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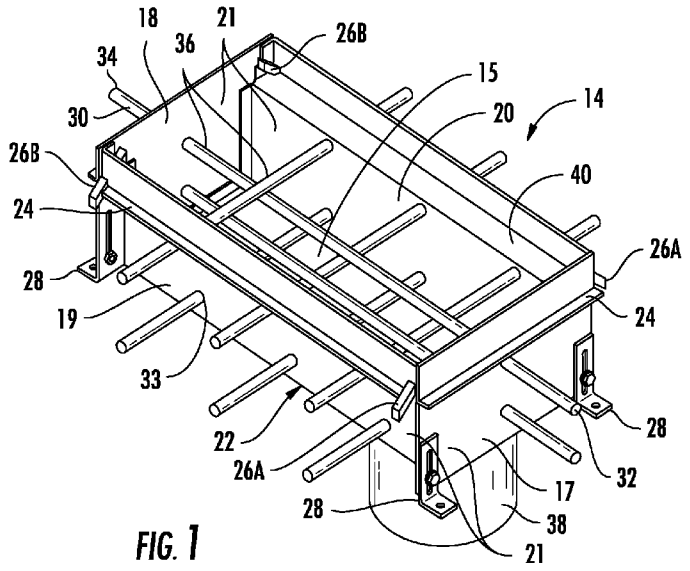


FIG. 1

(57) Abstract: The present invention is manufactured to prevent the difficulties that may arise when installing a drainage system into a trench that has been cut into a sidewall of a building containing a network of structural members. The present invention is developed to produce a secure and effective connection between the structural member(s) of a drainage system and the structural members in the sidewall of a building in order to increase the stability of the drainage system within the sidewall.

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DRAINAGE DEVICE AND METHODS FOR CONSTRUCTING AND USE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application No. 62/518,427, entitled "DRAINAGE DEVICE AND METHODS FOR CONSTRUCTING AND USE," filed June 12, 2017, U.S. Provisional Application No. 62/545,104, entitled "STRUCTURALLY REINFORCED DRAINAGE AND METHODS OF MANUFACTURE AND INSTALLATION," filed August 14, 2017, and U.S. Provisional Application No. 62/545,112, entitled "STRUCTURALLY REINFORCED DRAINAGE AND METHODS OF MANUFACTURE AND INSTALLATION," filed August 14, 2017. All three of the foregoing provisional applications are incorporated herein by reference in their entireties.

FIELD

[0002] The invention relates generally to drainage systems and, more particularly, relates to methods of manufacture and installation of a drainage system having an open-faced channel and at least one structural member for reinforcement.

BACKGROUND

[0003] Drainage systems comprising channels and trenches of various sizes and shapes are desirable for a number of applications. For example, manufacturing facilities typically require drainage systems that include trenches formed in the building floors to collect, remove, and/or recycle excess water or other liquids. These trenches may also be used as utility chases to provide temporary or permanent routing of electrical lines, pipes, conduits or the like below the level of the building floor. In addition, numerous outdoor industrial and commercial sites, such as parking lots and airports, also require drainage systems to collect and direct rainwater and

other liquids to underground storm sewers to prevent flooding and to decrease run-off. Likewise, buildings with flat or built-up roofs typically require drainage systems, including scuppers, formed in the sidewalls or roofs of the buildings to collect, direct, and prevent pooling of rainwater on the roofs of the buildings. Additionally, roadways, bridges, and the like may also require drainage systems, including trenches and scuppers.

[0004] A scupper is a drainage system that includes a trench cut into a sidewall of an open-air structure (e.g., a bridge or elevated roadway) for the purpose of draining water off the side of the structure, rather than allowing the water to create a pool within the sidewall(s). In the past, scuppers have generally been formed by first cutting a trench into an existing sidewall of an open-air structure and then placing and securing a precast, open-faced channel, which may have one or more channel sections, in the trench. A moldable composition, such as cementitious material, is then poured around the open-faced channel and allowed to set. In particular, the open-faced channel may be supported on a plurality of downwardly extending legs which are positioned on the surface at the bottom of the trench. If the open-faced channel has more than one channel section, pouring a subslab may be necessary to prevent the buoyancy of the channel sections in the wet concrete from causing the sections to float out of position and become misaligned. To form a subslab, a first pour of concrete is made to a level below the open-faced channel and allowed to harden. A second pour of concrete is then applied over the subslab up to the upper edges of the open-faced channel to fully embed the channel. Current designs limit the size of the components of the scupper to have minimum disruption of the panel reinforcement (i.e., concrete and rebar infrastructure of the open-air structure) or making the whole scupper sufficiently strong to transfer the structural loads around the panel penetration.

[0005] Once the concrete has set, it is normally desirable to finish the drainage channel with a trench cover, such as an elongate grate covering its open top, in order to prevent people from unwittingly stepping in the open trench, to provide a smooth surface, and/or to prevent relatively large objects from entering the trench and potentially blocking the flow of liquid therethrough. The trench cover is typically removable and supported by a support surface defined longitudinally along an inner portion of each opposed wall of the open-faced channel.

[0006] Scuppers are especially useful in draining parapet walls on flat or built-up roofs of buildings. A parapet is an extension of the sidewall at the edge of an open-air structure, such as a roof, terrace, balcony, or bridge. On certain open-air structures, parapet walls contain a continuous, internal network of structural members for reinforcement of the parapets. Difficulties may arise, however, when a trench must be cut into a parapet wall that contains a network of structural members in order to install a scupper. Unfortunately, cutting into a network of structural members inside a parapet wall creates a weak point in the sidewall that may cause a parapet to break off and detach from the open-air structure.

[0007] Traditionally, parapet walls were used as a defense against attack, shielding soldiers and warriors standing on top of open-air structures from arrows and projectiles shot or catapulted into the air. However, today, parapet walls are primarily used as guard rails, protecting people and objects from falling off the side of open-air structures. As such, it is of great importance to maintain the continuous, internal network of structural members for reinforcement when installing drainage systems into parapet walls.

BRIEF SUMMARY OF EMBODIMENTS OF THE INVENTION

[0008] The following is a brief summary of the invention and is not intended to limit the scope of the invention.

[0009] The present invention is manufactured to prevent the difficulties that may arise when installing a drainage system into a trench that has been cut into a sidewall of a building containing a network of structural members. The present invention is developed to produce a secure and effective connection between the structural member(s) of a drainage system and the structural members in the sidewall of a building in order to increase the stability of the drainage system within the sidewall.

[0010] In accordance with some embodiments, a drainage system having an open-faced channel, preferably precast, is provided. The drainage system may be structured to be fixedly embedded within a curable medium or pourable composition, such as concrete, which may have a structural support comprising a plurality of structural members. The drainage system may comprise a first and second lateral side and a first and second end member or, collectively, four sidewalls. The first end member is attached to one end of the first and second lateral sides, the second end member is attached to the opposing end of the first and second lateral sides, and the first and second lateral sides and the first and second end members are spaced apart by a predetermined distance to define an interior space therebetween. Preferably, the four sidewalls are connected to a bottom wall which is attached to a bottom end of the first and second lateral sides and a bottom end of the first and second end members.

[0011] At least one of said first lateral side, second lateral side, first end member, and second end member may define an aperture therethrough structured to receive one of the plurality of structural members to thereby tie the drainage system into the structural support for the curable medium. In some embodiments, at least one of said first lateral side, second lateral side, first end member, and second end member may define an aperture therethrough structured to matingly engage one of the plurality of structural members to thereby tie the drainage system

into the structural support for the curable medium. In some embodiments, a different one of said first lateral side, second lateral side, first end member, and second end member may define an additional aperture structured to matingly engage the one of the plurality of structural members.

[0012] Each sidewall of the open-faced channel preferably includes at least one anchor flange extending along its length to anchor the drainage system within the curable medium or moldable composition poured around the open-faced channel. The anchor flanges are preferably continuous and integrally formed in the sidewalls.

[0013] The drainage system may be configured to be attached to at least one structural member and, preferably, a network of structural members. The structural member(s) are preferably formed of stainless steel, galvanized, or coated on the exterior with a water-resistant substance. The first end of at least one structural member may extend through an aperture in at least one of the sidewalls of the open-faced channel. In some embodiments, the second end of the structural member may extend through an aperture in at least a different one of the sidewalls of the open-faced channel. The first and second ends of a structural member are adapted to connect to the ends of structural members located within the sidewall of a trench and are preferably permanently attached to the apertures in the sidewalls of the open-faced channel.

[0014] The open-faced channel further includes an upper side edge that preferably includes a support surface for supporting a trench cover, such as a grate or a plate. In such embodiments, the support surface may be defined longitudinally by an upper side edge of the first lateral side and an upper side edge of the second lateral side. According to one advantageous embodiment, the trench cover is formed of a metal, merely set upon the support surface, and held in place by gravity, without utilizing any additional hardware to attach the trench cover to the open-faced channel. Such an embodiment allows the trench cover to be

readily removed in order to access the trench, such as to clean the trench or remove some object from the trench. In another embodiment, the trench cover can be secured in place via retention members extending through the sidewalls, which can be inserted and removed as necessary to secure and remove the trench cover, respectively.

[0015] Additionally, the drainage system preferably includes a conduit connector capable of interconnecting various drainage system components, such as a conduit and a downspout. According to one advantageous embodiment, the conduit connector is embedded within the bottom wall of the open-faced channel such that the conduit connector does not protrude substantially beyond the inner and outer surfaces of the wall. In some embodiments, the bottom wall may be slanted at an angle toward the conduit connector.

[0016] In some embodiments, the drainage system may further comprise a stationary retention pin placed within a first hole in at least one of the first and second lateral sides and the first and second end members, wherein the stationary retention pin is configured to retain a first integrally-formed lug of the trench cover. The drainage system may further comprise a removable retention pin placed within a second hole in at least one of the first and second lateral sides and the first and second end members, wherein the removable retention pin creates a space between the removable retention pin and a second integrally-formed lug of the trench cover, wherein the drainage system further comprises a removable plate configured to occupy the space between the removable retention pin and the second integrally-formed lug of the trench cover to facilitate retention of the trench cover.

[0017] In some embodiments, the open-faced channel may further comprise one or more installation legs that are removably attached to the open-faced channel, where the installation

legs are configured to secure the open-faced channel within the curable medium or moldable composition.

[0018] The present invention also provides a method of manufacture and installation of a drainage system having an open-faced channel and at least one structural member for reinforcement. The method of installation comprises providing an open-faced channel having a first and second lateral side and a first and second end member, wherein the first end member is attached to one end of the first and second lateral sides, the second end member is attached to the opposing end of the first and second lateral sides, and the first and second lateral sides and the first and second end members are spaced apart by a predetermined distance to define an interior space therebetween. The method may further comprise providing at least one structural member having a first and second end, wherein the first end of a structural member extends through an aperture in at least one of the first and second end members or the first and second lateral sides, positioning the drainage system in a trench, wherein the trench comprises at least two sidewalls that each contain at least one structural member having an end, and securing the first end of a structural member of the drainage system to an end of a structural member in a sidewall of the trench.

[0019] In some embodiments, the second end of the structural member of the drainage system may extend through an aperture in at least a different one of the first and second end members or the first and second lateral sides. In such embodiments, the method may further comprise securing the second end of the structural member of the drainage system to an end of a structural member in a different sidewall of the trench.

[0020] The method of manufacturing the drainage system may comprise providing an open-faced channel having a first and second lateral side and a first and second end member,

wherein the first end member is attached to one end of the first and second lateral sides, the second end member is attached to the opposing end of the first and second lateral sides, and the first and second lateral sides and first and second end members are spaced apart by a predetermined distance to define an interior space therebetween, wherein at least one of said first lateral side, second lateral side, first end member, and second end member define an aperture structured to receive or matingly engage one of the plurality of structural members to thereby tie the drainage system into the structural support for the curable medium. In some embodiments, a different one of said first lateral side, second lateral side, first end member, and second end member may define an additional aperture structured to receive or matingly engage the one of the plurality of structural members.

[0021] In accordance with additional embodiments of the present invention, a drainage system having an open-faced channel may be provided. The open-faced channel may be defined by first and second ring members and a collection member. Each of the first and second ring members may comprise a pair of end members and a pair of lateral side members that can be formed integrally together or formed separately and then welded together or secured together using mechanical fasteners. Each of the first and second ring members may define an opening or aperture that is structured to receive the collection member. The first and second ring members may further comprise a plurality of reinforced apertures to which one or more structural members (e.g., rebar) may be attached. In this regard, the collection member may comprise a first set of apertures around a perimeter of the collection member which correspond to the apertures of the first ring member and a second set of apertures around the perimeter of the collection member which correspond to the apertures of the second ring member. Typically, the

first ring member is positioned above the second ring member such that the first set of apertures are located above the second set of apertures.

[0022] The first ends of a first set of structural members may be inserted through the apertures of the first ring member and the first set of apertures of the collection member, and the first ends of a second set of structural members may be inserted through the apertures of the second ring member and the second set of apertures such that the structural members of the open-faced channel may secure the collection member to first and second ring members. In this way, the collection member may be removably coupled to the first ring member and the second ring member. The second ends of the structural members of the open-faced channel may then be secured to the structural members within the sidewalls of the trench in order to secure the open-faced channel to the trench.

[0023] In some embodiments, the first ring member may additionally provide a support surface for installing a trench cover or grate. In some embodiments, the reinforced apertures within the first and second ring members may positioned in a staggered configuration such that the apertures of the first ring member are not vertically aligned with the apertures of the second ring member. In other embodiments, the apertures of the first and second ring members may be positioned in a stacked configuration such that said apertures are vertically aligned with one another.

[0024] In accordance with additional embodiments of the present invention, a drainage system comprising an open-faced channel may be provided. The open-faced channel may define an interior, a length, a width, or a depth and may resemble a rectangular prism with solid side surfaces, solid end surfaces, a solid bottom surface, and an open top surface. The interior of the open-faced channel is configured to receive liquids (e.g., rainwater) from a surface (e.g., a

driving surface, a roadway, or the like) that are channeled through the open top surface of the open-faced channel. The side and end surfaces of the open-faced channel are typically perpendicularly coupled to the bottom surface so that the open-faced channel forms a bottom portion that resembles an open-topped rectangular prism. The open-faced channel may comprise one or more reinforced apertures distributed laterally around a perimeter of the open-faced channel, wherein the reinforced aperture is a cylindrically-shaped opening oriented perpendicularly to the perimeter of the open-faced channel.

[0025] The bottom of the open-faced channel may comprise an aperture such as a conduit channel and associated drainage pipe extended from the conduit channel. The conduit channel and drainage pipe may be connected to any section of the bottom wall of the open-faced channel. The remaining portions of the bottom wall of the open-faced channel may be slanted at an angle in the direction of the conduit channel, such that fluid entering the open-faced channel is directed to the drainage pipe for drainage from the open-faced channel.

[0026] One or more coupling extensions (which may be referred to herein as "coupling members") may be positioned proximate to a top portion of the sidewalls and extend from the outer side walls of the open-faced channel for coupling the open-faced channel to a structure, such as a trench. The coupling member may comprise a diagonally oriented hollow portion configured to accept a removable retention pin, wherein the removable retention pin is configured to secure the open-faced channel within a curable medium or moldable composition. One or more pipe-to-pipe sleeves may also extend from the outer surface of the open-faced channel. In some embodiments, a hole is located through a sidewall in the open-faced channel and is in fluid connection with the pipe sleeve. In some embodiments, removable retaining pins

may be located on the interior of the open-faced channel extending from the interior corners of the open-faced channel.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0027] Having thus described embodiments of the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

Figure 1 is a top, left-side perspective view of a drainage system according to one embodiment of the present invention before being placed into a trench and secured with a moldable composition;

Figure 2A is a top, left-side perspective view of a drainage system according to a second embodiment of the present invention, comprising a trench cover, before being placed into a trench and secured with a curable medium;

Figure 2B is a plan view of the drainage system shown in Figure 2A;

Figure 2C is a cross-sectional view of the section 2C designated by the upwards arrows of the drainage system shown in Figure 2B after being placed into a trench and secured with a curable medium;

Figure 3 is a top, left-side perspective view of the drainage system shown in Figure 2 after being placed into a trench and secured with a curable medium;

Figure 4 is an enlarged cross-sectional view of the section 4 designated by the inwards arrows of the broken oval of the drainage system shown in Figure 2C;

Figure 5 is an enlarged cross-sectional view of the section 5 designated by the inwards arrows of the broken oval of the drainage system shown in Figure 2C;

Figure 6 is a cross-sectional view of the section 6 designated by the rightwards arrows of the drainage system shown in Figure 4;

Figure 7 is an enlarged cross-sectional view of the section 7 designated by the inwards arrows of the broken circle of the drainage system in Figure 6;

Figure 8A is a plan view of a drainage system in accordance with another embodiment of the present invention before being placed into a trench and secured with a curable medium;

Figure 8B is a cross-sectional view of the section 8B designated by the upwards arrows of the drainage system shown in Figure 8A after being placed into a trench and secured with a curable medium;

Figure 9A is top, left-side perspective view of a drainage system according to another embodiment of the present invention before being placed into a trench and secured with a curable medium;

Figure 9B is a plan view of the drainage system shown in Figure 9A;

Figure 9C is a cross-sectional front view of the drainage system shown in Figure 9A;

Figure 9D is a cross-sectional side view of the drainage system shown in Figure 9A;

Figure 9E is a cross-sectional cutaway view of the section 9E designated by the leftward arrows of the drainage system shown in Figure 9C;

Figure 9F is a cross-sectional cutaway view of the section 9F designated by the leftward arrows of the drainage system shown in Figure 9D;

Figure 9G is an exploded view of the drainage system as shown in Figure 9A;

Figure 10A is a top, left-side perspective view of a drainage system according to another embodiment of the present invention before being placed into a trench and secured with a curable medium;

Figure 10B is a plan view of the drainage system shown in Figure 10A;

Figure 10C is a cross-sectional view of the section 10C designated by the leftward arrows of the drainage system shown in Figure 10D;

Figure 10D is a cross-sectional view of the section 10D designated by the leftward arrows of the drainage system shown in Figure 10C;

Figure 10E is a cross-sectional cutaway view of the section 10E designated by the leftward arrows of the drainage system shown in Figure 10C;

Figure 10F is a cross-sectional cutaway view of the section 10F designated by the leftward arrows of the drainage system shown in Figure 10D;

Figure 11A is a top, right-side perspective view of a drainage system according to another embodiment of the present invention before being placed into a trench and secured with a curable medium;

Figure 11B is a plan view of the drainage system shown in Figure 11A;

Figure 11C is a cross-sectional front view of the drainage system shown in Figure 11A; and

Figure 11D is a cross-sectional view of the section 11D designated by the upward arrows of the drainage system shown in Figure 11B.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0028] Embodiments of the present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all, embodiments of the invention are shown. Indeed, the invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein;

rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Like numbers refer to like elements throughout.

[0029] Referring to the drawings and, in particular, Figures 1-8B, a drainage system **14** having an open-faced channel **15** is illustrated prior to being placed in a preformed trench and secured with a curable medium **13** (which may also be referred to herein as "moldable composition"), as can be seen in Figure 3. The curable medium **13** may be a pourable mixture such as cement, which may include various cementitious materials. The open-faced channel **15** has a first and second end member **17**, **18** and a first and second lateral side **19**, **20**, as shown in Figure 1. Individually, each end member **17, 18** and lateral side **19, 20** is a sidewall of the open-faced channel **15**, and collectively, the first and second end members **17**, **18** and first and second lateral sides **19**, **20** make up the sidewalls **21**, where the lateral sides **19**, **20** and end members **17**, **18** are connected at the edges in a substantially perpendicular manner to form a rectangular shape.

[0030] In particular, the first end member is **17** attached to one end of the first and second lateral sides **19**, **20**, and the second end member **18** is attached to the opposing second end of the first and second lateral sides **19**, **20**. In this way, the lateral sides **19**, **20** are substantially parallel to each other and the end members **17**, **18** are substantially parallel to each other, such that the first and second lateral sides **19**, **20** and the first and second end members **17**, **18** are spaced apart by predetermined distances to define an interior space therebetween. In an exemplary embodiment, the distance between the first and second lateral sides **19**, **20** may be 8 – 14 inches, and the distance between the first and second end members **17**, **18** may be 20 - 45 inches. It should be understood that the foregoing dimensions are provided for illustrative purposes only, and that it is fully within the scope of the present disclosure for other dimensions

to be used as required by the applications for which the drainage system is to be used. As shown in Figure 2C and 8B, the drainage system **14** can also include a bottom wall **22**, whereby the sidewalls **21** extend upwardly from opposite sides of the bottom wall **22**.

[0031] As best shown in Figures 1, 2A-2C, and 3-5, the sidewalls **21** preferably include one or more anchor flanges **24** extending along the length of the sidewalls **21** to retain the position of the drainage system **14** when the curable medium **13** is poured around the open-faced channel **15**. Typically, the curable medium **13** is poured to a level that rises above the anchor flanges **24** such that the anchor flanges **24** become embedded within the curable medium **13** once the curable medium **13** has hardened. The anchor flanges **24** are preferably continuous and integrally formed in the sidewalls **21** to facilitate the retention of the position of the open-faced channel **15** within the curable medium **13**.

[0032] As best shown in Figures 1, 2A, and 2C, the open-faced channel **15** may comprise one or more installation legs **28** that may be secured to the curable medium **13** and/or the preformed trench. In a preferred embodiment, the installation legs **28** may be L-shaped such that the installation leg **28** is divided into a short portion and a long portion, where the short portion is perpendicularly attached to the long portion. The short portion of the installation leg **28** may comprise a hole through which fastening elements may be inserted to secure the installation leg **28** to the trench and/or the curable medium **13**. Said fastening elements may include screws, nuts, bolts, clips, pins, or the like. The long portion of the installation leg **28** may comprise a vertical adjustment slot through which an adjustable fastening element may be placed to adjustably attach the installation leg **28** to a sidewall **21** of the open-faced channel **15**. The adjustable nature of the adjustable fastening element and vertical adjustment slot facilitate positioning the open-faced channel **15** at a desired height within the preformed trench and

retaining that desired height when the curable medium **13** is poured around the open-faced channel **15**.

[0033] The open-faced channel **15** can be formed from any suitable material, such as a cementitious and/or thermosetting or thermoplastic polymeric material. For example, the open-faced channel **15** can be formed from a polymer/concrete aggregate material. More particularly, the open-faced channel **15** of one advantageous embodiment is formed from a thermosetting polymeric resin, such as acetone, and an aggregate material. The aggregate material is preferably a chemically inert material, such as silica or glacial till. In one embodiment, the open-faced channel **15** includes greater than about 85% by weight of aggregate.

[0034] Referring now to Figures 1, 2A-2C, 3, 6, 7, and 8A-8B, the drainage system **14** may be configured to receive at least one structural member **30** and, preferably, a network of structural members **36**. In some embodiments, the structural member **30** may be a reinforcing bar (referred to herein as "rebar"), and thus the network of structural members **36** may be a rebar network. Each structural member **30** has a first end **32** and second end **34** and is preferably formed of stainless steel, galvanized, or coated on the exterior with a water-resistant substance. In some embodiments, the first end **32** of a structural member **30** extends through an aperture **33** in at least one of the sidewalls **21** of the open-faced channel **15**, while the second end **34** of the structural member **30** extends through an aperture **33** in at least a different one of the sidewalls **21** of the open-faced channel **15**. In such embodiments, the apertures **33** matingly engage with the ends of the structural member. In a typical embodiment, a structural member **30** may extend through an aperture **33** in a first sidewall and extend through an aperture **33** in a second sidewall which is across from the first sidewall. For instance, a structural member **30** extending through an aperture 33 in the first lateral side **19** may extend through an aperture **33** in the second lateral

side **20**. Additionally or alternatively, a structural member **30** extending through an aperture **33** in the first end member **17** may extend through an aperture **33** in the second end member **18**.

[0035] The first and second ends **32**, **34** of a structural member **30** are adapted to connect to the ends of structural members **30** of a structural support located within the sidewalls of the preformed trench and may be permanently or removably attached to the apertures **33** in the sidewalls **21** of the open-faced channel **15**. By connecting the open-faced channel **15** to the structural members **36** within the trench sidewalls, the open-faced channel **15** may be secured in a more stable manner when compared to conventional methods. In some embodiments, one or more of the apertures **33** may be sealed by a sealing structure such as a grommet, gasket, bushing, or the like. Said sealing structures, which serve to help reduce and/or prevent fluid leakage near the apertures **33**, may preferably be made of an elastic material such as rubber, but may also be made of plastic or metal.

[0036] In some embodiments, a conduit connector **38** may be embedded within one of the sidewalls **21** or within the bottom wall **22** of the open-faced channel **15**, as depicted in Figure 2C and 8B. The conduit connector **38** can effectively connect a drainage system component, such as a conduit, which can serve as either an inlet or an outlet to the drainage system **14**. Preferably, the conduit connector **38** is embedded within the bottom wall **22** of the open-faced channel **15** by being integrally molded within the material forming the open-faced channel **15** during casting. In some embodiments, the bottom wall **22** of the open-faced channel **15** may be angled downward toward the conduit connector **38** such that fluids may be channeled into the conduit connector **38** using gravity. In other embodiments, the bottom wall **22** may be substantially level.

[0037] Additionally, as shown in Figures 2A-2C, 3-7, and 8A-8B, the drainage system **14** may also include a trench cover **42** that is preferably supported by a support surface **40** on the upper portion of the open-faced channel **15**. In such embodiments, the support surface **40** may be created by a lateral and vertical extension of the top portions of the lateral sides **19**, **20**, as best seen in Figures 1, 2A, and 7. For instance, if the trench cover **42** is in the shape of a rectangular prism, the top portions of the lateral sides **19**, **20** may extend laterally at a 90 degree angle from the side wall, then vertically at a 90 degree angle from the lateral extension in order to accommodate the rectangular trench cover **42**. The trench cover **42** may be arranged in a lattice configuration (e.g., a grate, grille, mesh, or the like) to permit fluids to pass therethrough while providing resistance against downward forces, such as those caused by placing an object on the top portion of trench cover **42** (e.g., a vehicle tire, a person's foot, debris, or the like). The trench cover **42** can be made from a range of materials, such as metals, polymers, carbon fiber, and the like.

[0038] As best shown in Figures 2B, 2C, and 4-7, the trench cover **42** preferably includes at least a first and second integrally-formed lug **46A**, **46B**. During installation of the trench cover **42** in the drainage system **14**, the second integrally-formed lug **46B** is slid under a stationary retention pin **26B** that is fixed through a hole in one of the sidewall**s 21** and then the first integrally-formed lug **46A** is placed on the support surface **40**. Next, a removable retention pin **26A** is placed above the first integrally-formed lug **46A** and through another hole in one of the sidewalls **21**, such that a space is formed between the removable retention pin **26A** and the first integrally-formed lug **46A**. A removable plate **44** is then slid in the space between the removable retention pin **26A** and the first integrally-formed lug **46A**, creating an interference in the removal of the first integrally-formed lug **46A** past the removable retention pin **26A** and, in

turn, facilitating retention of the trench cover **42** in the drainage system **14**. The interaction between the second integrally-formed lug **46B** and the stationary retention pin **26B** also facilitates retention of the trench cover **42** in the drainage system **14**. In some embodiments, the removable retention pin **26A** and the stationary retention pin **26B** each extend through a hole in one of the sidewalls **21** and interact with the curable medium **13** poured around the open-faced channel **15** to secure the open-faced channel **15** in the curable medium **13** and bear any retention weight applied to the trench cover **42.**

[0039] The length of the open-faced channel **15** may be extended as needed by increasing the length of the first and second lateral sides **19**, **20**. As best shown in Figures 8A and 8B, the trench cover **42**, which may be a unitarily constructed piece or a combination of multiple separate trench cover pieces, may be secured to the lengthened open-faced channel **15** by alternating sets of stationary retention pins **26B** and removable retention pins **26A** to interface with the integrally formed lugs **46A**, **46B** of the trench cover **42**. In this way, the open-faced channel **15** may be configured to retain trench covers **42** even when the open-faced channel **15** is lengthened.

[0040] Referring now to Figures 9A-9G and 10A-10F, another embodiment of the present invention may provide a drainage system **14** comprising an open-faced channel **15** that is defined by a first and second ring member **51**, **52** and a collection member **53**. Each of the first and second ring members **51**, **52** may comprise a pair of end members and a pair of lateral side members that can be formed integrally together or formed separately and then welded together or secured together using mechanical fasteners. Each of the first and second ring members **51**, **52** may be formed such that the pair of end members and pair of lateral side members define an inner perimeter dimensioned such that the sidewalls **21** of the collection member **53** fit within the

inner perimeters of the first and second ring members **51**, **52**. Typically, the first ring member **51** is positioned above the second ring member **52** such that when the collection member **53** is lowered into the ring members **51**, **52**, each ring member **51**, **52** wraps fully around the collection member **53**.

[0041] The collection member **53** may comprise first and second lateral sides **19**, **20** and first and second end members **17**, **18**, which together will be referred to herein as the sidewalls **21** of the collection member **53**. In a preferred embodiment, the sidewalls **21** are connected to one another in a substantially perpendicular manner at their edges to form a substantially rectangular shape. The collection member **53** may further comprise a bottom wall **22**, which may be connected at the edges to the sidewalls **21** of the collection member **53** to create a floor portion of the open-faced channel **15**. In this way, the sidewalls **21** and the bottom wall **22** of the collection member **53** are combined to define an interior cavity of the open-faced channel **15**. In some embodiments, the sidewalls **21** and bottom wall **22** of the collection member **53** may be a part of a unitary construction. In other embodiments, the sidewalls **21** and bottom wall **22** may be individual parts that are affixed together by welding, adjustable fasteners, or the like. The bottom wall **22** may comprise a conduit connector **38** to facilitate the removal of fluids from the open-faced channel **15**.

[0042] Each of the first and second ring members **51**, **52** are preferably constructed using a highly durable and rust-resistant material, such as stainless steel, galvanized or coated steel, or the like. On the other hand, the collection member **53** may be constructed of cementitious and/or polymeric materials, metals, or the like. In this way, the open-faced channel **15** confers the benefit of high structural rigidity and stability provided by the strong first and second ring

members **51**, **52** while reducing manufacturing and/or replacement costs with respect to the collection member **53**.

[0043] The collection member **53** may further be removably coupled to the first and second ring members **51**, **52** when the drainage system **14** is installed into a trench. In this regard, the first and second ring members **51**, **52** may each comprise one or more reinforced apertures **51A, 51B** located along the perimeter of the first and second ring members **51**, **52**. Said apertures **51A, 51B** may take the form of a cylindrical opening which is oriented perpendicularly to the first and second ring members **51**, **52** in a horizontal manner; in other words, the apertures **51A, 51B** provide a lateral passageway through which a structural member **30** (e.g., rebar) may pass.

[0044] The sidewalls **21** of the collection member **53** may also comprise one or more apertures **33** through which a structural member may pass. The apertures **33** of the collection member **53** may be cylindrical openings which run perpendicularly to the sidewalls **21** of the collection member **53** in a lateral fashion. In particular, the collection member **53** may comprise a first set of apertures **33A** around the perimeter of the sidewalls **21** of the collection member **53**. The first set of apertures **33A** may correspond to the apertures **51A** of the first ring member **51** such that the apertures **51A** of the first ring member **51** and the first set of apertures **33A** of the sidewalls **21** of the collection member **53** may be aligned, as best shown by comparing Figure 9D with the cutaway view as seen in Figure 9E, or by comparing Figure 10D with the cutaway view as seen in Figure 10E. Accordingly, the apertures **51A** of the first ring member **51** and the apertures **33** of the collection member **53** are preferably formed in the same size and shape as one another, and are typically dimensioned to allow a structural member **30** to pass therethrough. In this way, the first ends **32** of a first set of structural members **30** may pass through both the

apertures **51A** of the first ring member **51** and the first set of apertures **33A** of the collection member **53**. Once the structural members **30** have passed through the first ring member **51** and the collection member **53**, the first end **32** of the structural members **30** may be affixed to the open-faced channel **15**. The second end **34** of the structural members **30** may then be secured to the structural members within the sidewalls of the trench, thereby securing the open-faced channel **15** to the trench and/or curable medium **13**.

[0045] The collection member **53** may further comprise a second set of apertures **33B** around the perimeter of the sidewalls **21** of the collection member **53** which correspond to the apertures **52A** of the second ring member **52** such that the apertures **52A** of the second ring member **52** and the second set of apertures **33B** of the collection member **53** may be aligned. In this way, the first ends **32** of a second set of structural members **30** may pass through both the apertures **52A** of the second ring member **52** and the second set of apertures **33B** of the collection member **53** such that the second ring member **52**, the collection member **53**, and the first ends **32** of the structural members **30** may be affixed to one another. The second ends 34 of said structural members **30** may then be affixed to the structural members **30** within the sidewall of the trench. In this way, the collection member **53** may be secured by an evenly distributed array of structural members **30**.

[0046] In some embodiments, the first ring member **51** may additionally provide a support surface **40** for installing a trench cover **42**, as best seen in Figures 9A, 9F, 9G, 10A, and 10F. Said support surface **40** may be formed by creating a lateral extension of the top portion of the first ring member **51**, then creating a vertical extension from the lateral extension such that a rectangular recess is formed by the top portion of the first ring member **51**. In this way, the rectangular recess forms a seat and/or frame that is dimensioned to accept a trench cover **42**.

[0047] As best shown in Figures 9A-9G, in some embodiments, the reinforced apertures **51A** of the first ring member **51** may be positioned in an offset manner in relation to the reinforced apertures **52A** of the second ring member **52**, such that the reinforced apertures **51A**, **52A** of the first and second ring members **51**, **52** are placed in a staggered configuration. In such a configuration, the apertures **51A** of the first ring member **51** are not vertically aligned with the apertures **52A** of the second ring member **52**. In this way, when the structural members **30** are inserted into the first and second ring members **51**, **52** and the collection member **53**, the potential load on the drainage system **14** may be more evenly distributed.

[0048] As best shown in Figures 10A-10F, in other embodiments, the apertures **51A**, **52A** of the first and second ring members **51**, **52** may be positioned in a stacked configuration such that the apertures **51A** of the first ring member **51** are vertically aligned with the apertures **52A** of the second ring member **52**. Such a configuration may be seen when the first and second ring members **51**, **52** have identical structures, as best seen in Figures 10C and 10D. In this way, the cost of manufacturing the first and second ring members **51**, **52** may be reduced.

[0049] Referring now to Figures 11A-11D, another embodiment of the present invention may provide a drainage system **14** comprising an open-faced channel **15** formed from first and second lateral sides **19**, **20** and first and second end members **17**, **18** which collectively make up the sidewalls **21** of the open-faced channel **15**. The open-faced channel **15** may further comprise a bottom wall **22** which may in turn comprise a conduit connector **38** or drainage port configured to receive a drainage pipe. The bottom wall **22** may be coupled with the sidewalls **21** in a substantially perpendicular manner to define the open-faced channel **15** to substantially resemble an open-topped rectangular prism. In some embodiments, the bottom wall **22** is coupled to the

sidewalls **21** such that the bottom wall **22** is substantially level. In such embodiments, the top edges and bottom edges of the sidewalls **21** may be substantially parallel to each other.

[0050] As best seen in Figure 11D, in other embodiments, the bottom wall **22** may be angled in the direction of the conduit connector **38** to facilitate the drainage of fluids entering the open-faced channel **15**. In such embodiments, the top edges of the first and second lateral sides **19**, **20** may be substantially level while the bottom edges of the first and second lateral sides **19**, **20** may be slanted at an angle in the direction of the conduit connector **38**. In addition, the height of the first end member **17** may be longer than the height of the second end member **18**, or vice versa, according to the direction in which the bottom wall **22** and the bottom edges of the first and second lateral sides **19**, **20** are angled.

[0051] The sidewalls **21** of the open-faced channel **15** may comprise one or more reinforced apertures **33** distributed laterally around the perimeter of the sidewalls **21** the open-faced channel **15**. Each reinforced aperture **33** may be located in the body of the sidewalls **21** and take the form of a cylindrical opening which is oriented perpendicularly to the sidewalls **21**. In this way, the reinforced apertures **33** are configured to receive structural members **30** (e.g., rebar) into the interior of the open-faced channel **15**. Once the first ends **32** of the structural members **30** have been inserted into the reinforced apertures **33**, the first ends **32** of the structural members **30** may be secured to the sidewalls **21**, and the second ends **34** of the structural members **30** may be secured to the structural members and/or structural member network **36** within the sidewall of the trench. In some embodiments, as best seen in Figures 11A, 11C, and 11D, the reinforced apertures **33** may further comprise pipe-to-pipe sleeves which may extend outward laterally from the outer surfaces of the sidewalls **21** of the open-faced channel **15**, which may further assist in securing the structural members **30** to the open-faced channel **15**. In

addition, the reinforced apertures **33** may comprise a sealing member such as a gasket, grommet, or the like, in order to prevent the leakage of fluids outside of the open-faced channel **15**.

[0052] In some embodiments, the open-faced channel **15** may be configured to accept a trench cover **42** to prevent foreign objects (e.g., non-liquid matter such as leaves, garbage, or the like) from entering open-faced channel. In such embodiments, the top portions of the first and second lateral sides **19**, **20** may comprise an outward lateral extension from the top edges of the first and second lateral sides **19**, **20** and an upward vertical extension from the edges of the outward lateral extension, as best seen in Figure 11A. In this way, the extensions may create a support surface **40** upon which a trench cover **42** may be placed.

[0053] In some embodiments, the open-faced channel **15** may further comprise one or more coupling members **60** that may be located proximate to the top portions of the sidewalls **21**. Each coupling member **60** may comprise an anchor portion **60A** combined with a hollow portion **60B**, where the hollow portion **60B** may be affixed to the anchor portion **60A** at a 45-degree angle. In a preferred embodiment, the coupling members **60** may be inserted upward and diagonally (e.g., at a 45-degree angle upward from parallel) into openings (e.g., holes **62**) located near the top of the first and second lateral sides **19**, **20**, such that the anchor portion **60A** is oriented vertically from parallel and the hollow portion **60B** is oriented upwards and diagonally into the open-faced channel **15**. For instance, as seen in Figure 11A, the coupling members **60** may be inserted diagonally upward into a hole **62** located along the corner created by the lateral extension and vertical extension of the first and second lateral sides **19**, **20**. The coupling members **60** may be then affixed to the first and second lateral sides **19**, **20** such that when a curable medium **13** is poured to surround the open-faced channel **15** to a level that is above the

coupling members **60**, the open-faced channel **15** may be anchored to the curable medium **13** via the anchor portions **60A** of the coupling members **60**.

[0054] In some embodiments, the hollow portions **60B** of the coupling members **60** may be configured to receive a removable retaining pin **61**. For instance, if the hollow portion **60B** of the coupling member **60** is cylindrical, then the removable retaining pin **61** may be a cylinder dimensioned to fit within the interior of the hollow portion **60B** of the coupling member **60**. Once the removable pin **61** is inserted into the hollow portion **60B** of the coupling member **60,** the removable pin **61** may provide a mechanism by which to secure the open-faced channel **15** within the trench by resisting any upward movements of the open-faced channel **15**. In embodiments in which the open-faced channel **15** comprises a trench cover **42**, the removable pin **61** may be inserted after the trench cover **42** is placed onto the support surface **40** of the first and second lateral sides **19**, **20**. In such embodiments, the removable pin **61** may be positioned above an integrally-formed lug of the trench cover **42** such that the removable pin **61** resists the upward movement of the trench cover **42**.

[0055] Many modifications and other embodiments of the inventions set forth herein will come to mind to one skilled in the art to which these inventions pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the inventions are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation. In addition, where possible, any terms expressed in the singular form herein are meant to also include the plural form and/or vice versa. As used herein, “at least one” shall mean “one or more” and these phrases are intended to be

interchangeable. Accordingly, the terms “a” and/or “an” shall mean “at least one” or “one or more,” even though the phrase “one or more” or “at least one” is also used herein.

THAT WHICH IS CLAIMED:

1. A drainage system that is structured to be fixedly embedded within a curable medium having a structural support comprising a plurality of structural members, the drainage system comprising:

an open-faced channel having a first and second lateral side and a first and second end member, wherein the first end member is attached to one end of the first and second lateral sides, the second end member is attached to the opposing end of the first and second lateral sides, and the first and second lateral sides and the first and second end members are spaced apart by a predetermined distance to define an interior space therebetween,

wherein at least one of said first lateral side, second lateral side, first end member, and second end member define an aperture structured to matingly engage one of the plurality of structural members to thereby tie the drainage system into the structural support for the curable medium.

2. The drainage system according to claim 1, wherein a different one of said first lateral side, second lateral side, first end member, and second end member define an additional aperture structured to matingly engage the one of the plurality of structural members.

3. The drainage system according to claim 2, wherein the drainage system further comprises a support surface for a trench cover, wherein the support surface is defined longitudinally by an upper side edge of the first lateral side and an upper side edge of the second lateral side.

4. The drainage system according to claim 3, wherein the drainage system further comprises a stationary retention pin placed within a first hole in at least one of the first and second lateral sides and the first and second end members, wherein the stationary retention pin is configured to retain a first integrally-formed lug of the trench cover,

wherein the drainage system further comprises a removable retention pin placed within a second hole in at least one of the first and second lateral sides and the first and second end members, wherein the removable retention pin creates a space between the removable retention pin and a second integrally-formed lug of the trench cover, wherein the drainage system further comprises a removable plate configured to occupy the space between the removable retention pin and the second integrally-formed lug of the trench cover to facilitate retention of the trench cover.

5. The drainage system according to claim 1, wherein the open-faced channel further comprises a bottom wall attached to a bottom end of the first and second lateral sides and a bottom end of the first and second end members, wherein the bottom wall comprises a conduit connector configured to couple with a drainage component.

6. The drainage system according to claim 5, wherein the bottom wall is slanted at an angle toward the conduit connector.

7. The drainage system according to claim 1, wherein the first lateral side comprises an anchor flange extending along a length of the first lateral side, wherein the second lateral side comprises an anchor flange extending along a length of the second lateral side, wherein the

anchor flange of the first lateral side and the anchor flange of the second lateral side are configured to retain a position of the drainage system within the curable medium.

8. The drainage system according to claim 1, wherein the open-faced channel further comprises one or more installation legs that are removably attached to the open-faced channel, wherein the installation legs are configured to secure the open-faced channel within the curable medium.

9. The drainage system according to claim 1, wherein the open-faced channel is defined by:

a first ring member comprising at least one aperture for receiving the structural member;

a second ring member comprising at least one aperture for receiving the structural member, wherein the first ring member is positioned above the second ring member; and

a collection member comprising a first set of apertures around a perimeter of the collection member, wherein the first set of apertures corresponds to the at least one aperture of the first ring member, wherein the collection member further comprises a second set of apertures around the perimeter of the collection member, wherein the second set of apertures corresponds to the at least one aperture of the second ring member, wherein the first set of apertures are located above the second set of apertures,

wherein the collection member is configured to be removably coupled to the first ring member by inserting a first structural member through the at least one aperture of the first ring member and an aperture of the first set of apertures, and by inserting a second structural member

through the at least one aperture of the second ring member and an aperture of the second set of apertures.

10. The drainage system according to claim 9, wherein the at least one aperture of the first ring member and the at least one aperture of the second ring member are in a staggered configuration such that the at least one aperture of the first ring member and the at least one aperture of the second ring member are not vertically aligned.

11. The drainage system according to claim 9, wherein the at least one aperture of the first ring member and the at least one aperture of the second ring member are in a stacked configuration such that the at least one aperture of the first ring member and the at least one aperture of the second ring member are vertically aligned.

12. The drainage system according to claim 1, wherein the open-faced channel comprises one or more reinforced apertures distributed laterally around a perimeter of the open-faced channel, wherein the reinforced aperture is a cylindrically-shaped opening oriented perpendicularly to the perimeter of the open-faced channel.

13. The drainage system according to claim 12, further comprising at least one coupling member positioned proximate to a top portion of at least one of the first and second lateral sides and the first and second end members, wherein the coupling member comprises a diagonally oriented hollow portion configured to accept a removable retention pin, wherein the removable retention pin is configured to secure the open-faced channel within a curable medium.

14. The drainage system according to claim 13, wherein the removable retention pin is positioned above an integrally-formed lug of a trench cover to facilitate retention of the trench cover.

15. A method of installing a drainage system, the method comprising:

providing an open-faced channel having a first and second lateral side and a first and second end member, wherein the first end member is attached to one end of the first and second lateral sides, the second end member is attached to the opposing end of the first and second lateral sides, and the first and second lateral sides and the first and second end members are spaced apart by a predetermined distance to define an interior space therebetween;

providing at least one structural member having a first and second end, wherein the first end of a structural member extends through an aperture in at least one of the first and second end members or the first and second lateral sides;

positioning the drainage system in a trench, wherein the trench comprises at least two sidewalls that each contain at least one structural member having an end; and

securing the first end of a structural member of the drainage system to an end of a structural member in a sidewall of the trench.

16. The method according to claim 15, wherein the second end of the structural member of the drainage system extends through an aperture in at least a different one of the first and second end members or the first and second lateral sides, wherein the method further

comprises securing the second end of the structural member of the drainage system to an end of a structural member in a different sidewall of the trench.

17. A method of manufacturing a drainage system that is structured to be fixedly embedded within a curable medium having a structural support comprising a plurality of structural members, the method comprising:

providing an open-faced channel having a first and second lateral side and a first and second end member, wherein the first end member is attached to one end of the first and second lateral sides, the second end member is attached to the opposing end of the first and second lateral sides, and the first and second lateral sides and first and second end members are spaced apart by a predetermined distance to define an interior space therebetween,

wherein at least one of said first lateral side, second lateral side, first end member, and second end member define an aperture structured to matingly engage one of the plurality of structural members to thereby tie the drainage system into the structural support for the curable medium.

18. The method according to claim 17, wherein a different one of said first lateral side, second lateral side, first end member, and second end member define an additional aperture structured to matingly engage the one of the plurality of structural members.

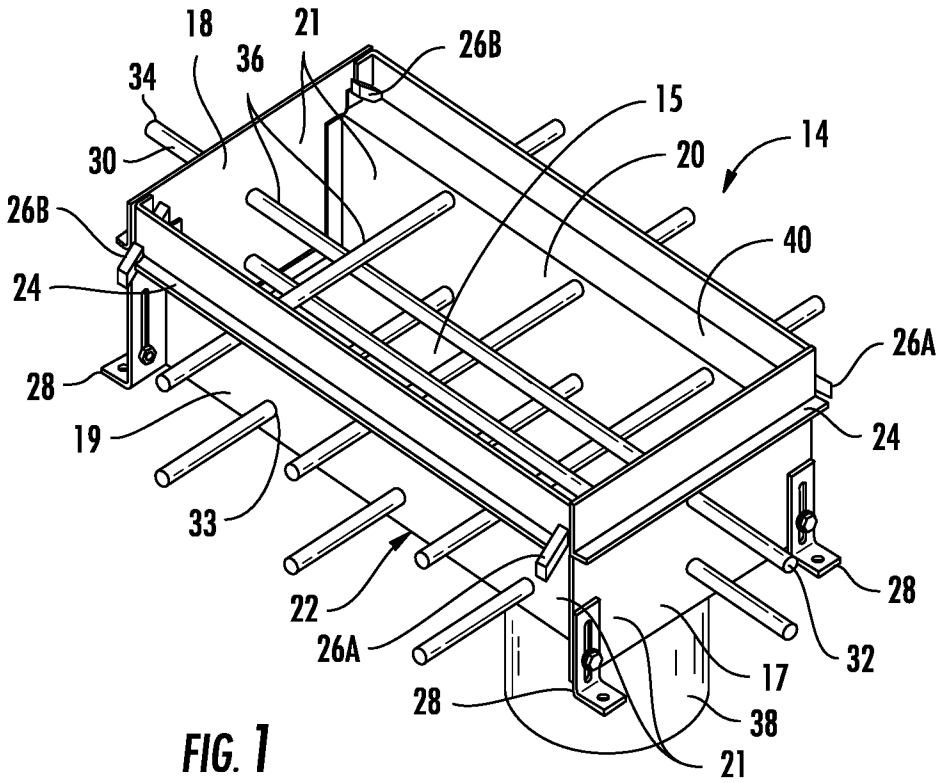

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FIG. 1

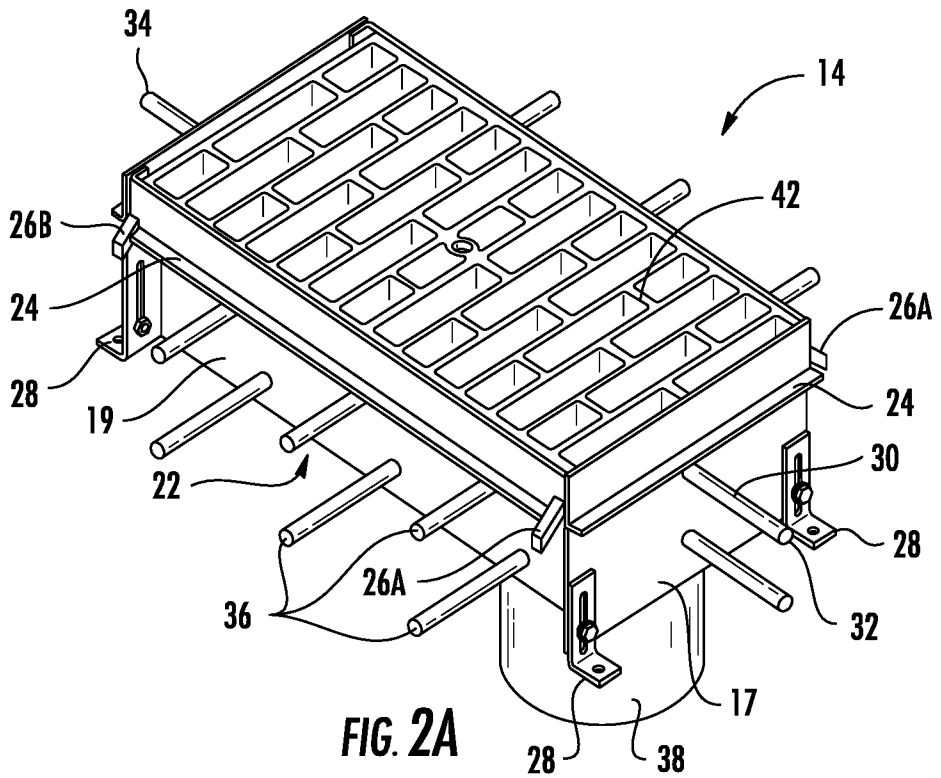

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FIG. 2A

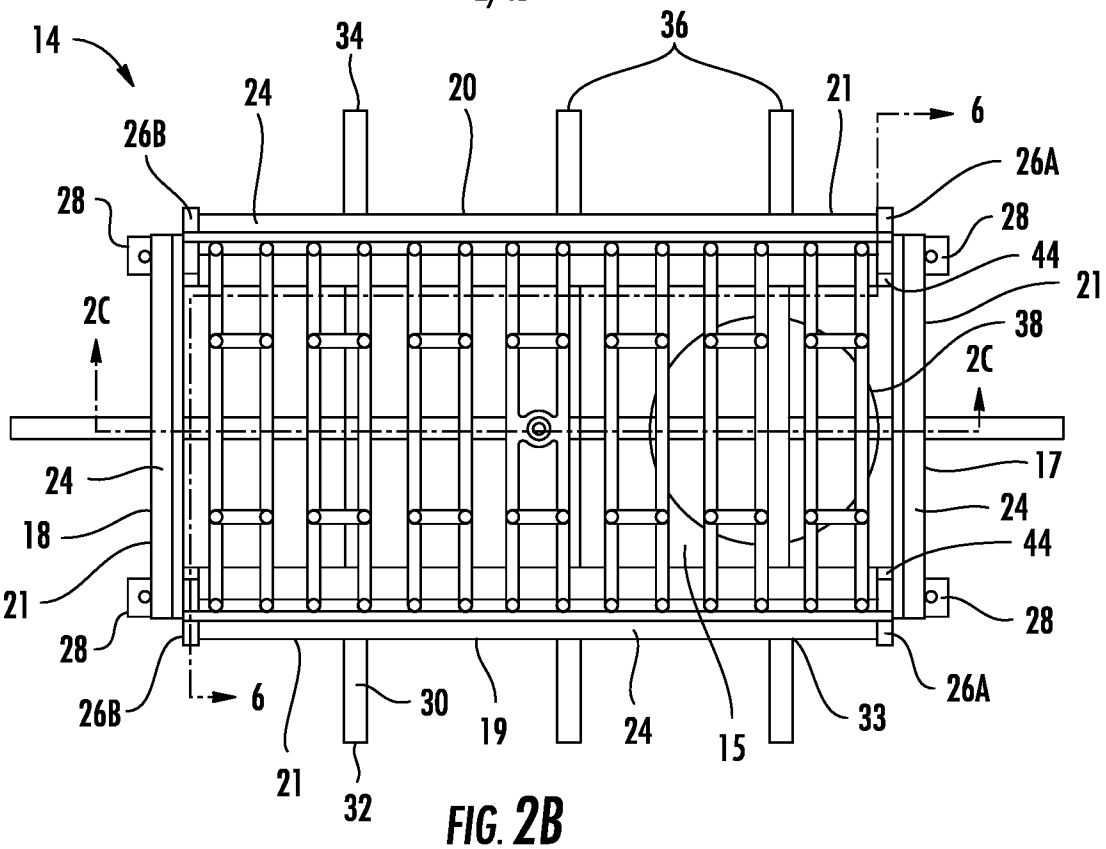

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2C
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FIG. 2B

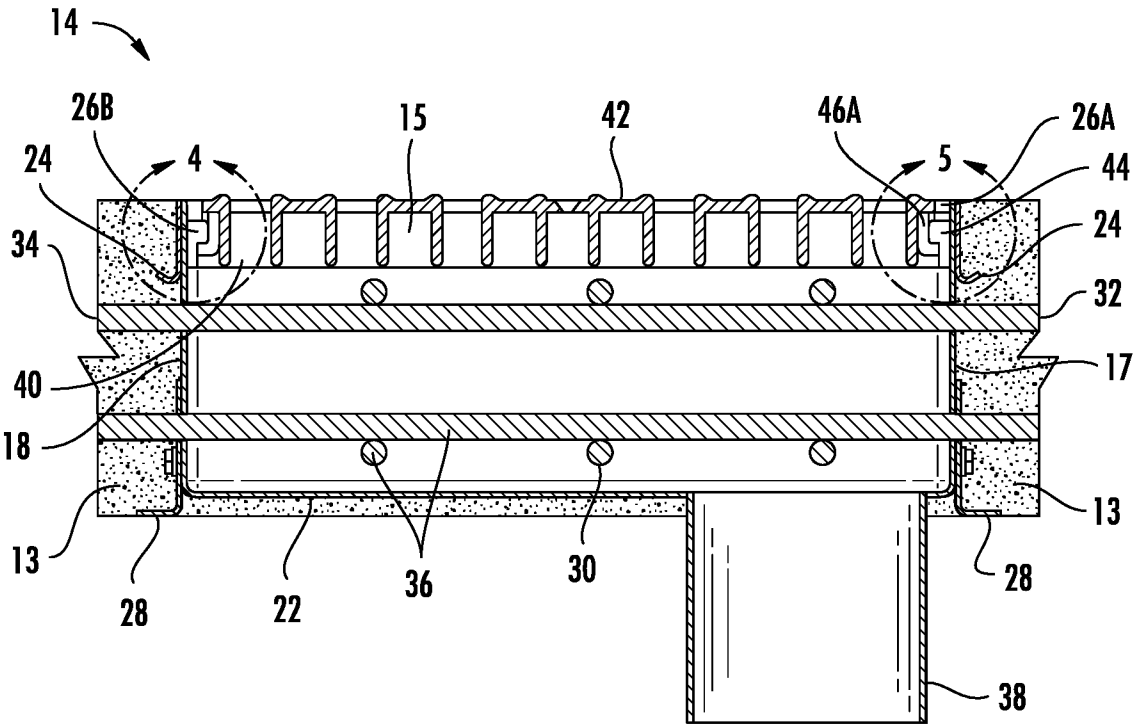

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FIG. 2C

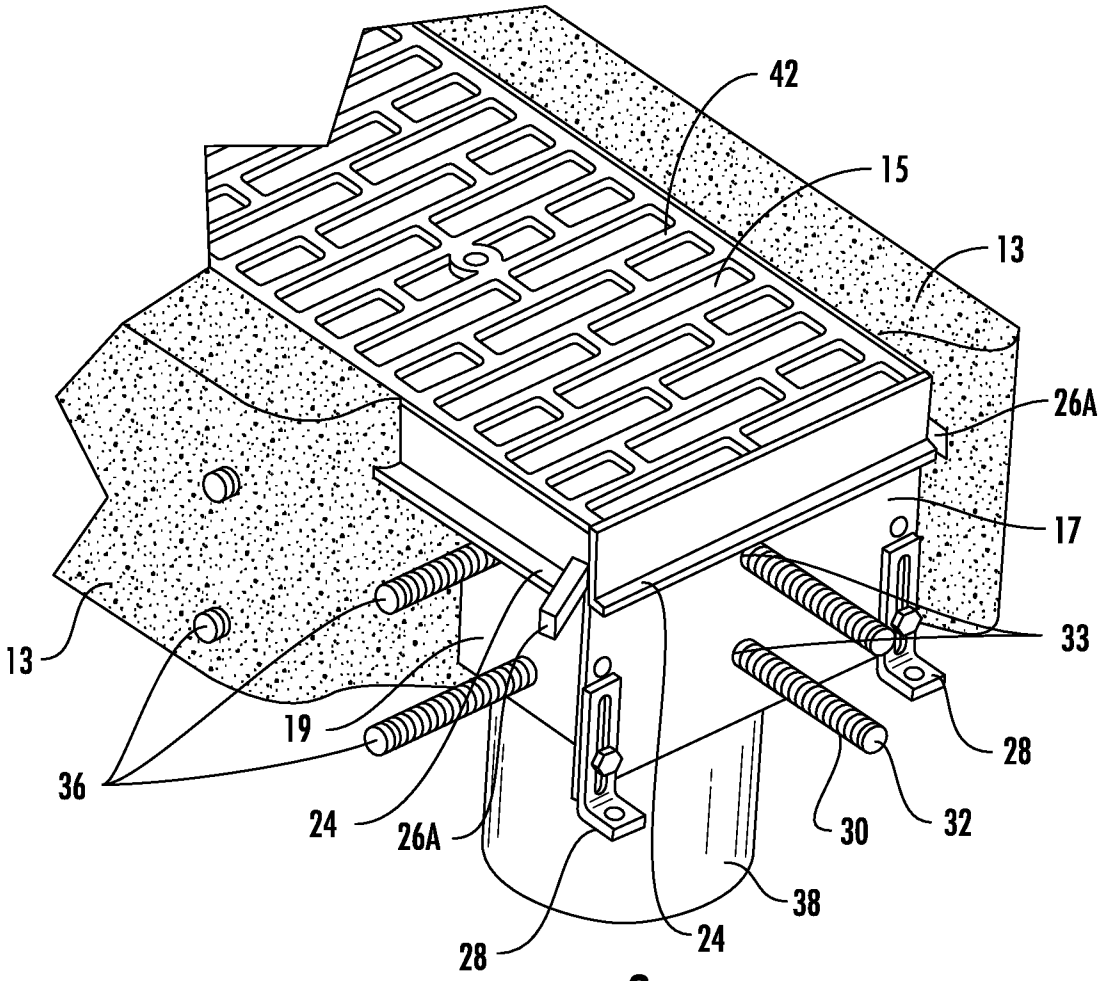


FIG. 3

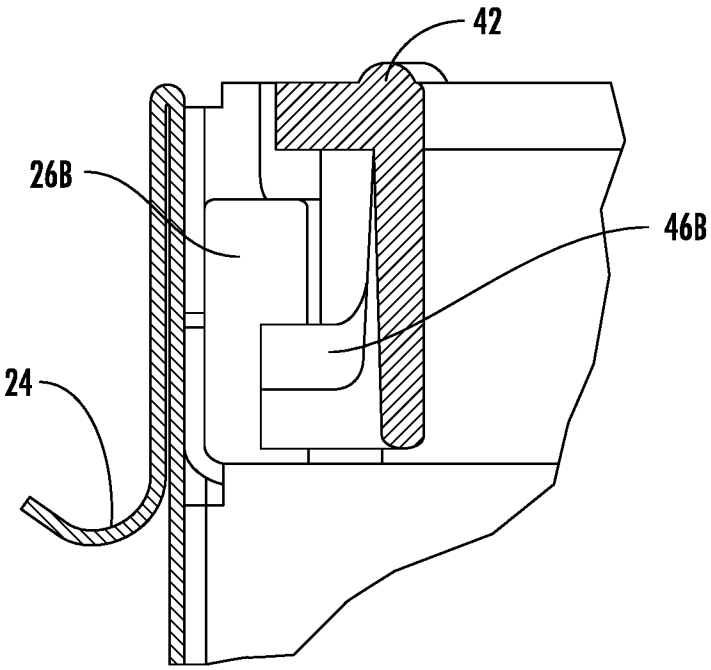


FIG. 4

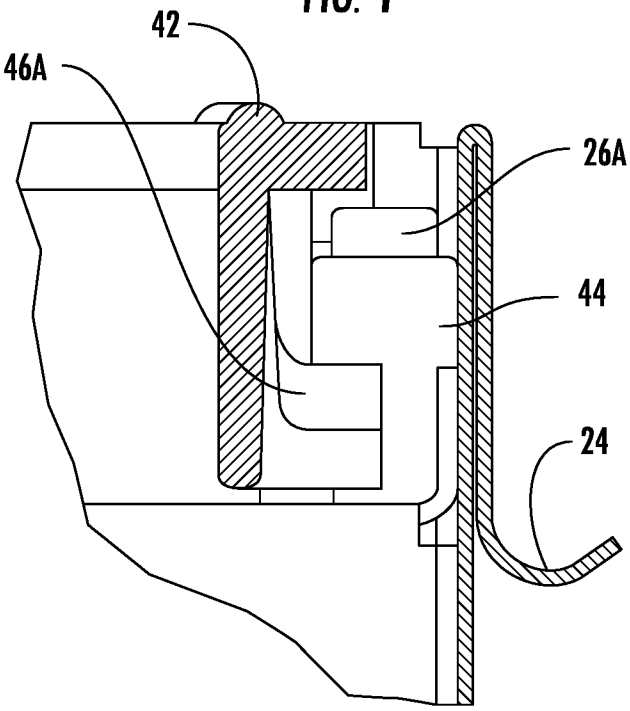


FIG. 5

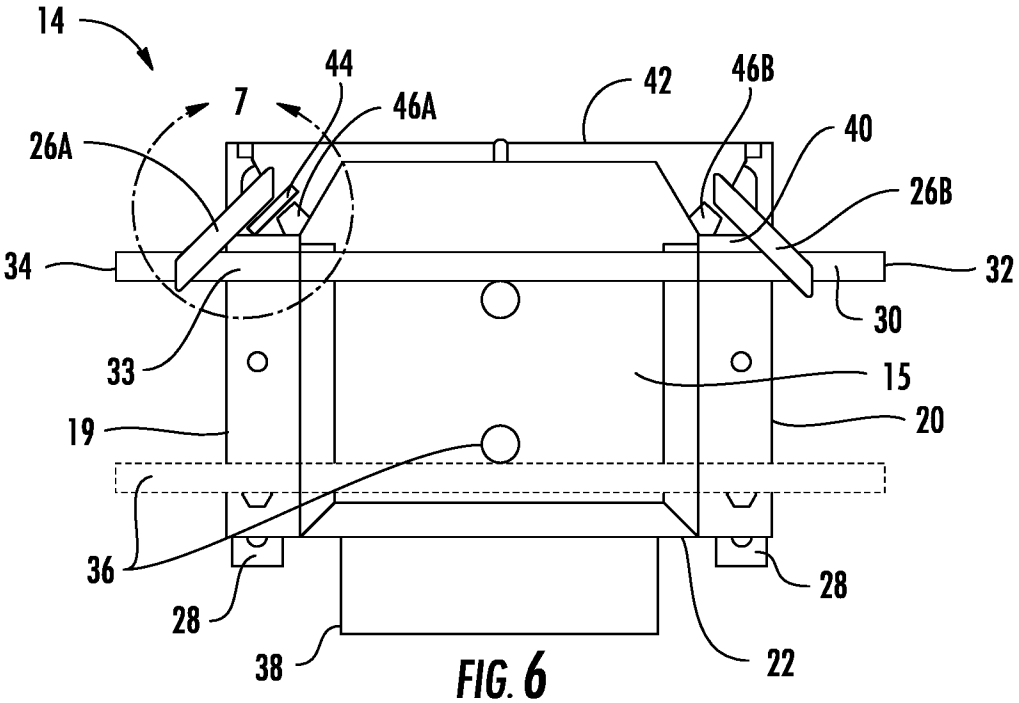

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FIG. 6

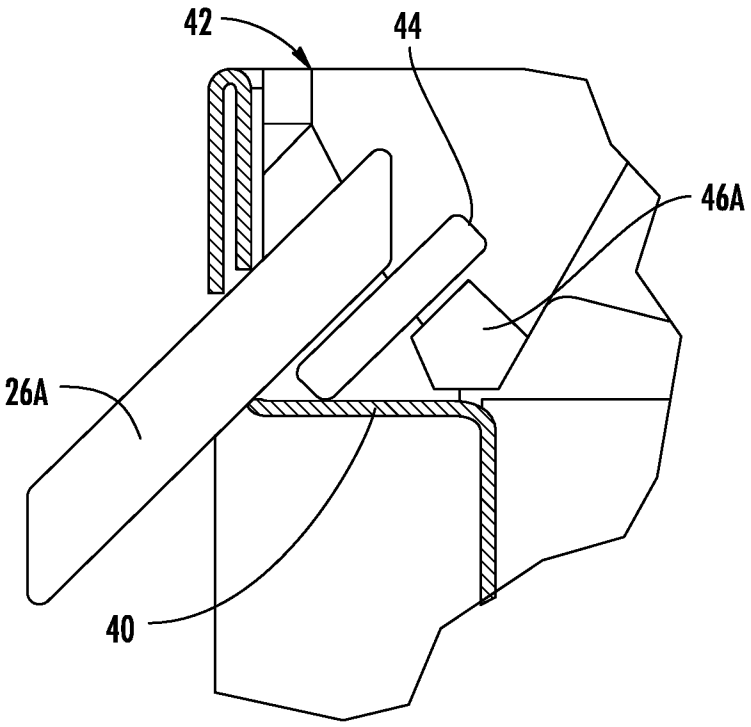

42
44
46A
26A
40

FIG. 7

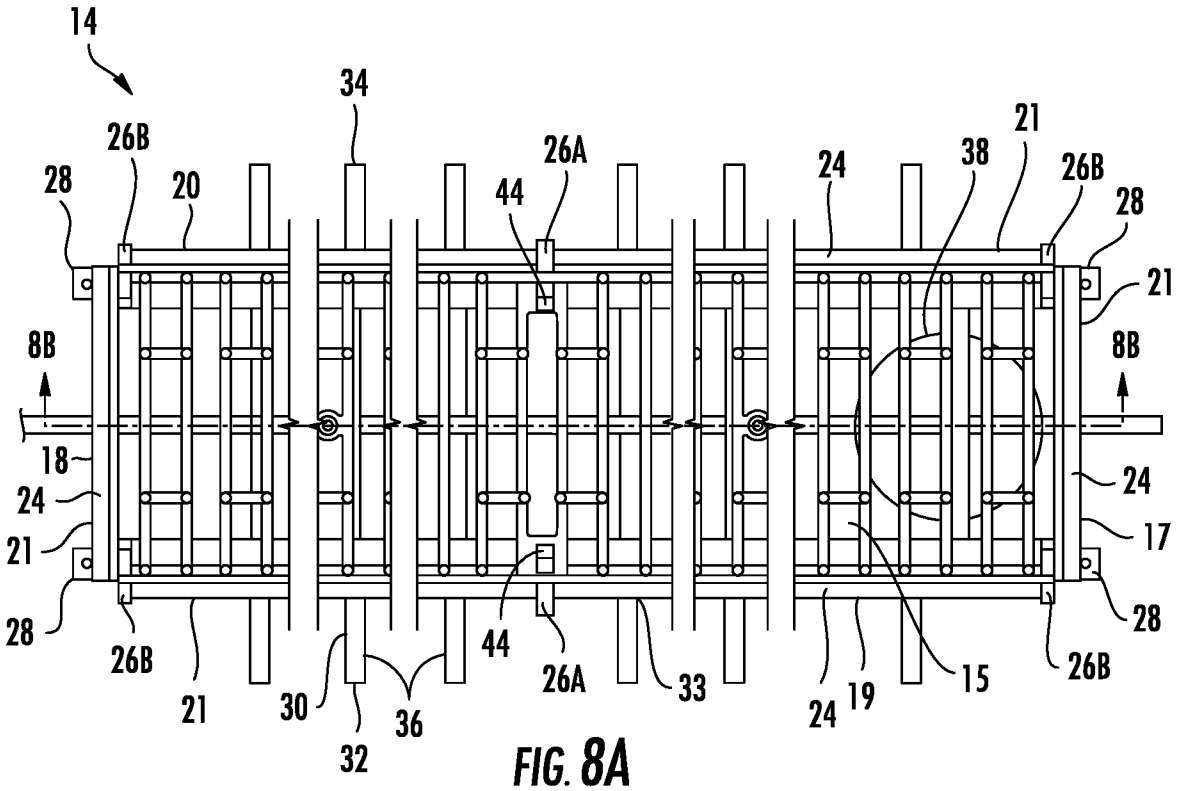

14
34
26B
26A
21
38
28
20
44
24
26B
28
21
8B
8B
18
24
24
21
17
28
28
26B
44
26A
33
15
26B
21
30
36
24
19
32

FIG. 8A

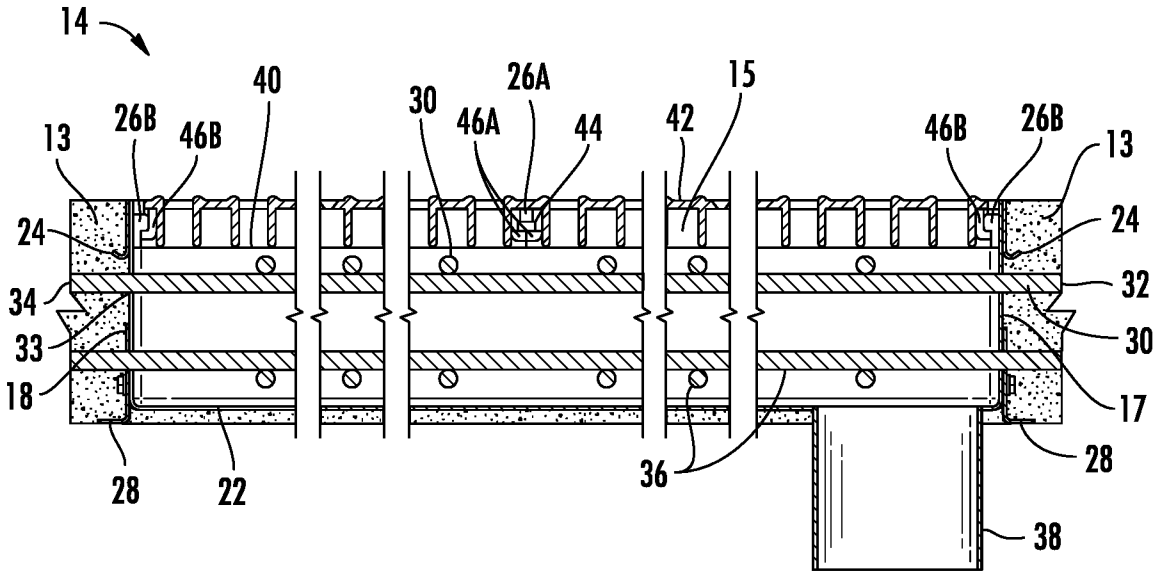

14
40
26A
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30
26B
46A
44
42
46B
26B
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26B
46B
24
24
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32
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FIG. 8B

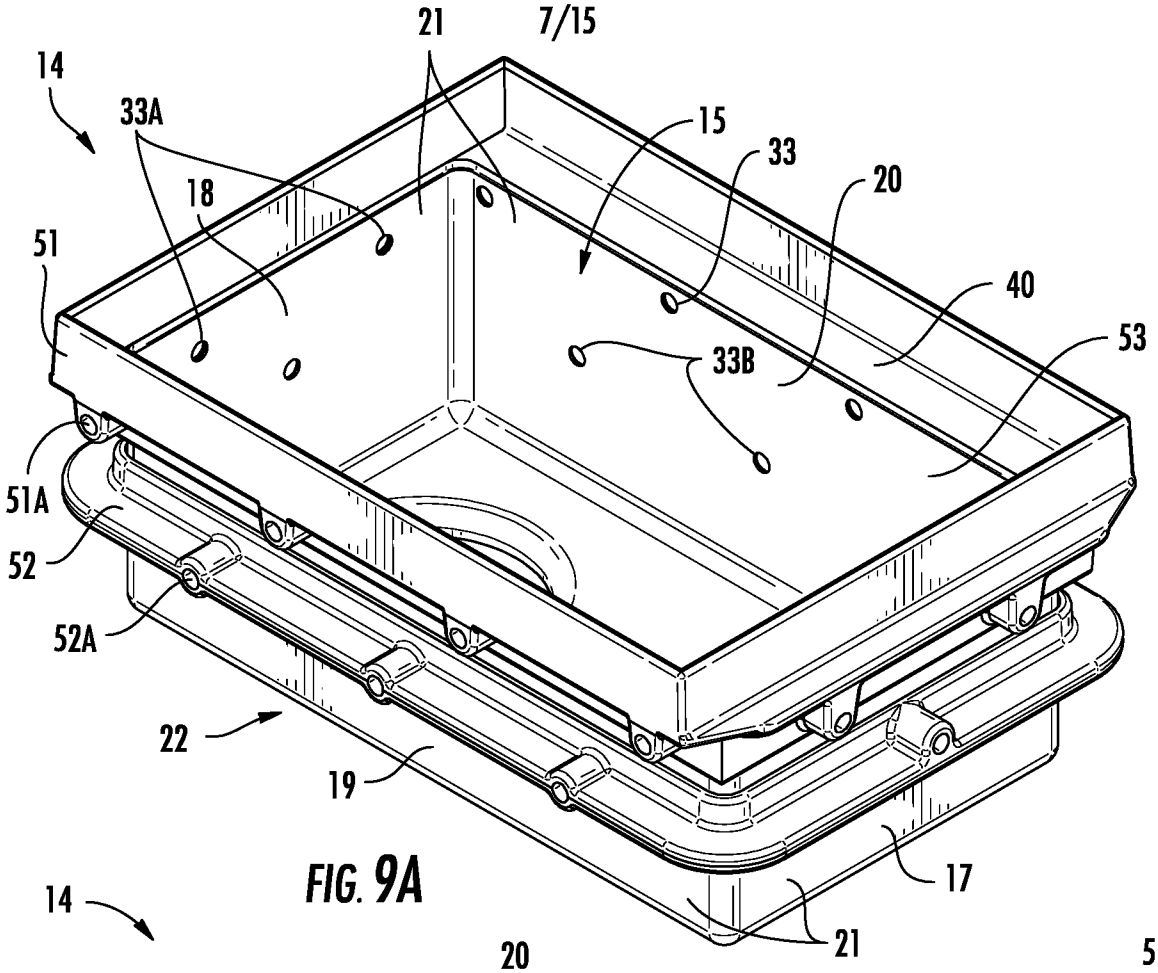

14
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33A
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15
33
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53
33B
51A
52
52A
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19
17
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FIG. 9A

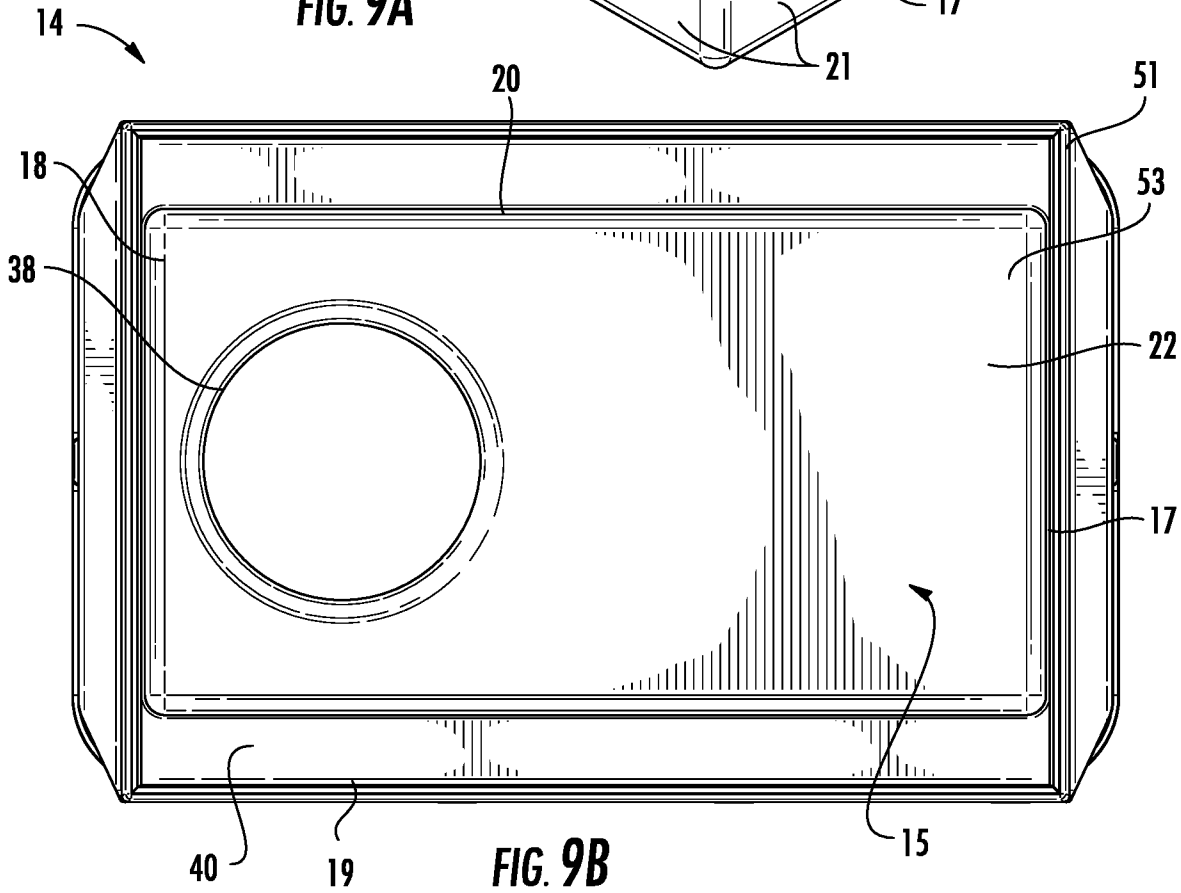

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FIG. 9B

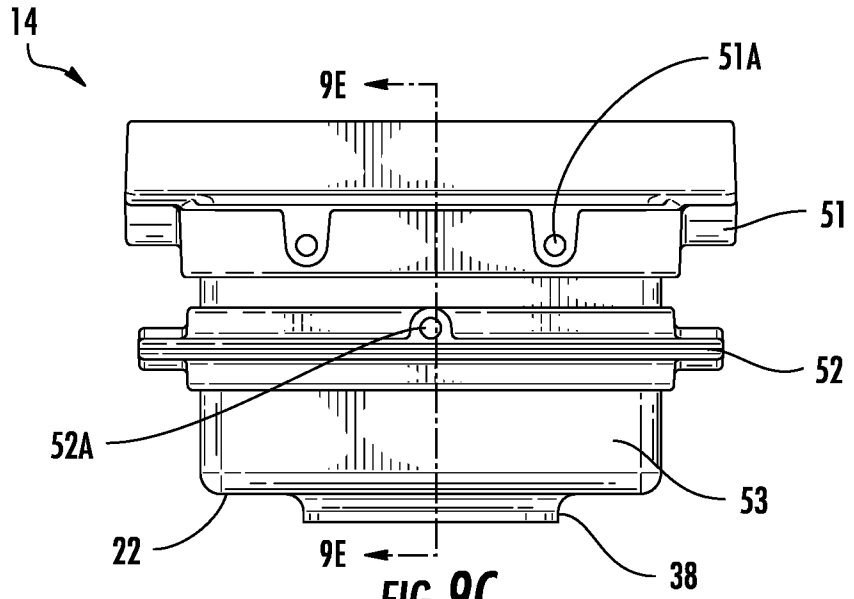

14
9E
51A
51
52
52A
53
22
9E
38

FIG. 9C

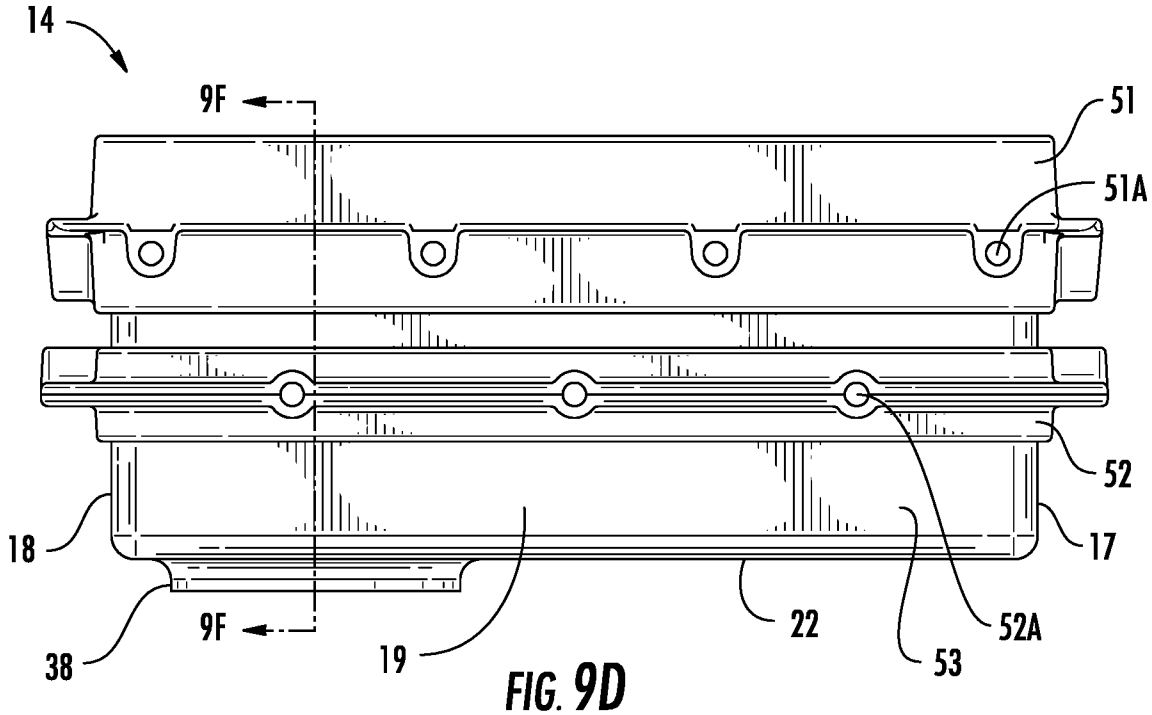

14
9F
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51A
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17
9F
38
19
22
53
52A

FIG. 9D

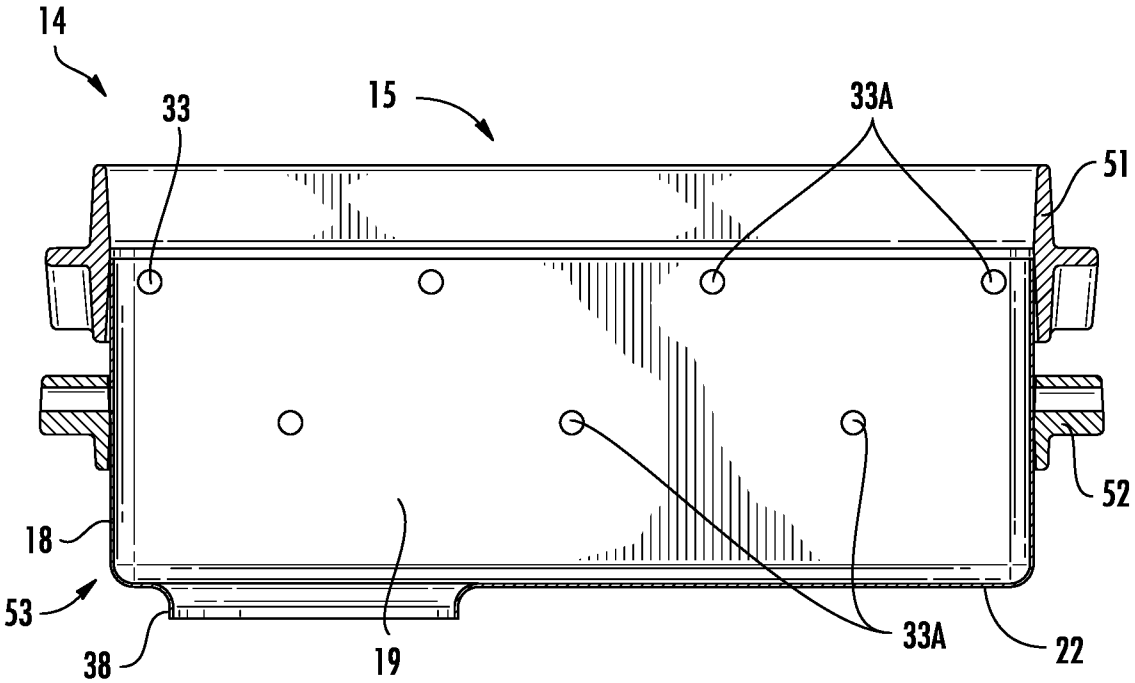


FIG. 9E

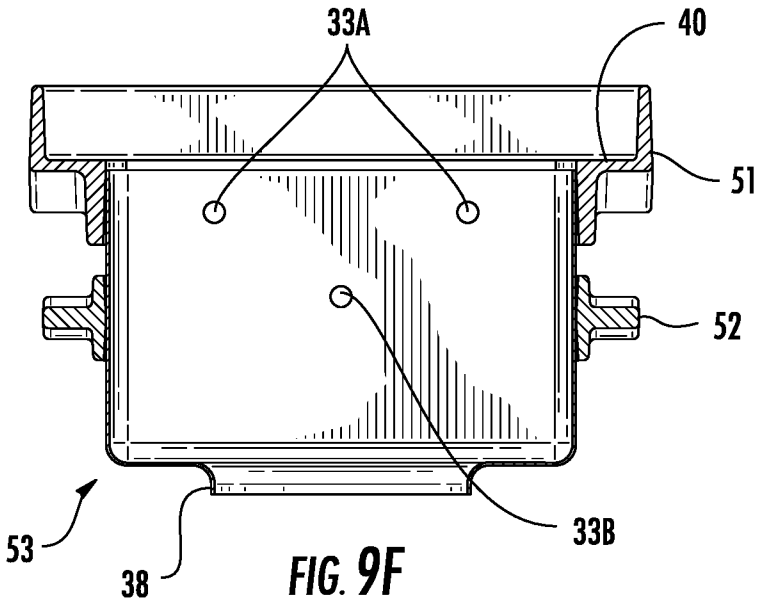


FIG. 9F

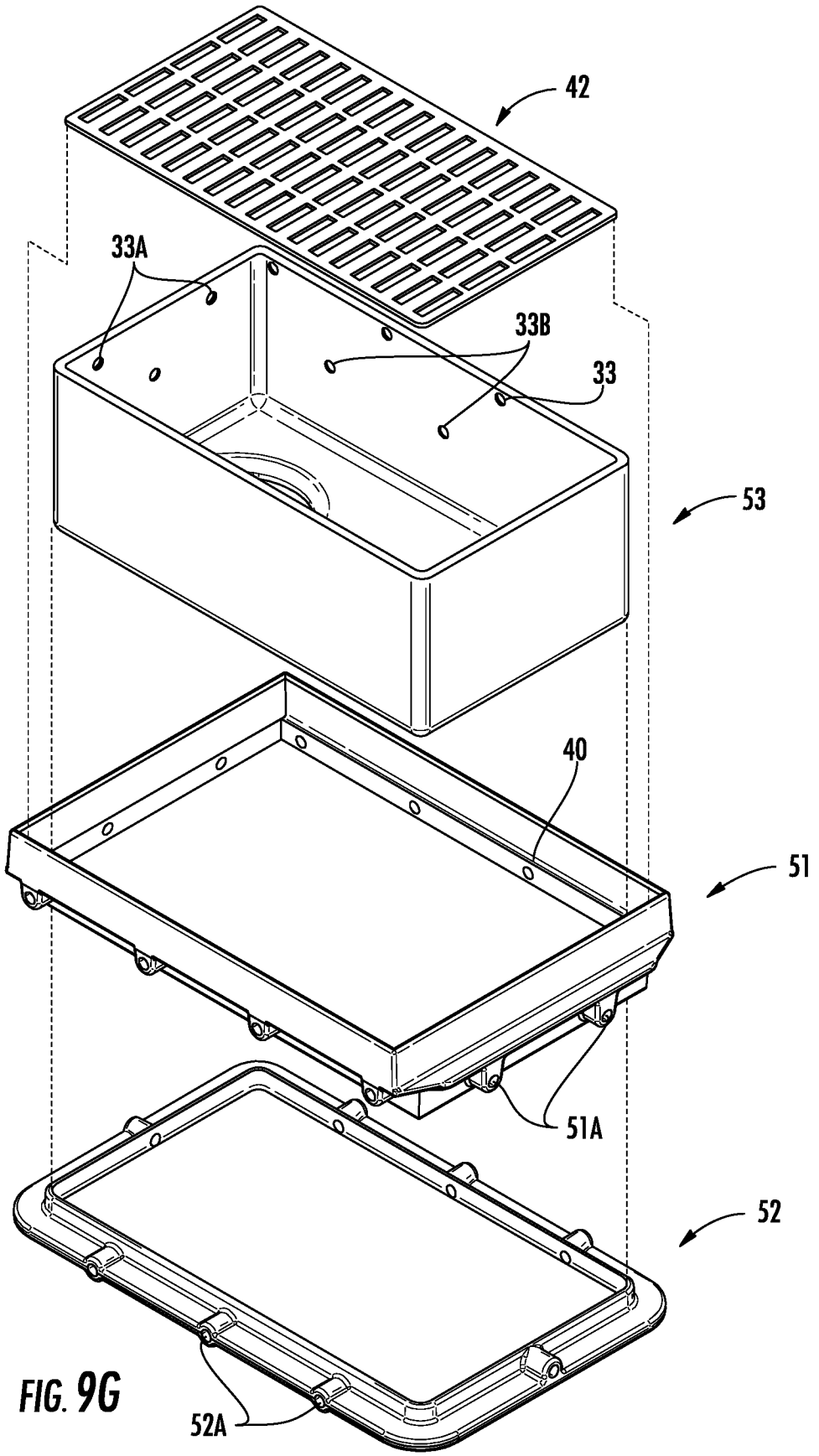


FIG. 9G

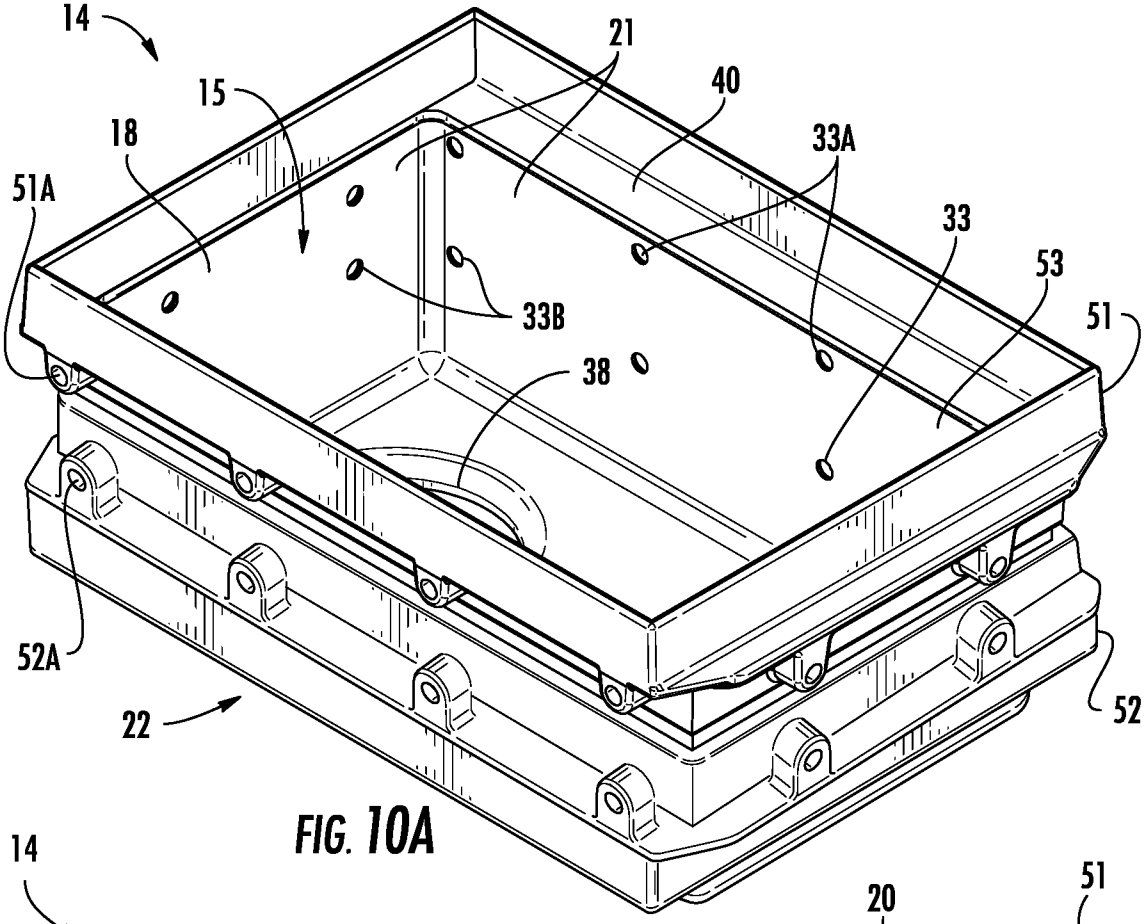


FIG. 10A

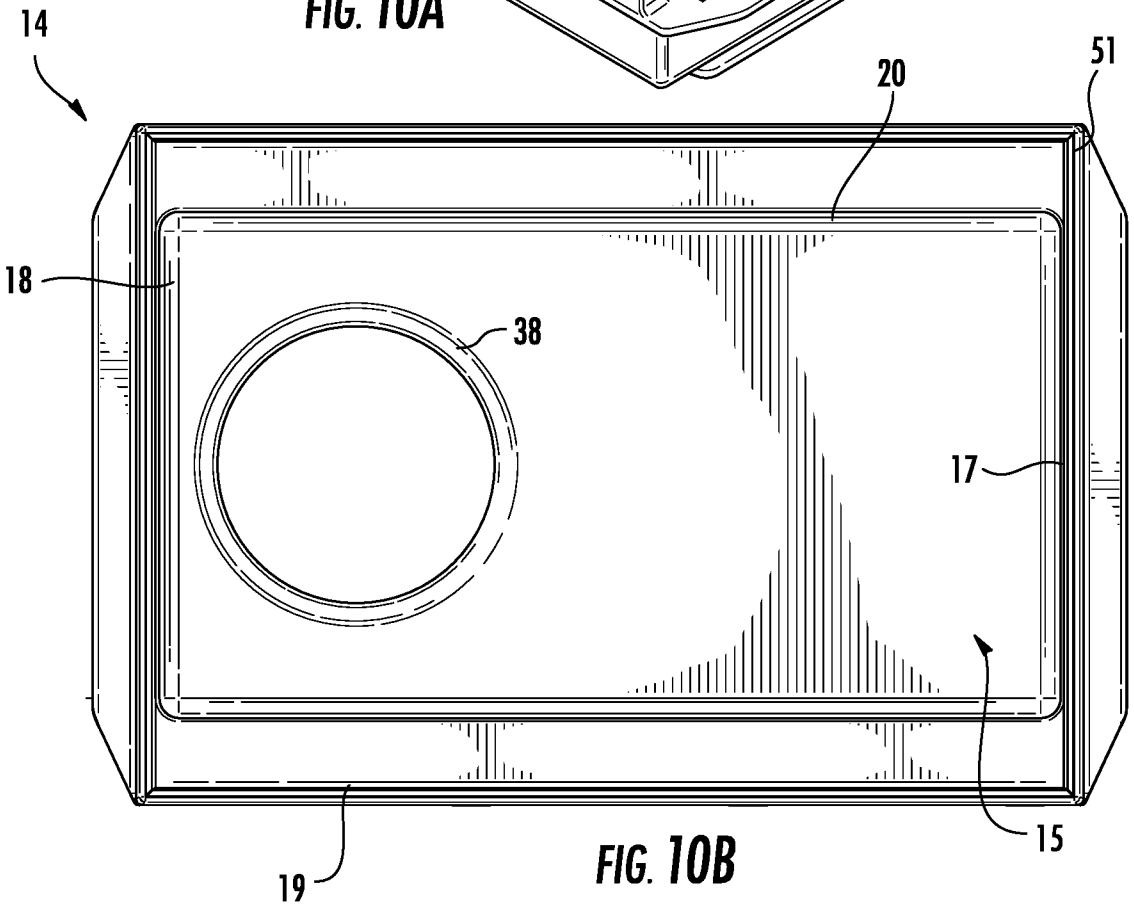


FIG. 10B

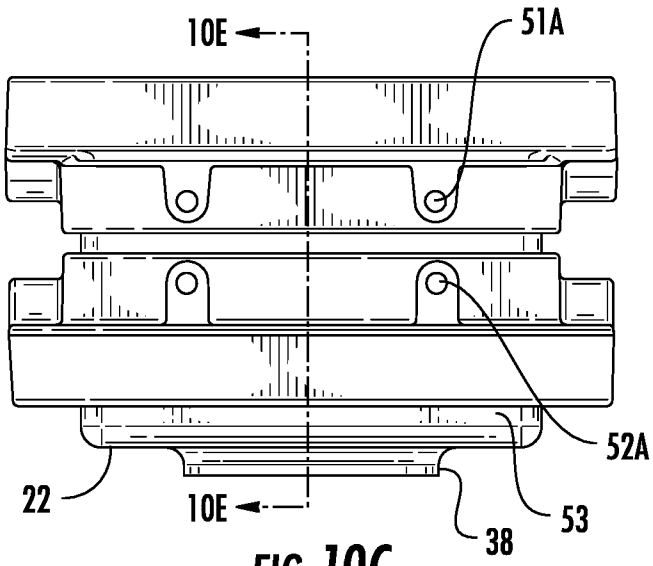


FIG. 10C

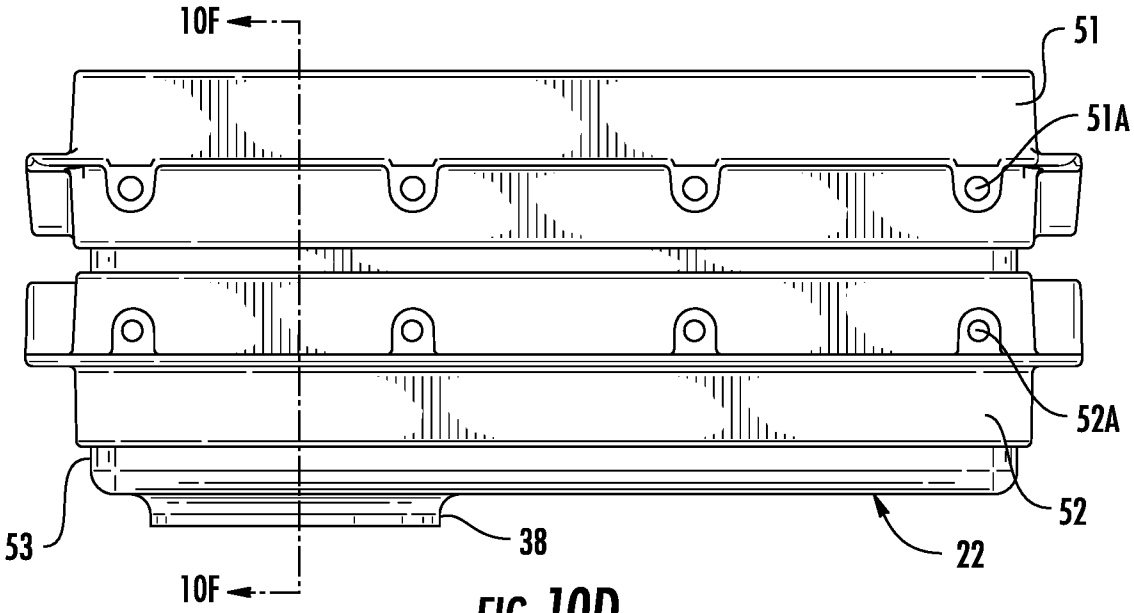


FIG. 10D

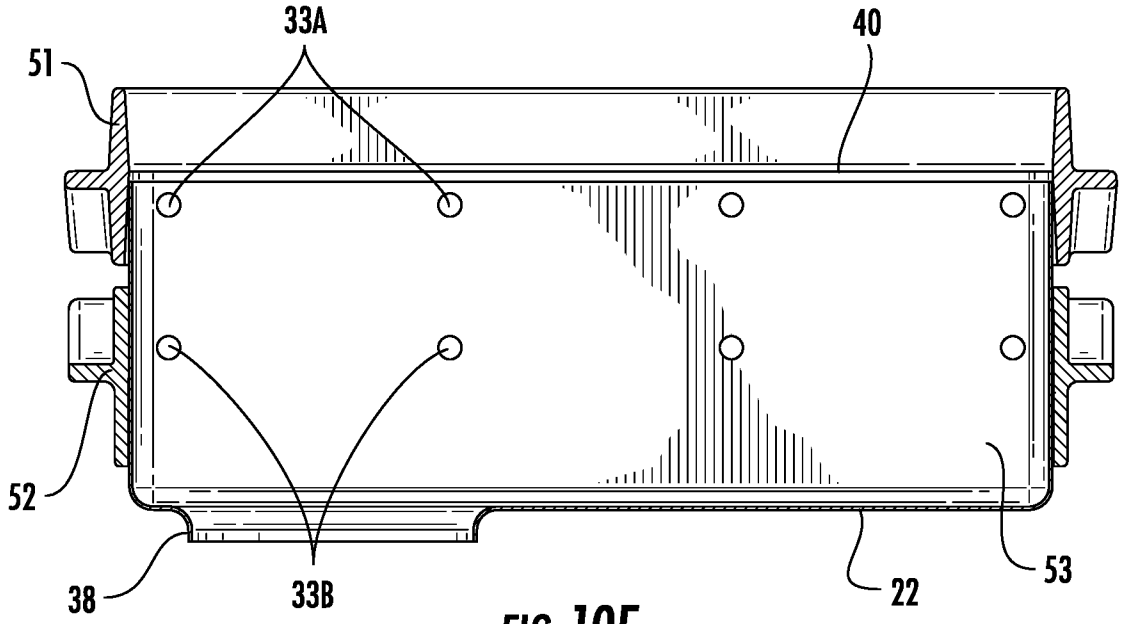


FIG. 10E

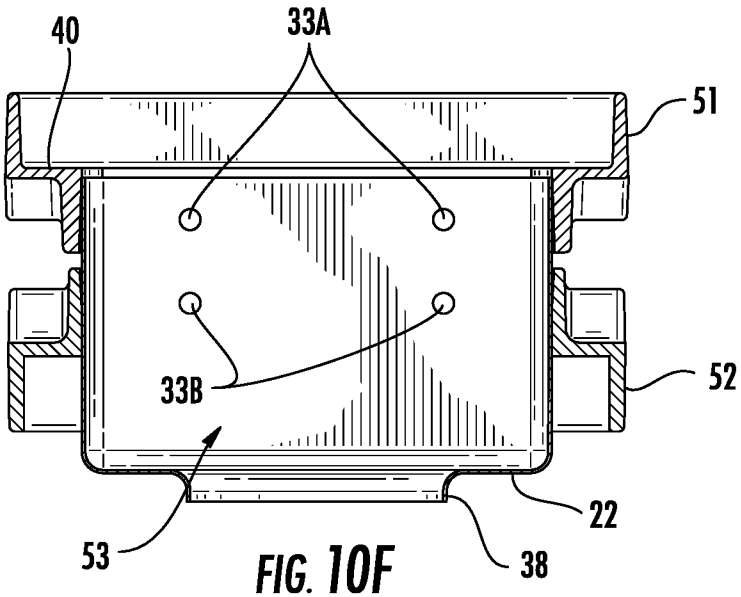


FIG. 10F

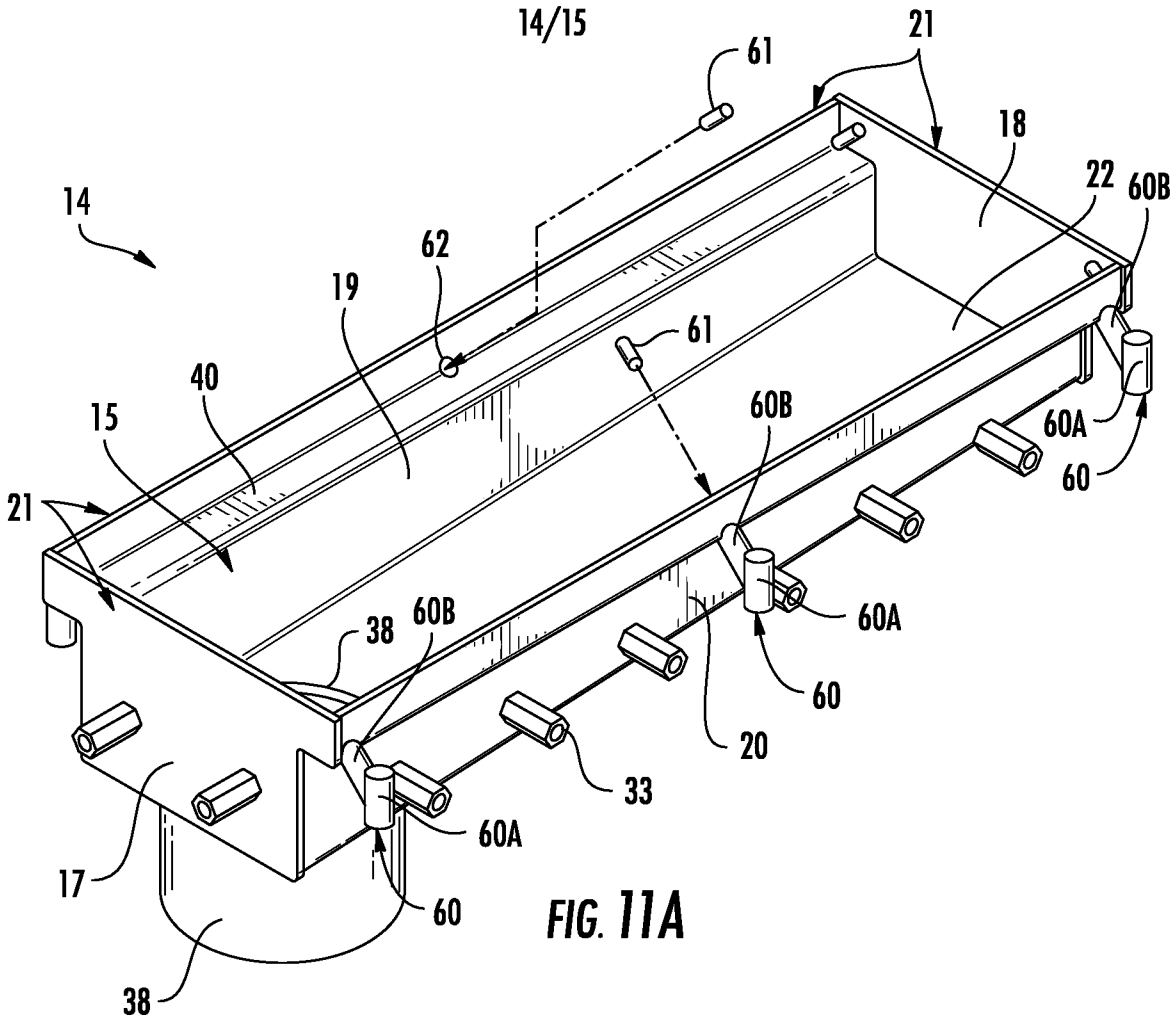


FIG. 11A

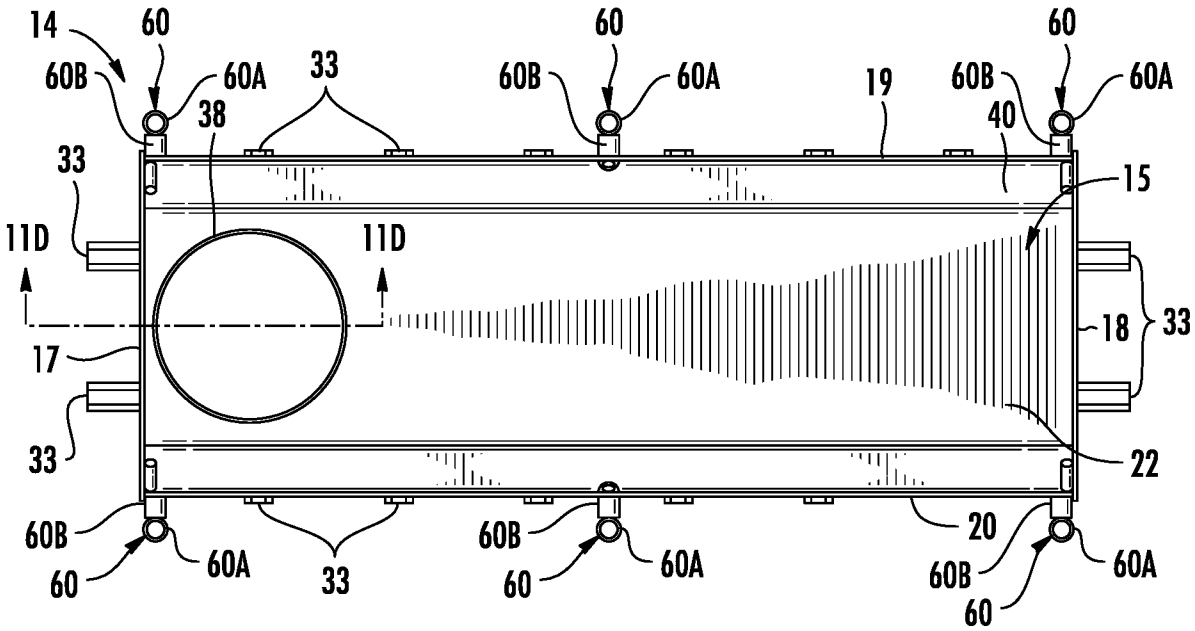


FIG. 11B

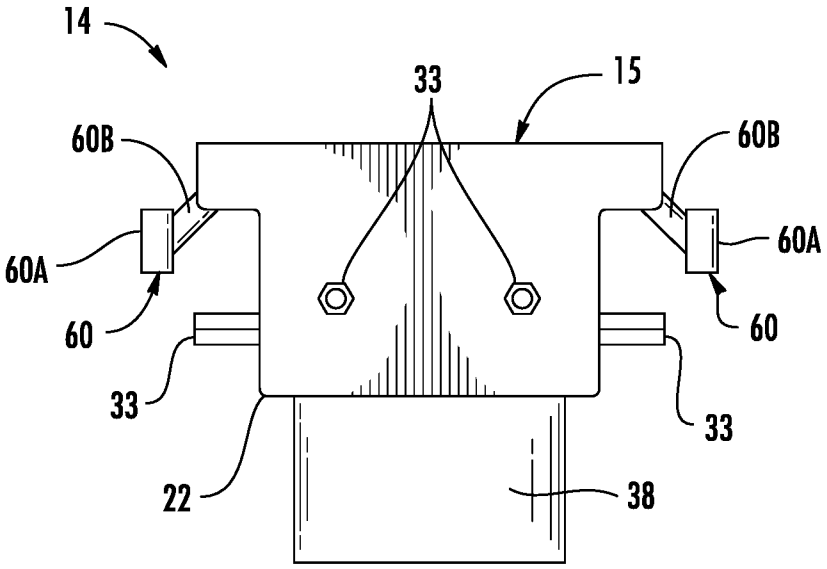


FIG. 11C

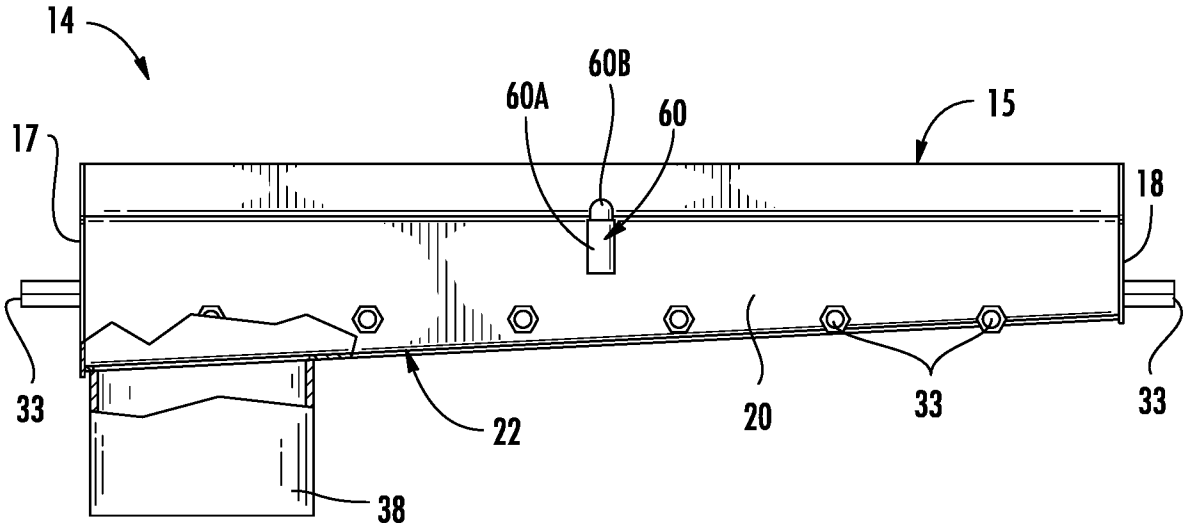


FIG. 11D

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US18/37138

A. CLASSIFICATION OF SUBJECT MATTER
IPC - E01C 11/22; E03F 5/04; E01D 19/08 (2018.01)
CPC - E01C 11/224, 11/227; E03F 3/046, 5/0401; E01D 19/086

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,522,531 A (Thomsen, B. et al) 1985.06.11; figures 1-5; column 2, lines 50-55; column 3, lines 24-30, 39-41; column 4, lines 54-56, 67-68; column 5, lines 21-23	1-2, 7, 12, 17-18
Y	US 2016/0362883 A1 (ABT, Inc.) 2016.12.15; figure 1; paragraphs [0023]-[0025]	1-3, 5-8, 12-16
Y	US 4,815,888 A (Stegmeier, W.) 1989.03.28; figures 1-2; column 2, lines 14-16; column 3, lines 20-24; column 4, lines 21-30, 31-37	1-3, 5-8, 12-14
Y	US 2,780,150 A (Yeoman, R.) 1957.02.05; figures 1-2; column 3, lines 47-50; column 4, lines 1-5	15-16
Y	US 6,443,656 B1 (Gunter, C.) 2002.09.03; figure 20; column 9, lines 52-58; column 10, lines 28-31	14
A	US 8,240,946 B2 (Applefield, S.) 2012.08.14; entire document	1-18
A	FR 2,967,428 A1 (Bouygues Batiment Ile De France) 2012.12.07; entire document	1-18
A	KR 100770164 B1 (LINE ARCHITECTS & ENGINEERS CO., LTD) 2007.10.25; entire document	1-18
A	JP 2013/185361 A (DOYU DAICHI CO., LTD.) 2013.09.19; entire document	1-18

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 August 2018 (18.08.2018)	31 AUG 2018
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)