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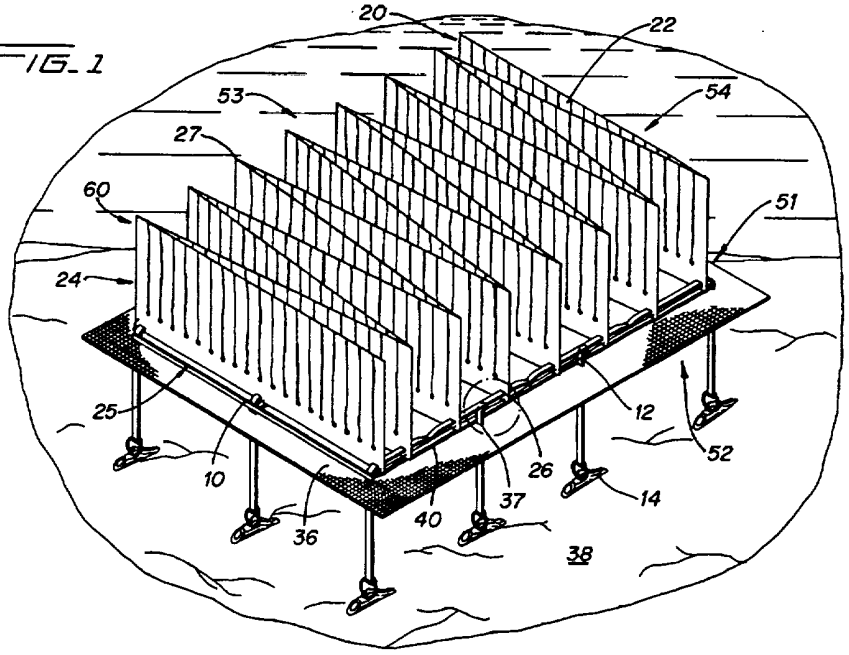
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(54) Abstract Title
Underwater erosion control mat for influencing sedimentation

(57) A structure 60 comprising a multitude of buoyant single fronds 22 (cut slits) extending from a fan-folded polyolefin sheet 24 and secured to a flexible frame assembly 10. The fonds can be spaced by controlling means to varying distances in order to create different erosion control. An underlying geotextile liner 36 isolates bottom sediments below it. The mat's 60 location and fixed permanence are assured by a system of anchor straps 12 and multiple single-piece earth anchors 14. The anchors depend from the frame via the anchor straps 12 that are securely fixed to the frame 10, and are driven into the seabed 38 by a powered driving tool. The mat can be rolled up around a reusable spool and is easily lowered to divers for installation underwater.

FIG. 1



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG_1

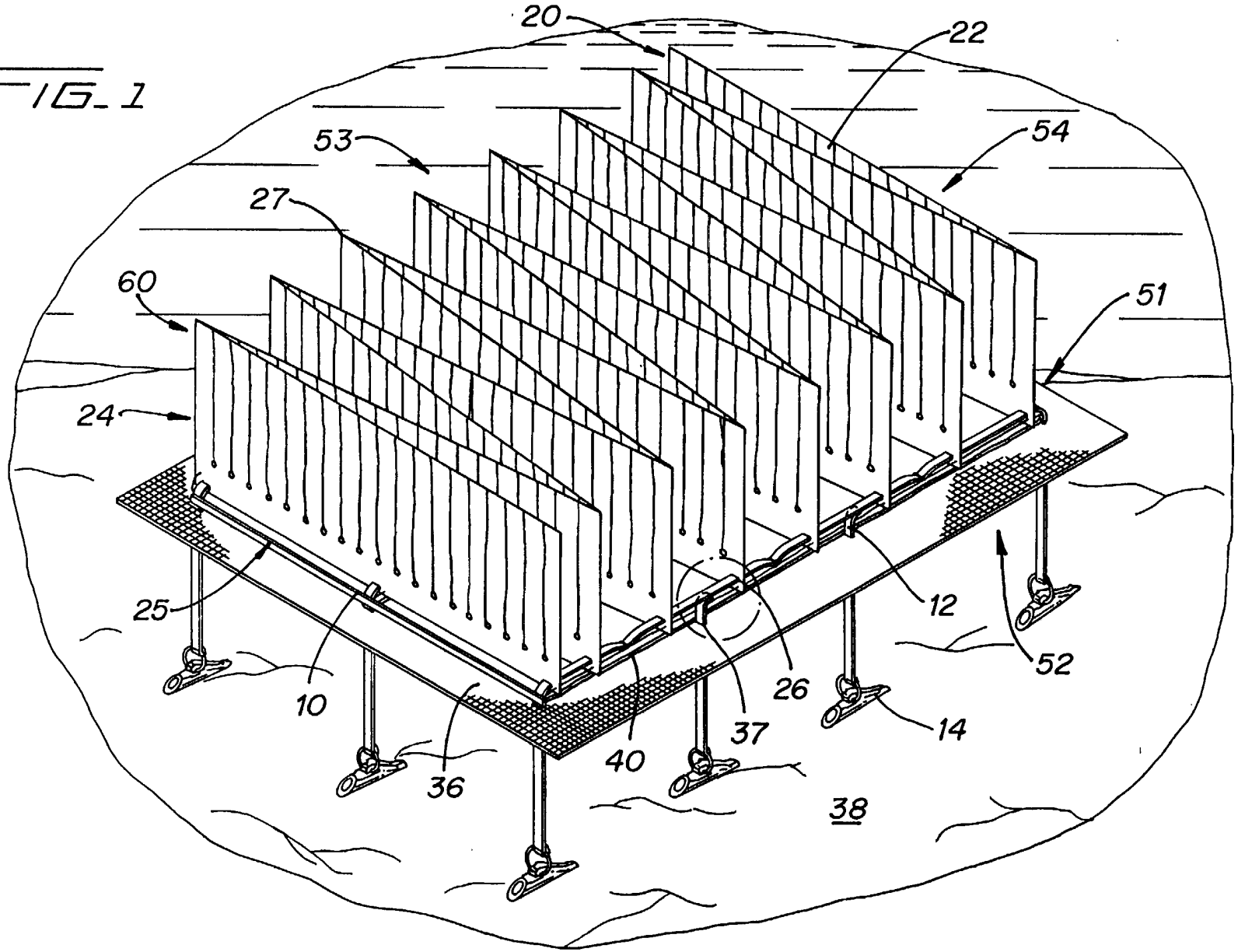
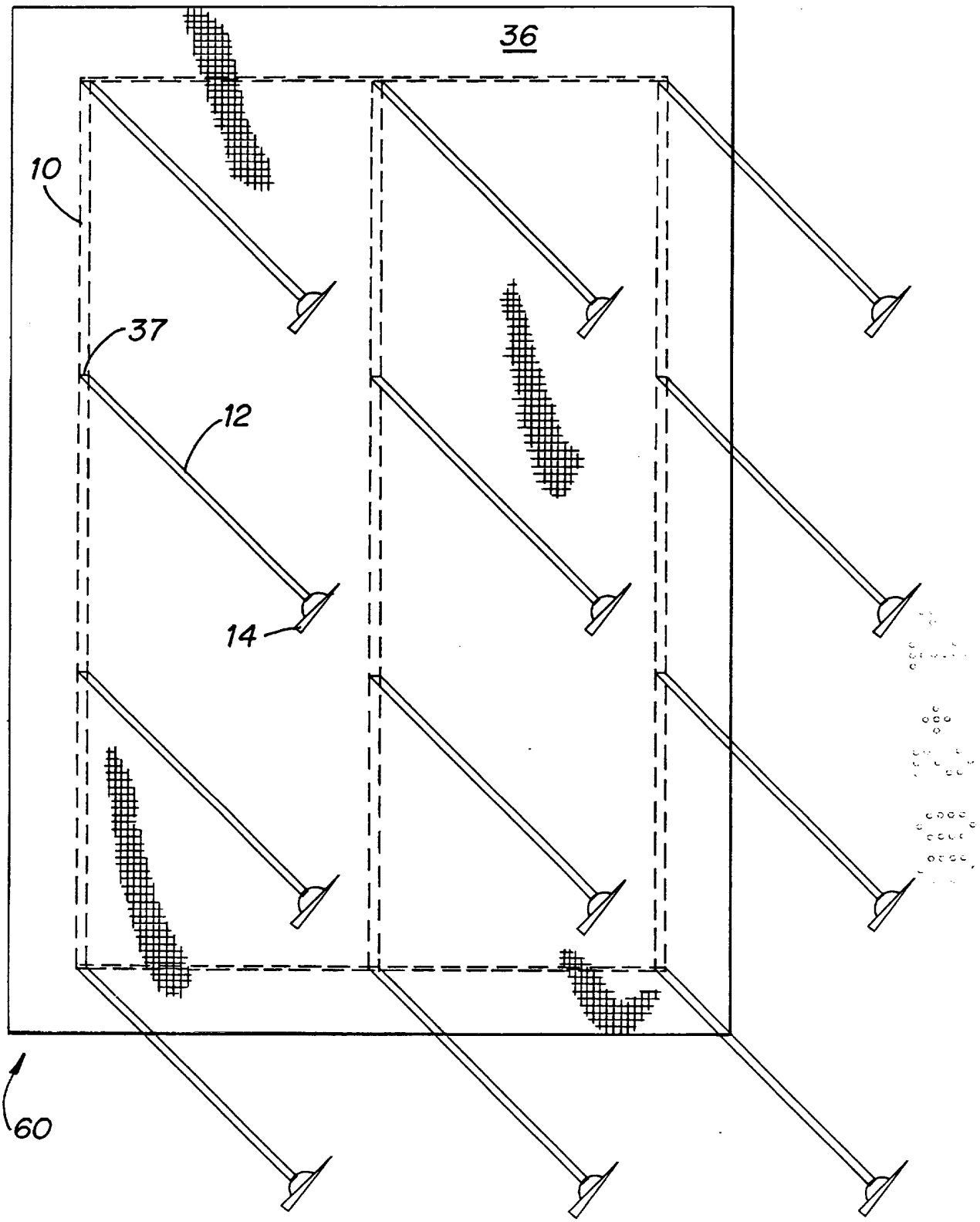


FIG_2



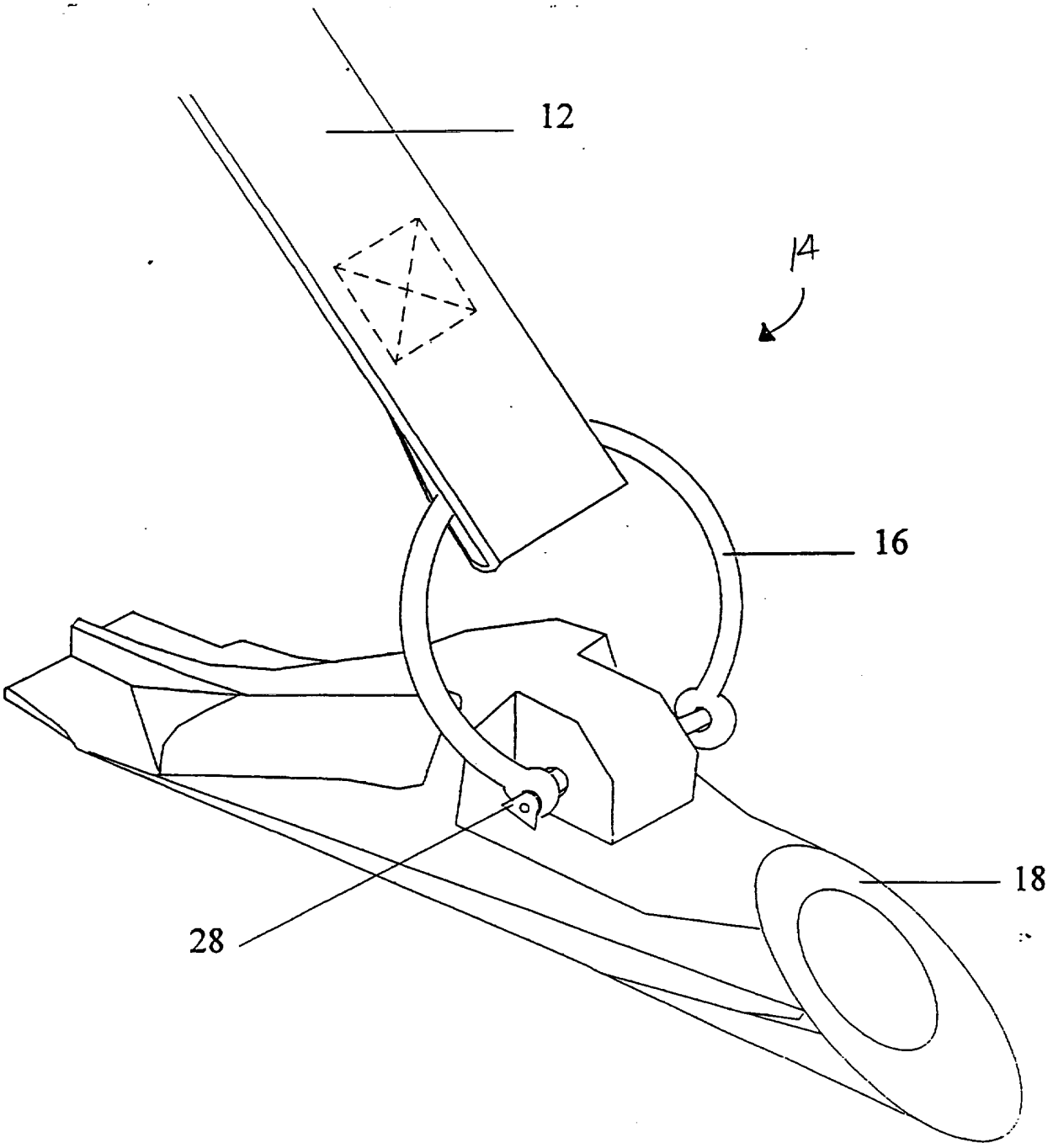
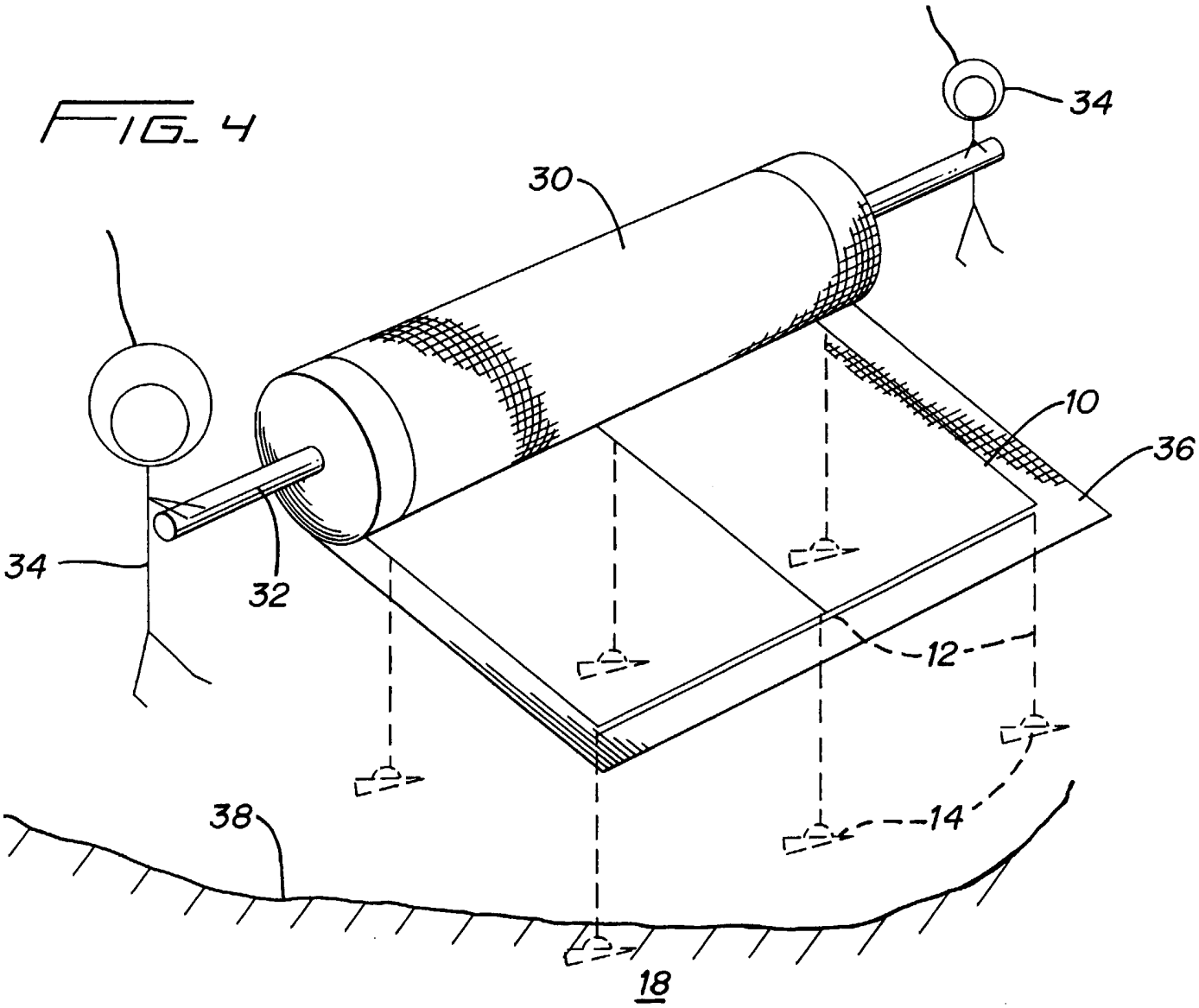


FIG. 3

FIG. 4



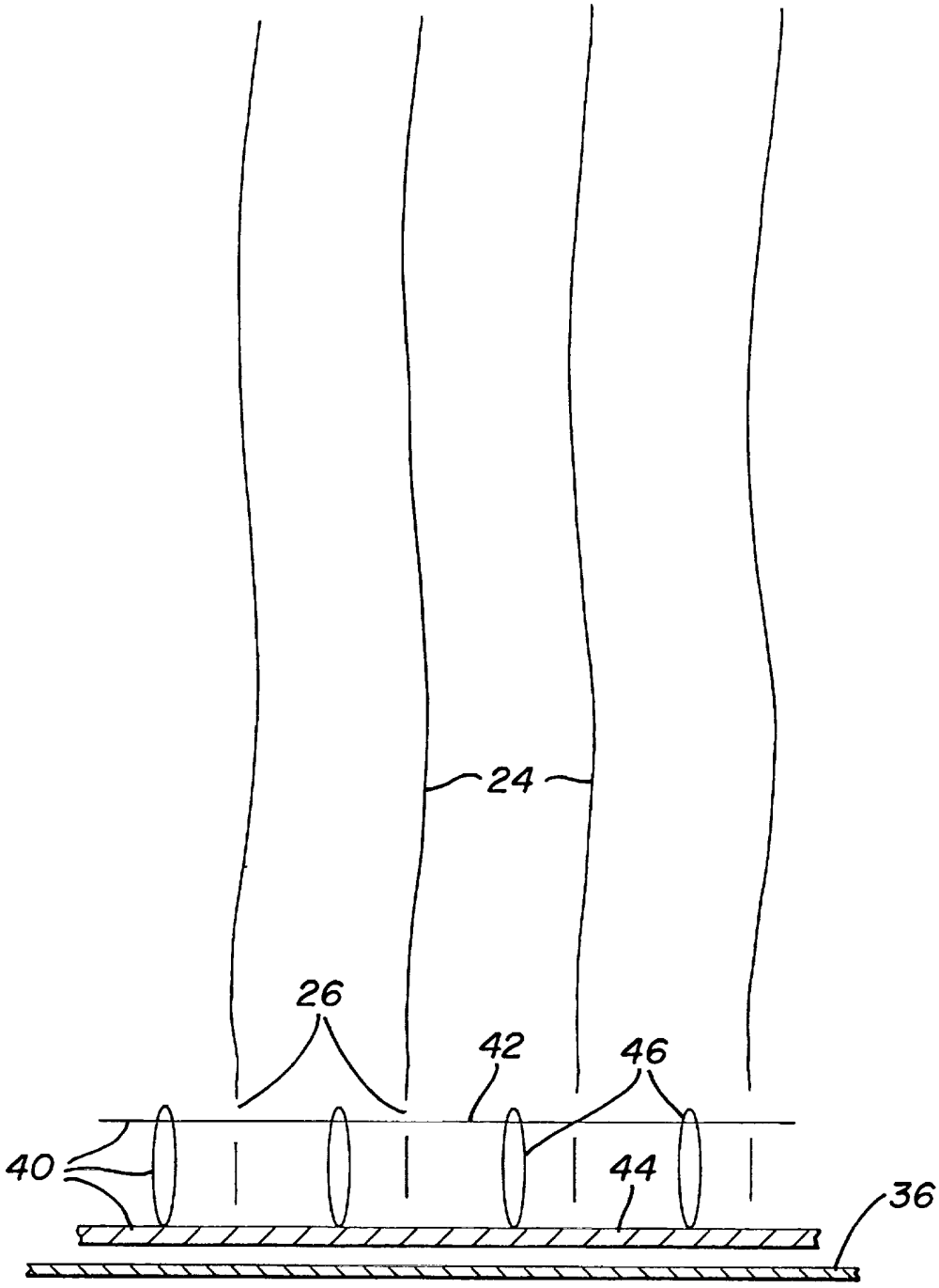


FIG_5

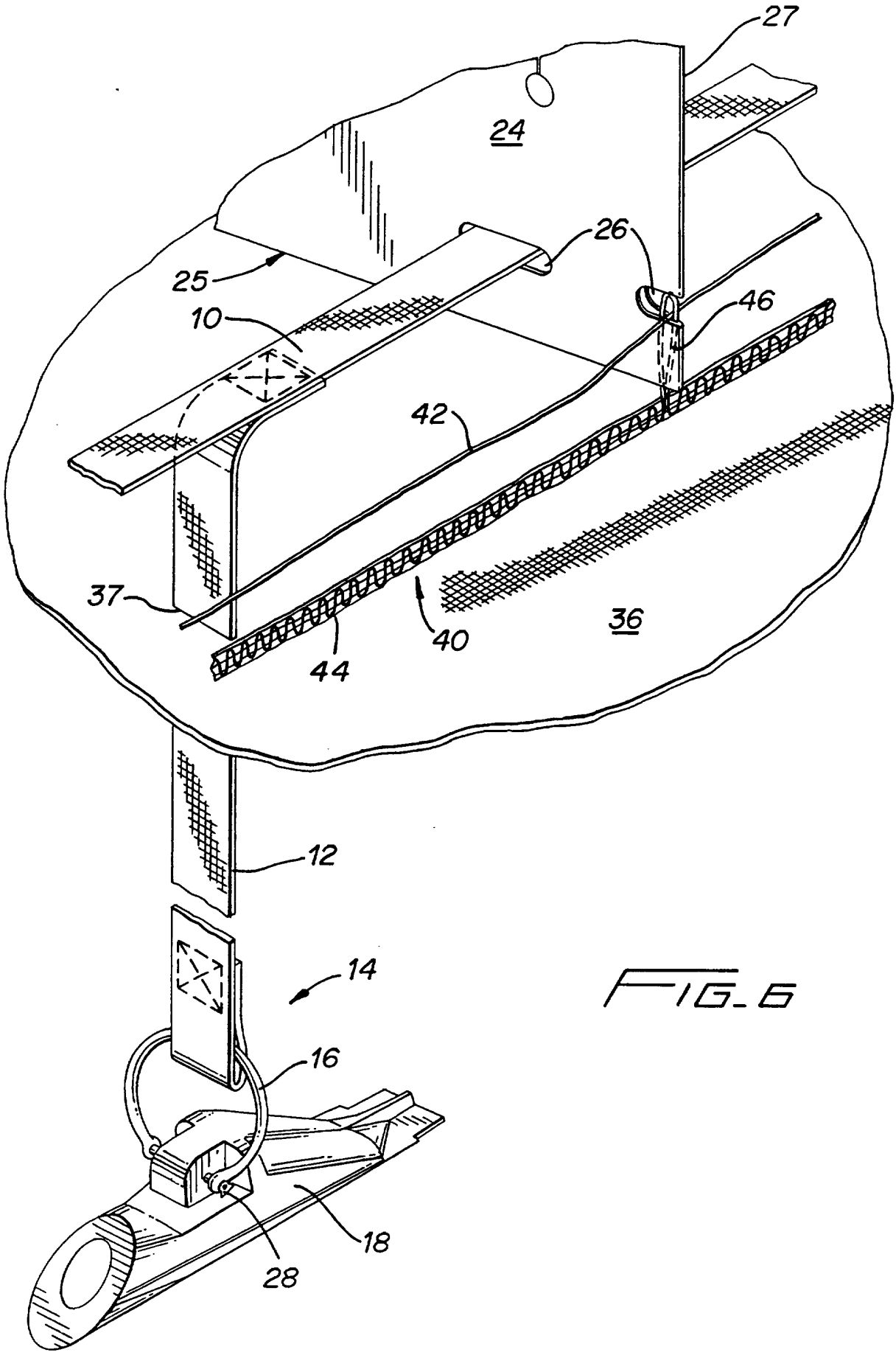
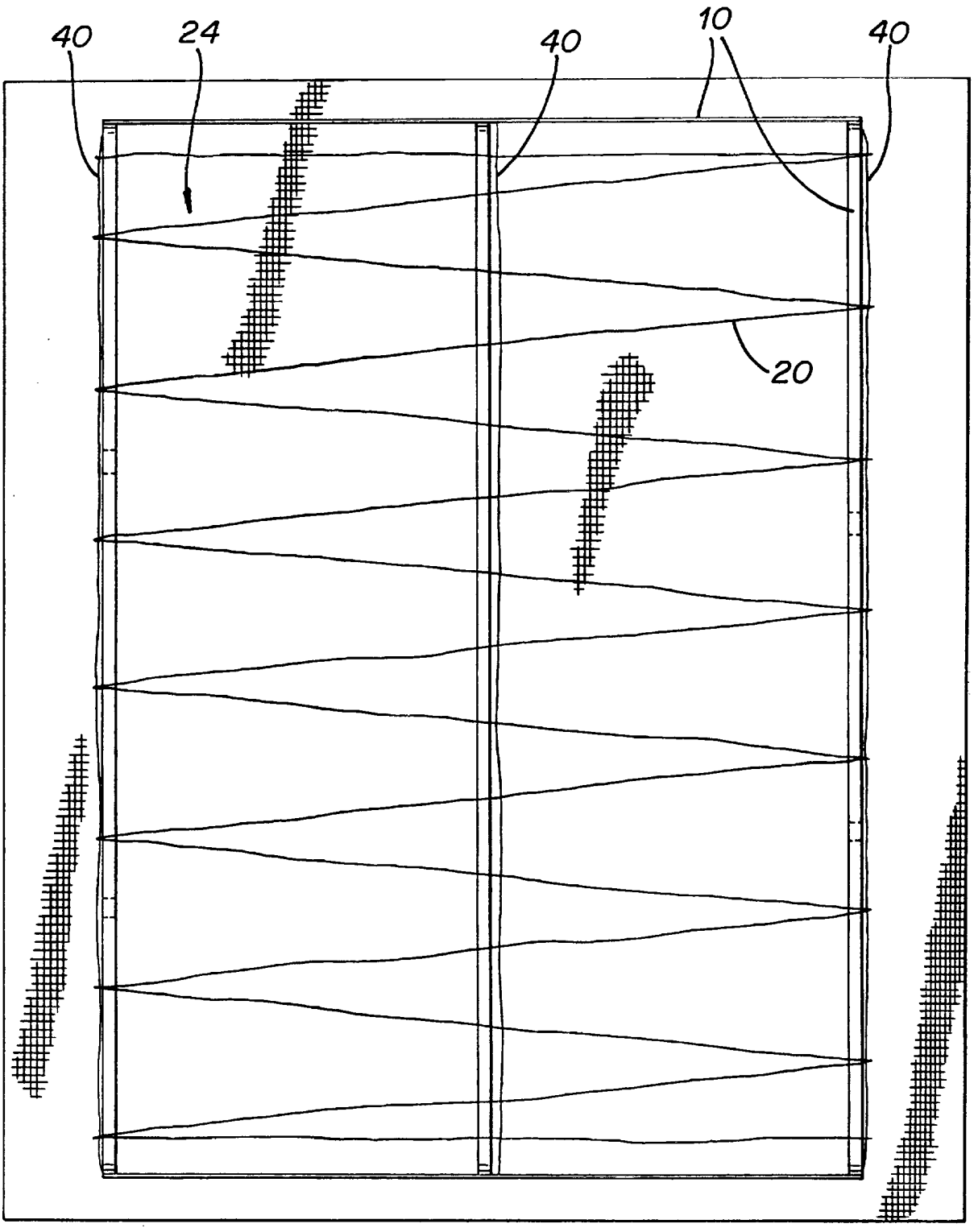


FIG. 6

FIG. 7



UNDERWATER EROSION CONTROL MAT FOR INFLUENCING SEDIMENTATION

Cross Reference to Related Applications

This application is a continuation-in-part of U.S. Patent Application Serial No. 09/185,121, filed November 3, 1998.

Field of the Invention

This invention relates to hydraulic and earth engineering, specifically to an improved artificial seaweed, or erosion control mat for underwater use.

Background of the Invention

Artificial seaweed mats are known devices causing suspended particulates in a moving column of water to deposit in and around the device. Typical devices consist of a multitude of buoyant fronds attached by some method to the seabed or riverbed. The purpose of such a device is arresting or reversing erosion of seabed sediments. To function properly, the base of the device must maintain continuous and direct contact with the seabed. As such, optimum operation requires an anchoring system that is reliable, uniform, and easy to employ. This assures original positioning is maintained, secure to the seabed, with minimal installation time.

U.S. Patent No. 4,490,071 to Morrisroe discloses an earlier typical dead-weight anchoring system employing sand or sediments pumped into an integrated sock to secure fronds to a lakebed. However, this type of anchoring provides no positive capture and is susceptible to sliding, uplifting, and relocation during storms and high-flow events.

U.S. Patent No. 4,722,639 to Alsop uses a ground anchoring system. However, these anchors contain moving parts and springs which can be susceptible to corrosion and failure. Also, the anchor driving steel receptacle is so small that a very narrow driving steel is required for installation. These narrow steels fail easily, significantly lengthening installation time while divers surface to replace bent equipment.

U.S. Patent No. 5,176,469 to Alsop employs yet another ground anchor plate, attached by carabiner clips along the sides of an artificial seaweed mat. Although the attachment is simple, it provides a point of relative motion between the anchor clip and the anchor line. This motion can cause the clip to saw through the anchor line after continuous back and forth wave-induced motion, rendering the anchoring ineffectual.

Uniform anchoring has been proven necessary for these buoyant structures to function properly at shorelines and in surf zones. If anchoring points do not exist in the interior of the mat, billowing or ballooning occurs in the center. This lifting in the center allows wave surge to continuously flush out accumulated sediments, reducing effectiveness. Alsop '469 discloses a structure with perimeter anchoring only, which can experience this undesired effect.

The frond material selection can limit the effectiveness and life of the mat. Alsop '639 utilizes a frond material of strong fibrillated strips. The material is strong in its long direction, however relatively weak in the cross-direction. Over time these fronds fray, become less sturdy, and ultimately resemble very thin, hair-like strands with a reduced collective viscous drag effect on the water current. U.S. Patent No. 5,575,584 to Alsop utilizes a strong, buoyant multi-layered thin film (MLTF). However, after continuous exposure and motion in seawater, MLTFs experience delamination. This delamination separates the very buoyant and the very strong elements, reducing frond effectiveness.

The general versatility of artificial seaweed mats is one of its primary strengths as a remediation device. New uses would be a further improvement of artificial seaweeds. Besides accumulating sediment, artificial seaweed arranged as large mats generally protect underlying sediments. Further improvement of this protecting capability would extend the use of mats to capping applications, those requiring the absolute isolation of underlying sediments under even vigorous or periodic high-flow conditions. Existing anchored mats such as Alsop '639, Alsop '469, and Alsop '584 are all of an open grid design. The open bases of these structures allow direct and open contact between the underlying sediment and newly accumulated sediment. An integral device, such as a liner, would isolate completely the underlying sediments even during events like a very high river flow from spring runoff. Isolation may be required over spots of contaminated sediments where re-suspension during high flows cause spread of contamination and health risks.

U.S. Patent No. 4,337,007 to Smith uses such a filter membrane at the base, but does not employ a secure, positive anchoring system. Its dead-weight system is not capable of withstanding high-flow conditions without moving.

And finally, secure, accurate placement of artificial seaweed necessitates diver-assisted installation. Rapid, easy, and accurate deployment by the most expeditious means is desired to reduce on-site costs. Remote installations make it important to minimize the need for special vessels or uncommon, expensive equipment. However, recent improvements to artificial seaweed have tended to make installation more difficult or specialized. Alsop '639 advises no installation method. Alsop '469 employs a unique and expensive dispenser box that delivers the structure to divers. It is extremely heavy, hard to maneuver, and no more than two exist today, severely limiting availability for installations. Alsop '584 requires a type of fluid pump to unroll

the array or a specialized frame to deliver the mat to divers on the seabed. The latter two methods require unique or additional equipment that may not be readily available at a remote location. A common and simplified method of mat delivery to the seabed would be an improvement.

Accordingly, a need exists for an underwater erosion control mat that can be adequately secured to the seabed and is reliable in its longevity. Further, a need exists for an underwater erosion control mat that allows rapid, controlled delivery in nearly any type of environment, with minimal external support required.

Objects and Summary of the Invention

Accordingly, several objects and advantages of my invention are:

(a) to provide an erosion control structure whose anchoring is both secure and reliable;

(b) to provide an erosion control structure whose anchors are one solid piece, not spring loaded or multi-piece units susceptible to failure;

(c) to provide an erosion control structure whose anchoring is joined securely, not clipped-on, which causes strap failure through repeated rubbing;

(d) to provide an erosion control structure whose anchoring is uniform throughout the mat perimeter and interior, presenting more positive contact with the seabed and thus preventing flushing under the mat from wave surge;

(e) to provide an erosion control structure whose anchoring provides positive capture, and is not susceptible to sliding or uplifting;

(f) to provide an erosion control structure whose fronds are durable under water and maintain their dimensions over time;

(g) to provide an erosion control structure whose fronds do not split longitudinally or delaminate over time;

(h) to provide an erosion control structure which is sturdy enough for a surf zone and can be reliably used in many extreme conditions;

(i) to provide an erosion control structure which can reliably cap and isolate underlying sediments even under high-flow conditions; and

(j) to provide an erosion control structure whose installation requires no expensive, specialized, or unusual equipment or vessels.

Further objects and advantages are to provide an erosion control mat whose anchors can be driven without drive steel failure.

The underwater erosion control mat of the present invention provides the above-mentioned and many additional objects by providing an improved erosion control mat for underwater use. The underwater erosion control mat includes a plurality of buoyant fronds attached to and controlled by a flexible frame. The frame is attached to a geotextile liner. The geotextile liner, with attached flexible frame, is then anchored to the seabed by a uniform and stable anchoring system. The geotextile liner isolates the underlying sediments.

The fronds are formed from a fanfolded polyolefin sheet with vertical folds, and vertical slits in the sheet. Small holes are cut into the base of the fanfolded polyolefin sheet for accepting either the flexible frame or a pitching string, which maintains proper frond spacing. These holes are cut at spaced intervals across the width of the fanfolded polyolefin sheet, as well as aligning in the mat's lengthwise direction, to allow for easy adjustability for various size mats.

Pitching strings located along each longitudinal perimeter of the fanfolded sheet, as well as down the interior of the fanfolded sheet, maintain desired spacing of the frond rows. An anchoring system, depending from the frame, secures the mat into the seabed.

When anchored in an area of erosion problems, or around a structure to prevent erosion, the mats act to form a frond-reinforced berm of sand/soil. As water currents encounter the mat, some of the water penetrates and is slowed down by the frond surfaces. As the water slows below transport velocity, the sand and sediment it was carrying drops down into and nearby the mat. Over time, the mat therefore fills within and around the frond rows to form a reinforced berm of sand/soil. This berm is suitable protection for submerged structures like pipelines and bridge footings. The mat is capable of withstanding severe flow conditions and algae growth while remaining firmly anchored, thus it can also be used effectively for shoreline and riverband protection and restoration.

In areas of little or no transport, small or no berms form. The mats may be used here for aquatic habitats. Fish find cover and spawn between the fronds. Algae and small organisms attach to the exposed fronds and form the nucleus of a new eco-system. Also, aquatic vegetation can become established where not previously possible. Mats provide a stable patch of riverbed/seabed, and an area of reduced currents. This allows root growth to penetrate the bed without dislodgment, and establishment of vegetation where previously not possible.

In addition to improving the mechanical stability of a mat, the liner allows mats to be used to safely cap contaminated sediments for the first time. By accumulating fresh soil on top of a contaminated "hot spot", the food chain is safer. Fish living nearby and plants growing in the newly accumulated clean soil no longer have direct access to buried dangerous chemicals, like PCB's or heavy metals, below the cap. This eliminates the toxins' entry point into the food

chain. The toxins also can no longer be resuspended during high flow events due to the protection provided by the liner and the secure and reliable anchoring system. Previous designs ignored an integral bottom liner, so underlying sediments were previously resuspended and spread during storm events. This reintroduction of toxins to the food chain posed a significant health and environmental hazard.

An alternative embodiment of the erosion control mat is one that is identical with the single exception of no liner attached. The operation is the same, but the mat is not used in a capping application. Instead it is employed where an open-bottomed mat is desirable, and the accumulated sediments are intended to mingle with the underlying sediments.

In accordance with the present invention, deployment of the underwater erosion control mat can be done in an efficient and easily completed manner. The mat arrives for installation encased in a netting, to contain the fronds, and spooled around a reusable spool and secured with straps. The spooled mat is ballasted if necessary by sliding a heavy pipe inside of the spool, and a diver then lowers it to the seabed. The first row of anchors is pounded into the bed using a hydraulic breaker with fitted driving steel. Then the spooled mat is rolled back to expose the next row of anchors, which are then driven in, and so on, until all anchors are secure. The spool and heavy ballast pipe are raised to the surface for reuse. Although bulky, a spooled mat can be easily maneuvered by divers due to its near-zero weight underwater. The preferred method allows rapid, controlled delivery in nearly any type of environment, with minimal external support required.

Thus, the erosion control mat provides an expanded-use, secure, reliable, and easy to install device. Because of improved anchor strap method and placement, improved anchoring devices, integral geotextile liner, and sturdier fronds, the improved erosion control mat provides

a myriad of new and reliable uses heretofore not possible. In addition, any commercial diver can easily accomplish installation of the mat. Such divers do not need any additional compressed air or pressured water rigs, no large cranes, no unique and expensive dispensers or frames, and no specialized vessels. Removing these other requirements greatly increases the availability of qualified divers. Divers then cost less and many potential sources of installation failure or complication are eliminated.

In sum, the present invention represents a significant improvement over the prior art in many ways. The underwater erosion control mat in accordance with the present invention allows for a secure and reliable mat that can be efficiently and easily installed, and overcomes the disadvantages of the prior art. These and other objects and advantages of the present invention will become apparent from the detailed description and accompanying drawings.

Brief Description of the Drawings

FIG. 1 is an isometric view of an erosion control mat constructed according to a preferred embodiment of the invention.

FIG. 2 is a bottom plan view of the erosion control mat shown in FIG. 1.

FIG. 3 is an isometric view, on an enlarged scale, of an anchor assembly shown in FIG. 1.

FIG. 4 is an isometric view of the installation of an erosion control mat according to one embodiment of the invention, shown partially schematic.

FIG. 5 is a cross-sectional view of a portion of the erosion control mat showing an arrangement of the pitching string according to one embodiment of the invention.

FIG. 6 is an isometric detail view partially in section, of a frame and anchor strap attachment, and a pitching string arrangement; and

FIG. 7 is a top plan view of an erosion control mat constructed according to a preferred embodiment of the invention.

Detailed Description of the Preferred Embodiment

FIG. 1 shows an isometric view of a preferred embodiment of my erosion control mat, labeled generally as 60. A flexible skeleton, or frame 10, forms the base of the mat 60 and is made from 1 inch to 1.5 inch wide synthetic strapping. The frame 10 passes through threading apertures 26 in a buoyant fanfolded polyolefin sheet 24. Attached to the underside of the frame 10 is a geotextile liner 36. Also, attached to the frame 10 are multiple anchor straps 12. At the opposite end of each anchor strap 12 is secured a respective anchor assembly 14. The anchor straps 12 extend from the frame 10 through slits 37 in the geotextile liner 36 to the anchor assemblies 14. The anchor assemblies 14 are driven into a seabed or riverbed 38 to secure the mat 60.

As can be seen in FIG. 7, frame 10 typically forms a continuous rectangularly-shaped perimeter. The frame 10 may be made up of four separate pieces of synthetic strapping, connected at each corner, although in the preferred embodiment the frame includes a fifth piece of strapping running down the center of the frame lengthwise, from end to end. The frame 10 is attached to the geotextile liner 36 by a method such as sewing, riveting, or ultrasonic welding. These attachments occur at spaced intervals along the perimeter of the frame 10 as is necessary for an adequately strong attachment. The number of required attachments is generally dependent upon the size of the mat 60 and the conditions to be incurred in use. As shown in FIG. 1, along

the longitudinal perimeters 52, 53 of the sheet 24 the frame 10 passes through threading apertures 26 in the fanfolded sheet 24, as is discussed in greater detail below. The frame 10 that runs along the front 50 and back 51 perimeters of the sheet 24 may then merely connect the frame 10 together.

As FIG. 1 shows, the exposed portion of the mat 60 consists of a rectangular length of a polyolefin sheet 24. The sheet 24 is made of a suitable synthetic polymer material having a specific gravity of less than 1.0 g/cm^3. It is preferable to use a polyolefin film with as low a specific gravity as possible, to counter the effects of algae growth on buoyancy. It is preferably a thin film polyolefin, that is preferably a homogeneous copolymer, such as a copolymer polypropylene film, preferably about .001 inch to .020 inch thick, which may or may not be foamed. A commercially suitable material, such as any of a variety of random copolymer or impact copolymer films, is available from many vendors including Exxon Chemical, Lake Zurich, Illinois, USA.

The sheet 24 is vertically slit completely through, generally at one to two inch intervals, to form single fronds 22. The slits terminate some distance, typically two to six inches, from the bottom edge 25 of the sheet 24. Threading apertures 26 are cut at spaced intervals, typically every four inches, across the width of the fanfolded sheet 24, as well as align in the mat's lengthwise direction, to allow for easy adjustability for various size mats. Threading apertures 26 located along the longitudinal perimeters 52, 53 of the polyolefin sheet 24 provide a path for the frame 10 to hold the sheet 24 securely. The sheet 24 is folded with vertical folds back and forth across the width of the mat 60 to form consecutive, continuous frond rows 20 (FIG. 7). The folds are located so as a threading aperture 26 is positioned directly on the bends

27 of the sheet to allow for threading of the pitching string 40, which is discussed in greater detail below.

The sheet 24 can be of any length and width desired to create a mat of any length, width, and height. The sheet 24 is preferably 5 feet wide to create a mat 60 with 5-foot high fronds 22. A preferable mat size is 10 feet wide by 15 feet long by 5 feet high, with a geotextile liner 36 protruding out one foot around the perimeter (i.e. geotextile liner 36 is 12 feet x 17 feet). The staggered frond rows 20 maintain spacing and density, typically desired one to three inch inter-row spacing, or pitch control, via one or more interposed synthetic pitching strings 40. The pitching strings 40 consist of a two-part loop and line assembly secured on both ends to the flexible frame 10, and passing through threading apertures 26 located on each of the bends 27 of the sheet 24 (FIG. 6).

Pitching strings 40 maintain the desired spacing between the frond rows 20 of the polyolefin sheet 24. Thus, the density of the fronds 22 can be adjusted as desired. Generally, a pitching string 40 runs along each length (longitudinal perimeter 52, 53) of the polyolefin sheet 24. At least one pitching string 40 can also be positioned to run down the center portion 54 of the polyolefin sheet 24 to help maintain center spacing as well. The number of middle pitching strings 40 needed will be dependent on the width of the frond rows 20.

As shown in FIG. 5, a pitching string 40 comprises a two-part loop and line assembly. Each pitching string 40 is secured on both ends to the flexible frame 10. Shown also in FIG. 6, each pitching string 40 includes a continuous woven lower string 44 which lies at the bottom 25 of the sheet 24. Loops 46 extend upward at spaced intervals, typically every three to four inches. An upper string 42 then is threaded through the loop 46 and through apertures 26 located at each bend 27 of the sheet 24. Threading apertures 26 are spaced up from the bottom 25 of the sheet

24 a distance approximately equivalent to the spacing between the lower string 44 and the upper string 42, generally about one inch. If the pitching string 40 is one which is run down the center portion 54 of the sheet 24, the upper string 42 will, again, be threaded through a line of apertures 26 (FIG. 5). Lines of apertures 26 are spaced throughout the width of the sheet 24 to accept either the frame 10 or the pitching string 40. The pitching strings 40 can easily be used to maintain a desired spacing and density. It is preferred to use a pitching string 40 with a spacing of three inches between loops 46 between each bend 28 on each longitudinal perimeter 52, 53, and a pitching string 40 with one and a half inches between loops 46 in the center portion 54 of the sheet 24 (FIG. 7).

FIG. 2 shows a bottom view of the mat 60 with the liner 36 that is attached by a suitable means, i.e., sewing, riveting, or ultrasonic welding (not shown), to the underside of the frame 10 (shown here in phantom). The attachment of the frame 10 to the geotextile liner 36 by one of these means can take place at intervals along the length of the frame 10 as is necessary for an adequately strong connection. The liner 36 consists of a sheet of any suitable material, preferably a woven filtration geotextile like Geotex 111F, commercially available from Synthetic Industries, Chattanooga, Tennessee, USA.

Attached to the frame 10 and extending through slits 37 in the geotextile liner 36 is an anchoring system, comprised primarily of the anchor straps 12 and the anchor assemblies 14. The number and spacing of the anchor straps 12 and their anchor assemblies 14 is variable and dependent upon the desired holding capacity. The preferred embodiment, as shown in FIG. 2, has three sets of anchor straps 12, in rows, each with four anchor assemblies 14, on a 10 foot by 15 foot mat.

As shown in FIG. 6, each anchor strap 12 depends from the frame 10 and extends through a slit 37 cut into the liner 36. The anchor strap 12 can be a 1 inch to 1.5 inch nylon strapping with 4,000 lbs to 6,000 lbs tensile strength. Each anchor strap 12 has secured to its end an anchor assembly 14. As best shown in FIG. 3, each anchor assembly 14 consists of a high-strength single piece earth anchor 18 attached by a shackle pin 28 to a shackle 16. The shackle 16 passes through a loop in the terminus of the anchor strap 12. An example of a suitable anchor is described more fully in Deike's U.S. Patent No. 4,044,513. An alternative anchoring system would be a concrete articulating mattress.

In accordance with the present invention, as shown best in FIG. 4, deployment of the underwater erosion control mat 60 can be done in an efficient and easily completed manner. After manufacture, the mat 60, being flexible, may be encased in netting to contain the fronds 22, and is then spooled around a reusable spool 32 and secured with straps. The spool 32 can be a fifteen-foot long, two-inch to six-inch diameter pipe of polyvinyl chloride ("PVC") or steel. After shipping and delivery to the work site, a spooled mat 30 is ballasted if necessary by sliding a heavy pipe inside of the spool 32, and a diver 34 lowers it to the bed 38.

As shown in FIG. 4, the divers receive the spooled mat 30, unfix the securing strap, and anchor the mat 60 into place. Fronds 22 are not shown in FIG. 4. The first row of anchors 18 is pounded into the bed 38 by any suitable means such as a hydraulic breaker with fitted driving steel. This driving action forces the entire anchor assembly 14 and anchor strap 12 down into the seabed to the depth of the anchor strap 12. An upward force on the frame 10 or the anchor strap 12 is transferred through the shackle 16 and the shackle pin 28 to the anchor 18, rotating it ninety degrees and setting it in place permanently. Then the spooled mat is rolled back to expose the next row of anchors 18. This row is driven in and so on, until all anchors 18

are secure. The spool 32 and heavy ballast pipe are raised to the surface for reuse. Although bulky, a spooled mat 30 can be easily maneuvered by divers 34 due to its near-zero weight underwater.

Although the invention has been herein shown and described in what is perceived to be the most practical and preferred embodiments, it is to be understood that the invention is not intended to be limited to those specific embodiments. It is recognized that modifications may be made by one of skill in the art without departing from the spirit or intent of the invention. Therefore, the invention is to be taken as including all reasonable equivalents to the subject matter of the appended claims.

CLAIMS

1. An underwater erosion control mat to be secured to a soilbed, the mat comprising:

a plurality of flexible fronds;

a flexible frame connected to and controlling the fronds;

a geotextile liner attached to an underside of the flexible frame;

an anchoring system depending from the flexible frame; and

a means for controlling the spacing of the fronds.

2. The mat of claim 1 wherein the flexible fronds are formed from a sheet of polyolefin film which is partially slit at spaced intervals.

3. The mat of claim 2 wherein the sheet of polyolefin film is bent back and forth across the geotextile liner to form rows of fronds.

4. The mat of any one of the preceding claims wherein the controlling means is at least one pitching string which runs the length of the mat.

5. The mat of claim 4 wherein the pitching string is comprised of a two-part loop and line assembly.

6. The mat of any one of the preceding claims wherein the anchoring system comprises at least one anchor strap depending from the flexible

frame, wherein the anchor strap ends in an anchor, and the anchor is driven into the soilbed to secure the mat to the soilbed.

7. The mat of any one of the preceding claims wherein the geotextile liner is attached to the underside of the flexible frame by means such as sewing or riveting.

8. The mat of any claim directly or indirectly dependent from claim 2 wherein the anchoring system depends from the flexible frame and extends through slits in the geotextile liner.

9. The mat of any one of the preceding claims wherein the flexible frame is a flexible synthetic open grid.

10. The mat of any claims directly or indirectly dependent from Claim 2 wherein the sheet of polyolefin film is a homogenous copolymer whereby structural integrity of the fronds is maintained over time.

11. The mat of any claim directly or indirectly dependent from claim 2 wherein the sheet of polyolefin film is composed of a copolymer polypropylene film.

12. The mat of any claim directly or indirectly dependent from claim 2 wherein the sheet of polyolefin film is foamed.

13. An underwater erosion control device to be secured to a soilbed, the device comprising:

a plurality of flexible fronds, wherein the flexible fronds are formed from partial slits cut into a sheet of polyolefin film;

rows of fronds formed from the sheet of polyolefin film being bent back and forth across the width of the device;

a flexible frame connected to and controlling the fronds;

an anchoring system depending from the flexible frame; and

a means for controlling the spacing of rows of fronds.

14. The device of claim 13 wherein a geotextile liner attaches to the underside of the flexible frame.

15. The device of Claim 13 or 14 wherein the anchoring system comprises at least one anchor strap depending from the flexible frame, wherein the anchor strap ends in an anchor, and the anchor is driven into the soilbed to secure the device to the soilbed.

16. The device of any one of claims 13 to 15 wherein the anchoring system depends from the flexible frame and extends through slits in the geotextile liner.

17. The device of any one of claims 13 to 16 wherein the geotextile liner is attached to the underside of the flexible frame by means such as sewing or riveting.

18. The device of any one of Claims 13 to 17 wherein the sheets of polyolefin film is homogenous copolymer whereby structural integrity of the fronds is maintained over time.

19. A method of installing an underwater erosion control mat that is spooled and secured around a spool into an underwater bed of soil, the method comprising the steps of:

lowering the spooled mat into the water;

forcing a first row of anchors into the bed of soil;

rolling the spooled mat back to expose a next row of anchors;

forcing in the next row of anchors into the bed of soil; and

continuing the processes of rolling back the spooled mat and then forcing the next row of anchors until all anchors are driven into the bed of soil.

20. The method as defined by claim 19, which further comprises the step of unfixing the securement of the spooled mat after the spooled mat is lowered into the water.

21. The method as defined by claim 19 or 20 wherein the steps of forcing the rows of anchors into the bed of soil are carried out by pounding the rows of anchors into the bed of soil.

22. The method as defined by any one of claims 19 to 21 which further comprises the step of raising the spool to the surface of the water after installation of the mat is completed.

23. An underwater erosion control mat substantially as described herein with reference to the accompanying drawings.

24. An underwater erosion control device substantially as described herein with reference to the accompanying drawings.

25. A method of installing an underwater erosion control mat substantially as described herein with reference to the accompanying drawings.

Application No: GB 9925833.7 **Examiner:** Guy Robinson
Claims searched: 1 to 18 **Date of search:** 16 February 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): E1H HJA

Int Cl (Ed.7): E02B 3/04, 3/12

Other: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2,127,469	(WILLIAM M GARRETT)	-
A	US 4,337,007	(ROBERT A SMITH)	-
Y	WO 97/48857	(MARINE ENVIRONMENTAL SOLUTIONS) page 8 lines 18 to 35 page 9 lines 1 to 13 page 11 lines 31 to 36 page 18 lines 27 to 36 and page 19 lines 1 to 14	1, 13
Y	WO 97/48856	(MARINE ENVIRONMENTAL SOLUTIONS)page 3 lines 3 to 19, page 10 lines 13 to 29 and figs 4 & 6	1, 2, 13,
Y	WO 85/03318	(PETER ALSOP) page 3 lines 12 to 20, page 5 lines 1 to 25 fig 3	1,13

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.