US 20110033242A1

(19) **United States**

(12) **Patent Application Publication**

Albrecht et al.

(10) **Pub. No.: US 2011/0033242 A1**

(43) **Pub. Date: Feb. 10, 2011**

(54) **MODULAR-UNIT FLOODWALL SYSTEM**

(75) Inventors: **Douglas Arnold Albrecht**, St. Louis, MO (US); **Thomas J. Birkenmeier**, Creve Coeur, MO (US)

Correspondence Address:
SENNIGER POWERS LLP
100 NORTH BROADWAY, 17TH FLOOR
ST LOUIS, MO 63102 (US)

(73) Assignee: **STEELE FLOOD STOP SYSTEM LLC**, Brentwood, MO (US)

(21) Appl. No.: **12/536,534**

(22) Filed: **Aug. 6, 2009**

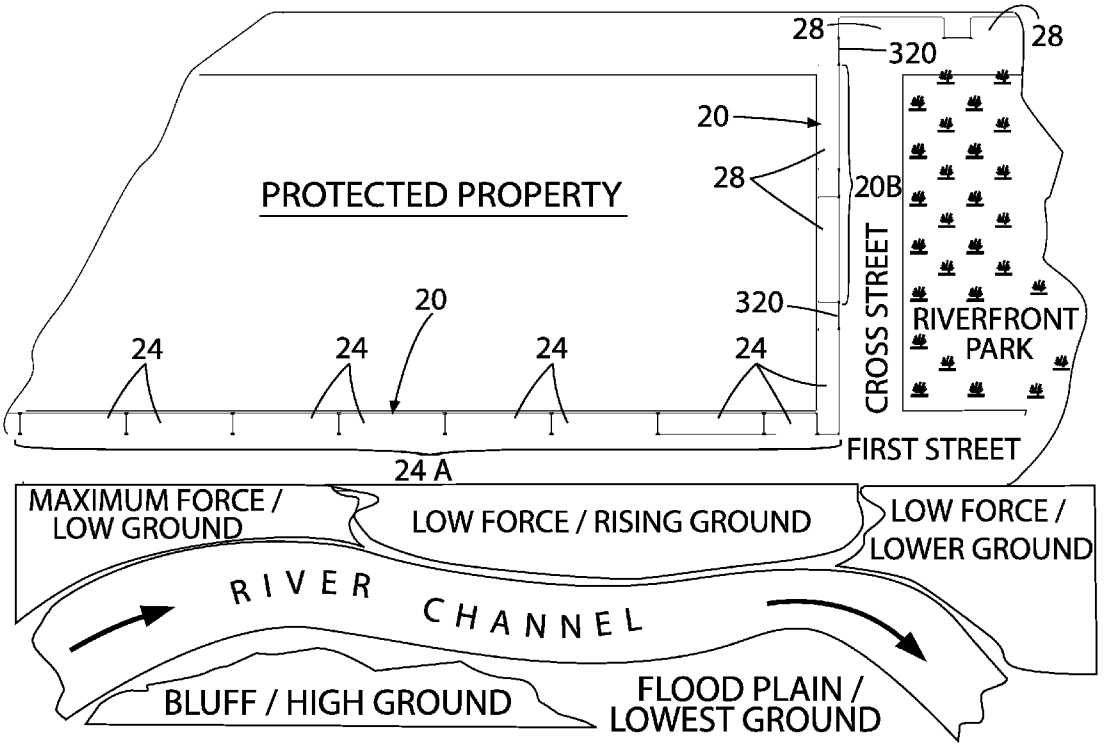
Publication Classification

(51) **Int. Cl.**
E02B 7/00 (2006.01)
E02B 8/06 (2006.01)

(52) **U.S. Cl.** **405/108**; 405/116

(57) **ABSTRACT**

A modular-unit floodwall system is disclosed. The system includes modular floodwall units configured for holding water and connecting and sealing devices for connecting the units together to form a barrier against floodwater. A method of constructing such a floodwall is also disclosed.



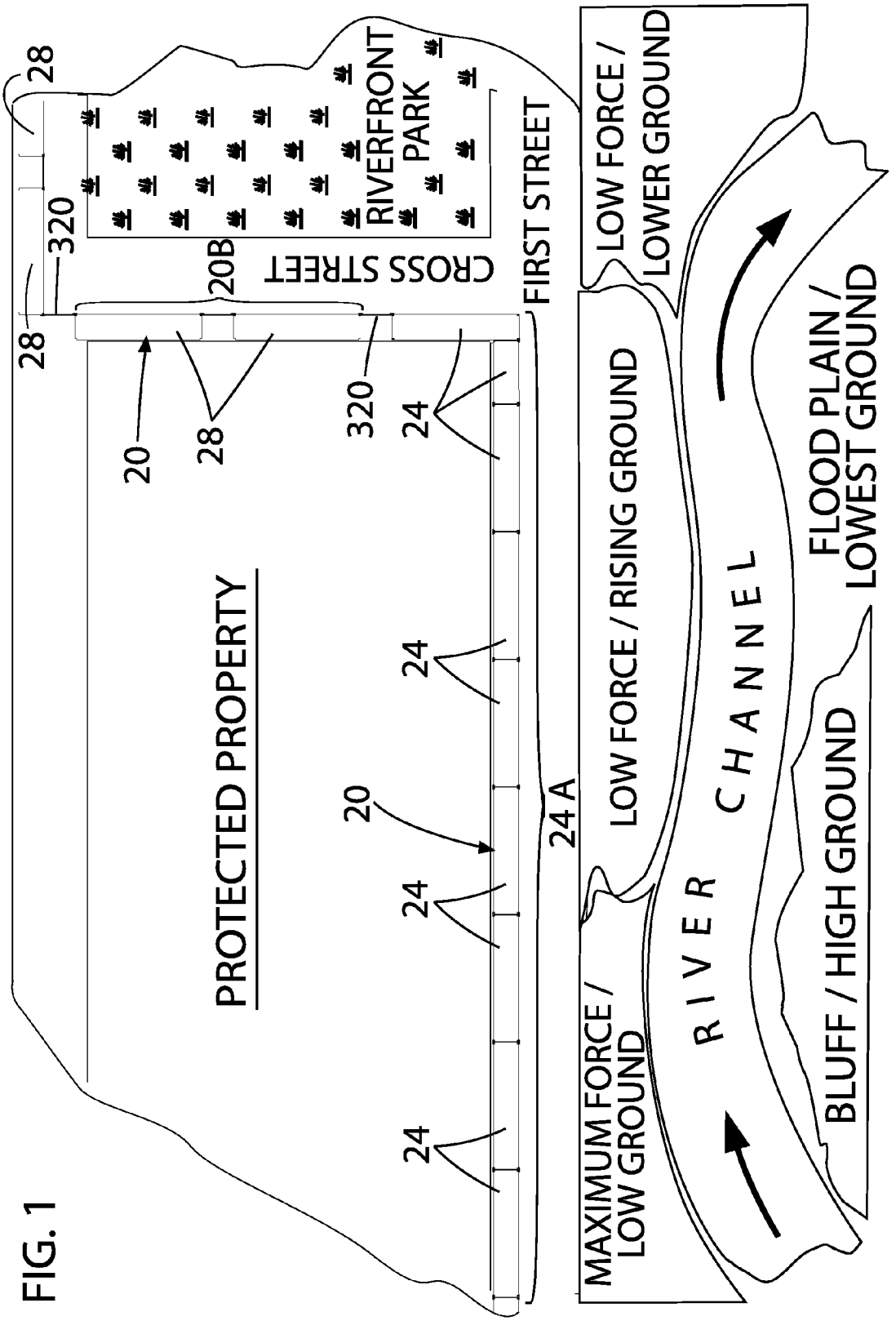
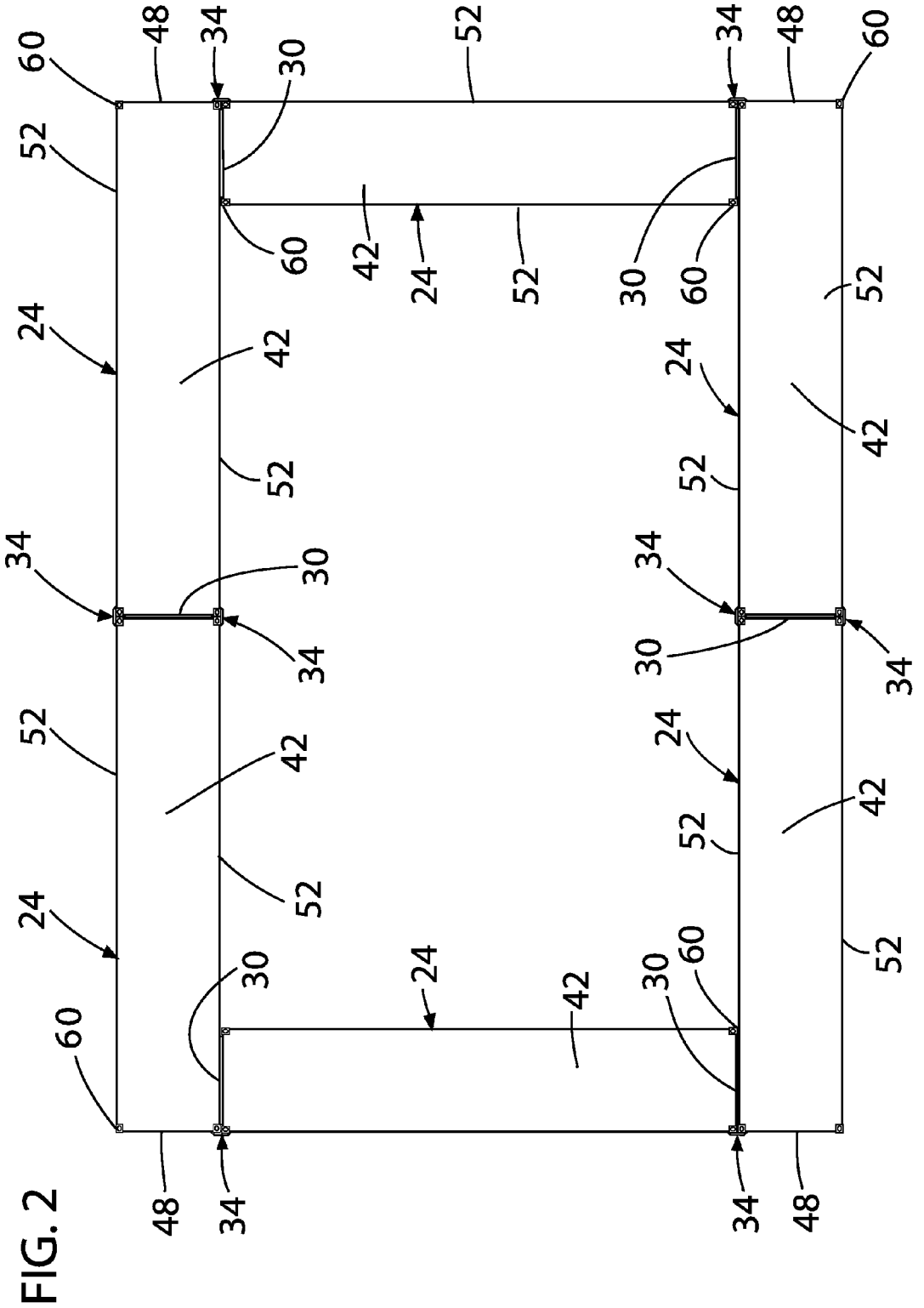

28
320
RIVERFRONT PARK
CROSS STREET
20B
FIRST STREET
LOW FORCE / LOWER GROUND
28
20
28
320
24
PROTECTED PROPERTY
24
20
24
24A
LOW FORCE / RISING GROUND
24
MAXIMUM FORCE / LOW GROUND
RIVER CHANNEL
FLOOD PLAIN / LOWEST GROUND
BLUFF / HIGH GROUND

FIG. 1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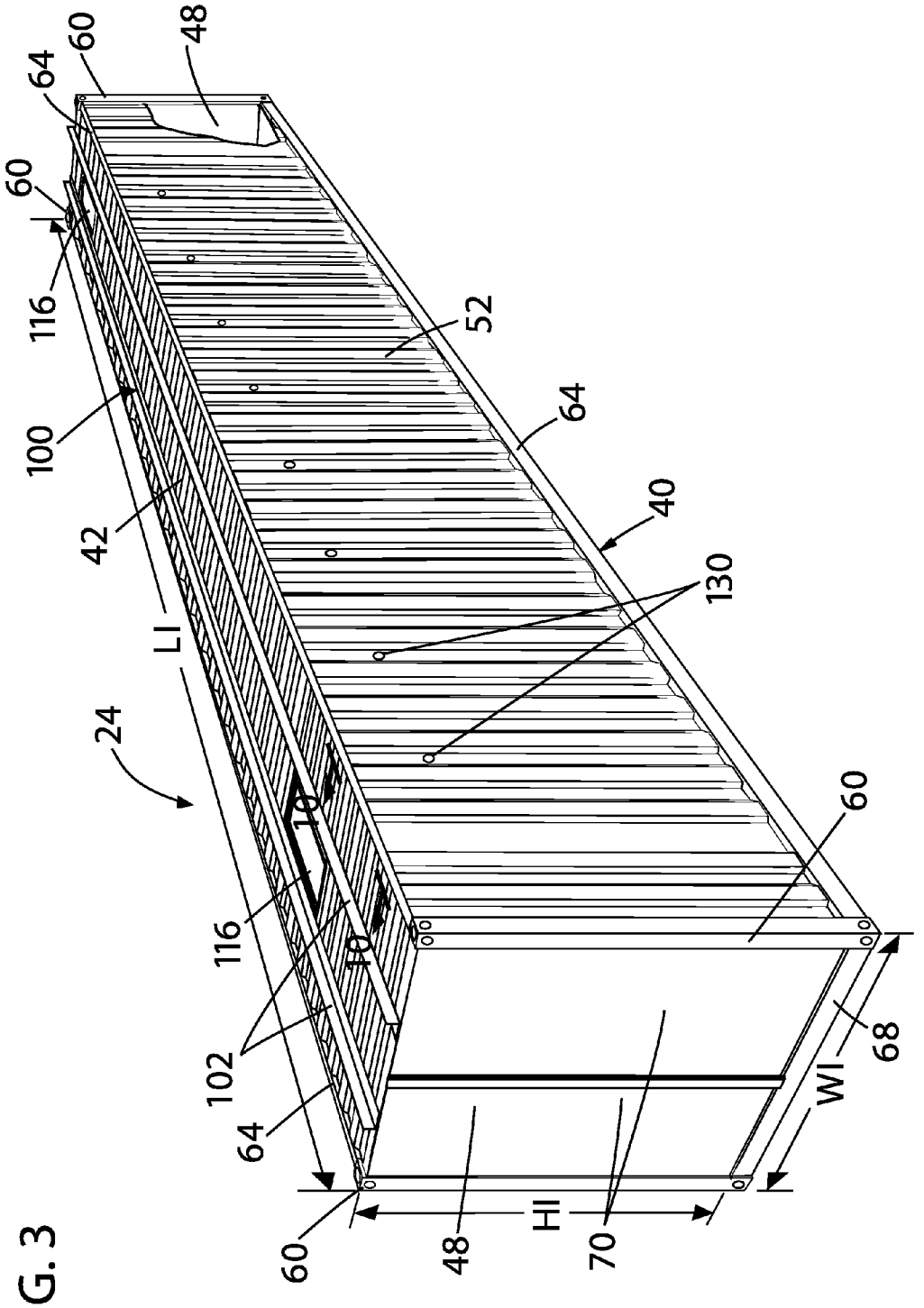
48

FIG. 2


60
64
48
60
116
52
64
100
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42
130
LI
24
60
116
102
64
68
WI
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48
HI
70

FIG. 3

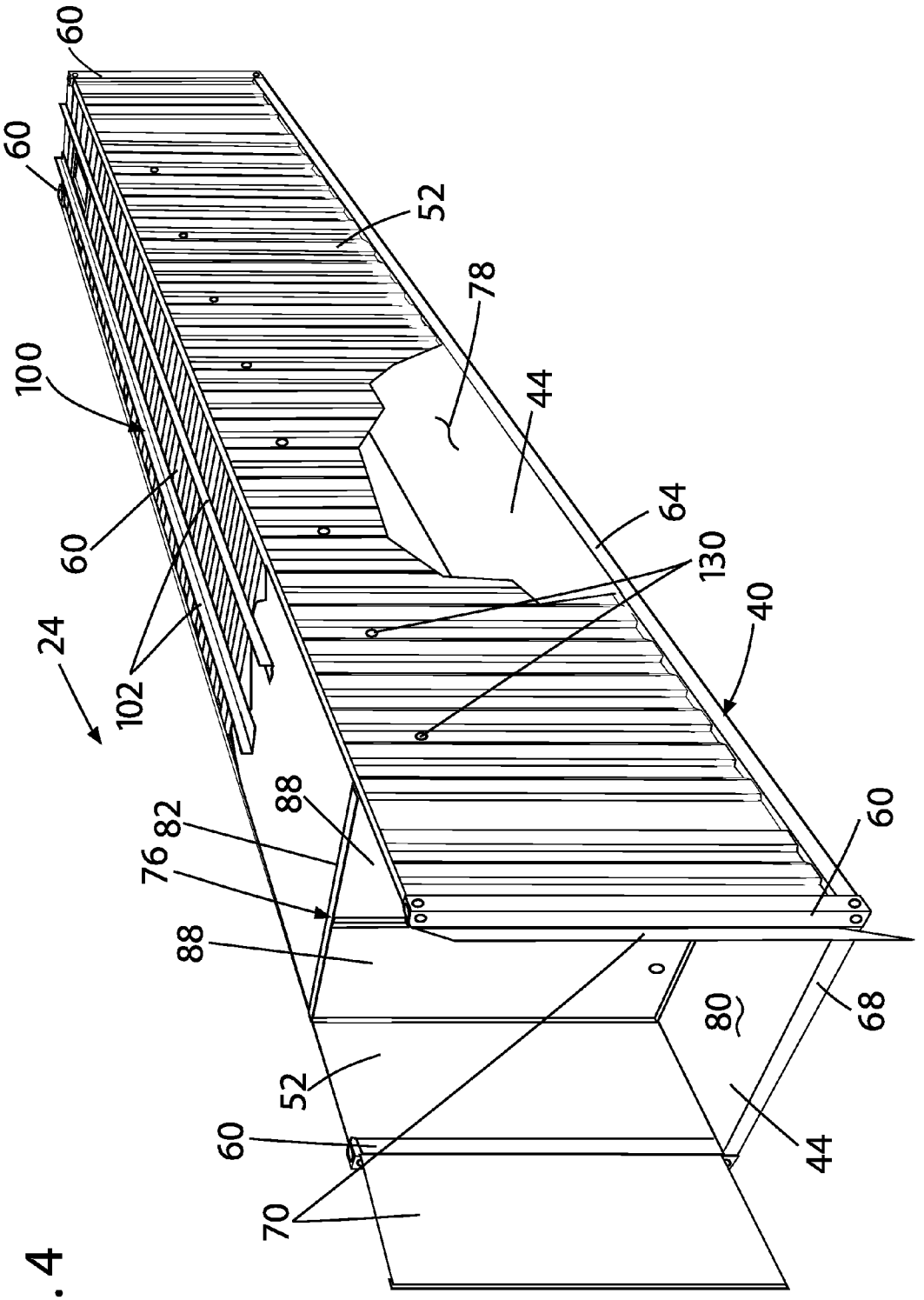


FIG. 4

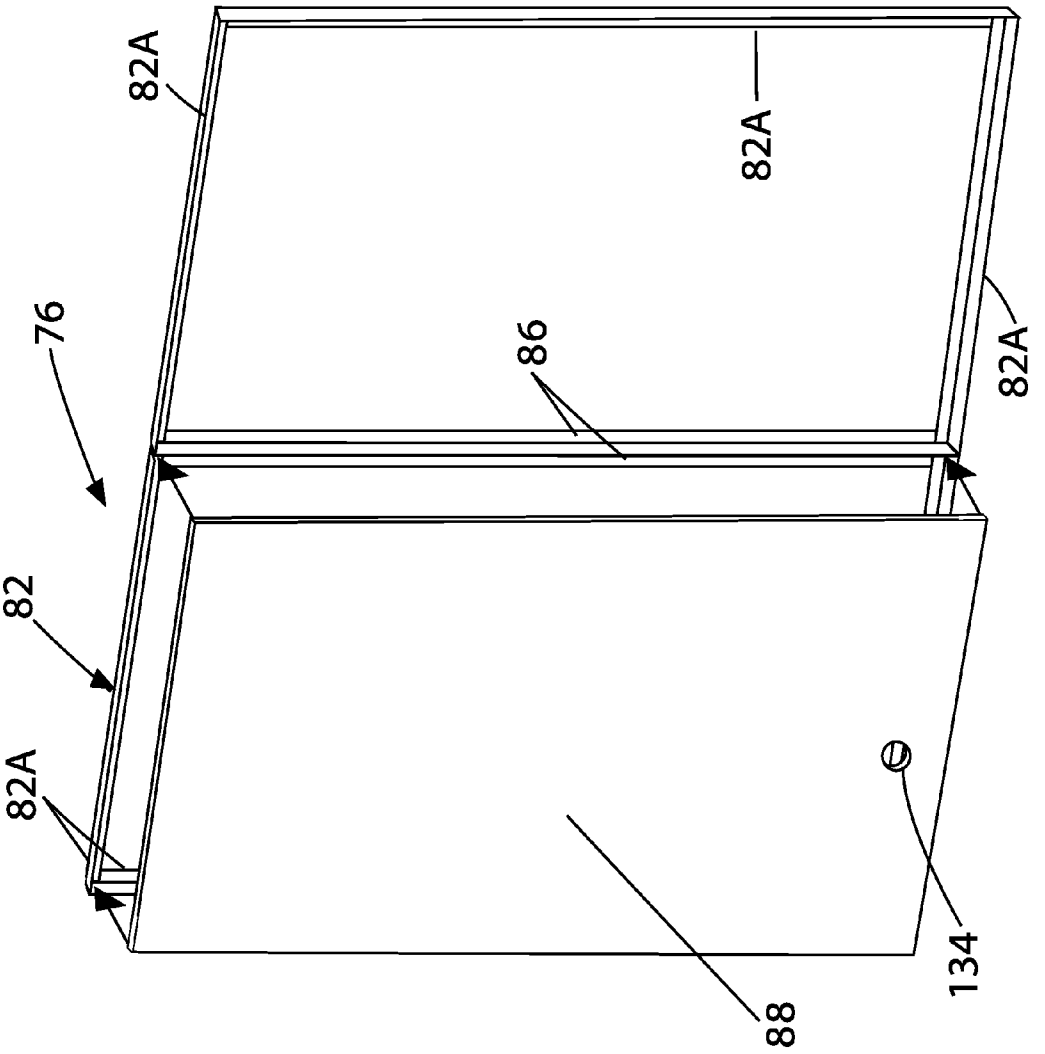


FIG. 5

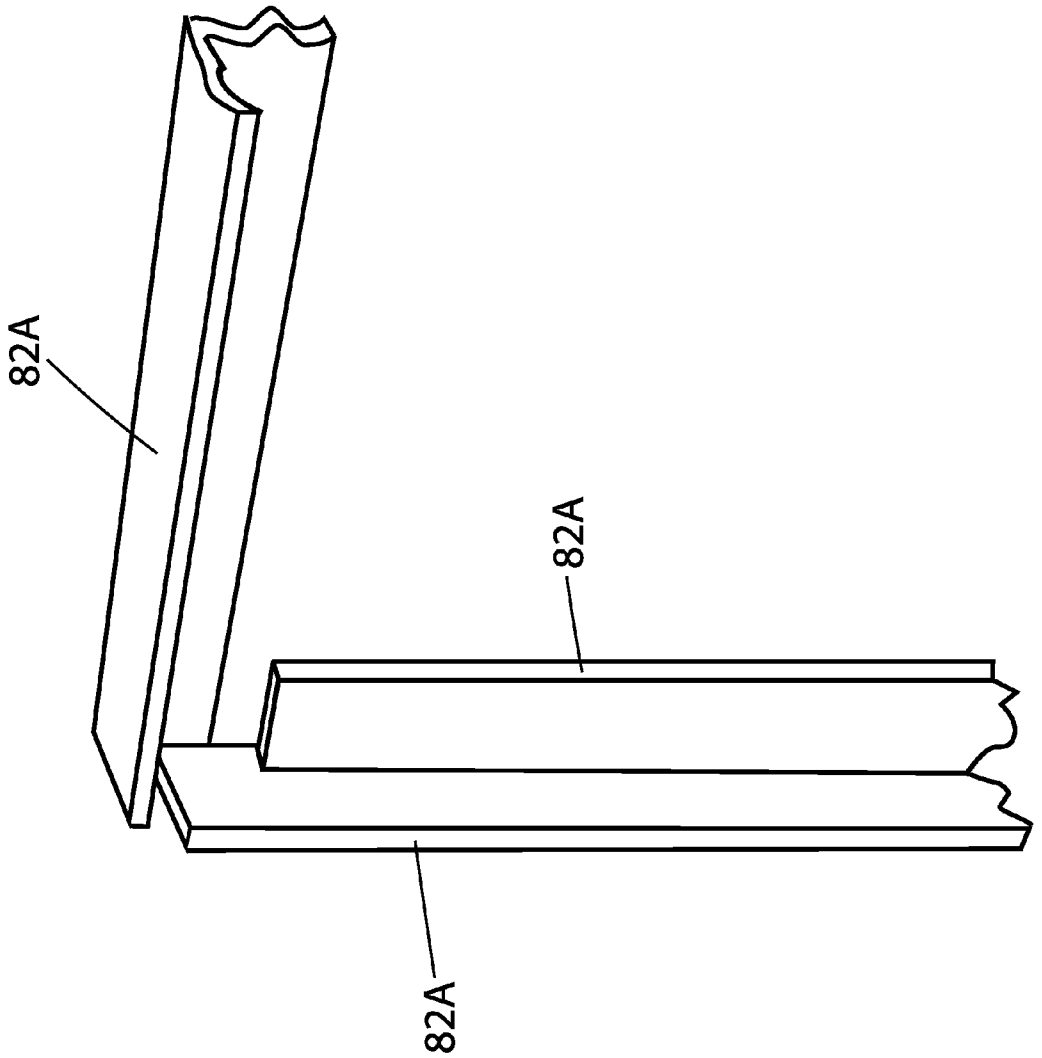


FIG. 6

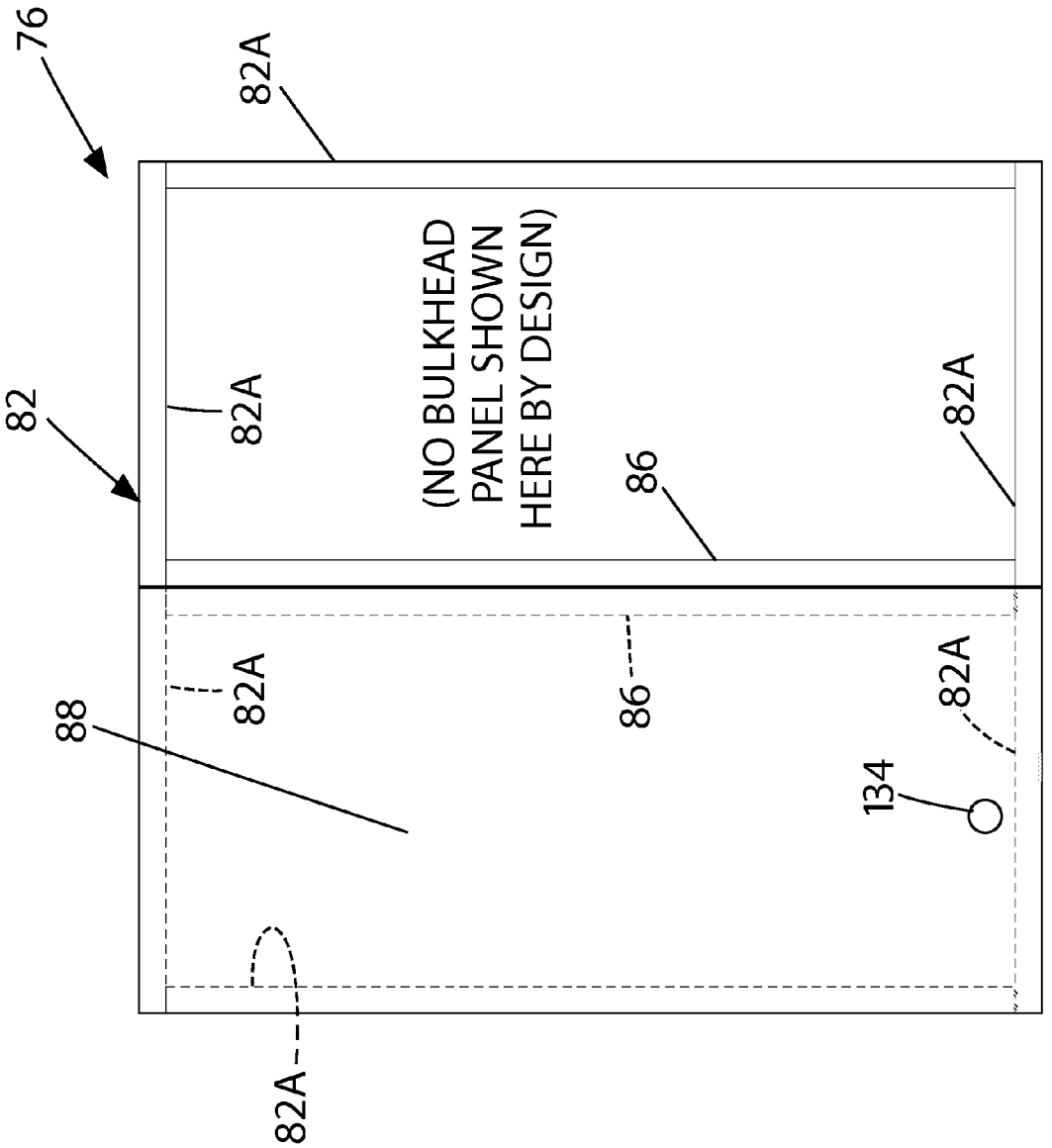

76
82A
82
82A
(NO BULKHEAD PANEL SHOWN HERE BY DESIGN)
86
82A
88
82A
86
82A
134
82A

FIG. 7

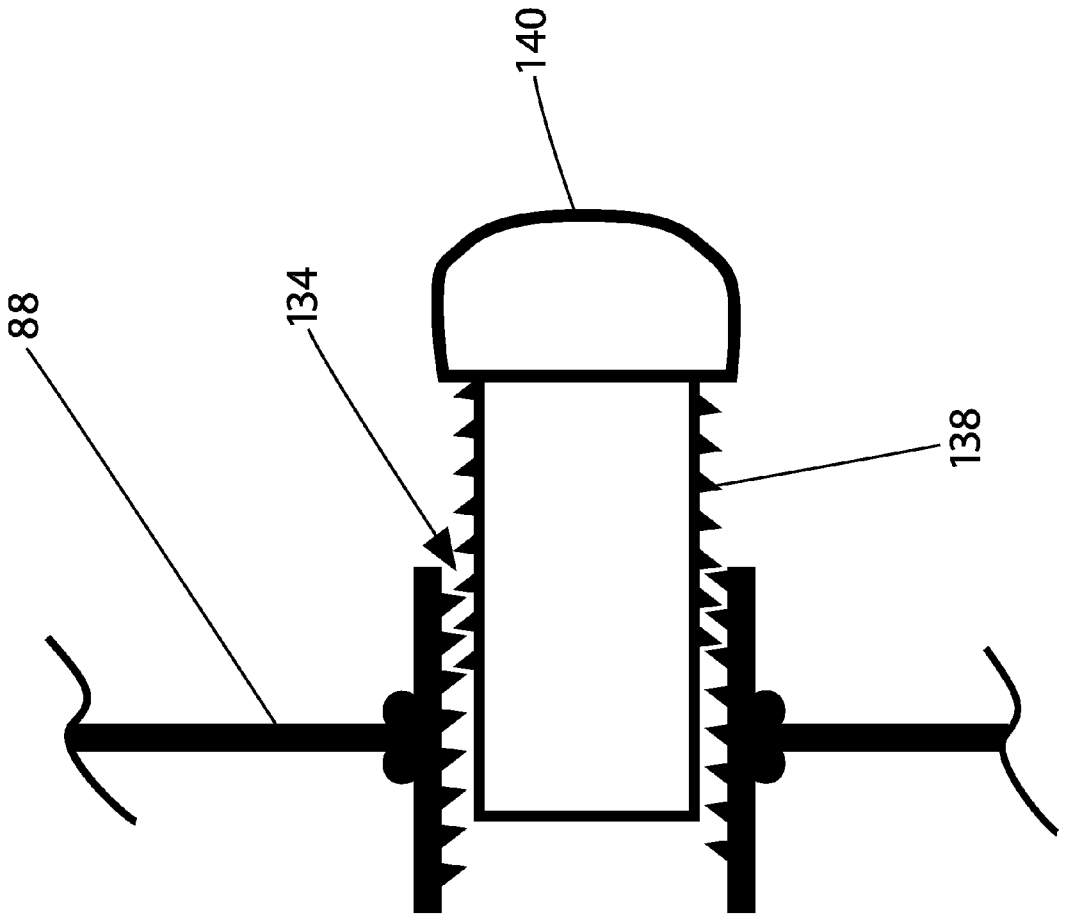


FIG. 8

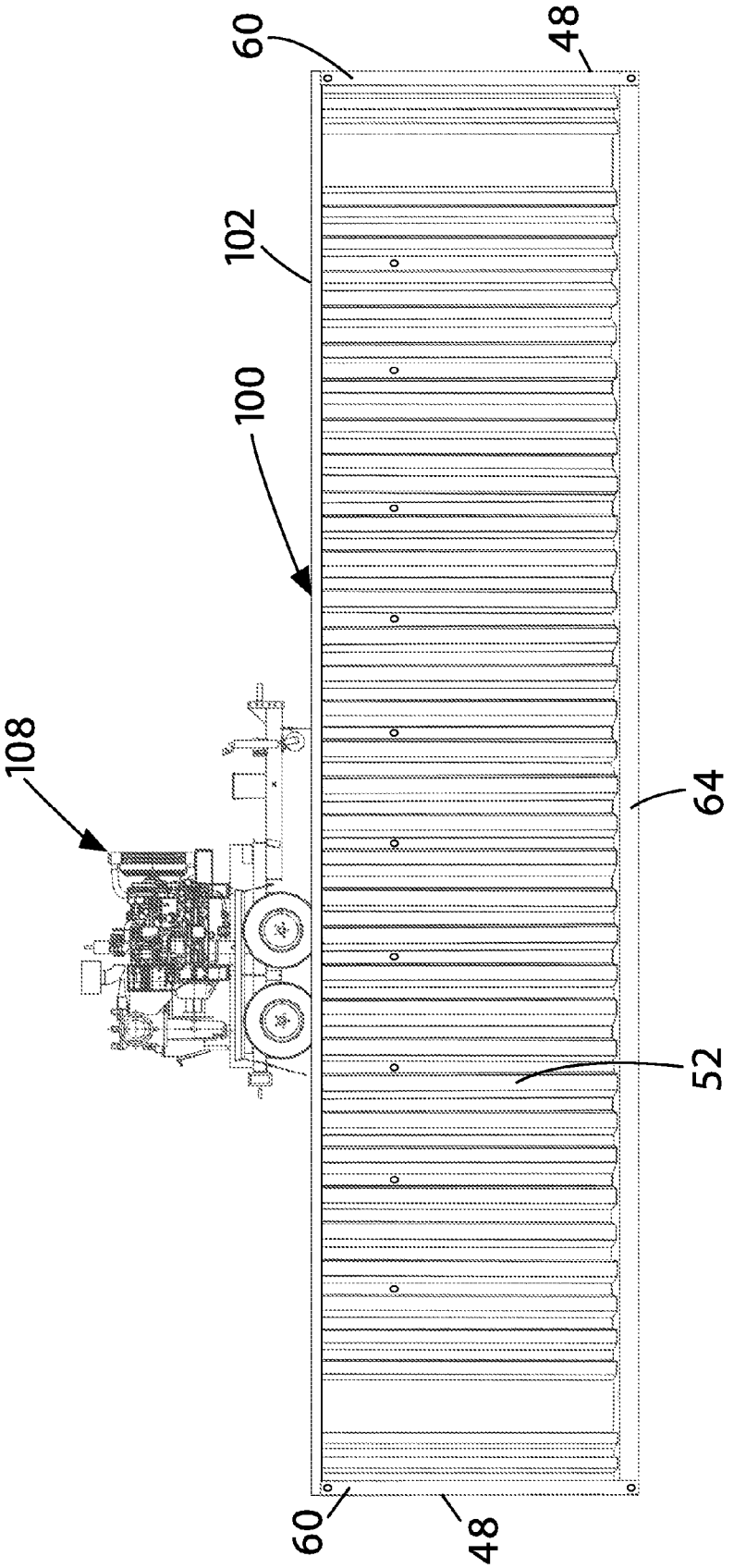


FIG. 9

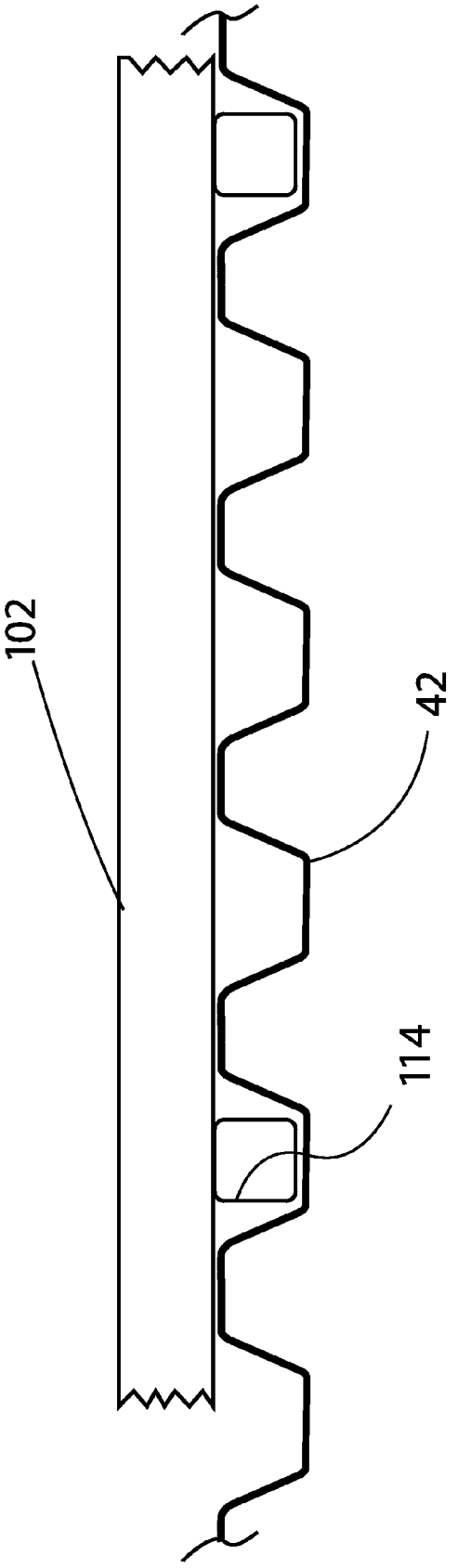


FIG. 10

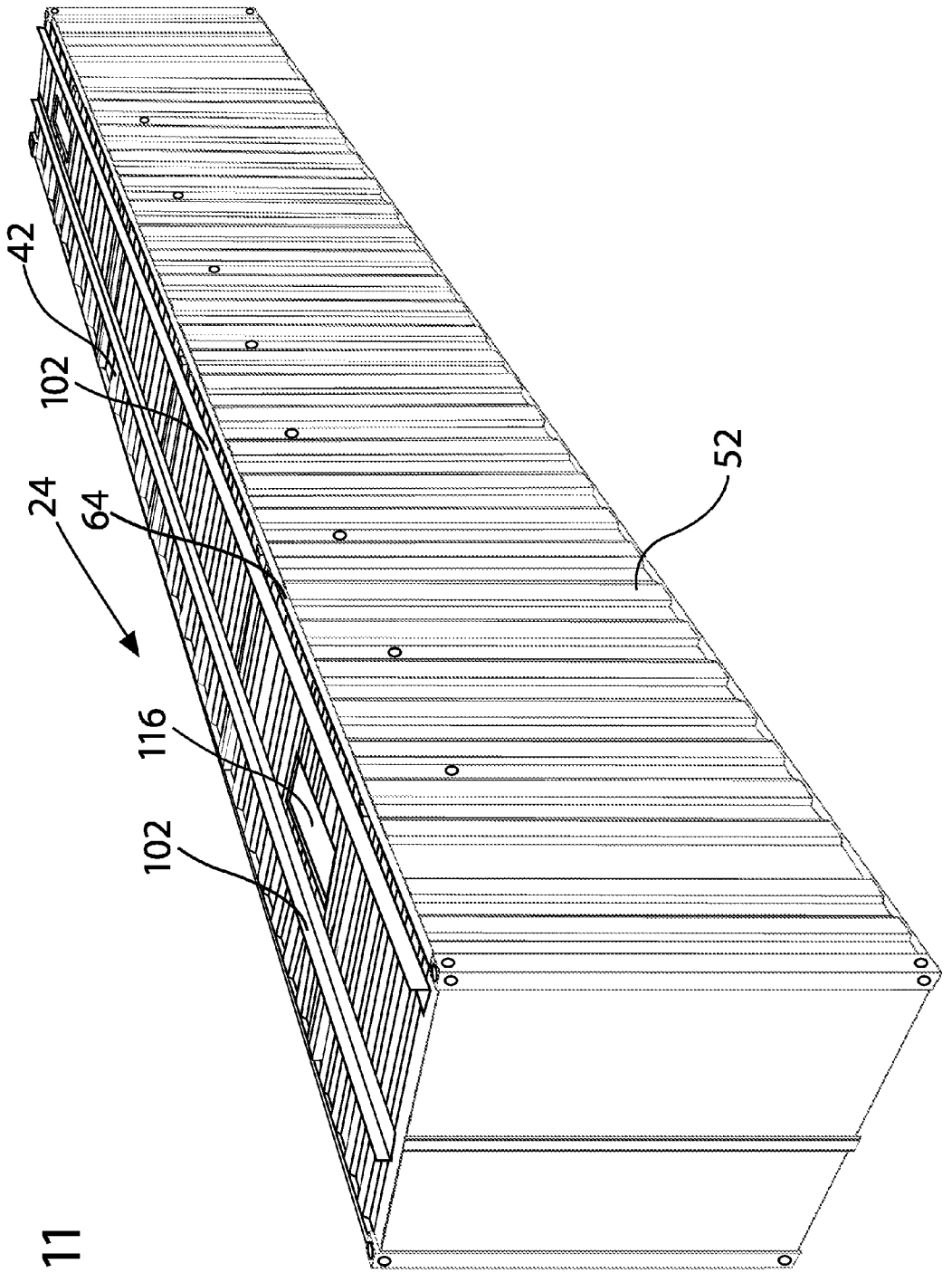


FIG. 11

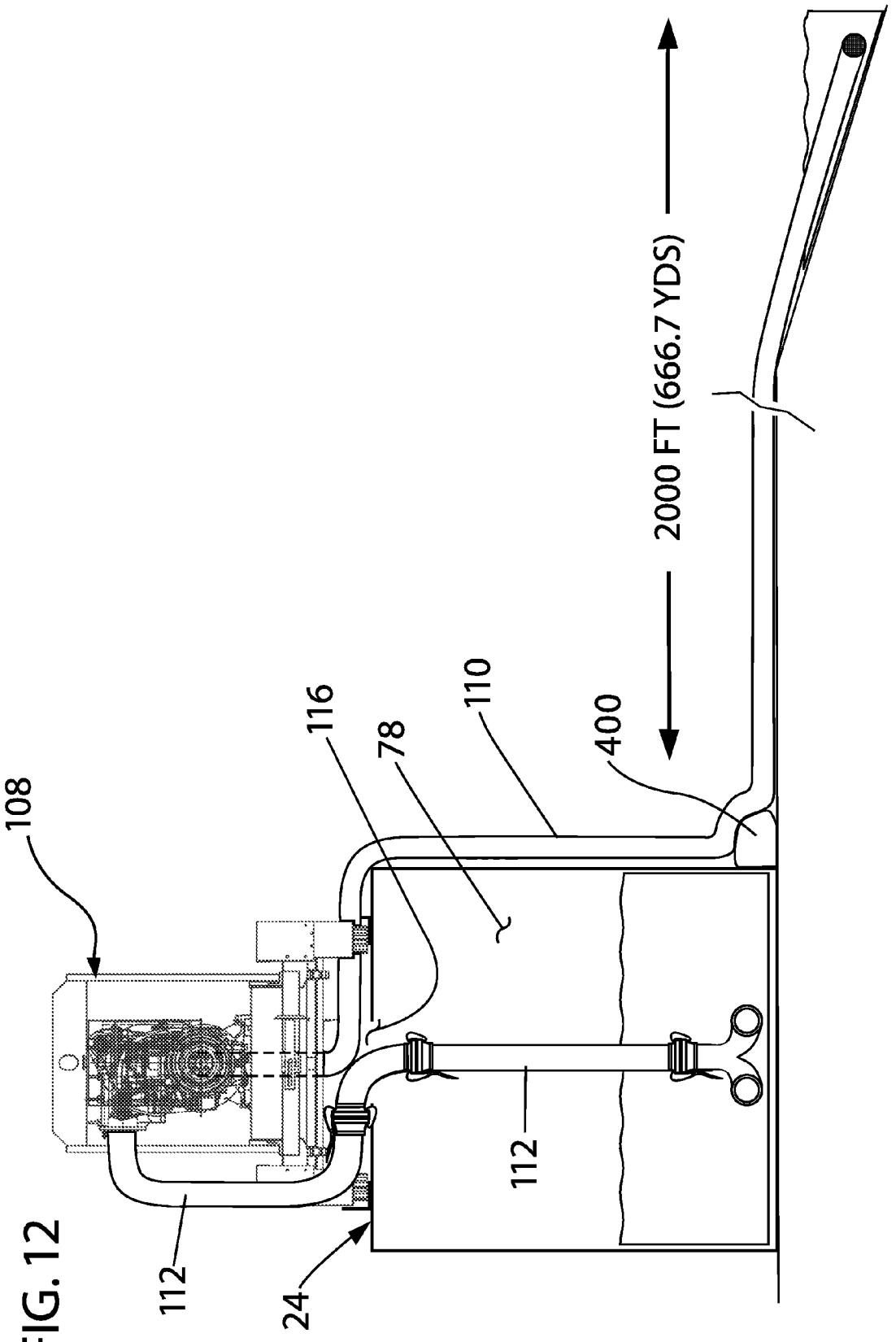


FIG. 12

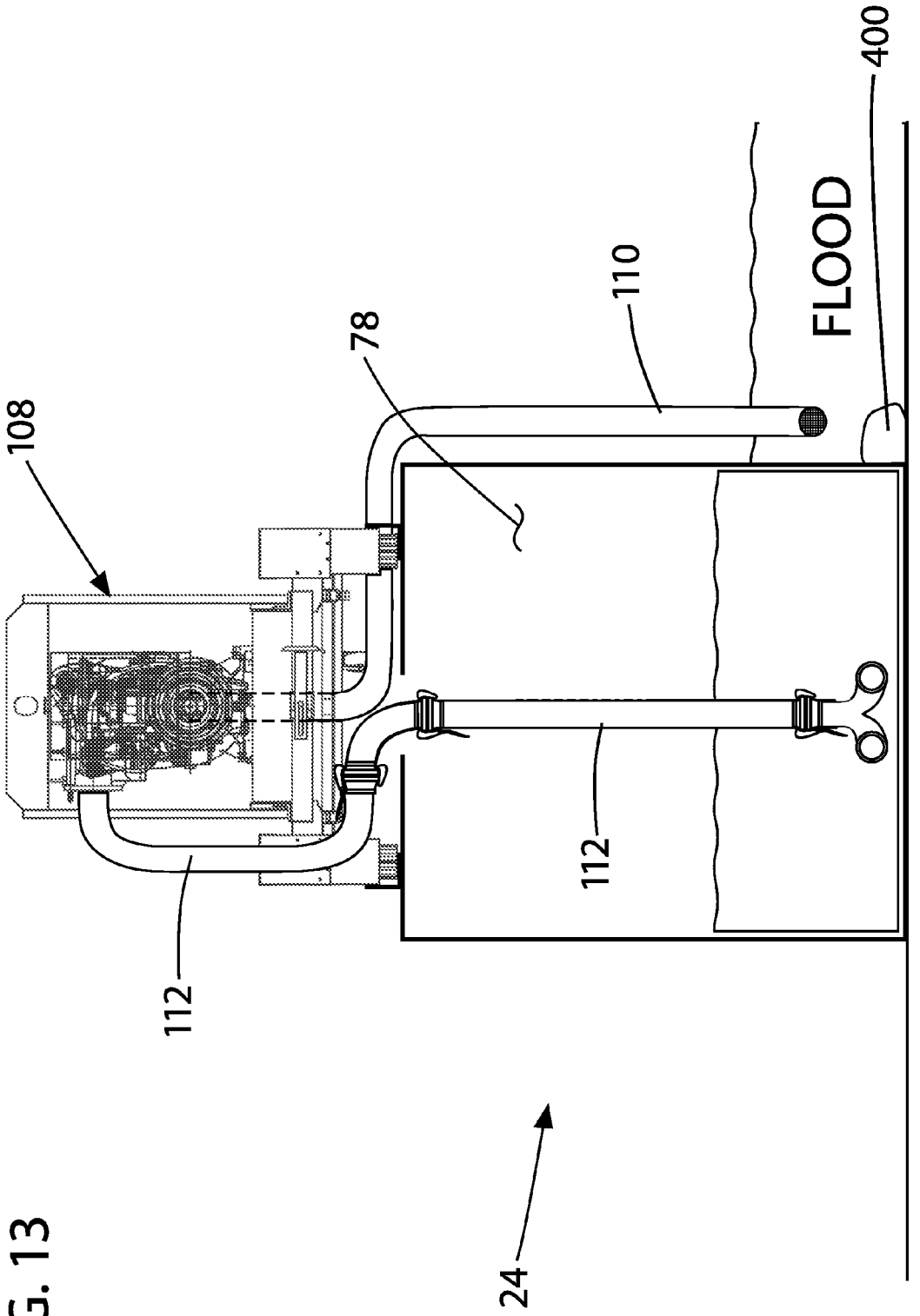


FIG. 13

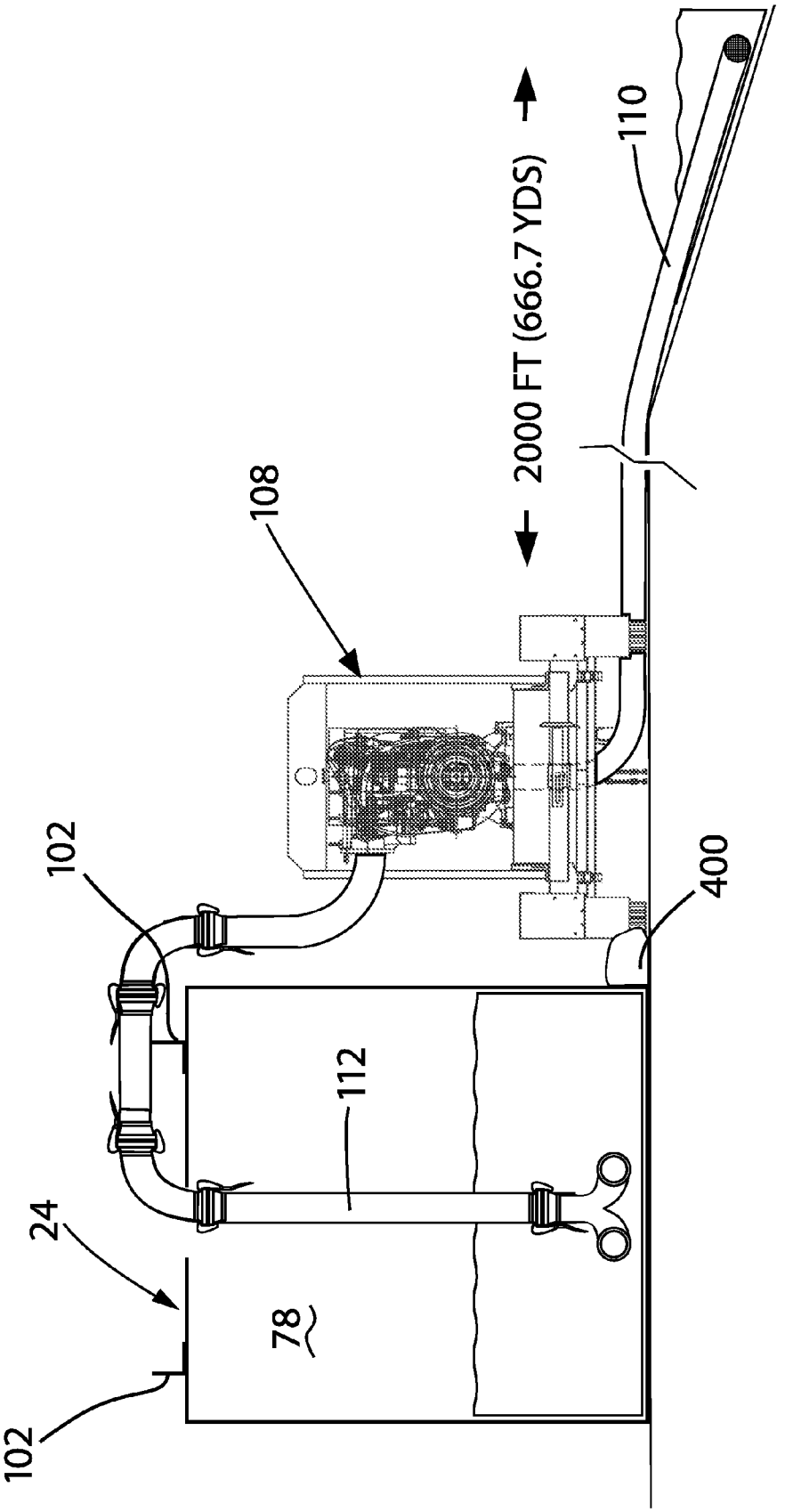


FIG. 14

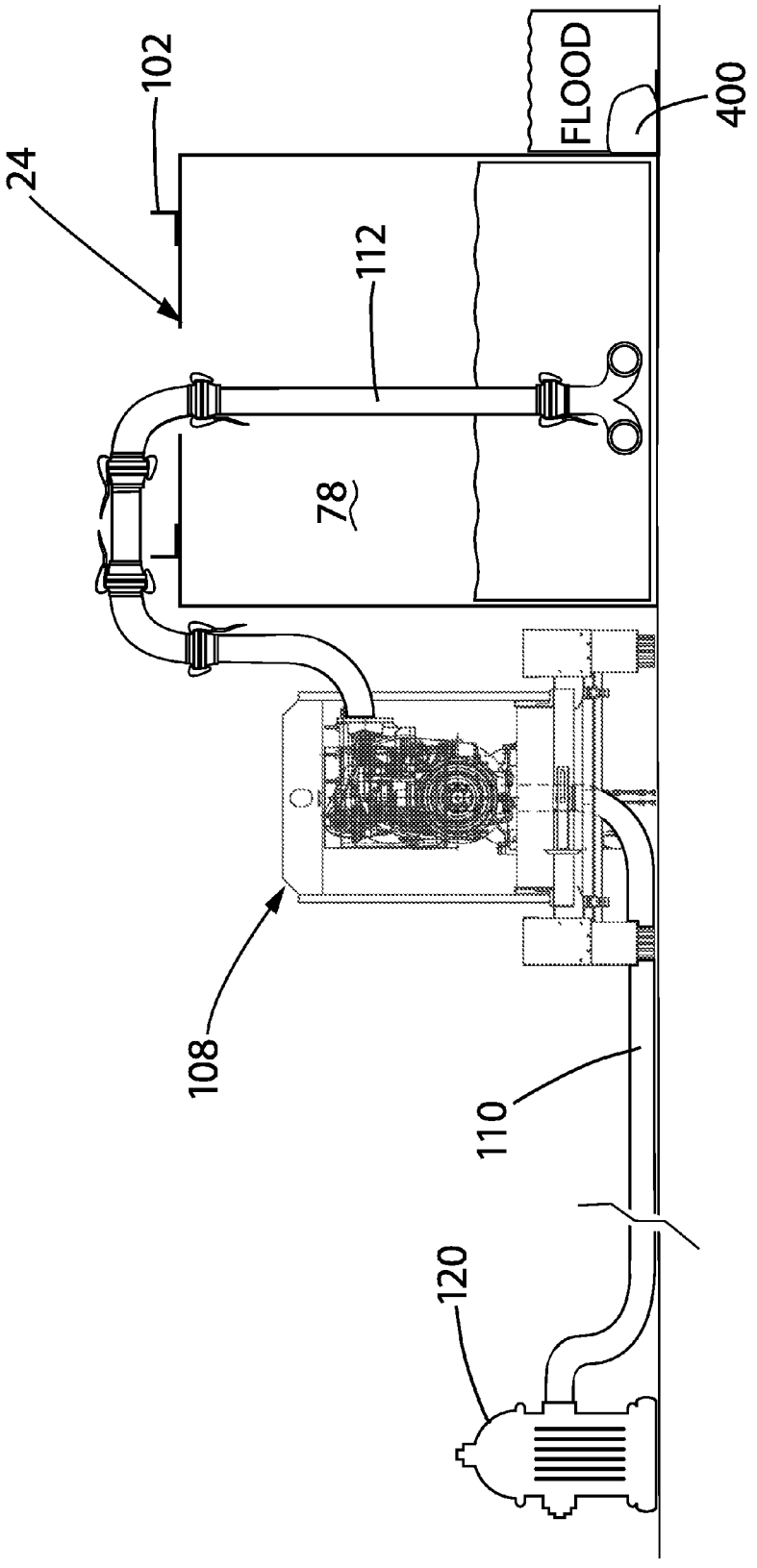


FIG. 15

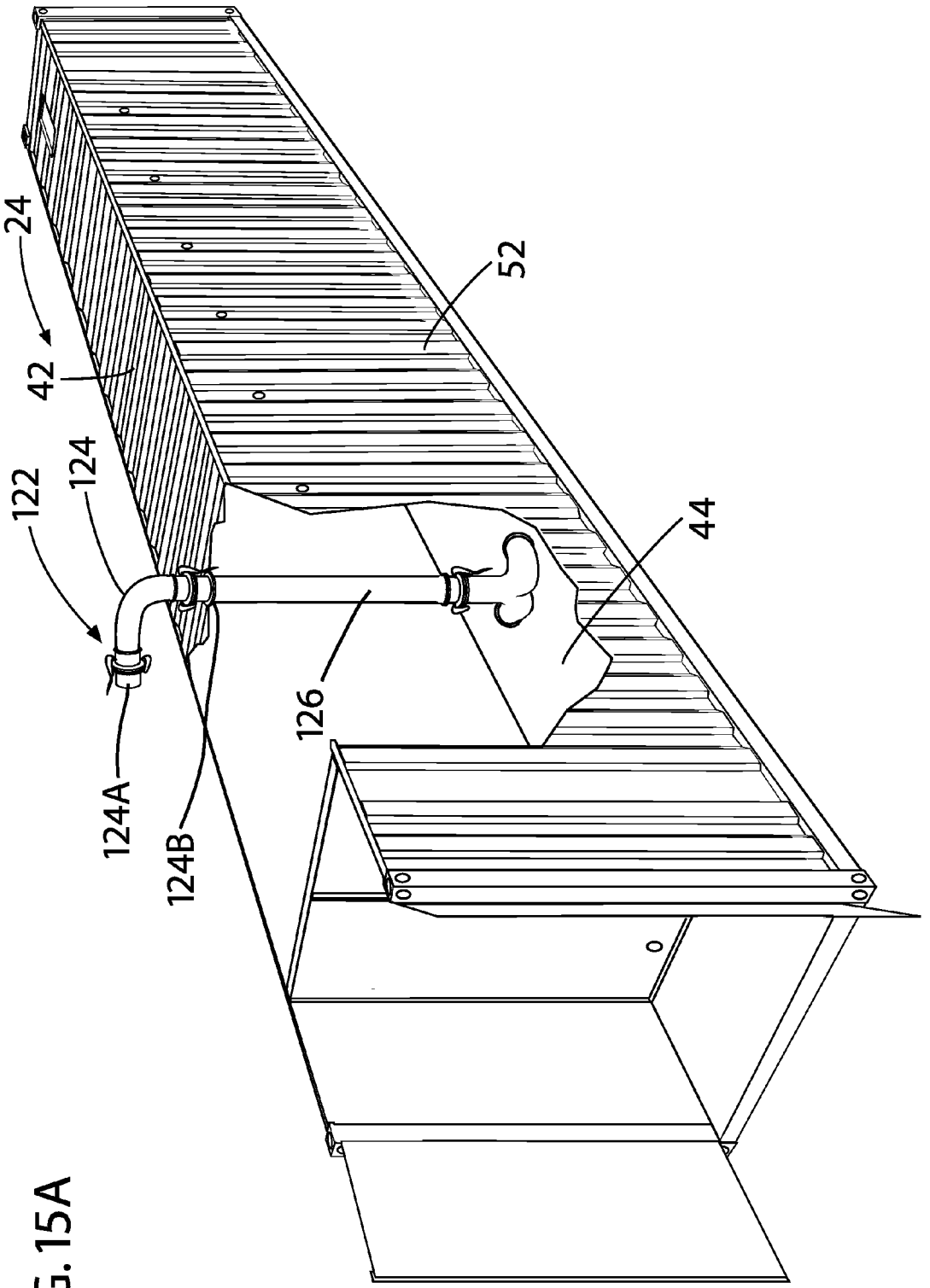
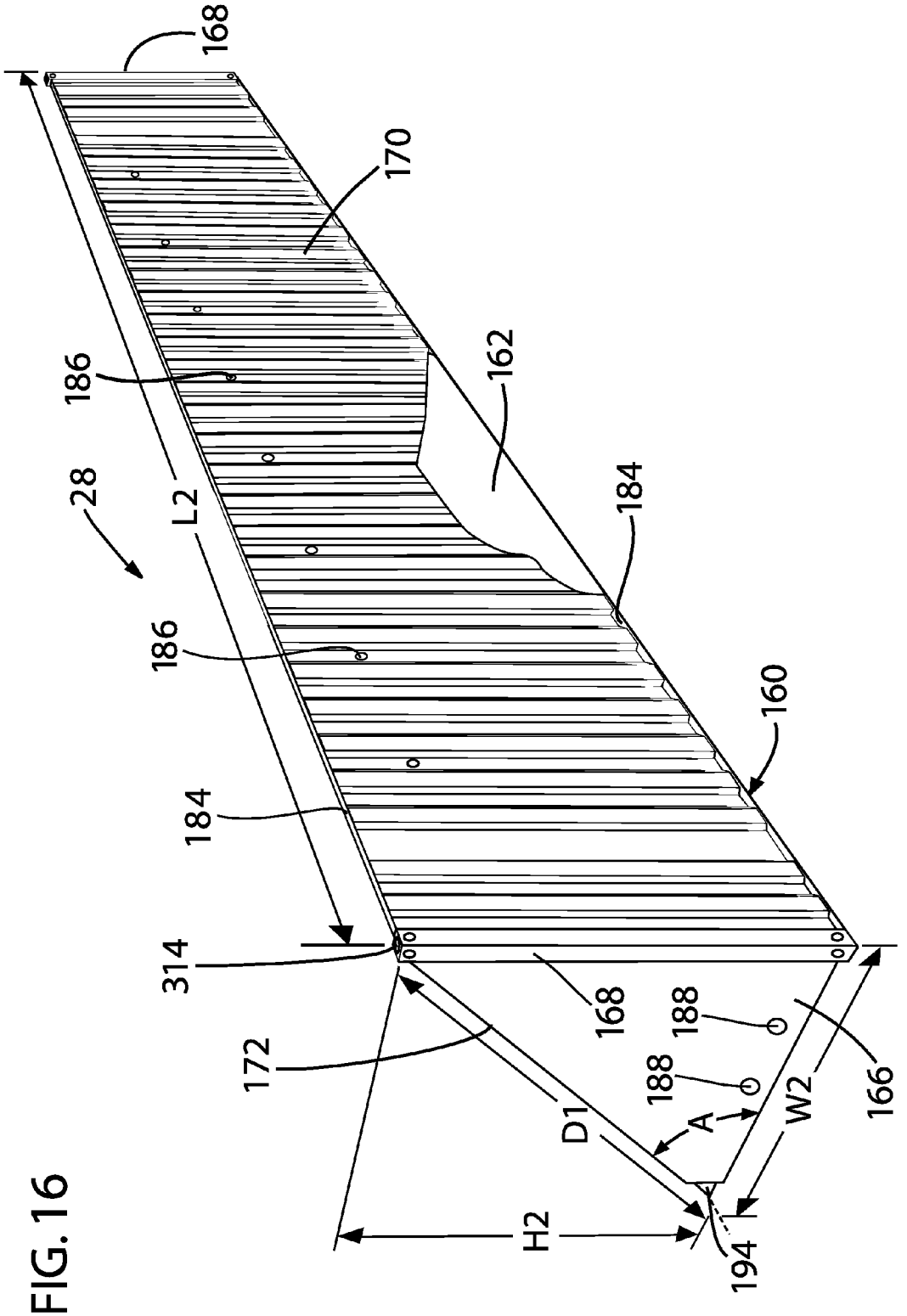


FIG. 15A


168
170
186
162
28
L2
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314
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188
172
188
166
D1
A
W2
H2
194

FIG. 16

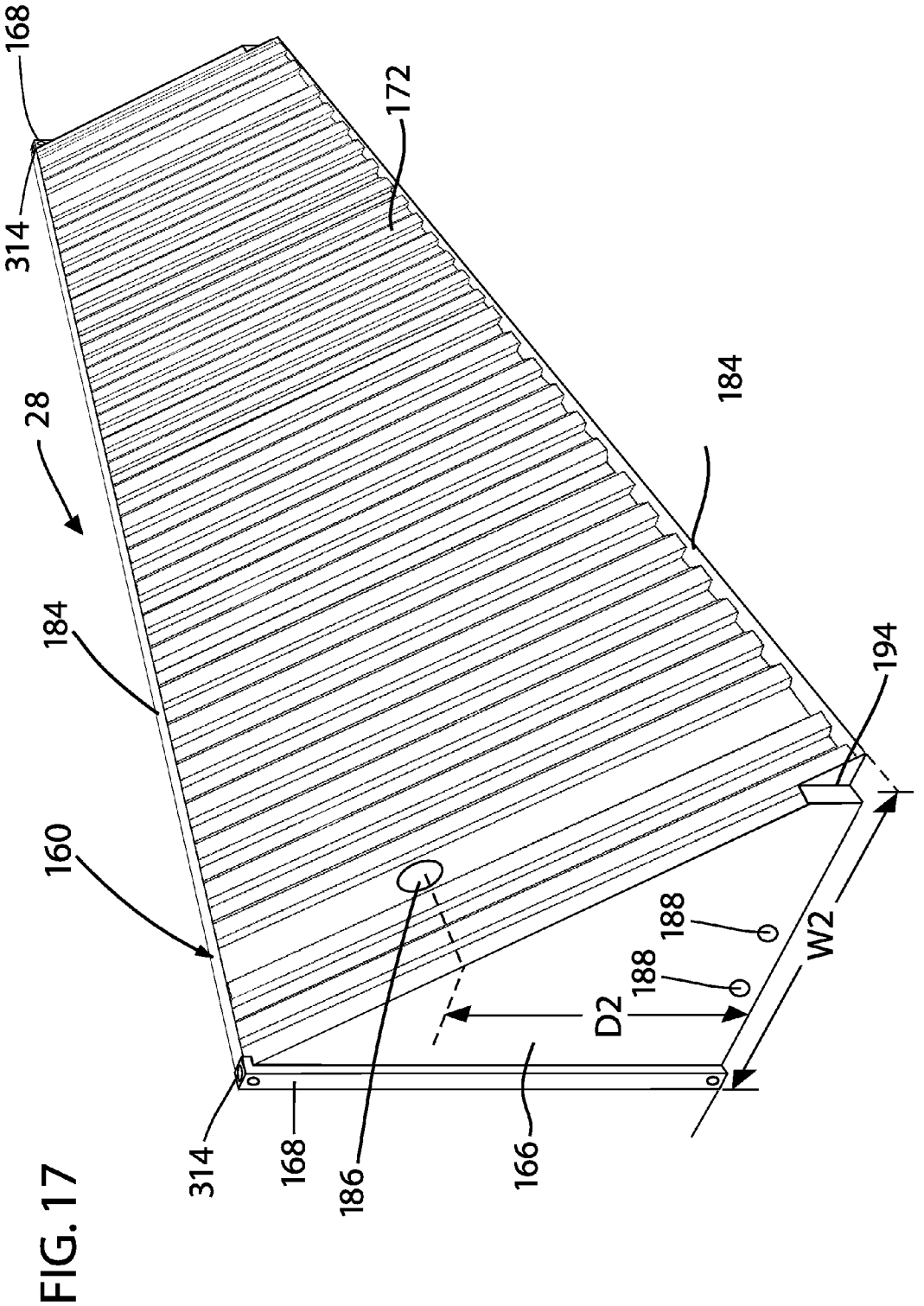

FIG. 17

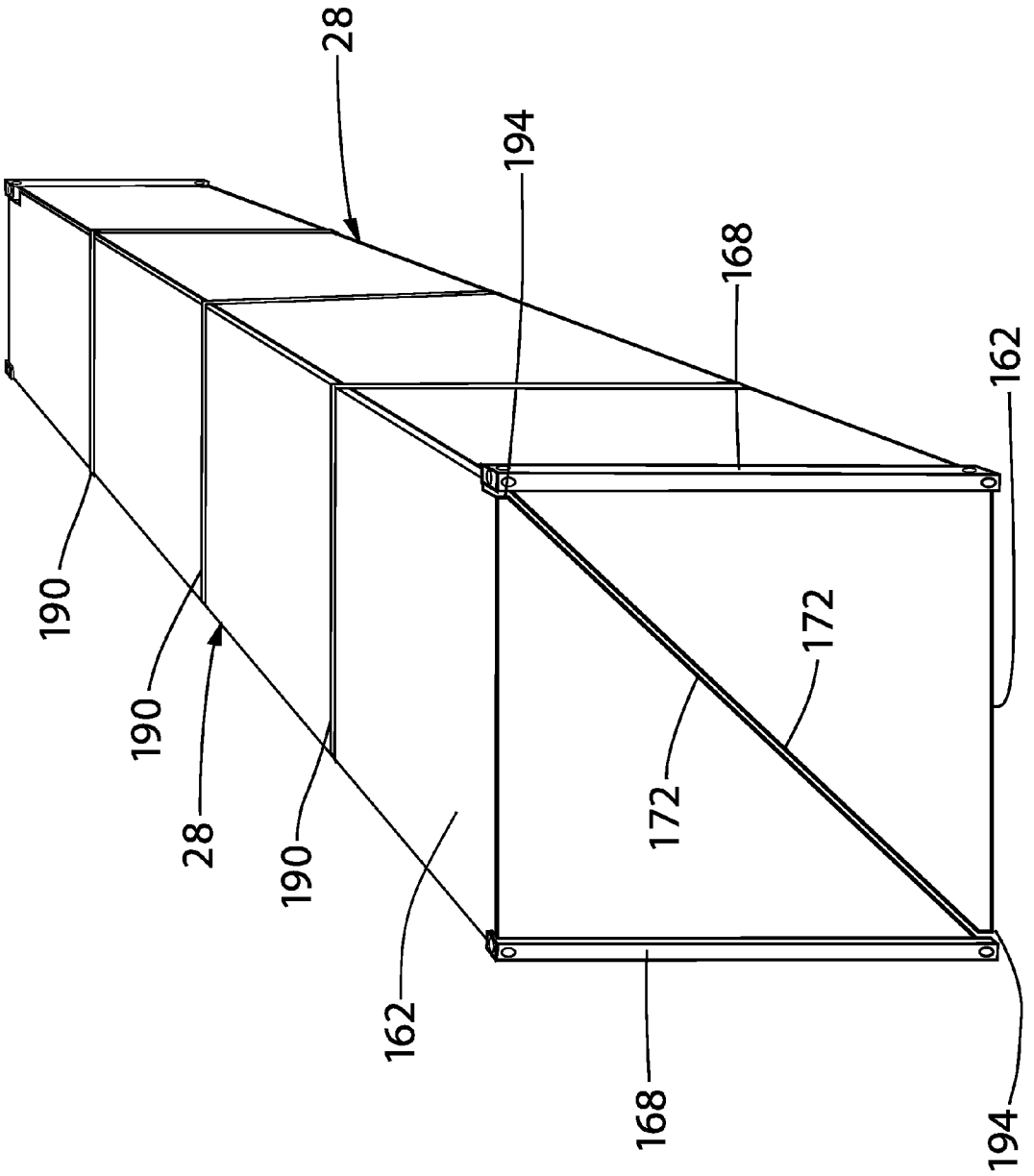

FIG. 18

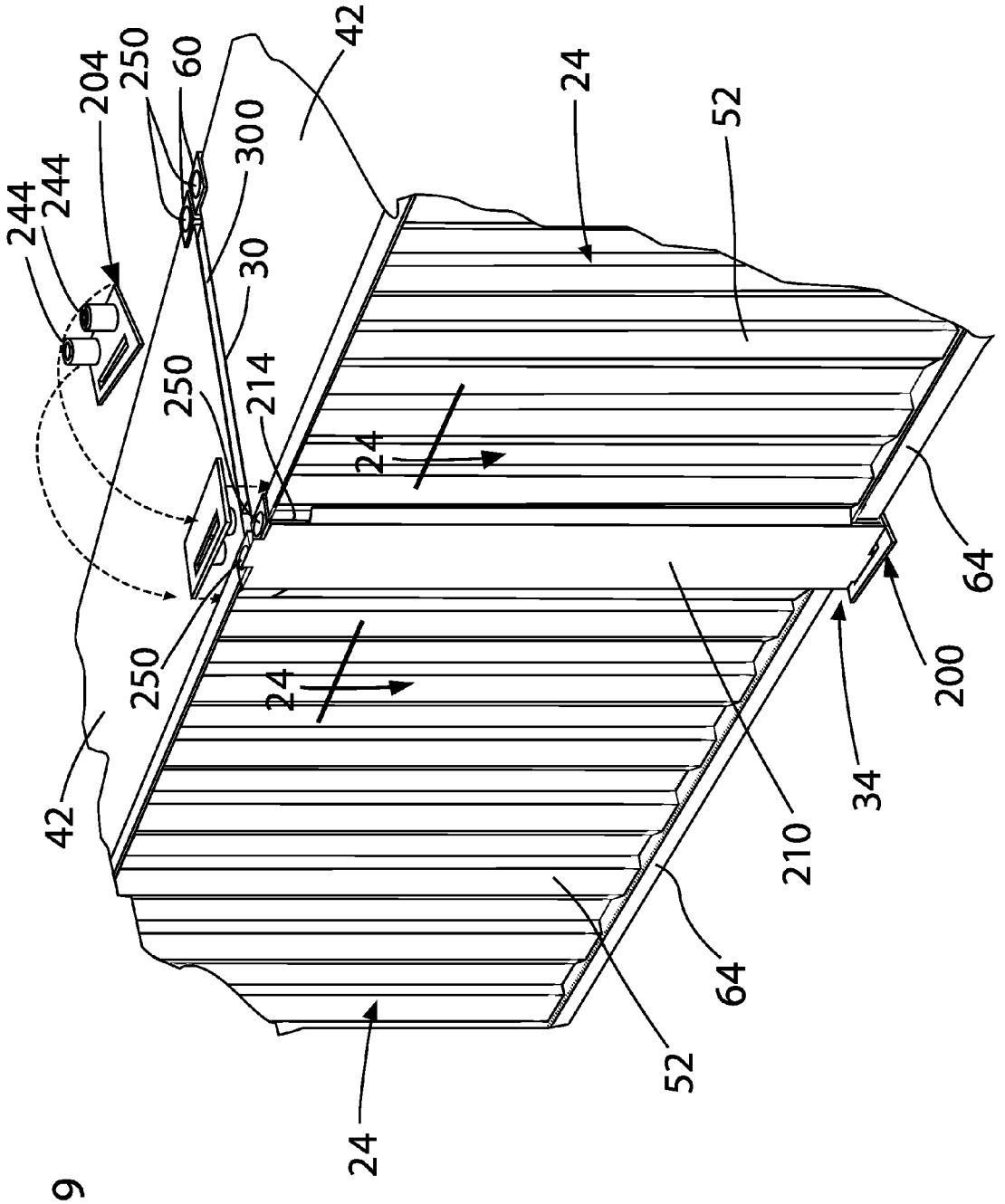
42
204
250
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FIG. 19

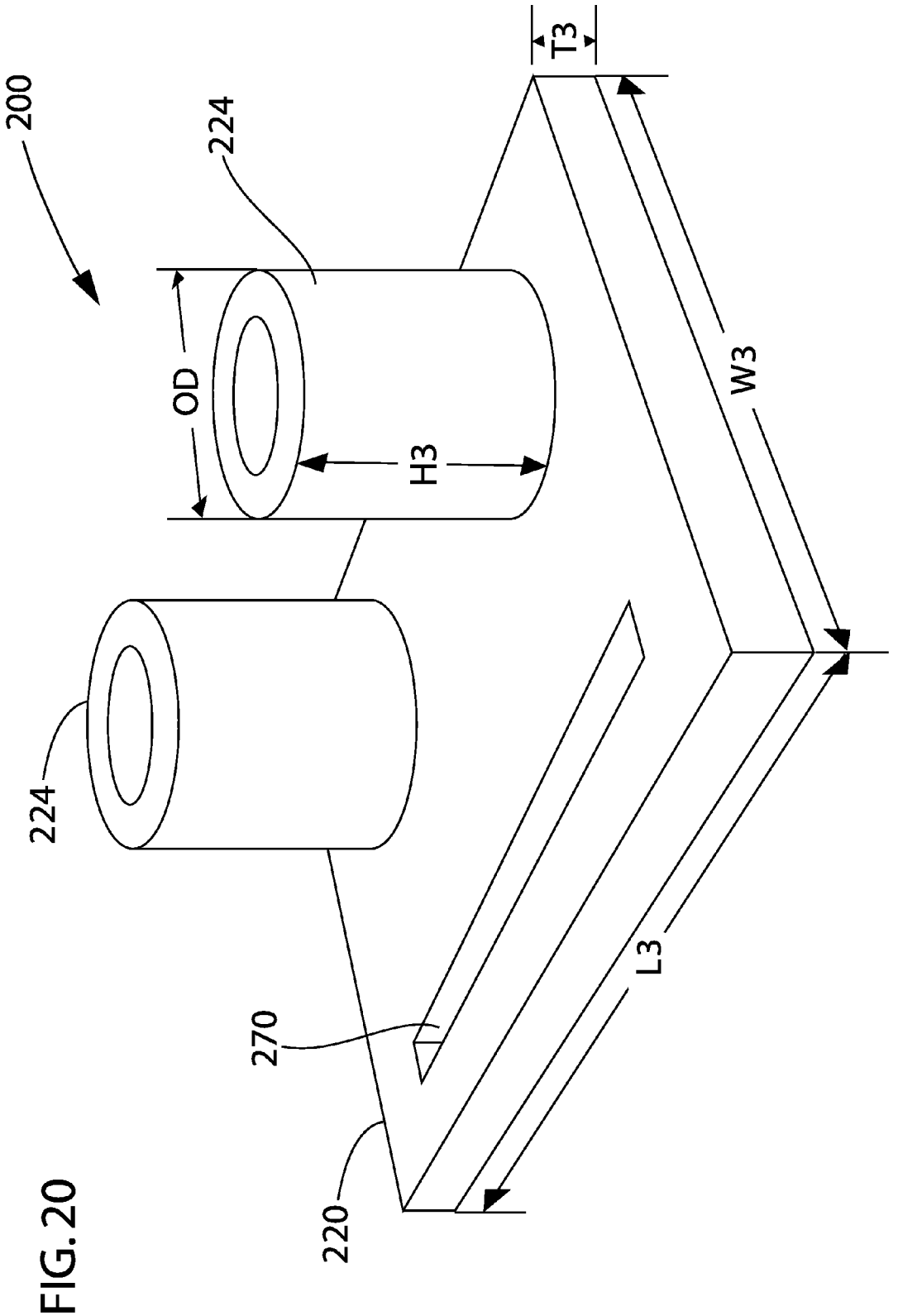
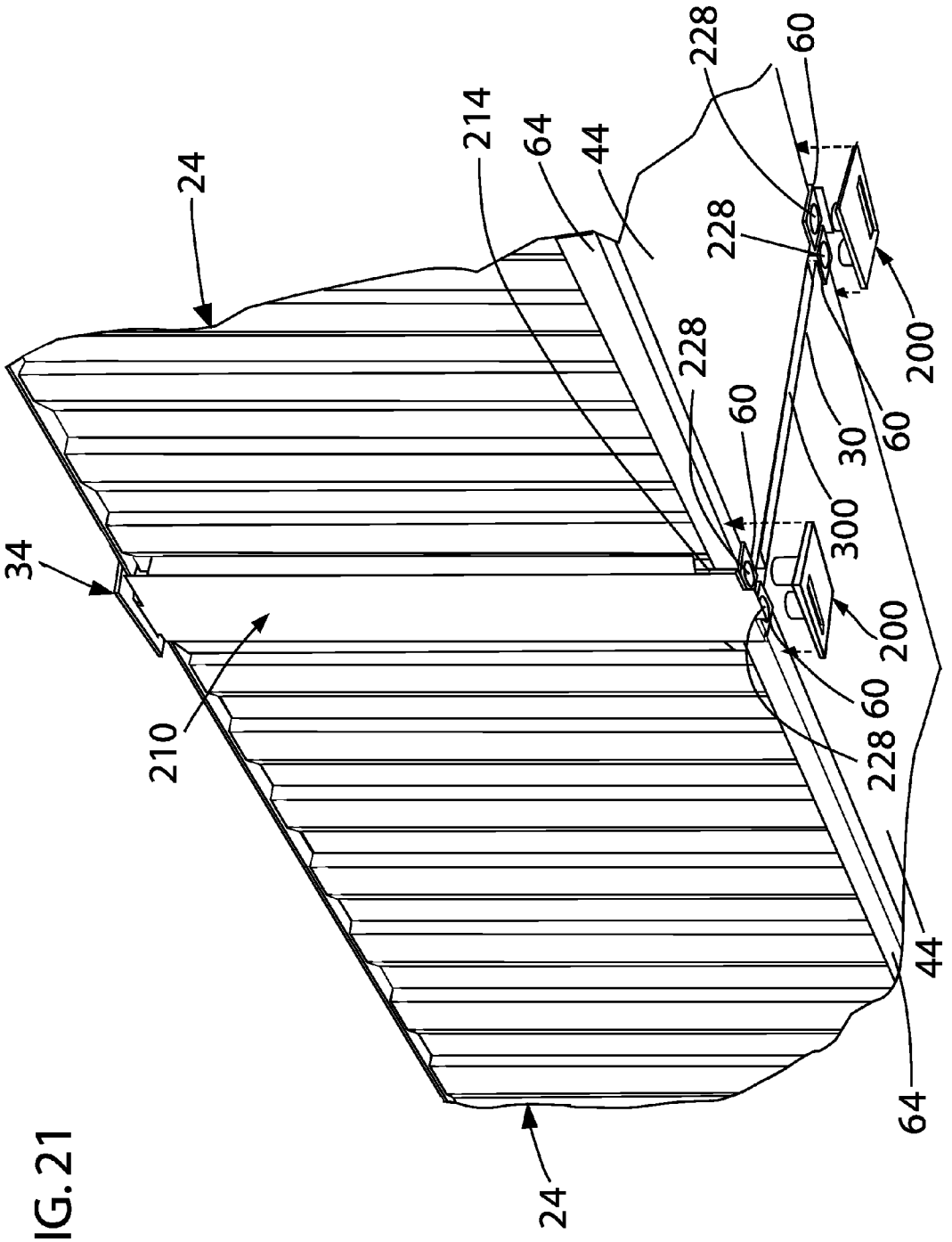


FIG. 20


24
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228
44
64
24

FIG. 21

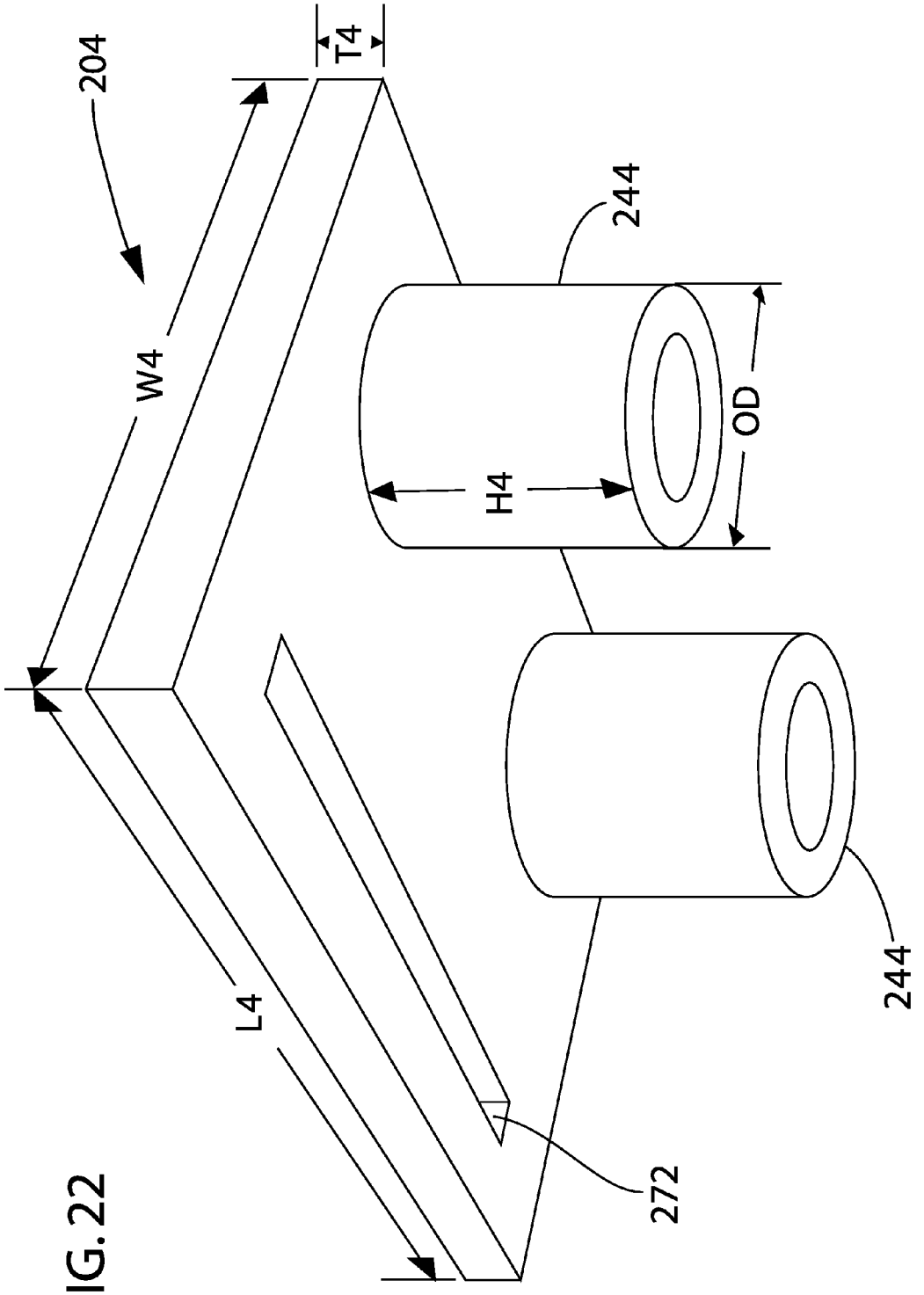
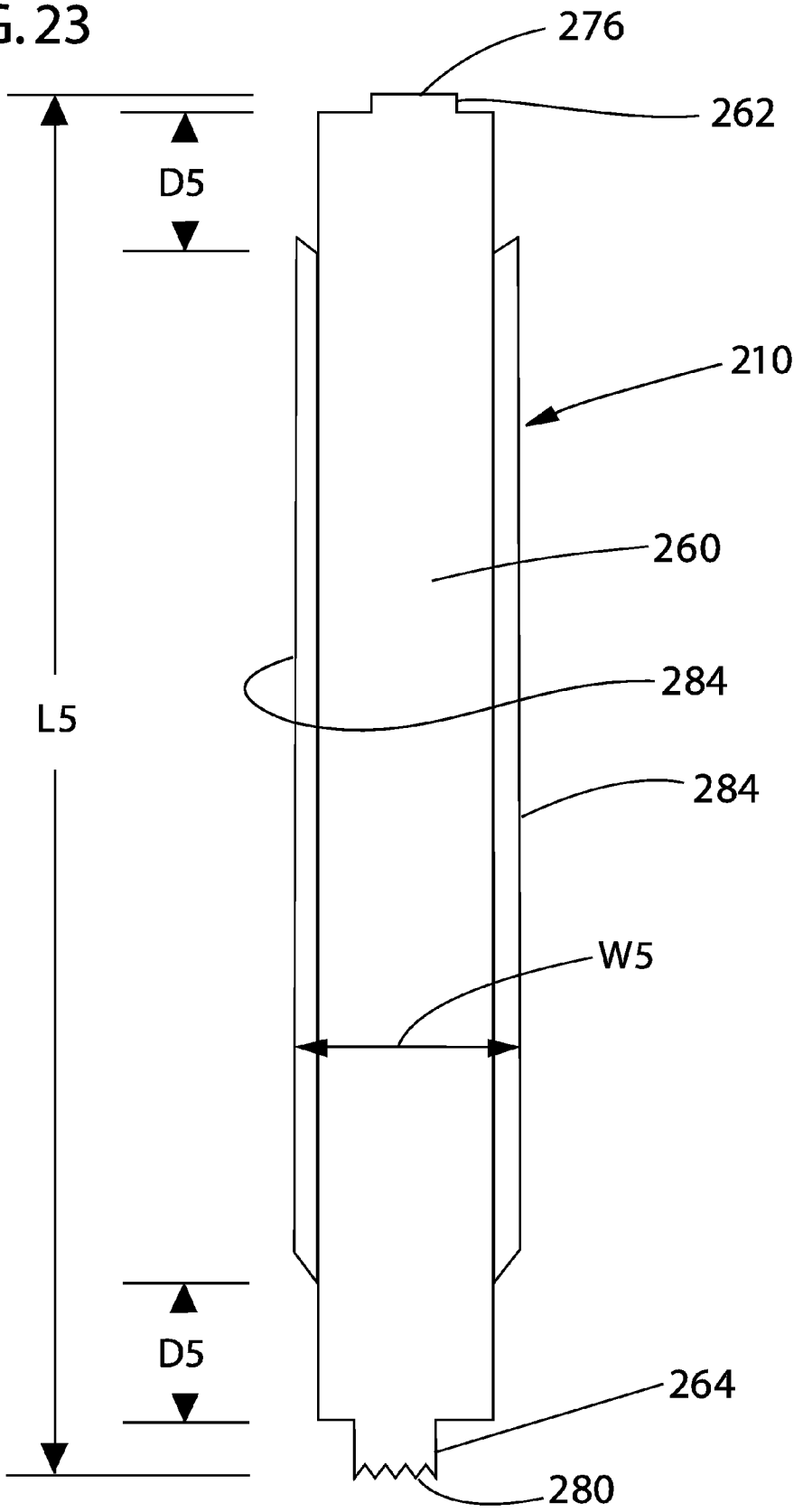


FIG. 22

FIG. 23



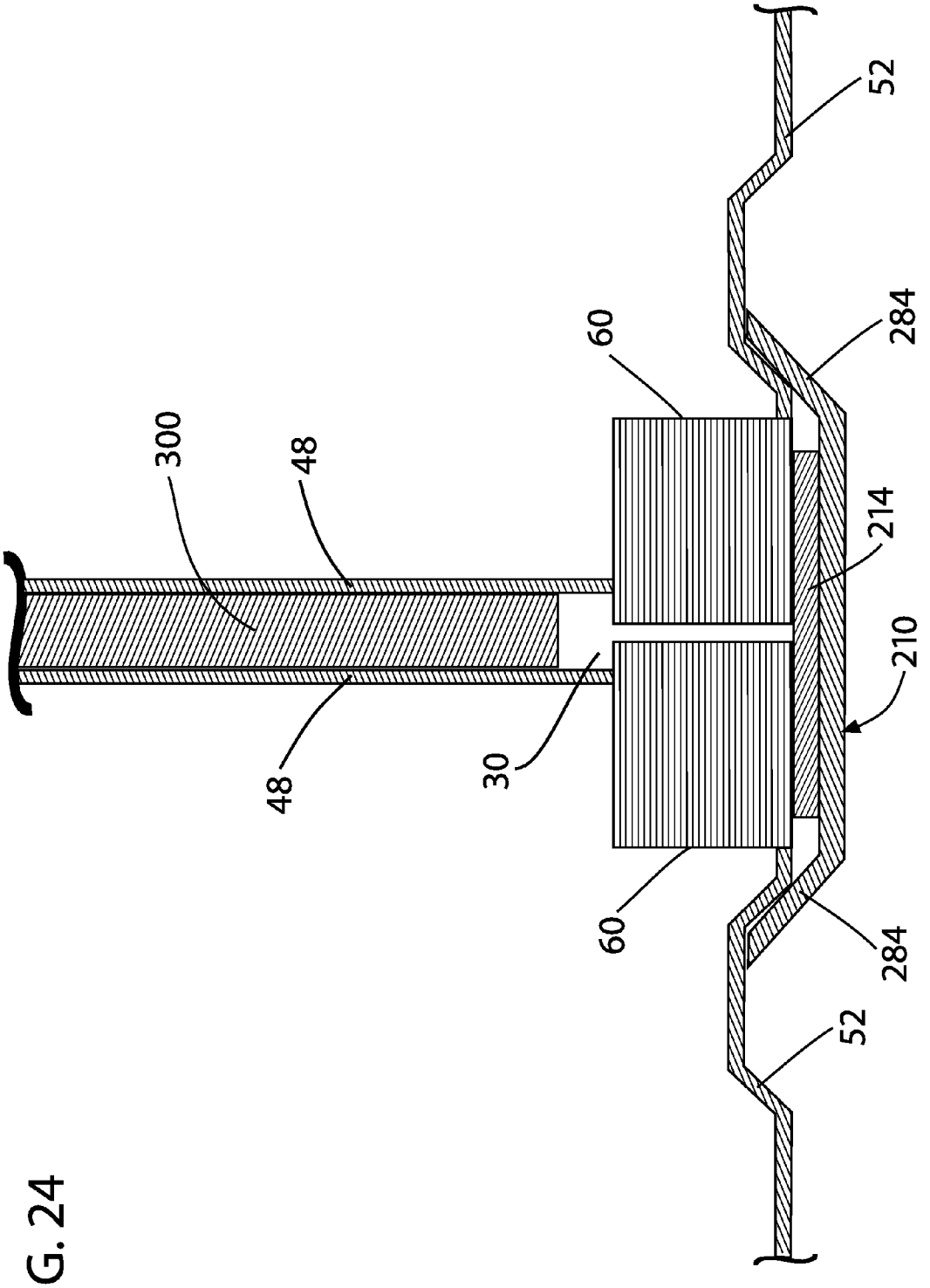


FIG. 24

FIG. 25

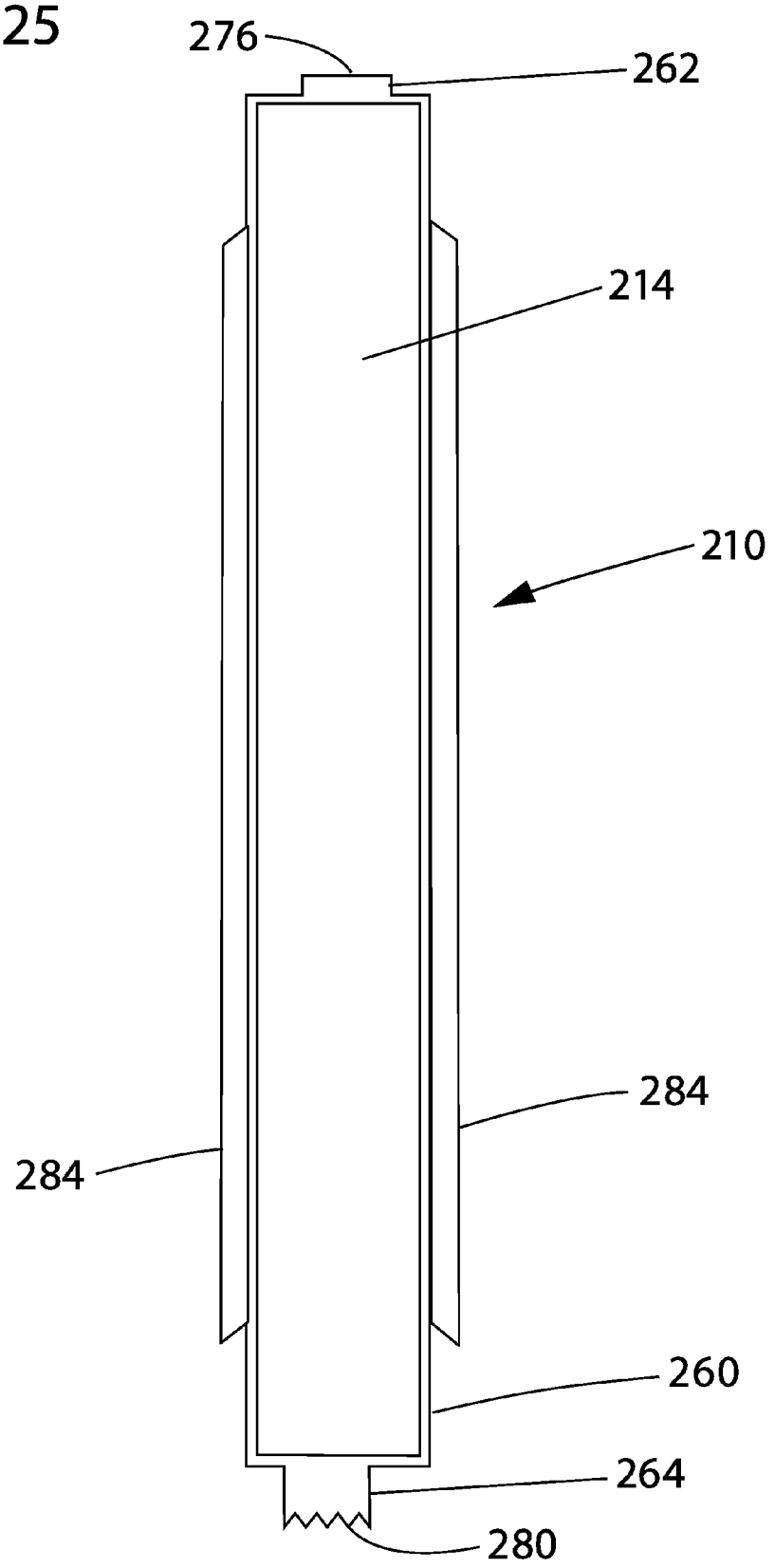
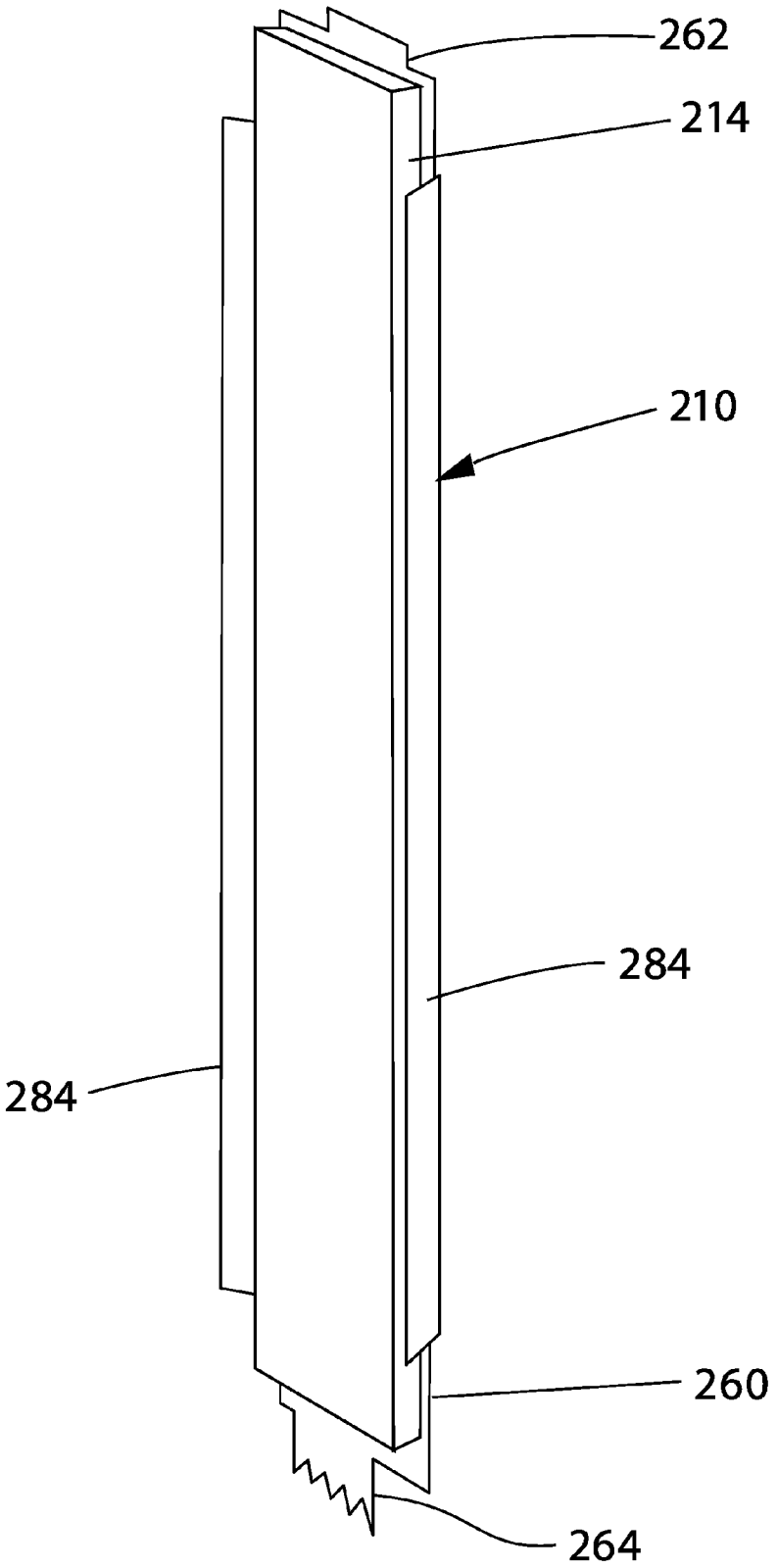


FIG. 26



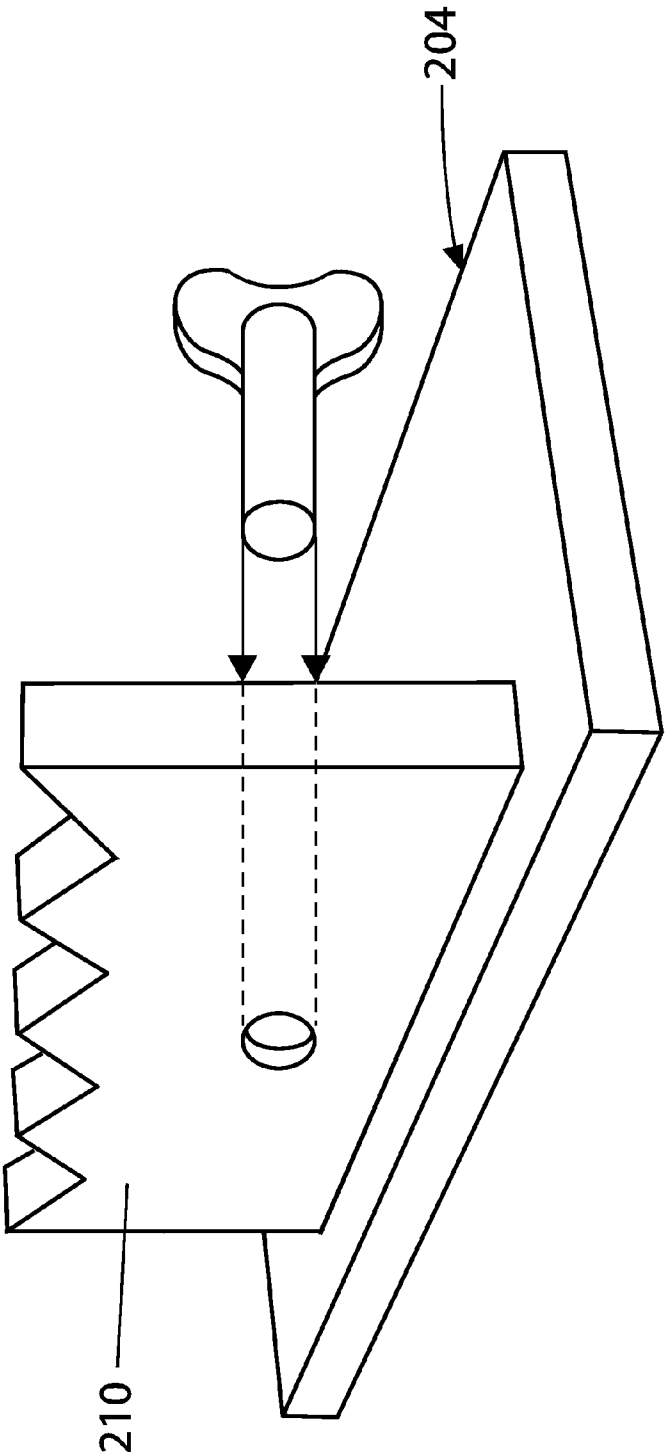


FIG.26A

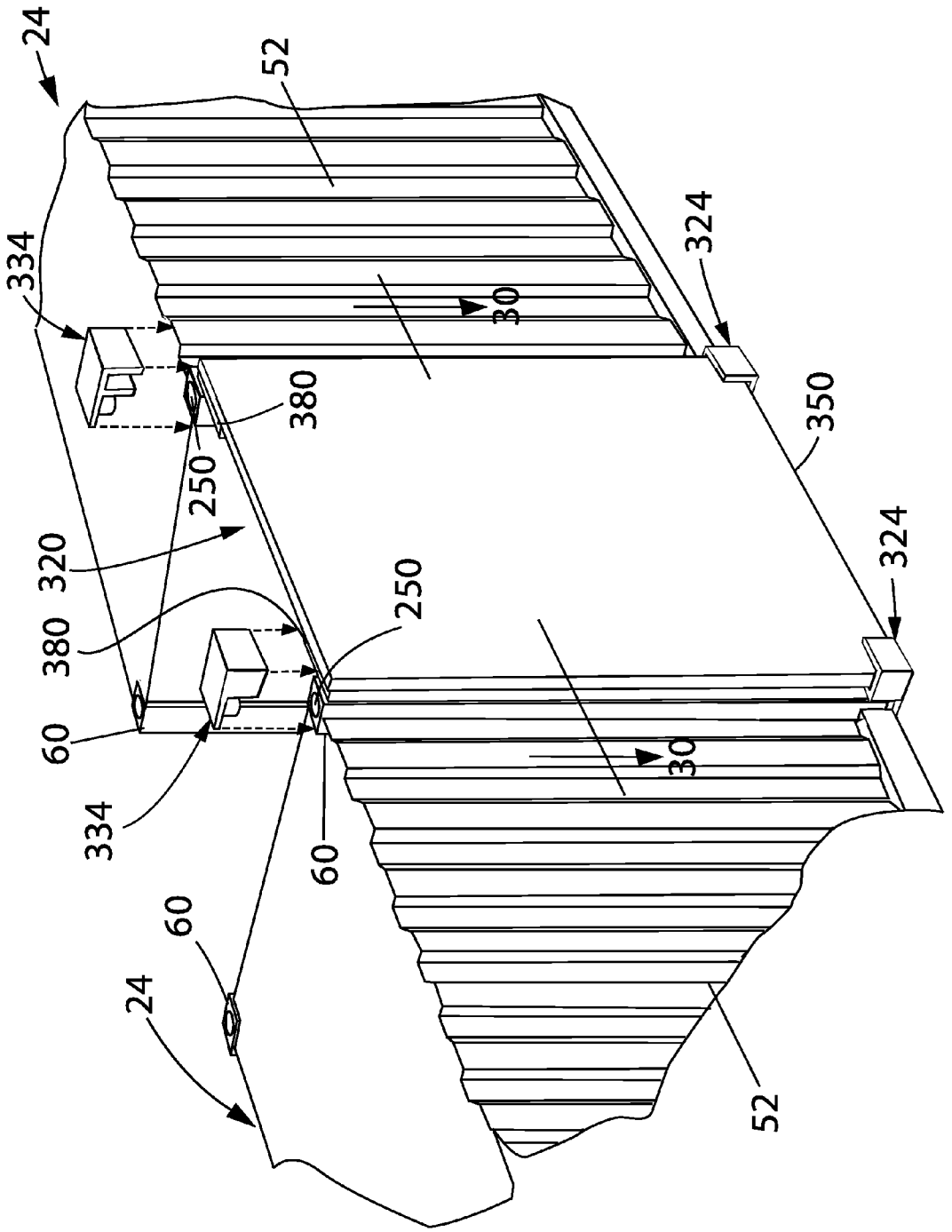


FIG. 27

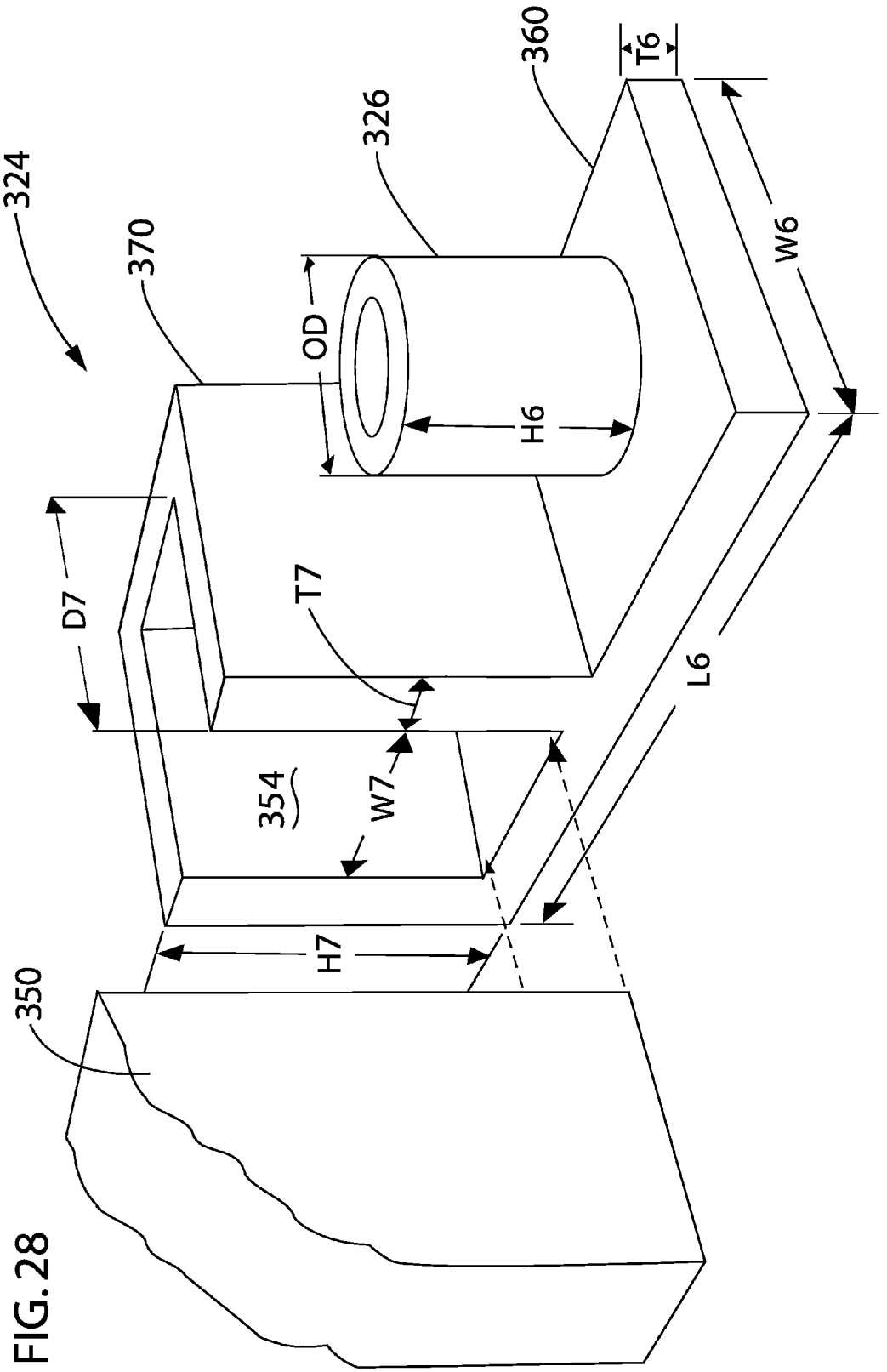


FIG. 28

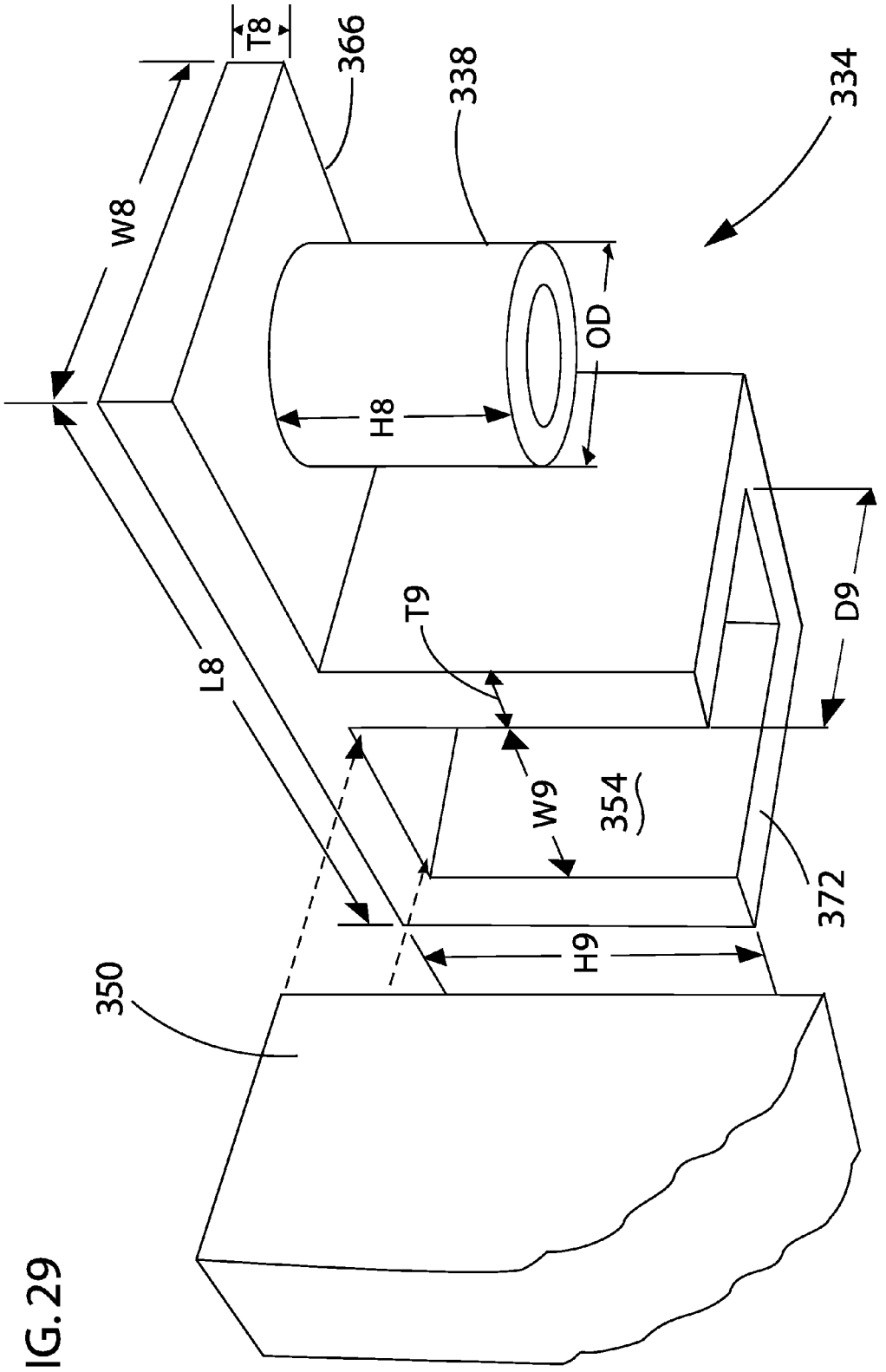


FIG. 29

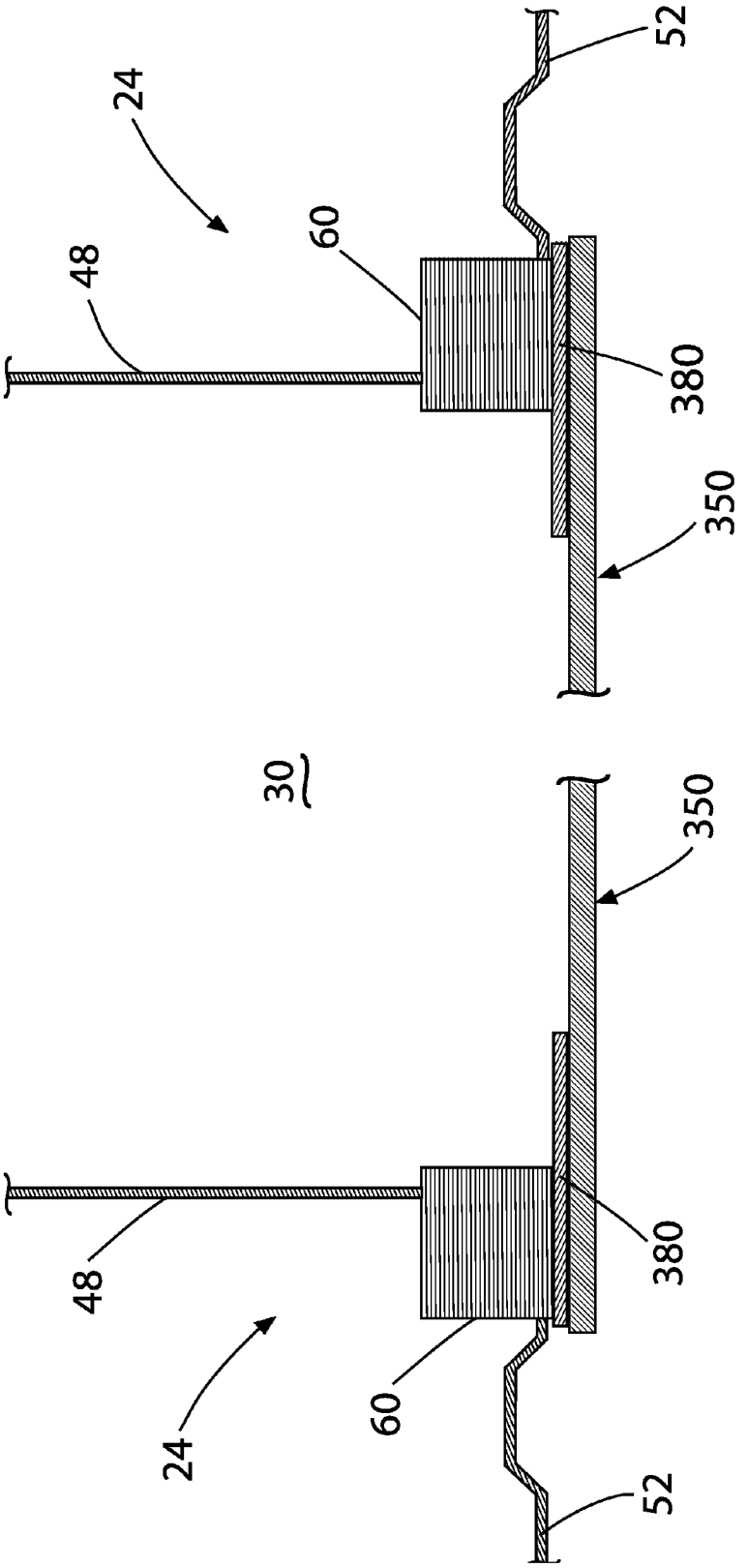


FIG. 30

MODULAR-UNIT FLOODWALL SYSTEM

FIELD OF THE INVENTION

[0001] The present invention generally relates to floodwall systems, and more particularly to a floodwall system constructed of modular units which can be readily configured to meet site-specific requirements.

BACKGROUND OF THE INVENTION

[0002] Every year flooding caused by melting snow and heavy rains results in extensive property damage, economic losses, disruption of business and personal activities, and injury and suffering to both humans and animals. Various types of barricades are used to control flooding, e.g., permanent floodwalls and dams, earthen dikes and levees, and temporary structures such as sandbag barriers. All such barricades have various drawbacks, including high installation costs, labor-intensive deployment, ineffective flood control, and/or substantial clean-up after flooding has subsided. There is a need, therefore, for an effective, cost-efficient flood mitigation system which can be readily customized to meet the needs of virtually any site to be protected against flooding, and which is also able to be readily deployed and readily removed with minimal clean-up.

SUMMARY OF THE INVENTION

[0003] This invention is directed to a modular-unit floodwall system comprising modular floodwall units adapted for holding water. Each unit has a bottom wall, opposite end walls and side walls. The system also includes connecting and sealing devices for connecting the modular units and sealing junctions between the modular units to form a barrier against floodwater. In one embodiment, each connecting and sealing device comprises a footer configured for connecting two units together generally adjacent the bottom walls of the units, a header configured for connecting the two units together adjacent the top walls of the units, and a generally vertical connecting member connecting the footer and the header and extending across a junction between the two units. A seal on the connecting member is provided for sealing the junction.

[0004] One type of modular floodwall unit comprises a rigid box-like structure having a top wall, a bottom wall, opposite end walls and opposite side walls. The structure has a water-holding capacity of at least 1800 cubic feet and at least one opening in the top wall. A pump-guide system is provided on the top wall for guiding a mobile pump along the top wall.

[0005] Another type of modular floodwall unit for controlling flood water comprises an elongate rigid structure having a bottom wall, opposite end walls, and a pair of corner posts extending up from the bottom wall adjacent the end walls. A first generally vertical side wall extends up from the bottom wall and is secured to the corner posts, and a second inclined side wall slopes up from the bottom wall to the vertical side wall. Openings are provided in upper and lower ends of the corner posts for receiving connecting devices for connecting the modular floodwall unit end-to-end to adjacent modular floodwall units. The structure has a generally triangular shape as viewed from an end of the structure.

[0006] This invention is also directed to a method of constructing a floodwall from modular floodwall units comprising a first plurality of first modular units having a first water-holding capacity and a second plurality of second modular units having a second water-holding capacity less than said first water-holding capacity. The method comprises the steps of connecting a plurality of first modular units and a plurality of second modular units together, and sealing junctions between the modular units to form a floodwall.

[0007] Other objects and features will be in part apparent and in part pointed out hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a plan view of a floodwall system constructed of modular floodwall units of this invention;

[0009] FIG. **2** is a plan schematic view of six modular floodwall units connected end-to-end and side-to-side;

[0010] FIG. **3** is a perspective view of a first modular floodwall unit having a pump-guide system on a top wall of the unit;

[0011] FIG. **4** is a perspective view similar to FIG. **3** but showing a door of the unit open to access a dry-storage compartment;

[0012] FIG. **5** is an exploded view showing parts of a bulkhead inside the unit;

[0013] FIG. **6** is an enlarged view showing details regarding a frame of the bulkhead;

[0014] FIG. **7** is a front elevation of the assembled bulkhead but with one bulkhead panel removed to show a portion of the frame;

[0015] FIG. **8** is a sectional view showing a drain port in the bulkhead;

[0016] FIG. **9** is a side elevation of the first modular floodwall unit of FIG. **3** and a pumping unit movable along the pump-guide system;

[0017] FIG. **10** is an enlarged vertical section taken in the plane of lines **10-10** of FIG. **3**;

[0018] FIG. **11** is a perspective view similar to FIG. **3** but showing the pump-guide system at a different location on the top wall;

[0019] FIGS. **12** and **13** are schematic views illustrating how a pumping unit on the pump-guide system can be used to fill a modular floodwall unit; and

[0020] FIGS. **14** and **15** are schematic views illustrating alterative ways to fill a modular floodwall unit;

[0021] FIG. **15**A is a perspective or a first modular floodwall unit with a swivel fitting for connection to a down-mover hose for filling and/or emptying the unit;

[0022] FIG. **16** is a front perspective view of a second modular floodwall unit of the system;

[0023] FIG. **17** is a rear perspective view of the second modular floodwall unit of FIG. **16**;

[0024] FIG. **18** is a perspective of two second modular floodwall units nested together for transport and/or storage;

[0025] FIG. **19** is a perspective illustrating how a connecting and sealing device of this invention is used to connect two modular floodwall units to one another and to seal a junction between the two units;

[0026] FIG. **20** is a perspective of a footer of the connecting and sealing device of FIG. **19**;

[0027] FIG. **21** is a partial bottom plan view showing openings in two adjacent modular units for receiving mating connectors on the footer of the connecting and sealing device, and further showing a vertical connecting member and gasket of the connecting and sealing device for sealing the junction between the two units;

[0028] FIG. **22** is a perspective of a header of the connecting and sealing device of FIG. **19**;

[0029] FIG. **23** is a front elevation of a connecting member for connecting header and footer components of the connecting and sealing device;

[0030] FIG. **24** is an enlarged horizontal section taken in the plane of lines **24-24** of FIG. **19**;

[0031] FIG. **25** is a rear elevation of the connecting member, showing a gasket on the back face of the member;

[0032] FIG. **26** is rear perspective of the connecting member and gasket;

[0033] FIG. **26**A is a view showing an optional locking feature for the connecting member;

[0034] FIG. **27** is a front perspective of an expansion connecting and sealing device as used to connect two modular floodwall units to one another and to seal the junction between the units;

[0035] FIG. **28** is a perspective of a footer member of the expansion connecting and sealing device;

[0036] FIG. **29** is a perspective of a header member of the expansion connecting and sealing device; and

[0037] FIG. **30** is an enlarged horizontal section taken in the plane of lines **30-30** of FIG. **27**.

[0038] Corresponding reference characters indicate corresponding parts throughout the drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0039] Referring now to the drawings, and more particularly to FIG. **1**, an exemplary modular-unit floodwall system of the present invention is designated in its entirety by the reference numeral **20**. As illustrated, the floodwall is positioned to control the flooding of a waterway such as a river to minimize damage to real estate, facilities and/or communities along the waterway ("protected property") in FIG. **1**).

[0040] In general, the system **20** comprises a series of modular floodwall units adapted for holding water. In one embodiment, the units comprise a first plurality of first modular units, each generally designated **24**, having a first configuration (e.g., a first water-holding capacity) and a second plurality of second modular units, each generally designated **28**, having a second configuration (e.g., a second water-holding capacity different from the first water-holding capacity of the first units). The system also includes connecting and sealing devices, each generally designated **34**, for connecting the units **24**, **28** together either end-to-end or end-to-side and for sealing junctions **30** (i.e., gaps or seams) between the units to form a barrier against floodwater. FIG. **2** shows one configuration in which six modular floodwall units **24** are connected end-to-end and end-to-side. (FIG. **2** is a schematic view which omits certain details of the units.) As discussed below, other configurations are possible.

[0041] FIGS. **3** and **4** illustrate one of the first modular units **24**. The unit comprises a rigid elongate box-like structure **40** having a top wall **42**, a bottom wall **44**, opposite end walls **48** and opposite side walls **52**. As viewed from one (either) end, the structure is generally rectangular in shape. The dimensions of the structure **40** may vary, but it typically will have a water-holding capacity of at least 1800 cubic feet. By way of example but not limitation, the structure **40** may have a width W**1** of about eight feet, a height Hi of about 8.5 feet, and a length L**1** which can vary from about 20 feet to about 80 feet (e.g., 20 feet, 40 feet, 48 feet, and 53 feet). When filled with water, the structure **40** is very heavy (e.g., about 70 tons for a modular unit 40 feet long).

[0042] Desirably, the structure **40** has a rugged construction similar that of an intermodal shipping container, making it durable and re-usable, even when subjected to harsh weather conditions, flood waters, floating debris, etc. The top wall **42**, bottom wall **44**, side walls **52** and one end wall **48** of the structure **40** are constructed of heavy-duty corrugated sheet metal supported by four corner posts **60** connected at their upper and lower ends by upper and lower longitudinal beams **64** extending the length of the structure and transverse beams **68** extending the width of the structure. The other end wall **48** comprises a door **70** of plate metal (e.g., 3/16 in.-thick plate metal) comprising two door leafs pivoted on respective corner posts **60**. The door is equipped with suitable seals (not shown) to make the door water-tight. Other door configurations are within the scope of this invention.

[0043] The structure **40** can be made of strong, durable materials other than metal, such as carbon-fiber materials that may have honey-comb interiors. The use of material lighter than steel, for example, has the advantage of reducing costs associated with transportation and assembly of a floodwall. The cost of manufacture may also be reduced. However, one disadvantage of using lighter materials is that steel adds weight which increases the stability of the structure **40** against forces exerted by flooding waters tending to tip or slide the structure. If necessary or desirable, the stability of structures made of lighter material can be increased by adding mechanical means such as pilasters or outriggers to the structure.

[0044] Referring to FIGS. **4-7**, each structure **40** defines an interior space divided by a bulkhead **76** into a water-holding tank compartment **78** and a dry storage compartment **80** accessed by the door **70**. The bulkhead **76** comprises a rectangular frame **82** made, for example, from angle-bar frame members **82**A secured to respective top, bottom and side walls of the structure, a vertical frame member **86** at the center of the rectangular door frame **82**, and a pair of metal panels **88** affixed (e.g., welded) to the frame members **82**A, **86**. (Only one bulkhead panel **88** is shown in FIGS. **5** and **7** so that details of the frame **82** are more apparent.) Desirably, the construction is such that the frame members **82**A, **86** and panels **88** can be installed from the storage-compartment side of the bulkhead **80**. The dry storage compartment **80** is relatively small (e.g., extending in about two feet from the end wall **48**) compared to the water-holding tank compartment **78** and is used for storing accessories, such as pump components, hoses, etc. The water-holding tank compartment **78** has a water-holding capacity which will vary according to its size. As noted above, the compartment is typically sized to have a water-holding capacity of 1800 cubic feet or more.

[0045] Alternatively, the bottom wall **44** of the structure **40** may be made of wood. In such case, one or more receptacles (e.g., flexible bladders and/or rigid tanks of PVC or other suitable material) supported in cradles may be placed inside the water-holding tank compartment **78** for holding water. This type of unit will typically have a lower water-holding capacity (and thus a lighter weight) and may be more appropriate for use at locations where the flood waters are relatively shallow and/or slow-moving. A series of such units, each designated **24'**, are shown in FIG. **1**.

[0046] On a related note, conventional intermodal containers can be modified to use as structures **40**. Such containers typically have a wood floor which can be replaced with a metal bottom wall **44**. Alternatively, one or more receptacles can be placed in the container to hold water, as discussed above.

[0047] As shown in FIGS. **3**, **4** and **9**, a pump-guide system, generally designated **100**, is provided on the top wall **42** of each structure **40** for guiding one or more mobile pumps **108** along the top wall (FIG. **9**). In the illustrated embodiment, the pump-guide system **100** comprises a pair of rails **102** located on opposite sides of the longitudinal centerline of the top wall. The rails **102** are generally L-shaped in cross section (e.g., angle bars) and form a guide track for rolling engagement by the wheels of a mobile pump unit **108**. One or more openings **110** are provided in the top wall **42** of the structure **40** for pumping water into and out of a respective floodwall unit **24**. If the mobile pump unit **108** is particularly heavy (some units weigh **3100** pounds or more), the top wall **42** may be reinforced by exterior or interior transverse roof reinforcing beams **114** (e.g., tubular steel beams) extending within the valleys of the corrugations of the top wall from one side of the structure **40** to the other (FIG. **10**). Desirably, the beams **114** are welded or otherwise secured to the rails **102** so that the entire rail-and-beam assembly can be transported to the flood site as a prefabricated assembly and then simply laid in place on the top wall **42** of a structure **40** with the reinforcing beams **114** in the valleys of the corrugations and the rails resting on the flat peaks of the corrugations. Alternatively, as illustrated in FIG. **11**, the rails **102** may be placed off-center closer to a side wall **52** of the structure **40** for support by the longitudinal upper beam **64** of the unit at that side of the unit.

[0048] The rails **102** allow the mobile pump unit **108** to move as needed along the top wall **42** of the structure **40**, and between adjacent units **24** connected end to end, to fill the water-holding tank compartments **78** of the modular units **24**. By way of example, as shown in FIGS. **12** and **13**, the inlet of the pump unit **108** may be attached to an inlet hose **110** for receiving water from a suitable source, and the outlet of the pump may connected to an outlet hose **112** for delivering water to the water-holding tank compartment **78** through one or more openings **116** in the top wall **42** of the modular unit. If necessary or desirable, the pump unit **108** can be used on the ground to pump water from either side of the unit **24**, as illustrated, for example, in FIG. **14**. The water can be pumped from any available water source, such as a waterway near the modular unit **24** or far from the unit (e.g., up to 2000 feet away, depending on the size of the pump unit **108**. Alternatively, the water can be pumped from a community water system, such as the fire hydrant **120** shown in FIG. **15**). The pump unit **108** is sized to have the appropriate water-pumping capability, e.g., 350-2800 gallons/minute.

[0049] If needed or desired, the modular units **24** can be also be filled without using one or more pumping units **108**, e.g., by using available pressurized water sources such as hydrants or fire pumpers.

[0050] FIG. **15**A illustrates a swivel connection, generally designated **122**, secured to the top wall **42** of a modular unit **24**. The connection **122** comprises a generally L-shaped pipe fitting **124** rotatable about a generally vertical axis. The fitting has a first (upper) end **124**A configured for quick-connection to and quick-disconnection from a pump or hose (not shown) supplying water to fill the water-holding tank compartment **78**, and a second (lower) end **124**B configured for quick-connection to and quick-disconnection from a hose or other conduit **126** extending down into the compartment **78** to a location generally adjacent the bottom wall **44** of the unit. The pipe fitting **124** can be rotated to any convenient angle to facilitate connection to a pump unit **108** or other source of water on the ground, thus eliminating the need for the pump-guide system **100** and openings **116** in the top wall **42** of the modular floodwall unit **24**.

[0051] The modular floodwall unit **24** has self-fill openings **130** spaced at intervals along the side walls **52** of the unit (see FIGS. **3** and **4**). In the event flood waters rise to the level of these openings **130**, water will flow into the water-holding tank compartment **82** of the unit to fill it. Desirably, the self-fill openings **130** are spaced a substantial distance, e.g., seven feet, above the bottom wall **44** of the unit and are sufficiently small to prevent large debris from entering the unit.

[0052] The modular unit **24** has a drainage system for draining water from the water-holding tank compartment **82**. As illustrated in FIGS. **7** and **8**, the system comprises one or more drain ports **134** adjacent the lower ends of the bulkhead panels **88**. Additional drain ports (not shown) can also be provided in the end wall **48** at the opposite end of the unit. Each drain port **134** comprises a pipe **138** and a removable cap **140** threaded on the pipe. After flooding has subsided, water is removed from the water-holding tank compartment **78** using the mobile pump unit **108**. The water-holding tank compartment **82** is cleaned by removing the cap **140** from each drain pipe **138** and flushing the compartment with fresh water which drains out through the (now open) pipe.

[0053] The second modular units **28** are configured to have a smaller water-holding capacity, e.g., one-half the capacity of the first modular units **24** (see FIGS. **17** and **18**). Each second modular unit **28** comprises an elongate rigid structure **160** having a bottom wall **162**, opposite end walls **166**, and two corner posts **168** extending up from the bottom wall adjacent opposite end walls. The structure **160** also has a first (front) generally vertical side wall **170** secured to the corner posts **168** and a second (back) inclined side wall **172** sloping up from the bottom wall to the first side wall **170** at a suitable angle A (e.g., in the range of 35-65 degrees, such as about 45 degrees as shown in FIG. **16**). Thus, as viewed from either end, the structure **160** has the general shape of a triangle and, in particular, a right-triangle. The structure **160** may have other triangular shapes (e.g., both side walls **170**, **172** may be inclined). The dimensions of the structure **160** may vary, but it typically will have a water-holding capacity of at least 1200 cubic feet. By way of example but not limitation, the structure **160** may have a width W**2** of about eight feet, a height H**2** of about 8.5 feet, a length L**2** which can vary from about 20 feet to about 80 feet (e.g., 20 feet, 40 feet), and a distance D**1** along the inclined side wall from the bottom to the top of the unit of about 11.5 feet. When filled with water, the modular unit **28** is very heavy (e.g., at least about 40 tons), but not as heavy as the first modular unit **24**. As a result, the second modular unit **28** is ideal for placement on levees, and/or around plants, warehouses and other property assets that are located in slow-moving flood waters (see FIG. **1**), and/or on streets and other structures which might be damaged if subjected to the full weight of the water-filled first modular unit **24** described above.

[0054] The second modular unit **28** is also of rugged and durable construction. The bottom wall **162**, end walls **166** and side walls **170**, **172** are constructed of heavy-duty corrugated sheet metal supported by the two corner posts **168**. The corner posts **168** are connected at their upper and lower ends by upper and lower longitudinal beams **184** extending the length of the structure. The corner posts **168** are also connected at their lower ends by transverse beams (not shown) extending

the width of the structure. In the illustrated embodiment, the second modular unit **28** does not have an interior bulkhead. Desirably, the unit **28** has self-filling openings **186** in both side walls **170**, **172** spaced a suitable distance D**2** (e.g., seven feet) above the bottom wall **162**. Drainage ports **188** are provided in the end walls **166** to facilitate emptying and cleaning of the unit.

[0055] The triangular design of the second modular unit **28** has certain advantages. Because it is smaller than the first modular unit **24**, it is less expensive to fabricate and requires less time to set up and fill in the field. Further, the triangular shape of the unit **28** permits two units to be stacked one on top of the other in a nested arrangement, as shown in FIG. **18**, for compact transport to and from the flood site. Straps **190** can be used to secure the two units **28** to one another during transport. The two corners of each unit **28** at the juncture of the bottom wall **162** and inclined side wall **172** are notched as indicated at **194** to receive the corner posts **168** of a unit **28** stacked on it.

[0056] The second modular unit **28** can be installed with its vertical side wall **170** facing the flood waters or with its inclined side wall **172** facing the flood waters. The latter is generally desirable in situations where the flood waters are exerting large lateral forces on the unit, because the weight of the water overlying the inclined side wall **172** will increase the frictional resistance of the unit against lateral movement due to such forces, thus making the unit more stable.

[0057] FIG. **19** illustrates components of a modular connecting and sealing device **34** for connecting the modular units **24**, **28** and sealing the junctions **30** between them to form a floodwall (e.g., floodwall **20**). Desirably, the same device **34** may be used for connecting two first modular units **24** to one another, and two second modular units **28** to one another, and first and second modular units **24**, **28** to one another. Further, the device **34** may be used to connect the modular units end-to-end or end-to-side, as shown for example in FIG. **2**. For convenience, the connecting and sealing device **34** is described immediately below in the context of connecting two first modular units **24** to one another.

[0058] In general, the device **34** comprises a footer **200** configured for connecting two modular units **24** together generally adjacent the bottom walls **44** of the units, and a header **204** configured for connecting the two units together at a location spaced above the bottom walls of the units (e.g., adjacent the top walls **42** of the units as illustrated). The device **34** also includes a generally vertical connecting member **210** that connects the footer **200** and header **204** and extends across the junction **30** between the two units. A seal **214** (FIG. **24**) on the connecting member **210** is provided for sealing the junction **30**. Each of these components is described in detail below.

[0059] Referring to FIG. **20**, the footer **200** comprises a generally rectangular base **220** having connector components comprising a pair of spaced-apart posts **224** extending up from the base. The posts **224** are configured for releasable connection with mating connector components **228** on the two modular units **24** being connected. In the embodiment illustrated in FIGS. **19-21**, these mating connector components **228** comprise holes (also designated **228**) in the lower ends of respective corner posts **60** of the two modular units **24** (FIG. **21**). The posts **224** on the footer **200** are sized for a relatively snug fit in the holes **228** of the corner posts **60**. The base **220** and posts **224** of the footer **200** are suitably dimensioned. By way of example but not limitation, the base **220** may be a metal plate having a length L**3** of about 13 in., a width W**3** of about 9.0 in. and a thickness T**3** of about 1.0 in., and the posts **224** may be formed by tubular metal pipes welded to the base each having a height H**3** of about 3.5 in. and an outside diameter OD of about 1.875 in. The mating connector components on the footer **200** and modular units **24** may have other configurations within the scope of this invention.

[0060] As shown in FIG. **22**, the header **204** comprises a generally rectangular base **240** having connector components comprising a pair of spaced-apart posts **244** extending down from the base. The posts **244** are configured for releasable connection with mating connector components **250** on the modular units **24** being connected. In the illustrated embodiment (FIGS. **19** and **22**), these connector components **250** comprise holes (also designated **250**) in the upper ends of respective corner posts **60** of the two modular units **24**. The posts **244** on the header are sized for a relatively snug fit in the holes **250** of the corner posts **60**. The base **240** and posts **244** of the header **204** are suitably dimensioned, and desirably have a construction identical to the base **220** and posts **224** of the footer **200**. By way of example but not limitation, the base **240** may be a metal plate having a length L**4** of about 13 in., a width W**4** of about 9.0 in. and a thickness T**4** of about 1.0 in., and the posts **244** may be formed by tubular metal pipes welded to the base each having a height H**4** of about 3.5 in. and an outside diameter OD of about 1.875 in. The mating connector components on the header **204** and modular units **24** being connected may have other configurations within the scope of this invention.

[0061] Referring to FIGS. **23-25**, the connecting member **210** comprises an elongate generally rectangular plate or panel **260** having opposite ends **262**, **264**. The ends are configured (e.g., tongue-shaped) for removable reception in openings comprising slots **270**, **272** in the bases **220**, **240** of the footer **200** and header **204**, respectively. Desirably, the connecting member **210** is reversible so that either end **262**, **264** may be inserted through the slot **270** in the footer **200**. One end **262** has an end face **276** which is smooth for use on hard surfaces like asphalt, heavy aggregate and concrete, and the other end **264** has an end face formed with teeth **280** for use on soft ground, dirt, small gravel, grass and clay surfaces. The connecting member **210** has side margins **284** along its opposite sides which are bent inward for reception in the corrugations of the side walls **52** of the two units **24** being connected, as shown in FIGS. **19** and **21**. The side margins **284** have upper and lower edges spaced a distance D**5** from respective upper and lower ends **262**, **264** of the connecting member **210** to accommodate the longitudinal beams **62** extending along the sides of the units **24**. The connecting member **210** is dimensioned such that when it is in place, it extends substantially the full height of the modular units **24** and spans the junction **30** between the units. By way of example, the connecting member **210** may have an overall length L**5** of about 10.125 feet, an overall width W**5** of about 22.0 in., and a dimension D**3** of about 7.5 in. The connecting member **210** may be constructed from a metal plate having a thickness of 0.125 in.

[0062] The seal **214** comprises a gasket (also designated **214** in FIGS. **24-26**) of compressible sealing material (e.g., a sealing foam material) on an inner surface of the connecting member panel **260** (facing the units **24** being connected). By way of example, the gasket **214** may be a 1.0 in. to 1.5 in.-thick sheet of closed-cell, water-resistant foam material

having a peel-off backing layer for ready application of the foam to the connecting member **210**. When the connecting member **210** is in place, the gasket **214** is compressed between the inner surface of the connecting member panel **260** and the side walls **52** of the two units **24** being connected, as illustrated in FIG. **24**. The gasket **214** spans the junction **30** between the two units **24** and seals it.

[0063] When the connecting member **210** is in place, the upper and lower ends **262**, **264** of the connecting member project through respective slots **270**, **272** of the footer **200** and header **204**. Optionally, as shown in FIG. **26**A, holes **290** may be provided in the ends of the connecting member so that the end of the connecting member extending up through and beyond the header slot **272** is able to receive a removable locking pin or key **294** to prevent unintentional withdrawal of the connecting member from the slot **272** in the header **204**. The locking pin **294** is threaded to receive a nut **296** to hold the pin in place. Other locking devices may be used, if desired.

[0064] One or two connecting and sealing devices **34** are used to connect two modular units **24**, depending on the desired configuration of the floodwall. If two units **24** are connected in an end-to-end configuration as shown in FIG. **19**, two connecting and sealing devices **34** are used to connect the two units. In this configuration, a first device **34** is used on the flood water side of the two units and a second device **34** is used on the opposite (flood-protected) side of the two units. If two units are connected in an end-to-side configuration, as shown in FIG. **2**, only one device **34** is used at the waterway side of the two units.

[0065] For added sealing protection, an additional seal **300** may be placed between the end walls **48** of the two modular units **24** being connected (FIGS. **19**, **21** and **24**). The seal **300** comprises a gasket of compressible sealing material (e.g., a sealing foam material). The gasket **300** is adhesively secured in place to the end wall **48** of one unit **24** before the two units are connected. The thickness of the gasket **300** is such that it is compressed between the end walls **48** when the modular units are connected. By way of example, the gasket **300** may be a 1.0 in. to 3.5 in.-thick sheet of closed-cell, water-resistant foam material having a peel-off backing layer for ready application of the foam to an end wall of one of the modular units.

[0066] The sealing and connecting device **34** described above can also be used to connect two smaller (second) modular units **28** illustrated in FIGS. **16** and **17**. If used in this manner, the posts **224** on the footer **200** of the device **34** are received in holes (not shown) in the lower ends of adjacent corner posts **168** of the two units **28** being connected. Similarly, the posts **224** on the header **204** of the device **34** are received in holes **314** in the upper ends of adjacent corner posts **168** of the two units **28** being connected. The connecting member **210** connects the footer **200** and header **204**, and the seal **214** on the connecting member seals the junction **30** between the two units **28**.

[0067] The sealing and connecting device **34** described above can also be used to connect a first modular unit **24** and a second modular unit **28**. If used in this manner, one of the posts **224** on the footer **200** of the device **34** is received in the hole **228** in the lower end of a corner post **60** of the unit **24** and the other post **224** on the footer is received in the hole (not shown) in the lower end of the adjacent corner post **168** of the unit **28**. Similarly, one of the posts **224** on the header **204** of the device **34** is received in the hole **250** in the upper end of a corner post in the unit **24** and the other post **224** is received in the hole **314** in the upper end of the adjacent corner post **168** of the unit **28**. The connecting member **210** connects the footer **200** and header **204**, and the seal **214** on the connecting member seals the junction **30** between the two units **24**, **28**.

[0068] FIGS. **27-30** illustrate an "expansion" connecting and sealing device of this invention, generally designated **320**. This device **310** is similar to the device **34** described above except that it has a footer comprising two separate, spaced apart footer members, each designated **324**, having connector components **326** configured for releasable connection with the mating connector components **228** on two modular units **24** being connected. The device **320** also has a header comprising a pair of separate, spaced apart header members, each designated **334**, having connector components **338** configured for releasable connection with the mating connector components **250** on the two modular units **24**. The connecting and sealing device **310** also includes a relatively wide connecting member comprising a generally rectangular expansion plate or panel **350** having top, bottom and side edges configured for removable reception in respective openings **354** in the footer and header members **324**, **334**. The width of the expansion panel **350** can vary has needed or desired. By way of example, the panel **350** may have a width of three feet, five feet, eight feet, ten feet, or other suitable dimension. The panel **350** has a height generally corresponding to the full height of the modular units **24** being connected.

[0069] Referring to FIG. **28**, each footer member **324** comprises a base **360**, and the connector component **326** comprises a tubular post (also designated **326**) extending up from the base for removable reception in the hole **228** at the lower end of a corner post **60** of a respective modular unit **24**, much like the connector post **224** of the footer **200** previously described. Similarly, as shown in FIG. **29**, each header member **334** comprises a base **366**, and the connector component **338** comprises a tubular post (also designated **338**) extending down from the base for removable reception in the hole **250** at the upper end of the corner post **60**, like the connector post **244** of the header **204** previously described. The openings **354** for receiving the edges of the expansion panel **350** are defined by generally U-shaped channels **370**, **372** on the footer and header members **324**, **334**, respectively. The channels **370** on the footer members **324** open upwardly and laterally outwardly toward one another. The channels **372** on the header members **334** open downwardly and laterally outwardly toward one another.

[0070] By way of example but not limitation, the base **360** of the footer member **324** may be in the form of a metal plate having a length L**6** of about 13 in., a width W**6** of about 6.5 in. and a thickness T**6** of about 0.5 in., and the posts **316** of the footer members may be formed by tubular metal pipes welded to the plate, each such pipe having a height H**6** of about 3.5 in. and an outside diameter OD of about 1.625 in. (see FIGS. **28** and **29**). The channels **370**, **372** may also be formed from metal plate having an overall height H**7** of about 5.5 in., an opening width W**7** of about 5.5 in., an opening depth D**7** of about 6 in., and a thickness T**7** of about 0.5 in. The footer members **324** can have other configurations without departing from the scope of this invention.

[0071] Similarly, the base **366** of the header member **334** may be in the form of a metal plate having a length L**8** of about 13 in., a width W**8** of about 6.5 in. and a thickness T**8** of about 0.5 in., and the posts **338** of the header members may be formed by tubular metal pipes welded to the plate, each such pipe having a height H**8** of about 3.5 in. and an outside

diameter OD of about 1.625 in. (see FIGS. **28** and **29**). The channels **372** may also be formed from metal plate having an overall height H**9** of about 5.5 in., an opening width W**9** of about 5.5 in., an opening depth D**9** of about 6 in., and a wall thickness of about 0.5 in. The header members **334** can have other configurations without departing from the scope of this invention.

[0072] As best shown in FIGS. **27** and **30**, a seal comprising a pair of gaskets **380** are positioned between the panel **350** and the side walls **52** of the modular units **24** facing the panel to seal the relatively wide junction **30** (gap) between the two units **24**. The gaskets **380** are of a compressible sealing material, such as a sealing foam material. Desirably, the gaskets **380** are adhesively secured to the inside face of the connector panel **350** and have a thickness such that they are compressed between the panel and respective side walls **52** of the modular units **24** when the connecting and sealing device **320** is installed. By way of example, each gasket **380** may be a 1.0 in. to 1.5 in.-thick sheet of closed-cell, water-resistant foam material having a peel-off backing layer for ready application of the foam to the connecting panel. Other gasket configurations are within the scope of this invention.

[0073] The "expansion" connecting and sealing device **320** can be used to construct a floodwall, or at least one or more segments of a floodwall, in which modular units **24** are spaced farther apart than when using the first-described connecting and sealing device **34**. An advantage of using the expansion connecting and sealing device **320** is that fewer modular units are required to construct the floodwall, thus reducing overall cost. In general, the use of this "expansion" feature is most appropriate at locations where the flood waters are shallow and/or slow moving.

[0074] The "expansion" connecting and sealing device **320** described above can also be used for connecting and sealing two second modular units **28** and/or for connecting and sealing first modular unit **24** and a second modular unit **28**. The connection process is substantially identical in each instance.

[0075] The modular floodwall system **20** is designed for rapid deployment. The modular units **24**, **28** are transported (e.g., by low-boy transportation trailers) to the site of a flood where they are unloaded, placed in position, and connected to form a floodwall having a desired configuration. The deployment process is described below.

[0076] The larger modular units **24** can be connected in either an end-to-end configuration or an end-to-side configuration. To connect two units **24** end-to-end, a fork lift truck or other lifting device is used to place a first unit **24** on the ground at an appropriate location, and two footers **200** are positioned adjacent the corners posts **60** at one end of the unit. The end of the unit **24** is lifted and then lowered to insert two connecting posts **224** of the footers **200** into the holes **228** at the lower ends of the two corner posts. After the unit is lowered, a second modular unit **24** is placed end-to-end with the first unit such that the other two connecting posts **224** of the footers **200** are received in respective holes **228** in the lower ends of the two corner posts **60** at the adjacent end of the second unit. The lower ends of two vertical connecting members **210** are placed in the slots **270** of the two footers **200** to cover the junction **30** between the first and second modular units **24** at opposite sides of the floodwall, and the headers **204** are placed in position with the upper ends of the vertical connecting members **210** extending up through the slots **272** in the headers and the connecting posts **244** of the headers extending down into the holes **250** at the upper ends of respective corner posts **60** of the two units. With the headers **204**, footers **200** and vertical connecting members **210** in place, the side-seal gaskets **214** are compressed between the connecting members **210** and the side walls **52** of the modular units **24** to seal the junction **30** between the units against floodwater.

[0077] For additional sealing protection, an end-seal gasket **300** is applied to an end of one of the two units **24** being connected before the units are placed end-to-end. When the units are connected, the end-seal gasket **300** is compressed between adjacent ends of the two units to seal the junction **30**.

[0078] A similar process is used to connect two modular units **24** in an end-to-side configuration. However, for this configuration, only one connecting and sealing device **34** is used to connect the units and seal the junction **30** at the floodwall side of the units. Optionally, an end-seal gasket **300** may be used for additional sealing protection.

[0079] Two smaller (½-size) modular units **28** can be connected end-to-end in a manner similar to that described above for connecting two larger units **24** end-to-end, except that only one connecting and sealing device **34** is used to seal the junction **30** at the floodwall side of the units. Optionally, an end-seal gasket **300** may be used between the units for additional sealing protection. In this application, the end-seal gasket **300** has a triangular shape to match the shape of the end walls **166** of the two units **28**.

[0080] Advantageously, the same connecting and sealing device **34** can also be used to connect a first modular unit **24** end-to-end to a second modular unit **28** and to seal the junction **30** between them. The process for connecting the two units **24**, **28** is identical to the process described above for connecting two first modular units **24** end-to-end, except that only one connecting and sealing device **34** is used (see FIG. **2**). Optionally, an end-seal gasket **300** between the two units may be used for additional sealing protection. In this application, the end-seal gasket **300** has a triangular shape to match the shape of the end wall **166** of the smaller triangular unit **28**.

[0081] The modular units **24**, **28** of the floodwall **20** can also be connected at appropriate locations using the "expansion" connecting and sealing devices **320** described above. For example, the "expansion" devices can be used where the flood waters are more shallow and/or slower-moving, thereby reducing the number of modular units needed to construct the floodwall.

[0082] The modular units **24**, **24'**, **28** and the connecting and sealing devices **34**, **320** are selectively used to construct a floodwall having a configuration designed to meet the specific needs of each flood control site. For example, the larger and heavier modular units **24**, **24'** can be used to control large amounts of fast-moving flood water, and the smaller and lighter units **28** can be used to control shallow, slower moving flood waters where the forces exerted on the floodwall are less. Further, modular units **24**, **24'**, **28** of different types can be strung together to form a floodwall which is designed to meet the specific characteristics of the site, such as the path followed by the flooding waterway, the depth of the floodwaters, the speed of the flood water, and the layout of the property being protected. For instance, as shown in FIG. **1**, a series of larger heavier modular units **24**, **24'** are connected to form a first segment **20**A of the floodwall along a first section of a flooding waterway subject to relatively larger water-flow forces, and a series of smaller lighter units **28** are connected to form a second segment **20**B of the floodwall along a second section of a flooding waterway subject to relatively smaller water-flow forces. Additional modular units of the appropri-

ate type or types can be connected to form additional segments of the floodwall, as needed. The segments are connected to one another using the connecting and sealing devices **34**, **320** to form an integrated floodwall system that is custom-tailored according to the expected nature of the flooding and the site-specific requirements of the property being protected.

[0083] The modular units **24**, **24'**, **28** can also used to construct back-up or secondary floodwalls, if needed or desired. For example, if floodwaters are expected to rise to a level that exceeds the height of the modular units **24**, **24'**, **28** making up a first (primary) floodwall, a second floodwall using additional modular units **24**, **28** can be formed a suitable distance spaced from the first floodwall, on the protected side of the first floodwall, to form an additional barrier.

[0084] The modular units **24**, **24'**, **28** are filled with the appropriate amounts of water, using the pump units **108**. In general, a unit **24**, **24'**, **28** is filled soon after it is connected to another unit, although this is not essential. However, a modular unit should be filled before it is exposed to substantial floodwaters so that it has weight sufficient to resist being moved by the floodwaters. The process of connecting and filling the modular units can be completed in a relatively short amount of time, e.g., 10 minutes per unit on average, for a total set-up time of 15.4 hours for a one-mile long floodwall comprising **185** modular units, including 79 40-foot long units **24** and 106 20-foot long units **24**, using two pump units **108** pumping at a rate of about 1700 gallons/minute to fill each modular unit to 50% of its capacity.

[0085] As illustrated in FIGS. **12-15**, barriers **400** of sandbags and/or plastic sheeting or the like may be placed at the base of each modular unit **24**, **24'**, **28** on the flood water side of the unit and, optionally, on the opposite (protected) side of the unit, to prevent or at least inhibit the seepage and flow of water below the modular units.

[0086] After flooding has subsided, the modular-unit floodwall system **20** of this invention can be readily disassembled and removed from the flood site. Water is pumped out of the modular units **24**, **24'**, **28** using the one or more pump units **108**. The units are disconnected by reversing the steps described above. After disconnection, the units are loaded onto suitable carriers and transported away from the flood site for storage. The modular units are cleaned by flushing them with cleaning fluid (e.g., fresh water) which is allowed to drain through the opened drain ports **134**. The cleaning will typically takes place at the storage site, but the units can also be cleaned at the flood site before storage. It will be observed, therefore, that the time and expense of clean-up is substantially reduced compared to that required for conventional floodwalls made from sandbags, for example. Further, the modular units **24**, **24'**, **28** can be used more than once and are easy to store when not in use.

[0087] Having described the invention in detail, it will be apparent that modifications and variations are possible without departing from the scope of the invention defined in the appended claims. It will also be apparent that a modular-unit floodwall system of this invention has numerous advantages, including but limited to: engineering superiority; engineering strength; flexibility of configuration; protection superiority; ease and speed of set-up; ease and speed of clean-up; and re-use of the components of the system.

[0088] When introducing elements of the present invention or the preferred embodiments(s) thereof, the articles "a", "an", "the" and "said" are intended to mean that there are one or more of the elements. The terms "comprising", "including" and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements.

[0089] In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

[0090] As various changes could be made in the above constructions and methods without departing from the scope of the invention, it is intended that all matter contained in the above description and shown in the accompanying shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A modular-unit floodwall system comprising

modular floodwall units adapted for holding water, each unit having a bottom wall, opposite end walls and side walls, and

connecting and sealing devices for connecting the units and sealing junctions between the units to form a barrier against floodwater,

each connecting and sealing device comprising a footer configured for connecting two units together generally adjacent the bottom walls of the units, a header configured for connecting the two units together adjacent the top walls of the units, a generally vertical connecting member connecting the footer and the header and extending across a junction between the two units, and a seal on the connecting member for sealing the junction.

2. A modular-unit floodwall system as set forth in claim **1**, wherein said footer comprises a base having connector components configured for releasable connection with mating connector components on said two units.

3. A modular-unit floodwall system as set forth in claim **2**, wherein said connector components comprise a pair of spaced-apart posts extending up from the base, and wherein said mating connector components on said two units comprise holes in adjacent lower corners of the units for receiving said posts.

4. A modular-unit floodwall system as set forth in claim **3**, wherein said base has an opening for removable reception of a lower end of said generally vertical connecting member.

5. A modular-unit floodwall system as set forth in claim **4**, wherein the lower end of the generally vertical connecting member is configured to project down through the base opening and to penetrate the ground.

6. A modular-unit floodwall system as set forth in claim **1**, wherein said header comprises a header base having connector components configured for releasable connection with mating connector components on said two units.

7. A modular-unit floodwall system as set forth in claim **6**, wherein said connector components comprise a pair of spaced-apart header posts extending down from the header base, and wherein said mating connector components on said two units comprise holes in adjacent upper corners of the units for receiving said header posts.

8. A modular-unit floodwall system as set forth in claim **1**, said footer comprising a pair of spaced apart footer members having connector components configured for releasable connection with mating connector components on said two units, said header comprising a pair of spaced apart header members having connector components configured for releasable connection with mating connector components on said two units, and said connecting member comprising a panel having

top, bottom and side edges configured for removable reception in respective openings in said footer and header members.

9. A modular-unit floodwall system as set forth in claim **8**, wherein said openings in the footer and header members are defined by channels on respective footer and header members.

10. A modular-unit floodwall system as set forth in claim **9**, wherein said seal comprises a gasket of compressible material on an inner surface of said panel.

11. A modular-unit floodwall system as set forth in claim **1**, wherein a first of said modular floodwall units comprises an elongate rigid structure that is generally rectangular as viewed from an end of the unit, and wherein a second of said modular floodwall units comprises an elongate rigid structure that is generally triangular as viewed from an end of the unit.

12. A modular-unit floodwall system as set forth in claim **11**, wherein said second modular floodwall unit is shaped as a right-triangle as viewed from an end of the unit.

13. A modular-unit floodwall system as set forth in claim **1**, wherein said modular floodwall units comprise a first plurality of units having a first water-holding capacity and a second plurality of units having a second water-holding capacity less than said first water-holding capacity.

14. A modular-unit floodwall system as set forth in claim **1**, wherein at least some of said floodwall units have top walls extending between the side walls, and openings in the top walls for pumping water into or out of a respective floodwall unit.

15. A modular-unit floodwall system as set forth in claim **1**, further comprising a pump-guide system on the top walls for guiding one or more mobile pumps along the top walls.

16. A floodwall system as set forth in claim **1**, wherein each floodwall unit defines an interior space divided by a bulkhead into a water-holding tank compartment and a dry storage compartment accessed by a door in an end wall of the unit.

17. A floodwall system as set forth in claim **1**, wherein said connecting and sealing devices are configured for connecting at least some of the modular units either end-to-end or end-to-side.

18. A modular floodwall unit comprising

a rigid box-like structure having a top wall, a bottom wall, opposite end walls and opposite side walls,

said structure having a water-holding capacity of at least 1800 cubic feet,

at least one opening in the top wall, and

a pump-guide system on the top wall for guiding a mobile pump along the top wall.

19. A modular floodwall unit as set forth in claim **18**, wherein said structure defines an elongate interior space divided by a bulkhead into a water-holding tank compartment and a dry storage compartment accessed by a door in an end wall of the structure.

20. A modular floodwall unit for controlling flood water, comprising

a rigid elongate structure having a bottom wall, opposite end walls, a pair of corner posts extending up from the bottom wall adjacent the end walls, a first generally vertical side wall extending up from the bottom wall and secured to the corner posts, and a second inclined side wall sloping up from the bottom wall to the first side wall, and

openings in upper and lower ends of the corner posts for receiving connecting devices for connecting the modular floodwall unit end-to-end to adjacent modular floodwall units,

said structure having a generally triangular shape as viewed from an end of the structure.

21. A method of constructing a floodwall from modular floodwall units comprising a first plurality of first modular units having a first water-holding capacity and a second plurality of second modular units having a second water-holding capacity less than said first water-holding capacity, said method comprising the steps of

connecting a plurality of first modular units and a plurality of second modular units together, and

sealing junctions between the modular units to form a floodwall.

22. A method as set forth in claim **21**, wherein said connecting step comprises connecting a plurality of first modular units to one another to form a first segment of the floodwall, connecting a plurality of second modular units to one another to form a second segment of the floodwall, and connecting said first and second segments of the floodwall.

23. A method as set forth in claim **22**, wherein some modular units are connected end-to-end and other modular units are connected end-to-side.

24. A method as set forth in claim **21**, wherein each first modular unit comprises a rigid structure having a generally rectangular shape as viewed from an end of the structure, and wherein each second modular unit comprises a rigid structure having a generally triangular shape as viewed from an end of the structure.

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