Reinforced flexible shutter and modular units to form such a shutter.

A flexible reinforcing shutter for location under water or over swampy or other terrain comprises co-extensive upper (10) and lower (11) layers joined by a plurality of spaced tubular elements (13). A mattress (21) made from such a shutter, the edges of the layers (10, 11) being joined together and the shutter filled with a concrete or other settable composition (25), reinforces and stabilizes the ground (2) and protects it against erosion and also provides support, for example for a pipeline (26) or for vehicles. The shutter can be made up of a plurality of modular units.
This invention relates to reinforced flexible shutters, that is, structures of flexible material which serve for the controlled placement of settable compositions, e.g. concrete mixes, so that the combination of the shutter and the composition, when the latter has set, becomes a fixed structure. Reinforced flexible shutters and fixed structures made using them can be employed in a variety of ways. One general class of use is under water, where such structures serve to minimize the scouring effect of water action on the beds and banks of water-flow channels, such as rivers, estuaries, canals, reservoirs and the sea. In particular, such structures provide protection for sea and like defences, where the severity of the water action is increased by tidal and storm waves as well as by waves created by shipping and other marine craft. Other uses can involve the placing of such shutters on the ground, which may be under water for periods which alternate with ones where there is no water, e.g. in tidal estuaries, or swampy or marshy ground. Such shutters and filled structures made using them can be very long and can be used, for instance, as causeways or roadways over terrain which could otherwise not be traversed.

Flexible shutters for receiving and retaining
concrete and other settable compositions for these and analogous purposes are already known and commonly consist of complex woven or other geotextile fabric structures, comprising two inter-connected webs which define a double-skin blanket-like structure which conforms to the shape of the ground or other solid material on which it is placed, e.g. a marine foreshore or river bank, and can receive and retain a liquid concrete mix, which sets in the space between the interconnected webs. One general disadvantage of known flexible cast shutters, however, resides in the considerable difficulty experienced in obtaining substantially thick structures, i.e. over 300 mm in thickness. This difficulty has so far limited the use of textile shutters to specially formulated concretes and grouts, to thin structures, to structures without in-built pressure relief arrangements and to structures without reinforcing. This has meant that heavy-duty applications where the structures are at least partly under water, e.g. in sea defence projects, have in the main been prevented and other expedients have had to be used. The flexible shutters of this invention overcome the difficulty of achieving substantial thickness, provide a practical and economic means of fabricating shutters of large area and facilitate the use of conventional concretes. They can also incorporate in-built pressure relief and reinforcement.

According to one aspect of this invention, a flexible shutter comprises two generally co-extensive layers or webs of flexible material capable of being mutually separated so as to define between them a fillable space which can receive and retain a settable composition introduced between the layers, opposed regions in the respective webs being interconnected by at least one tubular element extending across the fillable space.
Depending upon the intended use of the shutter and the structure made from it, the properties and nature of the webs and tubular elements can be arranged so that the settable composition occupies the space between the layers or webs except for the interiors of the tubular elements or the space and some only of the interiors of the tubular elements or none of them. As will appear from the description further below, the tubular elements can serve as pockets which receive reinforcing members and reinforced structures of particularly useful properties can be made by putting members into the pockets and then filling the pockets around the members as well as the fillable space across which the tubular elements extend.

According to a preferred embodiment of the flexible shutter of the invention, a plurality of the tubular elements interconnect sets of opposed regions in the respective webs, which are also connected together at the boundary edges of the flexible shutter, at least one access aperture being provided through which the selected settable composition can be introduced into the fillable space.

According to another preferred embodiment of the invention, a modular unit for association with a plurality of like modular units in order to form a flexible shutter comprises a pair of generally co-extensive layers or webs each including a respective one of a pair of opposed regions, which are interconnected by a tubular element, whereby connection of the edges of the respective layers or webs with those of adjacent similar modular units produces a fillable space of desired extent. In one form of such modular unit or the shutter made from a number of them, the space external to the unit or shutter on one side of one layer or web is connected through the respective regions.
and via the interior of the tubular element with the space external to the unit or shutter on the other side of the other layer or web. The regions can thus be regarded as parts of the layers or webs, the ends of the tubular elements being connected to the edges of such parts. In another form, the regions can be areas of the layers or webs made in a more open or different form from the main areas of the layers or webs, the ends of the tubular elements being connected to the edges of these different areas in the layers or webs.

The flexible material used to form the layers or webs of the shutter of the invention or of modular units for assembly to make such a shutter is preferably a woven textile structure of the properties appropriate to the reception and retention of liquid or plastic state settable compositions, such as concrete mixes. An example of a material suitable for forming the layers or webs and, if desired, also for forming the tubular elements, is woven polypropylene fabric, which is excellently suited to the purpose, as it is strong and durable, it retains the concrete mix or other settable composition used to fill the space within the shutter, but allows water to pass through as the mix sets. It will be appreciated that if the tubular elements are made, like the layers or webs, of a material which holds back or retains a concrete mix or other settable composition, then as the composition is introduced between the main co-extensive layers into the space it will progressively fill the space, but will not pass into and fill the interiors of the tubular elements. The finished structure thus takes the form of an integral concrete or other slab with throughgoing holes. A particular feature of the shutter structures of this invention is that by utilizing such tubular elements as the inter-
connecting members between the respective webs or layers, it is possible to provide relief of hydrostatic pressure, which may build up behind the filled structure after installation. Another notable advantage is that the tubular elements can also serve as cylindrical pockets in which supporting and reinforcing members are placed. This feature of the invention can be employed whether or not the tubular elements are filled or instead remain empty when the settable composition is introduced into the fillable space. Assembly of the fillable structure from a plurality of modular units simplifies and rationalises manufacture and facilitates quick production of the flexible structure at the intended point of use, to specific site dimensions.

The tubular elements cause the settable composition to assume the general shape of the interior of the flexible structure, though obviously the final shape of the resulting construction is determined by the behaviour of the component parts as they are brought together and as the composition fills the available space and sets. Generally speaking, the final structure conforms to the underlying ground, its upper surface is of broadly similar shape or, at least, area (i.e. it is generally coextensive with the lower surface), but the upper surface consists of a plurality of locally-domed regions where the upper web allows the shutter to expand upwardly as the settable mix enters. Where the shutter is of the kind in which the settable mix will not pass through the material forming the tubular elements, the structure also includes a plurality of throughgoing holes produced by the tubular elements, which holes extend throughout the thickness of the final construction and serve to allow the aforementioned hydrostatic pressure relief.
to occur. This can apply only to some of the tubular elements, if so desired.

In addition to the reinforcement extending between the respective upper and lower coextensive layers or webs of the shutter so as to join one layer to the other and control the shape of the filled structure eventually made with the mattress or shutter, the reinforcing shutter can itself be further reinforced internally, e.g. by means of reinforcing rods, bars, ties or like components. These desirably extend within the shutter and, most preferably, in two directions broadly parallel to the main layers or webs of the shutter and mutually at right angles. These reinforcing components can be positioned through the tubular elements, so that they can be carried by supporting members located in the pocket like tubular elements, though other reinforcing components can also be supported from ones carried by the supporting members. Where the reinforcing members extend in two or more mutually-crossing directions, as is often preferred, they are desirably interconnected as the crossing points.

In order that the invention may be fully understood, preferred embodiments of it are described below in conjunction with the accompanying drawings, which are given by way of illustration. In the drawings:

Figure 1 shows the principle of construction of one unit of a modular flexible shutter;

Figure 2 shows a diagrammatic plan view of a plurality of the modular units of Figure 1 being assembled to form a fillable structure;

Figure 3 shows one form of supporting and reinforcing member in the tubular element of a flexible shutter of the invention;

Figure 4 shows another embodiment of a
supporting and reinforcing member in a view similar to Figure 3;

Figure 5 shows diagrammatically in a part-elevational part-sectional view a reinforced flexible shutter after it has been placed upon the boundary of a region confining a body of water and has been filled and set;

Figure 6 shows a cross-section through a reinforced supporting mattress which protects the bed of a river or the sea and also carries a load, shown in Fig. 6 as a pipeline;

Figure 7 shows a cross-section through another form of reinforced mattress, which has transverse and axial reinforcement.

Figure 1 shows a modular unit comprising spaced first and second generally co-extensive layers or webs 10 and 11, each including a circular or other region 12, the edges of the respective regions 12 being joined by a cylindrical or other tubular element 13. The module can be regarded as having a spool-shaped structure with square flanges, though in practice the webs 10 and 11 constituting these "flanges" can be square or rectangular or can have any other suitable shape, e.g. hexagonal. The module is shown in Figure 1 as having rectangular webs 10 and 11 which measure W units in one direction and X units in the other, the webs 10 and 11 are spaced Y units apart, which also is the length of the tubular element 13, whilst the latter is shown as a cylindrical tube having a diameter of Z units. The dimensions W, X, Y and Z are interrelated, as shown, but are variable to suit the size of the desired module and the corresponding dimensions of a fillable structure made by assembling many of them, in the manner shown in Figure 2. The webs 10, 11 are joined together in regular patchwork fashion and it
It will be clear that in practice difficulty would normally arise if shapes other than square or rectangular are used, though such other shapes are not excluded. It is also possible to assemble modules of the principle illustrated in Figure 1 with blank web portions, if desired.

The regions 12 can be of the same construction as the rest of the layers or webs 10,11 or they can be of a different construction, e.g. being woven to have a more open mesh.

Figure 3 shows a cross-section through a module or the portion of a shutter containing a tubular element 13, where the latter is supported and reinforced by a member 14 in the form of a helical rod or wire. The supporting and reinforcing member 14 holds the tubular element 13 open and also retains the webs 10,11 in their fully-spaced relationship. The supporting member 14 can be put into position in the tubular element 13 before, during or after assembly of the flexible components 10,11 and 13 constituting the shutter per se or the shutter module. For instance, the member 14 can be located in the web portion used to make the tubular element 13, which is then attached at its ends to the webs 10 and 11. Another procedure is to attach the tubular element 13 to one of the webs 10,11, insert the supporting member 14 into the pocket formed by the element 13 and then attach the latter to the other of the webs 10,11. A further possibility is to assemble the flexible components and cut into or cut away the region 12 in the web 10 or 11. This is satisfactory, especially in the case where the cut or removed web parts are in the web which is underneath, i.e. contacts the ground, when the shutter is installed. Yet another possibility is to install the supports 14 after the other components have been
assembled, by passing the support 14 through the
web part forming the region 12 at one end of the
tubular pocket. The helical form of the supporting
member 14 is particularly suitable for this mode of
assembly, as it can be wound through a hole made,
say in the web 10, provided with an eyelet, made
as a small aperture in the web, or even formed by
spreading out the yarns it is woven from.

Another form of supporting and reinforcing
member is shown at 15 in Figure 4. This member 15
takes the form of a portion of a flexible spun-bonded
plastics or other structure, formed into a cylinder
which, when located in position in the tubular element
13 as shown, serves like the member 14 in Fig. 3
to hold the structure open. The cylinder can be made
very simply by rolling up a long rectangular portion of
the spun-bonded plastics sheet material.

In general, all the flexible materials used
in forming the webs 10, 11 and the tubular elements 13
of the structure are at least partly porous. The
settable composition used to fill the structures would in
one general embodiment of the invention be prevented from
penetrating through the walls of the tubular elements 13,
though a degree of penetration may be desirable in some
circumstances. In another general embodiment, the
tubular elements (or some of them) allow the settable
composition to pass into them so that all the space
inside the structure becomes filled.

In use, as illustrated in Figure 5, a
flexible shutter of the invention, whether made from
its component parts or by the assembly of modular units,
comprises a pair of generally co-extensive layers or
webs. One such web is shown at 16 in Fig. 5 and the
other at 17. At the edges of the blanket-like structure
formed from the webs 16, 17 they are joined together,
as indicated at 18, either by direct interconnection of
the peripheries of the webs 16, 17 or by connection to an edge member of gusset form. At spaced locations, over the resulting blanket-like structure, opposed regions in the webs 16, 17 are joined by tubular elements 19. In practice, at least some of these and, generally, all of them will accommodate a supporting and reinforcing member 20, e.g. such as shown in Fig. 3 or in Fig. 4 or some other suitable structure.

As indicated in Fig. 5, the flexible shutter, shown generally at 21, is used to protect the ground 22, e.g. a foreshore or bank, from the erosive effect of wave and other action of a body of water, shown at 23. The shutter 21 is laid upon the ground 22 over the entire area requiring protection. A liquid or plastic state settable composition, e.g. a pumpable concrete mix, is then introduced through access ports (not shown) in the periphery of the shutter 21 at a convenient location above the water level 24. The mix fills the entire space between the webs 16, 17 leaving the supported tubular elements 19 open. These can serve for receiving fixing members (not shown) for locating the shutter 21 in place, such fixing members being positioned through selected ones of the tubular elements 19 and being driven into the ground 22. The concrete mix expands the fillable space and sets to a concrete structure, indicated at 25, whose underside conforms to the shape of the ground 22 and whose top side forms the actual interface with the water 23. Ground water in the ground 22 is allowed to drain into the water space and, unlike many prior art shutters, is not held back, causing difficulty, as it can find its way through the supported apertures defined by the tubular elements 19. A major disadvantage of many known flexible shutters, whereby water seepage tends to lift or undermine them, is thus eliminated or
reduced to acceptable levels. The support provided by the steel helixes 14, coiled membrane sheets 15 or other members located in the tubes greatly rigidifies the structure and enables it to have a thickness greater than can be achieved with prior structures whilst using conventional concrete mixes. For example, the finished structure as shown in Fig. 5 can have a thickness well in excess of 300 mm, if required.

Referring to Fig. 6, this shows an embodiment in which the shutter is employed to support a pipeline 26 either over the ground or the sea-bed, indicated at 22. The shutter in this embodiment is made to have a length such that it can extend along the intended course of the pipeline 26 or at least those parts which are under water or where the terrain is swampy or otherwise difficult. The mattress made from the shutter has the great advantage of giving adequate support for the load represented by the pipeline 26 and its contents, by virtue of the way in which the shutter is constructed, which causes its internal reinforcing to support the top layer of fabric.

The mattress of Fig. 6, indicated generally at 28, can have a height to width ratio of as much as 1:3. The shutter from which it is made consists of a bottom layer 29 joined at intervals across its width to the bottom edges of upper layer components 30, each of which extends upwardly and inwardly so that its upper edge is joined to an intermediate part of the next inner component 30. The central component 30a upon which the pipeline 26 rests can be a large and integral strip as shown. Where each component 30 joins the next, rows of pockets or tubular elements 31 are provided and three rows of such tubular elements 31 are included in the central component 30a. These tubular elements 31 contain supports 32 of open structure, e.g. helical...
springs. As shown, the concrete mix 33 filling the shutter occupies the whole of the interior, the tubular elements 31 in this embodiment allowing the concrete mix to pass into them, so that both the pockets or tubular elements 31 and the rest of the fillable space inside the original shutter becomes filled with concrete. If fitter points are desired, at least at some places in the pipeline supporting mattress 28, for instance so as to allow ground water to pass through the mattress 28, this can be achieved by constructing some of the tubular elements 31 so that they do not allow access to the filling mix, when the structure is being installed and filled.

Referring to Fig. 7, a mattress 33 consists of a lower layer 34 and a co-extensive upper layer 35 between which tubular elements 36 are joined. Each element 36 contains a supporting member 37 in the form of a spiral or helical spring or a wound spun-plastics component, as shown in Fig. 3 or Fig. 4 respectively.

In the embodiment shown in Fig. 7, the concrete infilling 38 occupies the internal space of the shutter forming the mattress 33 except for the tubular elements 36. Additional internal reinforcement is provided, in the form of reinforcing wires, rods, ties or bars 39, which pass through the mattress 33 approximately in its mid-plane, preferably by passing through and being joined to the associated transverse rows of supporting members 37. Further reinforcing wires, rods, ties or bars 40 run longitudinally of the mattress 33. As shown, these are also approximately in the mid-plane of the mattress 33 and run, as shown for the reinforcing members 40a, through the longitudinal rows of the supporting members 37 and, as shown for the reinforcing members 40b, between such rows. A mesh-like or grid-like assembly of transverse and longitudinal reinforcing bars or other reinforcing members
40 is thus given. The members 40 are preferably joined together at their crossing points, as indicated at 41, for additional strength.

The detailed construction of the shutter and therefore of the mattress made from it, in accordance with this invention, depends to a large extent upon the nature and type of situation where reinforcement of the ground is required. It has been found, for instance, that less supporting members are usually sufficient, in a mattress of given construction, when it is to be used on level ground, as compared with inclined ground, e.g. a natural or artificial bank or foreshore.

The invention thus provides a relatively simple structural principle for flexible shutters, which provides a solution to all the main problems inherent in conventional practice.
1 CLAIMS:

1. A flexible shutter, which comprises two generally co-extensive layers or webs of flexible material capable of being mutually separated so as to define between them a fillable space which can receive and retain a settable composition introduced between the layers, characterised in that opposed regions in the respective webs are interconnected by at least one tubular element extending across the fillable space.

2. A shutter according to claim 1, wherein the tubular elements retain and so remain unfilled by the settable composition, whereby open filter points are formed in the finished structure.

3. A shutter according to claim 1, wherein at least some of the tubular elements allow the settable composition to pass into them and so become filled in the finished structure.

4. A shutter according to any preceding claim, wherein a plurality of the tubular elements interconnect sets of opposed regions in the respective webs, which are also connected together at the boundary edges of the flexible shutter, at least one access aperture being provided through which the selected settable composition can be introduced into the fillable space.

5. A shutter according to any preceding claim, wherein supporting and reinforcing members are located in at least some of the tubular elements.

6. A shutter according to claim 5, wherein the supporting members comprise helical rods or wires.

7. A shutter according to claim 5, wherein the supporting members comprise flexible spun-bonded plastics material.

8. A shutter according to any preceding
claim, wherein reinforcing members are provided which extend in the general plane of the shutter.

9. A shutter according to claim 8, wherein the reinforcing members comprise wires, rods, ties or bars and extend transversely and/or longitudinally of the shutter.

10. A shutter according to claim 9, wherein the reinforcing members extend both transversely and longitudinally and are interconnected at their crossing points.

11. A modular unit for association with a plurality of like modular units in order to form a flexible shutter, characterised in that the or each modular unit comprises a pair of generally co-extensive layers or webs each including a respective one of a pair of opposed regions, which are interconnected by a tubular element, whereby connection of the edges of the respective layers or webs with those of adjacent similar modular units produces a fillable space of desired extent.

12. A modular unit according to claim 11, wherein the space external to the unit or shutter on one side of one layer or web is connected through the respective regions and via the interior of the tubular element with the space external to the unit or shutter on the other side of the other layer or web.

13. A modular unit according to claim 11 or 12, wherein the regions comprise areas of the layers or webs made in a more open or different form from the main areas of the layers or webs, the ends of the tubular elements being connected to the edges of these different areas in the layers or webs.

14. A modular unit according to any of claims 11 to 13 or a flexible shutter made therefrom or
according to any of claims 1 to 10, which comprises polypropylene or another woven textile fabric structure.
## DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document with indication, where appropriate, of relevant passages</th>
<th>Relevant to claim</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FR - A - 2 352 107 (PORRAZ)</td>
<td>1,2</td>
</tr>
<tr>
<td></td>
<td>* Page 2, lines 18-40; page 3, lines 1-4; figures 1-3 *</td>
<td></td>
</tr>
<tr>
<td></td>
<td>--</td>
<td></td>
</tr>
<tr>
<td></td>
<td>US - A - 3 425 228 (LAMBERTON)</td>
<td>1,2,4</td>
</tr>
<tr>
<td></td>
<td>* Column 4, lines 3-15; column 5, lines 31-74; figures 1,2, 6 *</td>
<td></td>
</tr>
<tr>
<td></td>
<td>--</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FR - A - 2 255 803 (PORRAZ)</td>
<td>1,5,6, 8-11</td>
</tr>
<tr>
<td></td>
<td>* Page 5, lines 24-41; page 6, lines 1-4; figures 6a,7a *</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&amp; GB - A - 1 485 470</td>
<td></td>
</tr>
<tr>
<td></td>
<td>--</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FR - A - 2 297 959 (PORRAZ)</td>
<td>1,8-11</td>
</tr>
<tr>
<td></td>
<td>* Page 2, lines 4-38; figures 1,2 *</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&amp; GB - A - 1 487 986</td>
<td></td>
</tr>
<tr>
<td></td>
<td>--</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A US - A - 3 524 320 (TURZILLO)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A US - A - 4 154 061 ((UMEMOTO)</td>
<td></td>
</tr>
</tbody>
</table>

The present search report has been drawn up for all claims.

Place of search: The Hague
Date of completion of the search: 10-03-1981
Examiner: HANNAART