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Adler et al.

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(54) **FLOOD CONTROL SYSTEM PANELS FOR SUBWAY ENTRANCE**

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Related U.S. Application Data

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(51) **Int. Cl.**

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E02D 29/14	(2006.01)
E02B 7/20	(2006.01)
E04H 9/12	(2006.01)
E04H 9/14	(2006.01)
E04H 9/16	(2006.01)
E06B 5/10	(2006.01)

(52) **U.S. Cl.**
CPC ***E02D 29/149*** (2013.01); ***E02B 7/20*** (2013.01); ***E02D 29/1427*** (2013.01); ***E04H 9/04*** (2013.01); ***E04H 9/12*** (2013.01); ***E04H 9/14*** (2013.01); ***E04H 9/145*** (2013.01); ***E04H 9/16*** (2013.01); ***E06B 5/10*** (2013.01)

(58) **Field of Classification Search**
CPC E04H 9/04; E04H 9/12; E04H 9/14; E04H 9/145; E04H 9/16; E02B 7/20; E02D 29/14; E02D 29/1427; E02D 29/149; E06B 5/10
USPC 52/169.6
See application file for complete search history.

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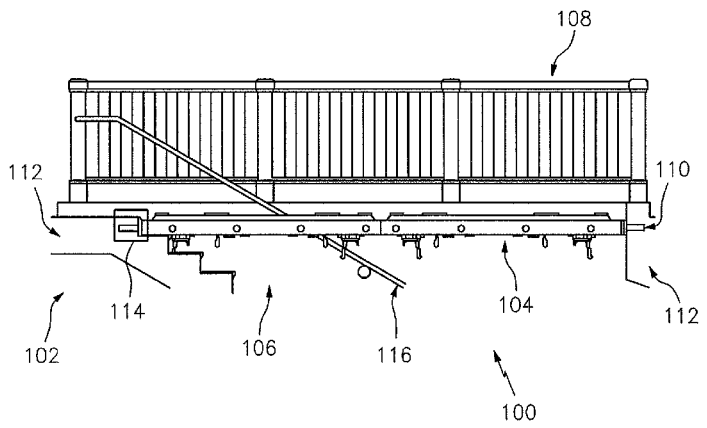
(57) **ABSTRACT**

A cover system for covering an entrance of an underground structure. The cover system comprises a frame structure attached to a foundation of the entrance; and a seal gasket configured to provide a seal between the frame structure and the foundation and between the frame structure and a panel of the cover system. The panel further includes a plurality of engagement members that engage the panel with the frame structure.

12 Claims, 15 Drawing Sheets



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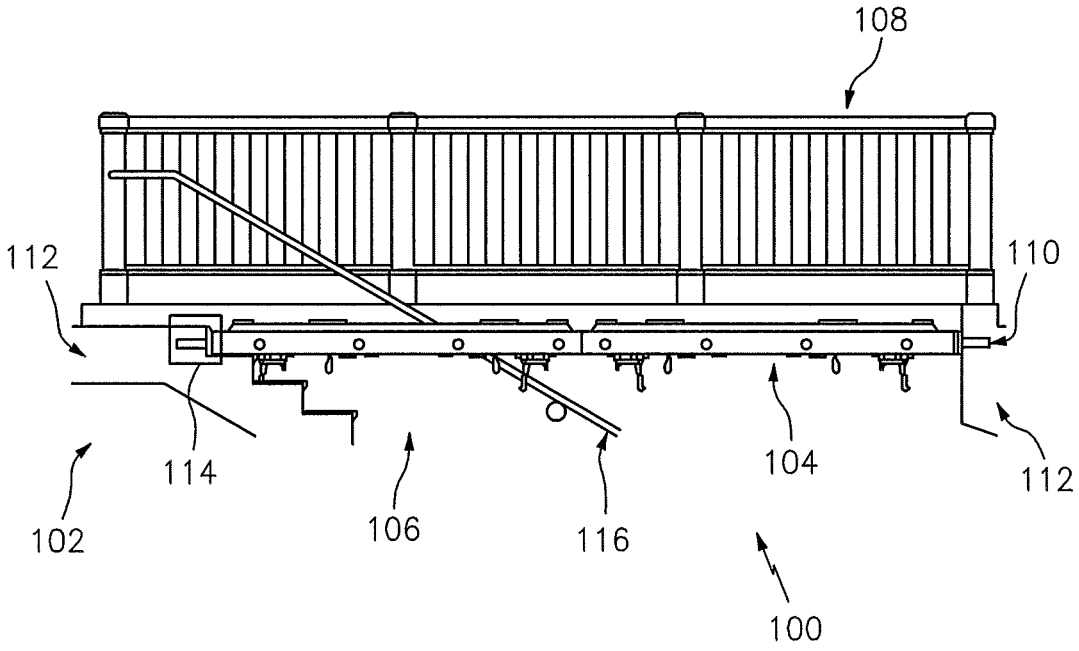

FIG. 1

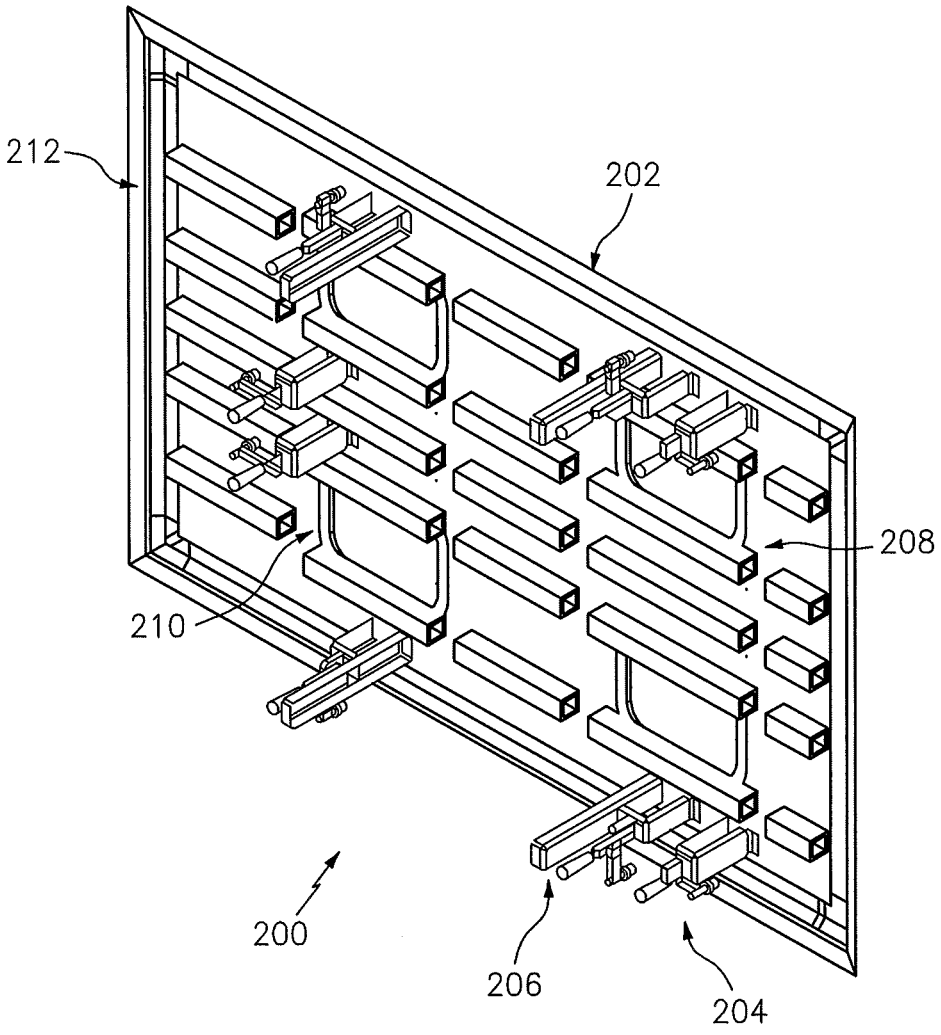

FIG. 2

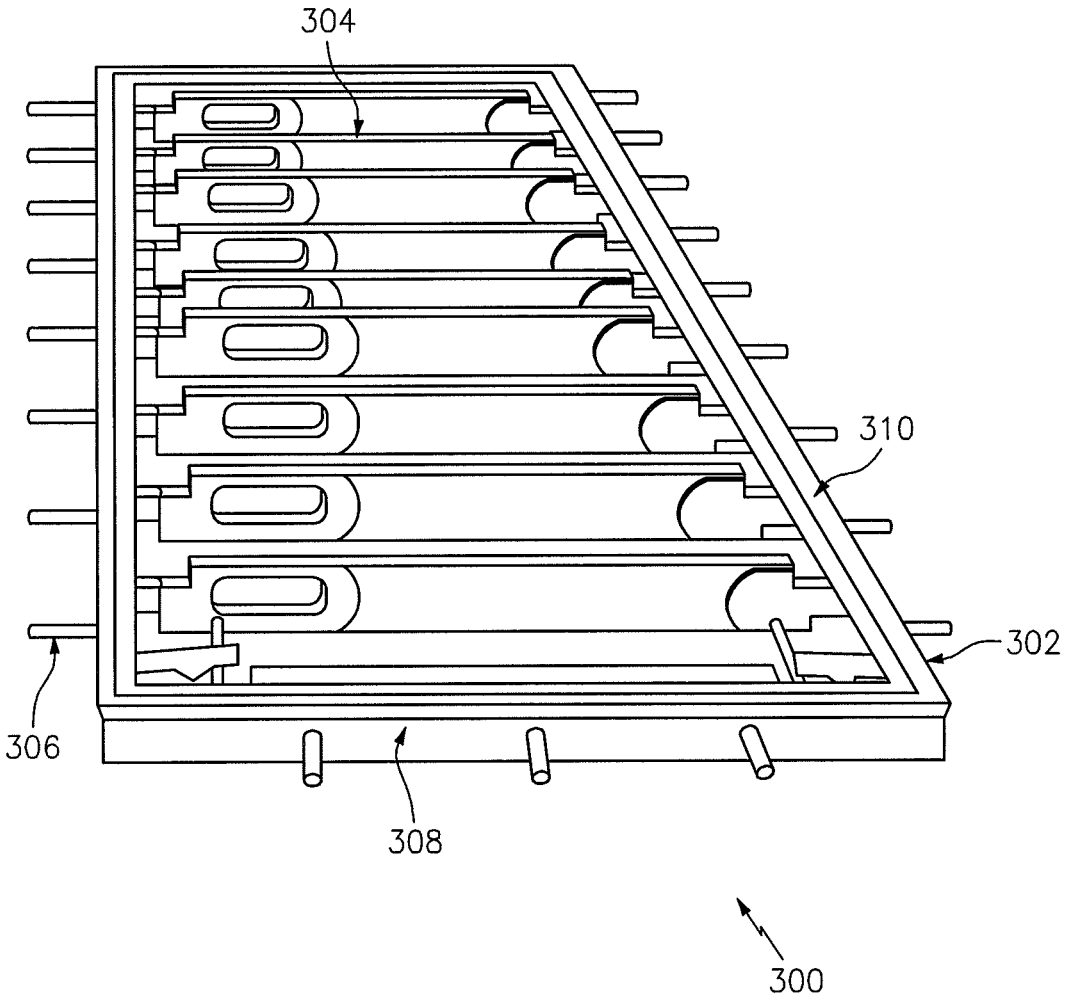

FIG. 3

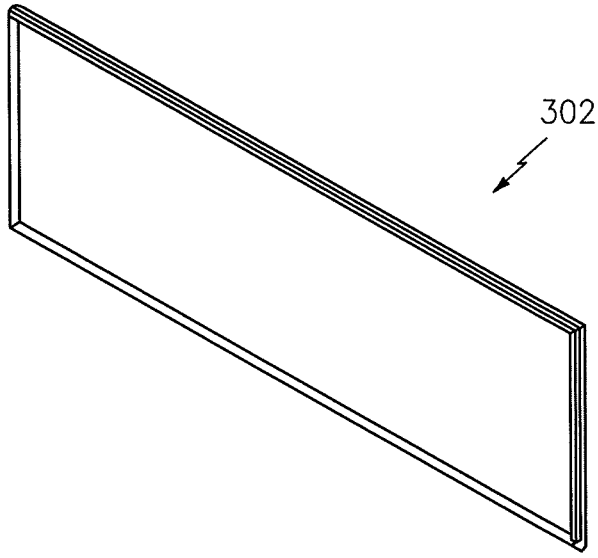

FIG. 4(a)

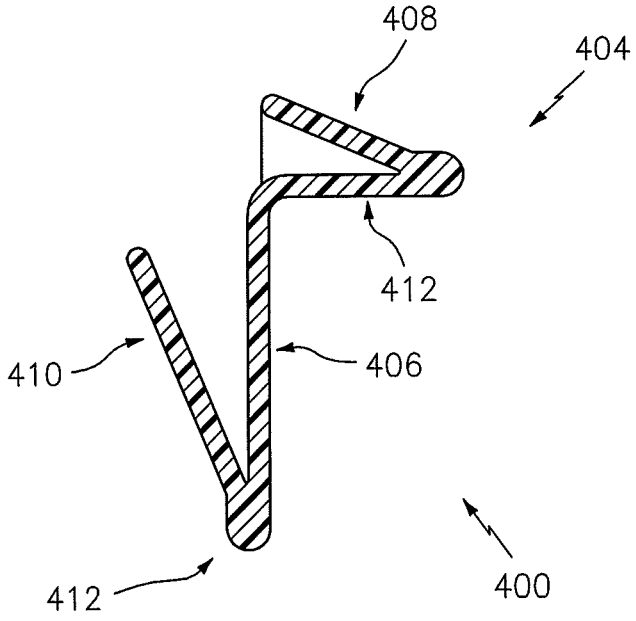

FIG. 4(b)

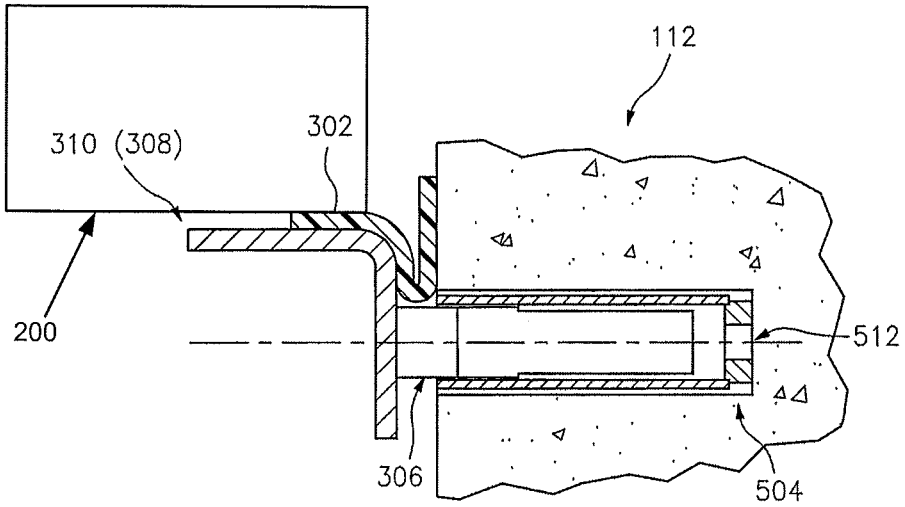

FIG. 5(a)

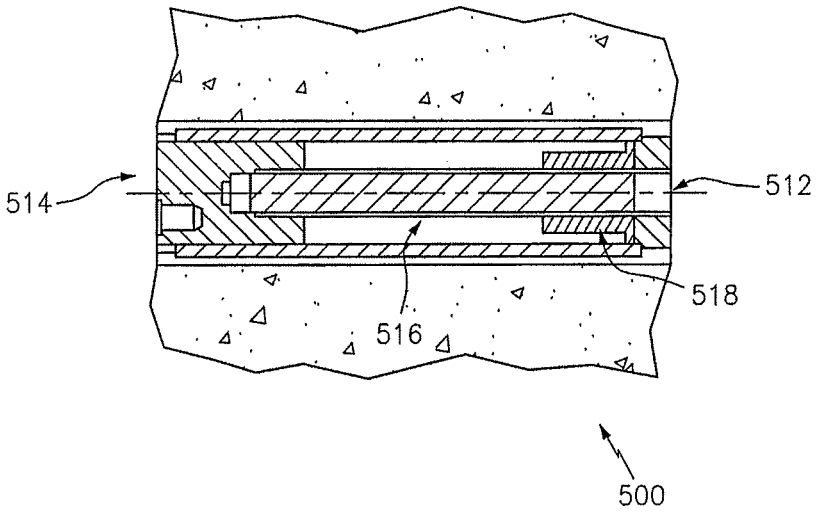

FIG. 5(b)

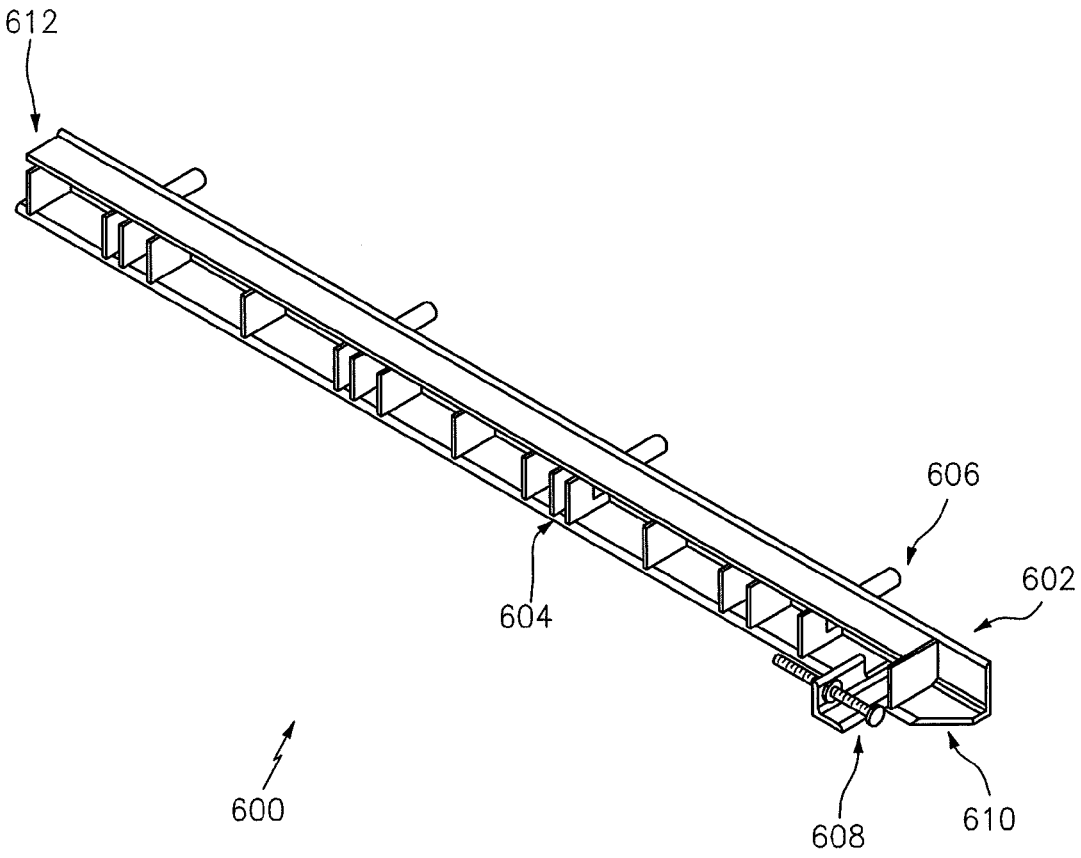

FIG. 6

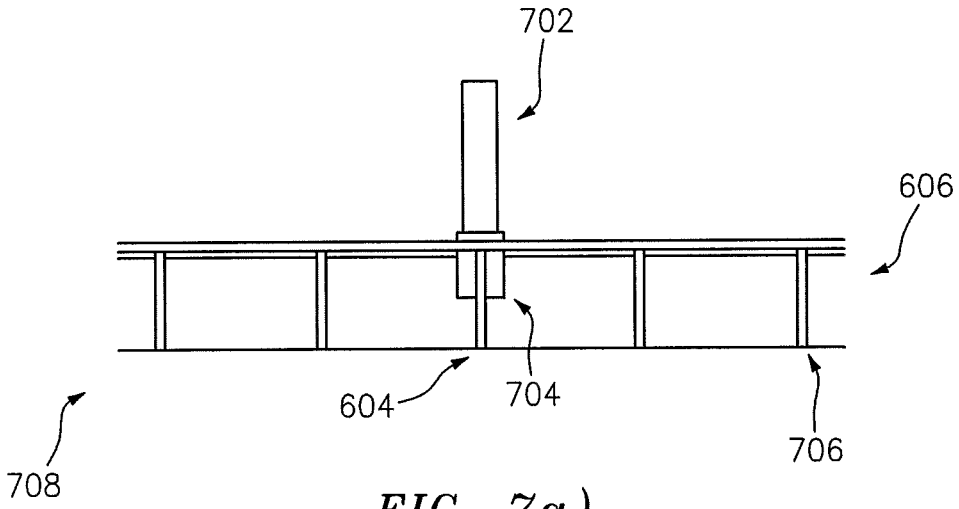

FIG. 7a)

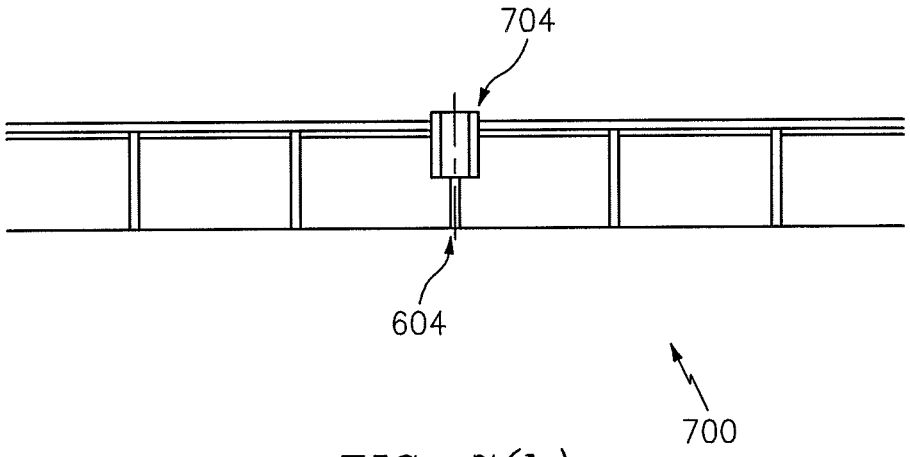

FIG. 7(b)

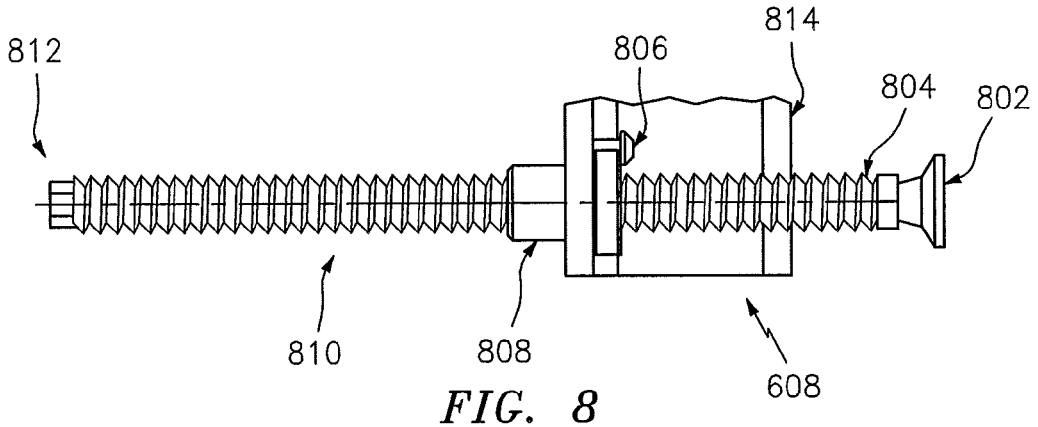

FIG. 8

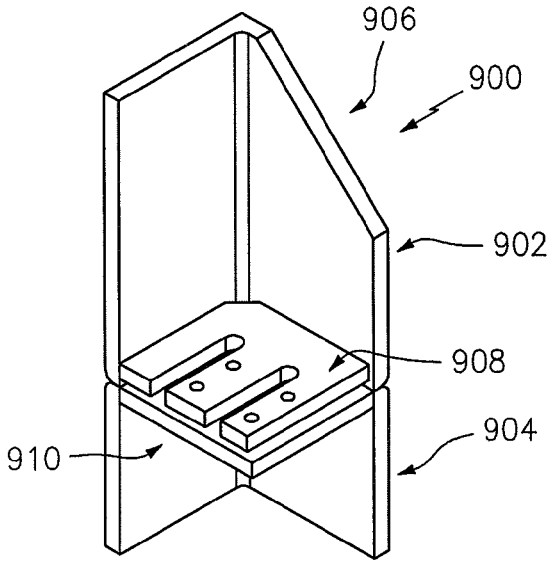

FIG. 9

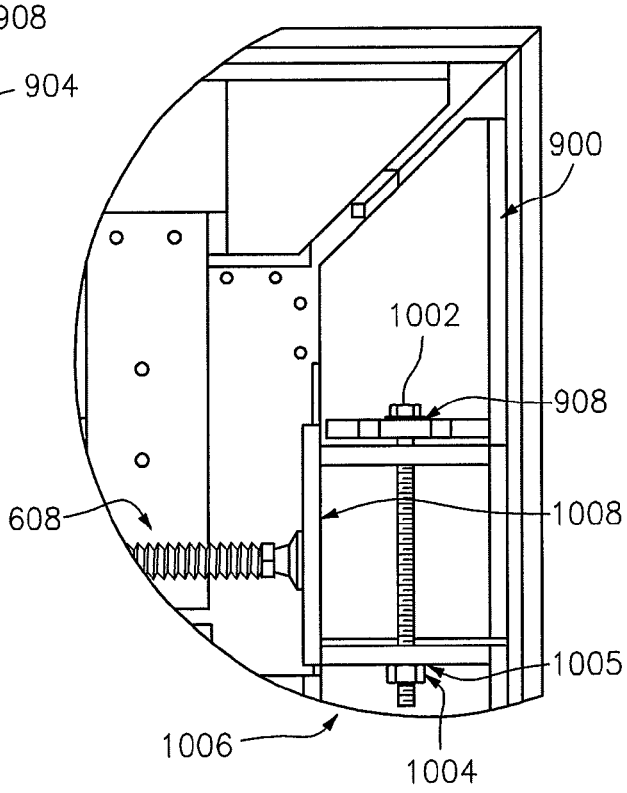

FIG. 10

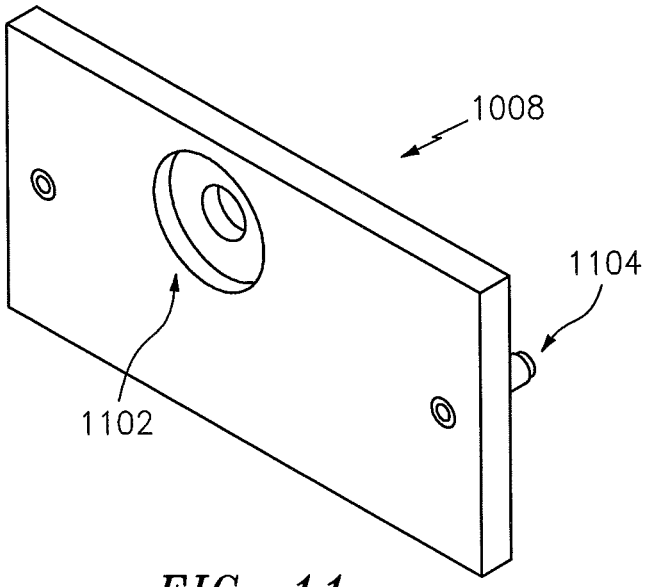

FIG. 11

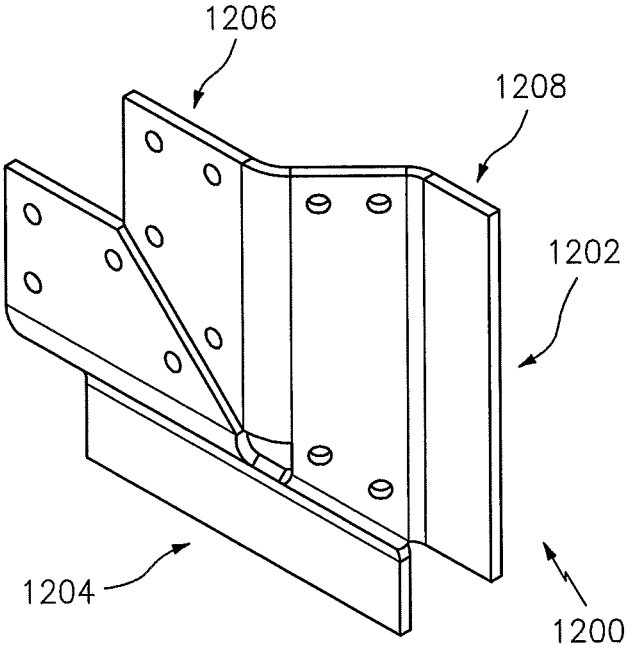

FIG. 12

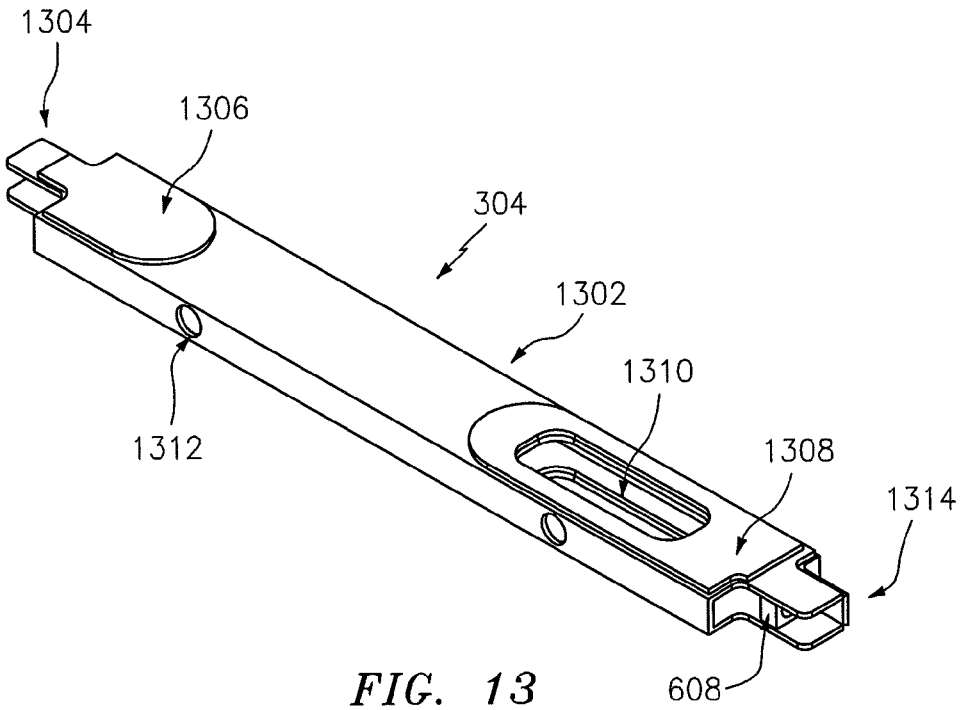

FIG. 13

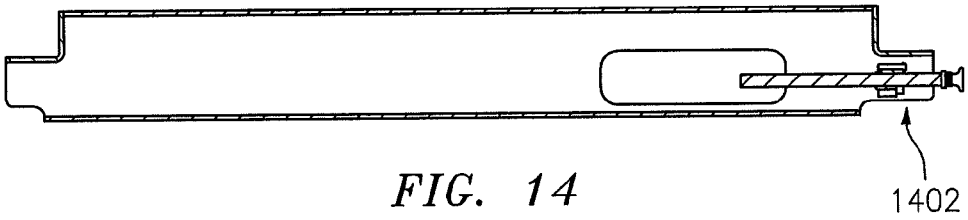

FIG. 14

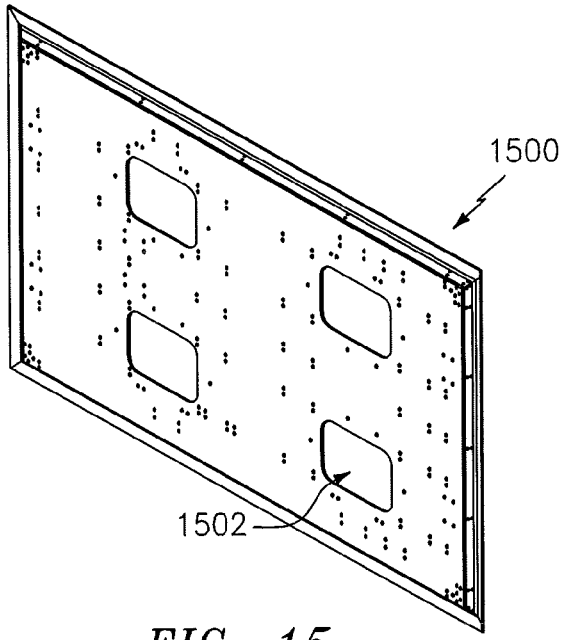

FIG. 15

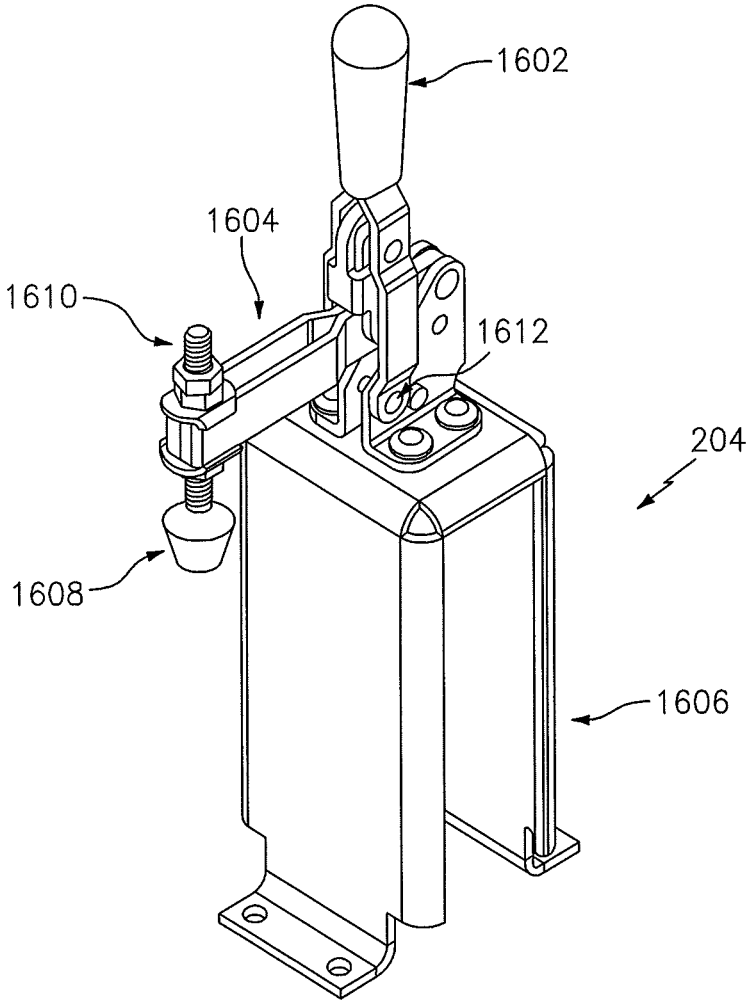

FIG. 16

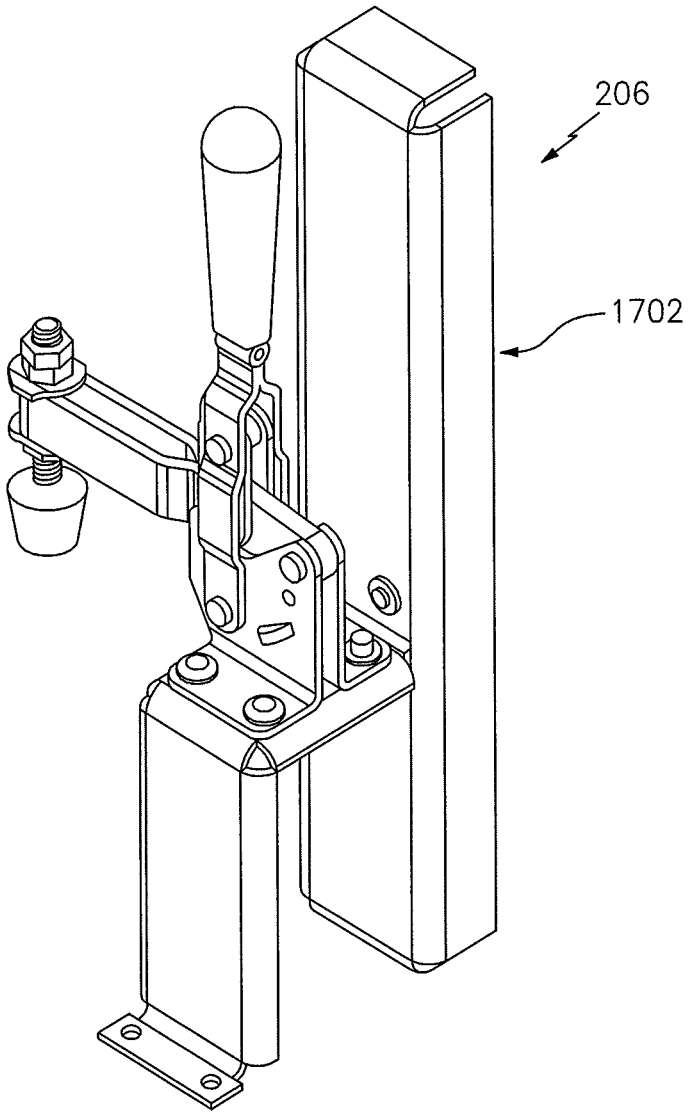

FIG. 17

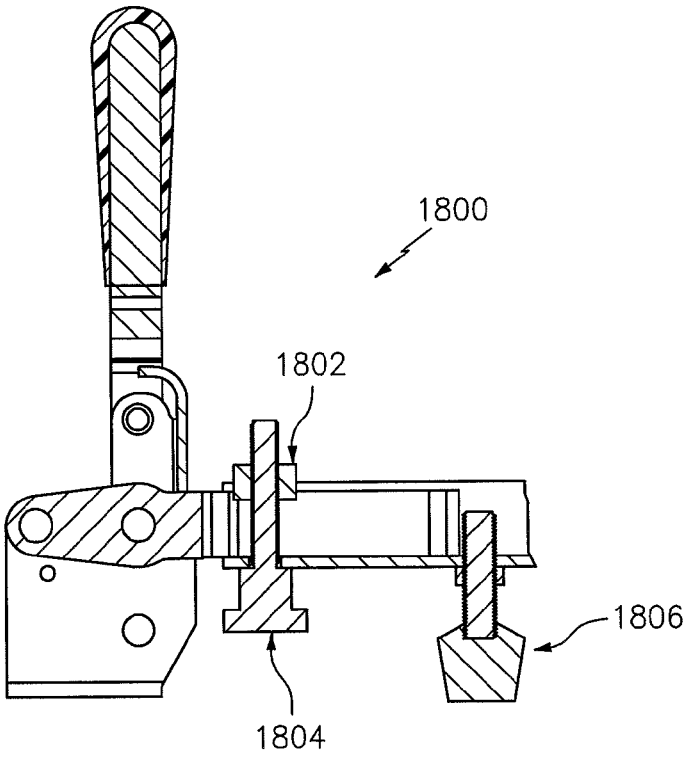

FIG. 18(a)

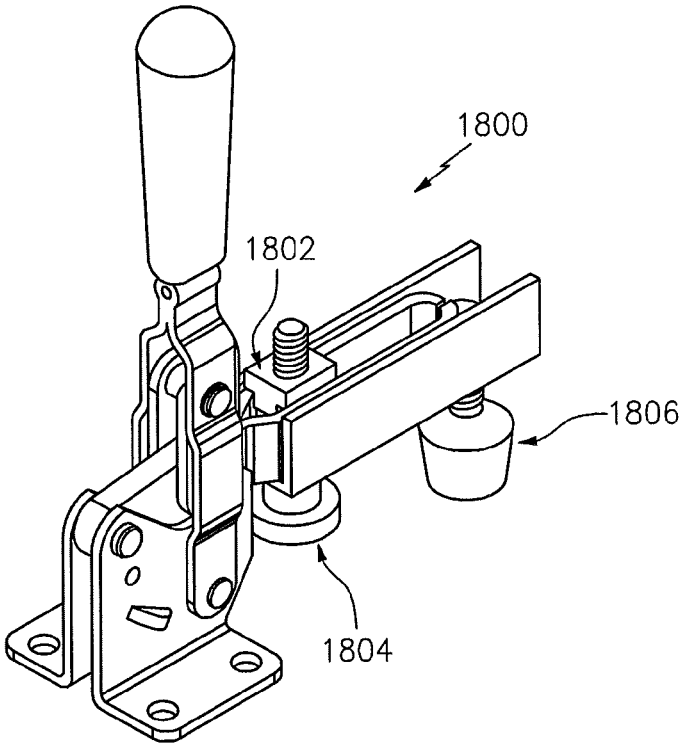

FIG. 18(b)

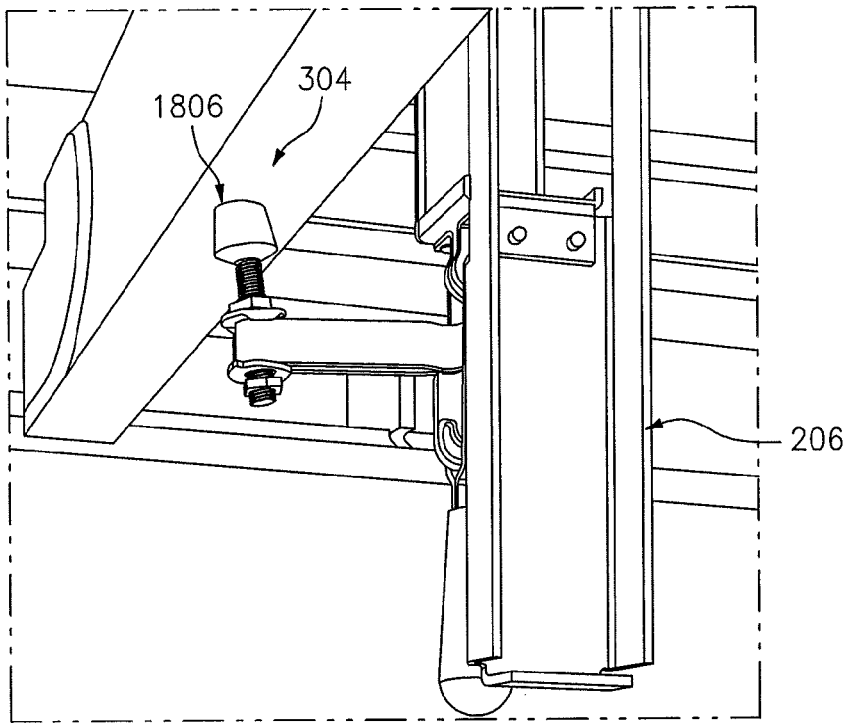

FIG. 19(a)

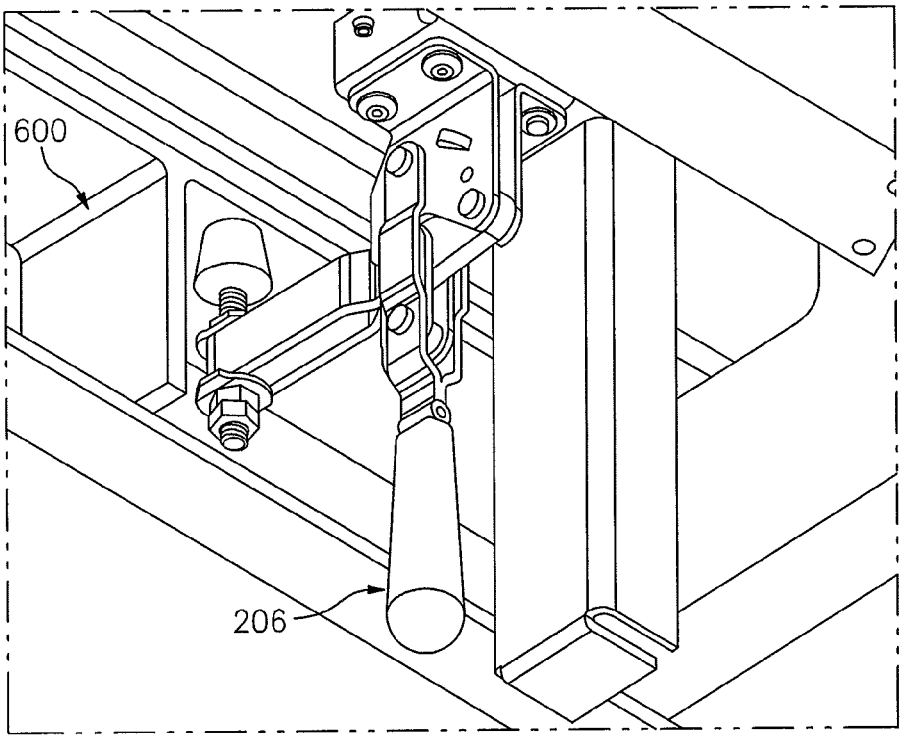

FIG. 19(b)

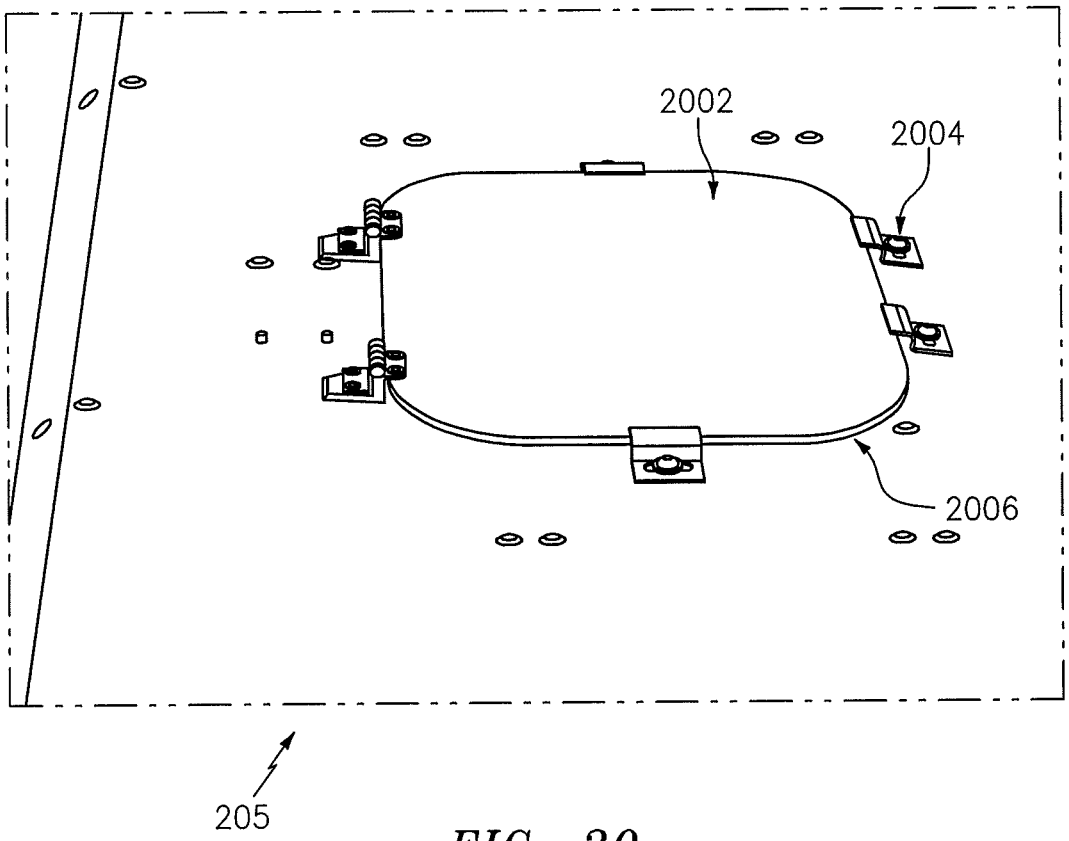

FIG. 20

FLOOD CONTROL SYSTEM PANELS FOR SUBWAY ENTRANCE

RELATED APPLICATIONS

This application claims benefit to provisional Application Nos. 61/956,204, filed on Jun. 3, 2013, 61/996,642 filed on May 12, 2014, 61/996,103, filed on Apr. 28, 2014, 61/961,046 filed on Oct. 2, 2013, 61/956,204, filed on Jun. 3, 2013 and 61/855,540, filed on May 16, 2013, the disclosures of all of which are incorporated herein by reference.

The disclosure of non-provisional application Ser. No. 14/295,052, titled "Removable Flood Control Cover System For Underground Facility Vents And Openings", filed on Jun. 3, 2014, is incorporated herein by reference.

BACKGROUND

The invention disclosed herein relates generally to a cover system for preventing water from entering underground facilities such as transportation facilities, storage facilities, vaults, data centers, basements, etc., through openings, e.g., for ventilation and/or ingress/egress.

Underground facilities, such as, but not limited to, those mentioned above, are under the threat of being flooded due to heavy rains, hurricanes, and storm surges, not only in areas traditionally prone to flooding close to rivers and shorelines, but also in metropolitan areas not traditionally flooded. For example, in 2012, The New York City subway system experienced unprecedented damage caused by storm surge and flood waters when Superstorm Sandy hit New York City. Parts of the NYC subway system were flooded, to a much lesser extent, at other times from torrential rains. Much of the flooding was caused by water entering the subway system through entrances and air vents.

SUMMARY

Embodiments presented in this application provide a cover system that covers and seals openings to low level or underground facilities (hereinafter referred to simply as "underground"). For example, such an opening may be at ground level. ("Ground level" is meant herein in a broad sense and encompasses levels near ground level, as well as at ground level. "Ground level" may also be used herein in a relative sense referring to the ground at the particular location of an opening, which may not be at ground level relative to the area nearby or surrounding the particular location. For example, a vent or entrance may be at sidewalk level, which is above street level, or above or below stairs, which are above or below a surrounding area, etc.) Such cover systems can substantially reduce the amount of water that might otherwise enter an underground facility due to ground water levels.

Some embodiments are directed to a cover system for covering an entrance opening of an underground facility. The cover system according to one or more of these embodiments comprises a waterproof panel and a seal gasket configured to extend peripherally relative to the panel and a frame attached to the inner periphery of the opening. Clamping devices are provided that engage the panel and the periphery of the opening and/or structure extending over and attached to the opening to clamp the panel over the opening and compress the seal gasket.

Some embodiments are directed to a cover system for covering an entrance of an underground structure. The cover system comprises a frame structure attached to a foundation of the entrance; and a seal gasket configured to provide a seal between the frame structure and the foundation and between the frame structure and a panel of the cover system. The panel further includes a plurality of engagement members that engage the panel with the frame structure.

According to some embodiments, the panel includes a plurality of openings that provide access to the engagement members. Each opening is covered by a lid with a seal gasket. The frame structure includes a plurality of rails with protrusions adapted to be inserted into receptacles in the foundation. The protrusions are detachable from the rails. The frame structure further includes a plurality of corner rails. The frame structure further includes a plurality of cross bars, each having a pressing member for pushing a corresponding rail against a foundation of the entrance. At least one rail includes a pressing member that pushes an adjacent rail against the foundation. The engagement member includes a toggle clamp. The toggle clamp includes a toggle part attached to a base that is attached to a surface plate of the panel. At least one toggle clamp includes a leg extending beyond a height of the toggle part. The seal gasket includes two angled flaps.

BRIEF DESCRIPTION OF DRAWINGS

To the accomplishment of the foregoing and related ends, certain illustrative embodiments of the invention are described herein in connection with the following description and the annexed drawings. These embodiments are indicative, however, of but a few of the various ways in which the principles of the invention may be employed and the present invention is intended to include all such aspects and their equivalents. Other advantages, embodiments and novel features of the invention may become apparent from the following description of the invention when considered in conjunction with the drawings. The following description, given by way of example, but not intended to limit the invention solely to the specific embodiments described, may best be understood in conjunction with the accompanying drawings, in which:

FIG. **1** illustrates a cover system installed at the entrance of a subway according to an embodiment of the present application.

FIG. **2** illustrates a cover panel according to an embodiment of the present application.

FIG. **3** illustrates a frame structure according to an embodiment of the present application.

FIG. **4***a* illustrates a seal gasket according to an embodiment of the present application

FIG. **4***b* illustrates a cross-section of a seal gasket according to an embodiment of the present application.

FIG. **5***a* illustrates an attachment and a seal gasket between a frame structure and a foundation according to an embodiment of the present application.

FIG. **5***b* illustrates a pin covered by a cap according to an embodiment of the present application.

FIG. **6** illustrates a rail of a frame structure according to an embodiment of the present application.

FIG. **7***a* illustrates an attached pin according to an embodiment of the present application.

FIG. **7***b* illustrates a socket on a rail to accept a pin according to an embodiment of the present application.

FIG. **8** illustrates a pressing member according to an embodiment of the present application.

FIG. **9** illustrates a corner rail according to an embodiment of the present application.

FIG. **10** illustrates an attachment between a corner rail and another rail according to an embodiment of the present application.

FIG. **11** illustrates a pushing plate according to an embodiment of the present plate.

FIG. **12** illustrates a corner plate according to an embodiment of the present application.

FIG. **13** illustrates a cross bar according to an embodiment of the present application.

FIG. **14** illustrates a fixture mechanism of a cross bar according to an embodiment of the present application.

FIG. **15** illustrates a surface plate of the cover panel according to an embodiment of the present application.

FIG. **16** illustrates a toggle clamp according to embodiment of the present application.

FIG. **17** illustrates a toggle clamp according to an embodiment of the present application.

FIG. **18**(*a*) illustrates a configuration of a toggle clamp according to an embodiment of the present application.

FIG. **18**(*b*) illustrates a configuration of a toggle clamp according to an embodiment of the present application.

FIG. **19**(*a*) illustrates an engagement between a toggle clamp and a cross bar according to an embodiment of the present application.

FIG. **19**(*b*) illustrates an engagement between a toggle clamp and a rail according to an embodiment of the present application.

FIG. **20** illustrates a lid of a cover system according to an embodiment of the present application.

DETAILED DESCRIPTION

Embodiments of cover systems, components, and methods of installation are disclosed or are apparent from and encompassed by the description herein.

FIG. **1** depicts a section view of an installed cover system **100** at an entrance **106** of an underground structure **102** according to an embodiment. The underground structure **102** may include a subway, a basement, a tunnel, a vault, and any other structures that below the street level. An opening **106** may be typically provided to an underground structure so that workers and instruments may be moved into the underground structure and or be removed from the underground structure. As an entrance to an underground structure, the opening **106** may be typically free of any screen or grates. Structures **108**, such as safety guards, railing assemblies, and hand rails, may be installed around the periphery of the opening **106**. A cover system of the opening **106** that prevents water from entering the underground structure needs to adapt to the existing configurations of the opening and may not substantially change the current structures.

The cover system **104** as set forth in the present application seals the opening of an underground structure as shown in FIG. **1**. According to an embodiment, the cover system **104** is attached to the foundations **112** surrounding the underground opening. Any attaching means may be used, including glue, adhesive, bolts, nails, and screws. According to an embodiment, a plurality of receptacles **110** may be installed in the foundation **112**. The cover system **104** includes a plurality of protrusions to be contained in the plurality of receptacles. The cover system **104** may be further attached to the foundation **112** by a plurality of cross bars that are inside the cover system **104** and pushes periphery rails of the cover system **104** against the foundation **112**.

To provide a water seal between the cover system **104** and the foundation **112**, a gasket is placed therebetween and is pressed by the cover system against the foundation to form a proper seal. The gasket may be placed around the periphery of the cover system **104** and conform to the general contour of the cover system **104**. In addition, any other gaps between the cover system **104** and the foundation **112** and any other gaps of the cover system **104** are filled with water impermeable materials, such as room temperature vulcanizing silicones, caulks, foams, or adhesives.

As shown in FIG. **1**, the cover system **104** may use the step **110** of the entrance as a support component. Although a handrail **116** is shown in FIG. **1**, it may be removed before the installation of the cover system **104**. According to an embodiment, the cover system **104** as shown in FIG. **1** is designed to provide a protection to the underground structure in at least a Category 2 storm event determined based on National Weather Service's storm surge model or Sea, Lake and Overall Surges Model from Hurricanes ("SLOSH). According to an embodiment, the cover system **104** is capable of resisting a high tide of approximately 18 feet.

The cover system **104** as shown in FIG. **1** may be divided into a panel portion as shown in FIG. **2**, a frame portion as shown in FIG. **3**, and a seal gasket as shown in FIGS. **4**(*a*) and (*b*). Each portion will be discussed in detail in the following section of the present application.

FIG. **2** illustrates a panel **200** of the cover system **104** according to an embodiment of the present application. The panel **200** may be disengaged from the cover system **104** and stored separately from other components of the cover system. The detachable design of the panel **200** reduces the amount of weight of each part of the cover system and allows the cover system **104** to be handled manually, i.e. without using lifting machines such as cranes. Workers with regular physical strength would be able to install or disassemble the cover system **104**. The detachability of the panel **200** may be achieved by a plurality of engagement means **204** and **206**, which may be clamps, fasteners, screws, bolts, or ties.

According to an embodiment, the panel **200** includes a surface plate **202**, a plurality of first toggle clamps **204**, a plurality of second toggle clamps **206**, a plurality of support members **208**, a plurality of openings **210**, and a plurality of edge reinforcements **212**. The surface plate **202** is waterproof and substantially encloses an underground opening. The surface plate **202** may be made of a metal plate. The edges of the surface plates **202** may be enforced with additional members such as metal strips **212**.

The support members **208** may be placed on top of at least a cross bar **304** of a frame structure **300** as shown in FIG. **3** and support the surface plate **202** such that the surface plate **202** may not have excessive deformation or damage due to the water pressure. According to an embodiment, the support members **208** may be arranged substantially along a longitudinal direction of the panel **200** and are supported by a plurality of cross bars **304**. The support members **208** may be any structural members as long as they have suitable profiles determined by the distance between the surface plate **202** and the cross bars **304**. The support members **208** may be tubular members or solid members.

The first toggle clamps **204** and the second toggle clamps **206** are used to clamp the panel **200** to the frame structure **304** of the cover system. Any engagement means, other than toggle clamps, may be used to secure the panel **200** on a frame structure. The engagement means may include bolts, toggles, ties, screws, adhesives, and clamps. The toggle clamps is configured to engage with the cross bars **304** in a manner to secure the panel **200** to the frame structure **300**. The second toggle clamps **206**, which have legs longer than the first toggle clamps **204**, may also be used to support the panel **200** during storage or transportation.

The plurality of openings **210** provide access to the engagement members **206** and **204** such that installers operate the engagement members via the openings **310** to secure the

panel to a frame structure. The plurality of openings may also be covered by a lid and a seal to prevent water from entering therethrough. The lid may be additionally secured to the surface plate **202** by screws, bolts, rivets, or any other proper means for securing purposes.

Any material that may provide structural strength may be used to make the panel **200**, the surface plate **202**, or any other components of the panel, including metal, stainless steel. Aluminum, alloy, and plastic. According to an embodiment, the surface plate is made of Alloy 6061-T6.

FIG. **3** illustrates a frame structure **300** according to an embodiment of the present application. The frame structure **300** is secured to the foundation **112** of an underground opening **106** and supports the panel **200**. The frame structure **300** includes a plurality of rails, such as a plurality of longitudinal rails **310** and a plurality of end rails **308**. A plurality of protrusions **306** may be provided to the rails **310** and **308**. These protrusions may be inserted into receptacles **504** as shown in FIG. **5**(*b*) installed in the foundation. The frame structure **300** further includes a plurality of cross bars **304**, which are configured to push the rails against the foundation. The cross bars **304** may be arranged along the longitudinal direction or the cross direction of the frame structure **300**. According to an embodiment, the cross bars **304** are preferably arranged along the cross direction. The cross bars **304** may be evenly distributed inside the frame structure to provide a uniform pressure against the foundation. According to an embodiment, one cross bar **304** is placed in the middle between every two protrusions **306**.

A seal gasket **302** may be placed over the frame structure **300** to cover both the top and side surfaces of the frame structure. The panel **200**, by way of this weight, the weight of water on top of it, and the pressure exerted by the engagement members, presses the seal gasket against the frame structure **300**, thus forming a water tight seal between the panel **200** and the frame structure **300**. The cross bars **304** presses the rails **310** and **308**, which in turn push the seal gasket **302** against the foundation, thus forming a water tight seal between the rails and the foundation of an opening.

FIG. **4***a* illustrates a general configuration of a seal gasket **302** according to an embodiment of the present application. The seal gasket **402** generally conforms to the contour of the frame structure or the underground opening and extends around the periphery of the frame structure **300**. The seal gasket **302** may be made of any flexible or elastic material including rubber, foam, metal, and plastic. According to an embodiment, the seal gasket **302** is prefabricated before installation of the cover system **104** and then assembled with the panel and the frame structure on site. The seal gasket **302** may be in a form of a single connected rectangular piece that fits snugly behind and around the rails. According to an embodiment, the seal gasket **302** is formed on site by using any curable polymeric materials.

FIG. **4***b* illustrates a cross-section view of the seal gasket **302** according to an embodiment of the present application. The cross-section **400** includes a top portion **404** and a side portion **412**. The top portion **404** includes a flat part **412** connected with a tilted part **408**. The tilted part **408** forms an angle with the flat part **412** and is deformable in response to the pressure exerted by the panel **200**. This angled flap **408** is capable of improving the watertight function between the panel **200** and the frame structure **300**. The side portion **412** also includes a vertical part **406** and a tilted part **410**. The tilted part **410** forms an angle with the vertical part **406** and is adaptable to the pressure exerted by the rails, thus forming an improved water seal like the top part **404**. As shown in FIG. **4**(*b*), the top part **404** and the side part **412** are integrated with each other and form a single piece. According to an embodiment, the two parts are separated from each other and may be applied or installed independently.

FIG. **5***a* illustrates the attachment and the seal between the cover system **104** and the underground opening **106**. A plurality of receptacles **504** may be first installed in the foundation **112** of an underground opening **106**. The receptacles may be a plurality of tubular members that are capable of holding an insertion. The receptacles may be secured to the foundation by any proper ways including anchors, adhesives, or self-expansion. According to an embodiment, the receptacles are attached in the foundation by epoxy. The rails **310** or **308** include a plurality of protrusions **306** that are inserted into the receptacles **504**. The insertion may be temporary or may be permanent. The protrusions are preferably to be slidable inside the receptacles **504**, which allow the rails **310** or **308** to get closer to the foundation **112**. The seal gasket **302** is place above the receptacles **504** and is pressed between the rails **310** or **308** and the foundation **112**, thus preventing water from entering or seeping through any gaps between the rails and the foundation. According to an embodiment, the receptacles **504** further include a retaining mechanism **512** adaptable to accept and retain an enclosure structure that covers the receptacle.

FIG. **5***b* illustrates a receptacle **504** that has a cap **514** according to an embodiment of the present application. When the cover system **104** is not installed, the receptacles **504** need to be enclosed to prevent external objects from clogging the receptacles. In an embodiment, the receptacle **500** is covered by a cap **514**. To maintain the cap **514** in a proper position, the cap **514** is attached to an extension **514** and a stopper **518**. The extension **514** and the stopper are attached to each other in a way to allow the distal end of the extension part fit properly inside the retaining mechanism **512**. The cap **514** may be attached to the proximal end of the extension part **516** by thread or welding or any other suitable ways.

FIG. **6** illustrates a rail **600** according to an embodiment of the present application. The rail **600** may be used as the longitudinal rails **310** or the end rails **308** as shown in FIG. **3**. The rail **600** is configured to be attached to a foundation of an underground opening and support a panel portion. The rail **600** may be of any shape or configuration as long as it provides adequate contact areas for the panel. The rail **600** may be made of any material with proper strength.

According to an embodiment, the rail represents a tubular member having an open or closed cross-section. The rail **600** may be formed by attaching a plurality of plates or strips made of metals, alloys, aluminum, or plastic. The rail **600** includes a first end **602**, a second end **612**, a plurality of protrusions **606**, a plurality of reinforcement ribs **604**, and a pressing member **608** at the **602**. The first end **602** may be beveled at its lower portion **610**, where the rail meets with another one. The plurality of protrusions **606** may be formed integrally with the rail by welding, adhesive, or any other proper ways. The protrusions may also be detachably attached to the rail **600**. According to an embodiment, the protrusion **606** represents a pin or a bar that is inserted into a socket **704** of the rail as shown in FIG. **7**(*b*). The reinforcement ribs **604** are placed adjacent to the sockets **704** to reinforce the sockets and prevent them or the protrusions or the surrounding plates from being damaged by the weight of the water load of the panel **200**.

According to an embodiment, cross bars **304** are used in a frame structure to push longitudinal rails **310** against the foundation. To engage the end rails along the cross direction with the foundation, a pressing member **608** is added to the longitudinal rails. The pressing member **608** is adapted to

move along a direction parallel to that of the rail **600**. After the rail **600** is firmly secured in position by the cross bars, the press member **608** is operated to exert pressure on an adjacent rail, such as an end rail, thus pressing that rail against the seal gasket and the foundation.

FIG. **7***a* illustrates the protrusion **606** on a rail according to an embodiment of the present application. A socket **704** is secured to the rail **708**. A reinforcement rib **604** is also used to enhance the attachment. In addition to the rib **604**, a plurality of ribs **706** may be attached to the rail **708** to enhance the mechanical strength of the rail. The socket **704** may be secured to the rail by welding, screws, bolts, or rivets. According to an embodiment, the socket **704** flushes with the surface of the rail **708** to have a smooth contact area with the seal gasket. The protrusion **606** may be a solid bar or a hollow pin that is permanently attached to the socket **704**. FIG. **7***b* illustrates a socket **704** after the protrusion **702** is removed. According to an embodiment, the protrusion **702** may be removable from the socket **704**.

FIG. **8** illustrates a pressing member **608** according to an embodiment of the present application. An extension member **814** attaches the pressing member **608** with the rail **600**. The extension member **814** is configured to be perpendicular to the rail such that the attached pressing member **608** has a movement parallel to the rail. The pressing member **800** includes a shaft **810** having a free end **812** and a contact end **804**. The free end **812** has a configuration for engaging with a tool, such as a screw driver or a socket driver, for operating the shaft **810**. The contact end **804** connects with a leveling member that is capable of rotating around the contact end **804**. When the shaft **810** is operated, the leveling member **802** attempts to apply an even pressure against another structure in contact. The shaft **810** engages with the extension part **814** via a tubular member **808** attached to the extension part **814** via a plurality of screws or rivets **806**. Both the shaft **810** and the tubular member **808** are threaded so that they can move relative to each other. According to an embodiment, the tubular member **808** is a nut.

FIG. **9** illustrates a supplemental segment **900** according to an embodiment of the present application. The supplemental segment **900** may be a corner rail that is attached to an end of a longitudinal rail or an end rail. In an application, the supplemental segment **900** may be used to make the rails be adaptive to openings with irregular shapes. According to an embodiment, the supplemental segment **900** includes an end portion **902** and a middle portion **904**. The middle portion **904** may be removable from the supplemental segment **900**, thus making the length of the supplemental segment **900** adjustable.

The end portion **902** may be beveled at the part **906** where the end portion meets with another one. The end portion also includes an attachment rib **908** that has at least one opening used to accommodate an attachment member such as a bolt. The middle portion **904** also includes a rib **910** that has a similar function as that of the rib **908**.

FIG. **10** illustrates a configuration of a corner of a frame structure wherein a supplemental segment **900** is attached to a rail **1006** according to an embodiment of the present application. A bolt **1002** and a nut **1004** secure the supplemental segment **900** with the rail **1006** via the rib **908** and the rib **1006**. To apply pressure evenly across both the supplemental segment **900** and the rail **1006**, the pressing member **608** presses both the corner rail and the rail via a pressing plate **1008**. The pressing plate **1008** has adequate length to cover both segments and has adequate stiffness to distribute the pressure of the pressing member **608** evenly.

FIG. **11** illustrates the pressing plate **1008** according to an embodiment of the present application. The pressing plate **1008** includes a depression **1102** and a plurality of protrusions **1104**. The pressing plate **1008** has a length that covers both the corner rail and the rail. The protrusions restrict the parallel movement of the pressing plate when the pressing member **608** engages with the pressing plate. The depression **1102** has a similar shape with the leveling member **804** of the pressing member **608**.

FIG. **12** illustrates a corner plate according to an embodiment of the present application. The corner plate **1200** may be used to reinforce the corner of the frame structure where two rails meet with each other. The corer plate may further be used to cover gaps formed between those two rails and provide a wider contract area with the panel **200**. The corner plate has a general "L" shape characterized by a first side **1202** and a second side **1204**, wherein the first side and the second side are perpendicular to each other. Both sides **1202** or **1204** are attached to the rails. The corner plate **1206** also has a step like configuration, wherein the portion **1206** and the portion **1208** are offset from each other by a predetermined distance corresponding to the thickness of a surface plate of the rails. The offset between portions **1206** and **1208** is set so that when the portion **1208** is placed under a rail, the portion **1206** flushes with the top surface of that rail.

FIG. **13** illustrates a cross bar **304** according to an embodiment of the present application. According to an embodiment, the cross bar **304** represents a tubular member with a center body **1302** and two tongues **1304** and **1314**. The center body **1302** supports the panel **200** via the plurality of support members **208** as shown in FIG. **2**. The two tongues **1304** and **1314** may be inserted into the rails **310** or **308**. The cross bar **304** also includes at least one pressing member **608** capable of extending though any one of the tongues **1304** and **1314**. As both the tongue **1304** and **1314** directly contact with the rails, reinforcement members **1306** and **1308** are placed at both tongues. The center body **1302** further includes an opening **1310** providing access to the pressing member **608** inside the cross bar **1300**. The cross bar **304** also includes a plurality of openings at the bottom. These openings are used to provide engagement locations to the toggle clamps **206** and **204**.

FIG. **14** illustrates a pressing member **1402** inside the cross bar **304** according to an embodiment of the present application. The pressing member **1402** may have a similar configuration as the pressing member **608** shown in FIG. **8**.

FIG. **15** illustrates a surface plate according to an embodiment of the present application. The surface plate **1500** includes a plurality of openings **1502** that provide access to components inside a panel. According to an embodiment, an installer of the cover system may use the openings **1502** to access toggle clamps inside the panel. According to an embodiment, each of the openings **1502** is covered by a lid and a seal gasket, which is sandwiched between the lid and the surface plate to form a water tight seal. The surface plate **1500** is preferably made of one piece of a metal plate that is bent in the corners to have suitable waterproof features and mechanical strength.

FIG. **16** illustrates an engagement member **204** according to an embodiment of the present application. The engagement member may be implemented as a toggle clamp which includes a toggle part **1610** attached to a base **1606**. The toggle part **1610** may include an engagement tip **1608**, a handle **1602**, and a lever **1604**. The handle **1602** is pivotally rotatable around a pin **1612**, which engages or disengages the tip **1608** with the cross bars **304**. The toggle part **1602** may use any commercially available one, such as toggle clamps made by Rockler. The base **1606** is attached to the surface plate of a panel. The height of the base **1606** is configured based on the height of the support member **08** and the cross bars **304** such

that when the toggle clamp **204** is in an engagement position, the engagement member **1608** firmly engages with a cross bar adjacent to the toggle clamp **204**. The tip **1608** is attached to the level by a bolt **1610**, which allows the relative position between the tip **1608** and the lever **1604** to be adjustable.

FIG. **17** illustrates an embodiment of a toggle clamp **206** according to an embodiment of the present application. The toggle clamp **206** may be used to support the panel. The toggle clamp **206** is similar as that of the toggle clamp **204** as shown in FIG. **16** except that the base includes a longer leg **1702**. The length of the leg **1702** is configured to be not shorter than the total height of the toggle part and the base. Thus, when the toggle clamp **206** is used to support the panel, the handle of the toggle part will not be damaged.

FIGS. **18**(*a*) and (*b*) illustrate an embodiment of a toggle part. The toggle part **1800** includes an engagement tip **1806**, whose height is adjustable. The toggle part **1800** further includes another adjustable tip **1804** attached to the lever via a nut **1802**. This additional tip **1804** may provide further engaging force between the clamp and the cross bars.

The cover system and components may be made of any suitable material that provides the required structural strength and satisfies use and environmental constraints, including aluminum, metal alloy, stainless steel, composites, plastic, etc. According to one embodiment, the panel, rails, and cross bars are made of an aluminum alloy, such as Alloy 6061-T6 or 5052-H4.

FIG. **19**(*a*) illustrates a toggle clamp engaging a cross bar according to an embodiment of the present application. The toggle clamp such as those clamps **206** in FIG. **2** is attached to a surface plate and extends beyond the bottom of the cross bar **304**. The engagement tip **1806** is configured to contact the bottom of the cross bar **304** such that the panel is secured to the frame structure of the cover system. FIG. **19**(*b*) illustrates a toggle clamp engaging a rail according to an embodiment of the present application. In addition to cross bars, a toggle clamp, such as the toggle clamp **206**, may engage a rail **600**. The toggle clamp may engage a top plate of the rail as shown in FIG. **19**(*b*) or engage the bottom of the rail **600**.

FIG. **20** illustrates a lid that covers an opening **210** of the panel **200** according to an embodiment of the present application. The lid or hatch **2002** is secured to the panel **200** by a plurality of clamps **2004**. A seal gasket **2006** is placed between the hatch **2002** and the surface plate of the panel **200** to form a water tight seal.

The particular embodiments disclosed above are illustrative only, as the invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the invention. Although illustrative embodiments of the invention have been described in detail herein with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments, and that various changes and modifications can be effected therein by one skilled in the art without departing from the scope and spirit of the invention as defined by the appended claims.

What is claimed is:

1. A cover system for covering an entrance of an underground structure, comprising:

a panel;

a frame structure having a plurality of protrusions that slidably engage a plurality of receptacles of the entrance,

wherein a first gap is formed between the panel and the frame structure, and a second gap is formed between the frame structure and the entrance; and

a seal gasket of a single piece configured to seal both first and second gaps between the frame structure and the entrance and between the frame structure and the panel of the cover system,

wherein the panel further includes a plurality of engagement members that engage the frame structure, and

wherein the entrance represents an entrance that allows a worker to enter a subway tunnel.

2. The cover system of claim **1**, wherein the panel includes a plurality of openings that provide access to the engagement members.

3. The cover system of claim **2**, wherein each opening is covered by a lid with a seal gasket.

4. The cover system of claim **1**, wherein the frame structure includes a plurality of rails with protrusions adapted to be inserted into receptacles in the foundation.

5. The cover system of claim **4**, wherein the protrusions are detachable from the rails.

6. The cover system of claim **4**, wherein the frame structure further includes a plurality of corner rails.

7. The cover system of claim **4**, wherein the frame structure further includes a plurality of cross bars, each having a pressing member for pushing a corresponding rail against a foundation of the entrance.

8. The cover system of claim **4**, wherein at least one rail includes a pressing member that pushes an adjacent rail against the foundation.

9. The cover system of claim **1**, wherein the engagement member includes a toggle clamp.

10. The cover system of claim **9**, wherein the toggle clamp includes a toggle part attached to a base that is attached to a surface plate of the panel.

11. The cover system of claim **10**, wherein at least one toggle clamp includes a leg extending beyond a height of the toggle part.

12. The cover system of claim **1**, wherein the seal gasket includes two angled flaps.

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