



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
17.08.2005 Bulletin 2005/33

(51) Int Cl.7: **E03F 3/02**

(21) Application number: **05250859.5**

(22) Date of filing: **15.02.2005**

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
 HU IE IS IT LI LT LU MC NL PL PT RO SE SI SK TR**
 Designated Extension States:
AL BA HR LV MK YU

(72) Inventor: **Mc Intyre, Walter Summerhill
 Ayrshire, KA6 6QL (GB)**

(74) Representative: **Moran, Paula
 OLSWANG
 90 High Holborn
 London WC1V 6XX (GB)**

(30) Priority: **17.02.2004 GB 0403500**

(71) Applicant: **ACO Technologies plc
 Shefford, Beds SG17 5TE (GB)**

(54) **Drainage system flow regulation**

(57) A surface drainage system 1 comprises a drainage channel 2 and a plurality of flow regulators 3 arranged therein. The plurality of flow regulators 3 improves the storage capacity of the system 1.

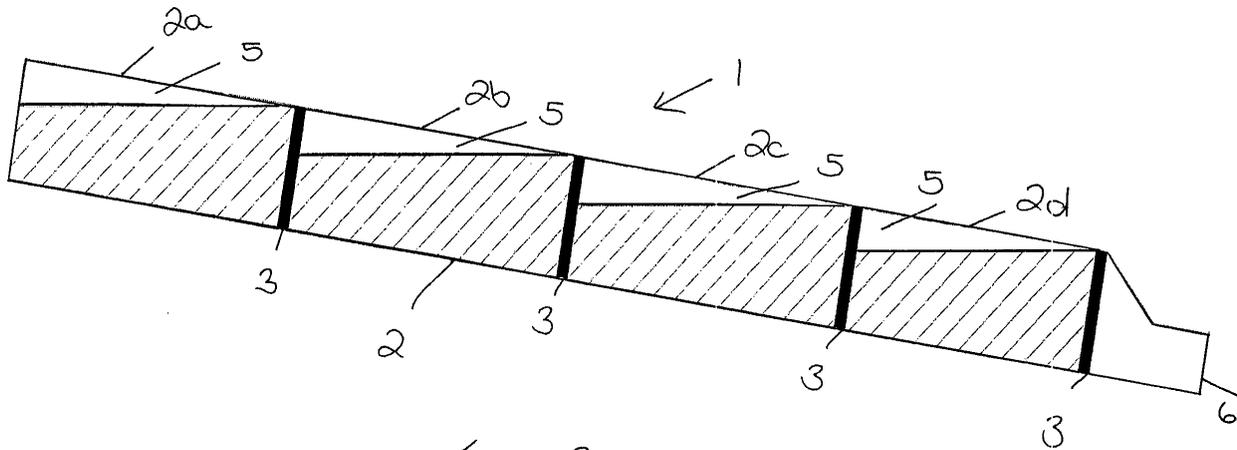


FIGURE 2

Description

Field of the Invention

[0001] The present invention relates to system flow regulation and in particular, to a surface drainage system incorporating a flow regulation system, and to a flow regulator for use in a surface drainage system.

Background

[0002] Drainage channels which are designed to contain large quantities of water, such as storm water, are well-known. Such channels are used to collect large volumes of water from surfaces that need to be drained quickly, such as airport pavements, and transport them to other suitable collection points downstream, such as storm sewers, watercourses or ponds. However, restrictions are often placed on the outflow from such channels, usually by local authorities or environmental agencies, in order to prevent flooding of the downstream sewers, watercourses and ponds to which the water is being transported. Although outflow rates in such channels can be as high as several hundred litres per second, the outflow restrictions can result in a requirement for outflow rates of as low as 10 litres per second. As a result, it is usually necessary to install a flow regulator at the channel outlet so as to control the flow rate of water from the channel so that it meets the necessary requirements.

[0003] Several types of flow regulation system have been suggested for use in channel outlets, including orifice plates. An orifice plate is a simple plate with an aperture, usually of a fixed cross-sectional area, in the lowermost region of the plate; the aperture of the plate is generally circular in cross-section. The plate only permits water to pass through the aperture, with the result that the outflow from the channel outlet is considerably restricted. Although orifice plates are relatively inexpensive and easy to install, their apertures tend to get blocked up with silt after extended use. Furthermore, there is a tendency for the aperture in an orifice plate to be "drowned" when the water level downstream of the orifice plate rises above the aperture; this reduces the effectiveness of the drainage channel.

[0004] Another example of a flow regulation system is a penstock. A penstock is essentially an adjustable gate valve which is positioned between a channel and an outlet pipe connected to the channel. The gate valve can be adjusted manually, mechanically or by means of a motor. In a mechanically-adjustable penstock, a float is mechanically coupled to the gate valve. In use, the float rises with the water level. Each movement of the float causes the gate valve to move and thus alter the cross-sectional area of the outlet pipe, i.e. as the float rises, the cross-sectional area of the outlet pipe is reduced, with the result that the flow to the outlet pipe is reduced. A disadvantage of penstocks is that they are

costly and take up a considerable amount of space. In addition, there is a tendency for them to get blocked up with silt.

[0005] Vortex flow regulators have also been suggested for use at the outlets of drainage channels. These flow regulators direct incoming water tangentially into the body of the regulator and create a back pressure that limits the outflow from the regulator. Although they are generally effective, vortex flow regulators are costly, take up a significant amount of space and need to be customised to the channel in which they are to be used.

[0006] Where the outflow from a drainage system is regulated in the manner described above, there is a resulting requirement for storage of water within the drainage system (i.e. where the inflow of water to the system exceeds the permitted outflow). Typically, this is achieved by using very high capacity drainage channels, which can accommodate the excess water. However, even high-capacity drainage channels can store only a limited amount of water, particularly when they are arranged at an incline, for example, in a sloped site. The inclination of the channel results in a large volume of water rushing to the lowermost point of the channel, so that it covers the cross-sectional area of the channel at that point (see Figure 1). In extreme cases, the channel starts to overflow at that point.

Summary of the Invention

[0007] It is a general aim of the present invention to ameliorate at least some of the disadvantages of the prior art discussed above.

[0008] In a first aspect, the present invention provides a surface drainage system comprising a channel and a plurality of flow regulators spaced at intervals therein.

[0009] The provision of a plurality of flow regulators, spaced at intervals, in a channel can considerably increase the storage capacity of the channel, particularly when the channel is installed in a sloping site so that the channel is inclined. Under normal circumstances, the inclination of the channel results in water rushing to the lowermost end of the channel where it tends to build up and flow slowly through an outlet. The water eventually covers the cross-section of the channel and can overflow at that point, yet further upstream, where the channel is closer to the ground, no water is present at all. As a result, the water is not stored efficiently in the channel because there is a large region of the channel that does not store water at all. However, by including at least two spaced flow regulators, and effectively compartmentalising the channel, a "cascade" effect is produced and each compartment of the channel fills up so that more of the channel's overall volume is used to store water.

[0010] In a preferred embodiment of the invention, at least one of the flow regulators is an orifice plate. Orifice plates are relatively inexpensive and are simple to install. It should be noted that the term "orifice plate" is used throughout the specification to indicate a plate that

has an orifice that extends therethrough, a plate that has a notch or cavity in at least one of its edges or a plate that has been truncated so that an orifice is present between the plate and the channel, in use.

[0011] The orifice plate preferably has a first orifice in the form of a notch that extends through an edge in the region of the plate that is intended to be arranged lowermost in the channel, in use. The provision of an orifice that extends through an edge of the plate in the lowermost region of the channel allows any debris, such as silt, in the lowermost region of the channel to be carried through the orifice and transported out of the channel. The cross-sectional area of the first orifice is preferably between 45cm² and 350cm². In a preferred embodiment of the invention, a second orifice is provided above the first orifice. This allows flow through the orifice plate, and therefore in the channel, to be regulated to varying degrees. For example, when the flow through the plate is relatively slow, water will only flow through the first orifice but when the water flow increases and the water level rises to the level of the second orifice, water can additionally flow through that orifice.

[0012] The second orifice is preferably V-shaped. It has been determined by experimentation that this configuration improves the flow regulation capabilities of the plate. Preferably, the included angle of the V is between 10° and 60°. Again, this included angle has been found empirically to be particularly advantageous. The cross-sectional area of the second orifice is preferably between 200cm² and 2500cm².

[0013] In a further preferred embodiment, the cross-sectional area of the first and/or second orifice is adjustable in use. This provides a further degree of control over the flow in the channel. The cross-sectional area of the first and/or second orifices is preferably adjusted by means of a screen which is adapted to be movable across the orifice or orifices for which the cross-sectional area is to be adjusted. Preferably, the screen is adapted to be moved manually, mechanically or by motorisation. The screen is preferably pivotable about a point on the orifice plate.

[0014] In another preferred embodiment of the invention, the orifice plate is truncated in a region arranged to be uppermost in the channel, so that the orifice plate does not extend to the top of the channel. This provides a further degree of flow regulation, in that, once the water level reaches the truncation point of the plate, the water will simply spill over the truncated edge.

[0015] In a yet further preferred embodiment the orifice plate and channel are wider in a region adapted to be uppermost, in use, than a region adapted to be lowermost, in use. This profile results in a faster flow of water in the channel, which is particularly significant in the case of low flow rates because any debris in the lower region of the channel can be flushed away as a result of the increased flow velocity. If the flow of water is not sufficiently rapid, debris tends to rest in the lowermost region of the channel. It is preferable if both the channel

and orifice plate are ovoid in cross-section.

[0016] The flow regulators are preferably located in the channel using locating means. In a preferred embodiment the channel is formed in multiple sections and the locating means is in the form of at least one groove between those sections, so that the flow regulators can conveniently be sandwiched between adjacent channel sections.

[0017] In a second aspect, the present invention provides a surface drainage system comprising a channel having a flow regulator located therein, wherein the flow regulator is a plate and the plate and the channel are wider in a region adapted to be uppermost, in use, than a region adapted to be lowermost, in use.

[0018] In a third aspect, the present invention provides a surface drainage system comprising a channel having a flow regulator, the flow regulator being a plate that is located entirely within the channel.

[0019] In a fourth aspect, the present invention provides a surface drainage system comprising a channel having a flow regulator, the flow regulator being an orifice plate that has a first and second orifice, the second orifice being above the first orifice, in use.

[0020] In a fifth aspect, the present invention provides a flow regulator for regulating flow in a surface drainage channel comprising an orifice plate, the orifice plate being wider in a region adapted to be arranged uppermost, in use, than a region adapted to be lowermost, in use.

[0021] In a sixth aspect, the present invention provides a flow regulator for regulating flow in a surface drainage channel comprising an orifice plate, the orifice plate having a first and second orifice, the second orifice being above the first orifice, in use.

Brief Description of the Drawings

[0022] Embodiments of the invention will be described, by way of example, with reference to the following drawings, in which:

Figure 1 shows a schematic side view of a prior art surface drainage system arranged at an incline;

Figure 2 shows a schematic side view of a surface drainage system in accordance with a first embodiment of the present invention;

Figure 3 shows a schematic side view of a surface drainage system in accordance with a second embodiment of the present invention;

Figure 4a shows a front view of a first embodiment of a flow regulator for regulating flow in the surface drainage systems of Figures 2 and 3;

Figure 4b shows a perspective view of the flow regulator of Figure 4a;

Figure 5a shows a front view of a second embodiment of a flow regulator for regulating flow in the surface drainage systems of Figures 2 and 3;

Figure 5b shows a perspective view of the flow regulator of Figure 5b;

Figure 6a shows a front view of a third embodiment of a flow regulator for regulating flow in the surface drainage systems of Figures 2 and 3, and

Figure 6b shows a perspective view of the flow regulator of Figure 6a.

Description of an Embodiment

[0023] The embodiment of the invention described below is a surface drainage system for removing large amounts of water, for example rainwater after heavy rainfall, from a surface and transporting that water to a downstream storage area. The water enters the surface drainage system by flowing into an inlet, in this case a slot running along the length of the uppermost region of a drainage channel in the system. The drainage channel then delivers the water to the downstream storage area but, usually, it is only permissible to deliver the water at a specified rate in order to prevent flooding of the downstream storage area. As a result, it is necessary to regulate the rate of flow of water from the surface drainage system to the downstream storage area and to ensure that the surface drainage system is capable of storing any water that is prevented from flowing out at a given time.

[0024] Any reference in the following description to water is intended to cover any fluid that is being drained from a surface.

[0025] In Figure 2, a surface drainage system 1 has a channel 2 with a plurality of flow regulators 3 arranged therein. The flow regulators 3 are intended to control the flow of water in the channel 2. The channel 2 has a slot (not shown) in its uppermost region that allows water from the surface to be drained to enter the channel 2.

[0026] The channel 2 is divided into a number of sections 2a, 2b, 2c, 2d and the flow regulators 3 are held in grooves (not shown) between each section of the channel. A flange 4 extending around the periphery of each flow regulator 3 (see Figures 4b, 5b and 6b) is attachable to the end face of any one of the channel sections 2a, 2b, 2c, 2d by means of screws, or other mechanical fasteners, so that the flow regulators 3 are fixed securely between the channel sections.

[0027] It can be seen from Figure 2 that the inclusion of a plurality of flow regulators 3 effectively creates a number of compartments 5 within the channel 1, and that each of these compartments 5 can be substantially filled with water, even when the channel 1 is arranged at an incline. In contrast, a prior art channel arranged at an incline is shown in Figure 1; it can be seen that almost

50% of the storage capacity of that channel is unused as a result of inefficient water distribution caused by the inclination. This will be explained in greater detail below.

[0028] Both the channel 2 and flow regulators 3 are ovoid in cross-section (with the smaller radius end lowermost) so that the flow of water in the channel 2 and across the flow regulators 3 is relatively fast, even at low flow volumes. A relatively rapid water flow is desirable so that debris, such as silt, is prevented from building up in the lowermost region of the channel 2.

[0029] An alternative embodiment of surface drainage system 1 is shown in Figure 3. In the channel 2 only one flow regulator 3 is included. The flow regulator 3 is contained entirely within the channel 2 upstream of (but preferably in the region of) an outlet 6 that leads to a downstream storage area, and is held in a groove (not shown) between the channel 2 and the outlet 6 in a similar manner to that described above with reference to Figure 2.

[0030] In the embodiment of Figures 2 and 3, each flow regulator 3 is an orifice plate. One example of an orifice plate 3 that can be used is shown in Figures 4a and 4b and has a single orifice 7 in the region of the plate 3 that is adapted to be arranged lowermost in the channel 2. The orifice 7 is configured as a notch which extends through an edge of the plate and has a cross-sectional area of between 45cm² and 350 cm².

[0031] The extension of the orifice 7 through the edge of the plate 3 allows any debris that lies in the lowermost region of the channel 2 to be flushed through the plate efficiently. In addition, the orifice 7 is widest at its lowest point so that the surface area over which debris can pass is relatively high. The orifice plate 3 is effectively self-cleansing as a result of these features. The orifice 7 tapers inwards from its widest point, which ensures that the flow of water through the orifice 8 is suitably restricted, as required. The degree of taper is approximately 30° to the horizontal.

[0032] An alternative embodiment of an orifice plate 3 is shown in Figures 5a and 5b. The orifice plate 3 of Figures 5a and 5b has an additional orifice 8 to the orifice 7, in use, and has a cross-sectional area of between approximately 200cm² and 2500cm². In addition, the orifice plate 3 is truncated in the uppermost region of the channel 2 so that the plate 3 does not extend to the top of the channel 2. The additional orifice 8 and the truncation of the plate 3 provide various levels of flow regulation.

[0033] The orifice 8 is V-shaped, and the included angle of the "V" can be varied according to the desired flow rate through the orifice. Typically, an included angle of between 10° and 60° would be suitable for most applications.

[0034] Figures 6a and 6b show a flow regulator 3 in which the flow regulation can be controlled further by providing a solid screen 9 in the vicinity of the orifice 7 and/or the additional orifice 8 which is movable across

the orifice(s) 7,8 in order to adjust the cross-sectional area and thus restrict the flow of water through the orifice (s) 7,8 further. The screen 9 is in two parts and is pivotable about a point 10 on the plate 3 between a number of different positions, each position providing a different level of coverage of the orifice(s) 7,8 over which it is located, and is movable manually, mechanically or by motorisation. The screen 9 could also be used in connection with the embodiment of orifice plate 3 shown in Figures 4a and 4b.

[0035] In order to extend the overall life of the orifice plates 3, they are made of an austenitic stainless steel, which is corrosion-resistant. The plates 3 are manufactured by simply cutting through a sheet of austenitic stainless steel using a CNC laser. The thickness of the orifice plates 3, viewed in the direction of flow of the water, is approximately 3mm.

[0036] In use, in the embodiment of the surface drainage system 1 shown in Figure 2, water drains from a surface into the channel through a slot (not shown) in the top of the channel 2. The slot extends along substantially the full length of the channel 2. In high flow conditions (e.g. during a storm), although the channel 2 is arranged at an incline and the water tends to flow towards the lowermost point of the channel 2, each orifice plate 3 prevents it from doing so by restricting the flow therethrough, with the result that most of the water in each compartment 5 remains within that compartment 5, thus resulting in a relatively even distribution of water along the length of the channel 2.

[0037] In contrast, in prior art channels arranged on slopes, it was found that, although water entered the channel along its length, it subsequently flowed to the lowermost end of the channel where it built up, as shown in Figure 1, meaning that most of the storage capacity of the channel remained unused. Furthermore, there was a tendency for the channel to overflow in its lowermost region, which substantially hindered drainage of the surface to be drained. For example, experiments showed that a slope of only 1% could limit the storage capacity of a channel to only 4% of its flat-storage capacity, yet the inclusion of only two orifice plates 3 resulted in an increase to 40% of the flat-storage capacity.

[0038] Under normal flat installation, the channel 2 operates in a similar way but the need for a plurality of orifice plates 3 can be avoided if required, as shown in Figure 3. Again, water spills into the channel 2 through a gap at the top of the channel 2 and starts to flow towards the outlet 6. If an orifice plate 3 of the type shown in Figures 4a and 4b is used, water will only be allowed to flow through the orifice 7 and the remaining water will be held back by the orifice plate 3. However, in cases where the flow is expected to reach a relatively high level, the orifice plate 3 shown in Figures 5a and 5b is likely to be used. In the orifice plate 3 of Figures 5a and 5b, the water flows through the orifice 7 at relatively low flow rates, as is the case in the orifice plate 3 of Figures 4a and 4b and the remaining water is held back by the or-

ifice plate 3. However, once the water level reaches the additional orifice 8, water will start to spill through that orifice 8. As the water level rises to a higher point on the orifice 8, i.e. at a wider point in the "V", more water is allowed to flow through the additional orifice 10. Once the water level rises above the widest point of the "V", it is allowed to flow over the truncated portion of the flow regulator 3. Since there is a gap between the flow regulator 3 and the outlet 6, some of this "overflow" can temporarily be stored there.

[0039] It will be appreciated by a person skilled in the art that a number of modifications can be made to the embodiments described above. For example, it is possible that the flange 4 on the flow regulator 3 would be attached to the channel sections 2a, 2b, 2c, 2d by non-mechanical means, such as adhesion, welding or any other suitable means. The flow regulator 3 may not have a flange 4 and may be simply held in the groove between adjacent channel sections 2a, 2b, 2c, 2d. In the case where a channel 2 is attached to a manhole connector, there is often a groove therebetween, which could also be used to locate a flow regulator 3.

[0040] In some circumstances, ribs that protrude from the wall of the channel 2 could be used to hold the flow regulators 3 in place.

[0041] Although both the channel 2 and the orifice plates 3 are described as being ovoid in cross-section, it would be possible to select any other suitable configuration for the channel 2 and/or the orifice plate 3 but it should be borne in mind that it is preferable that the uppermost region of the channel 2 and orifice plates 3 be wider than the lowermost region, in order to maintain a relatively rapid flow in the channel 2 and across the orifice plates 3. If a relatively rapid flow rate is not required, for example, this requirement could be dispensed with.

[0042] Although the orifice 7 extends through the edge of the lowermost region of the orifice plate 3, this does not have to be the case. For example, there could be a lip at the lowermost region of the orifice plate 3 so that the orifice 7 did not extend through the edge. Similarly, the orifice 8 does not have to be V-shaped and any other suitable configuration may be selected. Any number of orifices can be included in the orifice plate 3 and their location can be varied in accordance with the use requirements, in particular the required flow characteristics.

[0043] The flow regulator 3 could be arranged anywhere across the cross-section of the channel 2; it is not necessary for the flow regulator to extend substantially from the top of the channel to the bottom of the channel. For example, a flow regulator that extends across only a middle region of the channel 2 could be used, depending on the required flow control.

[0044] It would be possible to manufacture the orifice plates 3 from any other suitable material in place of austenitic stainless steel, provided that the selected material is sufficiently rigid to withstand the forces acting upon the flow regulators as a result of the flow of water.

Corrosion-resistant materials are preferable. Similarly, orifice plates 3 of different thicknesses can be used, if required and any suitable method of manufacture can be employed. Again, the thickness of the flow regulators 3 must be sufficient for them to withstand the forces acting upon it. The thickness required will generally depend on the material used.

[0045] The screen 9 can be attached to an inner surface of the channel 2, instead of being pivotable about a point 10 on the flow regulator 3. The screen 9 could even be slid between a number of different positions or moved in relation to the orifices 7, 8 in any other suitable way. Rather than being solid, the screen 9 could be in the form of a mesh in order to provide a further degree of flow rate control.

[0046] The flow regulators 3 described above are orifice plates but it would be possible to replace the orifice plates with any one of a number of suitable flow regulators, depending on the flow control requirements.

[0047] In cases where only one flow regulator 3 is used, it does not have to be located entirely within the channel 2.

Claims

1. A surface drainage system comprising a channel and a plurality of flow regulators arranged at spaced intervals therein.
2. A surface drainage system as claimed in Claim 1, wherein at least one of the plurality of flow regulators is an orifice plate.
3. A surface drainage system as claimed in Claim 2, wherein the orifice plate has a first orifice arranged in a region of the plate that is intended to be arranged lowermost in the channel, in use.
4. A surface drainage system as claimed in Claim 3, wherein the first orifice is a notch that extends through an edge of the plate that is intended to be arranged lowermost in the channel, in use.
5. A surface drainage system as claimed in Claim 3 or 4, wherein the first orifice is configured so that it is widest in the region that is intended to be arranged lowermost in the channel, in use.
6. A surface drainage system as claimed in Claim 5, wherein the first orifice tapers inwards from the region that is intended to be arranged lowermost in the channel, in use.
7. A surface drainage system as claimed in Claim 3, 4, 5 or 6, wherein the cross-sectional area of the first orifice is between 45cm² and 350cm².
8. A surface drainage system as claimed in any one of Claims 3 to 7, wherein the orifice plate has a second orifice, the second orifice being above the first orifice, in use.
9. A surface drainage system as claimed in Claim 8, wherein the second orifice is configured so that it is widest in the region that is intended to be arranged uppermost in the channel, in use.
10. A surface drainage system as claimed in Claim 9, wherein the second orifice is substantially V-shaped.
11. A surface drainage system as claimed in Claim 10, wherein the included angle of the V is between 10° and 60°.
12. A surface drainage system as claimed in any one of Claims 8 to 11, wherein the cross-sectional area of the second orifice is between 200cm² and 2500cm².
13. A surface drainage system as claimed in any one of Claims 3 to 12, wherein the cross-sectional area of the first orifice is adjustable.
14. A surface drainage system as claimed in any one of Claims 8 to 13, wherein the cross-sectional area of the second orifice is adjustable.
15. A surface drainage system as claimed in Claim 13 or 14, wherein the cross-sectional area is adjustable by means of a screen that is adapted to be movable across the area to be adjusted.
16. A surface drainage system as claimed in Claim 15, wherein the screen is adapted to be moved manually, mechanically or by motorisation.
17. A surface drainage system as claimed in Claim 15 or 16, wherein the screen is pivotable about a point on the orifice plate.
18. A surface drainage system as claimed in any one of Claims 2 to 17, wherein the orifice plate is truncated in a region arranged to be uppermost in the channel, in use, so that the orifice plate does not extend to the top of the channel.
19. A surface drainage system as claimed in any one of Claims 2 to 18, wherein the orifice plate and the channel are wider in a region adapted to be uppermost, in use, than a region adapted to be lowermost, in use.
20. A surface drainage system as claimed in Claim 19, wherein the orifice plate and the channel are sub-

stantially ovoid in shape.

- 21.** A surface drainage system as claimed in any one of the preceding claims, wherein the flow regulators are held in the channel by means of locating means. 5
- 22.** A surface drainage system as claimed in Claim 21, wherein the locating means is in the form of at least one groove. 10
- 23.** A surface drainage system as claimed in Claim 21, wherein the locating means is in the form of at least one rib.
- 24.** A surface drainage system comprising a channel having a flow regulator located therein, wherein the flow regulator is a plate and the plate and the channel are wider in a region adapted to be uppermost, in use, than a region adapted to be lowermost, in use. 15 20
- 25.** A surface drainage system comprising a channel having a flow regulator, the flow regulator being a plate that is located entirely within the channel. 25
- 26.** A surface drainage system comprising a channel having a flow regulator, the flow regulator being an orifice plate that has a first and second orifice, the second orifice being above the first orifice, in use. 30
- 27.** A surface drainage system substantially as herein described with reference to any one of the embodiments shown in the accompanying drawings.
- 28.** A flow regulator for regulating flow in a surface drainage channel comprising an orifice plate, the orifice plate being wider in a region adapted to be arranged uppermost, in use, than a region adapted to be lowermost, in use. 35 40
- 29.** A flow regulator for regulating flow in a surface drainage channel comprising an orifice plate, the orifice plate having a first and second orifice, the second orifice being above the first orifice, in use. 45
- 30.** A flow regulator substantially as herein described with reference to any one of the embodiments shown in the accompanying drawings. 50

55

55

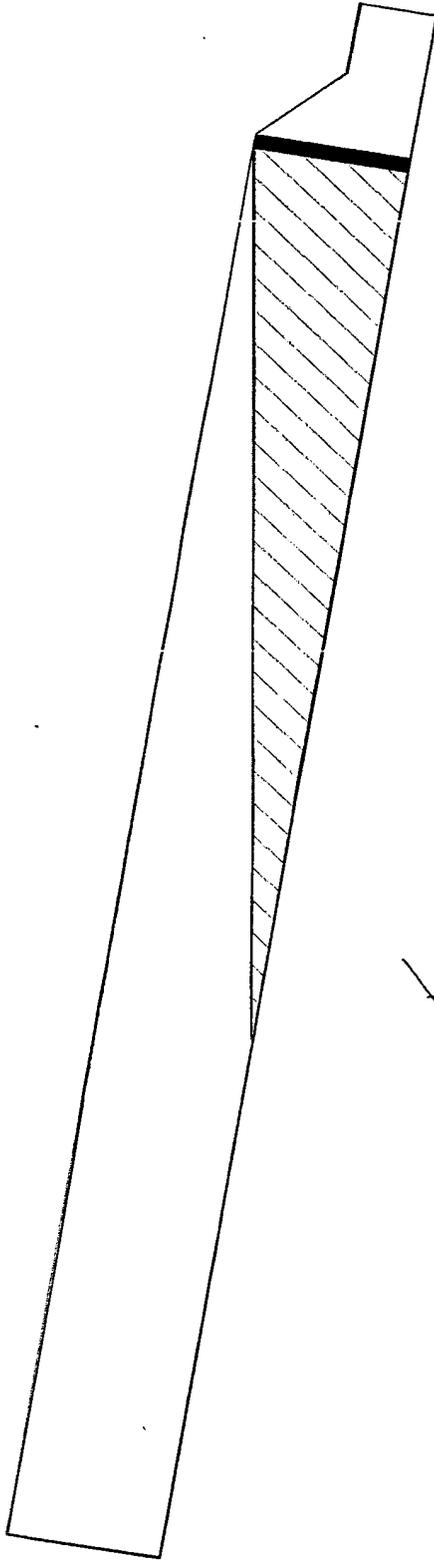


FIGURE 1

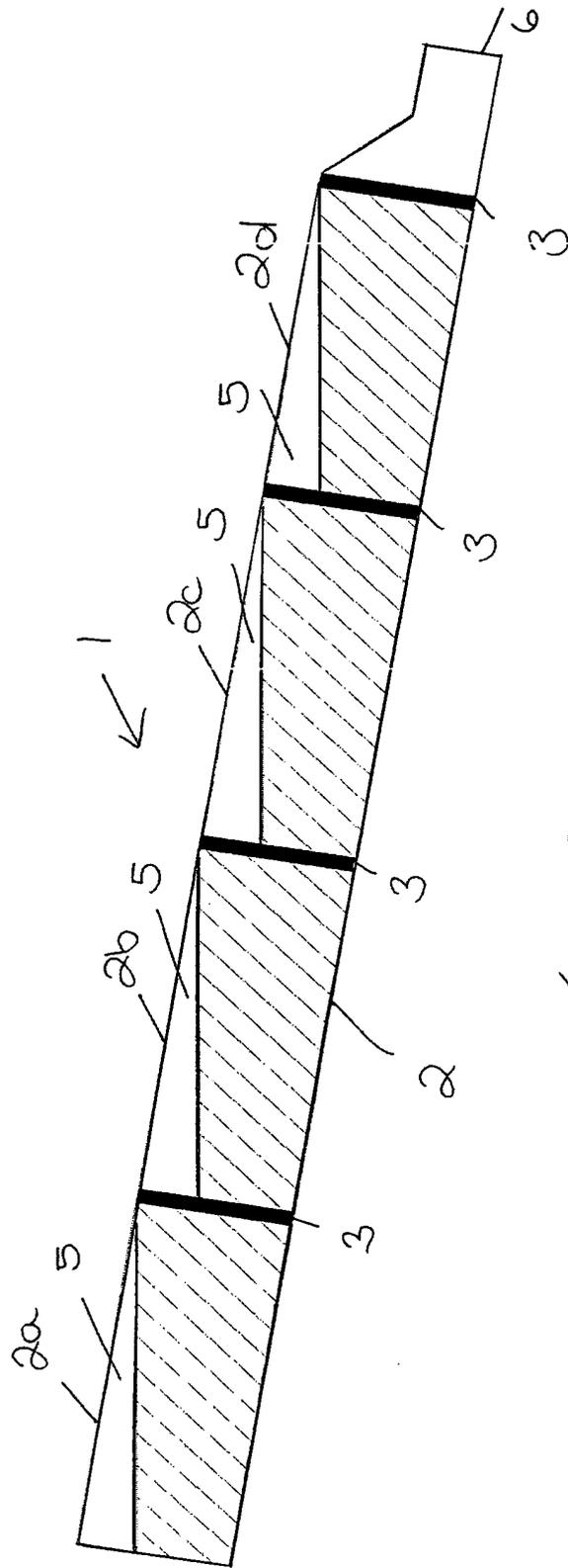


FIGURE 2

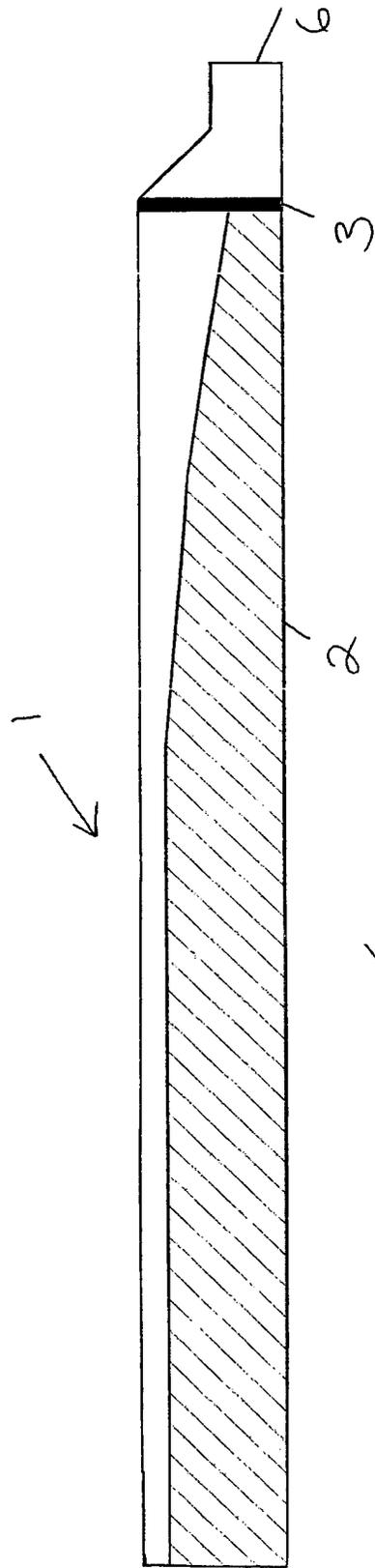


FIGURE 3

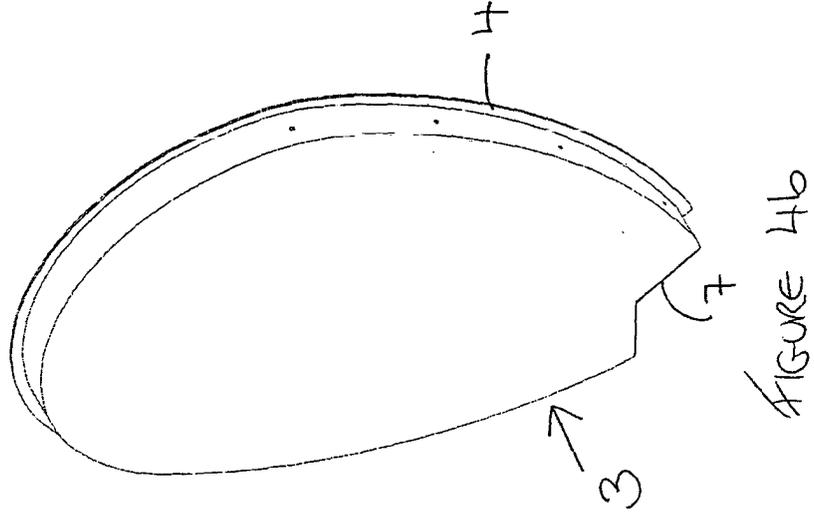


FIGURE 4b

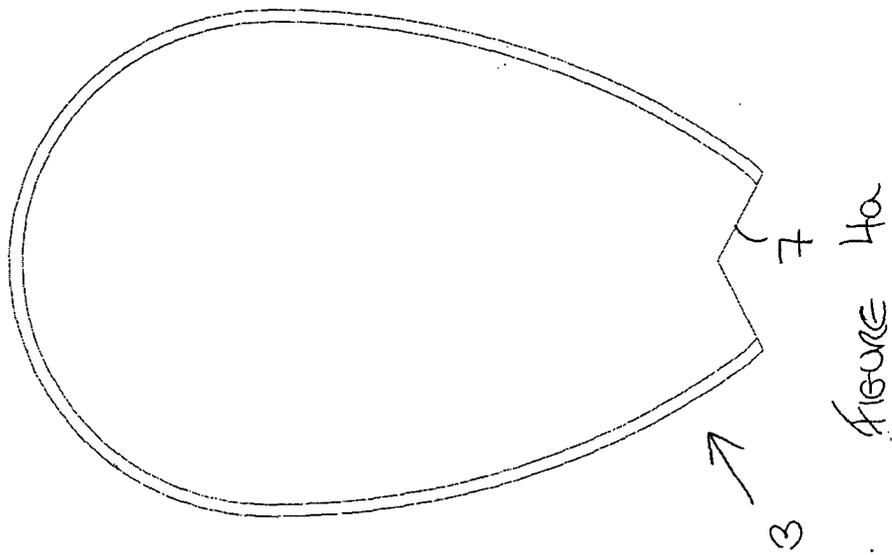


FIGURE 4a

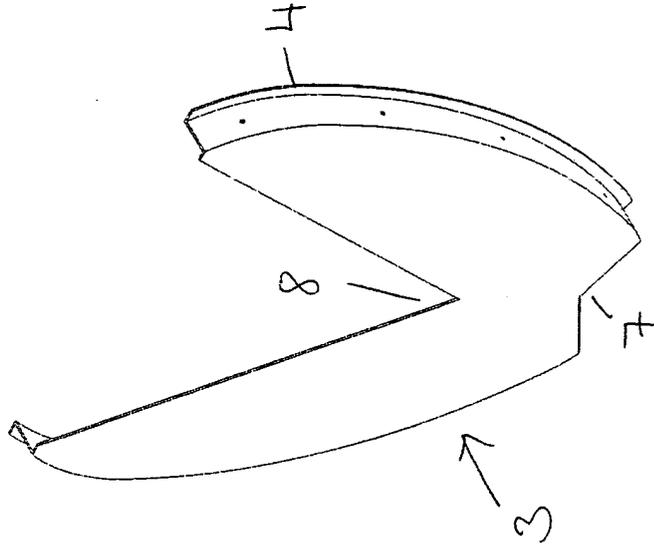


FIGURE 5b

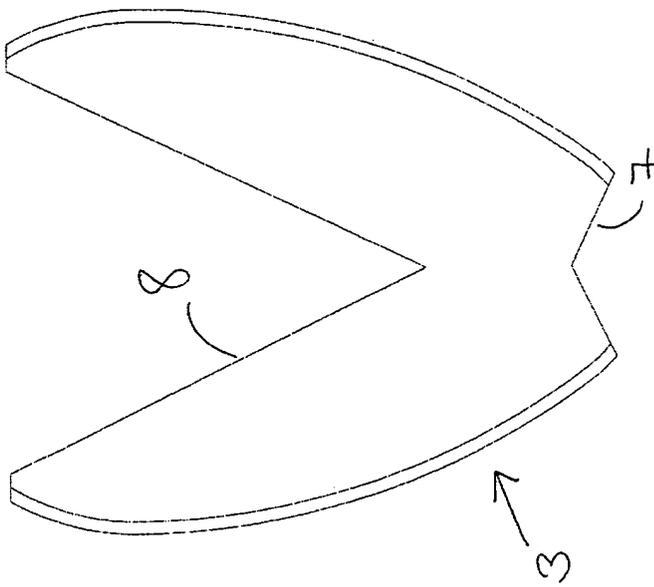


FIGURE 5a

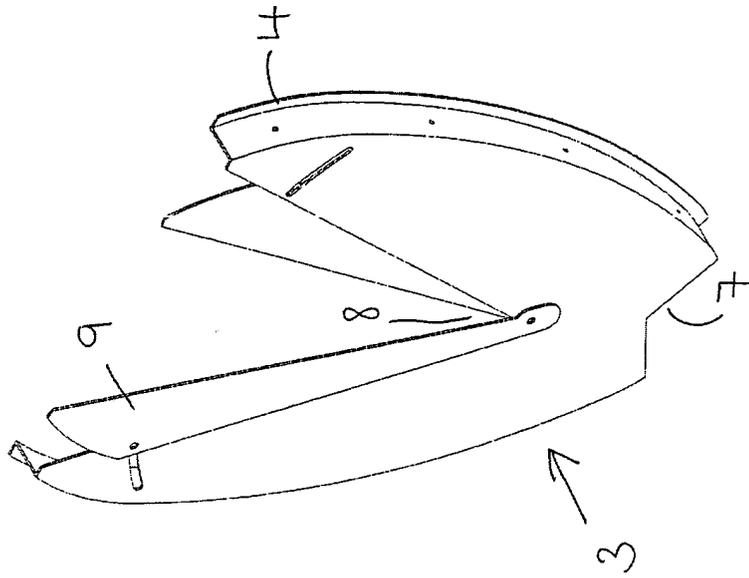


FIGURE 6b

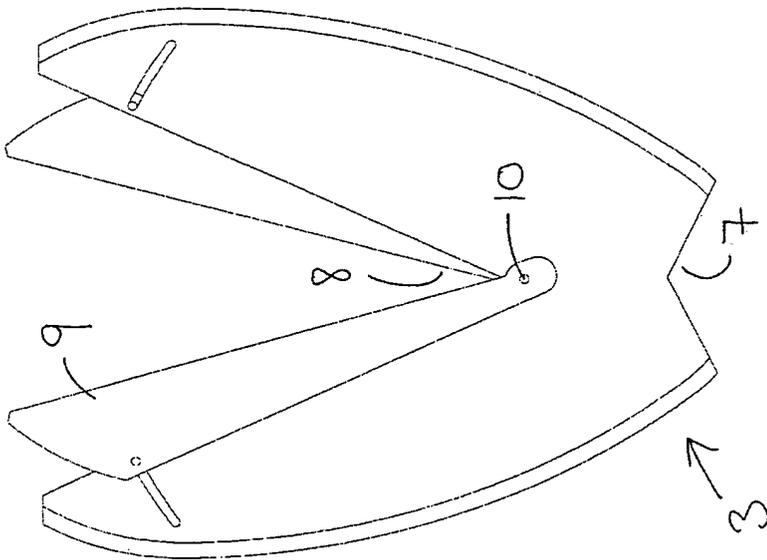


FIGURE 6a