control mechanism **130** (see **Figures 1B**, **1D**) configured to connect, mechanically, rigid assembly **120** to semisubmersible platform **110**, to limit a horizontal movements of rigid assembly **120**, and to control a relative position therebetween to provide at least two operational positions: a raised position **101** (**Figures 1A**, **1C**), in which rigid assembly **120** encloses corresponding vertical columns **115** in vertical cavities **121** , and a lowered position **102** (**Figures 1B**, **1D**) in which rigid assembly **120** is below corresponding vertical columns **115**. Mechanical position control mechanism **130** is configured to raise and lower rigid assembly **120** to maintain a required position of the cages with respect to sea level. Mechanical position control mechanism **130** may be configured to enable adjustment **101A**, **102A** of the depth of rigid assembly **120** within each of raised position

101 and lowered position **102**, respectively, to enable fine tuning of the cages' depth. It is noted that height **116** between operating deck **111** and sea level **90** is maintained in raised and lower positions **101**, **102** of rigid assembly **120** and assures that operating deck **111** is located stably and is not or almost not affected by wave action under rough sea conditions.

[0025] In certain embodiments, sections of cages **120** may be reinforced by supports **120A**, such as illustrated schematically in **Figure 1F**. Vertical cavities **121** may be open at one or two points on their perimeter, or may be fully enclosed by cages **120**. Vertical cavities **121** may be designed to be somewhat larger than the cross sections of vertical columns **115** and mechanical position control mechanism **130** may be configured to maintain vertical columns **115** within the volume of vertical cavities **121** and prevent an inner side **120B** of cages **120** in vertical cavities **121** from contacting vertical columns **115** during the raising and lowering of cages and/or during regular operation of open-sea aquaculture system **100**. Guiding elements **132, 147A** may be set on either or both vertical columns **115** and inner sides **120B** of vertical cavities **121** to protect either or both from possible impacts and/or to guide their relative movements, as explained in detail below.

[0026] In certain embodiments, cages **120** may be at least partially flexible and be made e.g., of flexible nets **120D**, possibly held by one or more rigid cage parts **120C**, **120E**, as illustrated schematically in **Figure 1G** in perspective, side and top views and in **Figure 2C** as a schematic illustration. Mechanical position control mechanism **130** may be connected to at least one of rigid cage parts **120C**, **120E** to raise and lower cages **120**.

[0027] Open-sea aquaculture system **100** further comprises a control unit **160** configured to control mechanical position control mechanism **130** to move rigid assembly **120** from raised to lowered position **101**, **102**, respectively, upon occurrence of specified rough sea conditions or operational requirements and to move rigid assembly **120** from lowered to raised position, **102**, **101**, respectively, upon specified conditions (**Figures 2A-2C**). Control unit **160** may be arranged to control mechanical position control mechanism **130** and to determine a depth of rigid assembly **120** with respect to sea level according to sea conditions or other operational requirements. Control unit **160** may comprise meteorological sensors and may be arranged to determine the optimal depth of rigid assembly **120** automatically with respect to measured and anticipated sea conditions, based on measurements from the meteorological sensors.

[0028] For example, regular operation under calm sea conditions may be carried out in raised position **101** while during storms (e.g., rough sea, high waves, strong currents etc.) rigid assembly **120** may be lowered to position **102** in which it is still connected to semisubmersible platform **110** but is maintained deeper in the sea and is allowed some horizontal movement **102B** in response e.g., to strong current, to avoid damage to platform **110** by strong forces exerted on and by rigid assembly **120** under rough sea or strong currents conditions. The lowering of the cages reduces or prevents damage to the fish in them and also prevents application of mechanical forces between vertical columns **115** and cage assembly **120**. Mechanical position control mechanism **130** is configured to be strong enough to maintain rigid assembly **120** connected to semisubmersible platform **110** while allowing some horizontal freedom of movement **102B**. During calm sea periods, cage assembly **120** may be in raised position **101** according to the requirements for the grown organisms. The disclosed mechanisms and control patterns provide protection to the fish or other organisms that are cultured, yet require a relatively small interventional effort – cage assembly **120** does not have to be moved horizontally (in raised position **101**), and no additional vessel and personnel are required for protecting or moving the cages. Moreover, the reaction times of control unit **160** are relatively short, as no intervention from shore is needed upon sea changes, and the sea conditions are measured at location (and not at shore) to provide most reliable data.

[0029] Floats **127** with buoyancy control of rigid cage assembly **120** may be part of mechanical position control mechanism **130**, e.g., as a floating unit **137**, and may be controlled by control unit **160** to support the raising and lowering of rigid cage assembly **120**. Rigid cage assembly **120** may be semisubmersible by itself, with Floats **127** providing the buoyancy mechanism which may be controlled independently from and/or in relation to the buoyancy of semisubmersible platform **110**. In certain embodiments, semisubmersible platform **110** and cages **120** may be independently semisubmersible sub-systems which are associated by mechanical position control mechanism **130**, with vertical columns **115** and floats **127** providing the respective independent buoyancy mechanism (possibly with respective one or more control units controlling their buoyancy).

[0030] Open-sea aquaculture system **100** may further comprise a guiding construction **165** configured to guide rigid assembly **120** when moving from lowered position **102** to raised position **101**, during the engagement of vertical columns **115** into vertical cavities **121**. Guiding construction **165** may be at least partly integrated with mechanical position control mechanism **130**, i.e., mechanical position control mechanism **130** may be configured to provide at least approximate proper positioning of vertical cavities **121** just below vertical columns **115** upon raising rigid assembly **120** from lowered position **102** to raised position **101** (see schematically in **Figures 2B** and **2C**). Guiding construction **165** may be further configured to protect vertical columns **115** and/or vertical cavities **121** and cages **120** during raising and lowering cages and/or during operation of open-sea aquaculture system **100**.

[0031] Mechanical position control mechanism **130** may comprise a plurality of chains **140** connecting rigid assembly **120** to at least one motor unit **135** on platform **110** which is configured to release and collect chains **140** under control of control unit **160**. Motor unit(s) **135** may be electric, hydraulic or of any type applicable to the required forces. Motor unit(s) **135** may be replaced and/or assisted by crane(s) onboard semisubmersible platform **110**.

[0032] **Figures 3A-3O** are high level schematic illustrations of mechanical position control mechanisms **130** in open-sea aquaculture system **100**, according to some embodiments of the invention. Mechanical position control mechanism **130** may comprise a plurality of chains **140** connecting rigid assembly **120** to at least one motor unit **135** (including motor(s), pulley(s) etc., shown very schematically) on platform **110** (e.g., on vertical columns **115**) which is configured to release and collect chains **140**, controllably by control unit **160** (see **Figures 2B**, **2C**). Guiding elements **132**, **139** in various configurations (see non-limiting examples below) may be used to guide the relative motion of vertical columns **115** and vertical cavities **121** and prevent damaging them during operation of open-sea aquaculture system **100** at various sea conditions and operational requirements. Elements from **Figures 3A-3G** may be combined in any operable combination and operated within the context of any of the disclosed system configurations illustrated in **Figures 1A-1G**, **2A-2C**, **4A-4D** and **5**. The illustration of certain elements in certain figures and not in others merely serves an explanatory purpose and is non-limiting.

[0033] Chains **140** may be guided along vertical columns **115** by one or more guides **131**, **139** (**Figure 3B**). Chains **140** may be connected to rigid assembly **120** at a corresponding plurality of attachment positions **146A**, possibly stabilized and supported by additional connection structures **146** (**Figure 3C**). Attachment positions **146A** may be selected to position the top openings of vertical cavities **121** of rigid assembly **120** against the bottoms of corresponding vertical columns **115** of semisubmersible platform **110**, upon raising rigid assembly **120** from lowered to raised position **102**, **101** respectively, by pulling chains **140** by motor unit(s) **135**.

[0034] Chains **140** may be guided along at least lower sections of corresponding vertical columns **115** of semisubmersible platform **110**, e.g., by top and bottom guiding elements **131**, **139**, respectively (**Figure 3B**) to control chain movement and direction of forces conveyed by chains. Chains **140** may be guided in parallel along vertical columns **115** and may be stabilized by connecting and/or guiding members **144A**, **144B** (**Figures 3D**, **3E**) and/or chains **140** may be guided together along vertical columns **115** and then split to multiple chains **140A** (**Figure 3F**) before connecting to rigid assembly **120**.

[0035] Open-sea aquaculture system **100** may further comprise guiding construction **165** (shown schematically in **Figure 2A** and implemented using various members in **Figures 3A-3O**, such as members **144A**, **144B**, **146** etc.). Guiding construction **165** may be configured to guide top openings of vertical cavities **121** of rigid assembly **120** toward bottoms of corresponding vertical columns **115** of semisubmersible platform **110**, upon raising rigid assembly **120** from lowered to raised position **102**, **101**, respectively (see a schematic explanation in **Figure 3K** and various embodiments in **Figures 3A-3O**). Guiding construction **165** may comprise multiple members, arranged geometrically and with respect to applied forces in a way that brings the top openings of vertical cavities **121** into the correct position below the bottoms of corresponding vertical columns **115** upon pulling chains **140** upwards by motor unit(s) **135** (see a schematic explanation in **Figure 3K** and various embodiments in **Figures 3A-3O**). For example, guiding construction **165** may comprise the configuration of chains **140A**, connection structures

146 connecting chains **140A** to rigid cage assembly **120**, top and bottom guiding elements **131**, **139** and edge guiding elements **144** on vertical columns **115**, as well as guiding elements **132** on vertical columns **115** and possibly on the inner sides of cavities **121** (not shown), configured to absorb mechanical shocks and guide the moving rigid cage assembly **120** up and down along vertical columns **115** in vertical movement **101A** (see also **Figures 3B** and **3C**). Guiding construction **165** may be configured to balance forces operating sideways during the raising and lowering of cages **120** to reduce or prevent lateral movement of cages **120** with respect to columns **115** and keep vertical columns **115** more or less centrally within vertical cavities **121** and prevent mutual impacts of vertical columns **115** and inner sides **120B** of cages **120** in vertical cavities **121**.

[0036] Figure 3E schematically illustrates mechanical position control mechanism **130**, according to some embodiments of the invention. **Figure 3E** schematically illustrates mechanical position control mechanism **130** on one of columns **115** in lowered position **102** and in raised position **101** in side view, as well as details of guiding elements in mechanical position control mechanism **130**. Mechanical position control mechanism **130** may comprise parallel chains **140**, guided along vertical columns **115** (e.g., by guiding elements **139**, **144**, **144A**), e.g., along edges of columns **115**. Guiding elements **139**, **144** and/or **144A** may be configured to stabilize chains **140** and maintain their parallel configuration during operation of mechanical position control mechanism **130**. In particular guiding element(s) **144A** shown in detail in cross section of column **115** may be configured to maintain a relative position of the chains **140**, minimize the horizontal movements of rigid cage assembly **120** and/or minimize the relative motion between cage assembly **120** and vertical columns **115**, as explained below in more details. Parallel chains **140** may be connected to rigid cage assembly **120** via connection structures **146** at different heights along rigid cage assembly **120**, selected to assure the stability of rigid cage assembly **120** in lowered position **102** and simplify the raising of rigid cage assembly **120** from lowered position **102** to raised position **101**, with cavities **121** enclosing columns **115**.

[0037] Figure 3F schematically illustrates usage of multiple chains **140A** in mechanical position control mechanism **130**, according to some embodiments of the invention.

Chains **140** may in some embodiments be split into multiple chains **140A** that are anchored on cages **120**, raise and lower cages **120** and maintain the relative position of vertical columns **115** in vertical cavities **121**. Guides **139**, **142** may be configured to guide and control the paths of chains **140A** during the operation of system **100**.

[0038] Figures 3G-3J schematically illustrate various elements of mechanical position control mechanism **130**, according to some embodiments of the invention. One or more chain assemblies may be positioned at corners of vertical columns **115**. **Figures 3G-3J** illustrate as an example such a chain assembly, possibly located along the respective external edge of vertical columns **115**. Guides **139**, **147A** may be configured to guide chains **140** along vertical column **115** and/or to direct one or more chain **140B** along a path that distances from vertical column **115** to improve the force application pattern of cages **120**, as explained below. Guide **139** may be a fixed top plate guide and guide **147A** may be a movable central plate, guided along support(s) **147B**. Additional guides **147D** may be used to assure correct motion of chain(s) **140B** upon raising and lowering cages **120**, and supports **147B** (e.g., as an I-beam guide) may be provided to mechanically stabilize mechanical position control mechanism **130** and possibly to enable movement of guide **147A** along vertical column **115**. Shock absorber(s) **147E** may be located at different locations (shown as an example close to the connection of chain **140B** to member **147C**, possibly similar to connection structure **146**) to attenuate shocks to mechanical position control mechanism **130**. Edge guiding elements **144** may be positioned below movable support **147A** and possibly function as a stopper thereto (see **Figure 3J**). Movable support **147A** may be guided along support(s) **147B** by various means. One or more chains **140** may be replaced by rod(s) and/or cable(s) and/or any other tension applying member.

[0039] Figure 3K is a high level schematic example for application of forces on chains **140** by motor unit **135** and by cages **120**, according to some embodiments of the invention. Mechanical position control mechanism **130** is configured to raise and lower cages **120** while maintaining a relative position of the chains **140** and minimizing the horizontal movements of cages **120** when guided along vertical columns **115**. In particular, mechanical position control mechanism **130** is configured to control and carry out the transitions between raised position **101** and lowered position **102**, wherein in the former cages **120** are moved along vertical columns **115** (movement **101A**) and in the latter cages **120** are freely connected to vertical columns **115** and may move horizontally below vertical columns **115** without impacting them (movement **102B**), as illustrated schematically in **Figures 2A-2C**. During the transition itself, mechanical position control mechanism **130** is configured to apply forces in an accurate manner to engage cages **120** onto columns **115** (**102→101**) to fit columns **115** into cavities **121** without damaging any of them while applying the immense forces required to carry out this transition. Mechanical position control mechanism **130** is further configured to carry out the opposite transition (**101→102**) while avoiding damage to cages **120** and columns **115**. In exemplary calculations, the force marked F_c in **Figure 3K** reaches between 600-1200 tons and the vertical component of the vertical force on movable support **147A** may reach 300-700 tons. Mechanical position control mechanism **130** may be configured accordingly to enable the application of such large forces reliably and accurately. It is emphasized that correct angles may be maintained to prevent impacts of cages **120** on columns **115**.

[0040] Figure 3L illustrates schematically a positioning mechanism **134** for controlling the position of movable guide **147A**, according to some embodiments of the invention. Illustrated positioning mechanism **134** may be configured to position movable guide **147A** at a height which is appropriate to prevent contact between cages **120** and vertical columns **115**, as derived e.g., from force calculations illustrated schematically in **Figure 3K** above, from realtime measurements, simulations, etc. For example, positioning mechanism **134** may be configured to position movable guide **147A** at a constant height above cages **120**, i.e., raise movable guide **147A** when cages **120** are raised and lower movable guide **147A** when cages **120** are lowered. Positioning mechanism **134** may comprise a motor unit **136** (e.g., independent of motor unit **135**) and a closed chain loop **141** (as a non-limiting example) to control the height of movable guide **147A** along vertical columns **115**.

[0041] Figures 3M-3O schematically illustrate elements of mechanical position control mechanism **130**, according to some embodiments of the invention. In some embodiments, mechanical position control mechanism **130** may be configured to use cables **140** (e.g., multi-wire cables), possibly with a sheave system instead or in addition to chains **140**.

Multiple cables may reduce the force in each cable with respect to F_c, using corresponding winches to anchor cables **140** on cages **120**, e.g., via heave compensator(s) **149B**. Cages **120** may be guided along columns **115** using guides **147B** and possibly gripper and/or brakes **149A** as movement limiters. Guides **147B** may be associated with cages **120** by a movable assembly **149C** which may comprise shafts (with radial and/or axial bearing(s)) with shock absorbers **149D** (e.g., hydraulic shock absorbers, possibly connected and moved by a chain drive and/or a pulley system, not shown) connected by joints **149E** such as universal joints to columns **115** and cages **120**. For example, **Figure 3N** illustrates schematically a configuration of movable assembly **149C** according to certain embodiments of the invention, in side view and in top plan view from the surface marked "A-A". **Figure 3O** illustrates schematically an alternative configuration of movable assembly **149C**, moved by guides and rollers **147F** along guides **147B**.

[0042] Figures 4A-4D are high level schematic illustrations of cage configurations in rigid cage assembly **120**, according to some embodiments of the invention. Rigid cage assembly **120** comprises a plurality of cages **120A**, **120B**, **120C**, **120D** etc. separated by cage grids **126**, which are shown schematically in a non-limiting manner, and may be rigid or at least partially flexible. Rigid cage assembly **120** may comprise a framework **122** with connecting members **124** that provide the backbone of rigid cage assembly **120** (**Figure 4B**) as well as multiple rails **124A**, **124B** configured to receive multiple cage grids **126** that define aquaculture cages **120A**, **120B** etc. Cage grids **126** may be covered by rigid or flexible nets **125** configured to maintain the animals in aquaculture in the respective cages. A corresponding framework **124** may be configured to support rails **124A**, **124B** etc., configured to receive cage grids **126**, possibly in a modular manner that enables to modify cage volumes according by introducing cage grids **126** into corresponding rails **124A**, **124B** etc. (**Figure 4C**). At least some of rails **124A**, **124B** may be double rails **124A**, **124B**, configured to enable replacement of corresponding cage grids **126** without disassembling cages **120A**, **120B**, **120C**, **120D** etc., by introducing an additional cage grid **126** before removing former cage grid **126** (**Figure 4D**). Note, in **Figure 4C**, the empty rails **124A**, ready to receive an additional cage grid **126** (not illustrated) if required while maintaining former cage grid **126** (illustrated) in occupied rail **124B**. Frameworks **122**, **124** may be configured to support mechanically rigid cage assembly **120** and rails **124A**, **124B** with cage grids **126** upon raising and lowering whole mechanically rigid cage assembly **120** between raised and lowered positions **101**, **102**, respectively, and during regular offshore operation of open-sea aquaculture system **100**. It is noted that rigid cage assembly **120** may be constructed in any way, modular or not modular. It is noted that rails **124A**, **124B** may be used in certain embodiments of cage assembly **120**, while other embodiments may comprise a permanent assembly of some or all of cage grids **126**, or assembly of at least some cage grids **126** in a manner different from described above.

[0043] Figure 5 is a high level schematic illustration of a movable cage floor **150**, used for fish handling in open-sea aquaculture system **100**, according to some embodiments of the invention. Rigid cage assembly **120** may be configured to enable volume changes and adaptation in at least some of cages **120**. The volume and depth of cages **120** may be adapted according to the specific aquaculture use, i.e., according to specific types of animals grown in the cages, their developmental stages and required conditions (sea conditions, density conditions etc.). Rigid cage assembly **120** may also be configured to enable moving (**159**) of fish or other types of animals in aquaculture from cage (**120A**) to cage (**120B**) to support different growth stages, to enable cage repair if needed, and to harvest the fish in a controlled and safe manner. At least some of aquaculture cages **120A** may comprise a vertically movable partition **150** connected by a partition positioning apparatus **152** to cage **120A** (e.g., a roller with supporting members) which is possibly controlled by control unit **160**). Vertically movable partition **150** may be horizontal or tilted and may have a revolving door mechanism at its bottom. Vertically movable partition **150** may enable moving fish from cage to cage through designated openings (e.g., removable cage grids **126** or cage grid parts). Partition **150** may be moved by motor(s) and chains, possibly in association with mechanical position control mechanisms **130**. Movements of partition **150** may be coordinated with movements of rigid cage assembly **120** (e.g., from raised to lowered position **101**, **102**, respectively) in order to protect the fish and make the change in conditions gradual. For example upon forecasts of rough sea, fish may be lowered within the cages by partition(s) **150**, and upon realization of the forecast rigid cage assembly **120** may be lowered while partition(s) **150** may be temporally raised, to allow more time for accommodation of the fish. Eventually, when maximal depth (e.g., in lowered position **102**) is required, partition(s) **150** may be lowered even in lowered position **102**. Partition(s) **150** may be further used to control the types or sizes of fish within each cage.

[0044] Fish may be removed from the cages using various methods, such as suction, pumping, using a crane, using a screw pump, etc. Open-sea aquaculture system **100** may further comprise a sorting system (not shown), arranged to sort fish by size and move them between cages **120A, 120B** etc. according to their size as they grow. Maintenance facilities **111** may comprise a computerized center for monitoring the cages and the fish (visually, chemically, and/or using environmental sensors such as oxygen, temperature, salinity sensors, and so forth), for example, measure the biomass of the fish, manage and control the feeding process, detect signs for diseases, and allow the crew to continuously supervise the aquaculture. Offshore open-sea aquaculture system **100** may further comprise facilities **111** that allow the crew to perform maintenance around the clock, with cages below water, including disassembling and replacing parts. Semisubmersible platform **110** may comprise ship mooring facilities allowing for supplies and fish transport, and helicopter landing gear.

[0045] Figure 6 is a high level flowchart illustrating an open-sea aquaculture method **200**, according to some embodiments of the invention. Method **200** may be implemented by system **100** and system may be configured to operate method **200**. Some of the listed stages are optional, and the order of the stages may be changed according to operational considerations.

[0046] Method **200** comprises connecting, mechanically, a rigid assembly of aquaculture cages to a semisubmersible platform which comprises a plurality of vertical columns (stage **202**), the semisubmersible platform configured to have storage and maintenance facilities for supporting aquaculture (stage **204**). The rigid assembly is configured to comprise a plurality of vertical cavities formed to receive corresponding vertical columns of the semisubmersible platform (stage **210**).

[0047] Method **200** further comprises configuring the mechanical connection to provide a controllable relative position between the rigid assembly and the semisubmersible platform, comprising at least two operational positions (stage **220**): a raised position configured to have the rigid assembly enclose the corresponding vertical columns in the vertical cavities (stage **230**) to limit a horizontal movement of the rigid assembly (stage **232**) while possibly enabling vertical positional adjustment in the raised position (stage **235**), and a lowered position configured to have the rigid assembly below the corresponding vertical columns (stage **240**), possibly allowing some horizontal and vertical movement of the rigid assembly in the lowered position (stage **245**).

[0048] Method **200** further comprises controlling the relative position between the rigid assembly and the semisubmersible platform (stage **250**) to move the rigid assembly from the raised to the lowered position upon occurrence of specified rough sea conditions, or at any other time as needed and to move the rigid assembly from the lowered to the raised position upon specified conditions (stage **260**) and moving the rigid assembly from the lowered to the raised position upon specified conditions such as calm sea (stage **270**).

[0049] Method **200** may further comprise guiding top openings of the vertical cavities of the rigid assembly toward bottoms of the corresponding vertical columns of the semisubmersible platform, upon raising the rigid assembly from the lowered to the raised position (stage **280**).

[0050] Method **200** may further comprise configuring the mechanical connection to comprise a plurality of chains connecting the rigid assembly to at least one motor unit on the platform (stage **290**), and configuring the at least one motor unit to controllably release and collect the chains (stage **295**).

[0051] Method **200** may further comprise connecting the chains to the rigid assembly at a corresponding plurality of attachment positions which are selected to position top openings of the vertical cavities of the rigid assembly against bottoms of the corresponding vertical columns of the semisubmersible platform, upon raising the rigid assembly from the lowered to the raised position by pulling of the chains by the at least one motor unit (stage **300**).

[0052] Method **200** may further comprise guiding the chains along at least lower sections of the corresponding vertical columns of the semisubmersible platform (stage **305**).

[0053] In certain embodiments, method **200** may further comprise configuring the rigid assembly to have a plurality of rails configured to receive a plurality of cage grids that define the aquaculture cages (stage **310**). Method **200** may further comprise configuring at least some of the rails as double rails that enable replacement of corresponding cage grids without disassembling the cages (stage **315**). Using rails is an optional feature, and method 200 may be carried out without stages **310** and **315**. Method **200** may further comprise configuring and using vertically movable partitions in at least some of the aquaculture cages to control cage volume, to move fish from cage to cage and/or to remove fish from the cages (stage **320**).

[0054] In the above description, an embodiment is an example or implementation of the invention. The various appearances of "one embodiment”, "an embodiment", "certain embodiments" or "some embodiments" do not necessarily all refer to the same embodiments. Although various features of the invention may be described in the context of a single embodiment, the features may also be provided separately or in any suitable combination. Conversely, although the invention may be described herein in the context of separate embodiments for clarity, the invention may also be implemented in a single embodiment. Certain embodiments of the invention may include features from different embodiments disclosed above, and certain embodiments may incorporate elements from other embodiments disclosed above. The disclosure of elements of the invention in the context of a specific embodiment is not to be taken as limiting their use in the specific embodiment alone. Furthermore, it is to be understood that the invention can be carried out or practiced in various ways and that the invention can be implemented in certain embodiments other than the ones outlined in the description above.

[0055] The invention is not limited to those diagrams or to the corresponding descriptions. For example, flow need not move through each illustrated box or state, or in exactly the same order as illustrated and described. Meanings of technical and scientific terms used herein are to be commonly understood as by one of ordinary skill in the art to which the invention belongs, unless otherwise defined. While the invention has been described with respect to a limited number of embodiments, these should not be construed as limitations on the scope of the invention, but rather as exemplifications of some of the preferred embodiments. Other possible variations, modifications, and applications are also within the scope of the invention. Accordingly, the scope of the invention should not be limited by what has thus far been described, but by the appended claims and their legal equivalents.

CLAIMS

What is claimed is:

1. An open-sea aquaculture system comprising:

   a semisubmersible platform having storage and maintenance facilities for supporting aquaculture, the semisubmersible platform comprising a plurality of vertical columns,

   a rigid assembly of aquaculture cages, the rigid assembly comprising a plurality of vertical cavities having forms configured to receive corresponding vertical columns of the semisubmersible platform,

   a mechanical position control mechanism configured to connect, mechanically, the rigid assembly to the semisubmersible platform and to control a relative position therebetween to provide at least two operational positions:

   a raised position in which the rigid assembly encloses the corresponding vertical columns in the vertical cavities, and

   a lowered position in which the rigid assembly is below the corresponding vertical columns, and

   a control unit configured to control the mechanical position control mechanism to move the rigid assembly from the raised to the lowered position upon occurrence of specified conditions, and to move the rigid assembly from the lowered to the raised position upon specified conditions.

2. The open-sea aquaculture system of claim 1, further comprising a guiding construction, configured to guide top openings of the vertical cavities of the rigid assembly toward bottoms of the corresponding vertical columns of the semisubmersible platform, upon raising the rigid assembly from the lowered to the raised position.

3. The open-sea aquaculture system of claim 1 or 2, wherein the mechanical position control mechanism comprises a plurality of chains connecting the rigid assembly to at least one motor unit on the platform which is configured to release and collect the chains, the at least one motor unit being controlled by the control unit.

4. The open-sea aquaculture system of claim 3, wherein the chains are connected to the rigid assembly at a corresponding plurality of attachment positions which are selected

to position top openings of the vertical cavities of the rigid assembly against bottoms of the corresponding vertical columns of the semisubmersible platform, upon raising the rigid assembly from the lowered to the raised position by pulling of the chains by the at least one motor unit.

5. The open-sea aquaculture system of claim 3 or 4, wherein the chains are guided along at least lower sections of the corresponding vertical columns of the semisubmersible platform.
6. The open-sea aquaculture system of any one of claims 1-5, wherein the rigid assembly comprises a plurality of rails configured to receive a plurality of cage grids that define the aquaculture cages.
7. The open-sea aquaculture system of claim 6, wherein at least some of the rails are double rails, configured to enable replacement of corresponding cage grids without disassembling the cages.
8. The open-sea aquaculture system of any one of claims 1-7, wherein at least some of the aquaculture cages comprise a vertically movable partition connected by a partition positioning apparatus to the cage and controlled by the control unit.
9. The open-sea aquaculture system of any one of claims 1-8, wherein the rigid assembly comprises a buoyancy mechanism, which is controlled by the control unit.
10. An open-sea aquaculture method comprising:

connecting, mechanically, a rigid assembly of aquaculture cages to a semisubmersible platform, the semisubmersible platform having storage and maintenance facilities for supporting aquaculture, and comprising a plurality of vertical columns,

wherein the rigid assembly is configured to comprise a plurality of vertical cavities formed to receive corresponding vertical columns of the semisubmersible platform,

configuring the mechanical connection to provide a controllable relative position between the rigid assembly and the semisubmersible platform, comprising at least two operational positions:

a raised position in which the rigid assembly encloses the corresponding vertical columns in the vertical cavities, and, a lowered position in which the rigid assembly is below the corresponding vertical columns, and

controlling the relative position between the rigid assembly and the semisubmersible platform to move the rigid assembly from the raised to the lowered position upon occurrence of specified conditions, and to move the rigid assembly from the lowered to the raised position upon specified conditions.

11. The open-sea aquaculture method of claim 10, further comprising guiding top openings of the vertical cavities of the rigid assembly toward bottoms of the corresponding vertical columns of the semisubmersible platform, upon raising the rigid assembly from the lowered to the raised position.
12. The open-sea aquaculture method of claim 10 or 11, further comprising configuring the mechanical connection to comprise a plurality of chains connecting the rigid assembly to at least one motor unit on the platform, and configuring the at least one motor unit to controllably release and collect the chains.
13. The open-sea aquaculture method of claim 12, further comprising connecting the chains to the rigid assembly at a corresponding plurality of attachment positions which are selected to position top openings of the vertical cavities of the rigid assembly against bottoms of the corresponding vertical columns of the semisubmersible platform, upon raising the rigid assembly from the lowered to the raised position by pulling of the chains by the at least one motor unit.
14. The open-sea aquaculture method of claim 12 or 13, further comprising guiding the chains along at least lower sections of the corresponding vertical columns of the semisubmersible platform.
15. The open-sea aquaculture method of any one of claims 10-14, further comprising configuring the rigid assembly to have a plurality of rails configured to receive a plurality of cage grids that define the aquaculture cages.
16. The open-sea aquaculture method of claim 15, further comprising configuring at least some of the rails as double rails that enable replacement of corresponding cage grids without disassembling the cages.

17. The open-sea aquaculture method of any one of claims 10-16, further comprising configuring vertically movable partitions in at least some of the aquaculture cages to control cage volume.

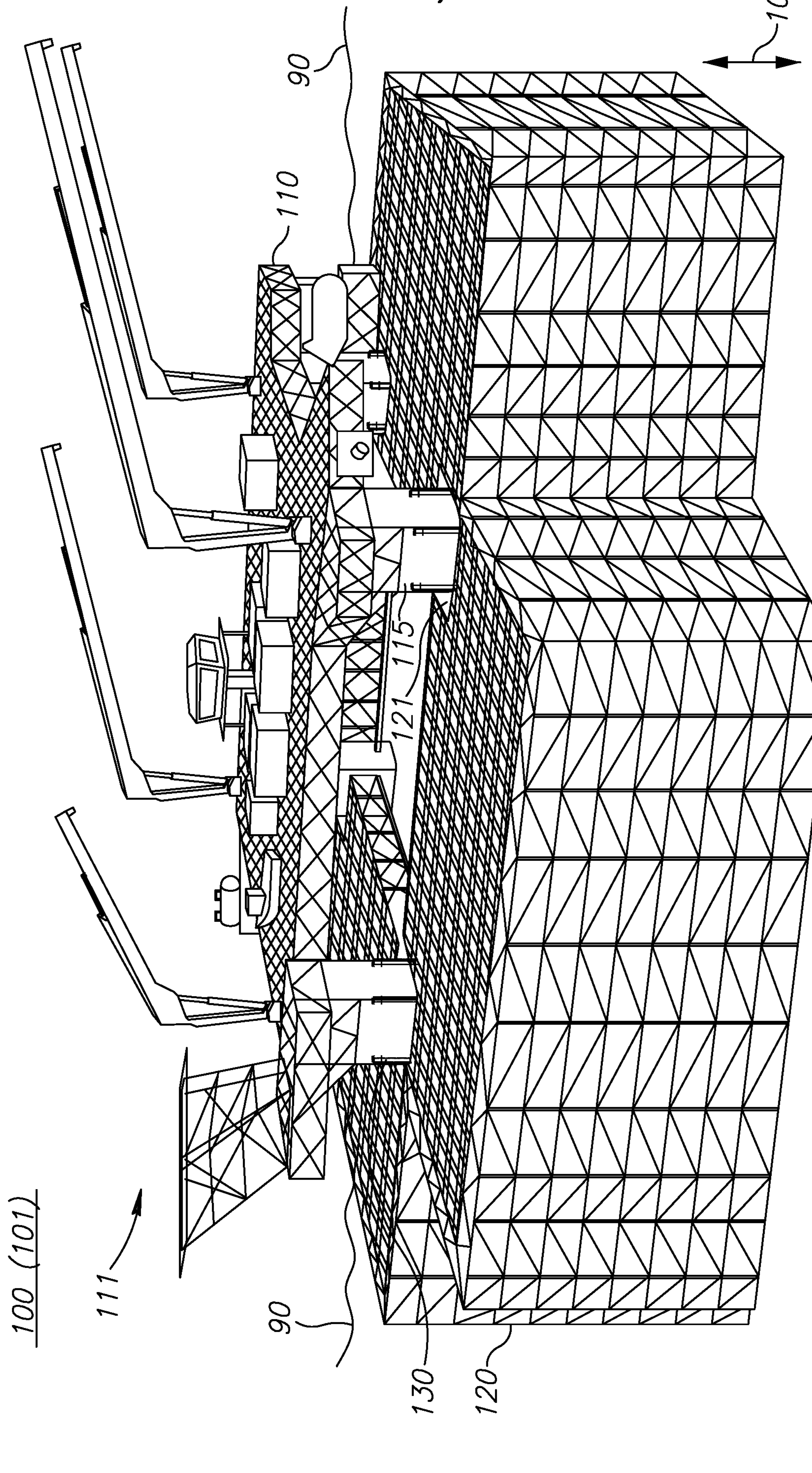


Figure 1A

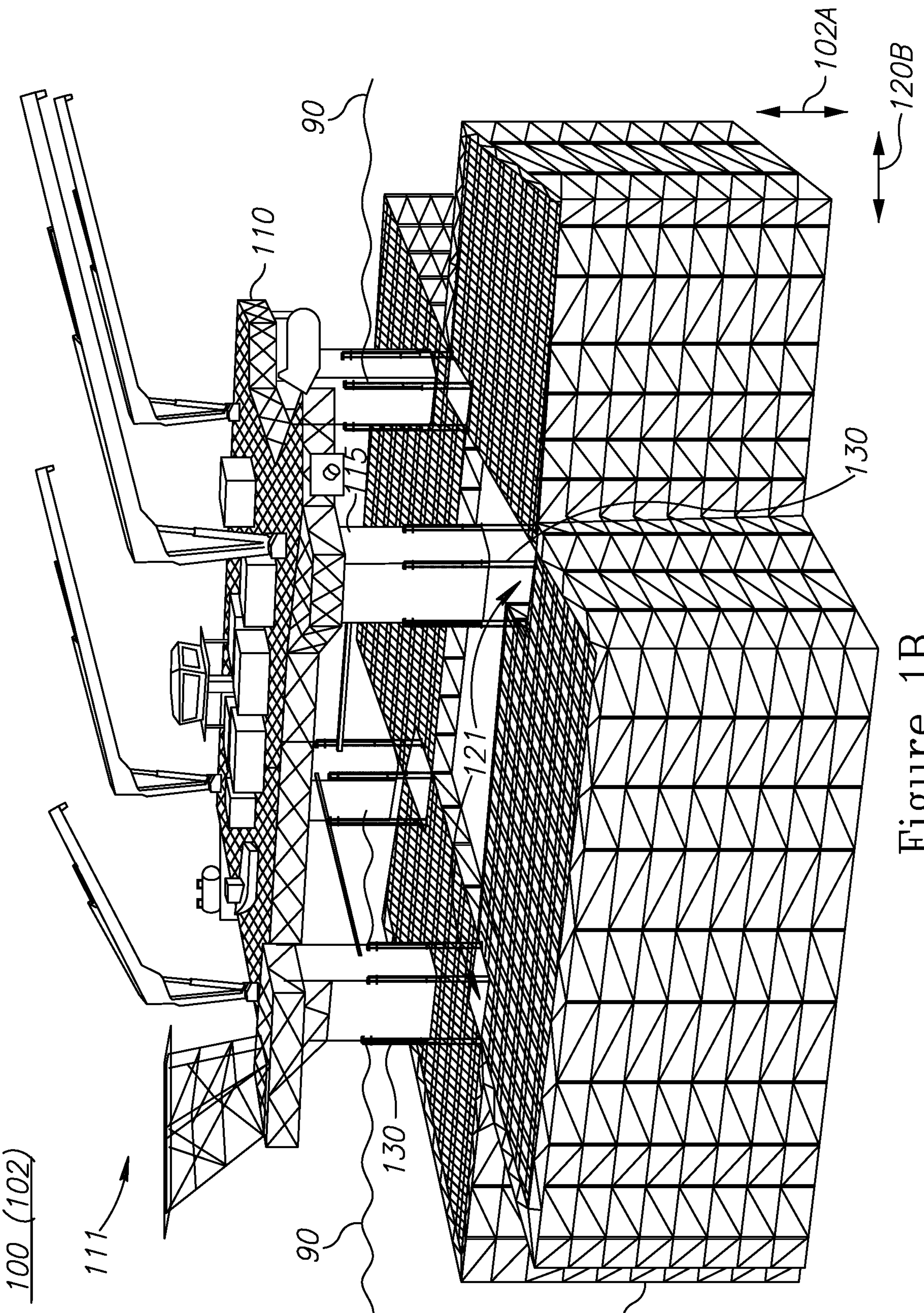


Figure 1B

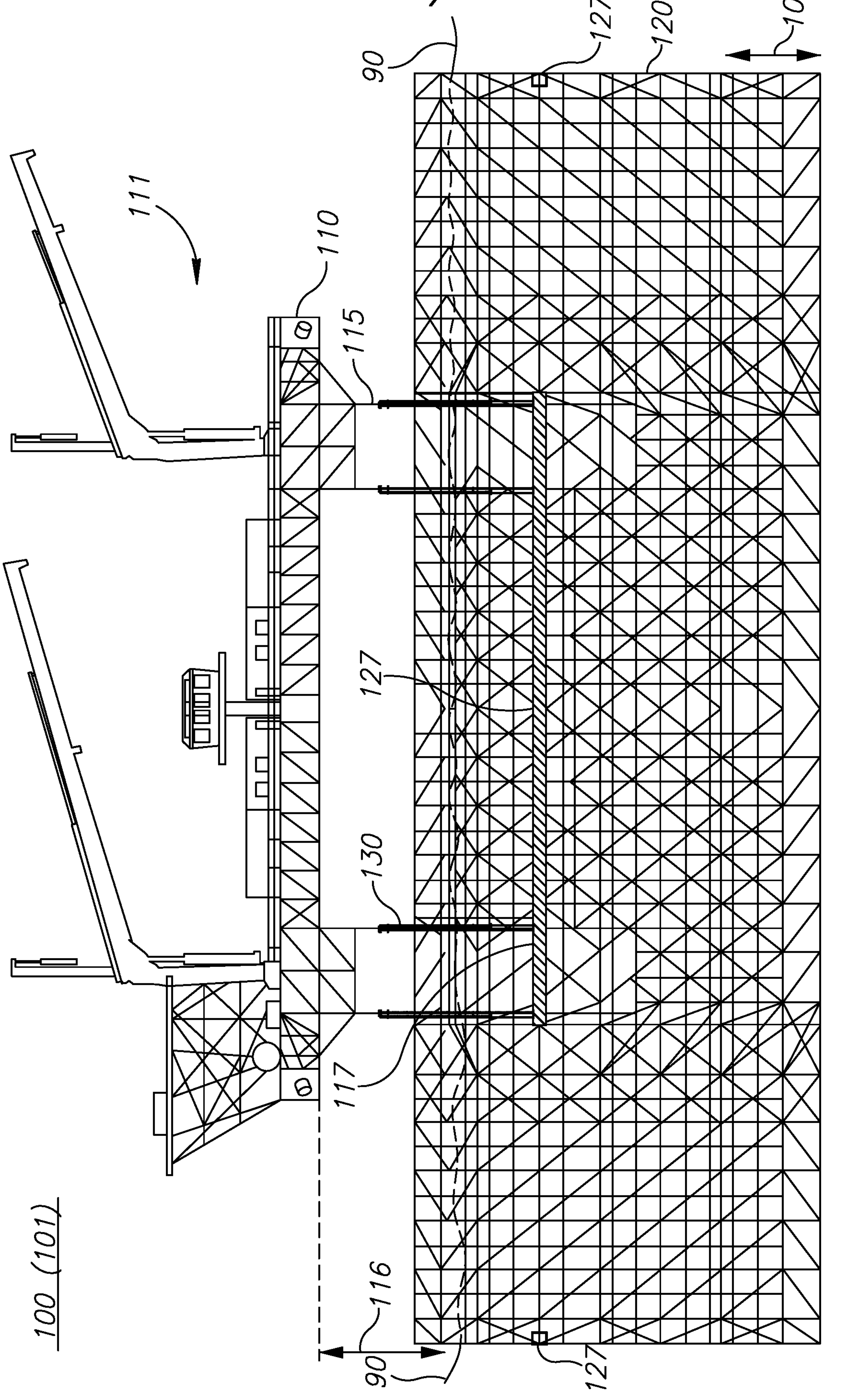


Figure 1C

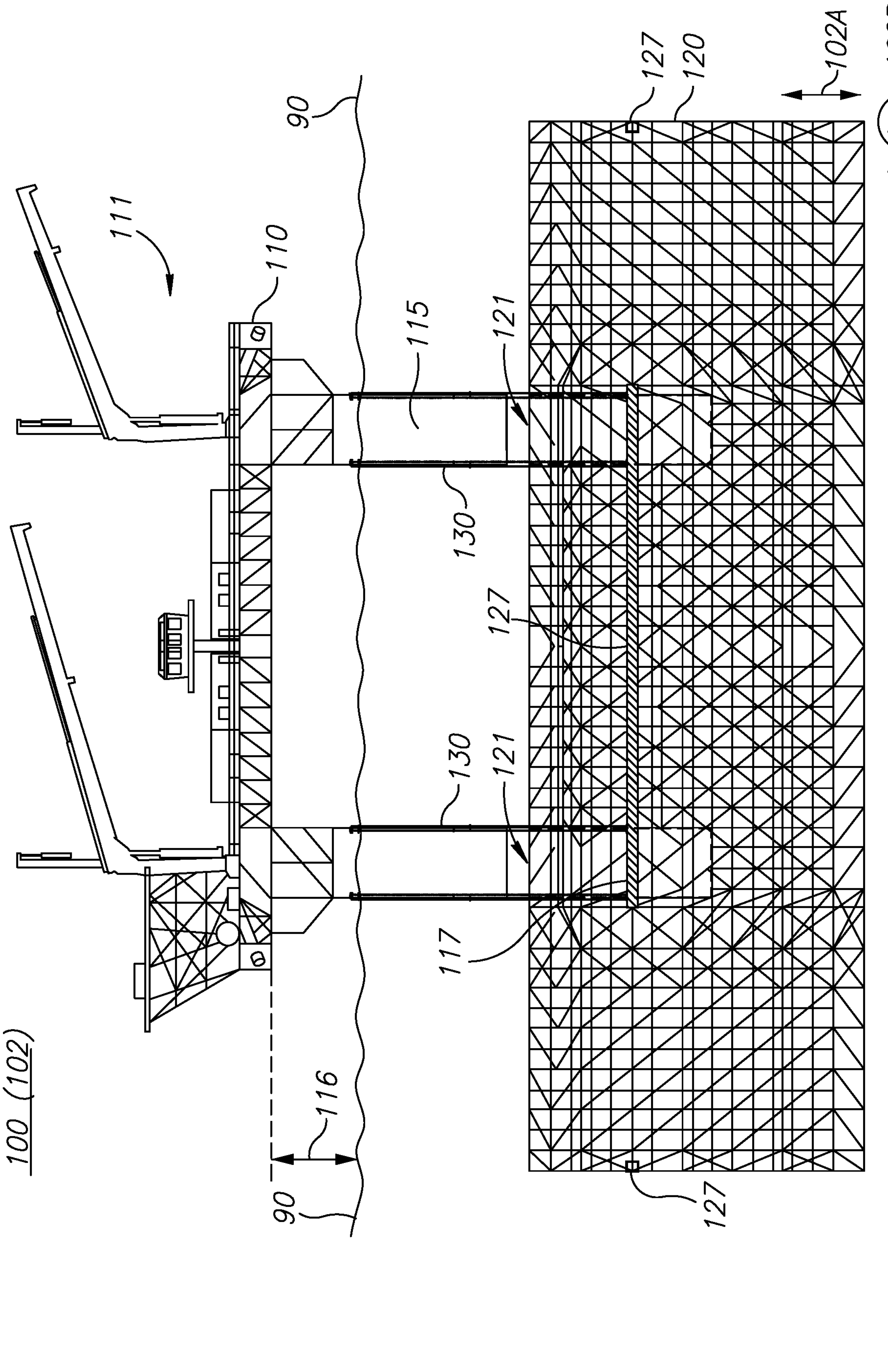


Figure 1D

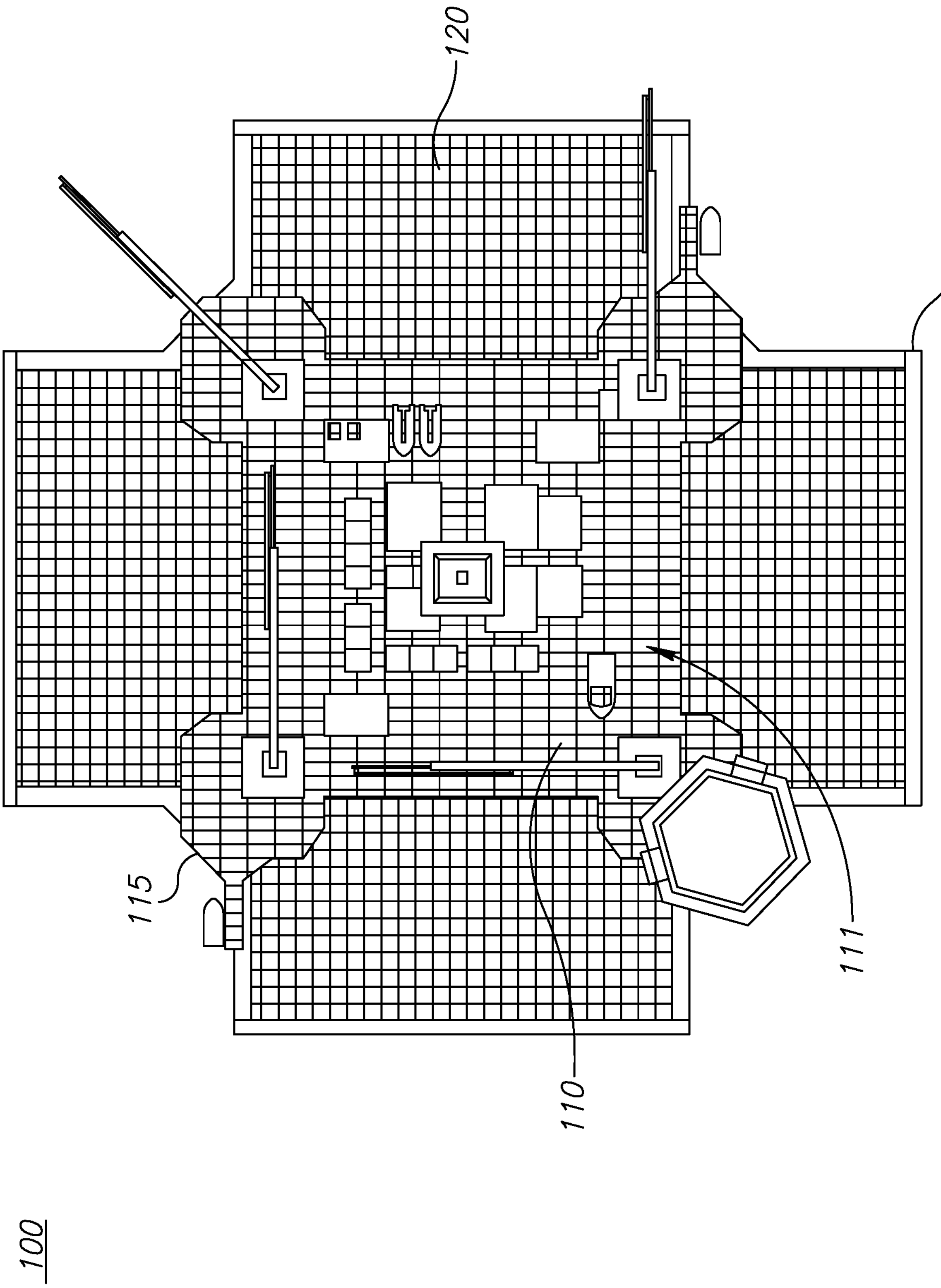


Figure 1E

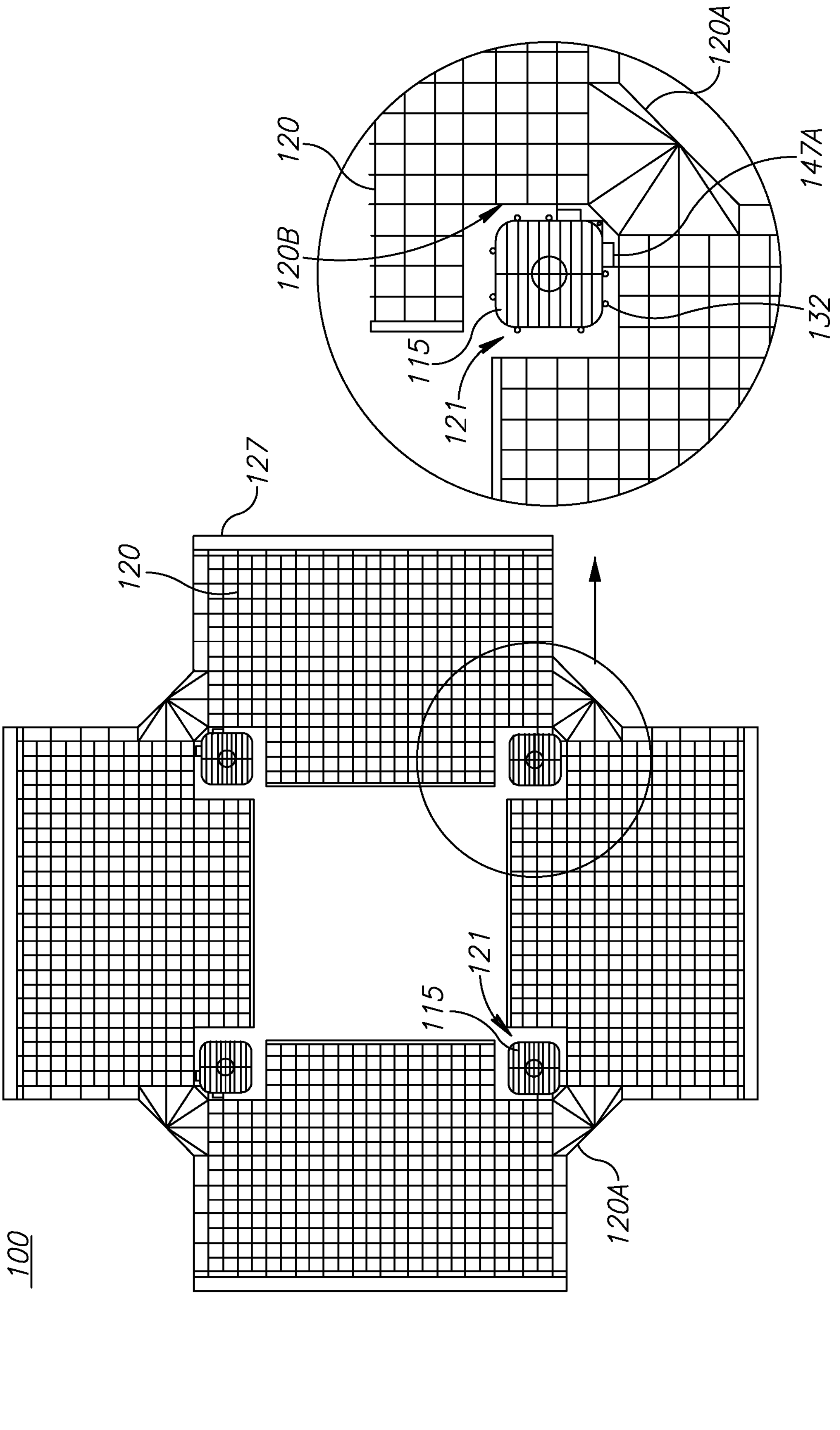


Figure 1F

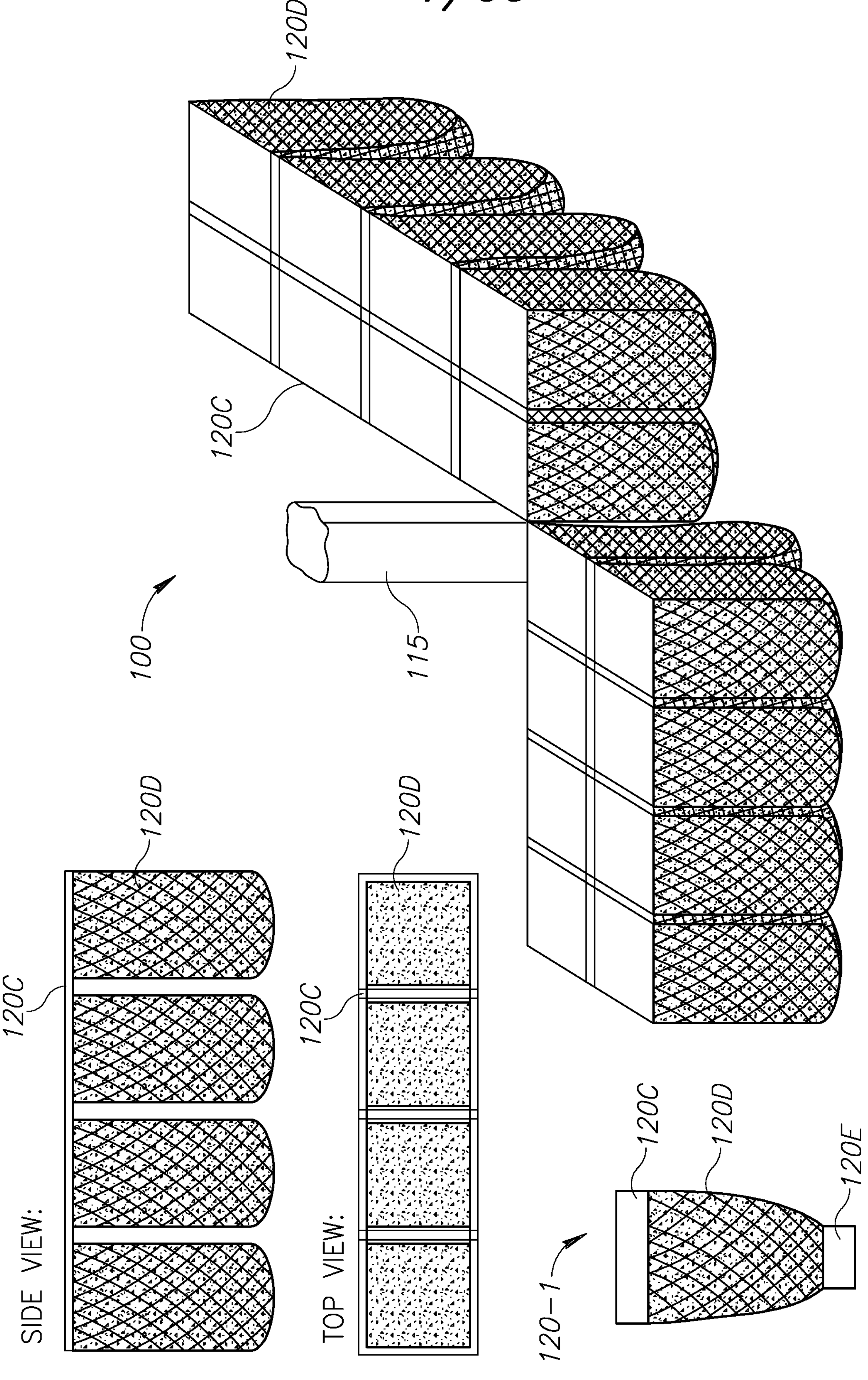

120D
120C
100
115
SIDE VIEW:
120D
120C
TOP VIEW:
120D
120C
120-1
120C
120D
120E

Figure 1G

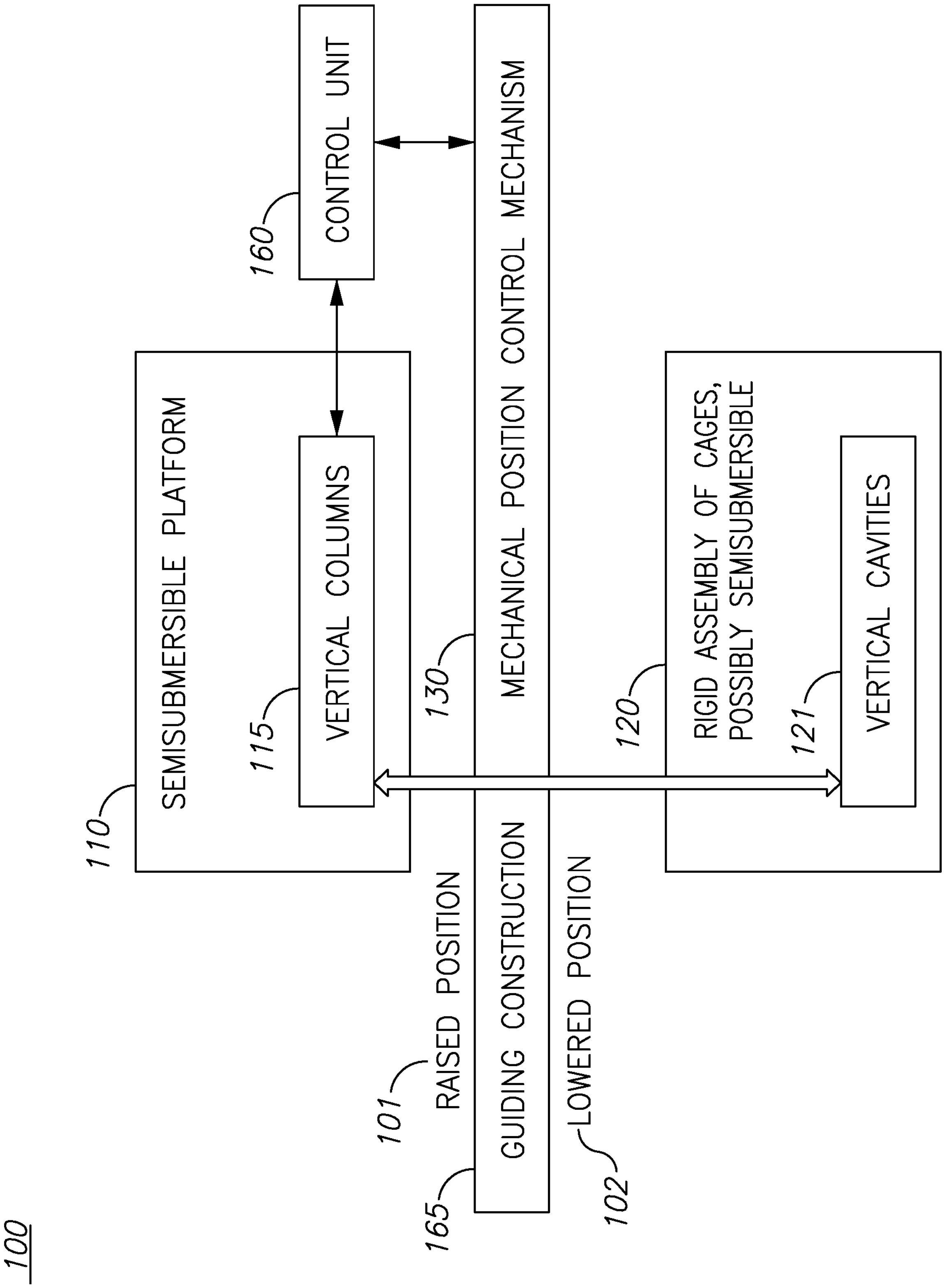

100
110
SEMISUBMERSIBLE PLATFORM
115
VERTICAL COLUMNS
160
CONTROL UNIT
130
MECHANICAL POSITION CONTROL MECHANISM
165
GUIDING CONSTRUCTION
101
RAISED POSITION
102
LOWERED POSITION
120
RIGID ASSEMBLY OF CAGES,
POSSIBLY SEMISUBMERSIBLE
121
VERTICAL CAVITIES

Figure 2A

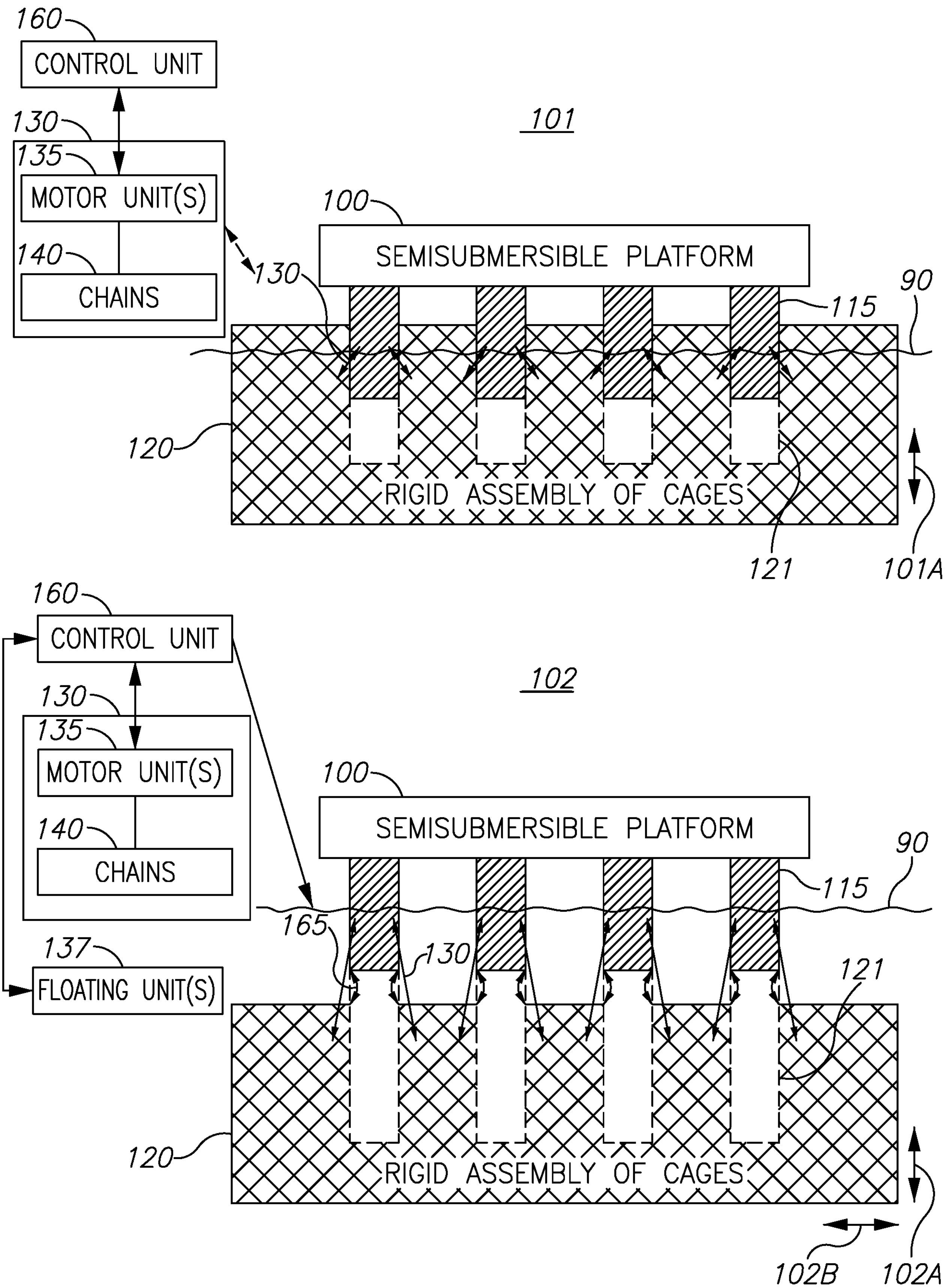

160
CONTROL UNIT
130
135
MOTOR UNIT(S)
140
CHAINS
101
100
SEMISUBMERSIBLE PLATFORM
130
90
115
120
RIGID ASSEMBLY OF CAGES
121
101A
160
CONTROL UNIT
102
130
135
MOTOR UNIT(S)
140
CHAINS
100
SEMISUBMERSIBLE PLATFORM
90
115
165
130
137
FLOATING UNIT(S)
121
120
RIGID ASSEMBLY OF CAGES
102B
102A

Figure 2B

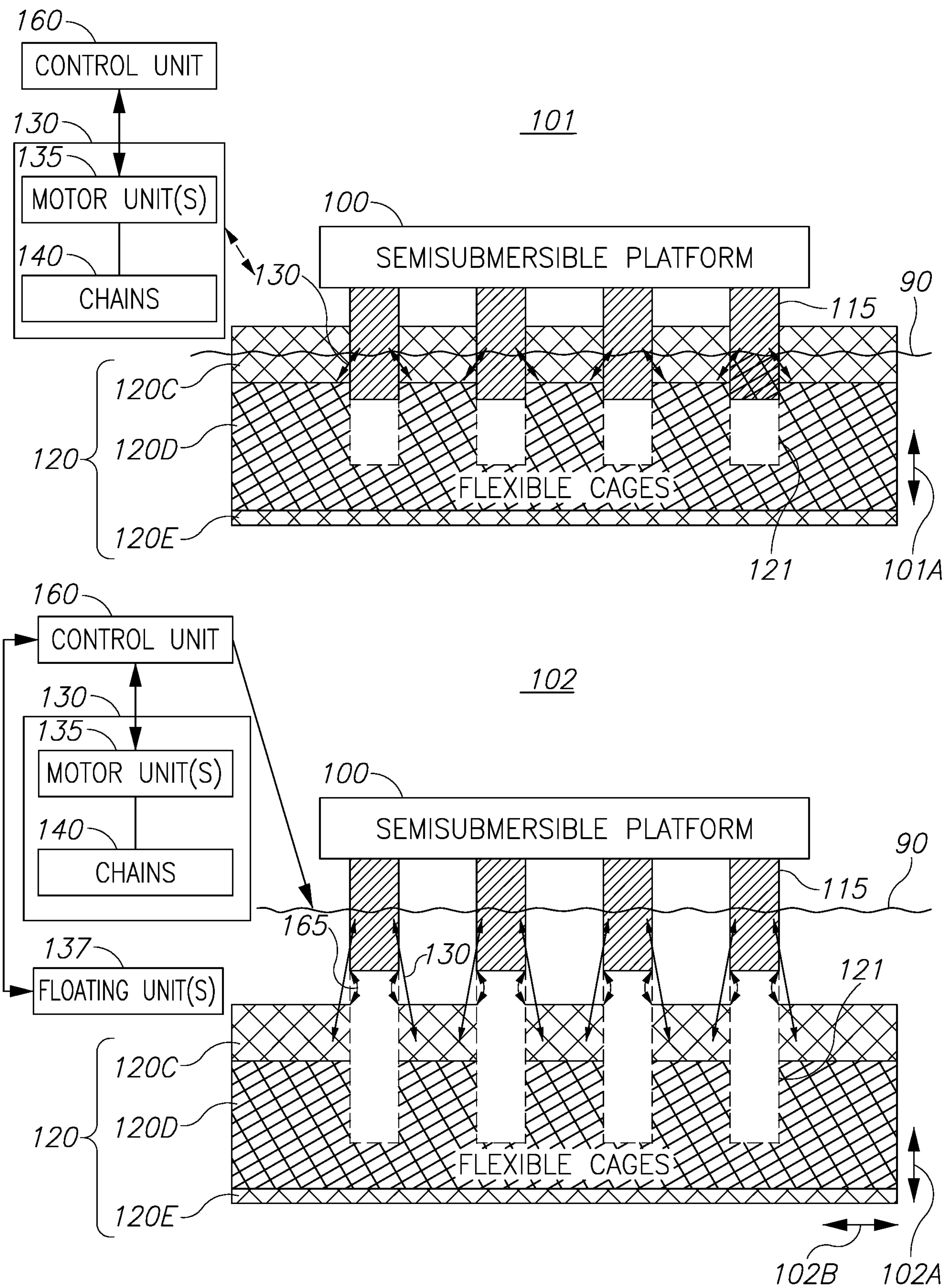

160
CONTROL UNIT
130
135
MOTOR UNIT(S)
140
CHAINS
101
100
SEMISUBMERSIBLE PLATFORM
130
90
115
120C
120
120D
FLEXIBLE CAGES
120E
121
101A
160
CONTROL UNIT
102
130
135
MOTOR UNIT(S)
140
CHAINS
100
SEMISUBMERSIBLE PLATFORM
90
115
165
130
137
FLOATING UNIT(S)
121
120C
120
120D
FLEXIBLE CAGES
120E
102B
102A

Figure 2C

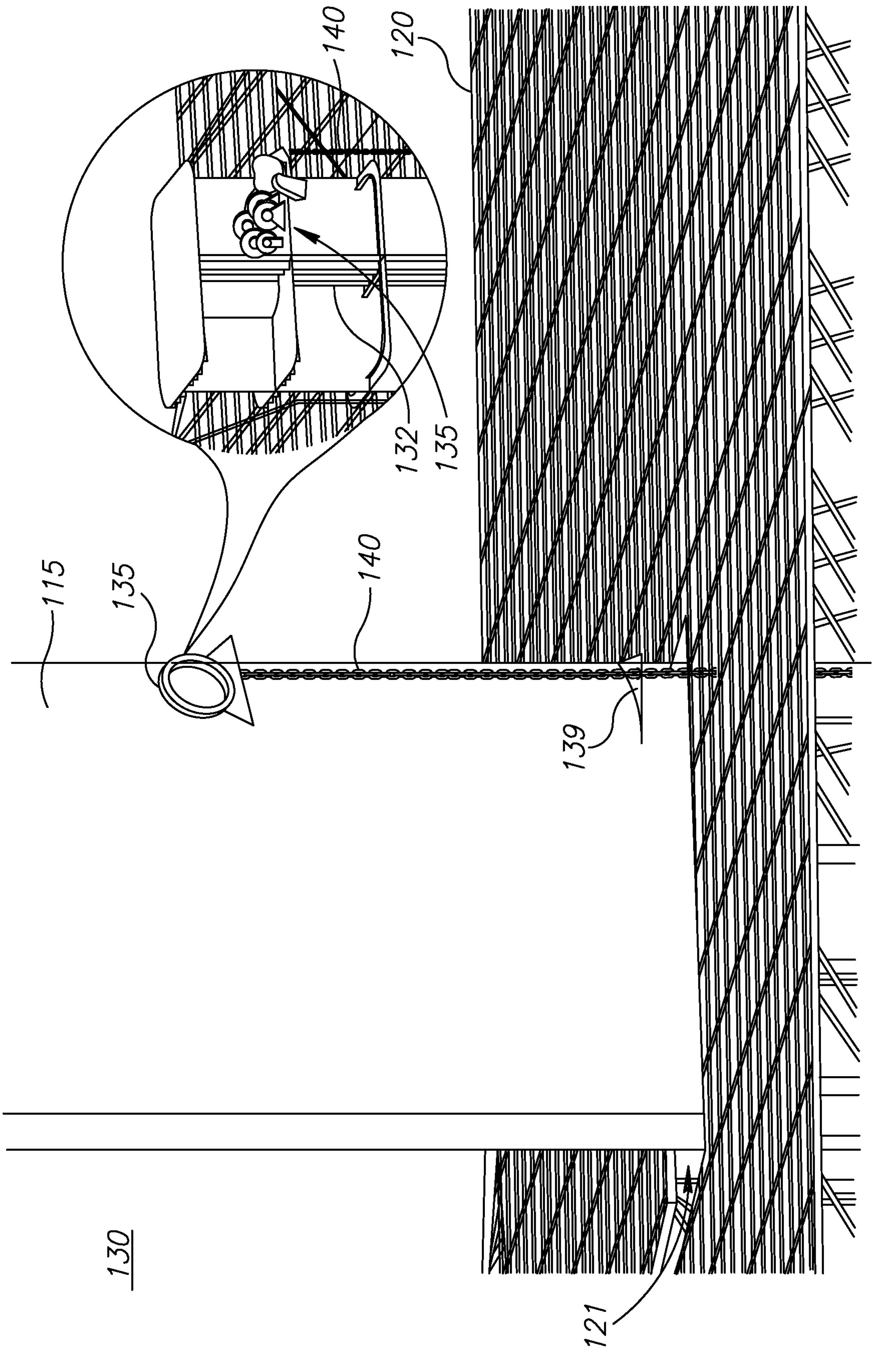


Figure 3A

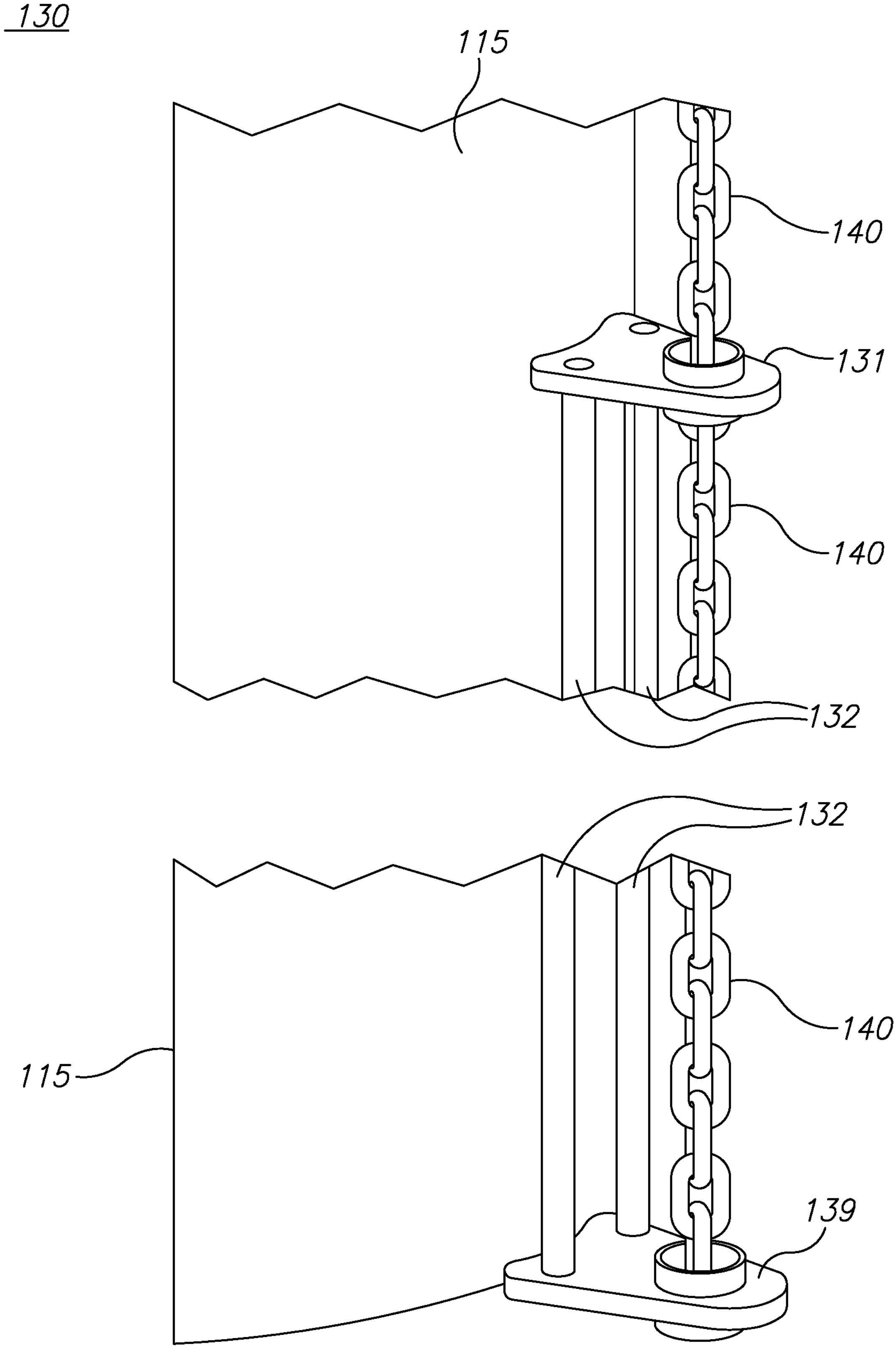


Figure 3B

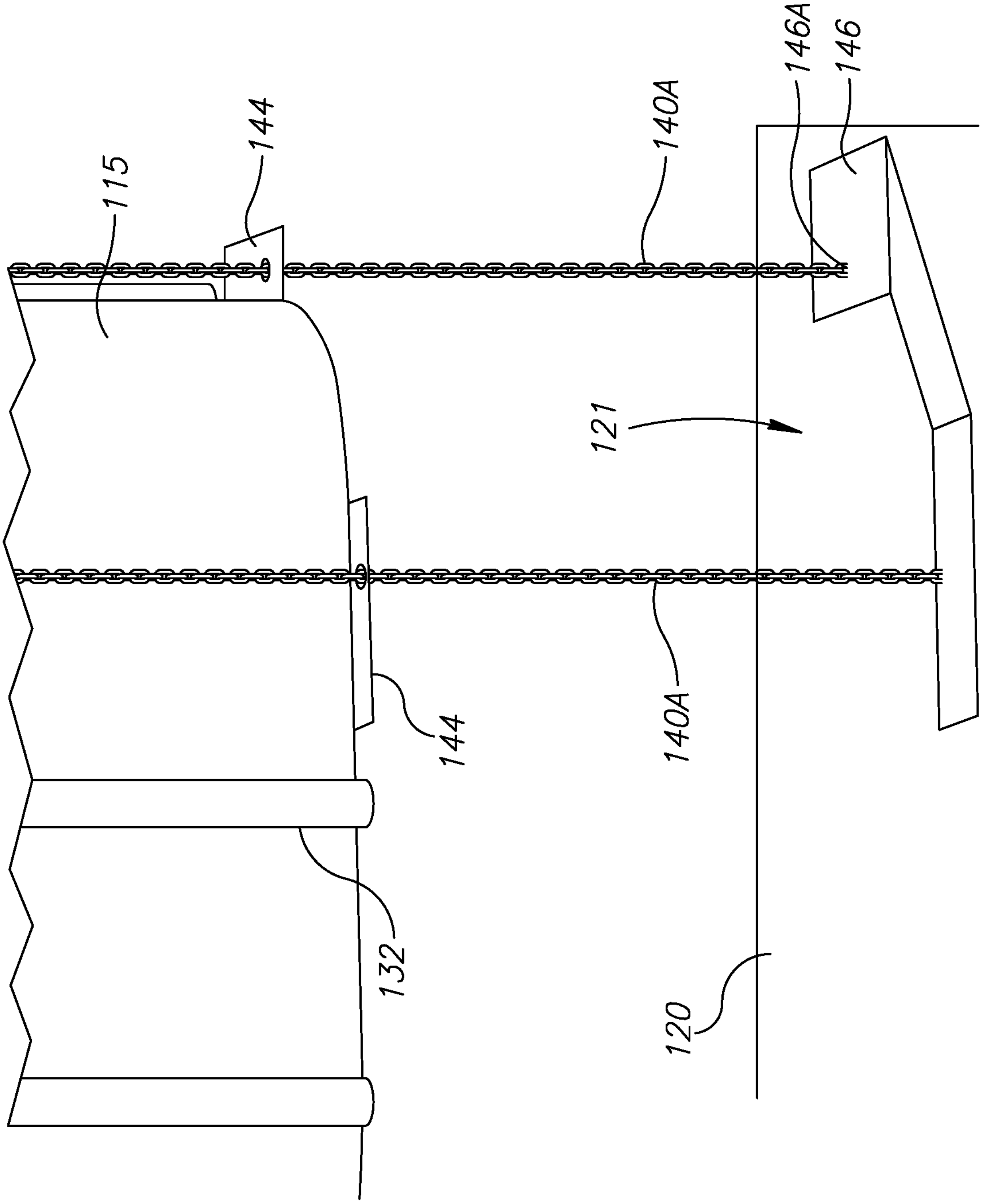


Figure 3C

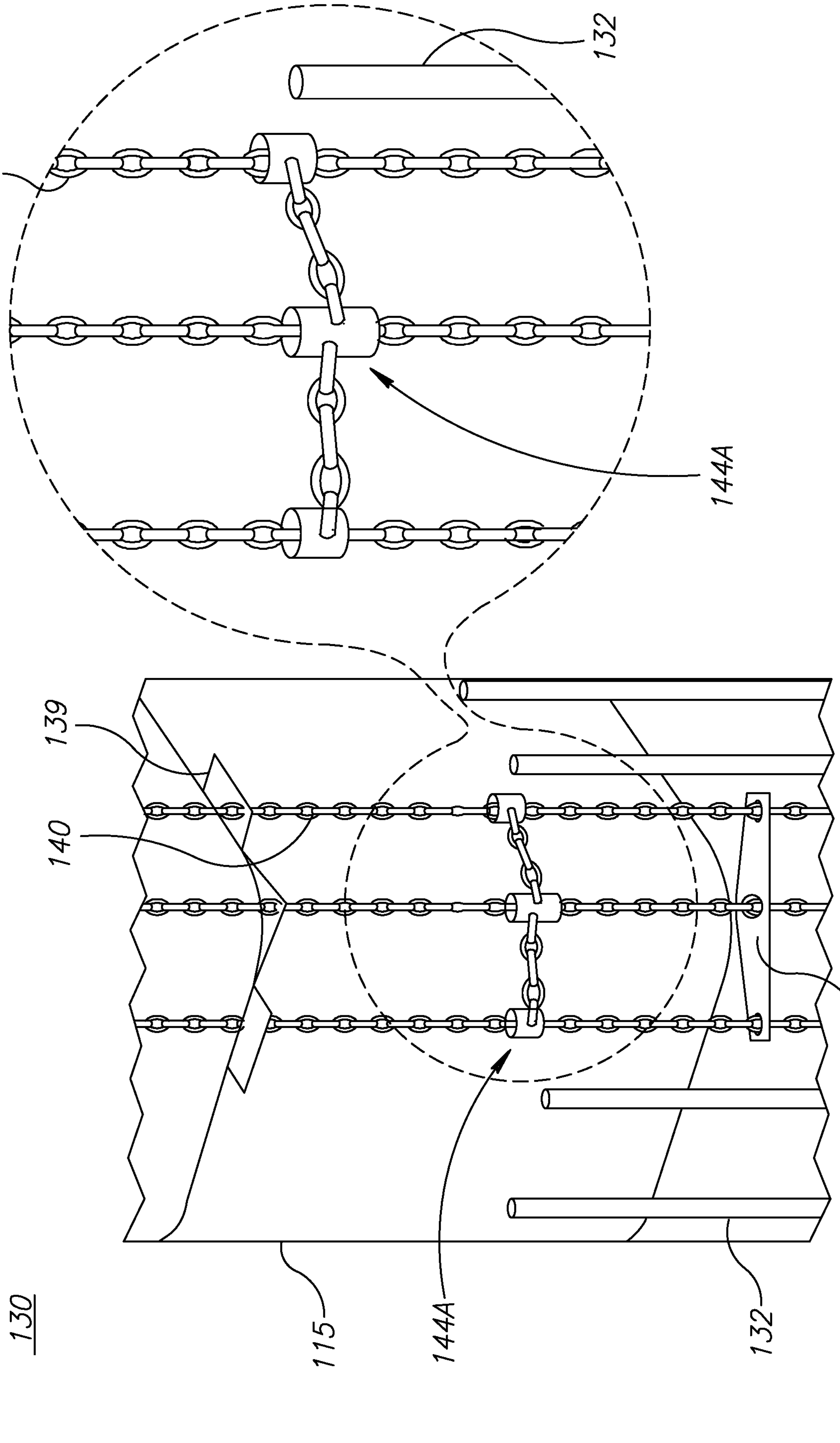


Figure 3D

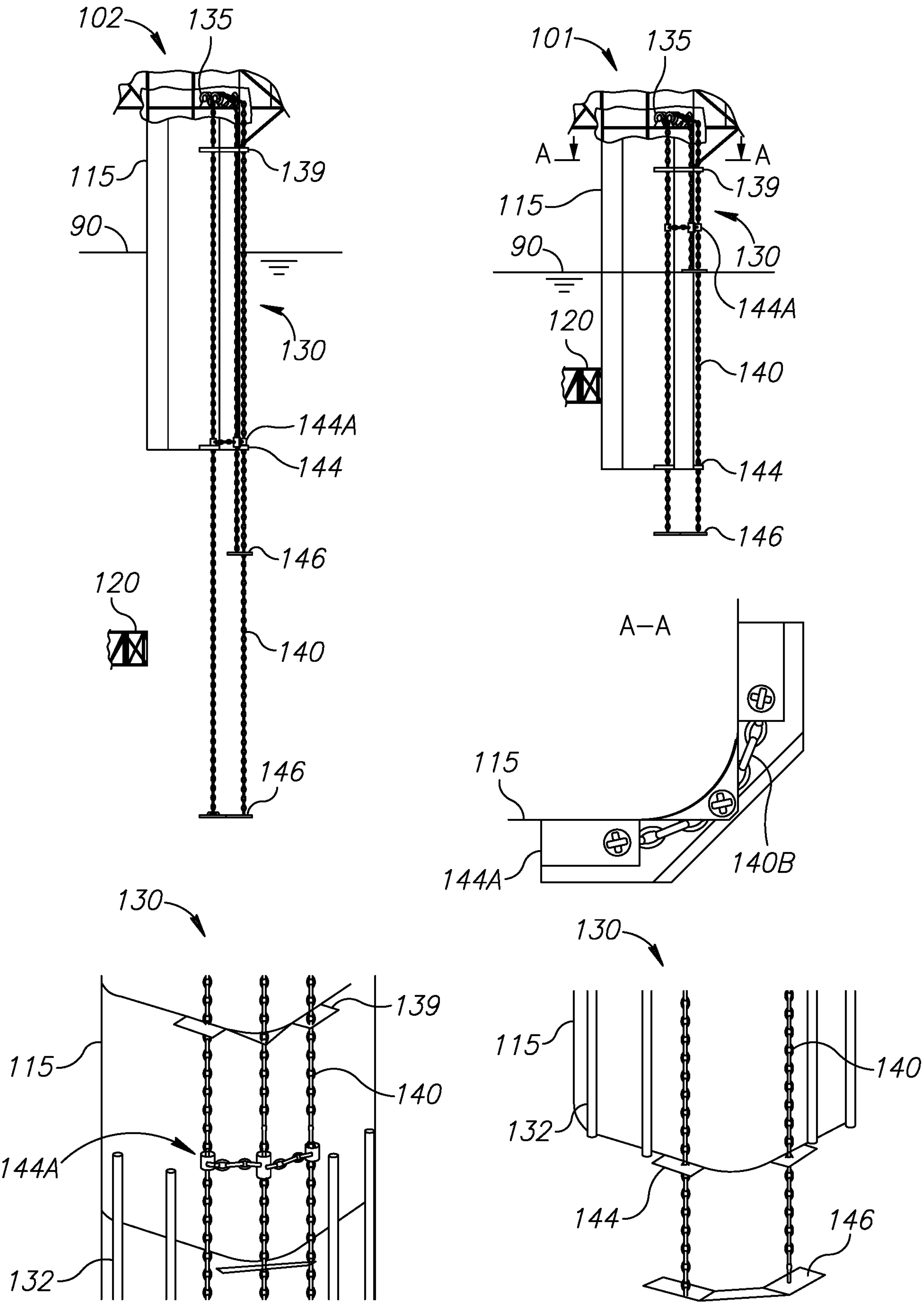

102
135
115
139
90
130
144A
144
146
120
140
146
101
135
A
A
115
139
130
90
144A
120
140
144
146
A–A
115
144A
140B
130
139
115
140
144A
132
130
115
140
132
144
146

Figure 3E

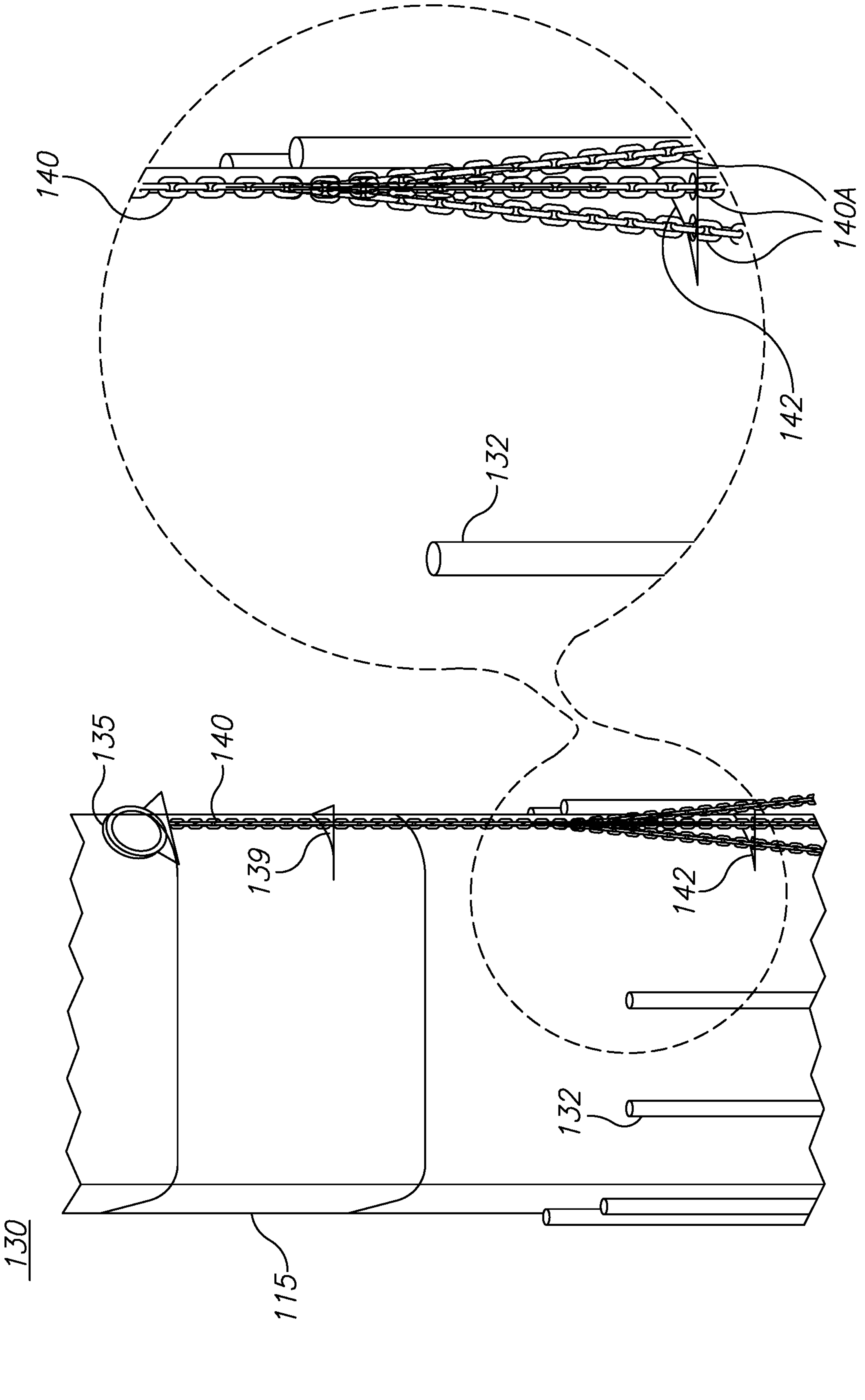


Figure 3F

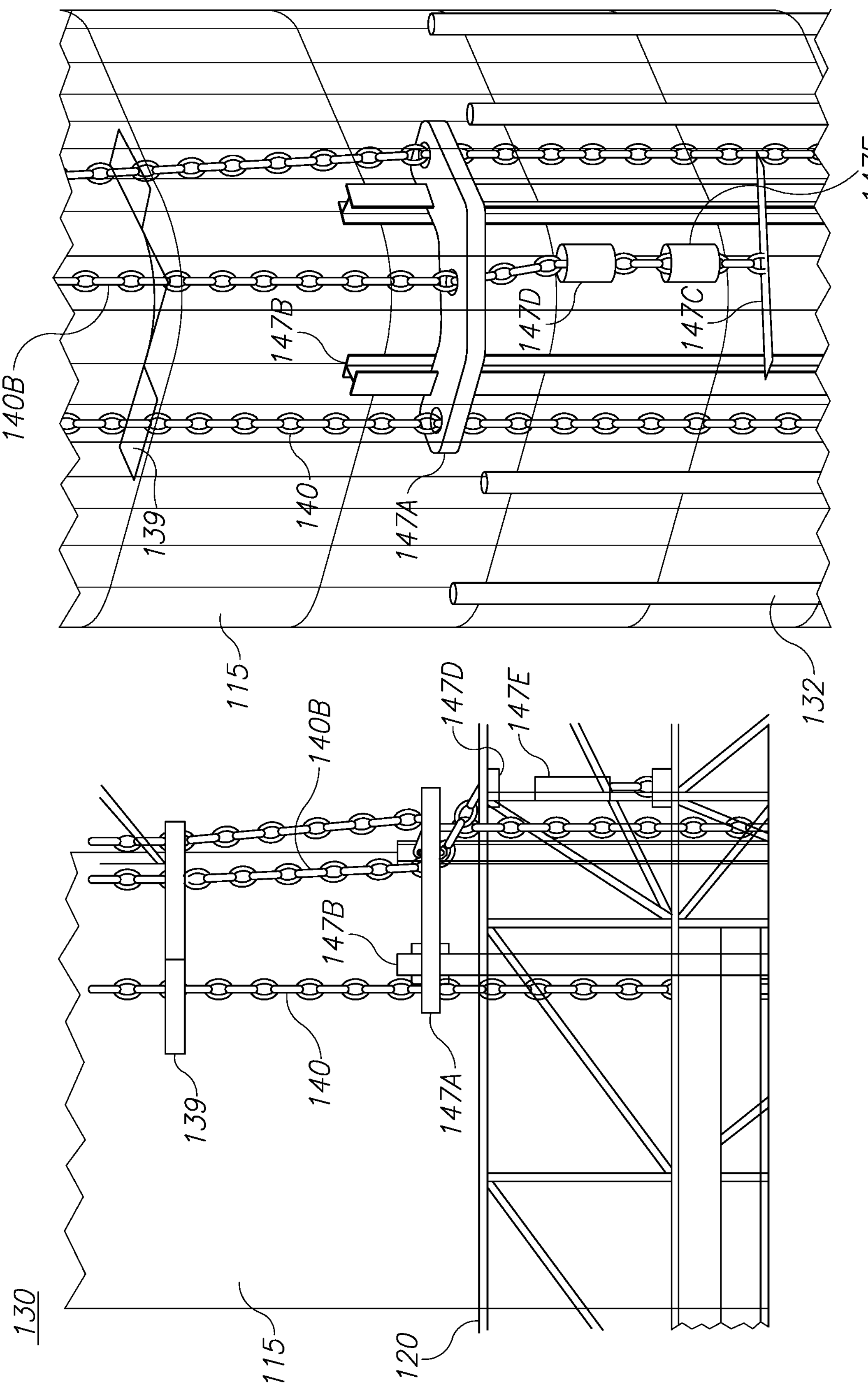


Figure 3G

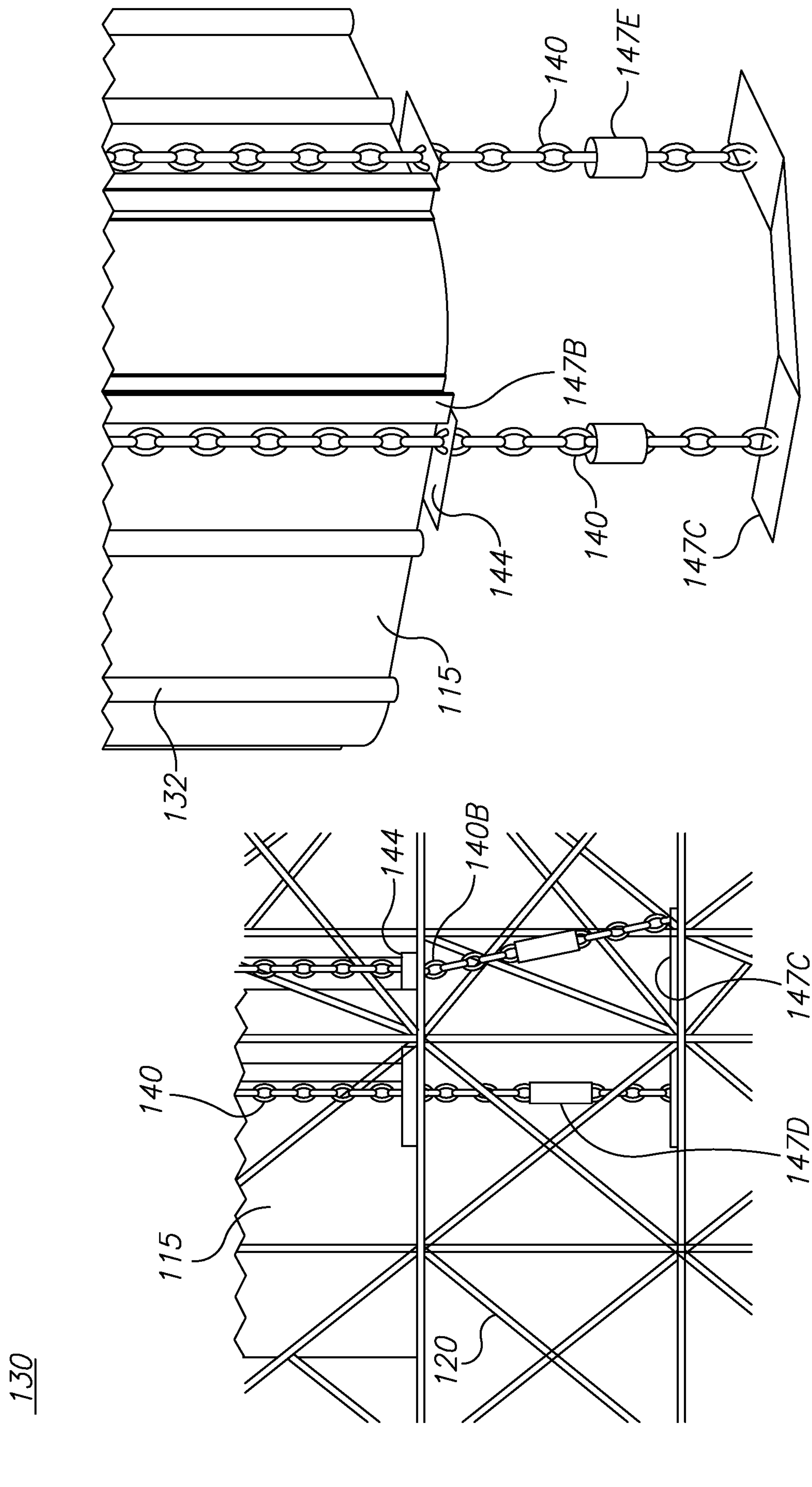

140
147E
147B
144
140
147C
115
132
144
140B
140
147C
147D
115
120
130

Figure 3H

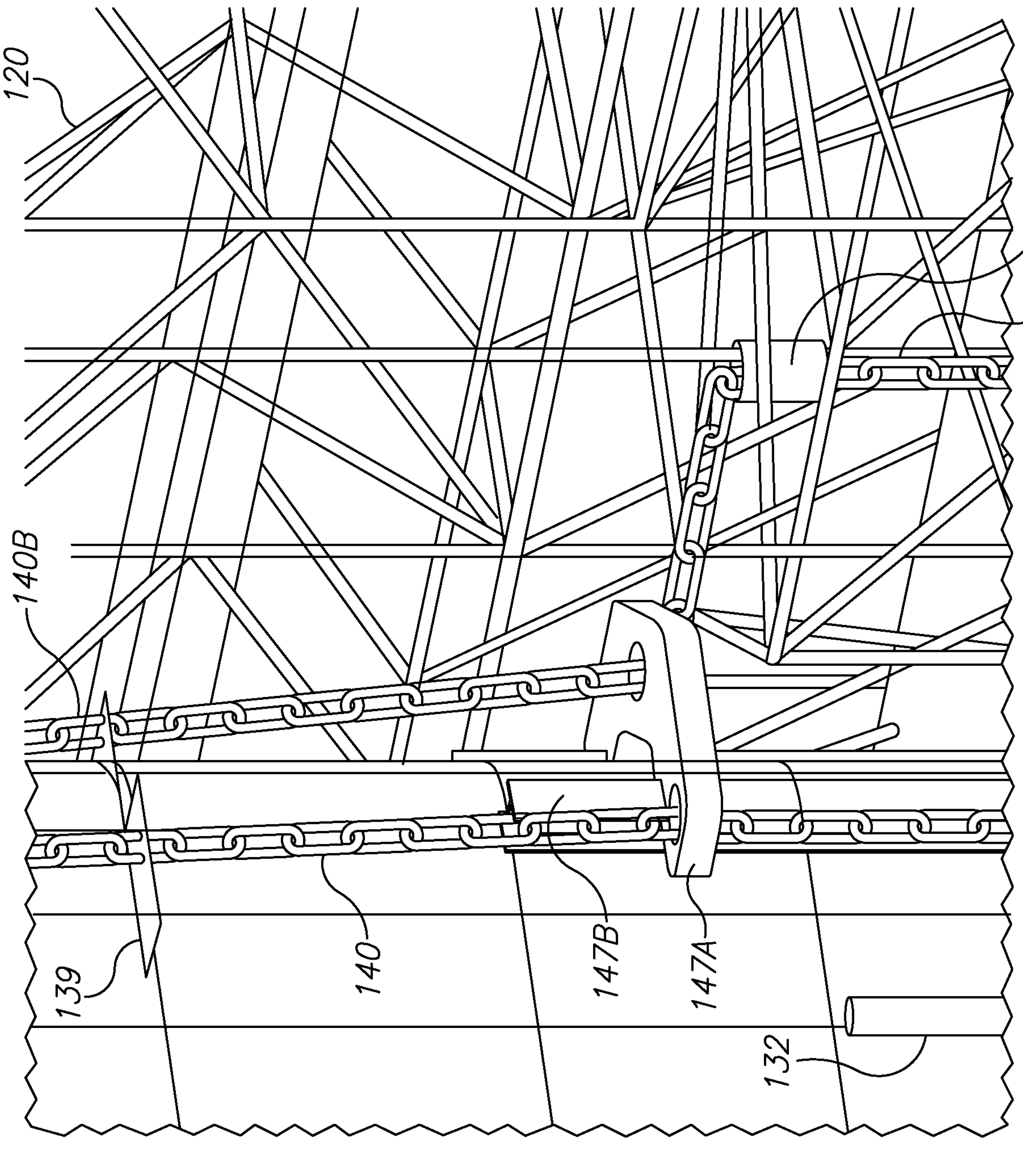


Figure 3I

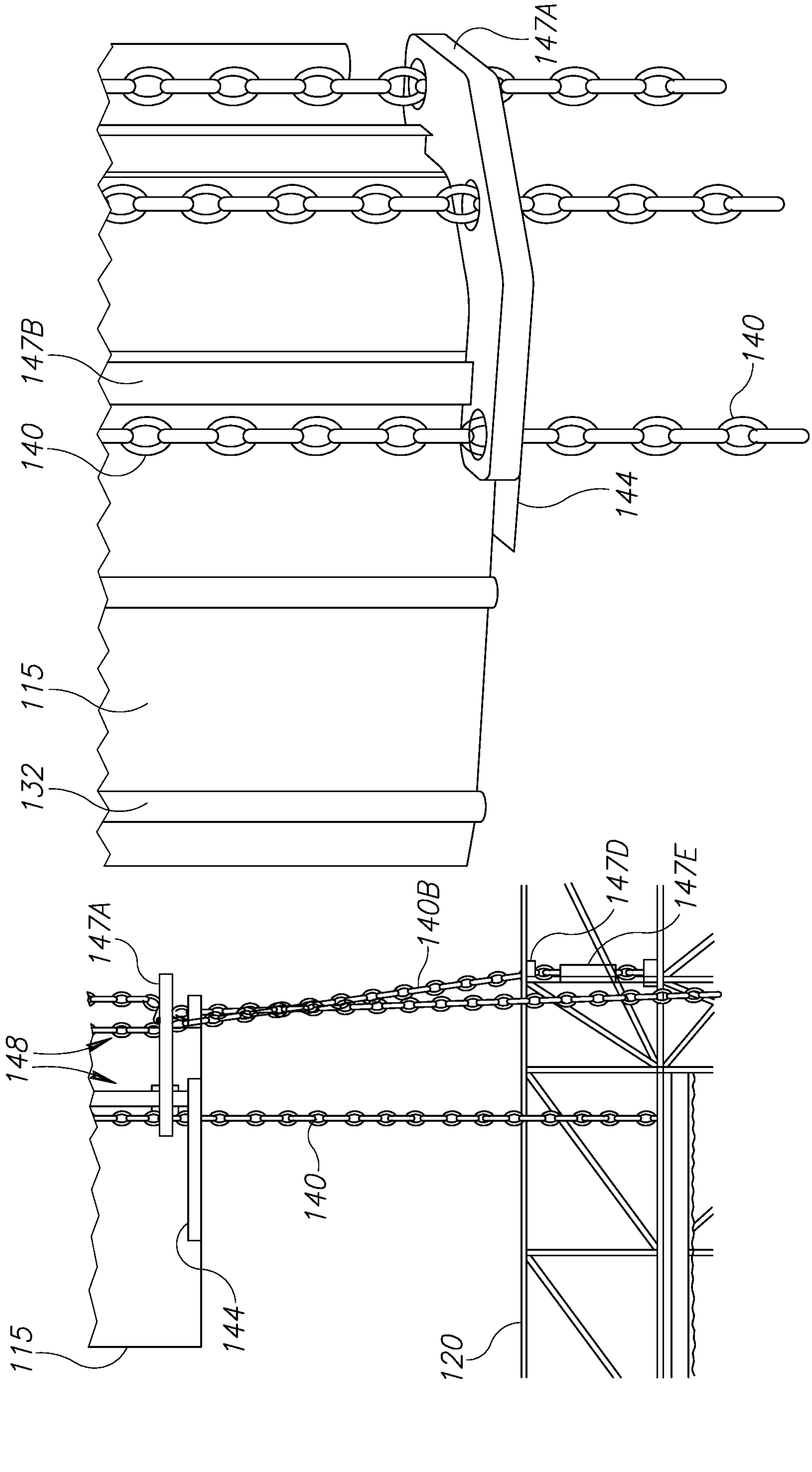

147A
147B
140
140
144
115
132
148
147A
140B
147D
147E
140
144
115
120

Figure 3J

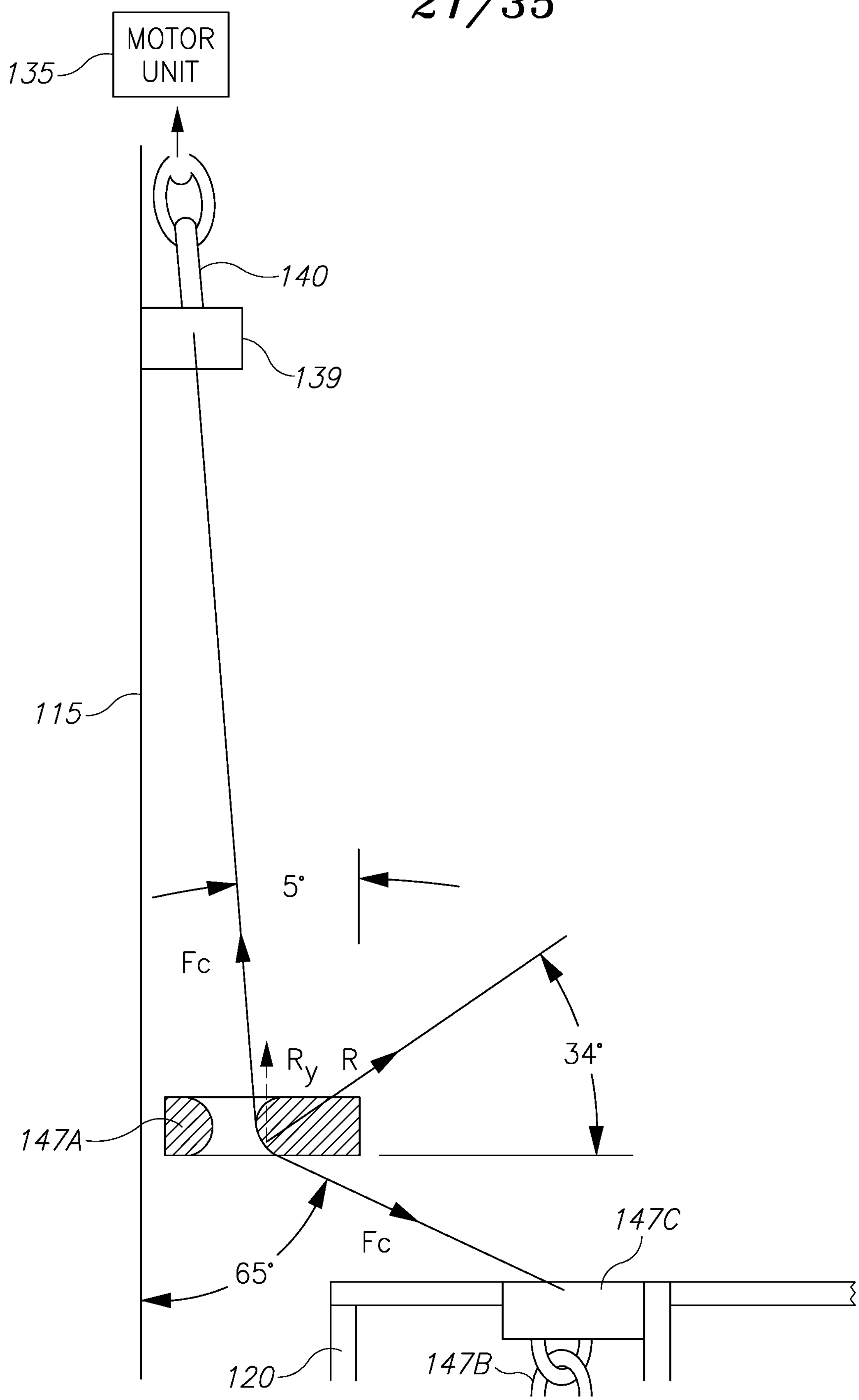


Figure 3K

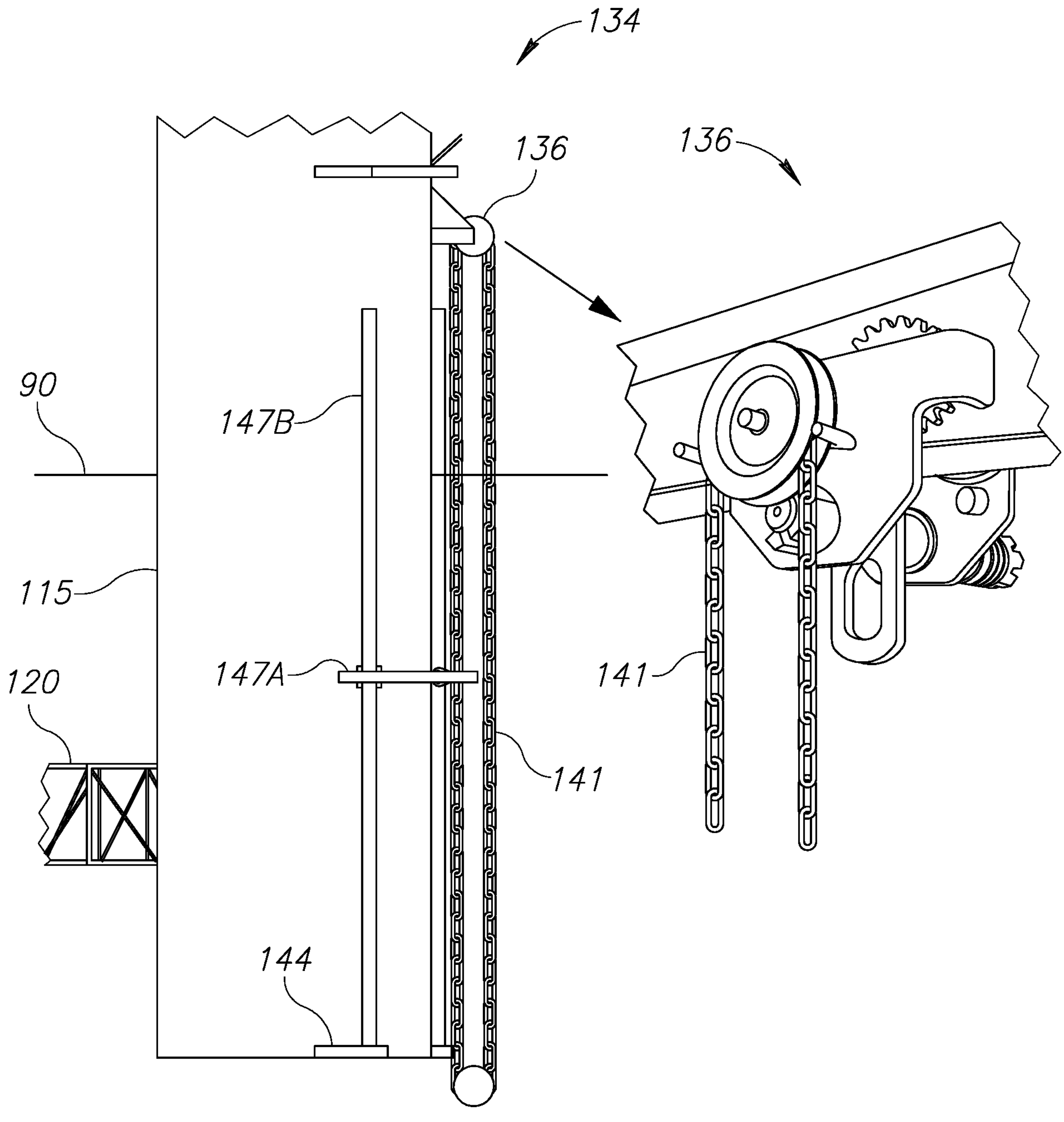


Figure 3L

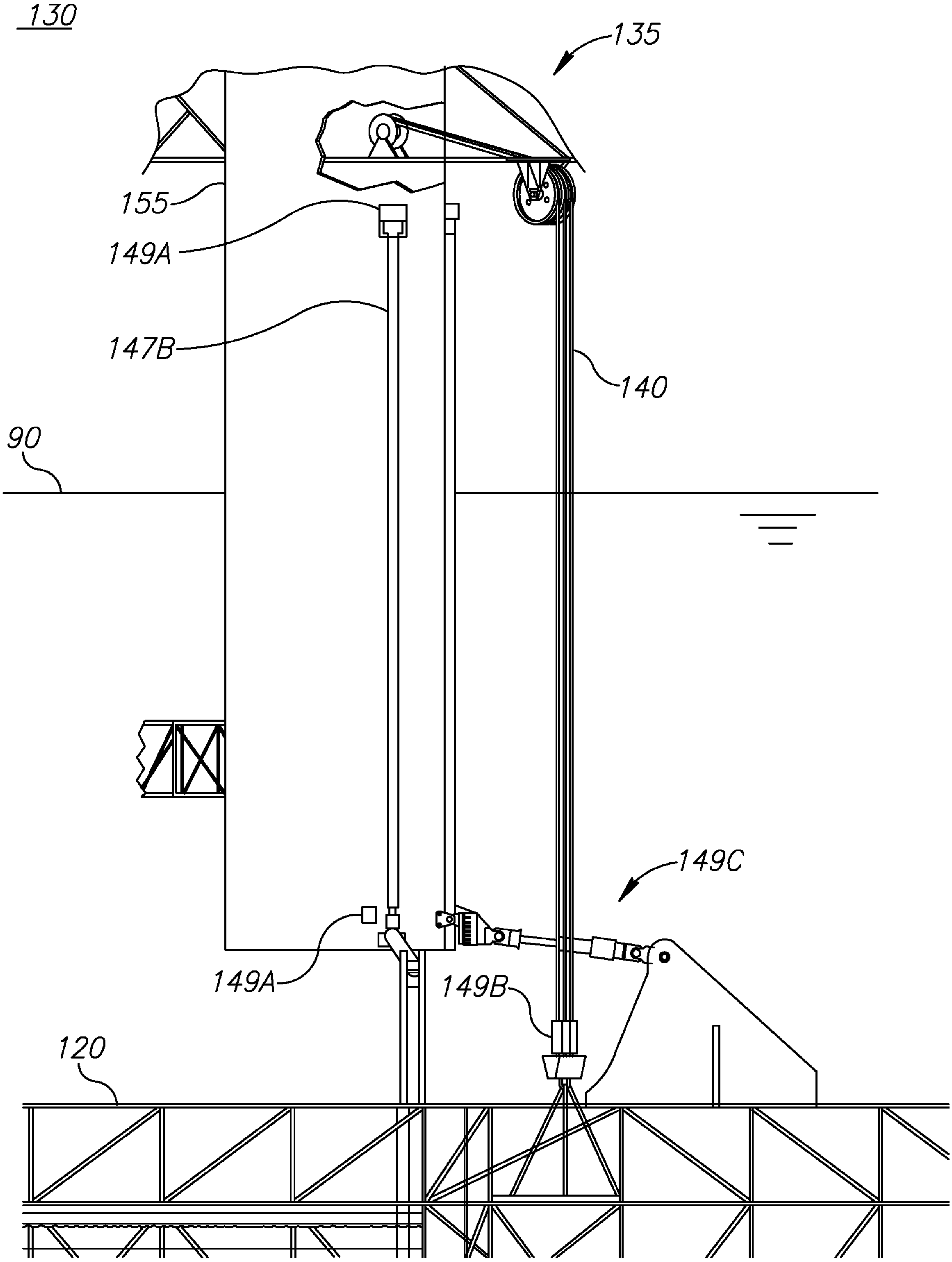


Figure 3M

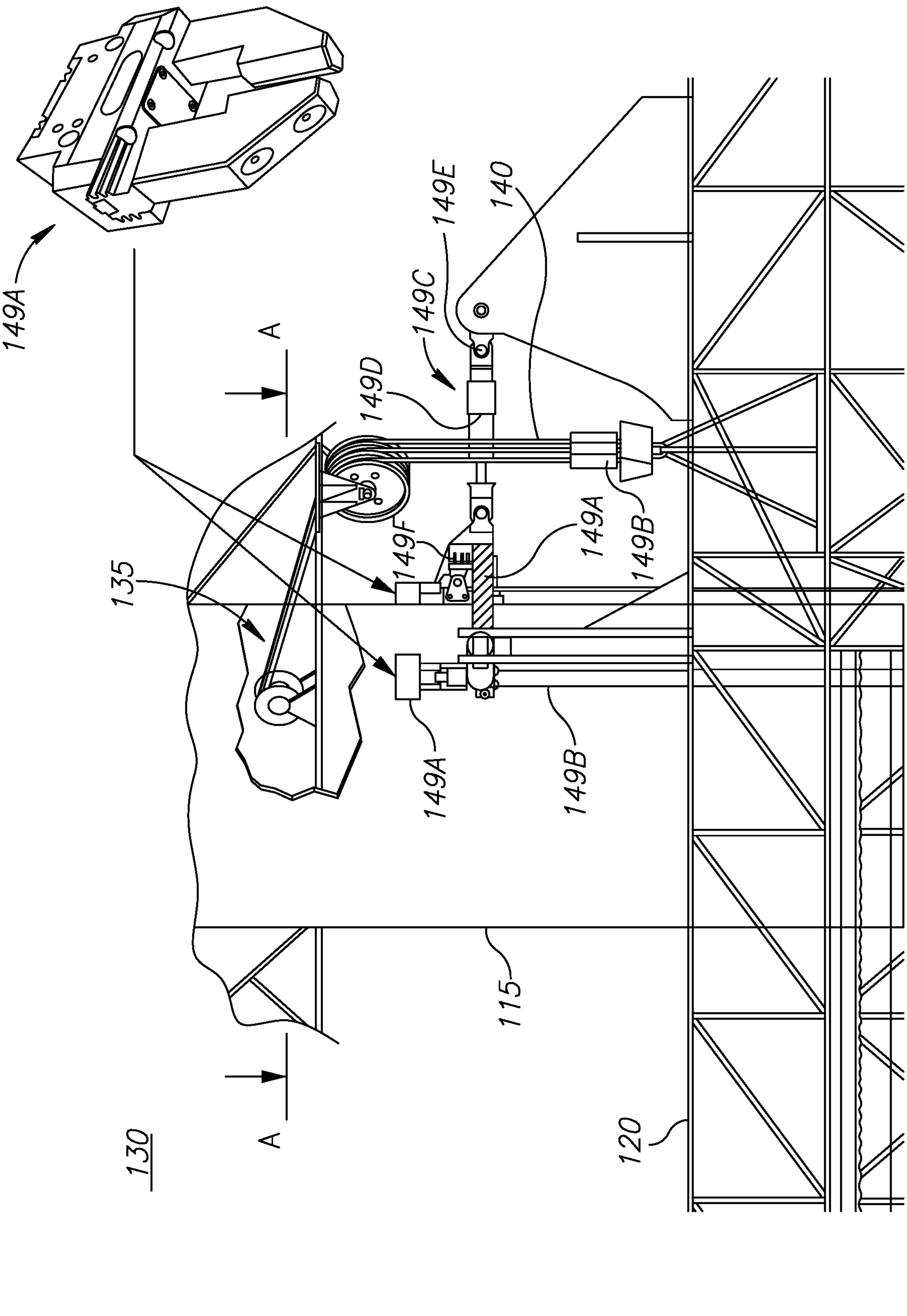
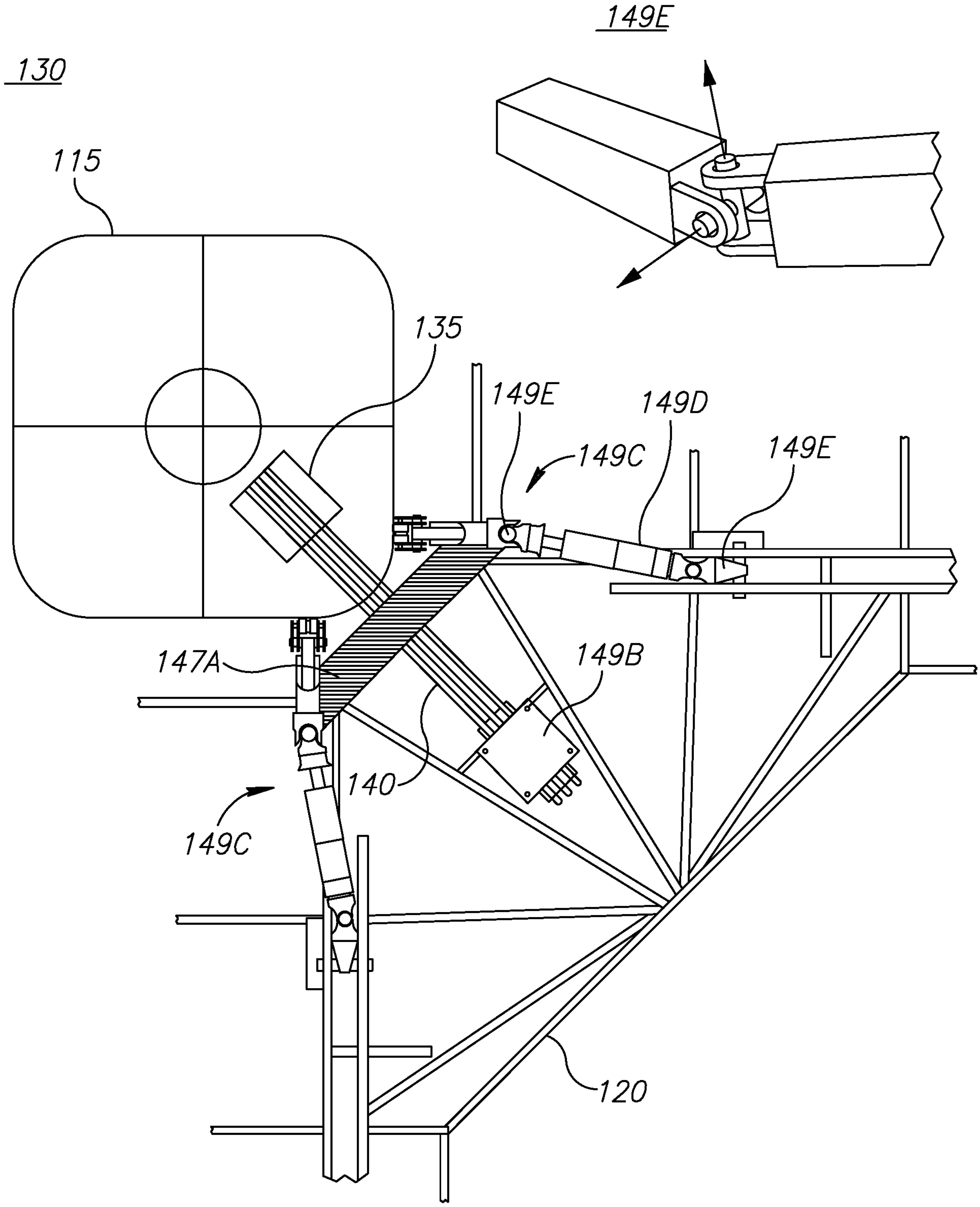

149A
149E
140
149C
149D
A
149F
149A
149B
135
149A
149B
115
130
120
A

Figure 3N



VIEW "A–A"

Figure 3N (cont.)

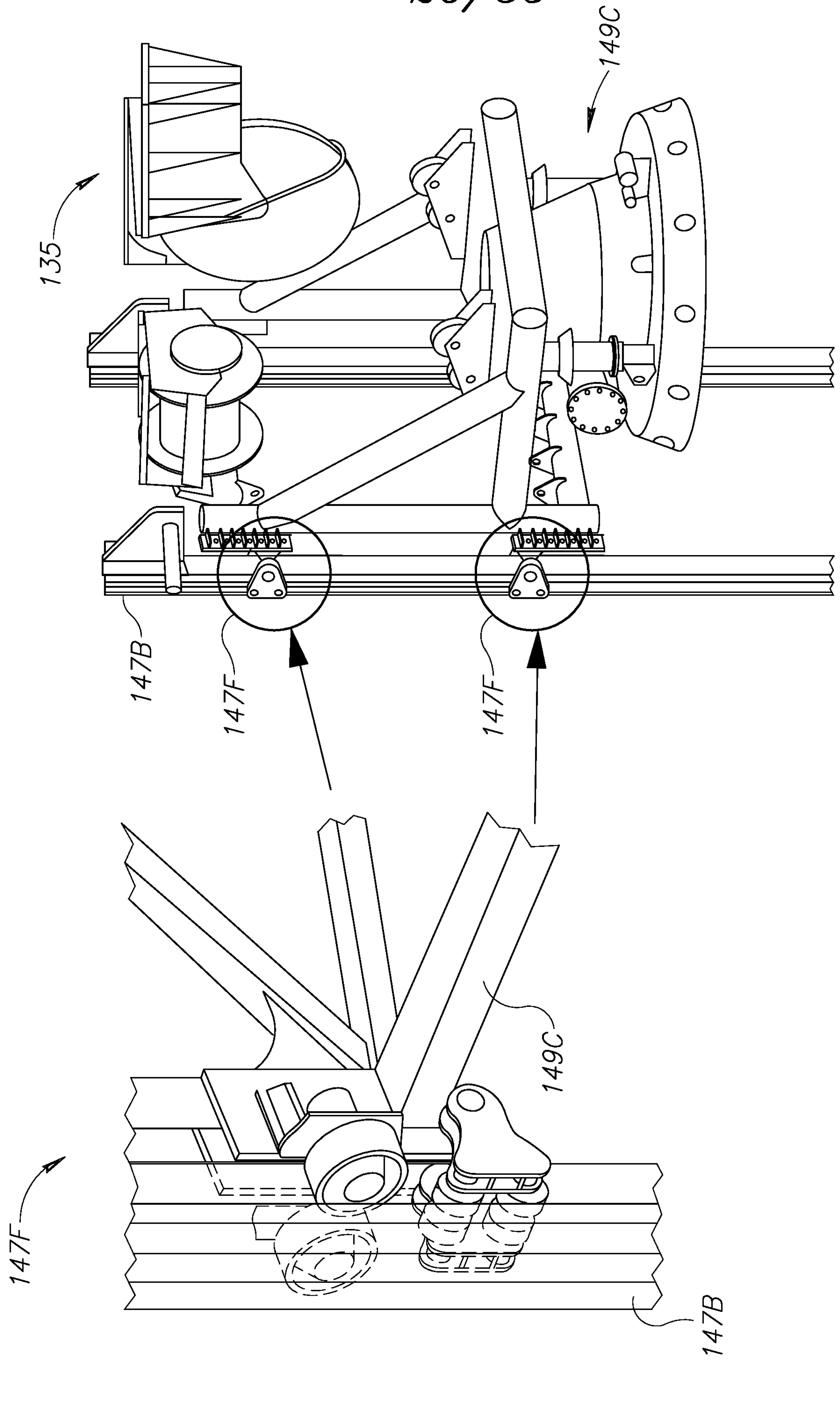


Figure 30

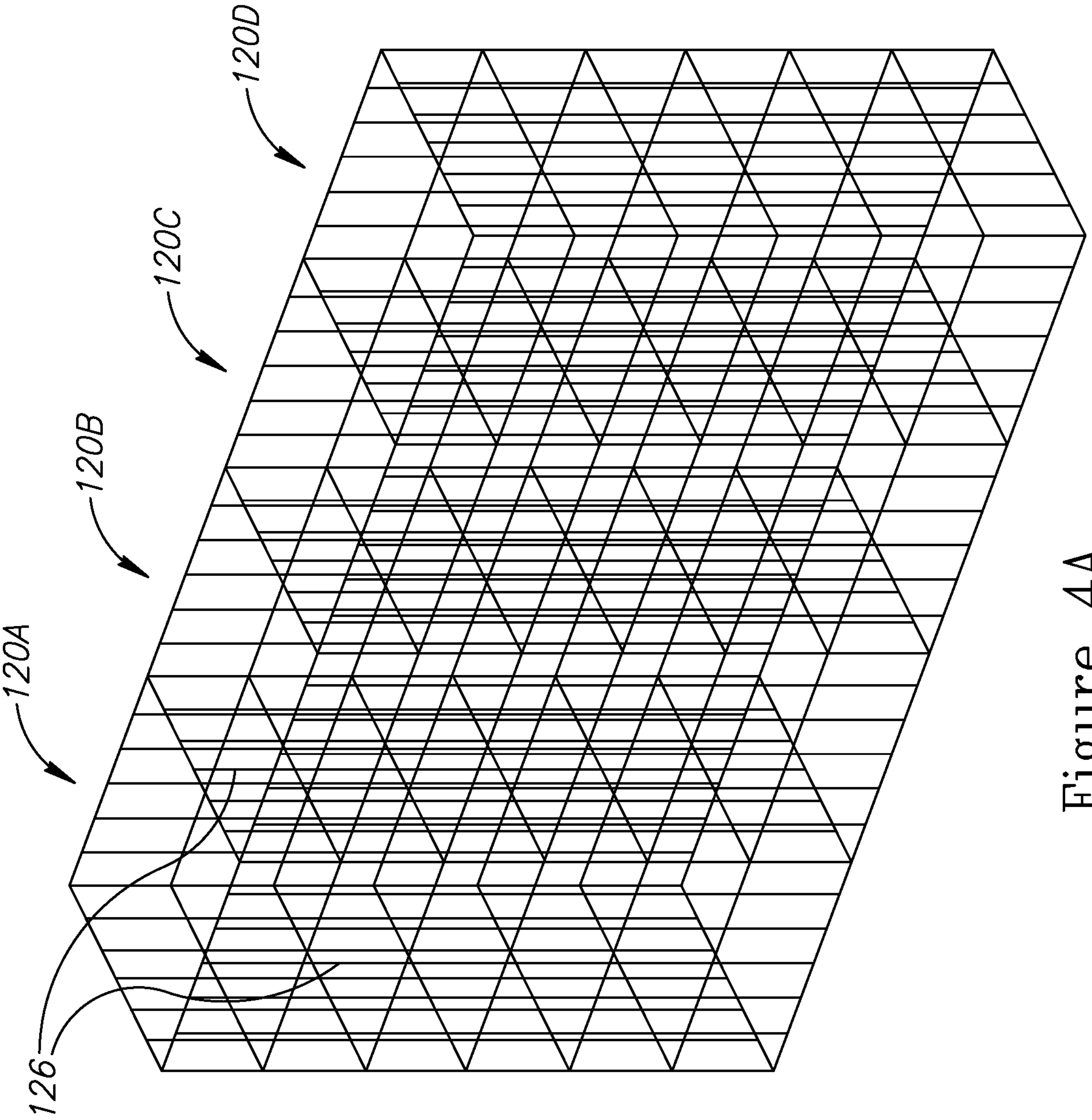


Figure 4A

120

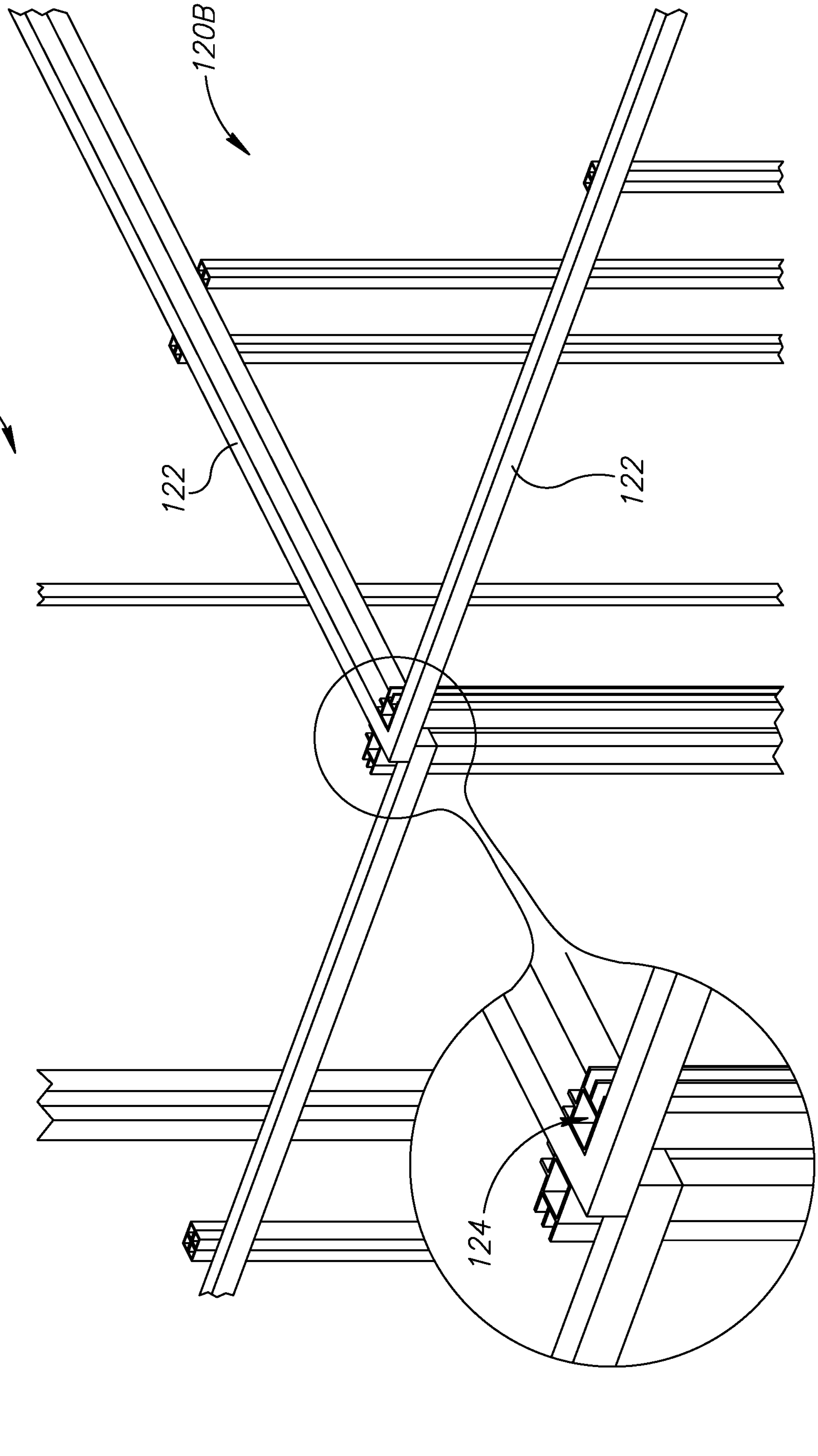


Figure 4B

120

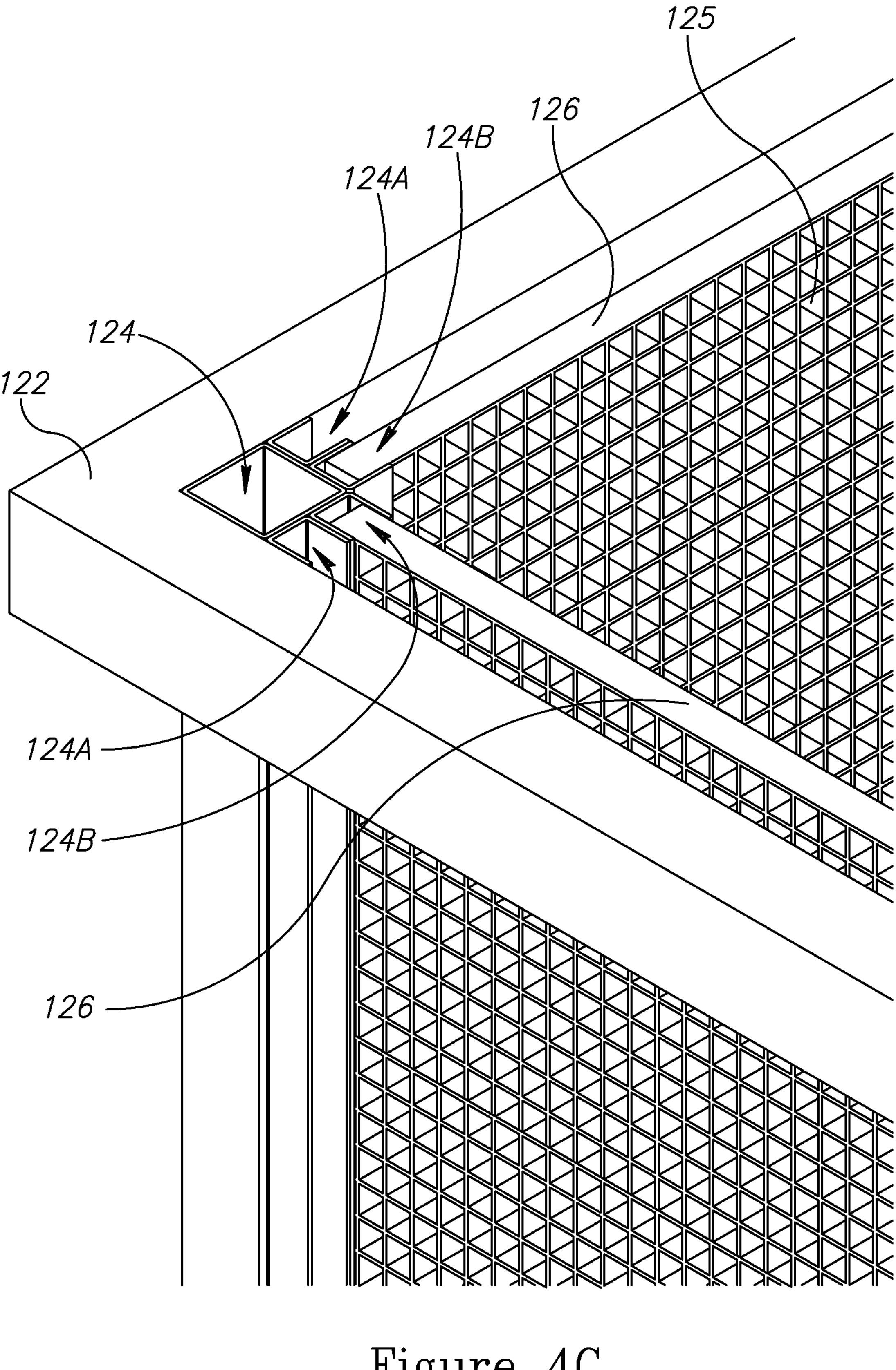


Figure 4C

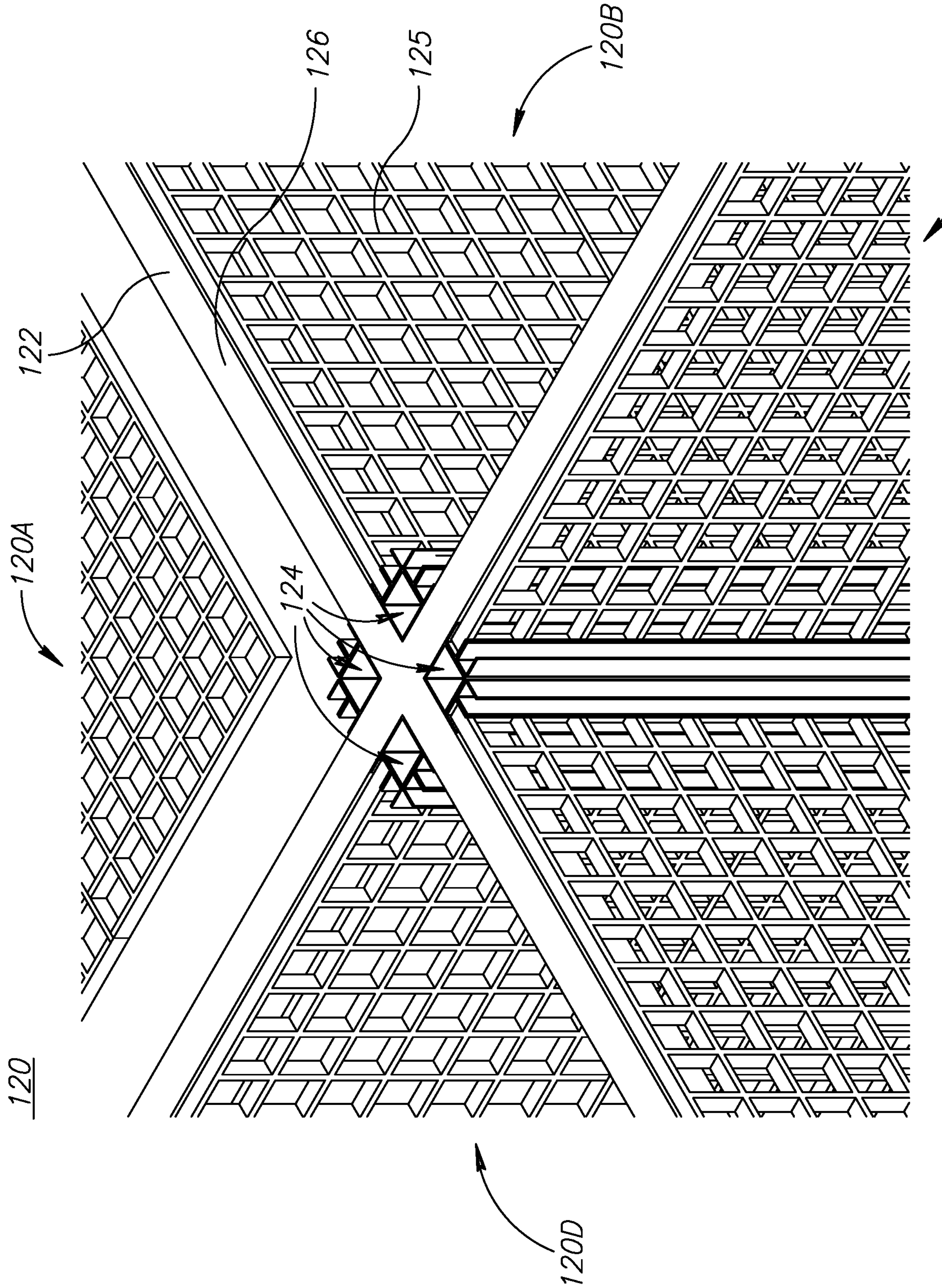


Figure 4D

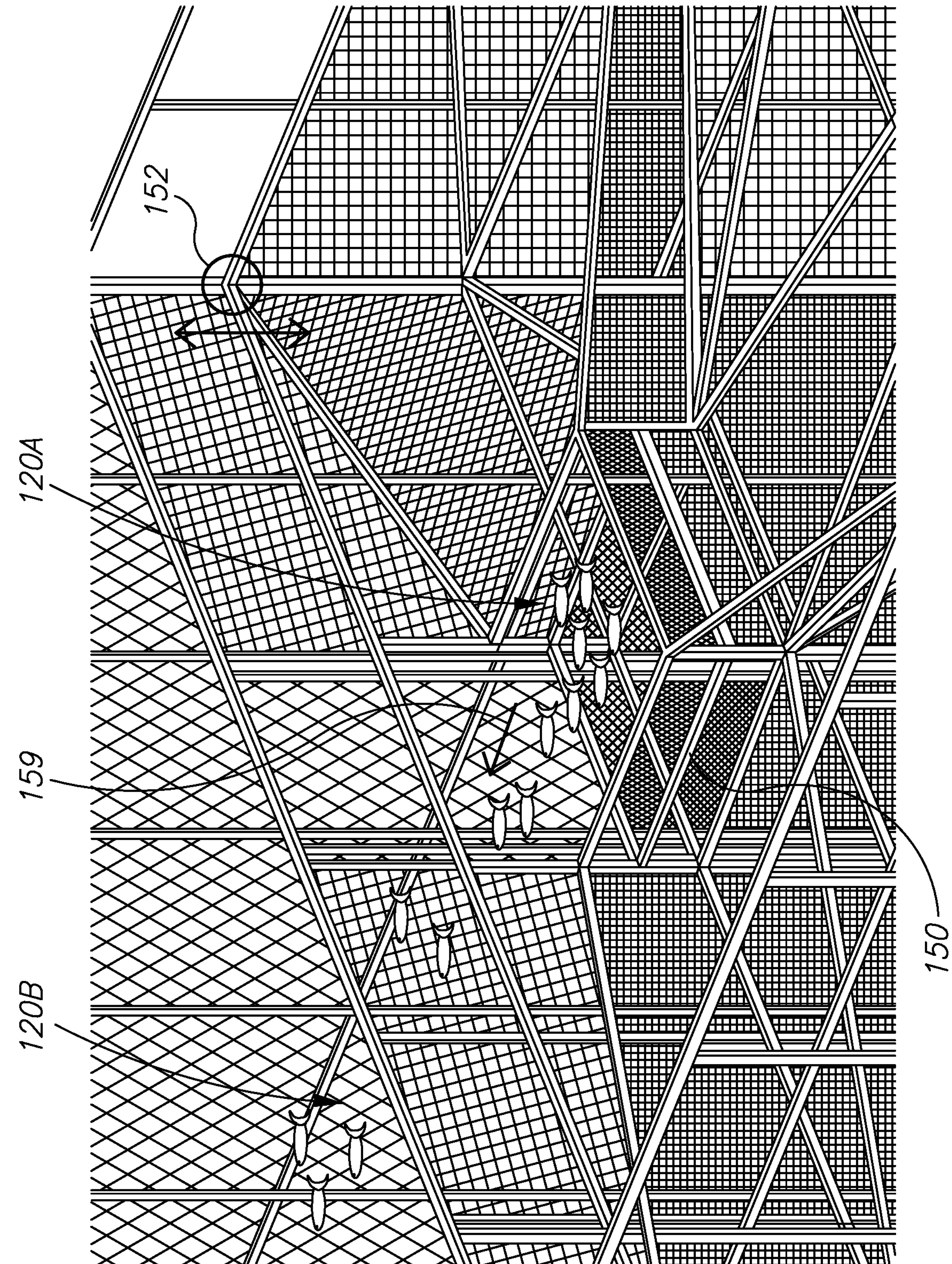


Figure 5

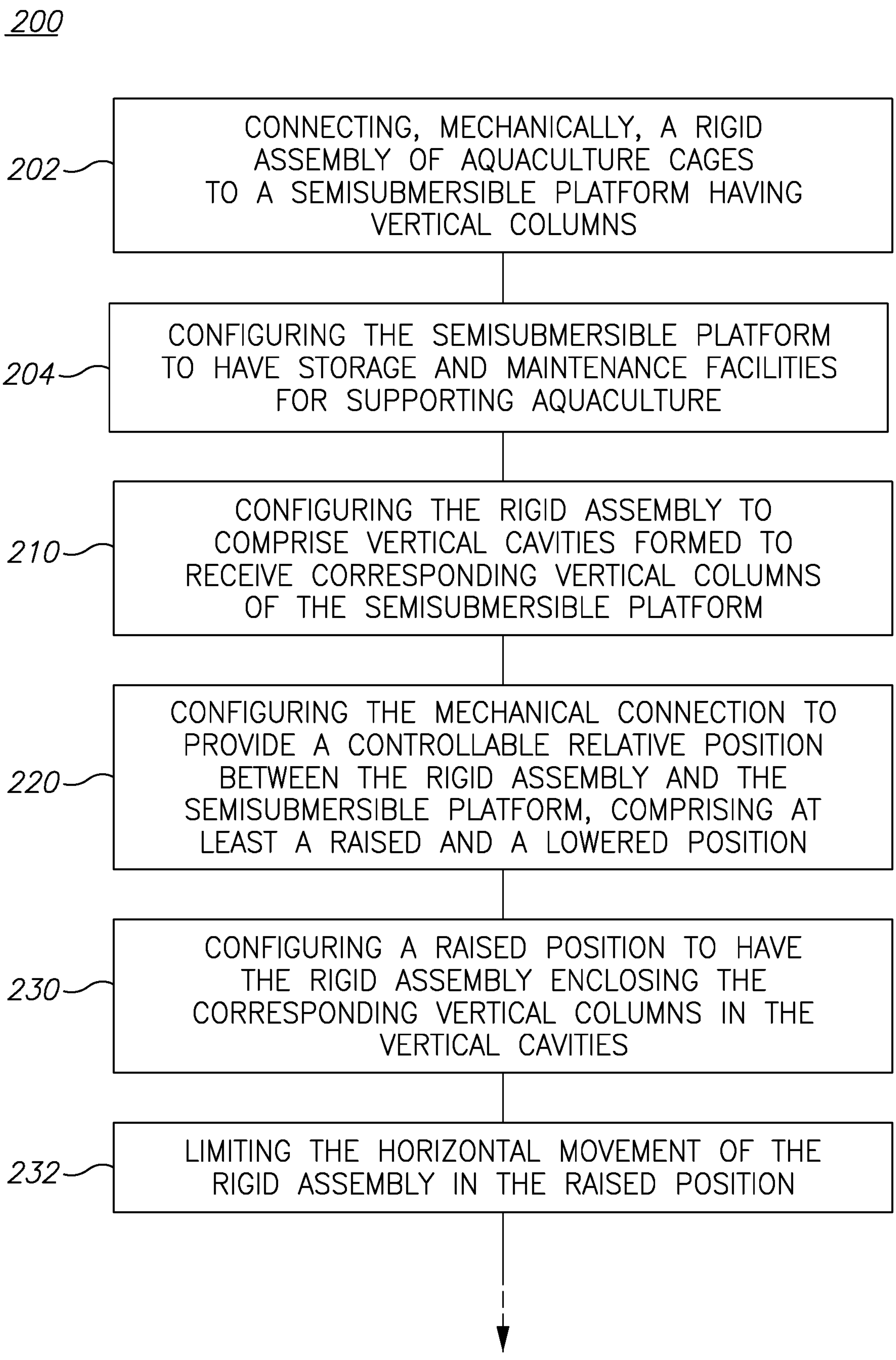

200
202
CONNECTING, MECHANICALLY, A RIGID ASSEMBLY OF AQUACULTURE CAGES TO A SEMISUBMERSIBLE PLATFORM HAVING VERTICAL COLUMNS
204
CONFIGURING THE SEMISUBMERSIBLE PLATFORM TO HAVE STORAGE AND MAINTENANCE FACILITIES FOR SUPPORTING AQUACULTURE
210
CONFIGURING THE RIGID ASSEMBLY TO COMPRISE VERTICAL CAVITIES FORMED TO RECEIVE CORRESPONDING VERTICAL COLUMNS OF THE SEMISUBMERSIBLE PLATFORM
220
CONFIGURING THE MECHANICAL CONNECTION TO PROVIDE A CONTROLLABLE RELATIVE POSITION BETWEEN THE RIGID ASSEMBLY AND THE SEMISUBMERSIBLE PLATFORM, COMPRISING AT LEAST A RAISED AND A LOWERED POSITION
230
CONFIGURING A RAISED POSITION TO HAVE THE RIGID ASSEMBLY ENCLOSING THE CORRESPONDING VERTICAL COLUMNS IN THE VERTICAL CAVITIES
232
LIMITING THE HORIZONTAL MOVEMENT OF THE RIGID ASSEMBLY IN THE RAISED POSITION

Figure 6

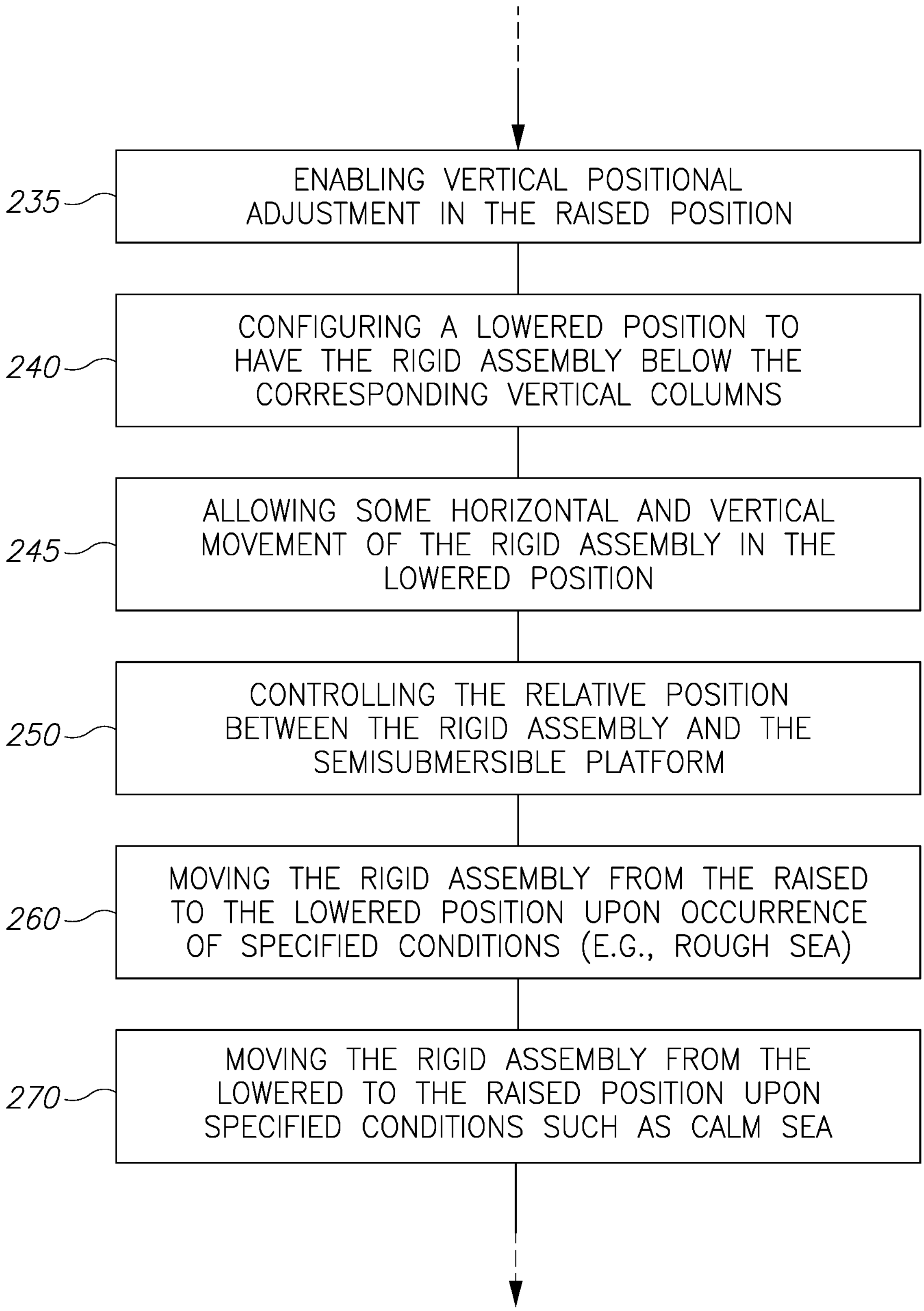


Figure 6 (cont. 1)

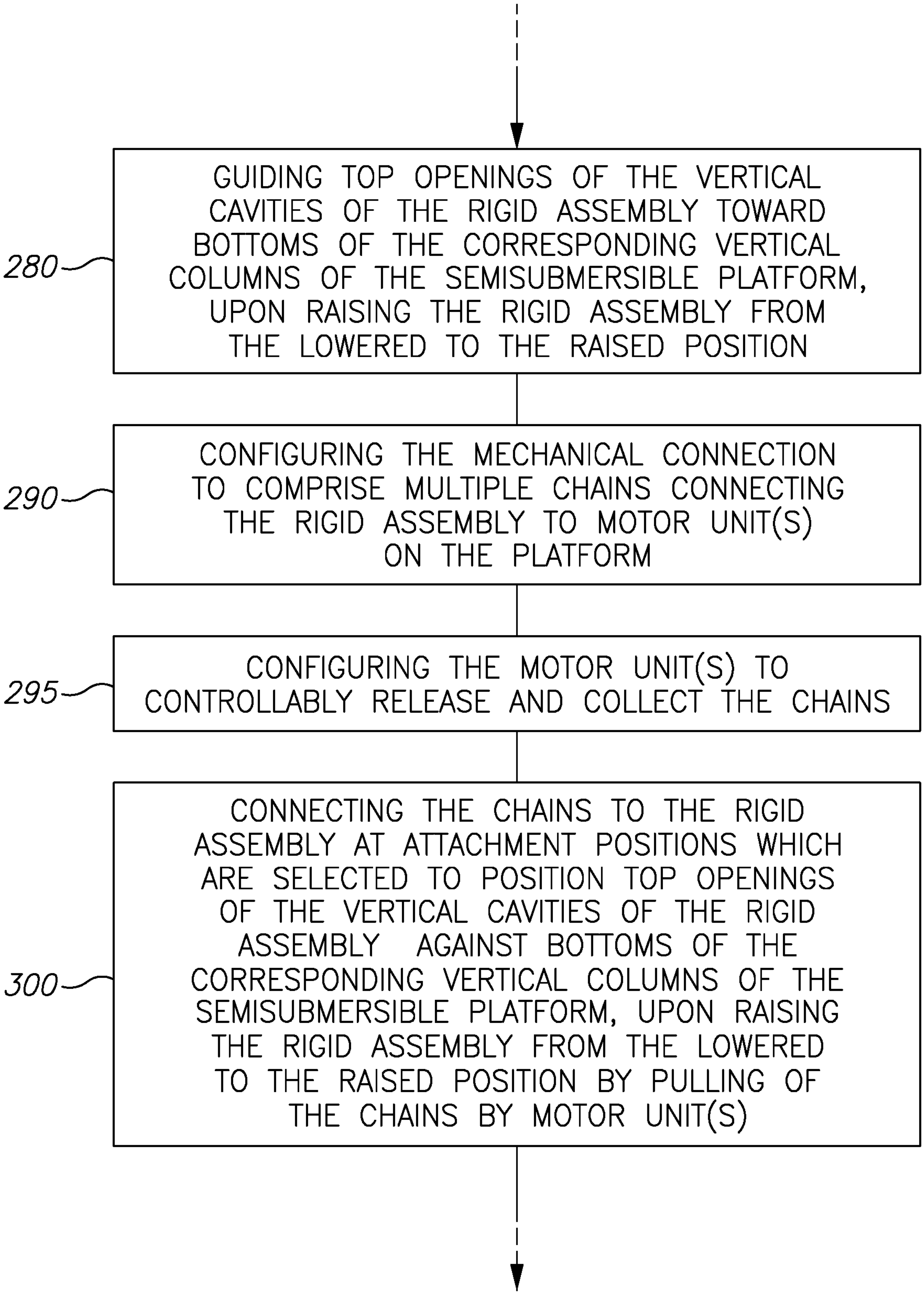


Figure 6 (cont. 2)

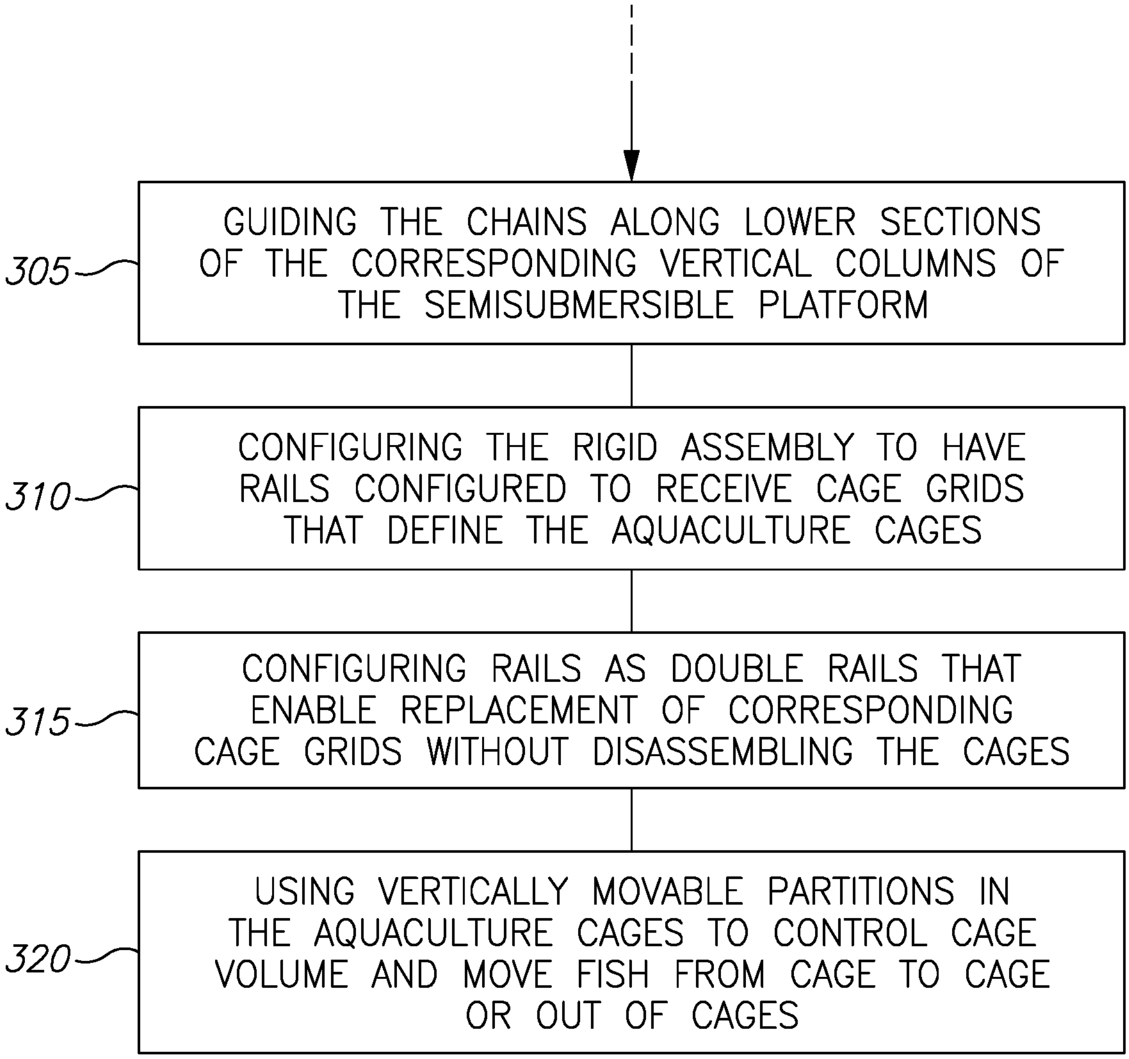


Figure 6 (cont. 3)

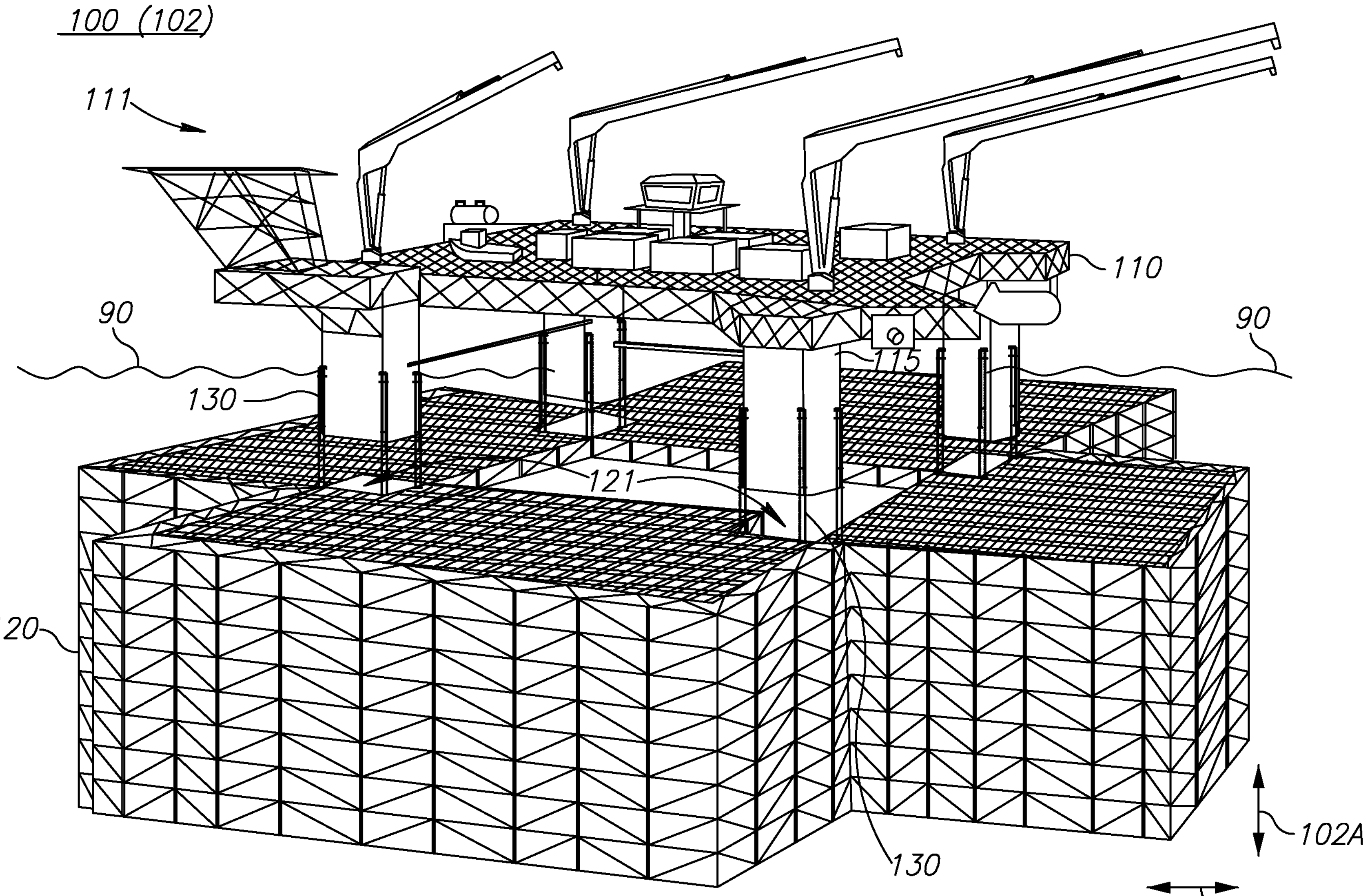


Figure 1B