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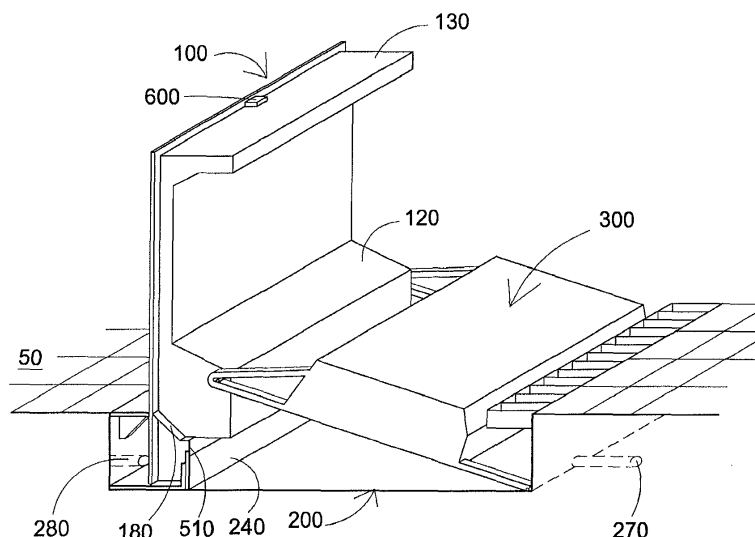
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(54) **SELF OPERATING BARRIER FOR FLOOD, SPILL AND OTHER PROTECTION**

(57) This invention relates to a self operating barrier for preventing the passage of flood water, chemical spills or other liquids from one area to an adjacent one, or for other protection. A gate is provided between the two areas so that the gate normally rests at grade level above a gate operating member. The gate and the gate operating member are hinged inside a housing so that on rotation they move away from each other. When liquid enters the housing, hydrostatic pressure develops on

both bodies and the latter urges the gate to rotate upwards so that the gate turns to upright position automatically before liquid level reaches grade level. The barrier may return automatically to flat position or lock in upright position. It may have modular construction thereby providing mobile flood protection. The same method of barrier operation barrier is used for preventing the passage of vehicles or other bodies.

FIG. 2b



Description

[0001] The invention relates to a barrier for protecting an area, for example for protecting the area from the entry of flood water, liquid spill, a vehicle, people, animals. The invention also relates to a method of protecting an area by using such a barrier.

[0002] Flooding is the covering by water of land not normally covered by water. Flooding is expected to be more intense and more frequent due to climate change. Living with the floods is a policy already adopted by the European Union and other states. Flood damage may be reduced by the use of flood barriers. Use of sand bags is the traditional type of flood barrier. Flood barrier technology is available and there are many barriers associated with different methods of construction (temporary or permanent), installation (pre-installed, partially pre-installed), deployment (manual, automatic, semi-automatic), materials (rigid, flexible), protection (perimeter barriers, aperture barriers).

[0003] Flood barriers protect areas from damage and losses due to flood water. Flood barriers are strong enough to resist the horizontal actions such as hydrostatic pressure, current, wave and wind actions, object impact. Flood barriers are also sufficiently watertight so that any leakage of water past the barriers is acceptable. When on stand-by, pre-installed flood barriers withstand traffic action, they blend with the environment and they do not obstruct underground services.

[0004] Flooding may be caused for example from the rise of level of water in rivers, canals, sewers, rainfall run-off, sea level rise, or from wave overtopping coastal promenades.

[0005] Liquid barriers may also be used for spill containment. Apart from liquid arrest, barriers may also be used for example for solid body arrest such as security barriers, preventing the entry of vehicles, people and other lifeless and living bodies from entering a protected area, sound barriers and other applications of flip up barriers.

[0006] A method of calculating the forces on flood barriers from hydrostatic loading, debris impact, wave, wind and current loading is posted on the internet by the inventor (www.floodresilience.eu "Innovations & Outcomes"). The method of calculating the stresses of the structural components of a flood barrier and the method of construction are also disclosed at the same web location. The method of closing and opening a bottom hinged flood barrier and possible applications are described on the internet. These disclosures were made as part of a European Union funded project in order to open the road-to-market for application of flood resilience technology. The tools provided allow the user to select or develop the method of operation, which is manual in the disclosed barrier, the materials and other parameters.

[0007] A bottom hinged flood barrier for the prevention of inland flooding is known from US 6623209. This discloses a horizontally pivoted flood gate which is floated

out of a housing in the ground due to water pressure bounded by the rising gate and two side walls. Another example is shown in US 2012/0163917. A low cost solution based on the same principle is described in EP 1880058, in which the barrier is founded in a trench back-filled with soil from the excavation. Barriers based on this principle have a disadvantage that they require side walls at the side ends of the gate.

[0008] Another bottom hinged flood barrier is disclosed in DE 19514205 A1 in which a gate inside a chamber is pivoted at the crest of a sheet pile. The part of the gate in front of the pivot is buoyant and the part at the rear of the pivot has a counterweight. On water entering the chamber buoyancy action on the front part of the gate urges the gate to rotate automatically to upright position. This barrier has the disadvantage that it requires deep excavation.

[0009] A self-deploying floodwall is described in US 2012/0148346 A1, in which a buoyant stem normally lays down flat at or below ground inside a porous pre-excavated shallow trench. The stem is pivoted at ground level. Water entering the trench imposes an uplift force on the stem which then rotates gradually and rises in the direction of the intruding water while providing flood protection. This barrier has the disadvantage that it requires side walls.

[0010] A bottom hinged flood barrier for automatic self-deployment is disclosed in JP2008184813 (A). In this barrier the gate is normally locked inside a recess. A pair of mechanical door closers are provided, respectively supported on a pair of gate posts, one on each side of the gate. The door closers continuously bias the gate from a lowered position to an upright position, but the door is held in the lowered position by a gate latch. When a float rises up it releases the gate latch, permitting the energy stored in the door closers to cause the door to rotate to the upright position. This barrier has the disadvantage that it requires the use of mechanical door closers.

[0011] DE19539611 A1 discloses a flood barrier for use in valleys, which have uneven topography. The flood barrier consists of a series of bottom pivoted gates, the pivots of adjacent gates having different slope. The facing edges of the gates engage with each other via a connection device, thus permitting relative movement in the plane of the gates but no relative movement about the pivot axis. This barrier may not be used to protect areas in which the flood water is approaching from a flat topography and not from a valley shaped area.

[0012] A flood barrier with collapsible side walls for protecting a building opening is disclosed in GB 2403254. A buoyant gate is pivotally mounted along the base of the opening and rotates upwards with the rising water level. The gate has collapsible side panels which allow the gate to pivot whilst preventing the ingress of flood water. This barrier has the disadvantage that it requires side walls.

[0013] An automatic aperture barrier which turns to an

upright position before liquid level reaches a threshold is described in WO 2012/076855. This barrier has a disadvantage that the level of the area protected must be higher than the level of the surrounding ground by the height of the threshold.

[0014] A floodgate which turns to upright position by means of gas struts is disclosed in US 2013/0209173. The floodgate is normally locked flat with grade. The gate is unlocked either manually or automatically after activation of an alarm. Similar flood gates operated by electrical pistons are also available in the market. These flood gates have a disadvantage that they depend on moving parts that require regular maintenance.

[0015] The pre-characterising parts of the independent claims of this application are based on this type of barrier, i.e. barriers which have gates rotatable to an upright position and are caused to rotate by a gate operating member.

[0016] A flood barrier which has a triangular shape when closed against floodwater is disclosed in GB2456394. The triangular shape is formed by a bottom hinged gate, a float disposed below the gate and pivoted at the front end of the gate and a membrane connected to the gate and the float. The gate is initially raised by the float and it is then raised by the hydrostatic action applied on the gate by the water bounded by side walls, and finally the float is held back by the membrane. This barrier has the disadvantage that it requires side walls. It also has the disadvantage that the gate never reaches an upright position thereby the flood level that the barrier can withstand is less than the flood level that an upright gate could withstand.

[0017] Other types of flood barrier do not involve rotation of a gate. An example of a vertically rising flood barrier is shown in US 5460462, in which a vertical barrier recessed into the ground is elevated between vertical posts when water rises within a subterranean housing containing the barrier. This barrier has a disadvantage that it requires space under the barrier deeper than the height of the barrier.

[0018] Another example of a vertically rising flood barrier is described in US 2011/0110722 in which, a vertical dam is forced upwards out of a chamber whenever the chamber fills up with water. The dam is normally underground and invisible to the surrounding environment. This barrier also has the disadvantage that it requires space under the barrier deeper than the height of the barrier.

[0019] Coastal flooding is produced when the run-up of sea waves exceeds the level of the crest of the coastal structures. Walls built along seawalls, coastal promenades, bulkheads, dikes, or levees to combat overtopping from sea waves are conventional solutions. However, these walls have a negative impact on the view of seascape, damage the view of landscape and form obstacles in the use of the coastal area.

[0020] US 2012/0163916 describes a self-actuating storm surge barrier. The gate is normally housed below

grade level some distance landwards from the edge of the coastline. A parapet wall is built seawards of the gate and transverse walls are built in between the gate and the parapet wall. Water from waves overtopping parapet wall is trapped between the parapet wall and the transverse walls. The accumulated water causes the gate unit to flip upright initially principally by buoyancy and then principally by hydrostatic pressure. This barrier has a disadvantage of requiring the permanent presence of a parapet wall and side walls in the coastal environment.

[0021] Bottom hinged barriers may also be used for spill containment. US 8246272 describes a spill barrier which may be either float activated or heat activated. This barrier has the advantage of containing spills when there is leakage whilst allowing unobstructed traffic through the passage. The activation is enabled with the use of springs. This solution has the disadvantage that the width of the barrier is limited, it requires the installation of structures at the two sides of the barrier and it requires springs for activation.

[0022] Bottom hinged barriers may be used for security and defence purposes. US 4705426 describes an example of a barrier capable of stopping a speeding vehicle. The barrier requires powered or manual means for deployment.

[0023] According to one aspect, the invention provides a barrier for protecting an area adjacent to the barrier, said barrier comprising a gate disposed adjacent to said area so that said gate rests for rotation upwardly, the gate being rotatable to an upright position, and a gate operating member for operating the gate and movable relative to the gate, characterised in that said gate operating member is buoyant, and in that the gate and the gate operating member are arranged so that when the gate operating member is caused to move upwardly by liquid acting thereon, the gate operating member urges said gate to rotate upwardly to said upright position.

[0024] According to another aspect, the invention provides a barrier for assembly to protect an area adjacent to the assembled barrier, the barrier comprising a gate and a gate operating member for operating the gate, the gate being configured so that in an assembled condition of the barrier the gate is supported so as to rest for rotation upwardly to an upright position, and the gate operating member, in the assembled condition of the barrier, being movable relative to the gate, characterised in that the gate operating member is buoyant, and in that the gate and the gate operating member are configured so that in the assembled condition of the barrier, when the gate operating member is caused to move upwardly by liquid acting thereon, the gate operating member urges said gate to rotate upwardly to said upright position.

[0025] According to another aspect, the invention provides a method of protecting an area by using a barrier as described herein.

[0026] Such a barrier can operate to rotate the gate to the upright position in response to the presence of liquid acting on the buoyant gate operating member. In pre-

ferred embodiments, therefore, it may require no power and need no human intervention.

[0027] The gate may have an upper surface when at rest, i.e. in its rest position. The level of the upper surface of the gate in its rest position may be considered as a grade level. Traffic, such as people or vehicles, may pass across the upper surface when the gate is in the rest position.

[0028] The gate operating member may urge the gate to rotate upwardly to the upright position thereby flipping up the gate.

[0029] The gate operating member is movable relative to the gate, so that a movement of the gate operating member can cause a different movement of the gate. In some embodiments, this can have the benefit that a small rise in liquid level, giving rise to a small upward movement of the gate operating member, can result in a larger movement of the gate. Thus the gate can advantageously be flipped up from the rest position to a flipped up, upright, or closed, position ahead of rising flood water, for example.

[0030] The gate operating member may be disposed laterally adjacent to the gate. In certain embodiments, the gate operating member is disposed below the gate when in its rest position. The gate operating member may comprise a buoyant body. It is convenient if at least the buoyant body of the gate operating member is disposed below the gate when in its rest position. A relatively low position for the buoyant body means that as the liquid level rises it can start to lift the gate operating member at an early stage.

[0031] The buoyant gate operating member may be mounted for linear, e.g. vertical, upward movement in response to liquid acting thereon. The gate operating member may be mounted for rotational movement in response to liquid acting thereon. The gate operating member may then comprise a gate operating arm. The direction of rotation of the gate operating member may be opposite to the direction of rotation of the gate. Thus, one may be clockwise and the other counter clockwise. In use, when the gate operating member rotates upwardly it urges the gate to rotate upwardly. In preferred embodiments, the axes of rotation of the gate and the gate operating member are horizontally spaced apart.

[0032] The area adjacent to the barrier which is to be protected may be an area behind the barrier.

[0033] In the rest position, the gate and the gate operating member may be located forwardly of the position occupied by the gate when upright. Such an arrangement may for example be suitable for protecting the area behind the barrier from the entry of flood water, liquid spill or vehicles, allowing the area rearwardly of the barrier to be relatively free from the operating components of the barrier when the gate is upright. In embodiments where the barrier is for protecting an area behind the barrier and the gate operating member is rotationally mounted, the gate operating member may be mounted for rotation upwardly and forwardly in response to liquid acting on the

buoyant body. The gate may then be urged by the gate operating member to rotate upwardly and rearwardly, in a rotational direction towards the area to be protected.

[0034] Alternatively, in the rest position the gate and the gate operating member may be located rearwardly of the position occupied by the gate when upright. Such an arrangement may for example be suitable for protecting the area behind the barrier from the entry of people, animals or other living bodies, allowing the area forwardly of the barrier to be relatively free from the operating components of the barrier when the gate is upright. In embodiments where the barrier is for protecting an area behind the barrier and the gate operating member is rotationally mounted, the gate operating member may be mounted for rotation upwardly and rearwardly in response to liquid acting on the buoyant body. The gate may then be urged by the gate operating member to rotate upwardly and forwardly in a rotational direction away from the area to be protected.

[0035] The barrier may comprise a cam mechanism configured to convert movement, e.g. rotation, of the gate operating member to rotation of the gate. The cam mechanism may be configured to convert upward rotation of the gate operating member to upward rotation of the gate, during a rise in liquid level. The cam mechanism may be configured to convert downward rotation of the gate operating member to downward rotation of the gate, during a lowering of liquid level. The cam mechanism may be configured to convert upward and downward rotation of the gate operating member to upward and downward, respectively, rotation of the gate.

[0036] By using a cam mechanism an appropriate mechanical advantage can be provided between the motion of the gate operating member and the motion of the gate. For example, a small rotation of the gate operating member may cause a larger rotation of the gate. Thus, liquid acting on the buoyant gate operating member may cause the gate operating member to move over a relatively small distance which is amplified to a movement over a larger distance by the gate.

[0037] In preferred embodiments, the cam mechanism is configured to convert rotation of the gate operating member through a first angle to rotation of the gate through a second angle larger than the first angle. This may be applicable to upward rotation of the gate operating member and upward rotation of the gate. It may be applicable to downward rotation of the gate operating member and downward rotation of the gate. It may be applicable to both upward and downward rotation of the gate operating member and, respectively, upward and downward rotation of the gate.

[0038] By having an arrangement in which a relatively small upward rotation of the gate operating member results in a larger upward rotation of the gate, the barrier may operate automatically when liquid reaches a certain level to flip the gate up to the upright position. The liquid level may be lower than that of an upper surface of the gate when it is in the rest position, i.e. lower than grade

level. Therefore, by the time the liquid level reaches grade level, the gate can already be flipped up into a substantially vertical orientation. Therefore, an early response is obtained. In the case of a defence against flooding or a liquid spill, for example, such early flipping up of the gate is beneficial. This is unlike certain prior art barriers, in which the upwardly rotating gate cannot stop rising liquid from passing around its lateral edges, and so side walls are needed for liquid containment.

[0039] The cam mechanism may be positioned so that when the gate is in the rest position the mechanism is nearer to an axis of rotation of the gate than it is to an axis of rotation of the gate operating member. This is one way in which a small rotation of the gate operating member may be amplified via the cam mechanism to a larger rotation of the gate.

[0040] The cam mechanism may comprise a cam surface and a cam follower, the cam follower being engageable with the cam surface during upward rotation of the gate operating member and the gate. One of the cam surface and the cam follower may be provided on the gate operating member and the other on the gate. In preferred embodiments, the cam surface is provided on the gate operating member and the cam follower is provided on the gate. The cam surface may face generally upwardly and may be engageable with a downwardly facing portion of the cam follower. The cam follower may protrude generally laterally, for example in a horizontal direction.

[0041] The barrier may be configured so that when the gate is in the upright position, and the gate operating member moves e.g. rotates downwardly, the gate operating member urges the gate to rotate downwardly. Thus the gate operating member may be arranged to rotate the gate both upwardly and downwardly. The upward rotation may be caused by the hydrostatic pressure of liquid acting on the buoyant body, and the downward rotation may occur as the liquid level reduces, for example in the case of receding flood water, whereby the hydrostatic pressure acting on the buoyant body reduces and the gate operating member rotates downwardly as a result of gravity. Therefore, in preferred embodiments, the barrier is both self-closing and self-opening.

[0042] In those embodiments having a cam mechanism configured to convert rotation of the gate operating member to rotation of the gate, this may comprise first and second cam surfaces and a cam follower, the cam follower being engageable with the first cam surface during upward rotation of the gate operating member and the gate, and the cam follower being engageable with the second cam surface during downward rotation of the gate operating member and the gate. In this manner, the cam mechanism is operable to cause both upward and downward rotation of the gate in response to respective upward and downward rotation of the gate operating member.

[0043] The gate may comprise a proximal protruding body protruding downwardly when the gate is at rest. In

those embodiments wherein the gate operating member has a buoyant body, the proximal protruding body may be disposed nearer to an axis of rotation of the gate than the buoyant body. The proximal protruding body may be buoyant. It may define a chamber filled with buoyant material. The proximal protruding body may be arranged so that when liquid acts thereon it may tend to lift as a result of its buoyancy, assisting upward rotation of the gate. The proximal protruding body may protrude downwardly from a main body of the gate when the gate is in the rest position. By virtue of the proximal protruding body being disposed nearer to an axis of rotation of the gate than the buoyant body when the gate is at rest (and, in those embodiments where the gate operating member is rotatably mounted, preferably further from an axis of rotation of the gate operating member than the buoyant body), a small movement caused by its buoyancy can give rise to a larger movement of an edge of the gate remote from its axis of rotation.

[0044] The proximal protruding body may provide a load bearing support to the gate when it is in the rest position. This may be beneficial as it can assist the barrier in taking heavy traffic when the gate is in the rest position.

[0045] The gate may comprise a distal protruding body protruding downwardly when the gate is at rest. In those embodiments wherein the gate operating member has a buoyant body, the distal protruding body may be disposed further from an axis of rotation of the gate than the buoyant body. The distal protruding body may then provide a load bearing support to the gate when it is in the rest position. Also, in embodiments in which the gate rotates upwardly and towards the area to be protected when flipping up, the distal protruding body can serve to reduce wave overtopping when the gate is in the flipped up, or upright, position. The distal protruding body may provide buoyancy. It may for example define a chamber filled with buoyant material.

[0046] The gate may comprise a counterweight to assist upward rotation of the gate. The counterweight may be positioned with respect to an axis of rotation of the gate such that its weight under gravity assists upward rotation of a main body of the gate. The counterweight may be positioned oppositely from the gate main body with respect to an axis of rotation of the gate.

[0047] In a preferred embodiment, the gate may have both a counterweight and one or more protruding bodies which provide buoyancy. Together, the counterweight and the one or more protruding bodies can be arranged to assist rotation of the gate upwardly, the one or more protruding bodies acting in this manner when liquid is above a certain level.

[0048] The barrier may comprise a hinge about which the gate is rotatable. The gate may comprise a first abutment disposed at a location higher than the hinge, and a second abutment disposed at a location lower than the hinge, wherein when the gate is in the upright position it engages the first and second abutments. In use, as the gate rotates upwardly, it may come into contact with the

first and second abutments simultaneously.

[0049] Such an arrangement can ensure that the gate is in a strong and secure condition when it is in the upright position. By providing first and second abutments at locations higher than and lower than the hinge respectively, the gate is able to resist hydrostatic pressure, vehicle impact or other actions urging the gate to rotate past its upright position with no or very little force acting on the hinge. This means that the barrier can be very robust without having to use a heavy duty and expensive hinge. The first abutment may be disposed at or below the grade level. In this arrangement, since the first abutment is no higher than grade level, when the gate is in the rest position the barrier may have an opening, which is between the area to be protected and the area opposite the area to be protected, and which is relatively unobstructed, for ease of traffic movement, for example.

[0050] The barrier preferably requires a minimal amount of excavation for installation. For example, when the gate is in the rest position the barrier may occupy a height which is less than or equal to 0.5 or 0.45 or 0.4 or 0.35 or 0.3 or 0.25 or 0.2 times the full height of the gate, when upright, above grade level. In an embodiment, the barrier occupies a vertical height when the gate is in the rest position which is approximately 0.25 times the full height of the gate, when upright, above grade level.

[0051] The barrier may be provided with a housing which supports the gate and the gate operating member, for example supporting both the gate and the gate operating member for rotation. The housing may be relatively compact in a vertical direction compared to the height of the gate when in the upright position. For example, the housing may have a height which is smaller than or equal to 0.5 or 0.45 or 0.4 or 0.35 or 0.3 or 0.25 or 0.2 times the full height of the gate, when in its upright position, above grade level.

[0052] The housing may have a base and opposite side walls. The side walls may extend in a forward or rearward direction and be located at the sides of the gate. The side walls may extend rearwardly and forwardly of an axis of rotation of the gate. The housing may have a laterally extending upper wall in an upper region of the housing, positioned oppositely from the gate operating member with respect to an axis of rotation of the gate. The upper wall may have an edge facing towards the gate when in its upright position, and this edge may provide the first abutment for engagement by the gate when it is rotated to the upright position. The housing may have an up-standing wall generally below the axis of rotation of the gate which provides the second abutment for engagement by the gate when it reaches the upright position.

[0053] The barrier may comprise a sealing arrangement for sealing between the gate and the housing when the gate is in the upright position. This can prevent passage of liquid from in front of the gate towards the protected area. There may be a substantially vertical partition firmly connected to the base and the side walls of the housing disposed adjacent and parallel to the axis of

rotation of the gate, a lower seal fixed to both the vertical partition and to the bottom of the gate, and side seals each fixed to the sides of the gate and closing a gap between the sides of the gate and the sides of the housing.

[0054] The barrier may comprise an entry portal for allowing entry of liquid into the housing. As the housing will be installed below grade level, water may enter it before it reaches grade level.

[0055] The barrier may comprise a drain portal for allowing drainage of liquid from the housing. The barrier may comprise a storage tank or other liquid receptor, thereby allowing for control of the level of liquid above a base of the housing and thereby control of the rotation of the gate operating member and the gate.

[0056] The barrier may comprise upright, e.g. vertical walls on each side of the gate, extending in a lateral direction. There may be respective seals between each vertical wall and the gate when it is in the upright position. The vertical walls may define an opening which is to be occupied by the gate when it is upright. The walls may form jambs along their vertical edges. The seals may be provided fixed to these jambs so as to seal with the gate when it is upright. If the seals on the jambs face forwardly, hydrostatic pressure acting rearwardly on the gate when it is upright will tend to energise the seals.

[0057] The gate may have a first surface portion facing away from the direction of rotation of the gate as it rotates upwardly, and the barrier may have a second surface portion adjacent to the first surface portion when the gate is in the upright position, and the first and second surface portions may extend in substantially the same plane when the gate is in the upright position. Such a configuration may for example be provided by appropriate positioning of an axis of rotation of the gate. It may also be achieved by appropriate dimensioning of the gate and other barrier portions adjacent thereto. Such an arrangement allows for the use of a sealing member which, when the gate is in the upright position, is substantially planar and extends between the first and second surface portions in sealing engagement with these surfaces.

[0058] The second surface portion may for example belong to an upright wall on the side of the gate, and/or to a lower portion of the barrier, such as the housing, which is below the gate when it is in the upright position. A sealing member extending between the first surface portion of the gate and the second surface portion belonging to such a lower portion may adopt a folded condition when the gate is at rest (i.e. not in the upright position).

[0059] The gate may have an axis of rotation extending in a lateral direction, the axis of rotation being in a position which, when the gate is in the upright position, is laterally in line with the first surface portion of the gate or is horizontally offset therefrom in the direction of rotation. This can assist in providing the co-planarity of the first and second surface portions when the gate is upright.

[0060] In embodiments having a buoyant proximal pro-

truding body, this may be positioned at a predetermined distance from an axis of rotation of the gate. With this arrangement, when the gate is at rest (i.e. not in the upright position), the sealing member may be folded with no interference with the proximal protruding body.

[0061] The gate operating member may comprise a counterweight to assist movement of the gate operating member upwardly. This can reduce the loading at an axis of rotation of the gate operating member, for example on a hinge which mounts the gate operating member. It can reduce a net upward force on the gate operating member under upward hydrostatic pressure, thereby assisting stability of the gate operating member.

[0062] The gate may comprise a plurality of main structural elements, said main structural elements being upright when the gate is upright. The gate operating member may comprise a plurality of structural elements aligned under the gate main structural elements when the gate is at rest. The gate operating member may further comprise a plurality of struts, said struts being upright when the gate is at rest and being aligned under the main structural elements of the gate and the structural elements of the gate operating member. Thus traffic load on the gate may be transferred through the structural elements of the gate and the gate operating member to the struts thereby imposing little or no bending on the structural elements.

[0063] The gate may comprise a plurality of secondary structural elements between the main structural elements and parallel thereto. This can reduce the spacing between the structural elements. The gate operating member may not require equivalent secondary structural elements.

[0064] The gate and the gate operating member may further comprise a plurality of transverse members. These may be parallel to a gate axis of rotation. These can transfer concentrated loads applied on one structural element to adjacent ones. Concentrated loads on the gate may then be transferred to adjacent structural elements, and the barrier can withstand large traffic loads with a large or small footprint.

[0065] The barrier may comprise a transportable module whereby the barrier may be temporarily assembled at a deployment site, said transportable module comprising at least a base support apparatus for supporting the gate and the gate operating member, and said transportable module comprising the gate and the gate operating member.

[0066] In situations where rising floodwater is anticipated, it is useful if the barrier is provided as a transportable modular system which can be installed ready for use while still allowing traffic to pass across it. The base support apparatus may be placed on the surface, e.g. ground or road surface, of the deployment site, to provide support for the gate and the gate operating member. In the rest position of the gate, traffic may pass across the barrier. The gate may be rotatably mountable to the base support apparatus and the gate operating member may

be movably mountable to the base support apparatus. The base support apparatus can provide a hinge for the gate and/or a hinge for the gate operating member.

[0067] The base support apparatus may provide sliding and overturning stability to the barrier. The barrier may comprise at least one dead weight body for weighing down the base support apparatus. The at least one dead weight body may be part of the base support apparatus, or it or they may be separate. If the at least one dead weight body is separate, it may weigh down the base support apparatus by resting on at least a portion of it. Additionally, or alternatively, a locking member may be provided for locking the at least one dead weight body to the base support apparatus.

[0068] There may be a single dead weight body. The barrier may comprise a first dead weight body at a first end of the base support apparatus in the direction of gate rotation, and a second dead weight body at a second end of the base support apparatus in the direction of gate rotation opposite to the first end. One of the dead weight bodies may weigh down, and thereby stabilise, a hinge for the gate. The other of the dead weight bodies may weigh down, and thereby stabilise, a hinge for the gate operating member.

[0069] The barrier may comprise a plurality of transportable modules for assembly side by side. The modules may be removably connected to each other at their sides. Said modules may for example be stored at a location and be transported and assembled adjacent to an area prone to flooding, thereby providing movable flood protection. Individual parts of a module, such as the base support apparatus, the gate and the gate operating member, may themselves be transported as separate items to a deployment site.

[0070] The elevation of the or each module relative to a ground surface may be adjustable. This may be achieved by a plurality of shims. The shims may be positioned beneath the base support apparatus. At some deployment sites, the ground surface, such as a road surface, may be at an angle to the horizontal in the lateral direction due to a camber or super elevation. By providing each of a plurality of modules with elevation adjustment, it is possible to place the gates of laterally adjacent modules in horizontal alignment.

[0071] In the preferred embodiments, the gates of laterally adjacent modules will rotate as one unit. This can be assisted by ensuring that the gates are in horizontal alignment. It can also be assisted by providing a rigid connection between adjacent gates. Sealing between adjacent gates can be provided by rigid strips at the side edges of adjacent gates, or by the lateral overlap of respective sealing members projecting at the sides of adjacent gates.

[0072] The gate may be arranged to carry traffic when in its rest position at a level which is above the surface of the deployment site. It is therefore possible to avoid excavation at the deployment site. Rather the base support apparatus may simply be placed on the existing sur-

face, stabilised by its own weight and/or a dead weight body and/or additional securing such as bolting to the ground. There may be at least one ramp to carry traffic up to or down from said level. At least one ramp may be provided at each end of the barrier (considered in the direction of traffic flow).

[0073] In the embodiments having first and second abutments for engagement by the gate, these may be provided as a single rigid unit, for example as part of the base support apparatus.

[0074] In order to define an opening which is to be occupied by the gate when it is in the upright position, vertical posts may be provided so as to be laterally adjacent to the gate when upright. Laterally outwardly of the barrier, additional flood protection may be provided with sand bags, plastic barriers or other barriers spanning between the posts at the sides of the barrier and the boundary of the overall area to be protected. For example for a 12 m wide road, the barrier will be e.g. 4m wide (which may consist of four 1 m wide transportable modules) so that emergency vehicles can cross over it. The remaining 8m, 4m each side, may be closed with sand bags or other barriers.

[0075] The barrier may comprise a buoyant latch arranged to lock the gate in the rest position, and responsive to a rising liquid level to unlock the gate and allow it to rotate upwardly. Such a buoyant latch can provide the barrier with a tamper-proof feature. The buoyant latch may be relatively inaccessible to an unauthorised person. For example, the buoyant latch may be positioned below grade level. It may be protected from unauthorised access by a lockable cover, the cover preferably having an upper surface at grade level. The latch may be rotatably mounted and arranged so that when the liquid is below a certain level it rests under its own weight to lock the gate in the rest position, and when the liquid level is above said certain level the buoyant latch rotates as a result of its buoyancy and thereby unlocks the gate to allow it to rotate upwardly.

[0076] In certain embodiments, the gate has a protruding locking element, and the latch has an edge portion above the locking element when the latch is in its rest position. The latch may not actually touch the locking element, and may be arranged to touch it only when an attempt is made to rotate the gate upwardly. The latch may then be configured so that when it rotates under the action of hydrostatic pressure from liquid (i.e. as a result of its buoyancy), its edge portion rotates downwards without touching the locking element so that the edge portion is then out of the way of the locking element for upward rotation of the gate. The buoyant latch may be arranged to unlock the gate when the liquid level is lower than the level at which the gate would start to rotate upwardly.

[0077] The gate may be arranged to return automatically to the rest position after a flood event, for example. In this situation, for example in an inland flooding scenario, the aforementioned camming mechanism can operate to return the gate to the rest position as flood waters

recede. It may however be desirable to maintain the gate in the upright position. The barrier may therefore have a gate closure latch arranged to latch the gate in the upright position. In coastal flooding applications, where waves may overtop grade level intermittently, the gate can thus be self locked in the upright position. The gate closure latch may be provided as part of the cam mechanism. It may for example be arranged so that the cam follower becomes trapped and cannot follow the second cam surface, for example, in a manner which would allow downward rotation of the gate operating member and the gate. The gate closure latch may be capable of being manually released so that as conditions improve and wave overtopping is no longer a concern the gate closure latch may be released to allow the gate to return to the rest position.

[0078] The barrier may comprise a gate rotation alarm arranged to be activated when a level of liquid is above a predetermined level thereby issuing a warning prior to upward gate rotation. This may be useful to warn people that the gate is about to rotate upwardly.

[0079] The barrier may comprise a gate position alarm arranged to be activated when the gate is not at rest, i.e. in the rest position. This may be useful to notify pedestrians or drivers that the gate is a potential obstacle.

[0080] The barrier may comprise a tying member which in use is connected at one end thereof to the gate and at the other end thereof to an anchor portion of the barrier spaced from an axis of rotation of the gate. With this arrangement, when the gate rotates to the upright position, the tying member can tie the gate to the anchor portion. This can assist the gate in resisting hydrostatic pressure, reducing stresses in the gate and the overturning moment at the bottom of the gate.

[0081] The tying member may be connected to the gate at or adjacent to the top thereof when it is in the upright position. The tying member may be part of a tying assembly which extends laterally as well as between the anchor portion and the gate. Any objects travelling towards the gate, e.g. debris in flood water, that hit the tying assembly can cause it to pull on the gate and urge the gate to rotate downwardly. As a result the force of object impact and hydrostatic pressure oppose each other and stresses in the gate from object impact can be reduced.

[0082] A plurality of tying members may be provided.

[0083] The tying assembly may include a screen extending laterally. The screen may be supported at a lateral interval by two laterally spaced tying members.

[0084] The tying member or members may be foldable. Thus when the gate is in the rest position the tying member(s) may be folded and lie generally flat with the gate. In a simple form, the or each tying member may be a flexible tension element, such as a rope, chain, or wire. In another form the or each tying member may be substantially rigid. The or each tying member may have at least one fold axis. If a laterally extending screen is provided, this may also be foldable.

[0085] The anchor portion of the barrier may be provided at a fixed point on the barrier, for example on the

housing of the barrier. It could however be provided on the gate operating member, for example at or close to a rotation axis of the gate operating member.

[0086] At least in the preferred embodiments of the invention, the gate and the gate operating member are arranged so that when the gate operating member is caused to move upwardly by liquid acting thereon, the gate operating member urges the gate to rotate upwardly to an upright, substantially vertical, position.

[0087] Certain embodiments of the invention will now be described, by way of example only, and with reference to the accompanying drawings, in which:

Figs. 1-5 show a first exemplary embodiment of a barrier preventing the entrance of liquid into a protected area for example a barrier at the entrance of a flood prone area or a spill containment barrier; Figs. 1a-d show the exemplary embodiment in isometric perspective view at four stages of barrier operation: at normal position flat with grade, at initial closing position, at intermediate closing position and at upright position;

Figs. 2a-b show the exemplary embodiment in axonometric sectional view at two positions: flat with grade and in upright position;

Figs. 3a-f show six vertical cross-sections of the exemplary embodiment at three different stages of rotation, flat with grade, during rotation and at upright positions and at two different sections locations, one adjacent to the side of the gate and one further from the side;

Figs. 4a-b show the internal structure of the exemplary embodiment in axonometric section flat with grade and in upright position;

Figs. 5a-d show the construction of the exemplary embodiment in axonometric exploded partial sections;

Figs. 6a-b show the operation of the self operating latch locking and unlocking the barrier in its normal position flat with grade and the operation of the self locking latch locking the barrier in upright position; Figs. 7a-c show an alternative embodiment of a flood barrier protection an area behind a river or canal edge;

Figs. 8a-b show an alternative embodiment of a flood barrier protecting an area adjacent to an area served by a drainage system;

Figs. 9a-b show an alternative embodiment of a flood barrier protecting an area behind a line across a paved road, the barrier installed over the existing road surface;

Figs. 10a-c show an alternative embodiment of a plurality of flood barriers protecting a coastal area from wave overtopping;

Figs. 11a-b show a different embodiment of a barrier protecting an area from the entry of vehicles; and

Figs. 12a-b show a different embodiment of a barrier protecting an area from the entry of people.

Figs. 13a-d show another embodiment, Fig. 13a showing a vertical section when the gate is flat with grade, Fig. 13b showing a vertical section when the gate is upright, Fig. 13c showing an axonometric detail of the bottom end when the gate is flat with grade, and Fig. 13d showing an axonometric detail of the bottom end when the gate is upright;

Figs. 14a and 14b show the internal structure in axonometric section, flat with grade, of the gate and the gate operating member of the Fig. 13 embodiment, respectively;

Fig. 15a shows the gate and the gate operating member of the Fig. 13 embodiment in axonometric section and flat with grade;

Fig. 15b shows the gate and the gate operating member of the Fig. 13 embodiment in axonometric section and in upright position;

Fig. 16a shows a vertical section of another embodiment, with a modular construction;

Figs. 16b, 16c and 16d show another embodiment showing the modular construction of Fig. 16a applied across a sloping pavement, respectively in cross section (Fig. 16b) and in isometric view (Figs. 16c and 16d);

Figs. 17a and 17b show another embodiment having a pair of barriers covering a culvert, providing increased drainage capacity in extreme events and a useable surface during normal conditions;

Figs. 18a and 18b show another embodiment having a barrier extending over water at the edge of a wall; Figs. 19a-c show another embodiment having a barrier hidden in front of a vertical up-stand wall and arranged to rotate automatically by 180 degrees during a flood event; and

Figs. 20a and 20b show another embodiment having a tying assembly.

[0088] The drawings, details and descriptions of the embodiments are non-limiting ways in which the concepts of the invention may be applied. Their aim is to illustrate to skilled persons the use of the present invention in any appropriate system, method, apparatus or construction.

[0089] Reference in this document to "an embodiment" means that a particular feature, structure, or characteristic is included in at least one embodiment and it does not necessarily refer to the same embodiment. Particular features, structures, or characteristics may be combined in one or more embodiments. Variations may be made within the scope of the invention and parts shown in the drawings or described may be implemented in a more separated or integrated manner, or removed or rendered as inoperable. Numerous alternative and different embodiments may be made using concepts of this invention. Drawings, details and descriptions are interpreted as illustrative and not as limiting the invention.

[0090] Figs. 1 to 19 are illustration examples of embodiments of the invention. The figures are not to scale.

Like or similar parts are marked on the figures and referred in the descriptions with the same numbers. Groups of parts are referred as a whole with numbers and are marked in the figures with arrowheads.

[0091] For the sake of clarity some parts in the figures are shown exaggerated, smaller or schematically, some are omitted and some details are not shown.

[0092] Figs. 1 to 6 show an exemplary embodiment of a flip up barrier which protects area 50 adjacent to the barrier from the entry of liquid. Area 50 may be considered as being behind the barrier. Area 50 in this exemplary embodiment is for example a flood prone area. Area 50 could also be a space adjacent to a storage area of liquids and the barrier is used for spill containment.

[0093] Fig. 1 a shows the barrier at normal position, with the gate 100 (see Fig. 1 b) in a rest position. Gate top surface 170 is flat with grade in front of protected area 50. The barrier prevents the entry of liquid into area 50 between vertical walls 250a and 250b over edge 210, which is also flat with grade, i.e. at grade level. Liquid approaching area 50 enters into a portal 260. During normal use, access to and from area 50 is unobstructed over portal 260, surface 170 and surface 220.

[0094] Figs. 1b and 1c show the barrier at two stages during rotation and Fig 1 d shows the barrier with the gate 100 in an upright flipped up position. Liquid enters through portal 260 inside housing 200. A gate operating member 300, which includes a buoyant body 350, normally rests under gate 100 inside housing 200. The gate operating member 300 is buoyant so that on submergence in liquid, it urges gate 100 upwards. The gate operating member 300 is rotationally mounted, and so may be considered as a gate operating arm. In the upright position top surface 170 presses firmly seal 530 and seals 540a and 540b. Seal 530 is affixed to edge 210 and seals 540a and 540b are affixed to recesses on the front faces of walls 250a and 250b. Side faces 252a and 252b are disposed so that gate top surface 170 fits in between them.

[0095] Figs. 2a and 2b show a part of the exemplary embodiment in axonometric section at normal position flat with grade and in upright position. Liquid enters housing 200 through portal 260 and exits through outlet 270. For spill containment, for example, outlet 270 is normally closed. For flood protection, outlet 270 is connected for example to a drainage system and controls the flow so that when drainage system can accommodate the flow entering housing 200 all water is drained away whereas when drainage system is full flood water accumulates inside housing and hydrostatic pressure develops on buoyant body 350 and gate 100. Liquid inside housing 200 is contained by gate 100, partition 240 and flexible seal 510. Seal 510 is affixed to gate 100 and partition 240. The space behind partition 240 is sealed both when gate 100 is flat with grade and when in upright position, thereby this space is normally dry. Liquid or other bodies might enter the space behind partition 240 during gate 100 rotation and outlet 280 allows exit to, for example, a

collection pit.

[0096] In this exemplary embodiment gate 100 is mounted for rotation about an axis. The gate 100 comprises buoyant protruding bodies 120 and 130 shaped so that buoyant body 350 rests in between bodies 120 and 130, allowing unobstructed rotation of gate 100 and body 300. Protruding body 120 may be considered as a proximal protruding body because it is nearer to an axis of rotation of the gate than the buoyant body 350, and the protruding body 130 may be considered as a distal protruding body because it is further away from the axis of rotation than the buoyant body 350.

[0097] Figs 3a-c show cross sections of the exemplary embodiment adjacent to the side edge of gate 100. Gate 100 is rotationally mounted by hinge 102 so that at normal position gate surface 170 is substantially flat with grade, close to edge 210 and bottom surfaces 122 and 132 resting on base 202. In upright position gate 100 is in contact both with edge 210 and stopping element 230. Edge 210 provides a first abutment disposed at a location higher than hinge 102, and stopping element 230 provides a second abutment disposed at a location lower than hinge 102, whereby when gate 100 reaches the upright position it engages simultaneously with the first and second abutments.

[0098] The gate operating arm 300 comprises, in addition to the buoyant body 350, protrusions 310, 320 and 360 disposed so that on rotation of the gate operating arm and the gate 100 these protrusions move freely at the sides of gate 100. Thus the gate 100 and the gate operating arm are movable relative to each other. Protrusion 360 is connected to hinge 302, forming the rotational mounting of the gate operating arm, so that on rotation of the gate operating arm upwards, protrusion 310 slides under protrusion 110, with the result that the gate operating arm urges the gate 100 upwards.

[0099] Thus the protrusion 310 of the gate operating arm and the protrusion 110 of the gate 100 form a cam mechanism configured to convert rotation of the gate operating arm to rotation of the gate 100. As can be seen in Fig. 3b, rotation of the gate operating member through a first angle is converted by the cam mechanism to rotation of the gate through a second angle larger than the first angle. The protrusion 360 provides a cam surface and the protrusion 110 provides a cam follower, wherein the cam follower is engageable with the cam surface during upward rotation of the gate operating member and the gate 100.

[0100] Seals 520 affixed to the side of top surface 170 and seals 522 affixed to the side of protrusion 180 close the gap between the side of gate 100 and sides 252.

[0101] When gate 100 is in upright position the centre of gravity of gate 100 is behind the axis of rotation of hinge 102, thereby gravity action on gate 100 urges gate 100 to rotate backwards towards area 50. After for example a flood event or spill event, gate 100 is in this upright position and the liquid level may recede below grade. The gate operating arm then tends to rotate down-

wardly under its weight, so that protrusion 320 of the gate operating arm urges protrusion 110 of the gate 100 downwards. In effect the gate operating arm urges gate 100 to rotate forwards away from area 50. At a predetermined level of liquid, the urging from gate operating arm on gate 100 to rotate forwards exceeds the urging of gravity on gate 100 to rotate backwards thereby gate 100 rotates forwards and returns to position flat with grade automatically.

[0102] It will be seen therefore that the barrier is configured so that when the gate is in an upright or flipped up position, and the gate operating arm moves downwardly, the gate operating arm urges the gate to rotate downwardly. The cam mechanism further comprises a second cam surface formed by the underside of protrusion 320 of the gate operating arm, and the protrusion 110 of the gate 100 engages with this second cam surface during downward rotation of the gate operating arm and the gate.

[0103] Cover 220 is supported on a plurality of elements 224. Elements 224 are connected to housing back face 204 thereby loading on cover 220 is transferred to housing 200.

[0104] Figs. 3d-f show cross sections of the exemplary embodiment near the middle of gate 100. Fig 3d shows the barrier flat with grade. Latch 400 prevents gate 100 from rotating upwards. On rising of liquid level inside housing 200 above a predetermined level, latch 400 unlocks, alarm 600 starts emitting a sound warning signal and gate 100 is free to rotate.

[0105] On further rising of liquid level above a further predetermined level gate 100 starts rotation upwards and alarm 600 starts emitting a light signal and a different sound signal notifying the movement of the barrier.

[0106] Valve 272 fitted on outlet 270 controls the flow of liquid away from housing 200. Valve 272 is for example normally firmly closed in spill containment embodiments. In other embodiments valve 272 is closed for testing the operation of the barrier.

[0107] Figs 4a-b show part sectional axonometric views of the barrier at normal position flat with grade and in upright position. Fig. 4a shows gate 100 above body 300 both resting on housing base 202. A plurality of structural elements 150 of gate 100 is disposed above a plurality of structural elements 330 of gate operating arm 300 so that traffic load on top surface 170 is transferred directly to base 202. Fig. 4b shows gate 100 in upright position. On application of hydrostatic pressure and other horizontal actions, gate 100 urges edge 210 backwards and stopping element 230 forwards thereby horizontal actions on gate 100 impose little or no urging on hinge 102.

[0108] Fig 5a-d show exploded axonometric part sections of the construction of the exemplary embodiment. Fig. 5a shows the barrier flat with grade. Fig 5b shows gate assembly 100, stopping element 230 and partition 240. Hinge 102 connects gate assembly 100 to partition 240. Flexible seal 510 closes the gap between partition

240 and gate 100. Seal 510 is affixed to gate surface 172 and to side protrusion 180 so that there is a continuous seal along the whole length of the barrier. The space between structural elements 150 behind hinge 102 is filled with heavy weight material 140 thereby material 140 acts as counterweight. The remaining space is filled with lightweight material 142. The weight and the centre of gravity of gate assembly 100 are thereby adjusted and the gate is closing and opening automatically. Alarm 600 is disposed at the front of gate 100 so that alarm 600 is not immersed in liquid and it is visible and audible. Top surface 170 is matching with the surrounding environment, for example it is marine timber for outdoor embodiments or non-slippery metal surface in an industrial area for spill containment. External surfaces 172 are for example metal sheets attached to structural elements 150. Structural elements 150 are rigid elements for example stainless steel, aluminium, other metal or composite material. Heavy weight material 140 is for example metal pieces, concrete or other material having density higher than water. Light weight material 142 is for example expanding foam.

[0109] Fig. 5c shows the gate operating arm assembly. The construction of structural elements 330 and external surfaces is similar to the construction of gate 100. Material 340 is lightweight material. Protrusions 310, 320 and 360 comprise rigid elements connected to structural elements 330.

[0110] Fig. 5d shows the construction of housing assembly 200 and parts connected to it. Housing base plate 202 is connected to perimeter plates. It is connected to back plate 204, side plates 206 and front plate 208. Back cover 220 comprises the same construction as top surface 170. Cover 220 is supported on elements 224 and it is removable allowing access to the space behind partition 240. Portal 260 comprises for example grill and it rests on support 422. Portal 260 disposed above latch 400 and valve 272 is removable allowing access to latch 400 and valve 272. Outlets 270 and 280 are for example pipes made of material resistant to the liquid flowing through them. Valve 272 controls the rate and direction of flow for example for an embodiment in which outlet 270 is connected to a drainage system the flow is one directional. Seal 530 is affixed to edge 210 so that when gate 100 is flat with grade seal 530 closes the gap between back edge of top surface 170 and edge 210 and when gate 100 is in upright position seal 530 is compressed and it transfers urging from gate 100 to edge 210.

[0111] Fig. 6a shows the operation of latch 400. Latch 400 comprises a support 406 connected to base 202 and a buoyant main body 404 hinged to support 406 so that body 404 normally rests on base 202 and its protruding edge 410 rests above protrusion 160. At normal position, gate 100 is prevented from rotating upwards. On rising of liquid level above base 202, latch 400 rotates about hinge 402, main body moving upwards and edge 410 moving downwards, thereby allowing gate 100 to rotate upwards. After for example a flood event, gate 100 ro-

tates back to its normal position flat with grade and protrusion 160 urges latch edge 410 to rotate downwards. On contact of gate 100 with base 202 edge 410 is released from urging from protrusion 160, latch 400 returns to its normal position thereby gate 100 is automatically locked in its normal position flat with grade.

[0112] Fig. 6b shows the operation of latch 322 hinged to protrusion 320 in embodiments in which gate 100 needs to be locked in upright position and not return automatically to its normal position flat with grade, for example in wave overtopping embodiments. Latch 322 allows protrusion 110 to slide over protruding element 310 when gate 100 is opening towards area 50. On sliding of protrusion 110 forward of latch 322 protrusion 110 is locked in forward position thereby gate 100 is locked in upright position.

[0113] Figs. 7a-c show an alternative embodiment of a barrier protecting an area from flooding from overflow of river or canal. In this embodiment portal 260 is disposed at the front housing side 208. Outlet 270 coincides with portal 260. Plate 262 covers the space between gate 100 and front plate 208. Gate 100 rotates automatically to upright position before river water level reaches grade level, thereby area 50 is protected from flooding requiring no side walls or threshold. Fig. 7c

[0114] Figs 8a-b shows an embodiment of a barrier providing flood protection to area 50 which is normally served by storm sewers. Protected area 50 is for example a subway station, an underground parking area or other urban area prone to flooding. Entry point of liquid inlet portal 260 is located remotely from housing 200 at a predetermined elevation so that water flows through portal 260 and enters into housing 200 when drainage capacity of the area is exceeded. After the flood water drains back to the sewers through outlet 270.

[0115] Fig. 9 shows an embodiment of a flood barrier protecting an area 50 behind a line across a road comprising elevated pedestrian pavement. In this embodiment housing base 202 is placed over the existing road surface thereby requiring no or very little excavation. The barrier is like a hump across the road, top surface 170 is at the same level as pedestrian pavement level. Flood water enters into housing 200 through remote portal 260 disposed on rising ramp in front of gate 100. Outlet 270 drains housing 200 to road surface.

[0116] Fig. 10 shows an embodiment of a plurality of barriers protecting a coastal area from sea water flooding. Housing side surfaces 202 enable the rotation of individual gates independently. Sea water inlet 260 is located in front of gate 100 at a predetermined elevation and drainage capacity of outlet 270 is controlled by valve 272 so that sea water piles up in housing 200 when storm poses risk of flooding. Storms that do not pose a risk of flooding do not cause pile up of water in housing 200 and gate 100 is not rotated. Rise of water inside housing urges gate 100 to rotate upwards thereby protecting hinterland from sea water flooding. Latch 322 automatically locks gate 100 in upright position thereby preventing the rota-

tion of gate 100 back to its normal position when wave run-down, wind load or other horizontal actions urge gate 100 to rotate forwards.

[0117] Surface water run-off behind the barrier is drained to the sea through bypass drainage portal 282.

[0118] Fig. 11 shows a different embodiment of a barrier protecting area 50 from the entry of vehicles. During normal use traffic passes unobstructed over surfaces 262, 170 and 220. Gate 100 is closing by allowing the entry of liquid inside housing 200 and it is self locked by latch 322. Speeding vehicles are arrested by gate 100. This embodiment has the advantage that the barrier is normally invisible and it requires no power, manual or other means to be operated. It only requires water nearby which can flow by gravity inside housing 200 and activate the barrier.

[0119] Fig. 12 shows a different embodiment of a barrier protecting area 50 from the entry of people or other living bodies. The barrier is normally flat with grade allowing unobstructed passage to and from area 50 over surfaces 262, 170 and 220. When there is a risk of unwanted people entering area 50, for example terrorists, demonstrators, hooligans or animals water is allowed to enter into housing 200 and gate 100 is rotated so that top surface 170 faces the unwanted people. Gate 100 is self locked by latch 322. The area in front of the gate, where people or animals may be, is undisturbed by flipping up of the gate.

[0120] Figures 13, 14 and 15 describe an alternative embodiment of a barrier in which individual components are shown in alternative arrangements compared to the first embodiment. These arrangements are examples which illustrate how the concepts of the invention may be applied in numerous cases.

[0121] In this embodiment, the structural elements 150 of the first embodiment are replaced by main structural elements 152 and secondary structural elements 154 (see Figs. 15a and 15b). Transverse elements 156 are shown in gate 100 connecting main structural elements 152, thereby a concentrated load on one or more structural elements is spread to adjacent structural elements. The secondary structural elements 154 between the main structural elements 152 provide additional support for the top surface 170 between the main structural elements 152 so that the gate can withstand large concentrated loads with a large footprint and small concentrated loads with a small footprint. Structural elements 330 of the gate operating member 300 are aligned under the main structural elements 152.

[0122] A plurality of struts 331 are provided below the structural elements 330 of the gate operating member 300, these struts being upright when the gate is at rest. The struts 331 are under the gate main structural elements 152 and the gate operating member structural elements 330, and thereby serve to carry vertical traffic load downwardly. Transverse structural members 332 in gate operating member 300 stiffen it. Such transverse members 332 also function in the embodiment of Figure

18 (described below) to transfer the vertical load to the hinge 302.

[0123] As seen in Figures 13a - 13d, a sealing member 500 has side seal portions 520 and a bottom seal portion 510. The sealing member 500 is mounted on a first surface portion of the gate which forms part of the gate external surface 172 and which faces away from the direction of rotation of the gate as it rotates upwardly. At the side edges of the first surface portion the sealing member 500 protrudes laterally to provide respective side seal portions 520. At the lower edge of the gate first surface portion, the sealing member protrudes to form the bottom seal portion 510. The bottom seal portion 510 is mounted on a planar surface of stopping element 230 and partition 240, which is below the gate when the gate is in the upright position, and which, in this embodiment, faces forwardly.

[0124] A second surface portion of the barrier is provided by the vertical walls 250 at the sides of the gate and the planar front surface of stopping element 230 and partition 240. When the gate is in the upright position, the first surface portion of the gate and the second surface portion of the barrier extend in substantially the same plane.

[0125] When the gate is in the rest position seen in Figures 13a and 13c, the sealing member 500 forms a laterally extending fold. When the gate is in the upright position seen in Figures 13b and 13d, the sealing member adopts a substantially planar configuration in sealing engagement with the first and second surface portions. The sealing engagement is assisted by hydrostatic pressure urging the sealing member towards the first and second surface portions, thereby providing water tightness protection.

[0126] The sealing member 500 is a single piece, providing sealing at both the sides of the gate and its bottom.

[0127] As seen in Figures 13a and 13b, the axis of rotation of the gate hinge 102 is horizontally offset from the first surface portion of the gate when it is upright, in the direction of rotation (this direction being considered when the gate is in the upright position, at which point the direction is generally horizontal). This axis is also between the first 210 and second 230 abutments, passing through the main structural elements 152 and secondary structural elements 154, so that when the gate is upright the first surface portion of gate 172 is in the same plane as the front face of second abutment 230.

[0128] Buoyant proximal protruding body 120 is positioned a predetermined distance from the axis of rotation of the gate hinge 102, so that the sealing member 500 can form the laterally extending fold when the gate is in the rest position without interference from the buoyant proximal protruding body 120.

[0129] The axis of rotation of the hinge 302 for the gate opening member 300 is located near the front of the gate operating member. A counterweight 370 at the front of operating member 300 contributes in increasing the upward urging of the operating member 300 on gate 100

and in reducing the downward force required to keep the hinge 302 stationary when buoyant action urges operating member 300 upwards.

[0130] In the embodiment of Figures 13, 14 and 15, the centre of gravity of gate 100 when in the upright position is in front of the gate hinge 102, so that gravity action urges the gate 100 to rotate forwardly and downwards. Therefore the protrusion 320 of cam mechanism, as provided in the first embodiment, is not required for automatic returning of the gate 100 to the flat position after a flood event.

[0131] The above differences and others may be applied in combinations and are aimed at illustrating how the concepts of this invention may be implemented to suit particular applications.

[0132] Figure 16 shows an embodiment which has been assembled from a kit, in particular a modular construction kit. The barrier comprises a gate 100 disposed adjacent to an area to be protected, a gate operating member 300 for operating the gate, and a base support apparatus 285 which comprises housing 200 and housing assembly 290. The barrier has been removably placed on a surface of a deployment site, such as a road surface. The gate and the gate operating member are each rotatably mounted to the base support apparatus. The area to be protected is to the rear of the gate, that is, to the left of the gate as seen in Figure 16.

[0133] The base support apparatus 285 provides sliding and overturning stability to the barrier. The base support apparatus, the gate, and the gate operating member form a module. The module may be movably connected to corresponding modules at the sides. Said modules may for example be stored at a location and be transported and assembled adjacent to an area prone to flooding, thereby providing movable flood protection. Thus the modules are transportable.

[0134] In this embodiment, the housing assembly 290, to which gate 100 is attached, is movable relative to the ground. Housing assembly 290 rests in front of a front protrusion of a rear deadweight 292. Locking body 293 prevents any relative motion between housing assembly 290 and rear deadweight 292.

[0135] On a sloping surface, for example on a road surface with super-elevation, such a modular form of barrier may be erected. Ramps 296a and 296b are placed across the road surface, having the same cross-slope as the road. The barrier, which consists of gate 100, gate operating member 300 and base support apparatus 285, is placed on a horizontal level formed from shims 298 positioned across the road. Thus laterally adjacent modules are horizontally aligned. In between the ramps and the barrier, rear dead-weight 292 and front dead-weight 294 close the gap. Dead-weights 292 and 294 are placed on shims 299 so that their top surfaces transverse to the road direction are horizontal but staggered in the direction across the road. The size of the dead-weights 292 and 294 and of ramps 291 a and 296b is predetermined so that they have adequate mass to hold the barrier in

place and some of these bodies may be omitted. On a horizontal road surface (without super elevation or camber) the shims may be omitted.

[0136] Figure 17 describes a different embodiment for a culvert application. In this embodiment the culvert is covered by a pair of barriers of the present invention. Figure 17a shows the culvert during normal conditions, when the water level in the culvert is below the bottom of the gate 100 and the gate operating member 300. In this condition the top surface 170 of the gate may be used for example as a pedestrian footpath or road pavement. The load from the top surface is transferred to central support 710 in the culvert and to supports 720 at the side walls of the culvert. During flood conditions, water level rises and buoyancy action urges the gate operating member 300 upwards which urges the gate 100 to rotate upwards as shown in Figure 17b. In this embodiment the culvert has a larger drainage capacity, thus accommodating more extreme events, and it also provides a usable surface in normal conditions.

[0137] A similar embodiment applied for example on the side wall of a canal or river is shown in Figure 18. During normal use the load is transferred to a support 710 which is for example a brace and to support 720 attached to the side of the wall. This embodiment provides additional pavement surface and automatic protection against flood hazard.

[0138] Fig. 19 shows an alternative embodiment for increased flood protection of an up-stand wall. In this embodiment the barrier is hidden in front of the up-stand wall. On flood level reaching the crest of the up-stand wall the barrier assembly which includes the gate 100, the gate operating member 300 and the housing assembly, rotates and becomes horizontal. The gate operating member is held in position by a flexible tensile member 730, for example a wire rope, and a rigid member 740. On water level rising above the crest of the up-stand wall the gate operating member 300 urges the gate 100 to rotate upwards, thus providing increased flood protection.

[0139] Figures 20a and 20b show an alternative embodiment with a tying assembly 900 connecting the top part of gate 100 to the base 200 in front of the gate. The tying assembly 900 comprises tying members 920 which support laterally extending screens 910. The tying members 920 extend in a folded condition below the bottom of top surface of gate 100 and sideways of the gate operating member 300 when gate 100 is in the rest position. When gate 100 is upright the tying members 920 are straightened. The screens 910 extend in a folded condition between the bottom of gate 100 and the top of gate operating member 300 when gate 100 is in the rest position, and when gate 100 is upright the tying members 920 are straightened.

[0140] The tying members 920 are attached on axis 902 disposed near the top of gate 100 and on axis 904 disposed on housing 200 near the front of gate 100 when gate 100 is in the rest position.

[0141] When gate 100 is in the upright position tying assembly 900 assists gate 100 in resisting the urging of hydrostatic and other pressures, thereby the member stresses in gate 100 and the overturning moments at the gate abutments are reduced. Objects moving towards gate 100 hit tying assembly 900 and urge gate 100 to rotate downwards, thereby the urging from hydrostatic pressure and the urging from object impact oppose each other and the member stresses in gate 100 are reduced.

[0142] The features of the tying assembly are not limited to that shown in Figures 20 and 20a and other arrangements are possible. The tying assembly may be just tensile elements such as ropes, chains or wires, or just rigid members, or rigid members with screens or nets in between the rigid members, or rigid members with rigid plates in between the rigid members, or just screens or nets or plates without tensile elements or rigid members.

[0143] It will be seen that there is disclosed herein a flip up barrier which is automatically self-closing. The flip up barrier is for preventing the passage of flood water, chemical spills or other liquids from one area to an adjacent one. A gate is provided between the two areas so that the gate normally rests at grade level above a buoyant body. The gate and the buoyant gate operating member or arm are hinged inside a housing so that on rotation the two bodies move away from each other. When liquid enters the housing, hydrostatic pressure develops on both bodies and the buoyant gate operating member or arm urges the gate to rotate upwardly so that the gate turns to upright position automatically before liquid level reaches grade level. The barrier has the option of returning automatically to its normal position flat with grade or locking automatically in upright position. The same method of barrier operation barrier is used for preventing the passage of vehicles, other lifeless or living bodies.

[0144] There is no need of labour or power use. The barrier is normally below grade level, the top surface blends with the surroundings, it can accommodate heavy traffic load and it does not need a threshold or side walls. The depth required under grade level is small compared with the barrier height, thereby avoiding the need for deep excavation and limiting the impact on underground services crossing the barrier. The same solution may be used for different barrier embodiments, for example flood barriers, spill containment barriers, security barriers, sound barriers. In inland flooding embodiments or spill containment the barrier returns automatically to its normal position when liquid level drops below grade level. In wave overtopping embodiments or security barriers the barrier is self locked into upright position.

[0145] At least in the preferred embodiments of the invention the following advantages are obtained:

1. The barrier is self-closing requiring no power or human intervention;
2. The barrier is completely upright before flood water or spill reaches the protected area, or liquid level exceeds the level of grade;

3. The barrier is normally flat with grade, requiring, no threshold/ step or side walls;
4. The construction of the barrier needs minimum excavation;
5. For inland flood applications the barrier is self opening automatically after the event;
6. For wave overtopping coastal applications, where water level rises and drops the barrier is self locked in upright position;
7. The barrier is robust both in normal position flat with grade and in operating condition upright position;
8. The barrier is normally securely locked inside the housing and it is self unlocked before activation is required;
9. The barrier top surface blends with the environment;
10. The barrier issues warnings when rotation is imminent and when it is in operation;
11. The barrier may have a modular construction and be transportable for deployment at different locations;
12. The gate of the barrier may have its surface facing away from the direction of gate rotation co-planar with the bottom and side walls of the portions of the barrier surrounding the gate when in the upright position, so that a seal affixed on the gate surface presses flat on the bottom and side walls achieving watertightness; and
13. The barrier may have an automatically deployed assembly tying the crest of the gate to the base in front of the gate, providing additional support to the gate and minimising the stresses on the gate.

Claims

1. A barrier for protecting an area adjacent to the barrier, said barrier comprising a gate disposed adjacent to said area so that said gate rests for rotation upwardly, the gate being rotatable to an upright position, and a gate operating member for operating the gate and movable relative to the gate, **characterised in that** said gate operating member is buoyant, and **in that** the gate and the gate operating member are arranged so that when the gate operating member is caused to move upwardly by liquid acting thereon, the gate operating member urges said gate to rotate upwardly to said upright position.
2. A barrier as claimed in claim 1, wherein the gate operating member is mounted for rotation in a rotational direction opposite to a rotational direction of the gate;
optionally wherein the barrier comprises a cam mechanism configured to convert rotation of the gate operating member to rotation of the gate; and
optionally wherein the cam mechanism is configured

to convert rotation of the gate operating member through a first angle to rotation of the gate through a second angle larger than the first angle.

3. A barrier as claimed in claim 2, wherein the cam mechanism comprises a cam surface and a cam follower, the cam follower being engageable with the cam surface during upward rotation of the gate operating member and the gate.
4. A barrier as claimed in claim 1, 2 or 3, wherein said gate comprises a proximal protruding body disposed nearer to an axis of rotation of the gate than a buoyant body of the gate operating member and protruding downwardly when the gate is at rest; and optionally wherein said gate comprises a distal protruding body disposed further from an axis of rotation of the gate than said buoyant body and protruding downwardly when the gate is at rest.
5. A barrier as claimed in any preceding claim, comprising a hinge about which the gate is rotatable, a first abutment disposed at a location higher than the hinge, and a second abutment disposed at a location lower than the hinge, wherein when the gate is in the upright position it engages the first and second abutments.
6. A barrier as claimed in any preceding claim, comprising a buoyant latch arranged to lock the gate in the rest position, and responsive to a rising liquid level to unlock the gate and allow it to rotate upwardly.
7. A barrier as claimed in any preceding claim, wherein the gate has a first surface portion facing away from the direction of rotation of the gate as it rotates upwardly, wherein the barrier has a second surface portion adjacent to the first surface portion when the gate is in the upright position, and wherein the first and second surface portions extend in substantially the same plane when the gate is in the upright position;
optionally wherein the gate has an axis of rotation extending in a lateral direction, the axis of rotation being in a position which, when the gate is in the upright position, is laterally in line with the first surface portion of the gate or is horizontally offset therefrom in the direction of rotation; and
optionally comprising a sealing member which, when the gate is in the upright position, is in a substantially planar configuration and extends between the first and second surface portions in sealing engagement with these surfaces.
8. A barrier as claimed in any preceding claim, wherein the gate comprises a plurality of main structural elements, said main structural elements being upright

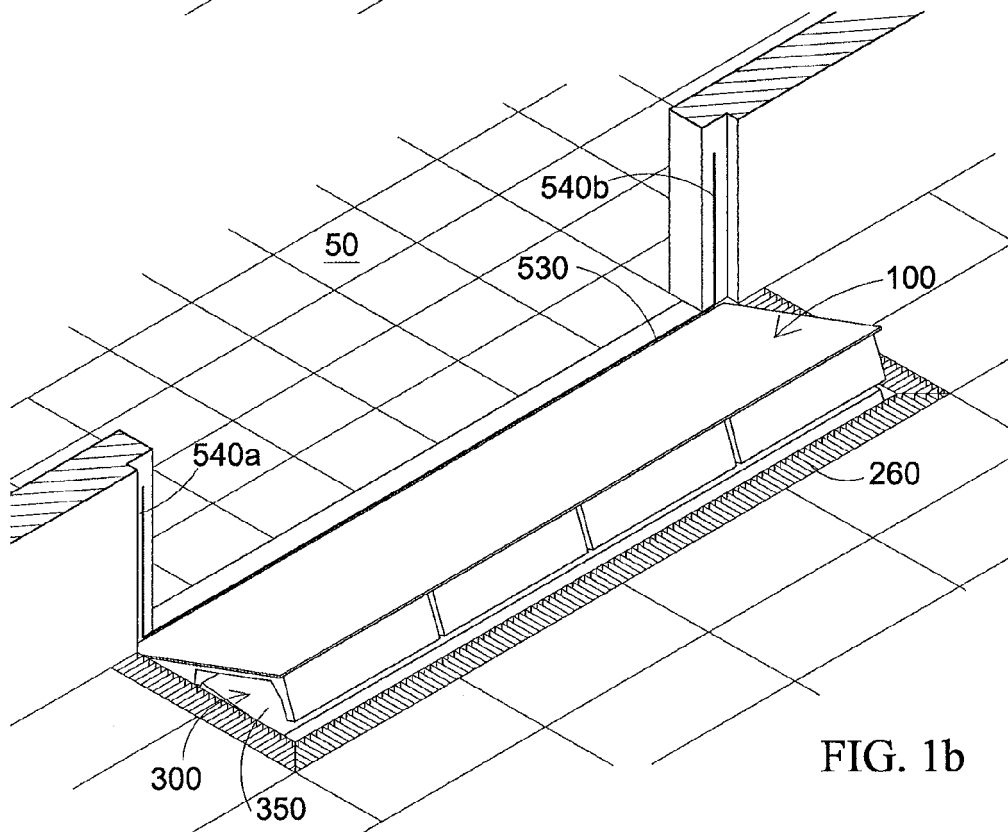
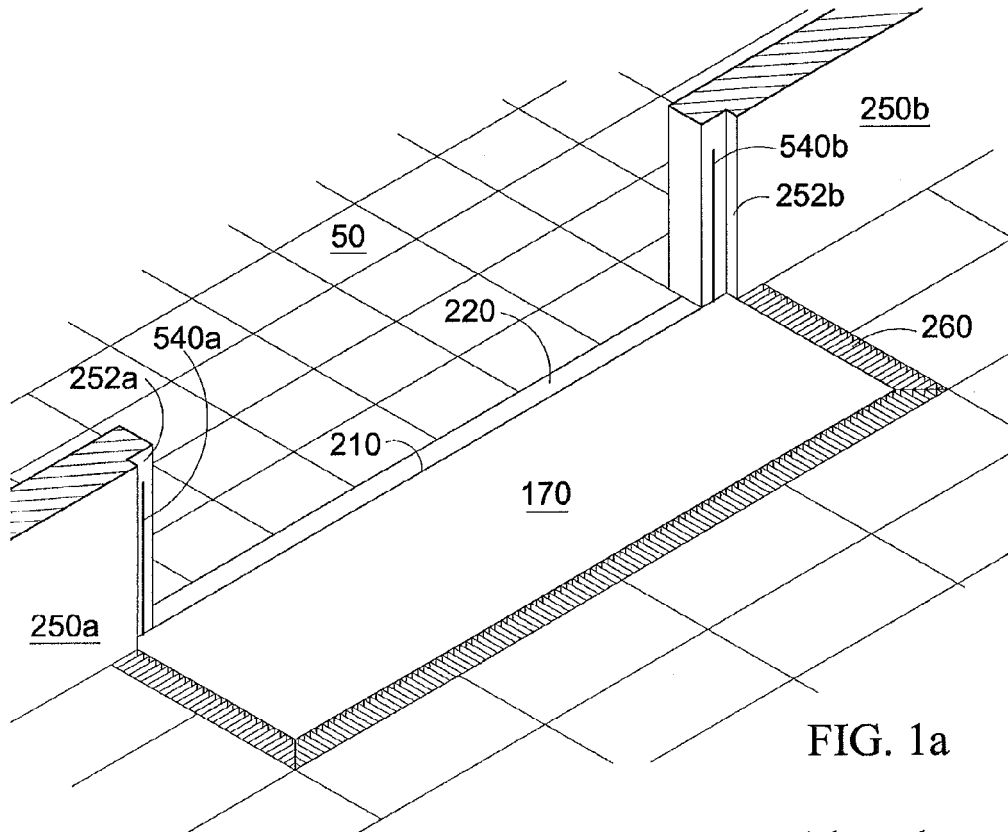
when the gate is upright; and

optionally wherein the gate operating member comprises a plurality of structural elements aligned under the gate main structural elements when the gate is at rest; and

optionally wherein the gate operating member further comprises a plurality of struts, said struts being upright when the gate is at rest and being aligned under the main structural elements of the gate and, optionally, under the structural elements of the gate operating member.

claimed in any preceding claim.

9. A barrier for assembly to protect an area adjacent to the assembled barrier, the barrier comprising a gate and a gate operating member for operating the gate, the gate being configured so that in an assembled condition of the barrier the gate is supported so as to rest for rotation upwardly to an upright position, and the gate operating member, in the assembled condition of the barrier, being movable relative to the gate, **characterised in that** the gate operating member is buoyant, and **in that** the gate and the gate operating member are configured so that in the assembled condition of the barrier, when the gate operating member is caused to move upwardly by liquid acting thereon, the gate operating member urges said gate to rotate upwardly to said upright position.
10. A barrier as claimed in any preceding claim, comprising a transportable module whereby the barrier may be temporarily assembled at a deployment site, said transportable module comprising at least a base support apparatus for supporting the gate and the gate operating member, and said transportable module comprising the gate and the gate operating member.
11. A barrier as claimed in claim 10, wherein the elevation of the or each module relative to a ground surface is adjustable.
12. A barrier as claimed in claim 10 or 11, wherein the gate is arranged to carry traffic when in its rest position at a level which is above the surface of the deployment site; and optionally comprising at least one ramp to carry traffic up to or down from said level.
13. A barrier as claimed in any preceding claim, comprising a tying member which in use is connected at one end thereof to the gate and at the other end thereof to an anchor portion of the barrier spaced from an axis of rotation of the gate.
14. A barrier as claimed in claim 13, wherein the tying member is foldable.
15. A method of protecting an area by using a barrier as



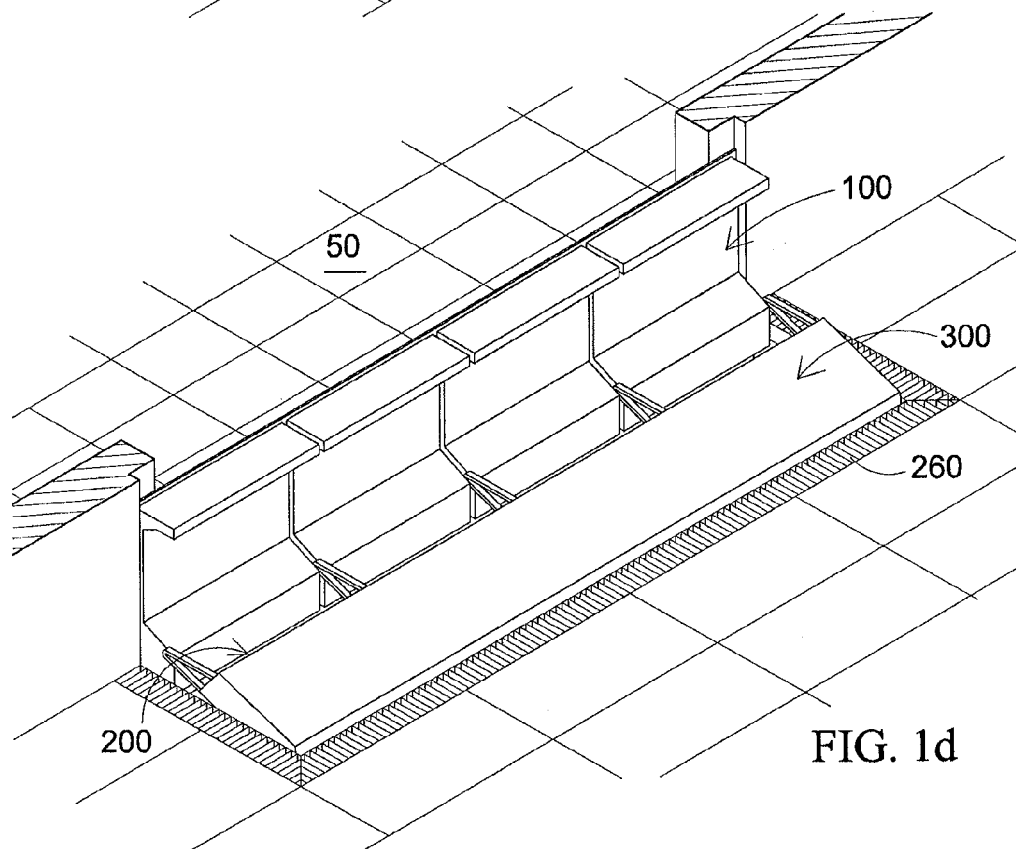
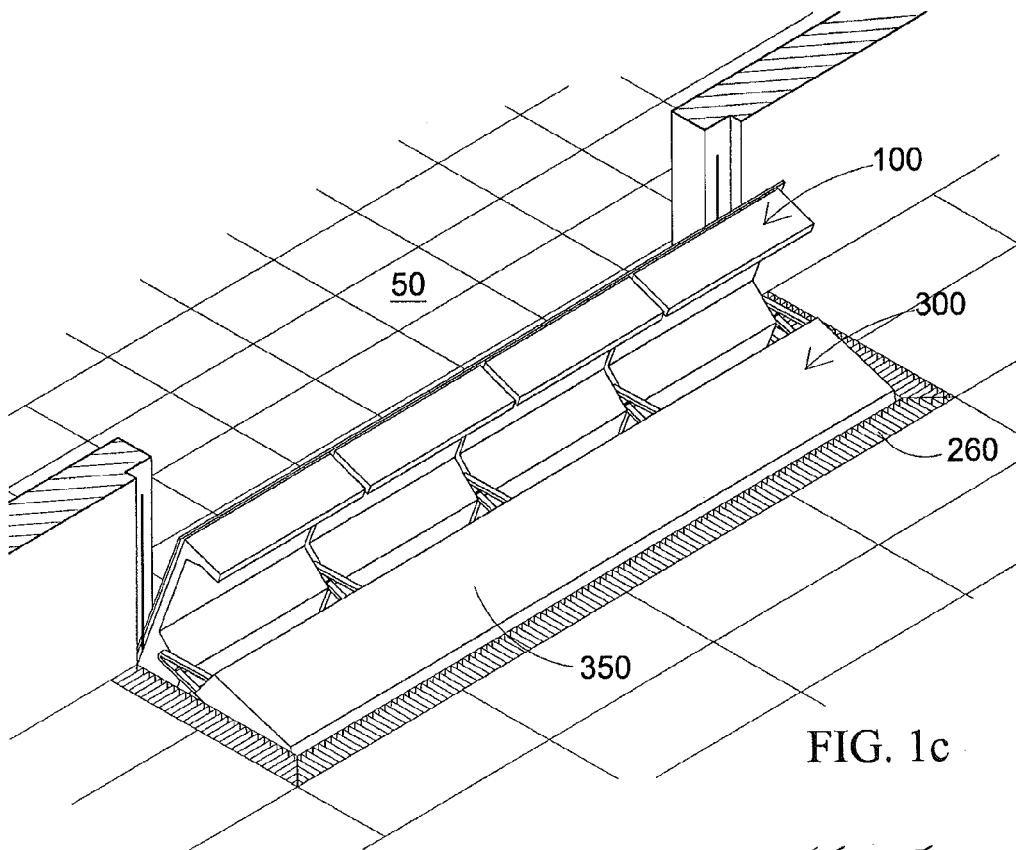


FIG. 2a

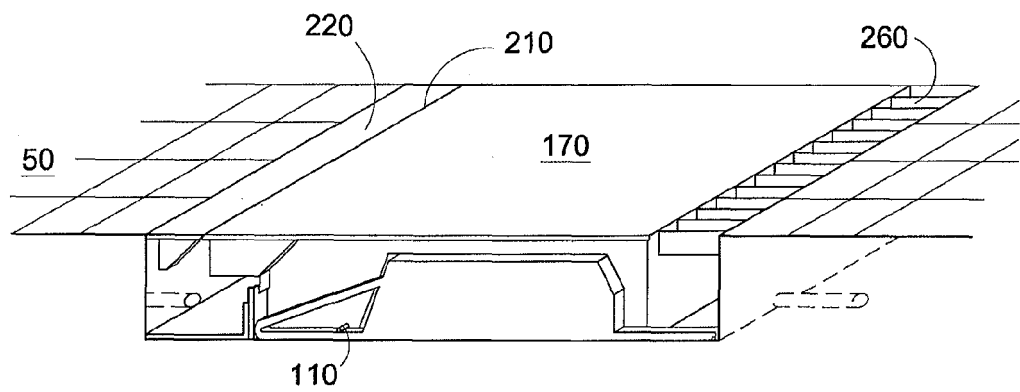


FIG. 2b

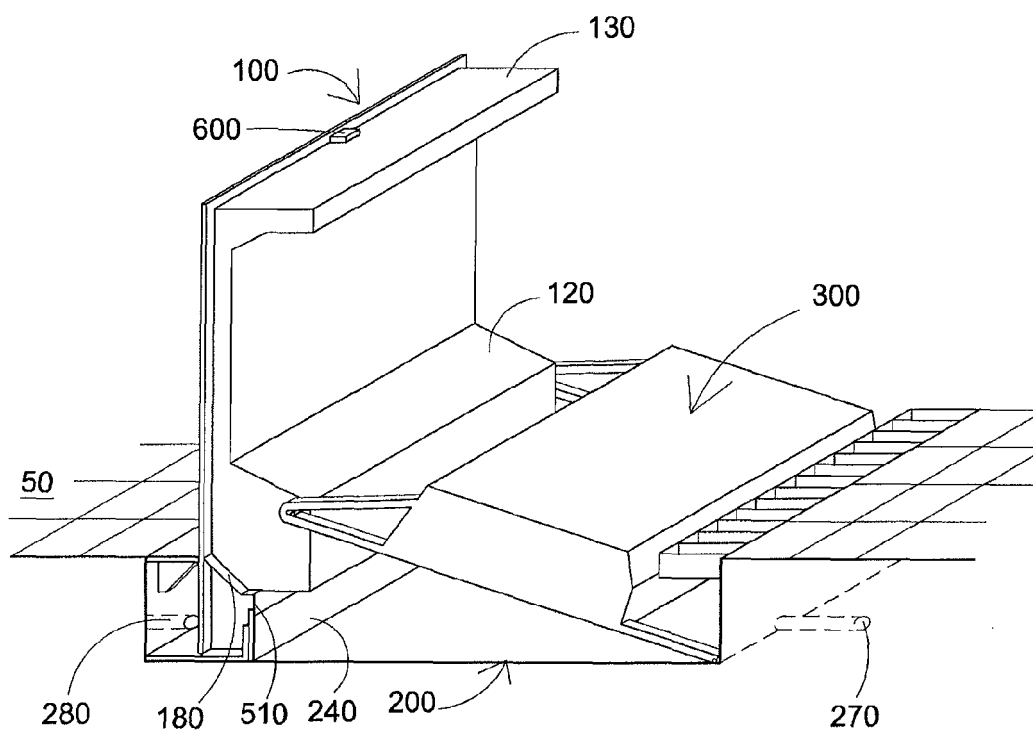


FIG. 3a

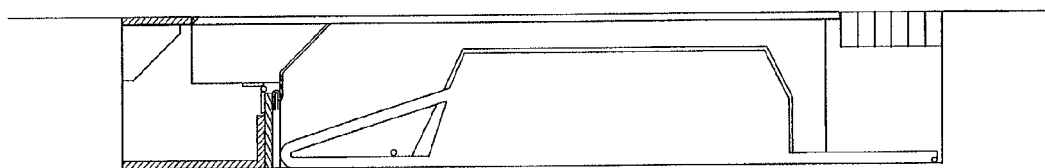


FIG. 3b

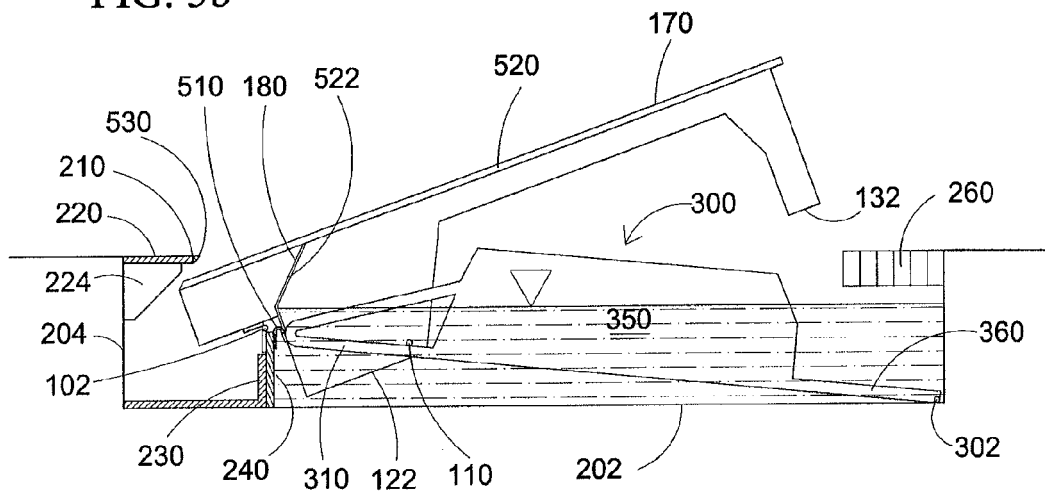


FIG. 3c

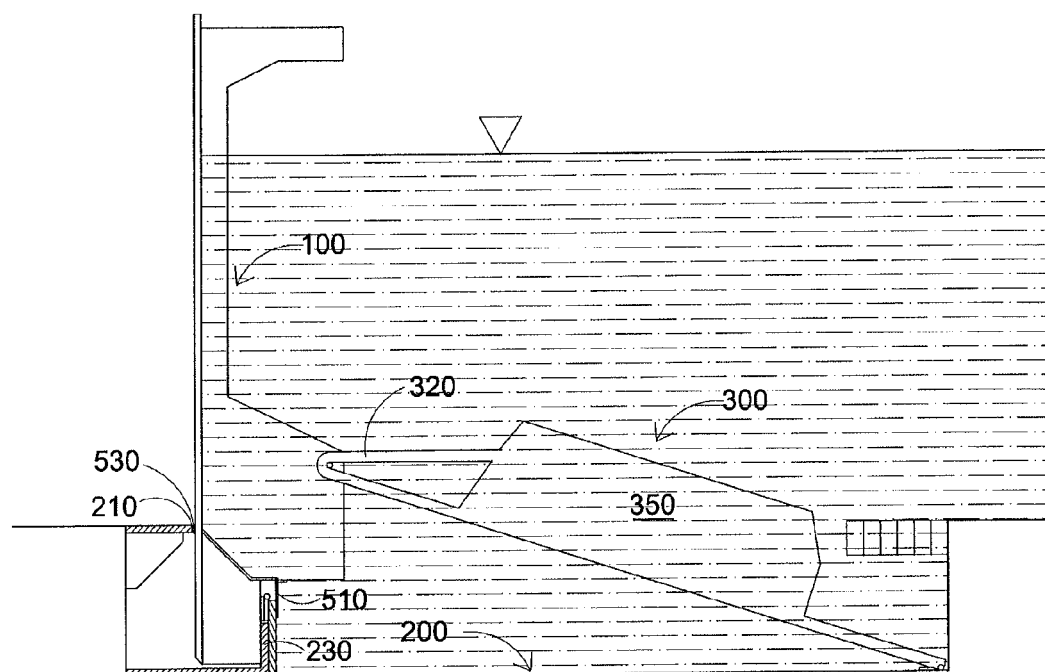


FIG. 3d

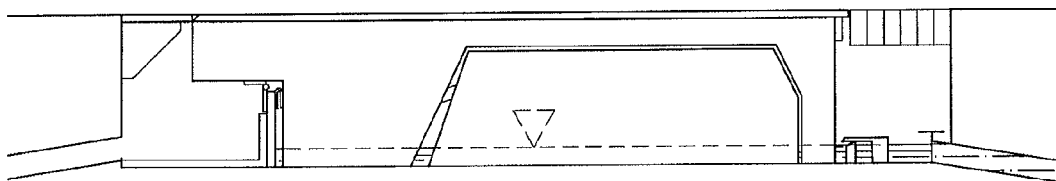


FIG. 3e

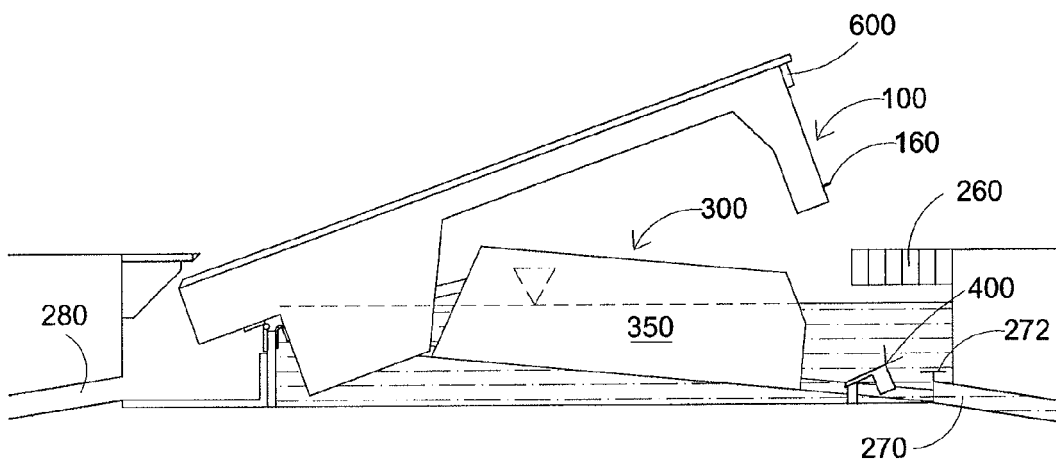
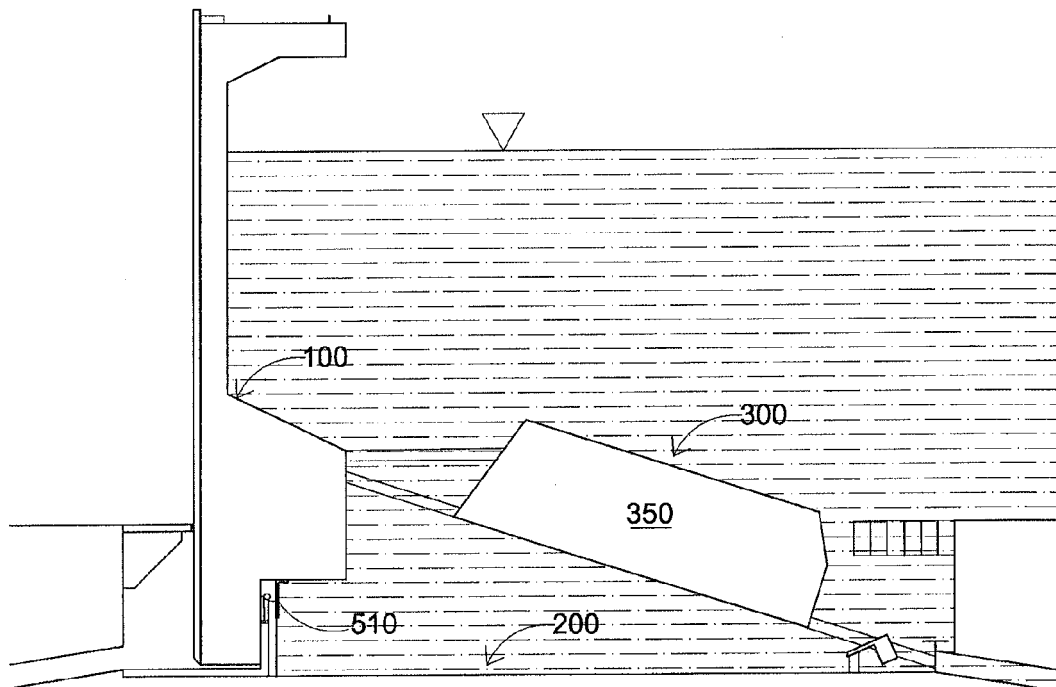


FIG. 3f



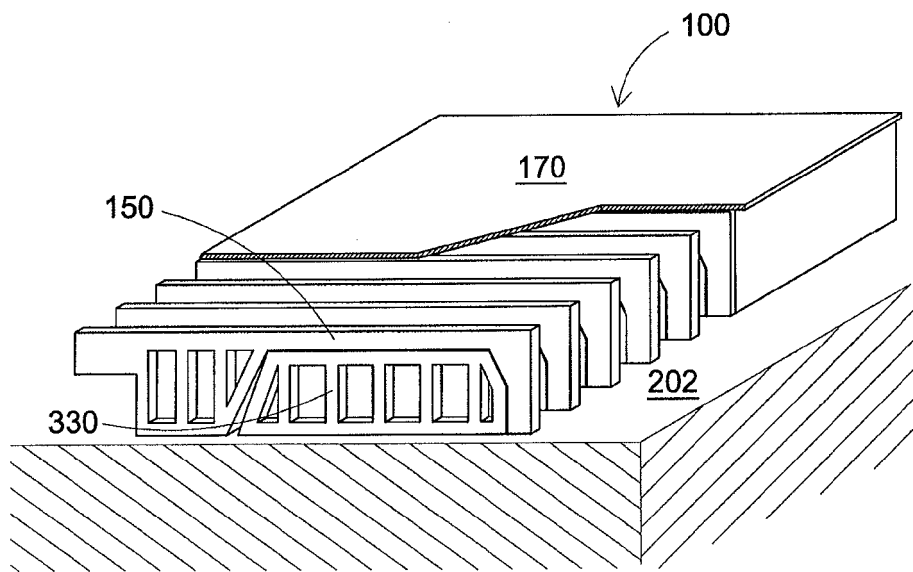


FIG. 4a

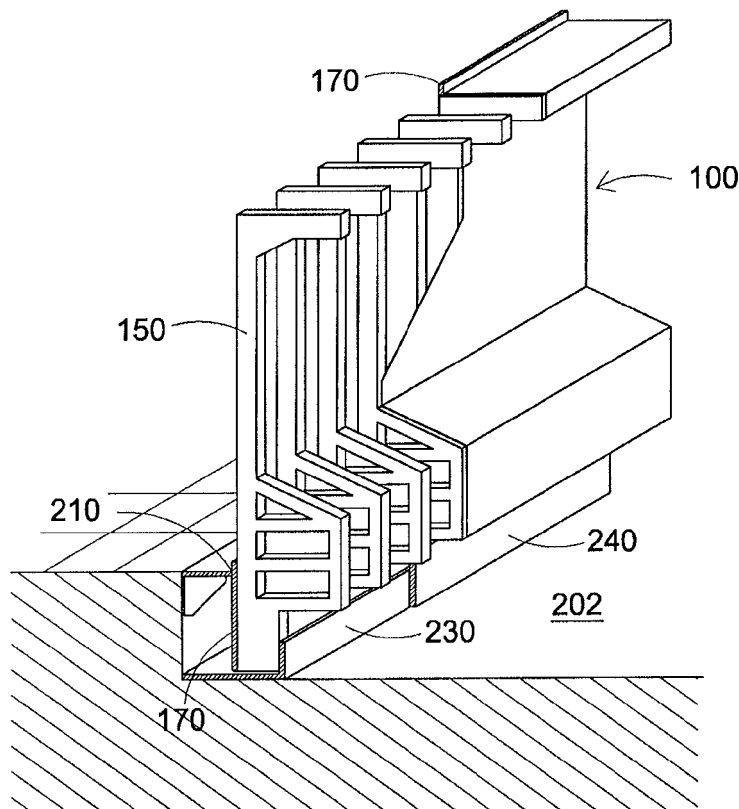


FIG. 4b

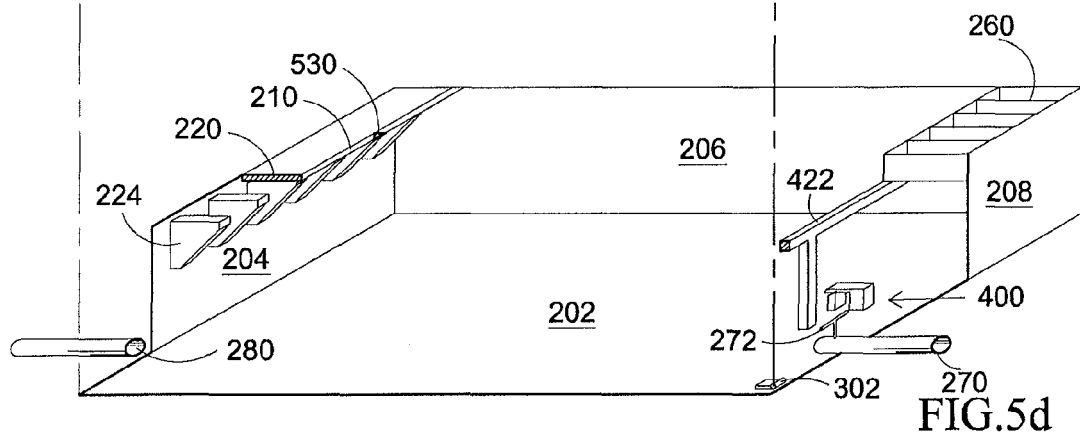
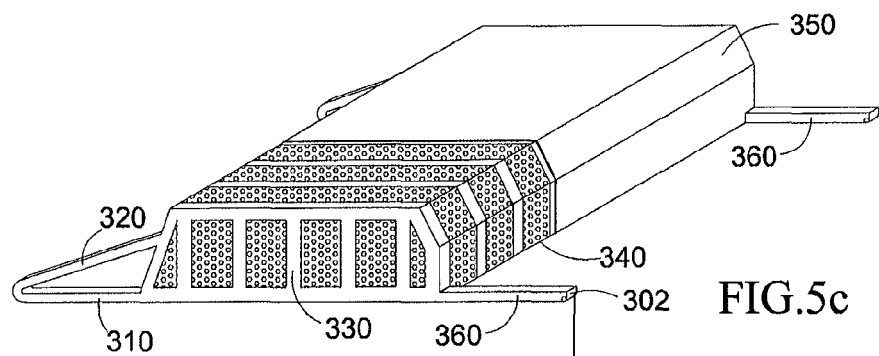
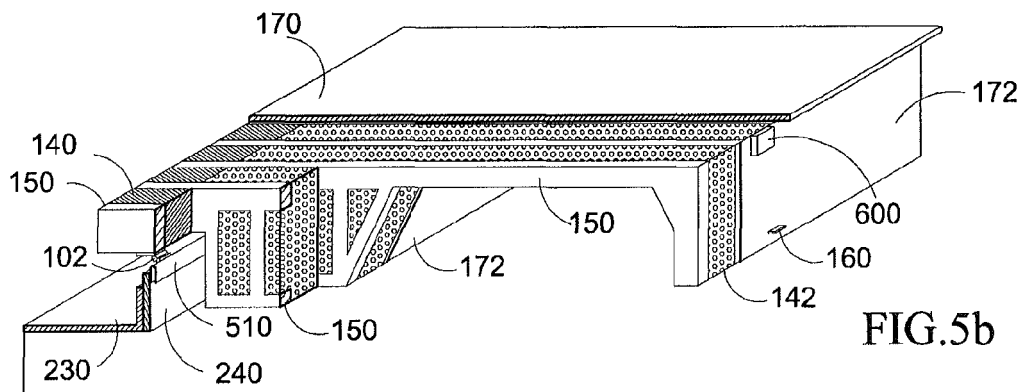
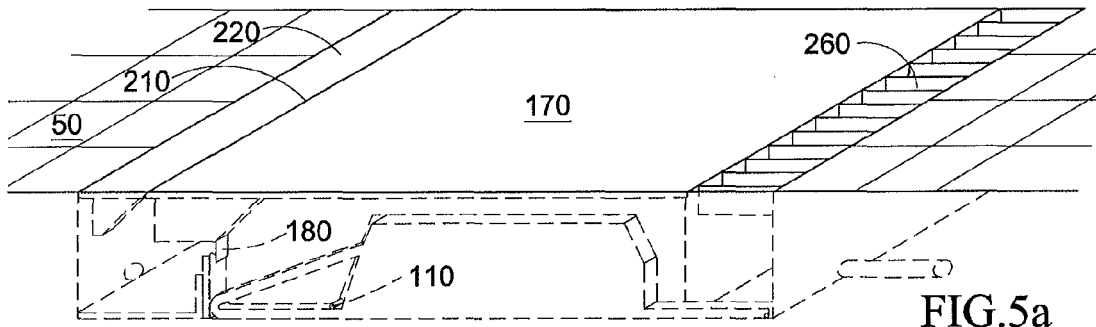


FIG. 6a

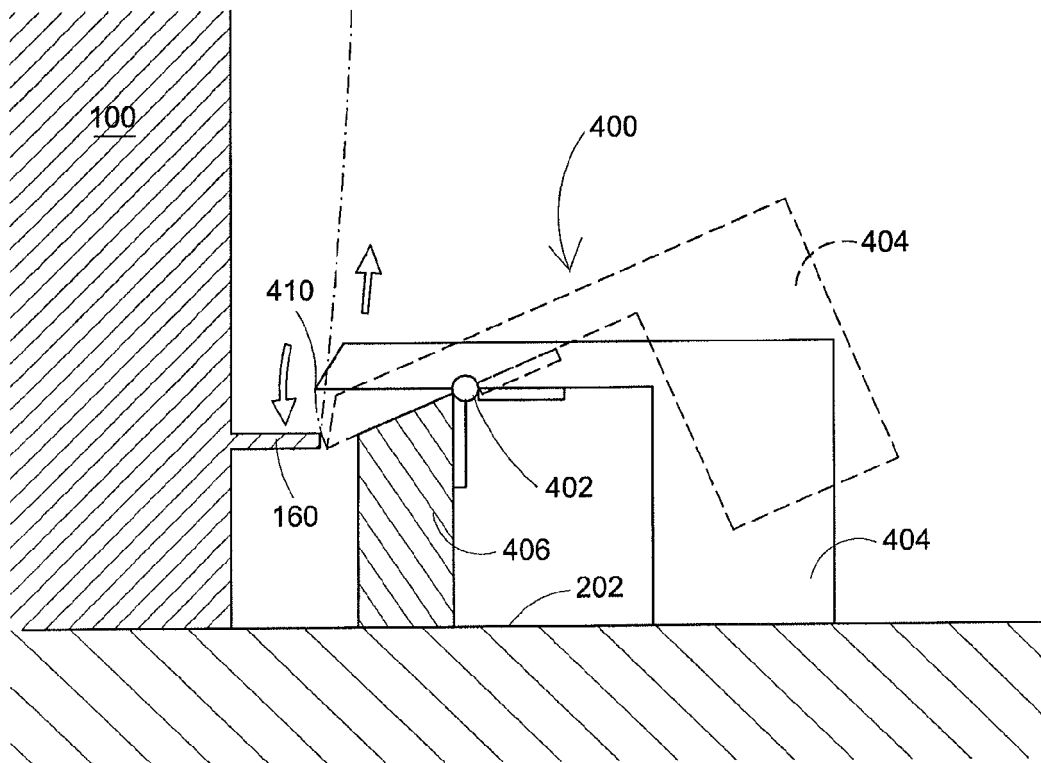


FIG. 6b

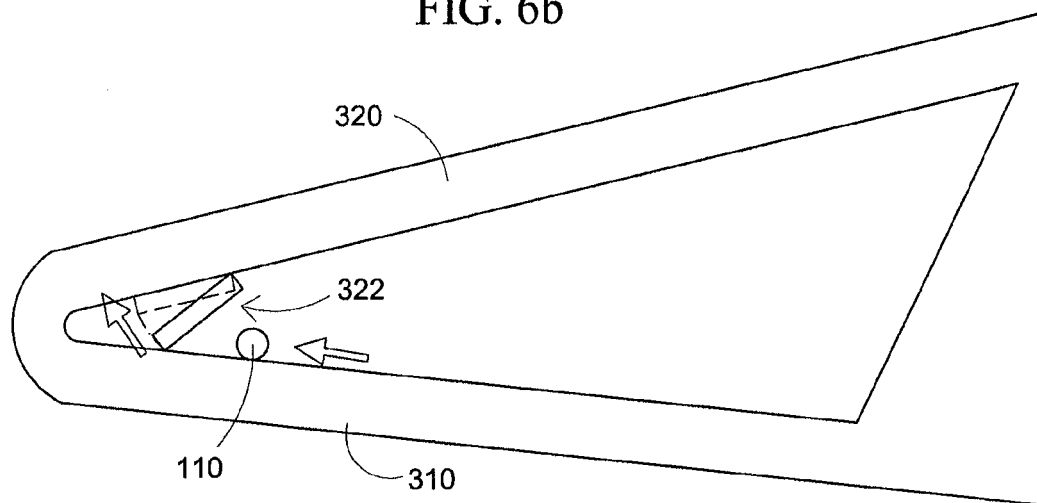


FIG. 7a

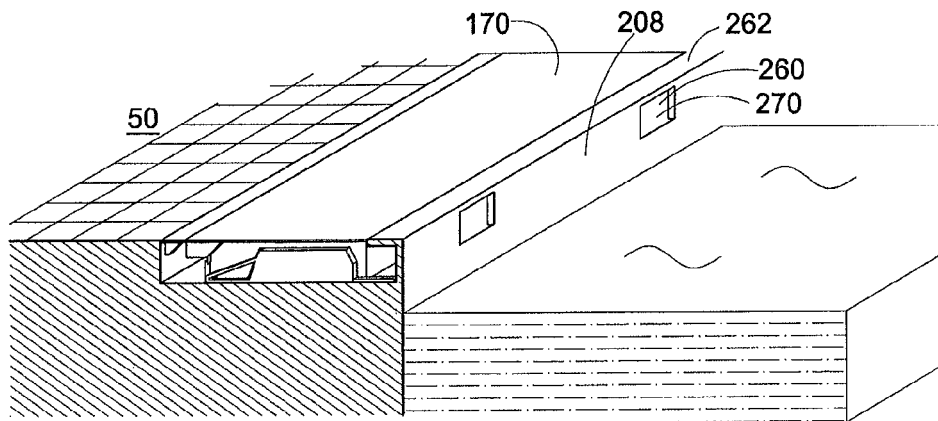


FIG. 7b

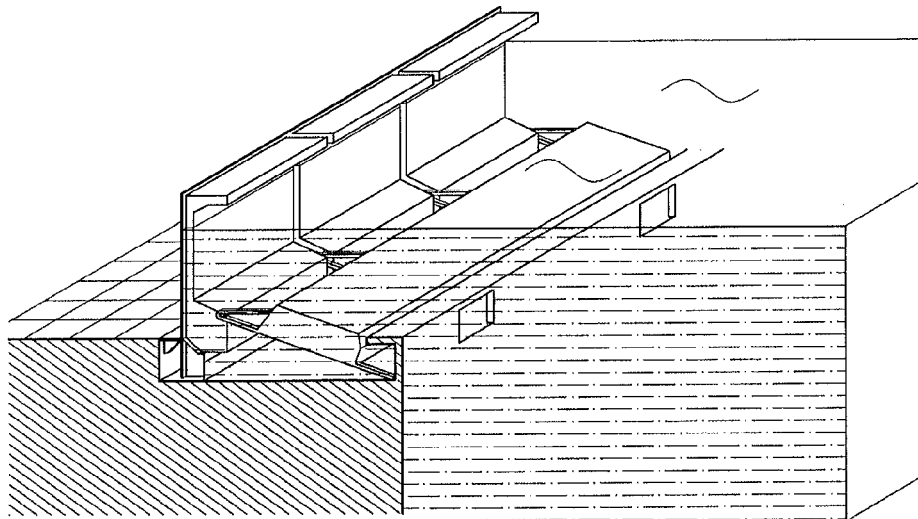


FIG. 7c

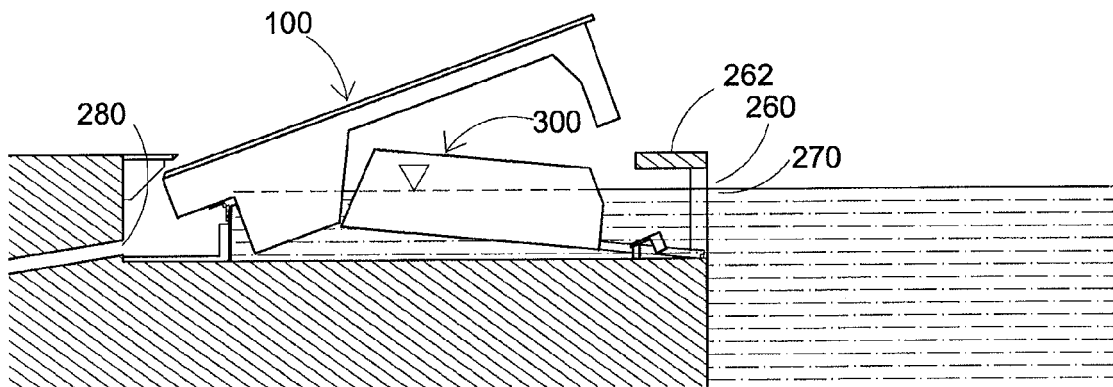


FIG. 8a

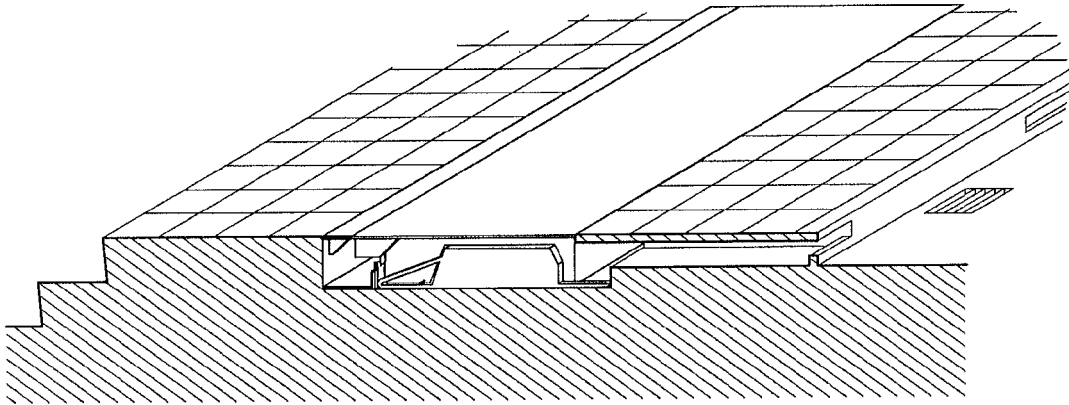


FIG. 8b

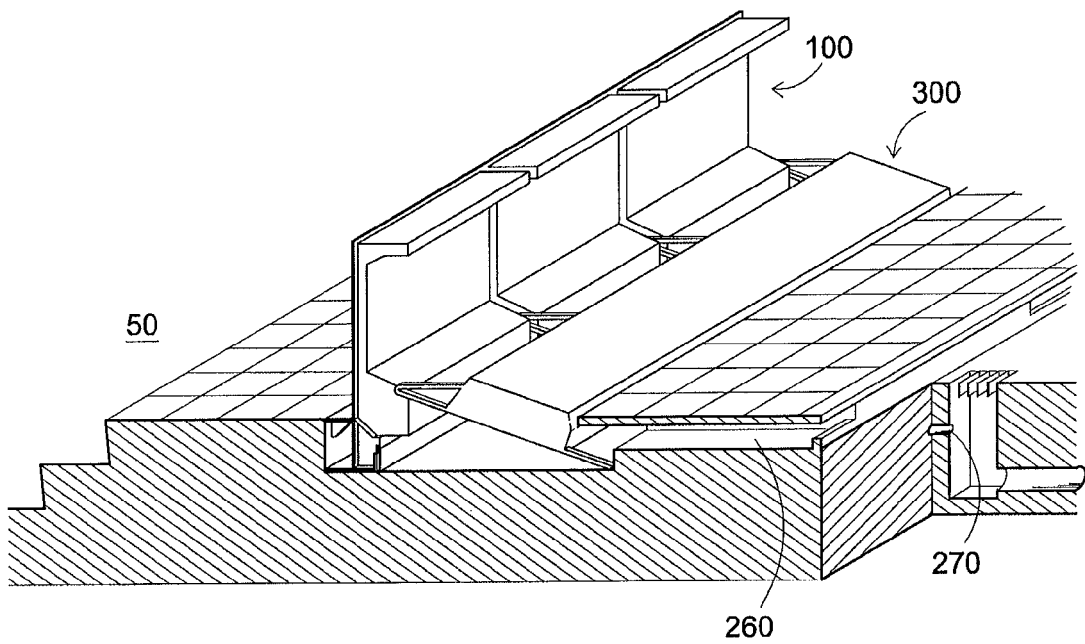


FIG. 9a

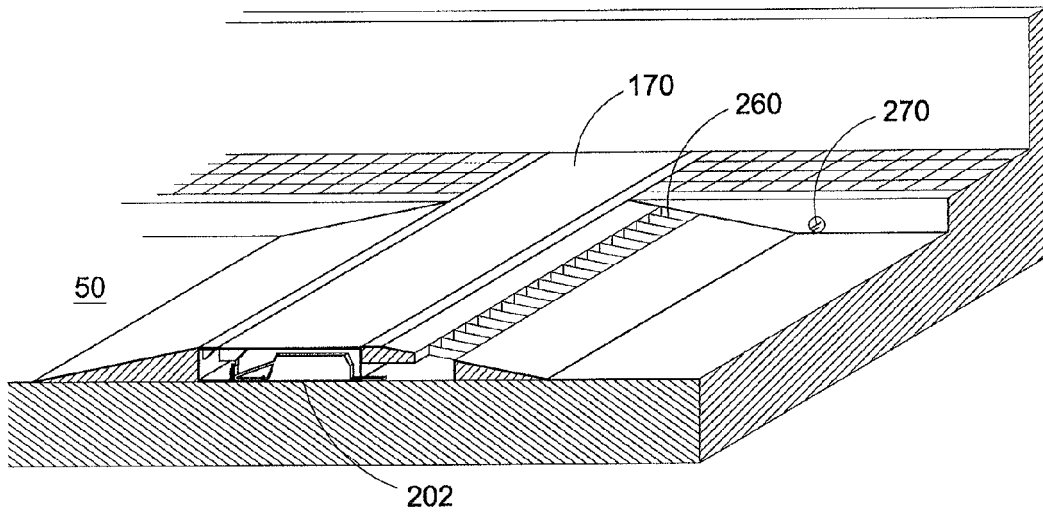


FIG. 9b

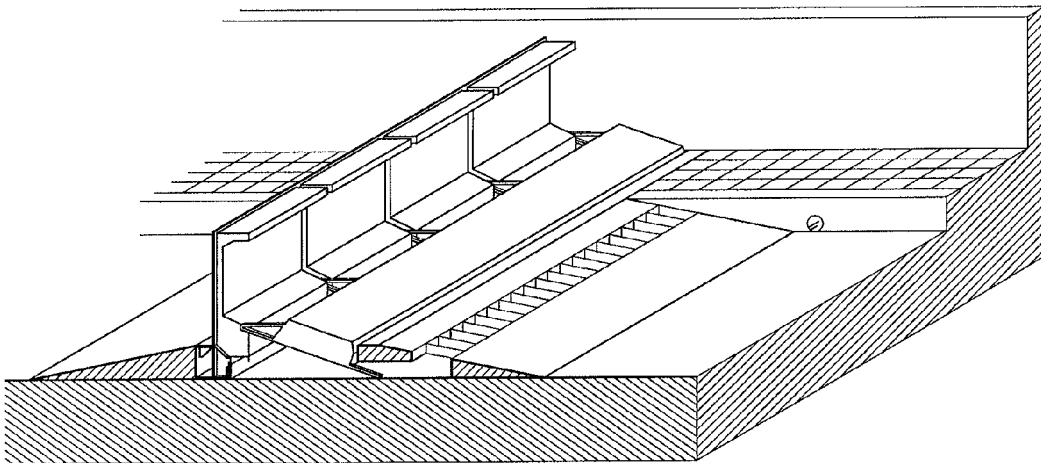


FIG. 10a

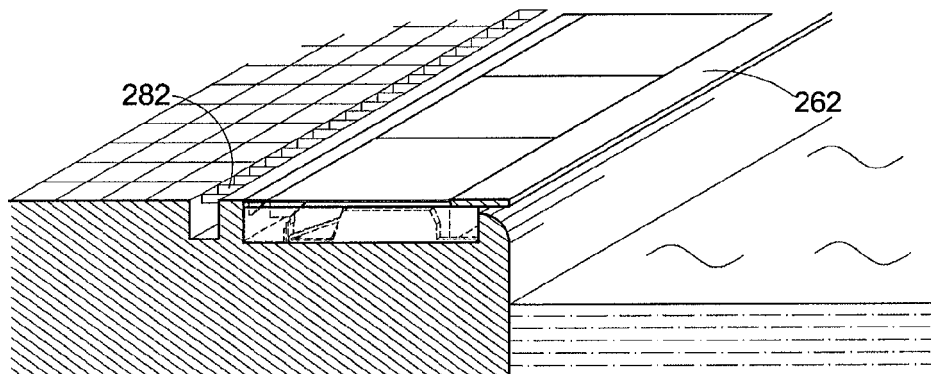


FIG. 10b

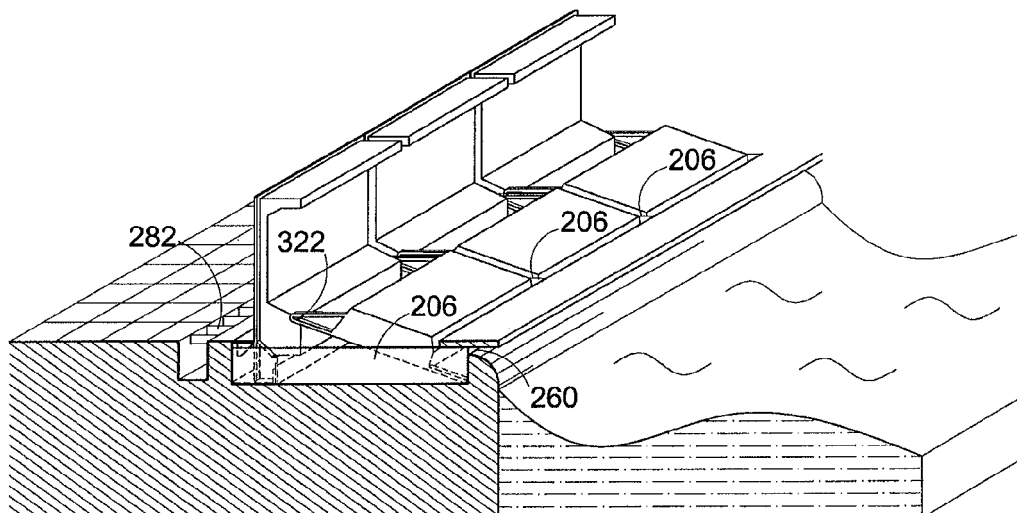


FIG. 10c

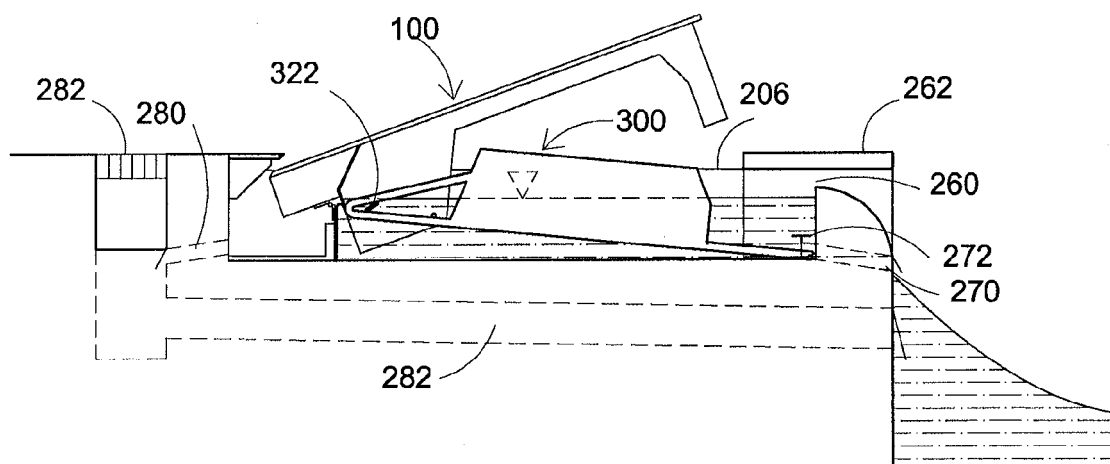


FIG.11a

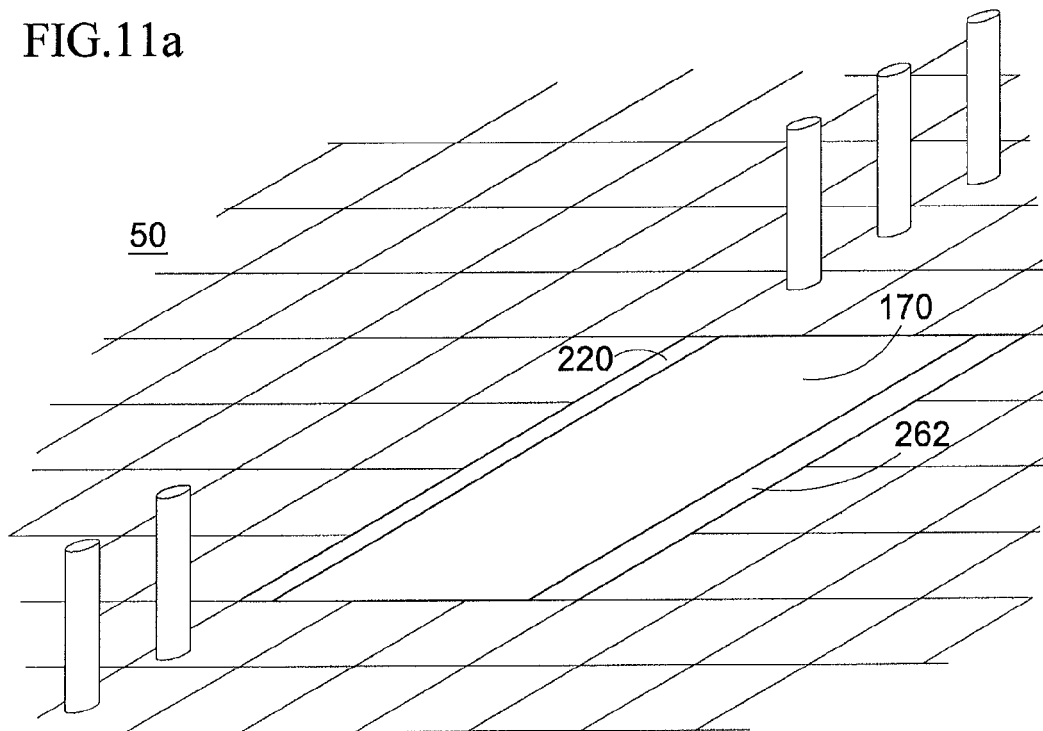


FIG.11b

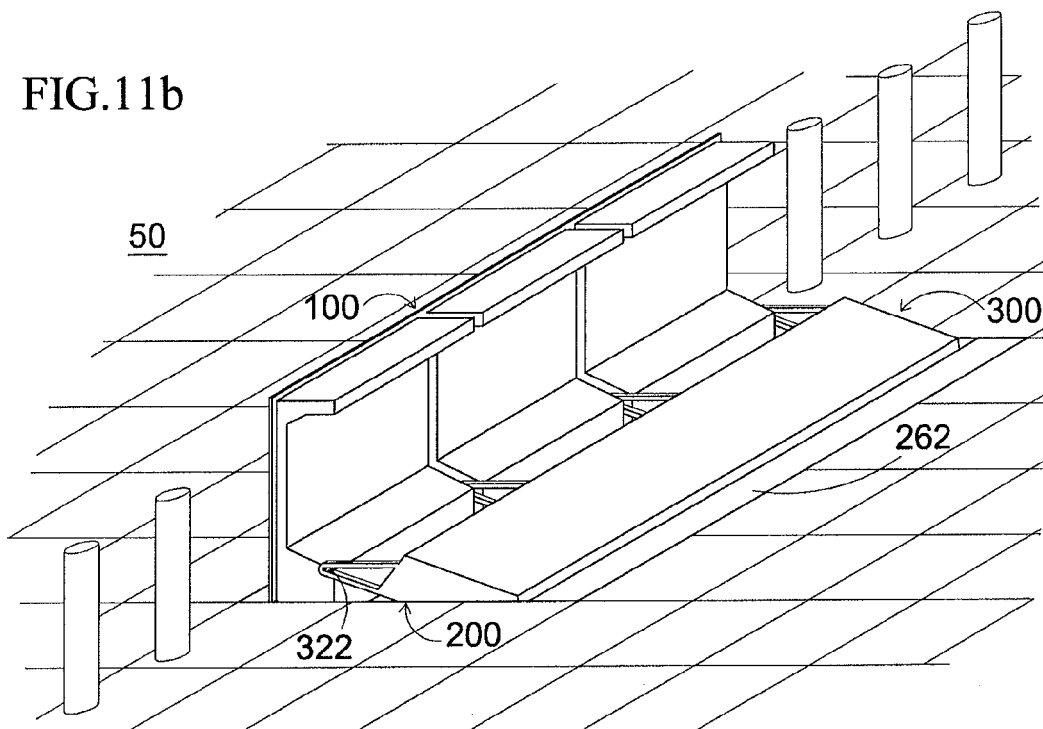


FIG.12a

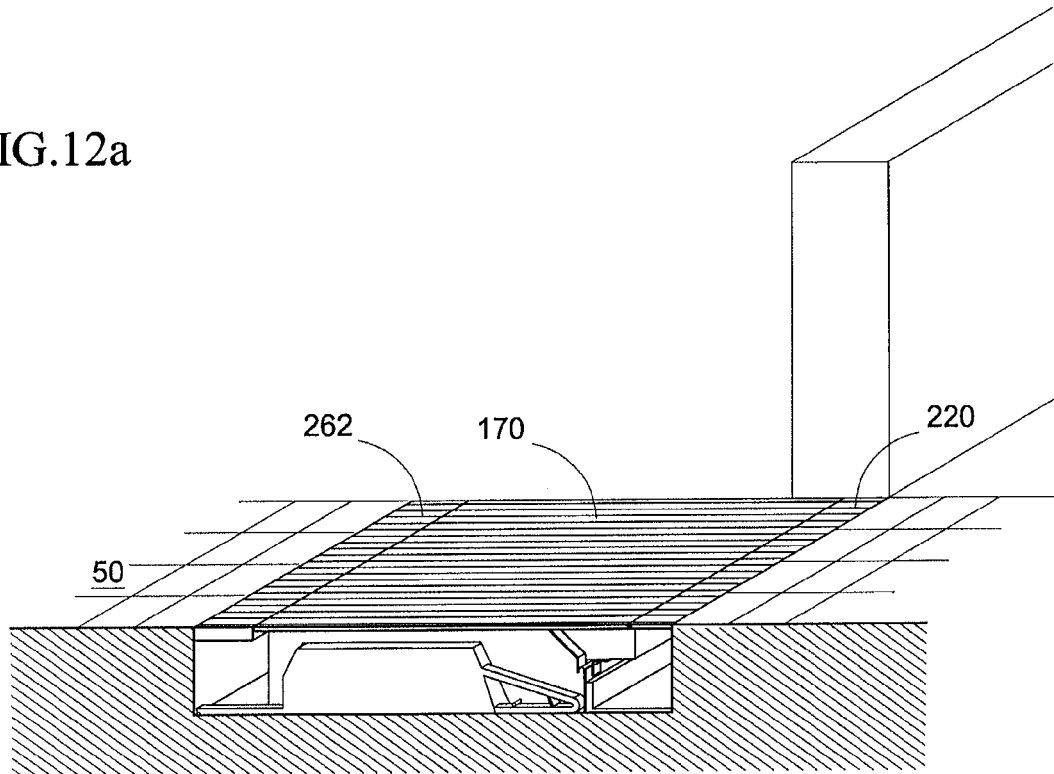


FIG.12b

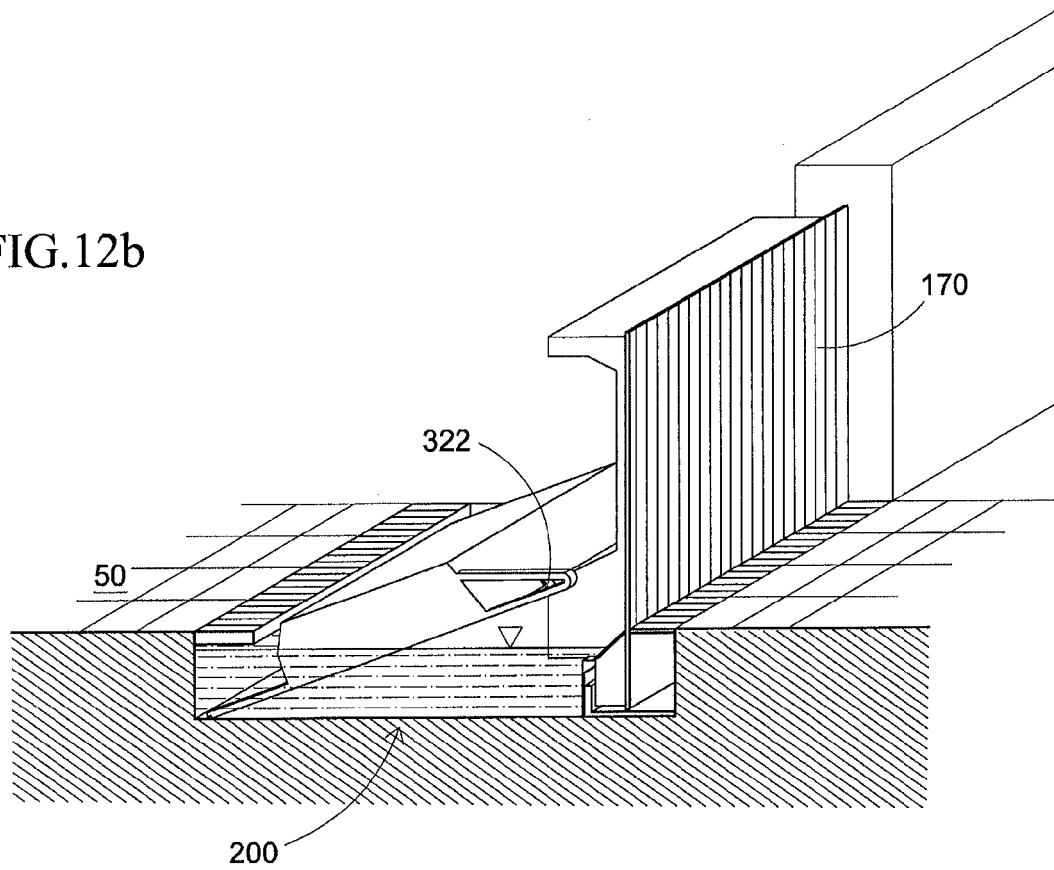


FIG. 13a

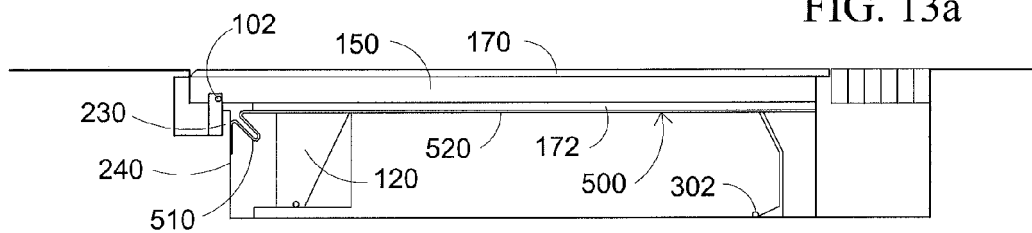


FIG. 13b

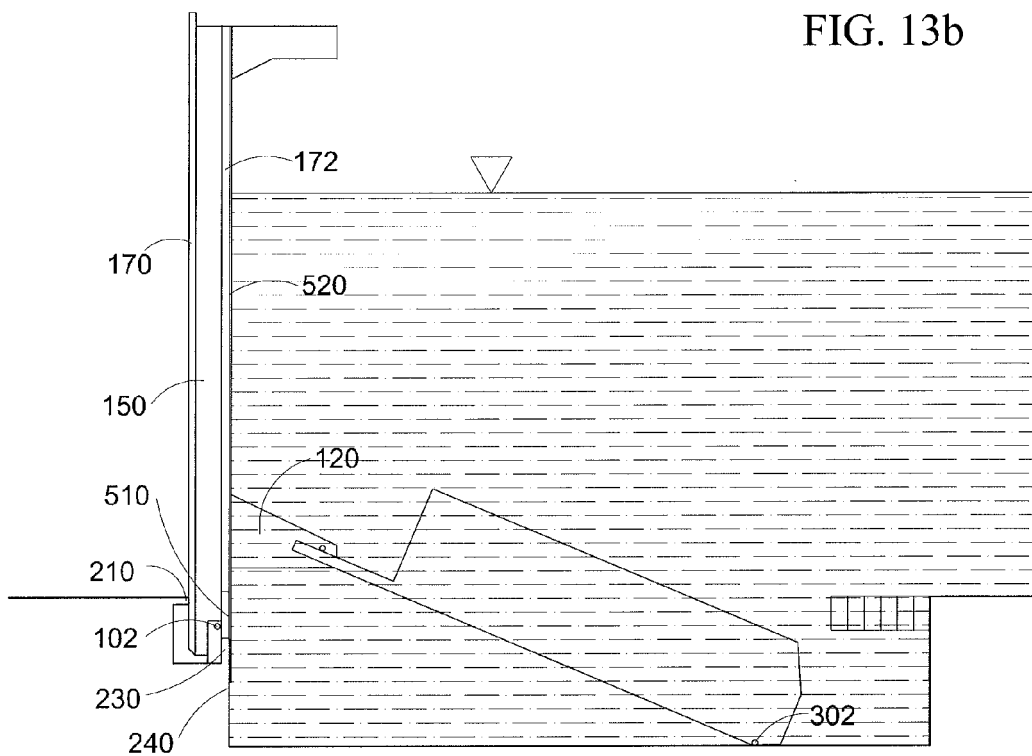


FIG. 13c

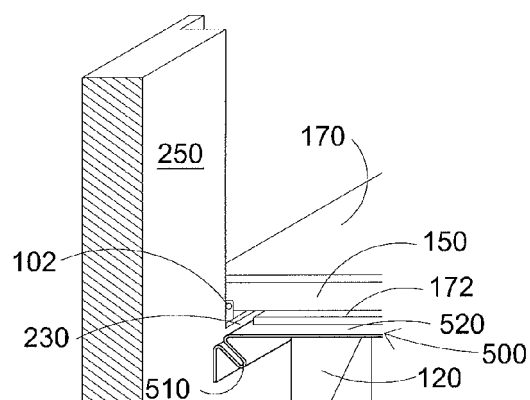


FIG. 13d

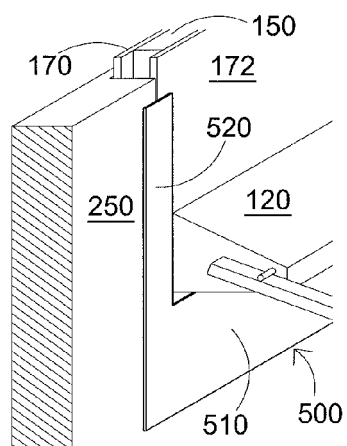


FIG.14a

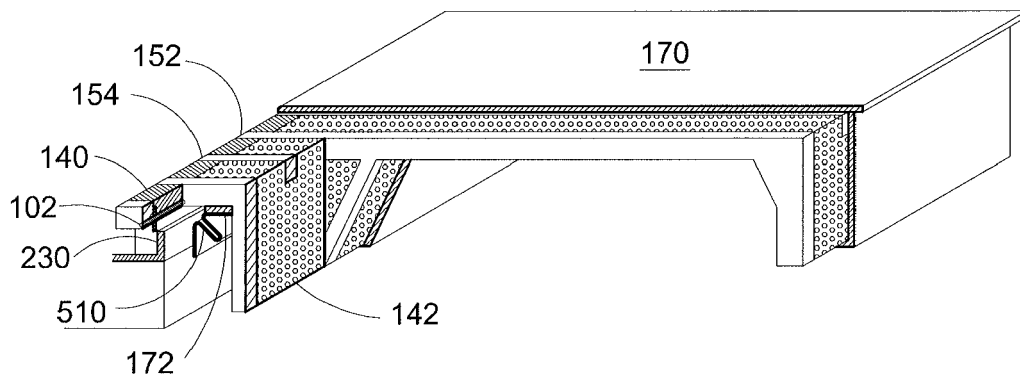
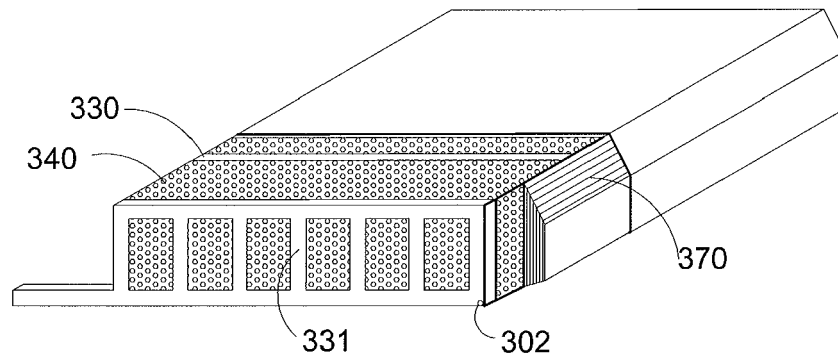


FIG.14b



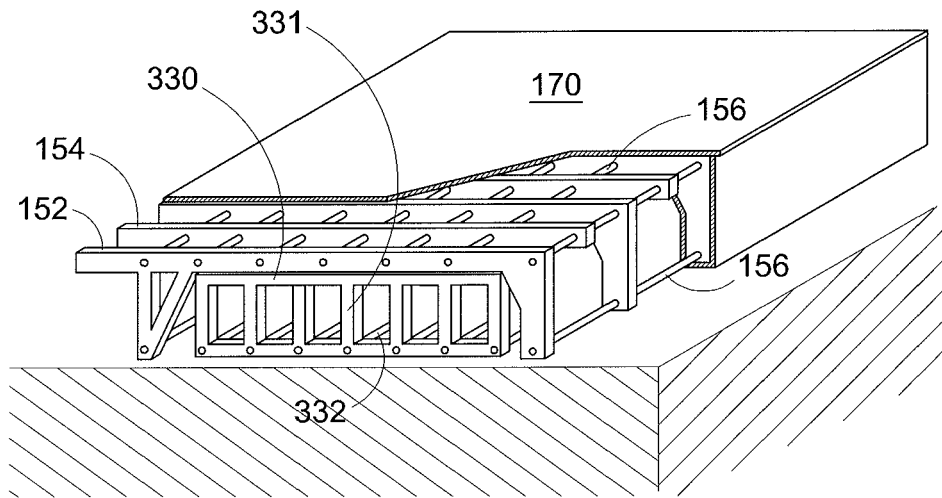


FIG. 15a

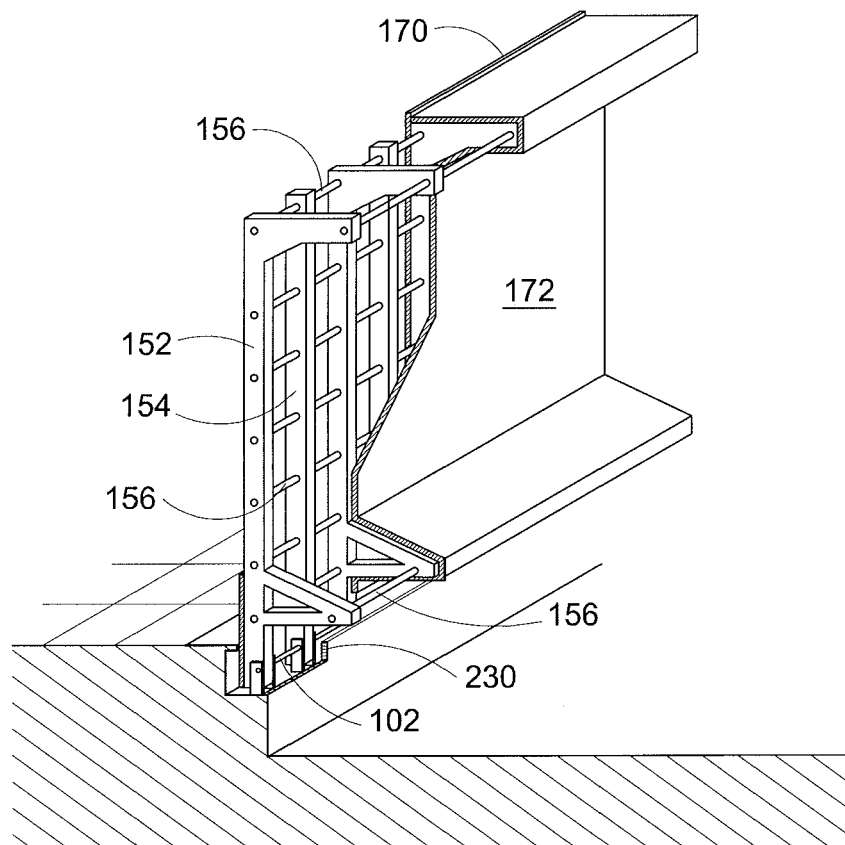


FIG. 15b

FIG.16a

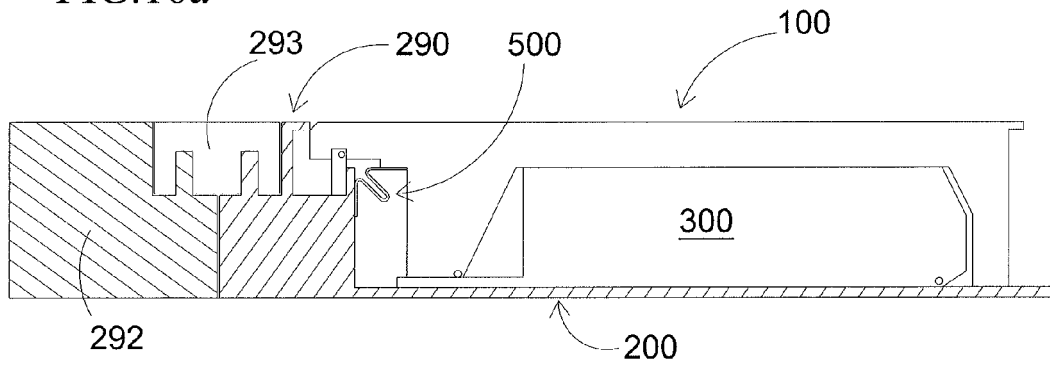


FIG.16b

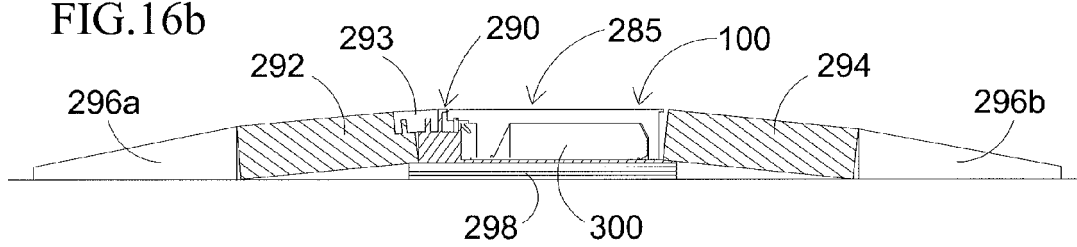


FIG.16c

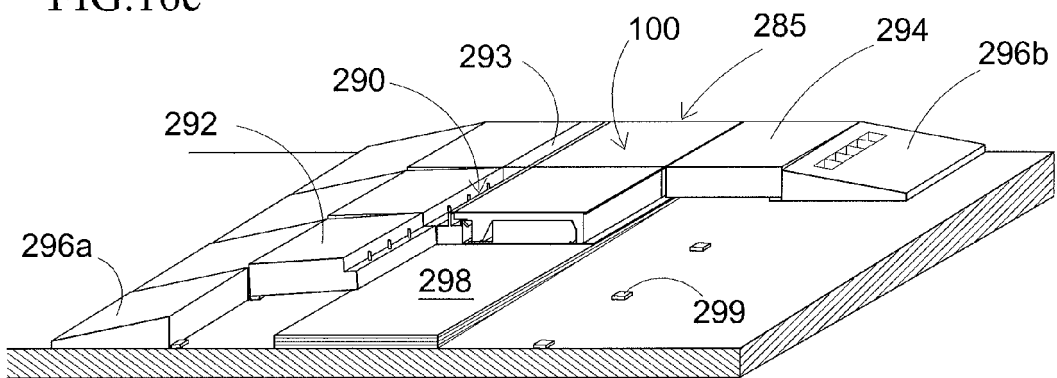


FIG.16d

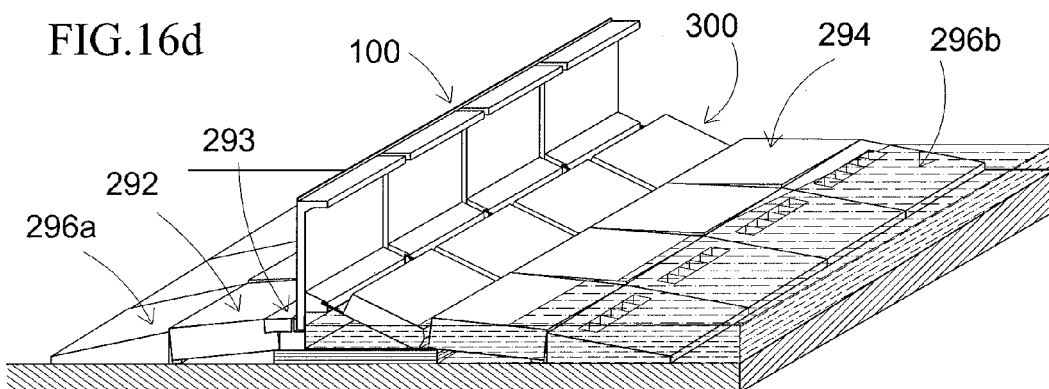


FIG. 17a

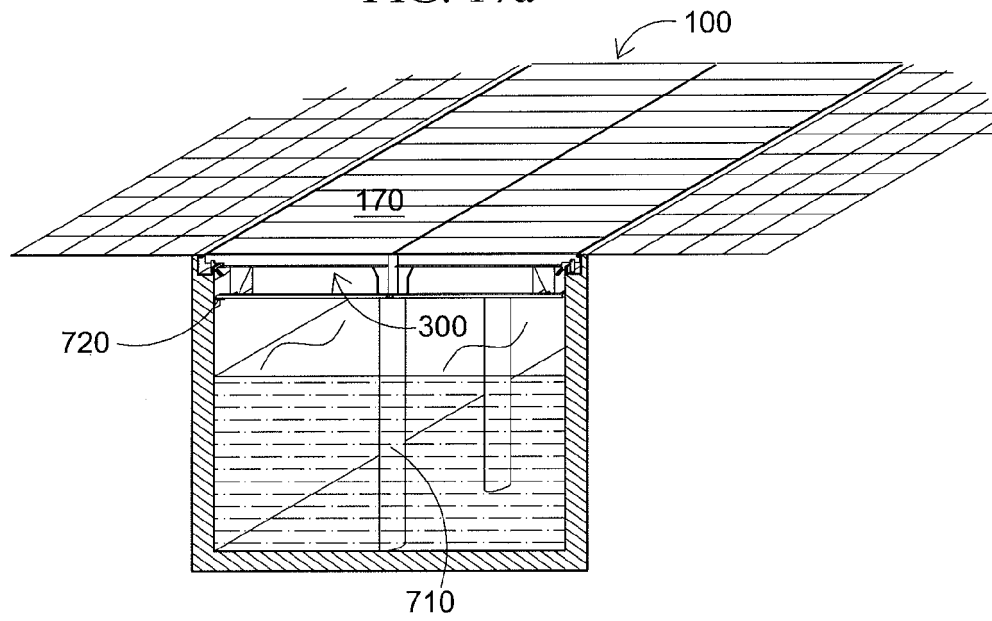


FIG. 17b

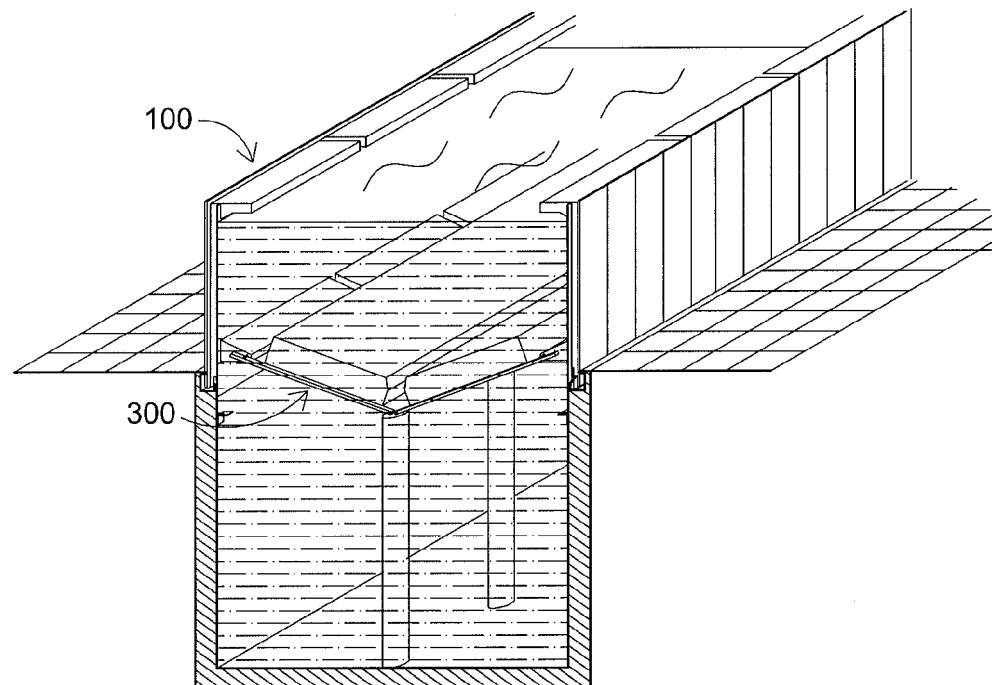


FIG. 18a

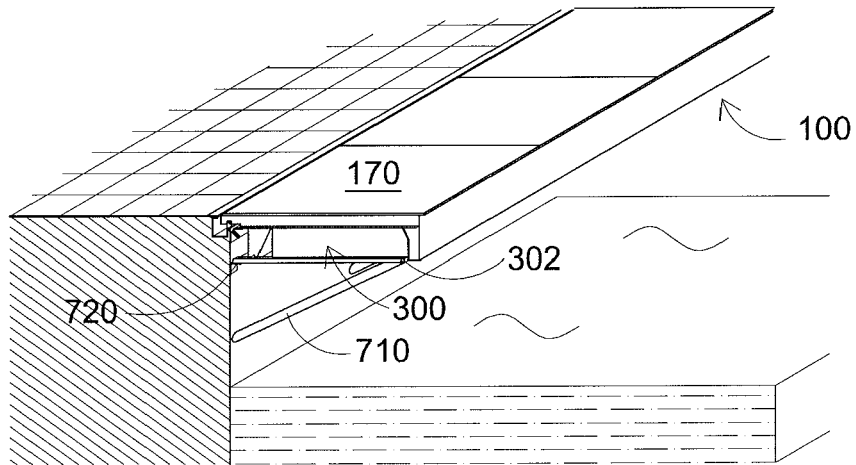


FIG. 18b

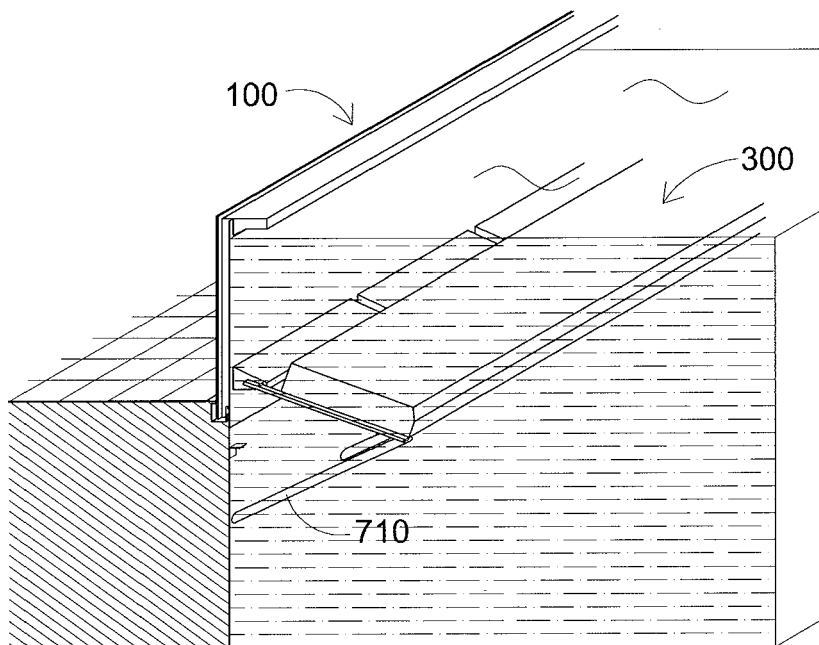


FIG. 19a

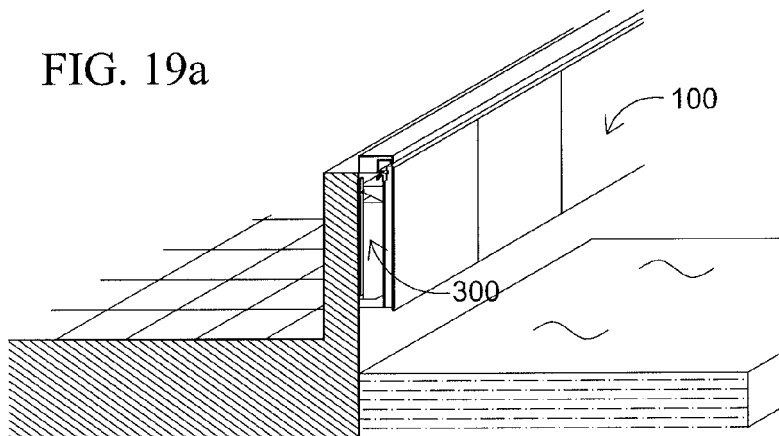


FIG. 19b

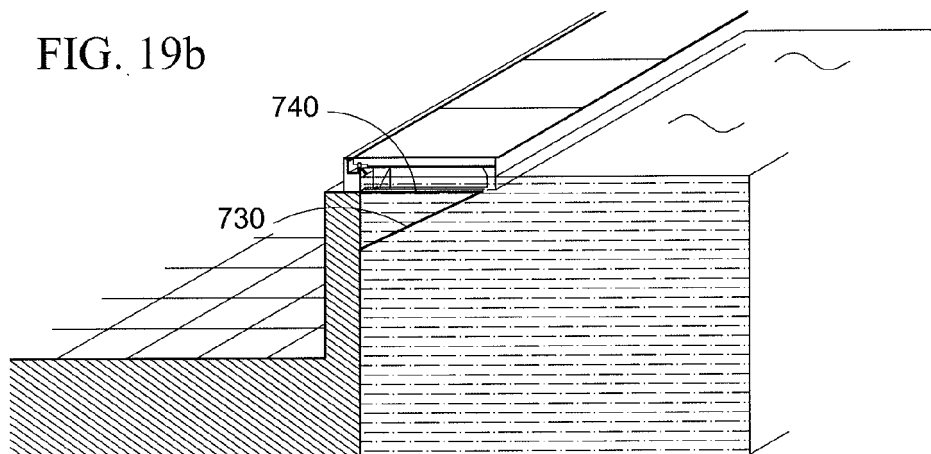


FIG. 19c

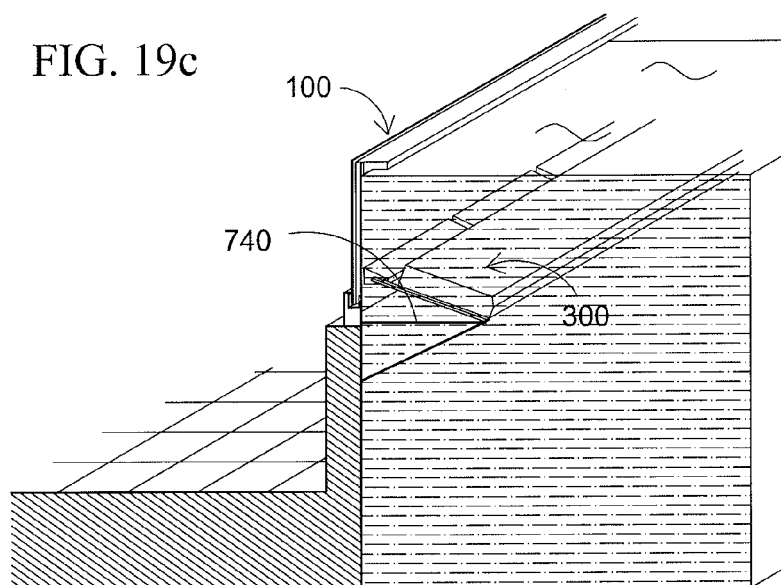


FIG. 20a

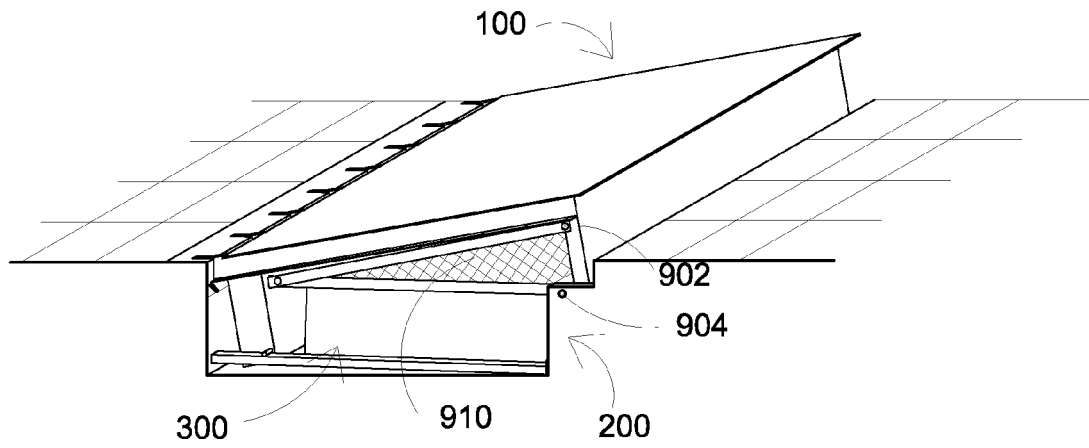
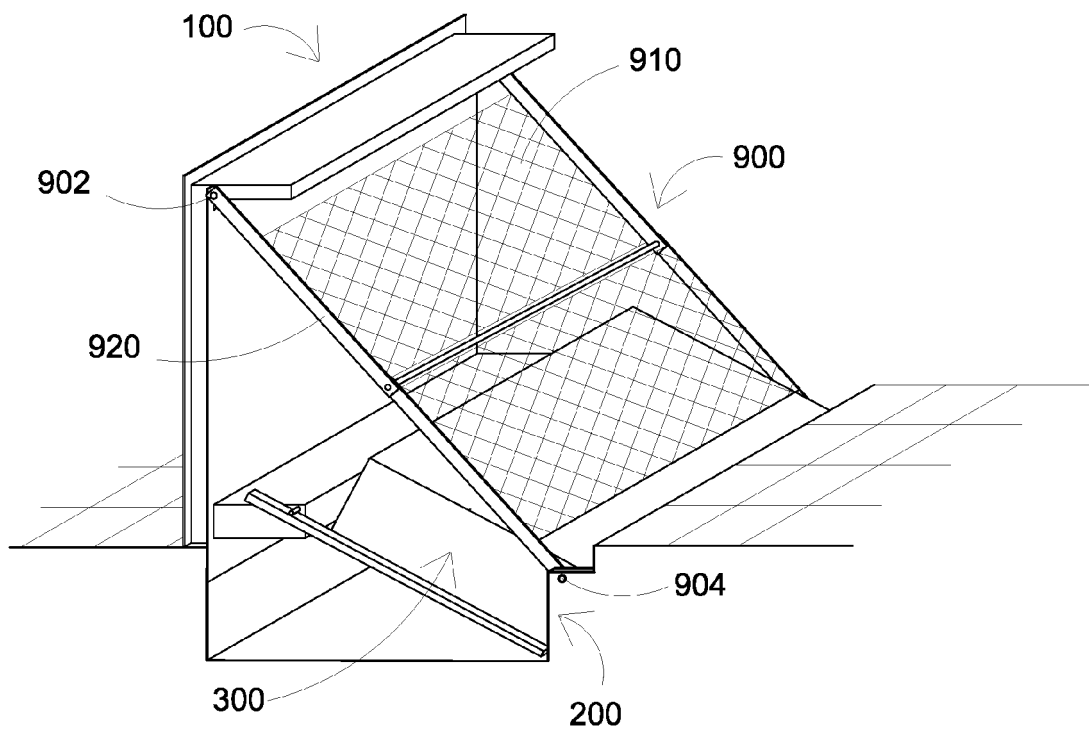


FIG. 20b





EUROPEAN SEARCH REPORT

Application Number
EP 15 15 7887

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	GB 2 456 394 A (SMYTH MATTHEW [GB]) 22 July 2009 (2009-07-22)	1-6, 8-12,15	INV. E02B3/10
Y	* page 2, paragraph 9 - page 3, paragraph 1; figures *	13,14	

X	EP 1 411 172 A2 (TBS SOEST B V [NL]) 21 April 2004 (2004-04-21) * paragraph [0017] - paragraph [0018]; figures 5,6 *	1,5-11, 15	
Y	FR 2 432 068 A1 (PETRISSANS & CIE) 22 February 1980 (1980-02-22) * figures 1-5 *	13,14	

The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			E02B
Place of search		Date of completion of the search	Examiner
The Hague		28 July 2015	De Coene, Petrus
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 1
EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 15 15 7887

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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28-07-2015

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FR 2432068	A1	22-02-1980	NONE

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