Dec. 1, 1970 J. AUBERT 3,543,521

CLOSURE DEVICE APPLICABLE TO WATER-SLOPE SYSTEMS

Filed July 15, 1968 5 Sheets-Sheet 1

Fig.1

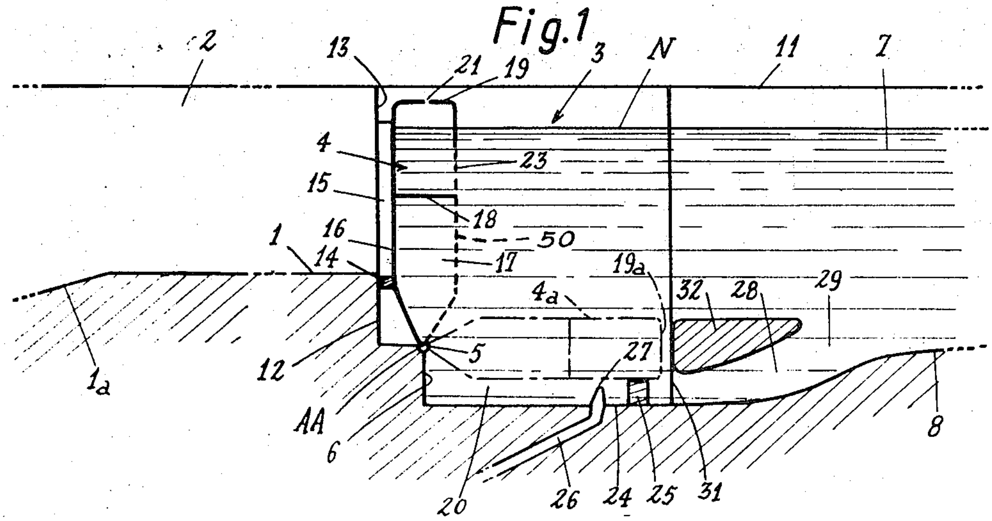

Fig.2

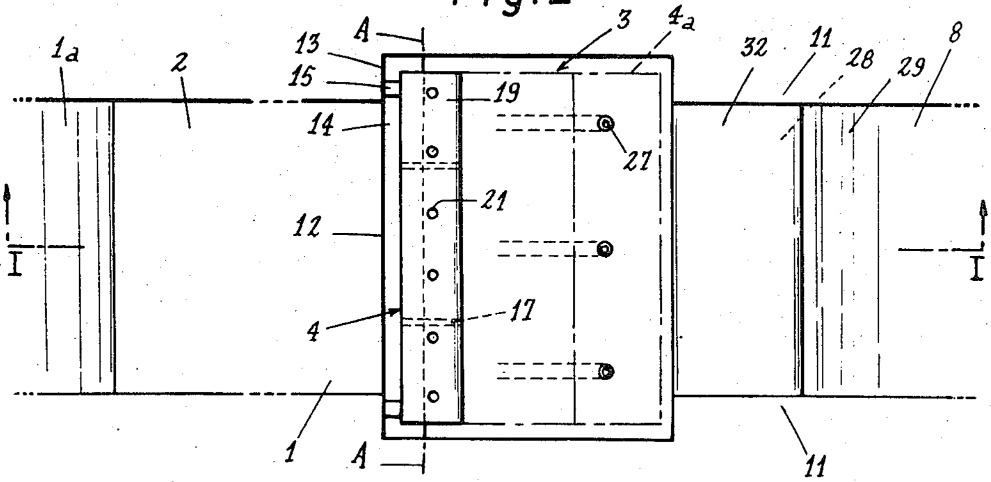

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Fig. 3

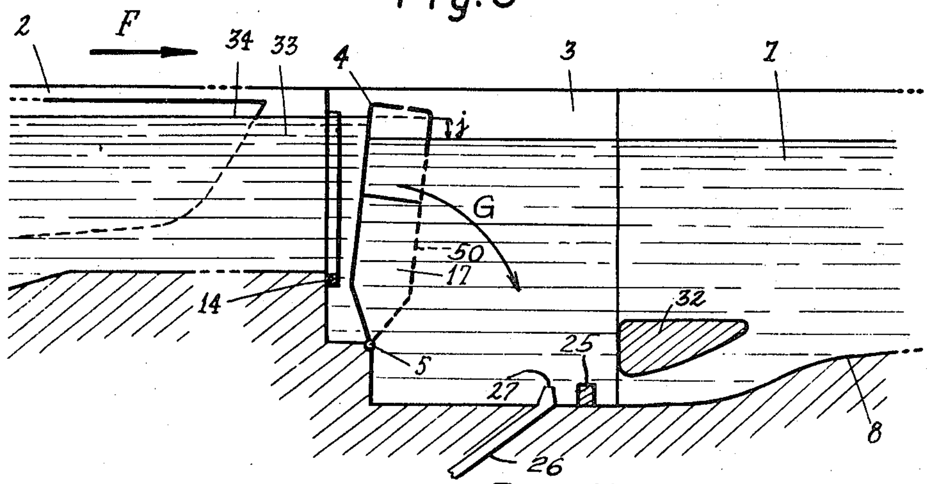


Fig. 10

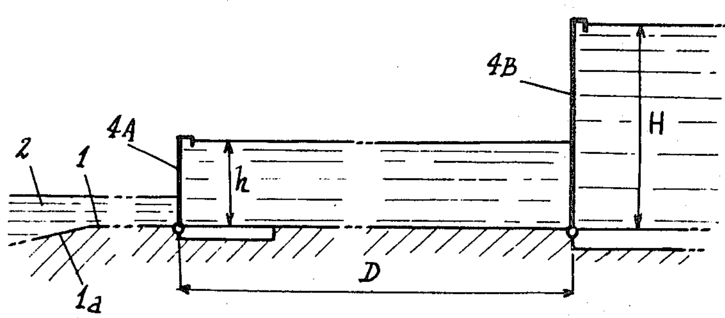
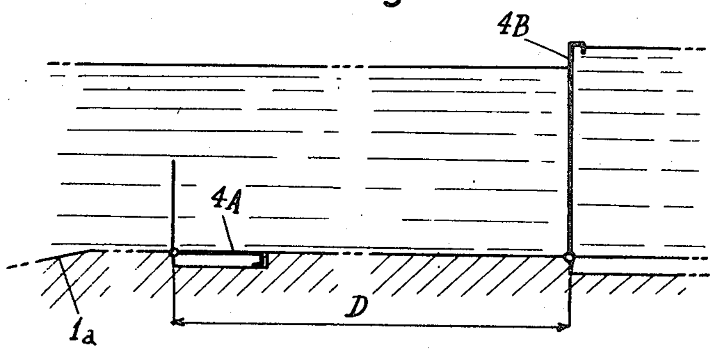


Fig. 11



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CLOSURE DEVICE APPLICABLE TO WATER-SLOPE SYSTEMS

Filed July 15, 1968 5 Sheets-Sheet 3

Fig.4

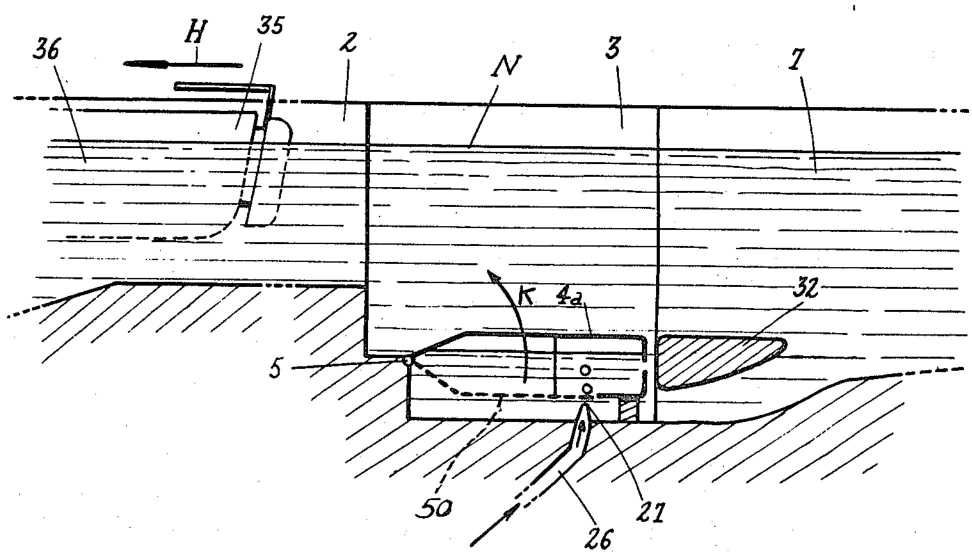
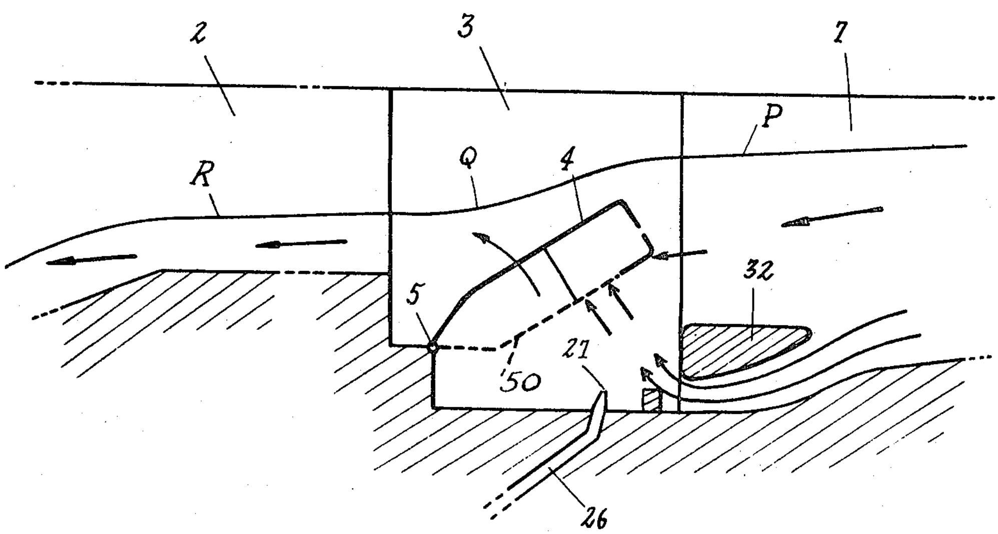


Fig.5



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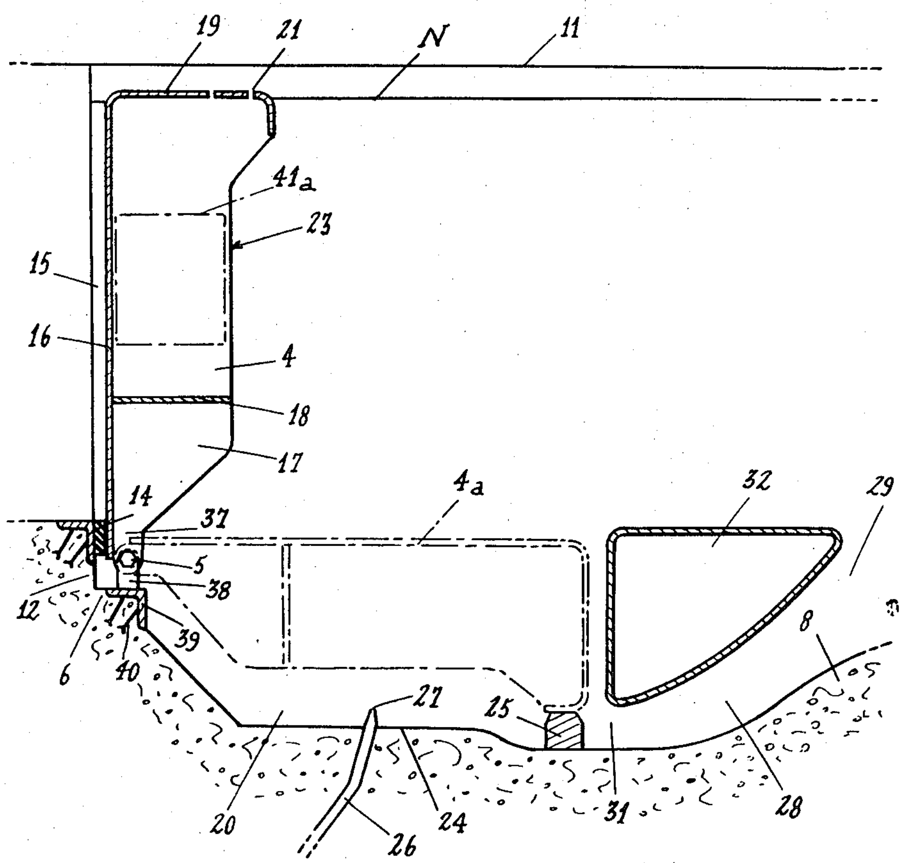
Filed July 15, 1968

Fig. 6



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CLOSURE DEVICE APPLICABLE TO WATER-SLOPE SYSTEMS

Filed July 15, 1968 5 Sheets-Sheet 5

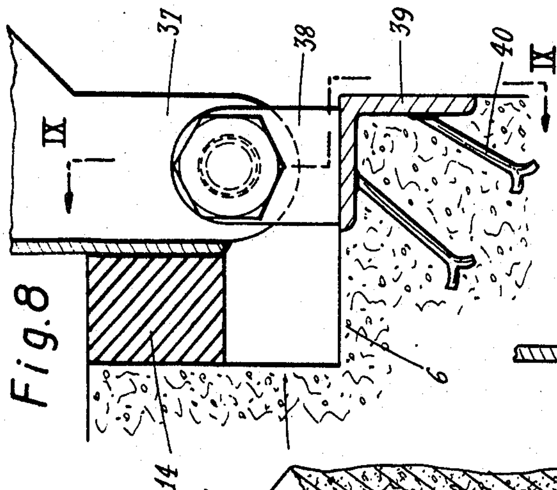

Fig. 8

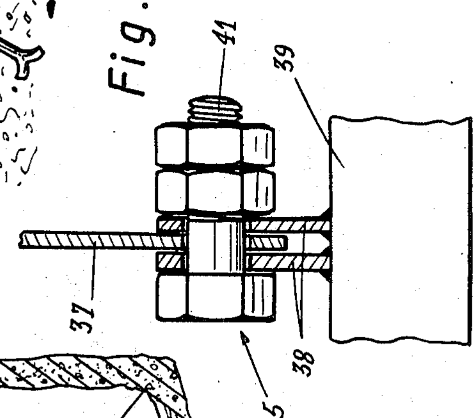

Fig. 9

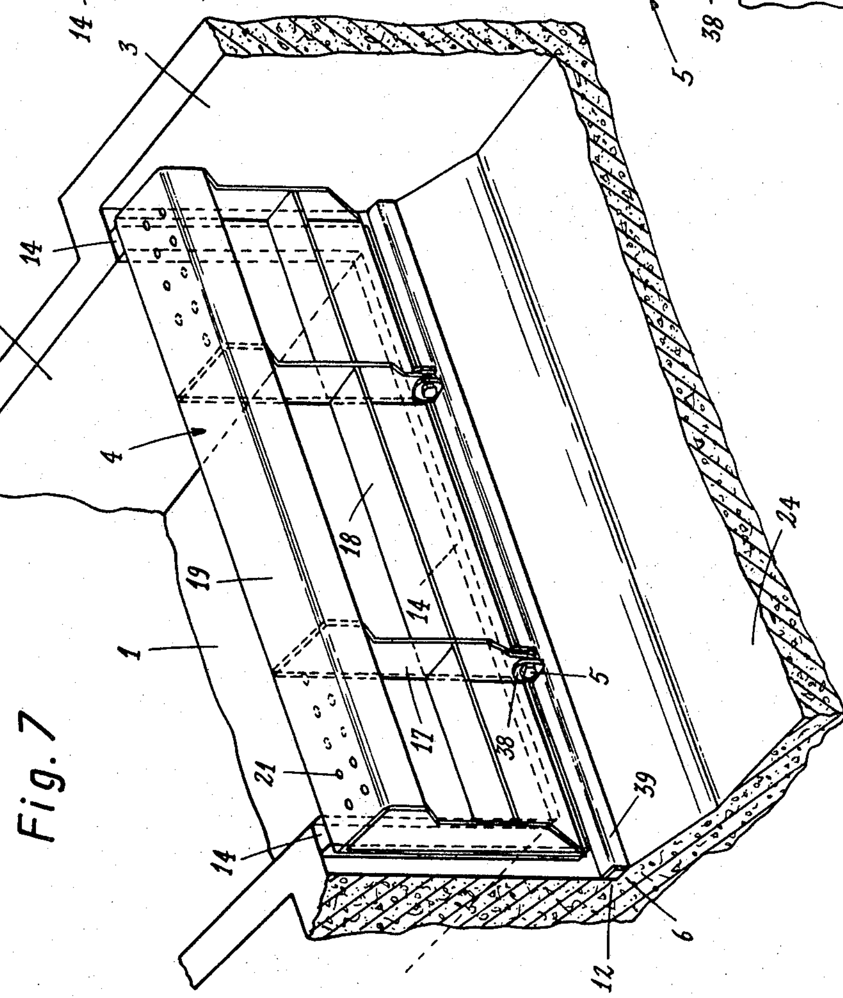

Fig. 7

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3,543,521

CLOSURE DEVICE APPLICABLE TO WATER-SLOPE SYSTEMS

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Claims priority, application France, Aug. 3, 1967, 116,691
Int. Cl. E02b 7/40
U.S. Cl. 61—25 2 Claims

ABSTRACT OF THE DISCLOSURE

A closure device which is intended to be fitted in the upstream portion of a water-slope channel and which comprises a guard gate which is pivoted on the channel sill about a horizontal axis, the connections which are provided being intended to permit the movement of said gate between a substantially vertical position of closure and a substantially horizontal position of withdrawal. Hydrostatic actuating means are provided for the purpose of carrying out a passive movement of withdrawal of the gate which is assumed to be in the raised position in the case of a predetermined pressure difference between its two faces. Additional means are provided for lifting the gate.

The present invention relates to a closure device which is applicable to water-slope systems for the purpose of effecting the controlled closure of the upstream portion of the inclined-plane channel which constitutes the water slope.

Water slopes for river navigation are already known and have been described in the literature, for example in French Pat. No. 1,341,681 as filed on Sept. 21, 1962. These systems comprise a sloping channel which connects an upstream water surface (or so-called "head-bay") to a downstream water surface (or so-called "tail-bay"). Provision is made in the channel for a movable barrier which retains a predetermined mass of water on which floats at least one boat such as a barge. The retention barrier can be moved from the downstream water surface to the upstream water surface by means of a pushing machine which is adapted to move along the channel, thus moving the boat which is carried by the water wedge formed between the channel and the movable retention barrier. The boat can thus be readily brought to the summit of the water slope or conversely.

In systems of this type, provision must be made for a device which closes off the upstream portion of the channel so as to prevent the flow of water from the head-bay when the retention barrier returns towards the tail-bay.

The closure device of this type with which the present invention is concerned offers particularly favorable operating characteristics.

In accordance with the invention, the closure device which is intended to be fitted in the upstream portion of a water-slope channel is characterized in that it comprises a guard gate which is pivoted on the channel sill about a horizontal axis, the connections which are provided being intended to permit the movement of said gate between a substantially vertical position of closure and a substantially horizontal position of withdrawal, that hydrostatic actauting means are provided for the purpose of carrying out a passive movement of withdrawal of the gate which is assumed to be in the raised position in the case of a predetermined pressure difference between its two faces and that additional means are provided for lifting the gate.

Withdrawal of the guard gate is thus necessarily carried out each time the retention barrier is moved upwards.

2

Preferably, but not necessarily, the gate-lifting means are of two types: firstly those which are controlled at will by an operator who ensures active elevation of the gate, especially by modification of the buoyancy of the gate, and secondly those which ensure passive elevation of the gate by hydrodynamic action in the event of rapid flow of the water in the channel in the downstream direction.

Under normal conditions, the passive elebation means come into operation only if the active elevation means have failed to operate or in the event of an error of operation.

Any danger of untimely emptying of the head-bay in the direction ofthe tail-bay is thus prevented.

According to an advantageous embodiment of the invention, the guard gate is constituted by a caisson, the downstream wall of which is smooth and continuous and the upstream wall of which is provided with openings. In addition, that part of the chamber floor which is covered by the gate in the position of withdrawal thereof is fitted with pipes for the injection of compressed air. It is apparent that air which is injected through said pipes penetrates into the caisson which is formed by the gate and thus serves to lift this latter.

According to another advantageous embodiment of the invention, the means for passive elevation of the gate in the event of rapid downstream flow of the water in the channel comprise a duct which extends from the head-bay sill which is located upstream of the position of withdrawal of the gate, the downstream end of said duct being adapted to open substantially opposite to the volume located between the gate which is assumed to be in the withdrawn position and the chamber floor. The pressure of the water within the duct in the event of rapid flow causes the elevation of the gate as a result of hydrodynamic action.

Further properties of the invention will become apparent from the description which now follows, reference being had to the accompanying drawings which are given by way of non-limitative example, and in which:

FIG. 1 is a sectional elevation view taken along line I—I of FIG. 2 showing a closure device in accordance with the invention, the guard gate being in the raised or top position;

FIG. 2 is a corresponding plan view;

FIGS. 3 to 5 are views which are similar to FIG. 1 and show the closure device in different cases of operation;

FIG. 6 is an enlarged sectional elevation view showing an industrial form of construction of the gate and of its ancillary components;

FIG. 7 is a fragmentary perspective diagram of the closure device, the gate being shown in the raised or top position;

FIG. 8 is a detail view showing the articulation of the gate;

FIG. 9 is a sectional view along line IX—IX of FIG. 8;

FIG. 10 is a simplified diagram which is similar to FIG. 1 and relates to a closure device which comprises two gates having different heights;

FIG. 11 is a similar diagram corresponding to another case of operation.

Referring now to FIGS. 1 and 2 of the accompanying drawings, there is shown at **1** the sill of the channel **2** which corresponds to the upstream portion of a water slope, the sloping portion of which begins at **1***a*;

The channel **2** opens into a chamber **3**, the guard gate **4** being mounted within said chamber and pivoted about a horizontal axis A—A by means of pins **5** which are fixed on a step **6** of the chamber **3**. Said chamber communicates on the opposite side with the head-bay **7**, the sill of which is shown at **8**. The complete assembly consisting of channel **2**, chamber **3** and head-bay **7** is bordered by a quay, the face of which is indicated at **11**.

Some of the elements of the structure referred-to above will now be described in detail within the scope of a particular embodiment.

The chamber **3** constitutes an enlarged extension of the channel **2** inasmuch as it has a greater width and a greater depth than this latter. The walls of the chamber **3** which are adjacent to the channel **2** thus constitute a transverse rebate **12** and two lateral rebates **13** which serve as abutments for the gate **4** when this latter is in the raised position. In order to ensure leak-tight closure, the rebates **12** and **13** are lined with flexible and compressible seals **14** and **15** which are formed, for example, by shaped strips of rubber or the like.

The gate **4** has a caisson structure with variable buoyancy. The downstream wall **16** of the gate is constituted by a smooth plate which is formed, for example, by an assembly of plates stiffened by means of vertical ribs **17** and horizontal ribs **18**.

The summit of the gate **4** constitutes a cover **19** which serves to retain air and the upstream wall of which extends beneath the level N of normal pool elevation of the head-bay **7**. The cover **19** is pierced by a succession of small holes **21** for the slow discharge of the air. The upstream wall **23** of the gate **4** is pierced by large openings for the admission of air as will be explained hereinafter.

The chamber **3** is hollowed-out so as to form a cradle **20** in which the gate **4** is intended to fit when in the withdrawn position *4a*, the floor **24** of the chamber **3** being thus located at a depth which is greater than the sill **1** of the channel **2**.

There are formed in the chamber floor **24** and upstream of the step **6** on the one hand non-continuous abutments **25** for receiving the gate **4** when this latter is in the withdrawn position *4a* and, on the other hand, air-blowing tubes **26**, the discharge nozzles **27** of which are located, for example, opposite to that portion of the gate which is located between the rib **18** and the cover **19**. The tubes **26** form part of means provided by the invention for ensuring active elevation of the gate **4**.

The closure device further comprises means which permit of passive elevation of the gate **4** in the event of rapid flow of water from the head-bay **7** towards the channel **2**. The means considered comprise a duct **28** which extends from the head-bay **7** towards the summit *19a* of the gate **4** which is assumed to be in the withdrawn position *4a*. The admission opening **29** of the duct **28** is formed by progressively lowering the sill **8** of the head-bay **7** and the discharge opening **31** of said duct terminates beneath the summit *19a*. The duct **28** is delimited by a cross-member **32** of masonry having a triangular wing-shaped cross-section with rounded edges. The cross-member **32** extends from one quay **11** to the other at a depth which is greater than that of the floor **1** of the channel **2** but which is less than that of the sill **8** of the head-bay **7**. The profiles of the sill **8** and of that portion which is located opposite to the cross-member **32** are such that the cross-section of the duct **28** decreases progressively from the upstream end to the downstream end.

The practical operation of the closure device as thus constituted is as follows:

The gate **4** being in the raised position thereof as shown in FIG. 1 and the channel **2** being empty, the water at the level N of the head-bay **7** fills the chamber **3** and applies the wall **16** of the gate **4** against the abutments **14** and **15** of the rebates **12** and **13**. Said abutments are compressed as a result of the hydrostatic thrust thus exerted on the gate **4**, with the result that leak-tight closure of the head-bay **7** is thus obtained with correlative retention of the water surface at the level N.

It will now be assumed that a pushing machine (which is not shown in the drawings) causes a volume of water **33** to progress upstream along the channel **2** in the direction of the arrow F as shown in FIG. 3, either one or a number of boats **34** being carried in said volume **33**. At the outset, the volume **33** is stopped by the wall **16** of the gate **4** so that the water level consequently rises within the channel **2**. When the pressure applied to the wall **16** by the volume **33** exceeds the opposing pressure of the water contained in the chamber **3**, the gate **4** begins to perform a downward pivotal movement in the direction of the arrow G about the axis A—A. The movement thus initiated then continues of its own accord by reason of the weight of the gate. The gate **4** thus comes to rest on the non-continuous abutments **25** of the chamber floor **24** in position *4a*. The gate **4** is thus withdrawn before the boat **34** passes into the chamber **3**. The motion of the pushing machine does not therefore need to be stopped and need only be slowed down if necessary whilst the screw of the boat **34** may be started up as soon as the gate **4** is in the withdrawn position.

It will now be assumed that a boat **35** is to be transferred downstream in the direction of the arrow H as shown in FIG. 4. If the level N is attained on each side of the gate **4**, the pushing machine having remained in the top position, the boat **35** passes with its screw and without any difficulty from the head-bay **7** into the channel **2**. In the contrary case in which the gate **4** is located in the top or raised position and the channel **2** does not contain any water at the downstream end, it is only necessary to await the upward motion of the water with the pushing machine, whereupon the gate **4** moves automatically into the withdrawn position at a given moment as has been explained.

When the pushing machine begins to move downwards with the volume of water **36** which carires the boat **35**, it is necessary to lift the gate **4** in order to prevent emptying of the head-bay **7** into the channel **2**. This lifting action is obtained by blowing compressed air through the nozzles **27** of the tubes **26** into the caisson which is formed by the gate **4**. In fact, the air penetrates into said gate through the openings of the wall **23**. The hydrostatic pressure exerted on the gate **4** whose buoyancy is thus modified causes this latter to lift in the direction of the arrow K. A part of the air escapes from the gate **4** during this movement, esepcially through the holes **21**. But the continuation and acceleration of the downward motion of the pushing machine has the effect of creating an overpressure of water on the upstream face of the wall **16**. Said overpressure contributes to the continuation of the movement of elevation of the gate **4**. When the gate has returned to the fully raised position, the air which remains within the caisson completely escapes through the holes **21**. A further lowering motion of the gate therefore becomes possible at the time of any subsequent upward return of the pushing machine.

If the machine which actuates the movable retention barrier were to continue downwards without being accompanied in its movement by the elevation of the gate **4** as a result of failure of supply of compressed air through the pipes **26**, the machine operator would be immediately warned of the fact by a progressively increasing overflow of water over the water-wedge retention barrier. The operator would then stop the downward motion of the machine and return it in the upward direction if necessary.

In the unlikely event of indisposition or less of control on the part of the operator which could result in continuation of the downward motion of the drive machine in spite of such advance warning, the process of emptying of the head-bay **7** into the channel **2** could not continue by reason of the spontaneous elevation of the gate **4** which is assumed to be in the withdrawn position *4a* at the beginning of the downward motion of the machine.

In fact, in such a case, the level of water in the head-bay **7** and the chamber **3** no longer remains at N but is established along the line of slope P, Q, R of FIG. 5.

The flow motion above the gate 4 becomes progressively faster whilst the depth of the layer of water which covers the gate progerssively decreases. At the same time, the water that tends to penetrate through the opening **29** of the duct **18** produces an overpressure within said duct as a result of a process which is similar to that which is observed in a Pitot tube.

Beneath the cross-member **32** and beneath the gate **4**, the flow rate is of very small value since it corresponds to very small leakages. The water consequently flows very slowly, with the result that the pressure which prevails at the level of the opening **29** is also maintained beneath the gate **4**.

Inasmuch as the pressure decreases on the top face of the gate in the withdrawn position **4***a* while it increases on the underface, a movement of elevation in the direction of the arrow K in FIG. 4 will accordingly begin, provided that the preponderant tendency towards lowering which is due to the weight of the gate is not excessive. Once it has started (as shown in FIG. 5), this movement tends to increase thereafter when pressure is exerted on the gate by the flow of water. There is then a tendency towards impact of the gate as it comes up against the rebates **12** and **13**. Said impact is damped by virtue of the resilience of the abtuments **14** and **15** and if necessary by means of shock absorbing devices which are not shown in the drawings.

Experience has shown that the operation of the safety means thus provided is particularly reliable.

In a particular form of construction which is shown in FIGS. 6 to 9, the downstream wall **16** of the gate **4** is straight and the ribs **17** have extensions in the form of lugs **37** which are adapted to engage in yokes **38**, said yokes being fixed on an angle-iron member **39** which is located along the edge of the step **6** and which is in turn retained by means of anchor-bolts **40**. The articulations are provided by means of not and bolt systems **41**. In this alternative form, the summit **19** of the gate **4** is straight and the holes **21** are grouped in the vicinity of the corner of said gate which is remote from the wall **16**. The space which is just sufficient for the pivotal motion of the gate **4** is provided between the cover **19** and the cross-member **32**.

It is thus apparent that the construction of the guard gate **4** is simple and inexpensive.

In accordance with an alternative form which is suitable when it is desired to secure even greater operational safety in order to guard against the danger of emptying of the head-bay **7** into the channel **2**, provision is accordingly made for two gates which are similar to the gate **4** and serially disposed at the upstream end of the water slope. The lifting ability of said gates is intended to be different. The upstream gate is normally in service whilst the downstream gate is intended to lift in the event of production of an exceptionally violent flow.

The arrangement of two guard gates has a further advantage as shown in the embodiment of FIGS. 10 and 11. In this alternative form, the closure device of the head-bay **7** comprises two stepped guard gates **4A**, **4B** of the type mentioned above but having different heights, the lower gate **4A** being located next to the channel **2**. For example, the gate **4A** can have a height h of 1.50 m. and the gate **4B** can have a height H of 4.50 m., said two gates being spaced at a distance D of, for example, 105 m.

Under these conditions, when the pushing machine approaches the upper end of the channel **2**, the deformation of the water wedge **33** which is pushed by the movable retention barrier and the tip of which is applied successively against the gate **4A**, then against the gate **4B**, produces only a small variation in the depth of water in front of the retention barrier. This result is ensured by the compensation volume formed between the two gates **4A**, **4B**, as shown in FIG. 11. In consequence, it is no longer necessary to provide a widening of the pool

at the level of the head-bay, thereby limiting civil engineering construction costs.

In a further alternative form, the buoyancy of the gate **4** can be regulated by means of auxiliary floats **41***a* (shown in FIG. 6), said floats being fixed in the caisson which is formed by the gate. The floats **41***a* can be adjusted for height. They can also be filled with water to a greater or lesser extent on the principle of ballast. This makes it possible to adjust the value of the difference j (FIG. 3) between the downstream and upstream levels of the water surfaces which initiates the withdrawal of the gate in the direction of the arrow G as and when the water wedge rises again.

It is apparent that the invention is not limited to the embodiments described and that alternative forms can be contemplated wihin the scope of the appended claims.

It accordingly follows that the seals which are adapted to cooperate with the gate **4** could be carried by the gate wall **16**.

Similarly, more than two gates can be disposed in series in an embodiment of the type shown in FIGS. 10 and 11.

What I claim is:

1. In a water-slope system that includes an inclined water-slope channel that has an upstream portion at its upper end, a closure device fitted in a chamber which opens into said upstream portion of the water-slope channel, said chamber having a sill, said closure device comprising a guard gate of caisson-like structure pivoted on said chamber sill about a horizontal axis above the chamber floor for movement within said chamber between an up-right position of closure preventing the flow of water from said chamber to said upstream portion of the channel and a substantially horizontal position thereby allowing a free passage to water between said upstream portion of the channel and said chamber; the improvement in which said guard gate is freely rotatable between said upright and horizontal positions so that it undergoes a downward pivotal movement under the action of a predetermined pressure difference between its two faces subsequent to elevation of the water level in said upstream portion of the channel above the water level in the downstream portion of the channel, the floor of the chamber being hollowed out to form a cradle in which are disposed abutments for receiving the gate in the horizontal position thereof and for defining between said gate and the floor a space, means in the chamber floor for blowing compressed air through said space into the caisson structure when the gate lies in the horizontal position for changing the buoyancy of said gate to cause a pivotal lifting movement thereof towards its upright closure position, and a duct upstream of the horizontal position of the gate and opening into said space for causing a passive litfing movement of the gate toward its upright position by the hydrodynamic action of water flowing through said duct.

2. A system as claimed in claim **1**, the duct being formed between the chamber floor and a shaped cross member which is disposed above said floor.

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