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(54) **A WATER-LEVEL CONTROL UNIT WITH A DOWNWARDLY HANGING HINGED LOWER FLAP PORTION OF A VALVE ELEMENT AND A FLOATING BODY CONNECTED THERETO**

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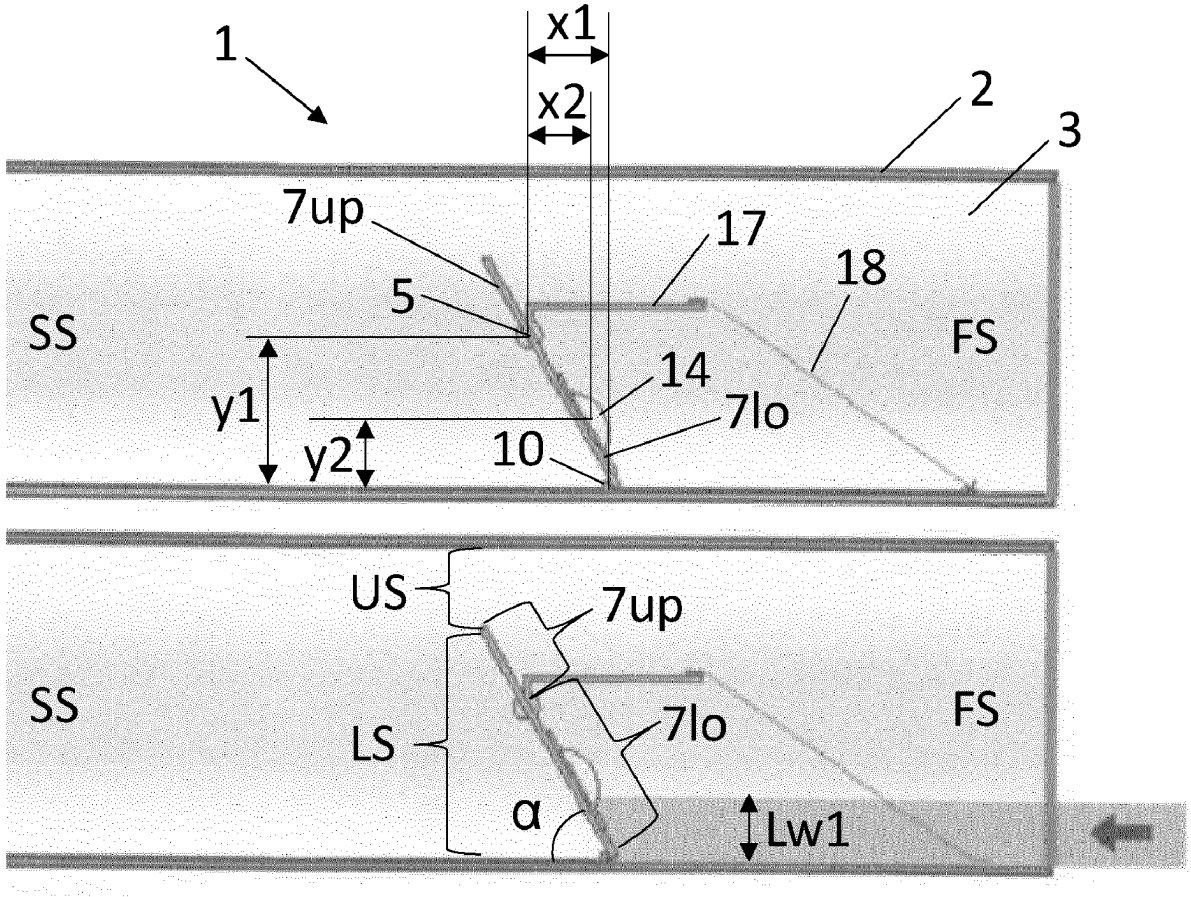
(57) **ABSTRACT**

A water-level control unit includes a housing with a flow channel. A valve element is positioned rotatable around a hinge axis inside the flow channel to close off a lower section of the flow channel while dividing it in a first upstream side and a second downstream side. The hinge axis is provided at a height above a bottom of the flow channel. The valve element includes a lower flap portion that in a closed position hangs down from the hinge axis. A floating body is provided at and connected to a side of the lower flap portion for moving the valve element from its closed towards an open position in dependence of a rising level of water at the first upstream side in the flow channel.



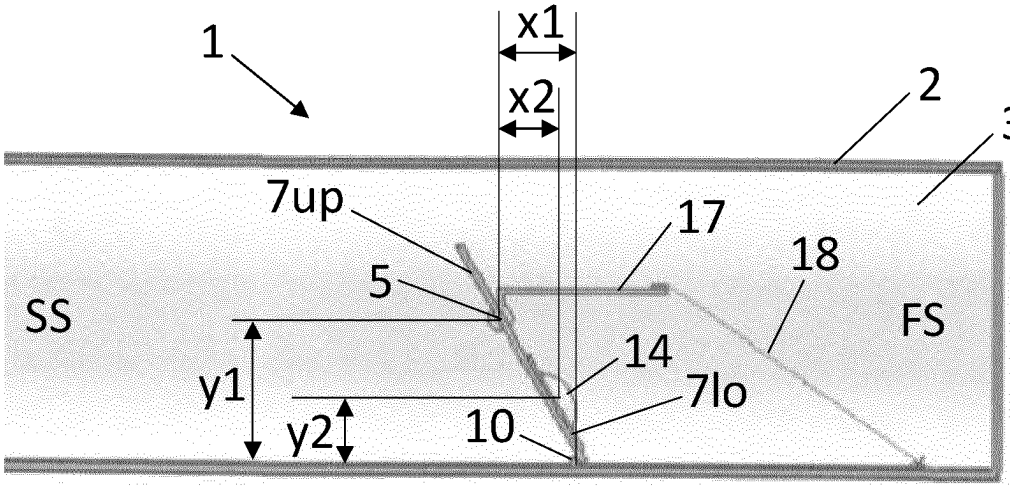


Fig. 1a

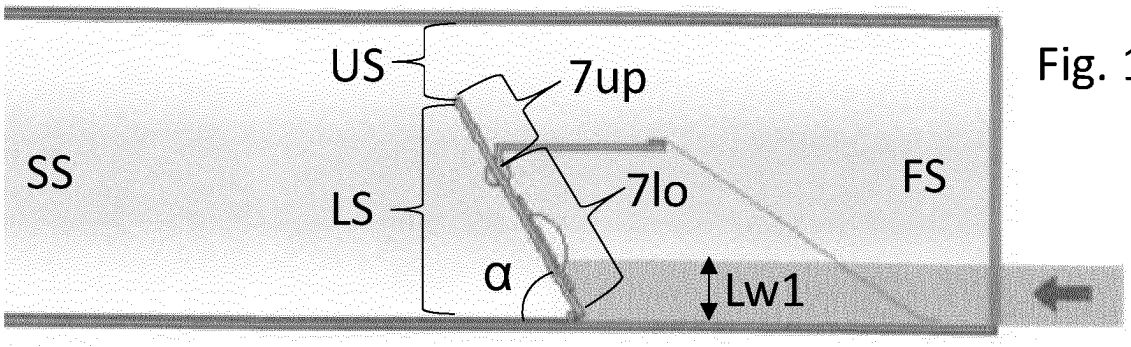


Fig. 1b

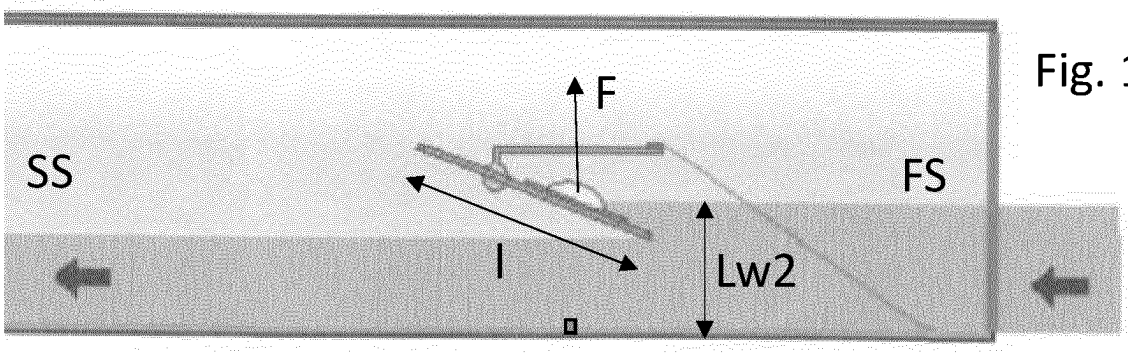


Fig. 1c

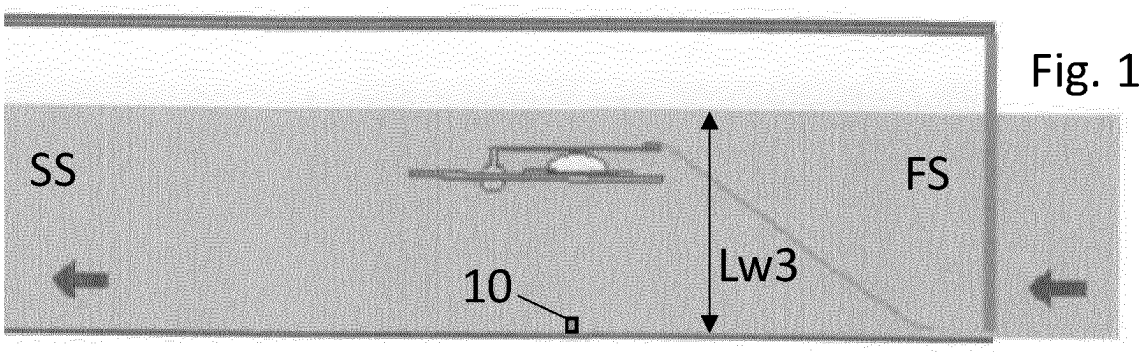


Fig. 1d

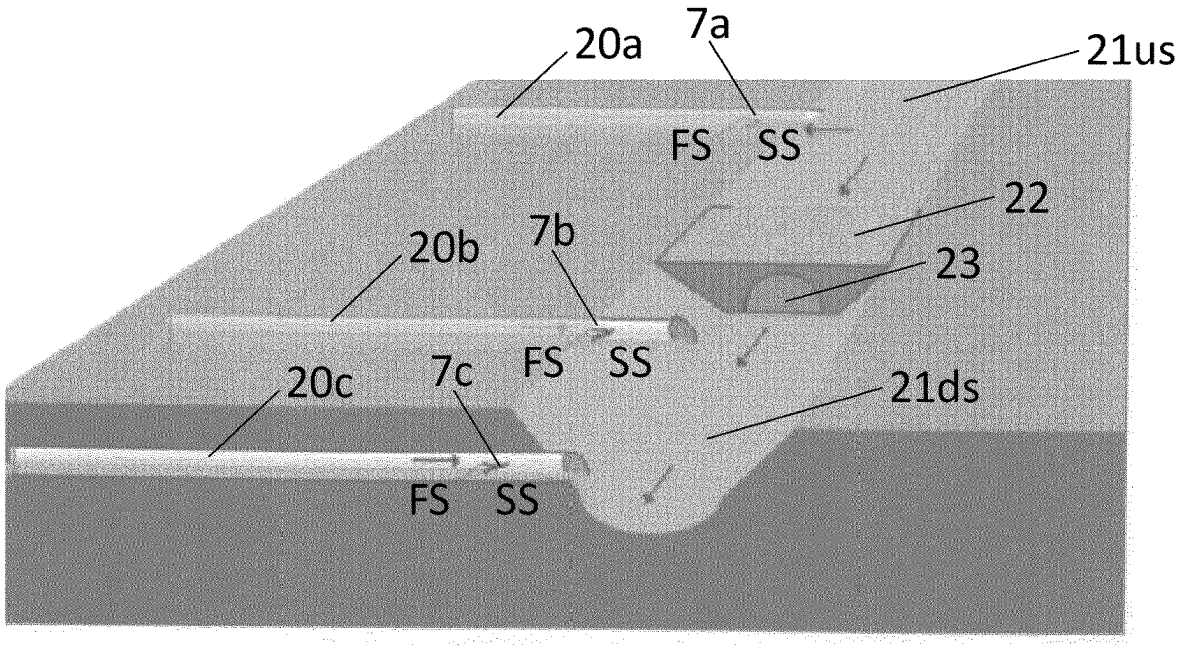

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Fig. 2b

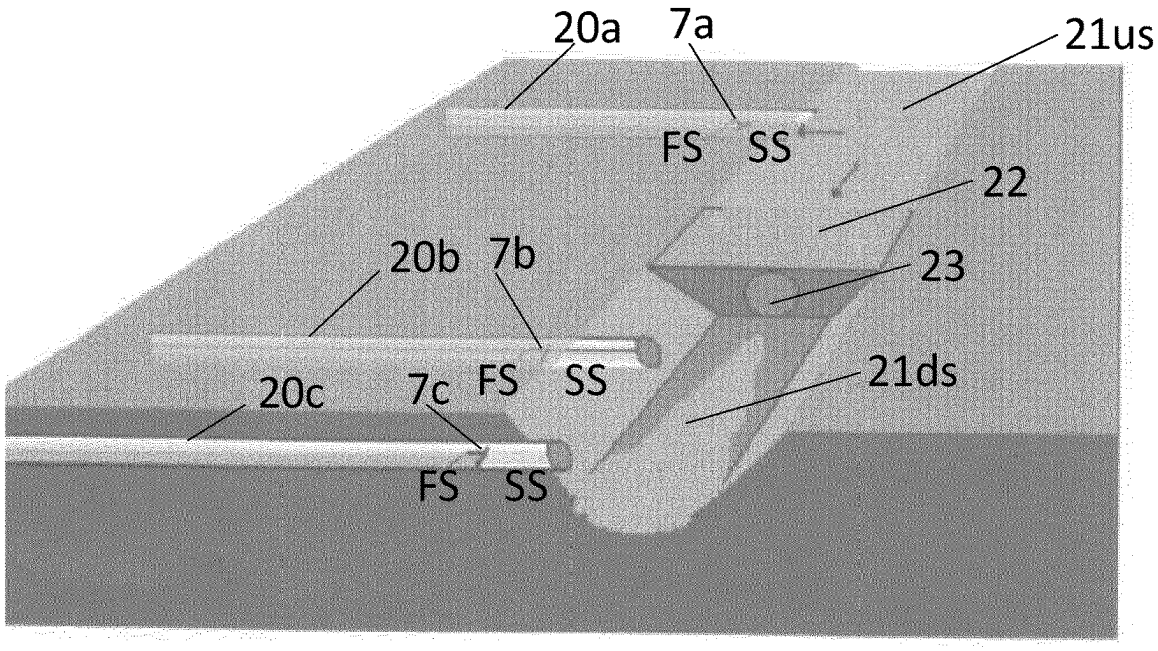
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Fig. 2a

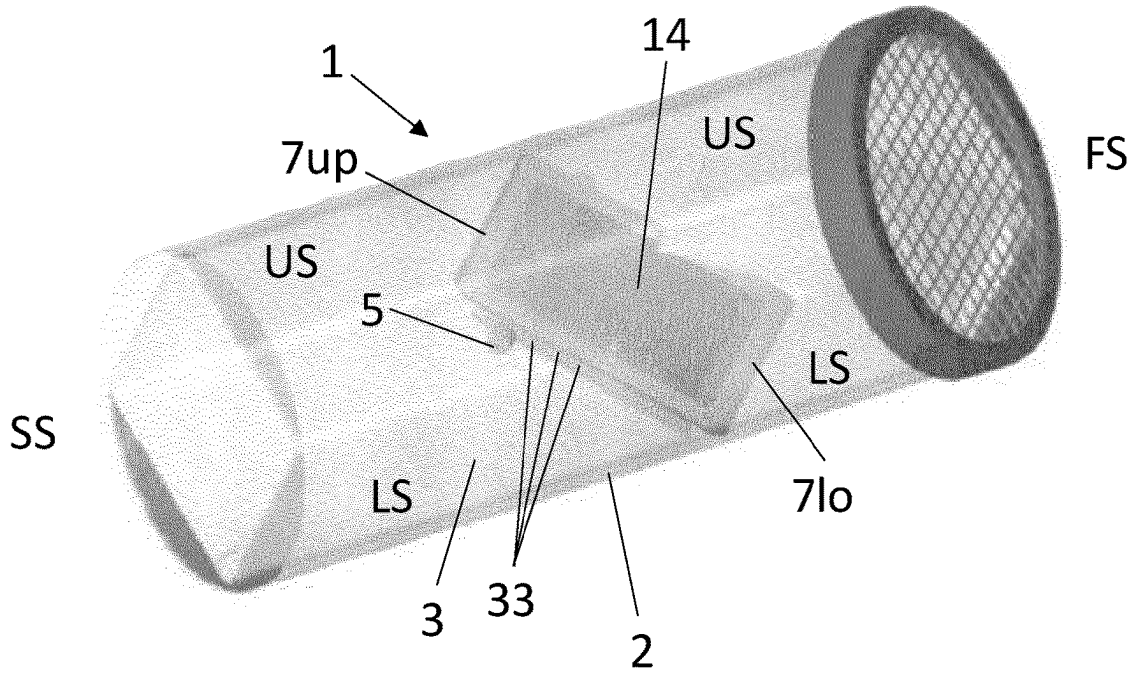
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Fig. 3a

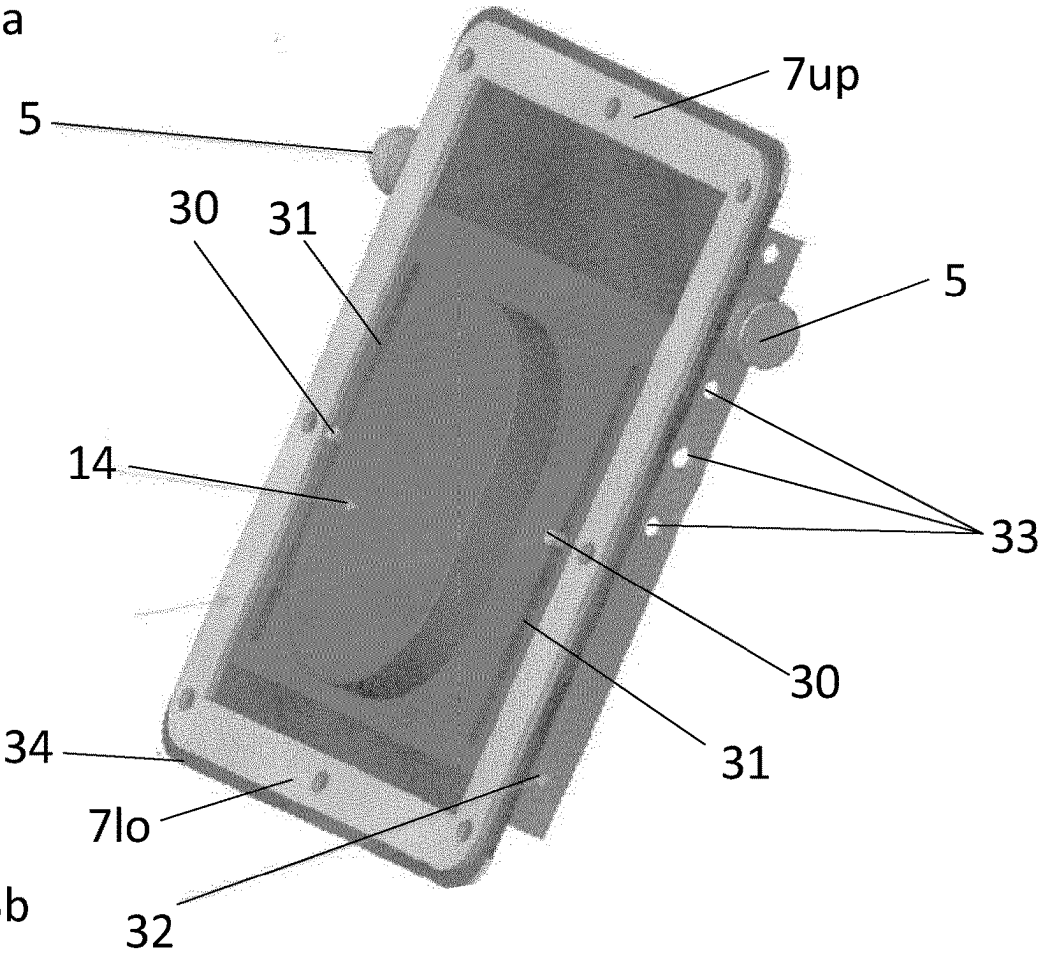
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Fig. 3b

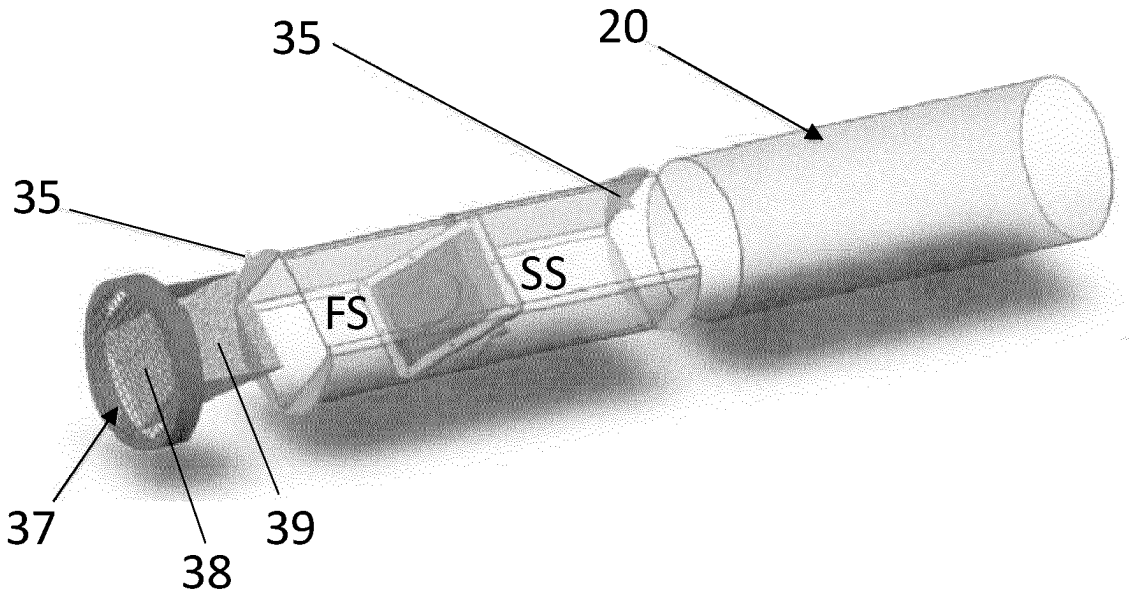

Fig. 3c

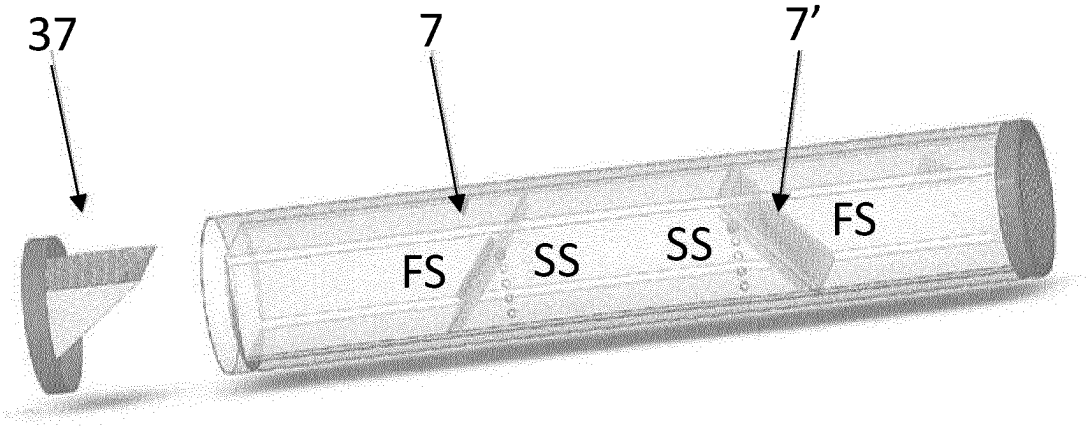

Fig. 4

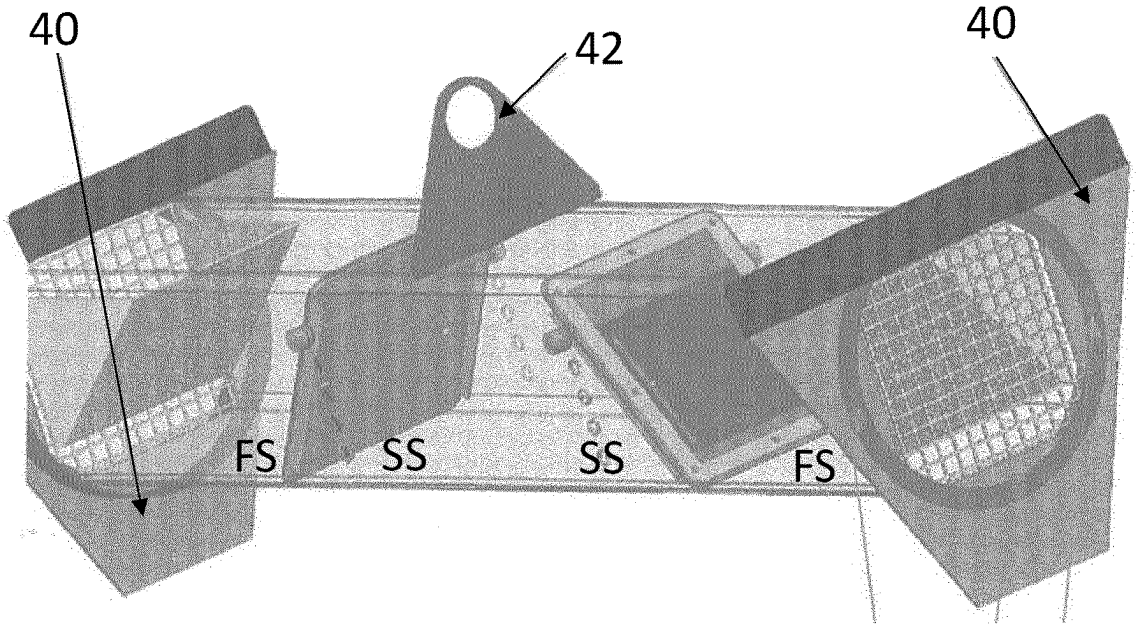

Fig. 5

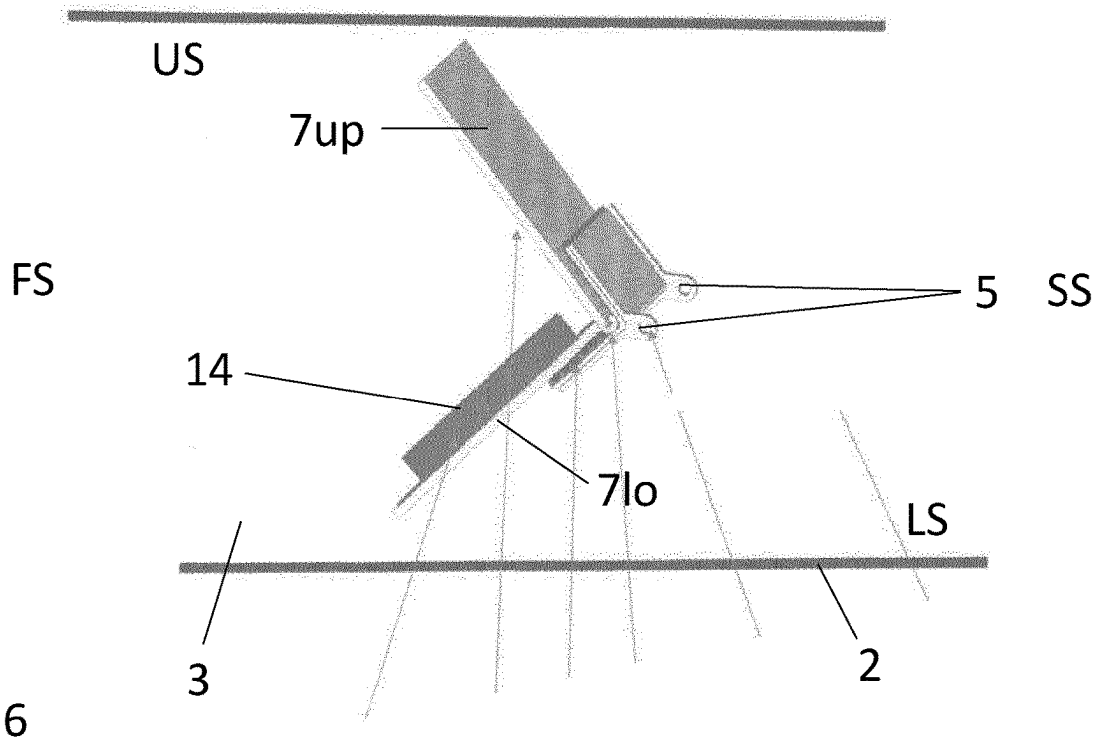

Fig. 6

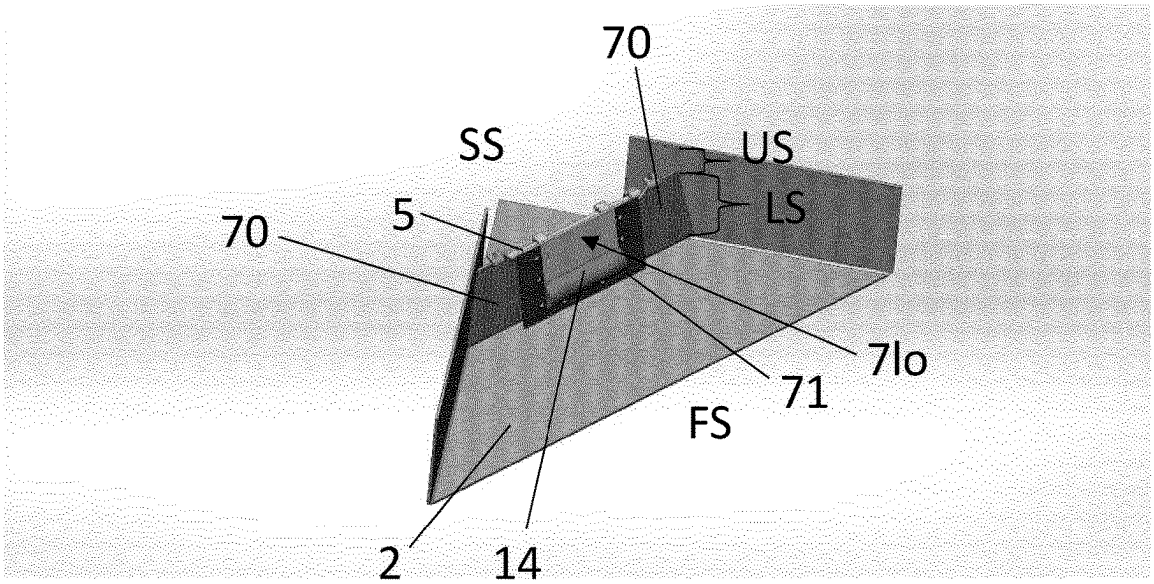
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Fig. 7a

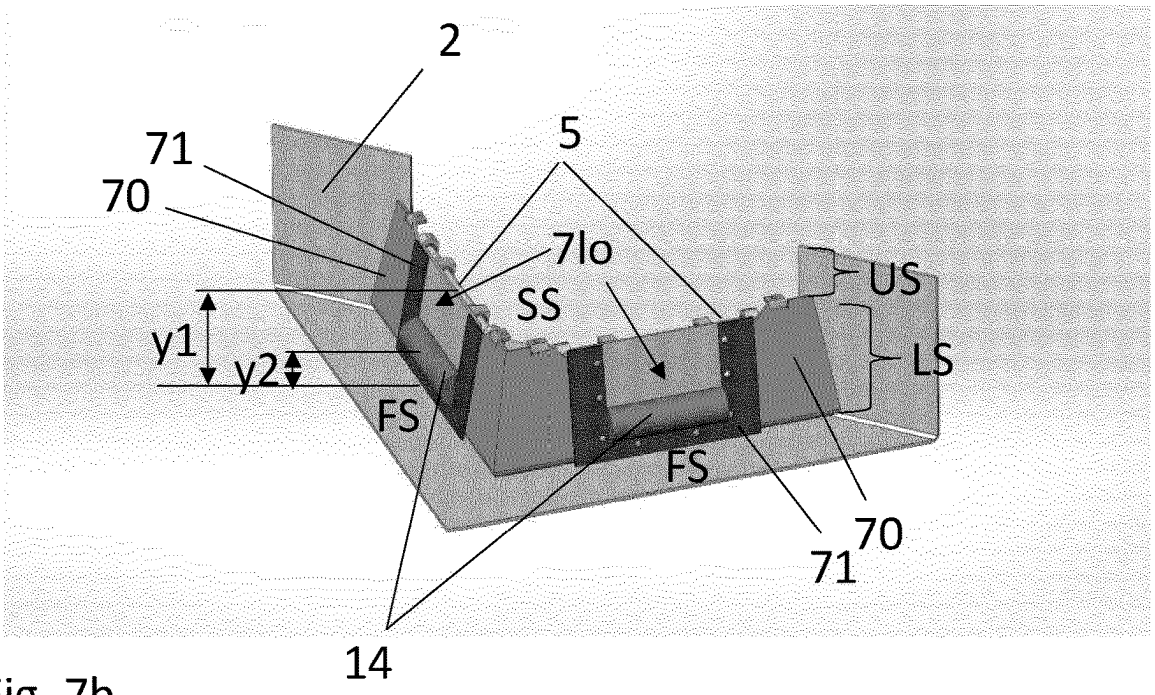
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Fig. 7b

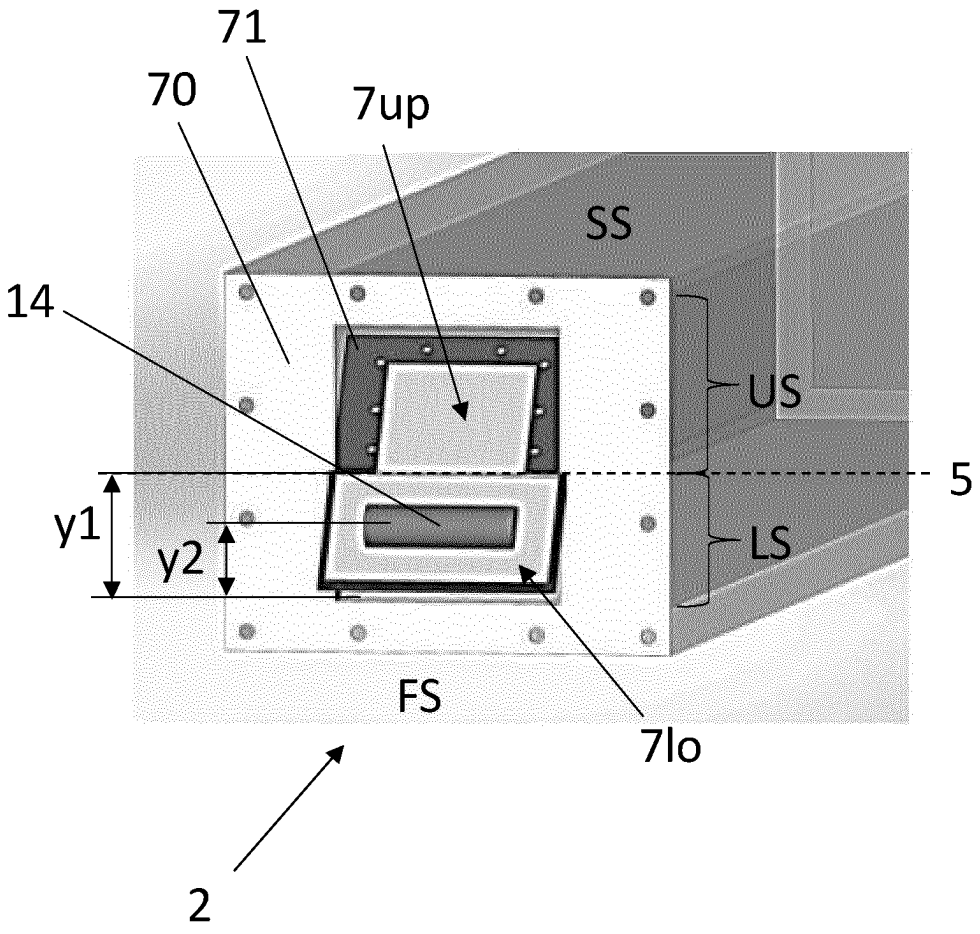


Fig. 8

Fig. 9a

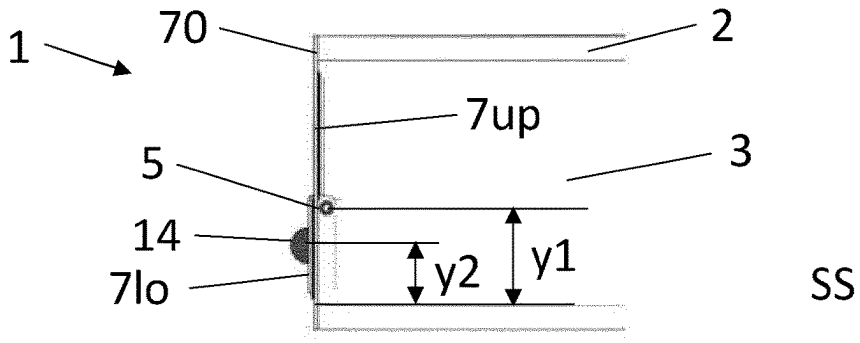


Fig. 9b

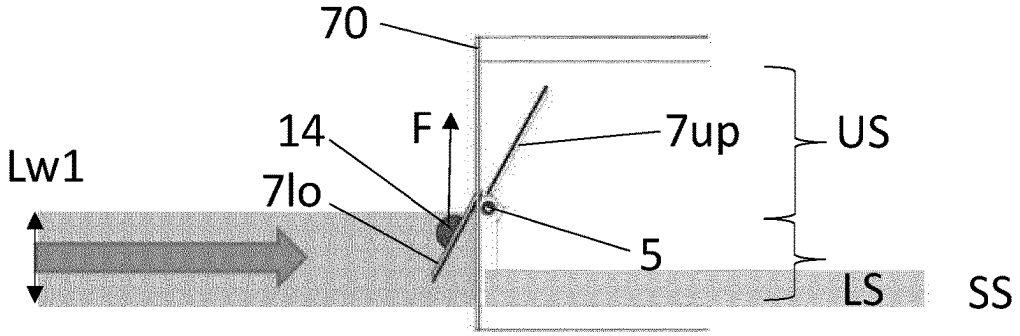


Fig. 9c

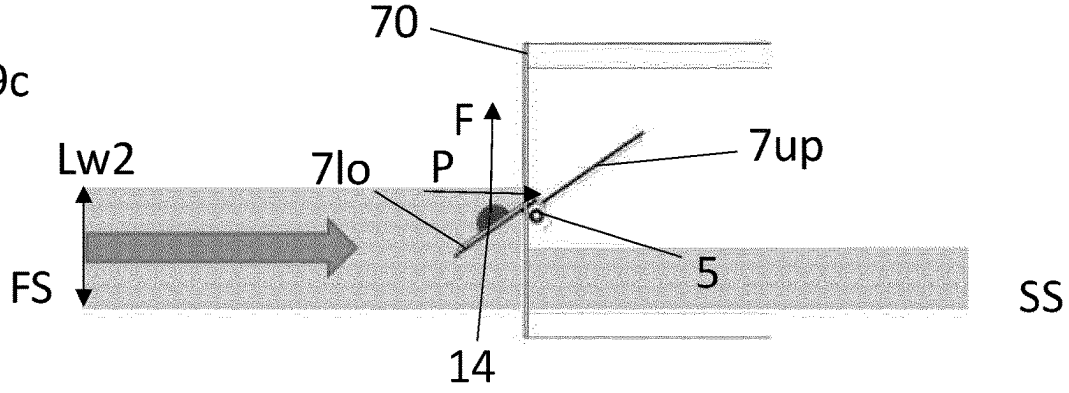
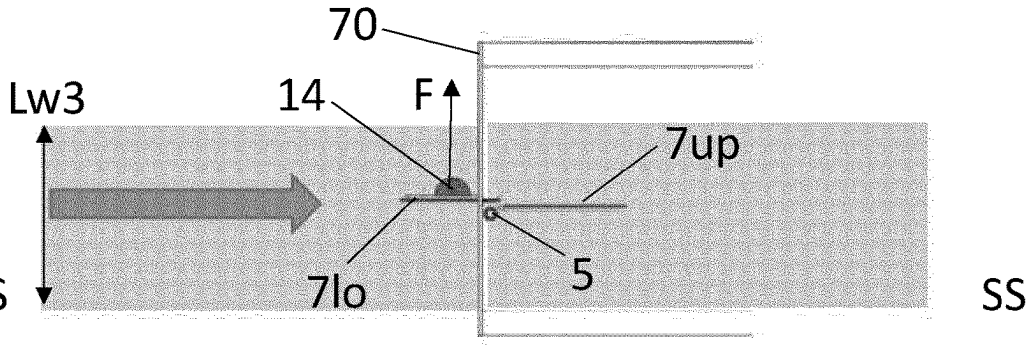


Fig. 9d



A WATER-LEVEL CONTROL UNIT WITH A DOWNWARDLY HANGING HINGED LOWER FLAP PORTION OF A VALVE ELEMENT AND A FLOATING BODY CONNECTED THERETO

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is the National Stage of International Application No. PCT/EP2023/060508, filed Apr. 21, 2023, which claims the benefit of Netherlands Application No. 2031673, filed Apr. 22, 2022, the contents of which is incorporated by reference herein.

FIELD OF THE INVENTION

[0002] The present invention relates to water-level control units that in combination with a culvert, ditch or drainage piping and/or system can be used to control water-levels of a surface area, like for example a piece of farming land.

BACKGROUND TO THE INVENTION

[0003] Such water-level control units are known in various embodiments. For example it is known to provide constructions with large concrete level boxes around outer ends of drainage pipes that extend underground underneath a piece of farming land. Those large concrete level boxes then are dug in into a slope that delimits the piece of farming land. Inside each level box, a piece of thick-walled hose is connected to the outer end of the drainage pipe. A rigid end connector is provided at the free outer end of the piece of thick-walled hose. The end connector hangs at a certain height position underneath an upper part of the level box by means of a chain. A measure is provided inside the level box. The measure extends in the vertical direction and indicates different height positions for the end connector. By changing the length of the chain, the end connector can be positioned at an aimed height position. By changing the height position of the end connector, also the height position of the outflow opening of the drainage pipe gets influenced. This makes it possible for a farmer to manually change a desired minimum water-level of the piece of farming land to be maintained instead of having all the water getting drained away relative quickly.

[0004] A disadvantage herewith is that a changing of the water-drainage level needs to be done manually. This is a heavy and time-consuming laborious task for the farmer, particularly because it needs to be done for all level boxes, of which the number is equal to the number of drainage pipes, which normally are provided at intervals of merely a few meters apart from each other. Another disadvantage is that having to dig in the large concrete level boxes around each outer end of the drainage pipes, is expensive and a lot of work. Furthermore, with this system, a farmer always runs behind. This is because a farmer never knows up front how much or how little rain is going to fall on the piece of farming land.

[0005] U.S. Pat. No. 10,053,829 shows a level box that can be connected to an outer end of a water conveying tube or pipe that allows water to be carried downstream. Inside the level box, a gate valve is provided. With this, the assembly of level box and gate valve are constructed such that water needs to flow over an upper edge of the gate valve in order to be able to pass the level box. This type of level box is referred to as flashboard riser, that is to say an overflow dam. The gate valve here is provided rotatable back and forth around a lower hinge axis inside the level box. The gate valve can be actively rotated to change a height of its upper edge, and thus be set fully closed, partly open or fully open. The foreseen method of operation may be manual or automated.

[0006] A disadvantage here is that there is a risk of dirt, sewage or the like to accumulate more and more in front of the gate valve, and in the end even clogging the tube or pipe.

[0007] A disadvantage of the manual version here also is that a changing of the water-drainage level is a time-consuming laborious task and inherently is done too late or too early, because of never knowing upfront how much or how little rain is going to fall.

[0008] A disadvantage of the automated version is that it requires an operable drive unit for actively rotating the gate valve between its respective positions, in combination with water-level sensors and a control unit for steering the drive unit, as well as an energy source for operating the drive unit. This all makes the construction way too expensive to be able to provide it in large numbers at for example all outer ends of drainage pipes of a piece of farming land. Furthermore, it makes the level boxes rather big and vulnerable for malfunction.

[0009] CN-210263349-U discloses an automatically operating rainwater drainage weir that is configured to be installed between for example a river and a culvert, and that is destined to stay closed until a certain water level is first reached. For that the weir comprises a multi-chamber box that delimits a central drainage flow chamber that can be closed off or opened by means of gate valve elements. Those gate valve elements are plate-shaped and at their lower sides are hingedly connected to a stepped bottom part of the box. Furthermore, those plate-shaped gate valve elements are connected to lower ends of two-part lever arms that with their upper ends are fixedly connected to a rotation axis. At both opposing sides of the central drainage flow chamber, flotation tank chambers are provided. Those flotation tank chambers at their upper ends are provided with relative large inlet openings that open out to an upstream side of the weir box, and at their lower ends are provided with relative small outlet openings that open out to a downstream side of the weir box. The outer ends of the rotation axis lie above the flotation tank chambers and each carry a floating body that is fixedly connected thereto while hanging down into its respective flotation tank chamber.

[0010] In a situation that the gate valves are initially closed, excess rainwater coming from a piece of land and trying to flow away into a river, first shall accumulate inside the culvert at the upstream side in front of the closed gate valve elements. As soon as the rising water level reaches the height position of the inlet openings of the flotation tank chambers, the flotation tank chambers shall start filling themselves with this water. Due to this, the floating bodies shall start to exert upwardly directed floatation forces onto the rotation axis, which in turn shall start to force the gate valve elements to rotate around their hinge axis towards their open positions in which they lie flat on the bottom of the central drainage flow chamber, such that all excess rainwater can flow away into the river.

[0011] As soon as the water level drops to below the height position of the inlet openings again, no new water shall flow into the flotation tank chambers, and the flotation tank

chambers shall slowly empty via their outlet openings. This shall cause the floating bodies to return to their down hanging positions while at a same time closing the gate valve elements again.

[0012] A disadvantage with this is that a proper and save functioning cannot always be guaranteed. In particular a risk exists that the gate valve elements stay open too long. This for example may be caused by the relative small outlet openings having a tendency to get blocked by sewage or the like. Furthermore, the force of flowing water may well be strong enough to keep the gate valve elements in their open positions as soon as they are opened. This risk may even be increased when sewage or the like accumulates in front of and/or on top of and/or between side edges of the gate valve elements.

[0013] Another disadvantage with this is that the exact moment of opening/closing of the gate valve elements is uncertain and not only depends on the height of the inlet openings of the flotation tank chambers that the excess rainwater needs to reach, but also of the speed with which the flotation chambers get filled respectively emptied.

[0014] JP-2019/120120 shows a flap gate for closing a water outlet between a river, lake or the like and a sea. The purpose hereof is to prevent backflow of seawater towards the river, lake or the like in the case of high water at the downstream side of the sea, in particular during a tsunami or storm surge at sea. The flap gate comprises a flap door that hangs down via supporting arms from a hinge axis. The flap door is rotatable around the hinge axis towards the downstream side of the sea to rotate from a closed position into an open position, and is rotatable around the hinge axis towards the upstream side of the river, lake or the like to rotate from an open position into a closed position. The rotating of the flap door into its open position towards the downstream side of the sea takes place under the influence of increasing water pressure at the side of the river, lake or the like. The rotating of the flap door into its closed position towards the upstream side of the river, lake or the like takes place under the influence of high water at the side of the sea.

[0015] The supporting arms protrude on either side of the hinge axis. A balance weight is provided between free upper ends of the supporting arms. A floating body is attached to the flap door at the side of the river, lake or the like. A sealing rubber is mounted around the circumferential edge of the flap door facing the water outlet.

[0016] In the closed position, a center of buoyancy of the floating body lies upstream of the hinge axis, such that the buoyancy of the floating body acts to help to keep the flap door closed even when the water level on the upstream side of the river, lake or the like would start to rise during the time the sea level is also high.

[0017] In the open position, the center of buoyancy of the floating body lies downstream of the hinge axis, such that the buoyancy of the floating body acts to help to open the flap door when the water level on the upstream side of the river, lake or the like would start to rise during the time the sea level is low.

[0018] A disadvantage is that it is not possible to buffer water at the upstream side of the river, lake or the like with this known flap gate. A slight water pressure at the upstream side of the river, lake or the like already causes the flap door to swing open in the direction of the downstream side of the sea, particularly because not only the water pressure, but also the flowing water as well as the buoyancy of the floating body then act in the same downwards direction.

[0019] Another disadvantage is that a mere dropping of the water level at the upstream side of the river, lake or the like to below a height position of the floating body, shall be unable to lead to a full closure of the flap gate. For such a full closure to be obtained, firstly the water level at the downstream side of the sea needs to rise high enough.

[0020] Yet another disadvantage is that when the flap gate of JP-2019/120120 has reached its closed position, it runs a risk of getting stuck in that closed position. This might occur when the water level on the upstream side of the river, lake or the like has started to rise during the time the sea level also was high, because then in this closed position, the center of buoyancy of the floating body lies upstream of the hinge axis, such that the buoyancy of the floating body acts to keep the flap door closed even when the water level at the downstream sea side drops again. This then leads to no water of the river, lake or the like being able to drain away towards the sea until somebody comes along and forces the flap gate to rotate such far towards the downstream side of the sea that the center of buoyancy of the floating body comes to lie downstream of the hinge axis again.

[0021] Finally it is noted that with this known flap gate it is only possible to have fresh water drain away from the upstream side towards the downstream side. Should it be desired to have water flow in the opposite direction, then this only would be possible when the flap gate would be manually forced to rotate to its open position and kept there.

BRIEF DESCRIPTION OF THE INVENTION

[0022] The present invention aims to overcome those disadvantages at least partly or to provide a usable alternative. In particular the present invention aims to provide an automatically operating water-level control unit that is reliable, economic and user-friendly, and that can easily be adjusted to specific local circumstances.

[0023] According to the present invention this aim is achieved by a water-level control unit described herein. This unit is configured for installation inside or onto a culvert, ditch or outlet of a drainage pipe and/or system of a water collecting surface area, and comprises a housing that delimits a flow channel that has a lower section and an upper section, and a valve element that is positioned rotatable around a hinge axis inside the flow channel between a closed and an open position. The valve element is configured to in its closed position close off the lower section of the flow channel while dividing the flow channel in a first upstream side and a second downstream side, and to in its open position open the lower section. A floating body is provided for moving the valve element in dependence of a rising level of water. The hinge axis of the valve element is provided at a height spaced above a bottom of the flow channel. The valve element comprises a lower flap portion that in its closed position hangs down from the hinge axis. The floating body is provided at and connected to a side of the lower flap portion at a height position in between the hinge axis and the bottom of the flow channel.

[0024] According to the inventive thought, the lower flap portion, that in its closed position hangs down from the hinge axis, is rotatable around the hinge axis towards the first upstream side to rotate open from its closed position into its open position, wherein the floating body is configured for moving the valve element from its closed position

towards its open position in dependence of a rising level of water at the first upstream side in the flow channel.

[0025] Further according to the inventive thought, the floating body can be configured for starting to pull the lower flap portion towards the first upstream side from its closed position into its open position due to buoyancy forces when a level of water is reached at the first upstream side that corresponds to the height position at which the floating body is provided, while rotating the lower flap portion through the level of water at the first upstream side and opening up the lower section of the flow channel for the water to flow away towards the second downstream side.

[0026] Thus the invention provides a reliable, economic and user-friendly automatically operating water-level control unit that can easily be installed and then adjusted to specific local circumstances. Since the lower flap portion of the valve element gets automatically forced by water flow from the first upstream side towards the second downstream side itself to take back its closed position again when the floating body is no longer undergoing an upwardly directed floating force due to a dropping water level at the first upstream side, a proper, swift and save closing as soon as the water level at the first upstream side drops again to below the height position of the floating body, can always be guaranteed.

[0027] Furthermore, the force of flowing water from the first towards the second downstream side shall have an automatic cleaning effect on any dirt, sewage or the like trying to accumulate at the first upstream side in front of and/or between side edges of the lower flap portion of the valve element.

[0028] Since the opening/closing of the lower flap portion of the valve element in the case of a rising water level at the first upstream side is only dependent on the water level reaching the height position of the floating body at that first upstream side itself, the moment of opening/closing of the lower flap portion valve element can exactly be determined.

[0029] Advantageously, water, for example rainwater or irrigation water, that drops down on a piece of open farming land or other type of open surface area can be kept locked there at a higher aimed desired water-level than a height at which a drainage system or the like itself is foreseen for that piece of farming land or other type of surface area. Thus a large additional amount of surface water can for example be stored inside the ground and there increase a ground water level while at a same time being prevented from quickly evaporating away again. In the present times of climate change this is particularly important and may even help to reduce sea level rise.

[0030] During dry season the invention makes it possible to make more efficient use of valuable rainwater and save upon costly irrigation water. This may help to prevent the land or other type of surface area from falling dry. Farming land thus can be kept wetter which may help the plants growing upon it to flourish and prosper and lead to higher production. In hotter areas, the productive growing seasons can thus be lengthened. Furthermore, irrigation with groundwater shall be less necessary.

[0031] During rainy season, like monsoon, the invention makes it possible to prevent that rivers, brooks, canals, and the like, get too heavily loaded. This may help to prevent flooding or at least less damaging caused by natural disasters, which is becoming more and more important due to climate changes all over the world.

[0032] For same reasons, it is also possible to use the invention for temporarily locking rainwater in ditches and/or on (green) flat roofs. By buffering amounts of rainwater on roofs, those roofs can be kept cooler and/or greener and at a same time help to release sewers during heavy rainfall.

[0033] Besides being usable to (temporarily) lock large amounts of surface water at the first upstream side of the unit, and only have excess surface water drain away each time the water level at that first upstream side reaches the height position of the floating body, the invention offers another important advantage the other way around as well, that is to say that the invention can also be used for irrigation of the piece of open farming land or other type of open surface area as well via a drainage system or the like that is foreseen for that piece of farming land or other type of surface area. This is because the downwardly hanging lower flap portion of the valve element has full freedom to be pushed to rotate open from its closed position towards its open position when water is offered at its second downstream side as well. As long as this offering of water at the second downstream side leads to a higher water level at the second downstream side than at the first upstream side, the difference in water pressure shall keep on exerting an opening force on the lower flap portion and keep on pushing it open for water to flow through the unit towards the piece of farming land or other type of surface area, and thus irrigate it the other way around.

[0034] Thus a two-way operating water-level control unit is obtained, that in the direction of the first upstream side to the second downstream side is able to lock water until a certain water level is reached, and that in the direction of the second to the first upstream side is able to give full freedom for water to flow in an opposite direction.

[0035] It is noted that the water-level control unit and/or drainage system to which it is connected can easily be flushed clean, for example periodically or whenever a blockage is detected. This can for example be done with the aid of a high pressure cleaner.

[0036] The invention can easily be adapted to existing systems, like being installed into or onto outer ends of (drainage) pipes or culverts. It is however also possible to place the unit inside a ditch or the like itself, or to integrate it in an outlet opening a blocking wall, like an upwardly projecting roof edge or corner. The unit is economic to build, easy to place, and hardly requires maintenance. After placement, the unit can quickly and easily be set at its aimed water level opening conditions.

[0037] In a preferred embodiment the floating body can be provided at and connected to the first upstream side of the lower flap portion at the height position in between the hinge axis and the bottom of the flow channel. Thus advantageously it is positioned there where it is well able to exert its upwards directed buoyancy force onto the lower flap portion of the valve element at a reliable protected position as well as at a relative large effective lever arm for this upwards directed buoyancy force around the hinge axis.

[0038] In a preferred embodiment a primary height-adjustable connection system can be provided between the floating body and the first upstream side of the lower flap portion, which primary height-adjustable connection system is configured for varying the level of water to be reached at the first upstream side for the floating body to start pulling the lower flap portion towards the first upstream side from its closed position into its open position. Thus advanta-

geously the height position of the floating body can easily be adapted to local situations and/or changing weather conditions whenever this is desired. The height adjustment can be performed manually, but also can be automated by equipping the primary height-adjustable connection system with an operable drive unit.

[0039] The primary height-adjustable connection system in particular may comprise complementary mounting means that are fixedly mountable against the lower flap portion while extending perpendicular to the hinge axis, and that are configured to mount the floating body at different height positions against the lower flap portion in between the hinge axis and the bottom of the flow channel.

[0040] In a preferred further or alternative embodiment the valve element can be configured to leave open an upper section of the flow channel in its closed position. Thus advantageously an overflow is provided for large amounts of water to be drained away or for situations that the valve element for whatever reason is unable to open.

[0041] In a preferred further or alternative embodiment a partition wall can be provided between the lower and upper section, which partition wall projects towards the first upstream side, and wherein the partition wall is configured for the floating body and/or lower flap portion to abut against in the open position. Thus advantageously an automatic stop is provided for the opening rotation, while at a same time a somewhat protected position is obtained for the floating body and lower flap portion during draining away of water from the first towards the second downstream side.

[0042] In a preferred further or alternative embodiment the hinge axis may extend between the lower and upper section. Thus advantageously the entire upper section may remain unhindered for overflow of water.

[0043] In a preferred further embodiment the valve element further may comprise an upper flap portion that in its closed position projects upwardly from the hinge axis. In case that the water level at the first upstream side then should rise above the height of the hinge axis, the water pressure at the first upstream side then shall start to exert an additional opening force on this upper flap portion in a direction away from the first upstream side towards the second downstream side, and thus, together with the already exerted pulling force on the lower flap portion by the floating element, cause the valve element to rotate open around the hinge axis from its closed position into its open position. This for example might be necessary in the case of quickly rising water level at the first upstream side and/or in the case that for some reason the lower flap portion is hindered by debris or the like to smoothly and quickly rotate open.

[0044] In a preferred further or alternative embodiment a secondary height-adjustable connection system may be provided between the valve element and the hinge axis. This makes it possible to change a surface area relation between the lower flap portion and an upper flap portion that extend from both opposing sides of the hinge axis. Thus, the opening and closing forces of the valve element can be changed, and the entire valve element can be balanced, if desired.

[0045] In a preferred further or alternative embodiment the housing may comprise an inwardly projecting abutment at the lower section of the flow channel and configured for the lower flap portion to lie against in its closed position. Thus an exact position is known for the valve element in its closed position, which makes it easier to control and set its opening conditions and behaviour. By having the abutment forming a valve seat, advantageously an improved sealing can be obtained for the lower flap portion of the valve element in its closed position.

[0046] Instead of an inwardly projecting abutment or in addition thereto, it is also possible to provide another type of holding/blocking arrangement at the lower section of the flow channel and configured for the lower flap portion to be temporarily held in its closed position until the level of water at the first upstream side in the flow channel has risen far enough for the floating body to pull the valve element towards its open position. As an example hereof a permanent or operable holding magnet can be placed underneath or at the lower section of the flow channel and configured for the lower flap portion to lie against or held with a certain magnetic force in its closed position. Thus also an exact position can be known for the valve element in its closed position, which makes it easier to control and set its opening conditions and behaviour.

[0047] In addition thereto the inwardly projecting abutment or holding/blocking arrangement can be positioned at such a distance x from the hinge axis that the lower flap portion in its closed position hangs down obliquely angled towards the first upstream side while lying against the abutment or while being kept in place by the holding/blocking arrangement. Thus advantageously the lower flap portion does not hang down vertically in its closed position and the floating body connected to the first upstream side thereof has a relative large level arm relative to the hinge axis for immediately starting to exert a large enough opening force onto the lower flap portion when the water level at the first upstream side reaches the height position of the floating body. The other way around, it thus also has become easier for using the invention to have the lower flap portion opened by water that gets actively offered at the second downstream side of the lower flap portion for irrigation purposes.

[0048] The invention also relates to an assembly of the inventive water-level control unit and a culvert, ditch or outlet of a drainage pipe and/or system of a water collecting surface area, as well as to a method for controlling a water-level by means of the inventive water-level control unit.

[0049] Further preferred embodiments of the invention are described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0050] The invention shall now be explained in more detail below by means of describing some exemplary embodiments in a non-limiting way with reference to the accompanying drawings, in which:

[0051] FIG. **1***a-d* shows a water-level control unit according to the invention with different water levels at a first upstream side of a lower flap portion of its valve element leading to different closing and opening positions;

[0052] FIG. **2***a-b* shows different use of the units when installed into outer ends of drainage pipes ending out in a ditch that is pre-filled with water or is to run dry;

[0053] FIG. **3***a* shows a pipe-insertion-type embodiment of the water-level control unit that is configured to be inserted into a tubular pipe;

[0054] FIG. **3***b* shows an enlarged view of the valve element of FIG. **3***a;*

[0055] FIG. **3***c* shows a view of the unit of FIG. **3***a* shortly before placement inside a pipe;

[0056] FIG. **4** shows a pipe-insertion-type double-acting variant;

[0057] FIG. **5** shows a ditch-insertion-type double acting variant;

[0058] FIG. **6** shows an angled variant;

[0059] FIGS. **7***a* and **7***b* show variant embodiments of water-level control units for use along straight roof edges or at roof corners;

[0060] FIG. **8** shows a front side perspective view of another variant embodiment of a water-level control unit for mounting against an outer end of a duct; and

[0061] FIG. **9***a-d* shows the water-level control unit of FIG. **8** with different water levels at a first upstream side of a lower flap portion of its valve element leading to different closing and opening positions.

DETAILED DESCRIPTION OF THE INVENTION

[0062] In FIG. **1** a water-level control unit is shown that has been given the reference numeral **1**. The unit **1** comprises a housing **2** that delimits a flow channel **3**, that here extends around a horizontal central axis. At a central position inside the housing **2**, spaced a height y**1** above a bottom of the flow channel **3**, a hinge axis **5** is provided. The hinge axis **5** here also extends in the horizontal direction but then perpendicular to the central axis. A plate-shaped valve element **7** is rotatable around the hinge axis **5** between a closed position (FIGS. **1***a* and *b*) and open positions (fig. c and d). The plate-shaped valve element **7** comprises a lower flap portion **7***lo* and an upper flap portion **7***up* that lie on opposing sides of the hinge axis **5**.

[0063] An abutment **10** is provided at a bottom of the flow channel **3**. The abutment **10** lies at a distance x**1** in the horizontal direction underneath the hinge axis **5** such that the lower flap portion **7***lo* in its closed position gets to hang down under its own weight in an oblique angled orientation a from the hinge axis **5** while being blocked by the abutment **10**.

[0064] The flow channel **3** is defined as having a lower section LS and an upper section US. The lower section LS is the part that is closable and openable by the valve element **7**. The upper section US is the part that remains open, such that it can form an overflow.

[0065] The flow channel **3** furthermore is defined as having a first upstream side FS and a second downstream side SS. The first upstream side is here is formed by an upstream drainage side respectively downstream irrigation side of the unit **1** (at the right side of the valve element **7** in the FIG. **1**), whereas the second downstream side here is formed by a downstream drainage side respectively upstream irrigation side of the unit **1** (at the left side of the valve element **7** in FIG. **1**).

[0066] The lower flap portion **7***lo* and upper flap portion **7***up* together have width and length dimensions that are complementary with a cross-sectional profile of the lower section LS of the flow channel **3**, seen over a line extending through the hinge axis **5** and the abutment **10**.

[0067] A floating body **14** is connected to the lower flap portion **7***lo* at its first upstream side FS. The floating body **14** can be formed by an air- or gas-inflatable or filled hollow body, but may also be filled with or formed by any kind of material having floating capacity on water. The floating body **14** is connected to the lower flap portion **7***lo* at a position in between the hinge axis **5** and the abutment **10**, and in the closed position of the valve element **7** lies at a height y**2** above the bottom of the flow channel **3**, and at a distance x**2** in the horizontal direction from the hinge axis **5**.

[0068] A partition wall **17** is provided just above a level of the hinge axis **5**. The partition wall **17** extends in the horizontal direction from the hinge axis **5** towards the first upstream side FS.

[0069] A internal filter **18** extends obliquely angled towards the first upstream side FS between a free outer end of the partition wall **17** and the bottom of the flow channel **3**.

[0070] An advantageous method of operation shall now be described for the FIG. **1** embodiment.

[0071] In FIG. **1***a* the situation is shown in which the unit **1** is fully dry. Due to the own weight of the lower flap portion **7***lo* minus the own weight of the upper flap portion **7***up*, a clockwise directed momentum acts on the valve element **7** to maintain lying against the abutment **10** in its closed position.

[0072] In FIG. **1***b* the situation is shown in which water has entered the unit **1** from its first upstream side FS (in that situation forming an upstream drainage side), which water at that moment has built up in front of the closed valve element **7** to a water level Lw**1** that lies beneath the initial height position y**2** of the floating body **14** in the closed position of the valve element **7**. Due to the own weight of the lower flap portion **7***lo* minus the own weight of the upper flap portion **7***up*, added with the water pressure acting on the valve element **7** at its first upstream side, an increased clockwise directed momentum acts on the valve element **7** to maintain lying even stronger sealed against the abutment **10** in its closed position.

[0073] In FIG. **1***c* the situation is shown in which water has kept on entering the unit **1** from its first upstream side FS, which water at that moment has built up in front of the closed valve element **7** to an increased water level Lw**2** that lies above said initial height position y**2** of the floating body **14**. Due to the floating body **14** having started to float on top of the increased water level Lw**2**, a corresponding upwardly directed pulling force F is exerted on the lower flap portion **7***lo* of the valve element **7** to have it rotate counter-clockwise to a semi-open position against the weight forces and against the water pressure also still acting on the valve element **7** at its first upstream side. In this semi-open position, water is able to start draining away towards the second downstream side SS (in that situation forming a downstream drainage side) via the partly opened up lower section LS of the flow channel **3**.

[0074] In FIG. **1***d* the situation is shown in which a further increased water level Lw**3** is offered to the unit **1** at its first upstream side FS. This further increased water level Lw**3** even lies above the height y**1** of the hinge axis **5**. In that situation the valve element **7** has fully opened up with the floating body **14** having come to lie against the partition wall **17**, and with both the lower flap portion **7***lo* and the upper flap portion **7***up* having come to lie in a horizontal position. With this the water draining away to the second downstream side SS, advantageously exerts an additional opening force upon the upper flap portion **7***up*. Together with the clockwise directed momentum due to the buoyancy force F also acting on the valve element **7**, this shall lead to the valve element **7** to maintain lying even stronger against the partition wall **17** in its closed position. In this fully-open position, water is able to drain away at even higher capacities towards the

second downstream side SS via the now fully opened up lower section LS of the flow channel **3**.

[0075] Should more water get offered to the first upstream side FS, then also the already open upper section US shall automatically get used for water to drain away towards the second downstream side SS. This may be important in situations of heavy rainfall, monsoon, flooding or the like.

[0076] As soon as the level of offered drainage water at the first upstream side FS drops again to below the initial height position y**2** of the floating body **14** in the closed position of the valve element **7**, the valve element **7**, due to the own weight of the lower flap portion **7***lo* minus the own weight of the upper flap portion **7***up*, added with the water pressure still acting on the valve element **7** at its first upstream side, shall exert a counter-clockwise directed momentum on the valve element **7** to return to its sealing closed position against the abutment **10**.

[0077] In dry situations it is also possible to use the unit **1** according to the invention in a reverse direction for irrigation purposes. This is possible by, in the dry situation as is shown in FIG. **1***a*, actively offer irrigation water to the second downstream side SS (in that situation forming an upstream irrigation side). As soon as this irrigation water then reaches the closed valve element **7**, water pressure shall start acting on the lower flap portion **7***lo* of the valve element **7**. As soon as this water pressure is high enough to be able to overcome the weight forces of the valve element **7** itself, this shall cause the valve element **7** to rotate counter-clockwise to a semi-open position. In this semi-open position, irrigation water is able to start flowing from the second downstream side SS towards the first upstream side FS (in that situation forming a downstream irrigation side) via the opened up lower section LS of the flow channel **3**. In this reversed irrigation situation, buoyancy of the floating body **14** does not play a role in the opening behaviour of the valve element **7**.

[0078] In FIGS. **2***a* and *b* it is schematically shown as an example that units with hinged downwardly hanging lower flap portions of valve elements **7***a-c* are provided inside free outlet ends of regularly spaced apart drainage pipes **20***a-c*. For that a housing of each unit comprises a sealing arrangement that is configured to fit sealing inside its drainage pipe **20***a-c*. The outlet ends of the drainage pipes **20***a-c* end out above a ditch **21**. Halfway the ditch **21** a culvert **22** is provided of which a throughflow opening **23** can be controlled. In FIG. **2***a* the opening **23** is substantially closed, whereas in FIG. **2***b* the opening **23** is partly opened.

[0079] In the upper half of FIGS. **2***a* and *b* a situation is shown in which an upstream portion **21***us* of the ditch **21**, that is to say upstream of the culvert **22**, is filled with a relative large amount of water at a level above the outlet end of the drainage pipe **20***a*, whereas in the lower halves of FIGS. **2***a* and *b* situations are shown in which a downstream portion **21***ds* of the ditch **21**, that is to say downstream of the culvert **22**, is only filled with a relative small amount of water at a level far underneath the outlet ends of the drainage pipes **20***b* and *c*.

[0080] Due to high water level in the upstream portion **21***us* of the ditch **21**, water shall start to flow from out of the ditch **21** into the drainage pipe **20***a* while pushing open the respective valve element **7***a*. This water then shall distribute itself over the length of the drainage pipe **20***a* and from there be able to irrigate the surrounding land. This same situation is also shown in FIG. **2***b*.

[0081] Due to low water level in the downstream portion **21***ds* of the ditch **21**, water falling on the land above the drainage pipes **20***b* and *c* may drain into those drainage pipes **20***b* and *c* and start to accumulate in front of the respective closed valve elements **7***b* and *c*. This is shown in FIG. **2***a*. As soon as the water level inside the drainage pipes **20***b* and *c* then reaches the level of floating bodies on lower flap portions of their valve elements **7***b* and *c*, the floating bodies shall pull the valve elements **7** to their open positions, such that water may drain away into the downstream portion **21***ds* of the ditch **21**. This is shown in FIG. **2***b*.

[0082] In FIG. **3***a-c* an embodiment is shown in which the housing **2** and flow channel **3** have a substantially rectangular cross-sectional profile with round edges. This brings the advantage that the valve element **7** also can be made with a substantially rectangular plate-shape with rounded edges with a width dimension complementary to the one of the flow channel **3**.

[0083] In FIG. **3***a-c* an obliquely angled closed position is shown for the valve element **7** in which its lower flap portion **7***lo* fully closes off the lower section LS of the flow channel **3**, and in which its upper flap portion **7***up* partly closes off the upper section US of the flow channel **3**.

[0084] The floating body **14** is mounted at the first upstream side FS to the lower flap portion **7***lo* by means of a primary height-adjustable connection system **30**. This primary height-adjustable connection system **30** here comprises a left and right mounting screw with thickened heads that are threaded into the lower flap portion **7***lo* while extending through longitudinal slits **31** that extend perpendicular to the hinge axis **5**. Thus the floating body **14** is mountable at different height positions onto the lower flap portion **710**.

[0085] The valve element **7** is further provided with a secondary height-adjustable connection system **32** that here comprises mounting rails that extend along opposing side edges of the valve element, here at its second downstream side SS. The mounting rails are equipped with a plurality of holes **33** into which pins of the hinge axis **5** can be placed. Thickened head ends of the pins then come to lie outside the housing **2** against the side walls thereof while projecting through complementary openings in those side walls. Thus the position of the valve element **7** relative to the hinge axis hinge axis **5** is adjustable, due to which the valve element **7** in its closed position may come to lie at a steeper or less steep angle, and due to which the surface areas of the lower flap portion **7***lo* and upper flap portion **7***up* can quickly and easily be increased respectively decreased relative to each other.

[0086] Along the outer edge of the valve element **7** a sealing rubber **34** is provided that is configured to lie sealing against the inner bottom and side walls of the housing **2** in the closed position.

[0087] At the outer ends of the housing **2** blocking/sealing arrangements **35** are provided that are complementary to the pipe **20** into which the unit **1** is to be inserted. Those arrangements **35** here are formed by outwardly projecting flange portions that are provided alongside the bottom and side walls of the housing **2** and that together delimit three-quarter of a circle, such that when the unit **1** is inserted into the pipe **20** no water can leak away underneath or sideways of the unit **1**.

[0088] Furthermore, at the outer end of the housing **2** that lies at the first upstream side FS, a dismountable anti-

intrusion cap **37** is provided. This ant-intrusion cap **37** comprises an external grating **38** with a relative coarse mesh and an internal filter **39** with a relative fine mesh. The grating **38** covers the entire cross-section of the pipe **20** respectively flow channel **3** and is destined to block relative large strange objects from entering the unit **1**. The filter **39** merely covers the lower section LS of the flow channel **3** and is destined to filter out any debris that otherwise might hinder or block the proper functioning of the valve element **7**. The cap **37** can easily and quickly be removed for periodic cleaning purposes.

[0089] In FIG. **4** a double-acting variant is shown in which the unit **1** comprises two mirrored height-adjustable valve elements **7** at opposing sides of the unit **1**, one valve element **7** being orientated with its height-adjustable floating body **14** towards the first upstream side FS, whereas the other valve element **7'** is orientated with its height-adjustable floating body **14'** towards the second downstream side SS. This makes it possible to in both directions be able to actively control the level of water that first needs to be reached before having the respective valve element **7**, **7'** be pulled towards its open position.

[0090] In FIG. **5** a double-acting variant is shown that is configured to be placed inside a ditch. For that the at the outer ends of the housing **2** blocking/sealing arrangements **40** are provided that are complementary to the ditch into which the unit **1** is to be inserted. Those arrangements **40** here are formed by outwardly projecting flange portions that are provided alongside the bottom and side walls of the housing **2** and that together delimit a somewhat triangular-shape. When the unit **1** is lowered into the ditch the plate-shaped flange portions can penetrate to some extent into the ground walls that delimit the ditch such that no water can leak away underneath or sideways of the unit **1**. For the picking up and lowering of the unit a hoisting ring **42** is provided on top of the housing **2**.

[0091] In FIG. **6** a variant is shown in which the valve element **7** besides comprising the lower flap portion **7***lo* with the floating body **14** mounted against it at its first upstream side FS, also comprises a perpendicular angled upper flap portion **7***up* that is configured to automatically close off the upper section US of the flow channel **3** when the lower flap portion **7***lo* of the valve element **7** is rotated towards the open position of the lower section LS of the flow channel **3**.

[0092] In FIGS. **7***a* and *b* variants are shown in which the valve elements **7** merely comprise lower flap portions **7***lo* that hang down from hinge axes **5**. The hinge axes are positioned at heights y**1**. At first upstream sides FS of the valve elements **7**, floating bodies **14** are fixedly mounted onto the lower flap portions with centres of buoyancy positioned at heights y**2** that are lower than the heights of the hinge axes **5**. The lower flap portions **7***lo* here are dimensioned such that in the shown closed positions they entirely cover corresponding outlet openings of a drainage system of a water collecting surface area, for example a roof. The housings **2** here are shaped such that they can easily be integrated into upstanding side walls, like roof edges, that circumvent the water collecting surface area. The housings **2** comprise blocking walls **70** that extend upwardly up till the level y**1** of the hinge axes **5**. The outlet openings are provided at upper center positions of those blocking walls **70**, and are delimited by U-shaped frames **71** against which circumferential side and lower edges of the lower flap portion **7***lo* lie sealing against in the closed position.

[0093] In FIGS. **8** and **9** a variant is shown in which a housing **2** comprises a blocking wall **70** that is mounted in front of a flow channel **3**. An outlet opening is provided inside the blocking wall **70**. This outlet opening is bordered by a sealing frame **71**. A hinge axis **5** is positioned at an intermediate height position y**1** of the outlet opening. A valve element **7** is mounted rotatable around the hinge axis **5** between a closed position (FIG. **9***a*) and open positions (FIG. **9***b-d*).

[0094] The valve element **7** comprises a lower flap portion **7***lo* that in the closed position hangs down from the hinge axis **5** while covering a lower section LS of the outlet opening, and an upper flap portion **7***up* that in the closed position projects upwardly from the hinge axis **5** while covering an upper section US of the outlet opening.

[0095] At a first upstream side FS of the valve element **7**, a floating body **14** is fixedly mounted onto the lower flap portion **7***lo*. In the closed position of the valve element **7**, a centre of buoyancy of the floating body **14** is positioned at a height y**2**. As can be seen y**2**<y**1**, that is to say that the floating body **14** in the closed position finds itself below the hinge axis **5**.

[0096] In the closed position, edges of the lower flap portion **7***lo* are blocked by and lie sealing against the sealing frame **71** at the first upstream side FS of the blocking wall **70**, whereas edges of the upper flap portion **7***up* are blocked by and lie sealing against the sealing frame **71** at the second downstream side SS of the blocking wall **70**. In the closed position the lower and upper flap portions **710**, **7***up* together entirely cover the outlet opening. See FIG. **9***a*.

[0097] When a water level Lw**1** at the first upstream side FS starts to rise to above the initial height level y**2** of the floating body **14**, this floating body **14** starts to exert an upwards directed pulling force F on the lower flap portion **7***lo*. This causes the valve element **7** to rotate open around the hinge axis **5** (clockwise in FIG. **9**). The edges of the lower flap portion **7***lo* then are rotated away from the sealing frame **71** towards the first upstream side FS of the blocking wall **70**, whereas edges of the upper flap portion **7***up* are rotated away from the sealing frame **71** towards the second downstream side SS of the blocking wall **70**. See FIG. **9***b*. Water then starts to flow from the first upstream side FS towards the second downstream side SS via the partially opened outlet opening.

[0098] When the water level Lw**2** at the first upstream side FS rises further to above the height level y**1** of the hinge axis **5**, the floating body **14** increases its upwards directed pulling force F on the lower flap portion **710**. Furthermore, the water pressure of the water above the height level y**1** of the hinge axis **5** then starts to exert a pushing force P on the upper flap portion **7***up* as well. Together this causes the valve element **7** to rotate further open around the hinge axis **5** (clockwise in FIG. **9**). See FIG. **9***c*. More water then starts to flow from the first upstream side FS towards the second downstream side SS via the half opened outlet opening.

[0099] When the water level Lw**3** at the first upstream side FS then even rises further, the floating body **14** further increases its upwards directed pulling force F on the lower flap portion **7***lo*, and the pushing force P by the water above the height level y**1** of the hinge axis **5** then also increases. The valve element **7** then may take in its fully open position, that is to say here a horizontal position, as shown in FIG. **9***d*. Water then even starts to flow over the valve element **7**, that

is to say through the upper section US, from the first upstream side FS towards the second downstream side SS.

[0100] Besides the shown and described embodiments, numerous variants are possible. For example the dimensions and shapes of the various parts can be altered. Also it is possible to make combinations between advantageous aspects of the shown embodiments. Instead of using substantially rectangular-shaped flow channels and valve elements, they may have any other desired shape, like circular, triangular, oval, etc. The valve element, floating body, abutment, valve seat, sealing rubber, and the like also may have all kinds of desired shapes, thicknesses, etc. All kinds of materials can be used for the various components of the unit. Preferably however they are made of aluminium, stainless steel, plastic, etc. Instead of using the unit inside a pipe or inside a ditch, it can also be placed inside a throughflow opening of a culvert, or be mounted onto an outer end of a pipe or the like. Instead of making the floating body height adjustable relative to the lower flap portion of the valve element, it is also possible to fixedly connect it thereto. Instead of only providing a floating body one-sided at the first upstream side of the valve element, it is also possible to provide an additional floating body at the second downstream side of the valve element. Thus a two-sided floating body, that is to say at both opposing sides of the valve element, is obtained. If desired the lower flap portion of the valve element may also be weighted, biased, or the like, in a direction away from the first upstream side, in order to deteriorate the valve element's opening moment/movement during drainage when the water level starts to rise at its first upstream side, for example when it has started to rain. This weighting, biasing, or the like, might help to prevent flapping of the valve element at too high frequencies between its closed and open positions. It may also help to speed up the valve element's closing moment/movement against a sealing seat when the water level drops again at its first upstream side, for example when it has stopped raining again. Furthermore, the weighting also may help to deteriorate the valve element's opening moment/movement when the water level rises at its second downstream side, for example when irrigation of water in the opposing direction from the second downstream side towards the first upstream side is desired. If desired also an operable lock can provided that is configured to temporarily lock the valve element in its closed position whenever desired.

[0101] It should be understood that various changes and modifications to the presently preferred embodiments can be made without departing from the scope of the invention, and therefore will be apparent to those skilled in the art. It is therefore intended that such changes and modifications be covered by the appended claims.

1. A water-level control unit configured for installation inside or onto a culvert, ditch or outlet of a drainage pipe and/or system of a water collecting surface area, the unit comprising:

a housing that delimits a flow channel that has a lower section and an upper section;

a valve element that is positioned rotatable around a hinge axis inside the flow channel between a closed and an open position, wherein the valve element is configured to in its closed position close off the lower section of the flow channel while dividing the flow channel in a first upstream side and a second downstream side, and to in its open position open the lower section; and

a floating body for moving the valve element in dependence of a rising level of water,

wherein the hinge axis of the valve element is provided at a height spaced above a bottom of the flow channel,

wherein the valve element comprises a lower flap portion that in its closed position hangs down from the hinge axis,

wherein the floating body is provided at and connected to a side of the lower flap portion at a height position in between the hinge axis and the bottom of the flow channel,

wherein the lower flap portion, that in its closed position hangs down from the hinge axis, is rotatable around the hinge axis towards the first upstream side to rotate open from its closed position into its open position, and

wherein the floating body is configured for moving the valve element from its closed position towards its open position in dependence of a rising level of water at the first upstream side in the flow channel.

2. The water-level control unit according to claim **1**, wherein the floating body is configured for starting to pull the lower flap portion towards the first upstream side from its closed position into its open position due to buoyancy forces starting to act on the floating body when a level of water is reached at the first upstream side that corresponds to the height position at which the floating body is provided, while rotating the lower flap portion through the level of water at the first upstream side and opening up the lower section of the flow channel for the water to flow away towards the second downstream side.

3. The water-level control unit according to claim **1**, wherein the floating body is provided at and connected to the first upstream side of the lower flap portion at the height position in between the hinge axis and the bottom of the flow channel.

4. The water-level control unit according to claim **1**, wherein a primary height-adjustable connection system is provided between the floating body and the lower flap portion, which primary height-adjustable connection system is configured for varying the level of water to be reached at the first upstream side for the floating body to start pulling the lower flap portion towards the first upstream side from its closed position into its open position.

5. The water-level control unit according to claim **4**, wherein the primary height-adjustable connection system comprises complementary mounting means that are fixedly mountable against the lower flap portion while extending perpendicular to the hinge axis, and that are configured to mount the floating body at different height positions against the lower flap portion in between the hinge axis and the bottom of the flow channel.

6. The water-level control unit according to claim **1**, wherein

the valve element is configured to leave open at least part of the upper section of the flow channel in its closed position.

7. The water-level control unit according to claim **1**, wherein a partition wall is provided between the lower and upper section, which partition wall projects towards the first upstream side, and wherein the partition wall is configured for the floating body and/or lower flap portion to abut against in the open position.

8. The water-level control unit according to claim **1**, wherein the hinge axis extends between the lower section and upper section.

9. The water-level control unit according to claim **8**, wherein the valve element further comprises an upper flap portion that in its closed position projects upwardly from the hinge axis.

10. The water-level control unit according to claim **1**, wherein a secondary height-adjustable connection system is provided between the valve element and the hinge axis.

11. The water-level control unit according to claim **1**, wherein the housing comprises a holding/blocking arrangement, in particular an inwardly projecting abutment, more in particular forming a valve seat, at the lower section of the flow channel and configured for the lower flap portion to be held by and/or lie against in its closed position.

12. The water-level control unit according to claim **11**, wherein the holding/blocking arrangement, in particular said inwardly projecting abutment, is positioned at such a distance from the hinge axis that the lower flap portion in its closed position hangs down obliquely angled towards the first upstream side.

13. The water-level control unit according to claim **1**, wherein the housing comprises an outer blocking or sealing arrangement that is configured to fit blocking or sealing inside a culvert, ditch or outlet of a pipe.

14. The water-level control unit according to claim **1**, wherein the housing comprises an inner blocking or sealing arrangement that is configured to fit sealing onto a culvert, ditch or outlet of a pipe.

15. The water-level control unit according to claim **1**, wherein the flow channel at the first and/or second downstream side is covered by a filter and/or grating.

16. An assembly of a water-level control unit according to claim **1** and a culvert, ditch or outlet of a drainage pipe and/or system of a water collecting surface area.

17. A method for controlling a water-level by means of a water-level control unit according to claim **1**, comprising the steps:

installing the unit inside or onto a culvert, ditch or outlet of a drainage pipe and/or system of a water collecting surface area;

positioning the floating body at a height position in between the hinge axis and the bottom of the flow channel that corresponds to an aimed level of water that needs to be reached at the first upstream side before starting to pull the lower flap portion through the level of water towards the first upstream side from its closed position into its open position due to buoyancy forces starting to act on the floating body; and

passively and automatically controlling the water-level by means of:

each time the level of water at the first upstream side of the lower flap portion reaches the height position of the floating body, have the floating body pull the lower flap portion through the level of water towards the first upstream side from its closed position into its open position due to buoyancy forces acting on the floating body, while opening up at least the lower section of the flow channel for the water to flow away towards the second downstream side; and

each time the level of water at the first upstream side of the lower flap portion has dropped again to underneath the height position of the floating body, have the lower flap portion move back again from its open position into its closed position due to the buoyancy forces on the floating body dropping again, while closing off at least the lower section of the flow channel for the water to be blocked again at the first upstream side draining away towards the second downstream side.

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