United States Patent

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[54] **COMPOSITE STRUCTURE**
7 Claims, 1 Drawing Fig.

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[50] Field of Search .... 61/3, 4, 5, 1, 2; 28/76 T

[56] **References Cited**

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3,188,813	6/1965	Foster et al.	61/5
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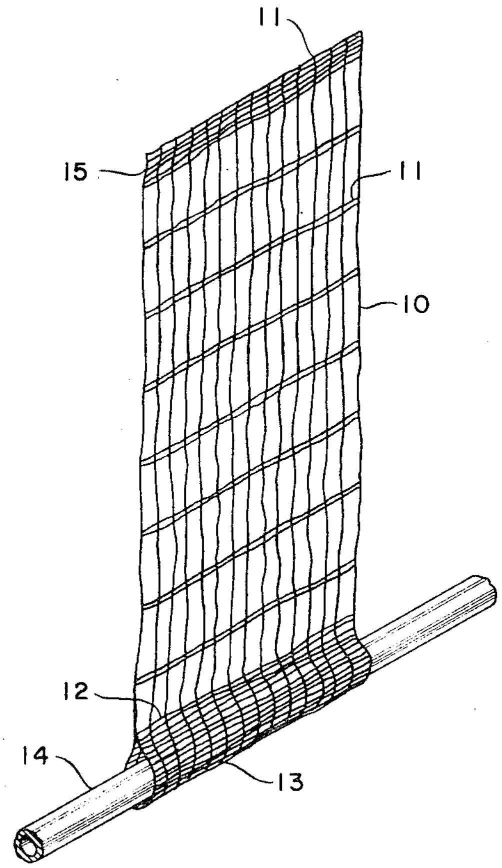
ABSTRACT: An improved form of "artificial seaweed" for combating coastal erosion and the like comprises an anchored array of seaweed elements which are buoyant, water-resistant filamentary strands, preferably of foamed, stretched polyolefin having an internal plexiform structure surrounded by a substantially closed, thin skin. The structure as manufactured has water-decomposable filaments, such as of polyvinyl alcohol, interwoven at spaced intervals with the water-resistant seaweed elements to provide a more easily handled and transportable composite article. In a preferred mode, the lower ends of the seaweed elements are interwoven with transverse, water-resistant filaments to provide a fabric, preferably in tubular form, which is readily attached to an anchoring element or converted into an anchoring element by being filled with cement or sand.



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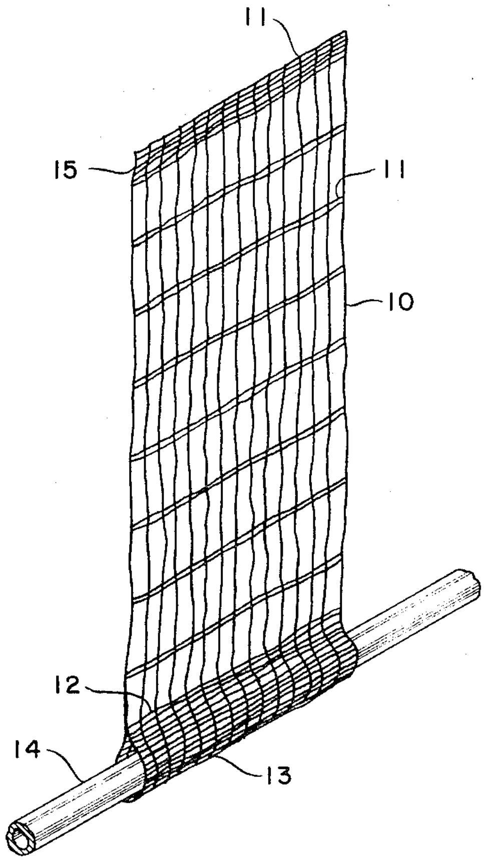

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COMPOSITE STRUCTURE

This invention is directed to an improvement in artificial seaweed, comprised of assemblages of buoyant, water-resistant synthetic polymer strands. Such assemblages are useful as a means for influencing the migration of material at the bottom of bodies of water, as in combating coastal erosion.

As known heretofore and described, for example, in U.S. Pat. No. 3,299,640 to Nielsen, such a protective assemblage of artificial seaweed may consist of a wide screen formed by a large series of filamentary plastic elements or strands which are secured at one end to an anchoring means to be placed at the bottom of the sea. The strands have a lower density than water so that the screen formed of these elements will assume and retain an upright position in the water, thereby reducing currents in the surrounding water and promoting the deposition of sand or other solid materials entrained by the water. Erosion of sea floors in coastal waters, which is sometimes a serious problem in the absence of sea vegetation, can thus be successfully combated. A similar problem is experienced with structures erected on the sea bottom, like landing stages, piers and fixed drilling platforms, where strong currents and turbulence around the foundation piles and beams may erode the sea bottom and wash out the foundation. By providing a zone protected by artificial seaweed around the bottom end of the support members of the foundation, the scouring action of the sea no longer endangers the stability of the foundation.

The filamentary elements known heretofore can be formed by a plurality of single or composite strands of a thermoplastic material. The strands may be solid material if the density of this material is less than that of water. It has also been proposed to use single hollow fibers closed at either end.

A preferred form of strands, disclosed in copending application Ser. No. 778,757, filed Nov. 25, 1968, consists of elongated, flexible, buoyant strands, such as filaments or tapes having an open plexiform network structure surrounded with a substantially closed, thin-walled skin, such as are formed by extruding multicellular foam strands of a pololefinic material having a density less than 300 g./l. and subsequently stretching the strands in a ratio of at least 5:1. The strands are preferably made of polypropylene. In spite of the open internal structure of the elements, no substantial volume of water can penetrate into them because they have a relatively unbroken outer skin and because polypropylene is a non-water-absorbent material. The air within the elements remains entrapped even under relatively high fluid pressures and continues to contribute greatly to the buoyancy of the elements.

It is desirable that the seaweed, once installed under water, has its strands extending freely and independently, forming a kind of screen in the water. This structure could be obtained by securing the strands individually in side-by-side arrangement, rather than in groups or bundles fastened jointly at spaced locations. Unfortunately, individual attachment of the lower ends of the strands to anchoring means in a regularly spaced side-by-side relationship is complicated and expensive and is therefore unsatisfactory or unacceptable for commercial utilization since these articles are typically required in very large volumes to protect an extensive coastal area and hence only low-cost, easy-to-produce materials are feasible for this purpose.

One problem experienced with such artificial seaweed during its transport, handling and laying on the bottom of the sea is that the elongated elements or strands easily become entangled. This will be understood if it is realized that the strands are from 1 to 3 or more yards long. To avoid this problem, the strands could be tied together at regular intervals along their length to reduce the freely movable length of the strands, but this solution is unacceptable since for its underwater service the seaweed should have its strands extending freely and independently.

It is an object of this invention to provide an artificial seaweed of which the strands are restrained so as not to become knotted and entangled during handling or placement, and which nevertheless, once installed under water, will be capable of performing like a seaweed having individually mounted strands. It is a further object to provide a simple arrangement for anchoring strands in a regular and parallel pattern.

The invention provides an artificial seaweed comprising a plurality of elongated, flexible, buoyant elements of a synthetic thermoplastic material, preferably cellular polypropylene, secured to anchoring means adapted to maintain the elements near the bottom of a body of water and interconnected at spaced intervals along their length by filaments of a water-decomposable material.

In a preferred mode, the elements are interwoven at one end with suitable water-resistant filaments to form a fabric strip to which anchoring means are secured, adapted to maintain the elements near the bottom of a body of water.

The woven structure at the lower end of the seaweed can be such as to ensure a parallel side-by-side arrangement of the strands for forming under water a wide continuous screen of strands; if formed of water-insoluble crossing filaments, it reinforces the lower ends of the strands permanently and provides a simple, strengthened method of connecting the anchoring means to the strands.

In the drawing, the sole FIGURE illustrates a preferred structure according to this invention. The drawing is not to scale.

Foamed strands suitable for conversion to the articles of this invention are produced by the methods described in detail in Netherlands Patent applications No. 6,511,455, published Mar. 3, 1967 and No. 6,610,834, published Feb. 5, 1968. In these methods, polypropylene is admixed with a volatilizable fluid blowing agent which expands when a melt of polypropylene and blowing agent is extruded into a zone of lower pressure, e.g., from an extruder into the atmosphere. A small proportion of a chemically decomposable blowing agent may be present as a foam-nucleating agent for the volatilizable fluid blowing agent. The extruded polypropylene foam strands have a cellular structure. The extrusion conditions are controlled to provide strands having a measured density of no more than 300 g./l. The extruded, unstretched strands are relatively weak, having typically a tensile strength of about 0.1 g./denier. After being stretched at a ratio of at least 5:1, the strands have an open, plexiform structure rather than a cellular structure, and have a greatly improved tensile strength, for example, between 1 and 5 grams per denier. Therefore, the stretched foam strands are tens of times stronger than the unstretched foam strands. The improved tensile strength is not only of importance to prolong the useful life of the seaweed under water but also to avoid excessive waste by breakage during manufacture of the seaweed, when the elements are being tied to an anchoring device, and during the subsequent handling and transportation.

The stretching is suitably performed at elevated temperatures, for polypropylene usually between 110° and 165° C. The stretching ratio of the extruded foam strands may be between 5:1 and 15:1, and preferably between 7:1 and 10:1.

In practice, such stretched and extruded polypropylene foam strands were found to perform very well as an artificial seaweed; the problem of vulnerability and easy breakage experienced with unstretched foam strands was overcome by the stretching operation. Although the density of the foam strands increases when being stretched, this imposes no problem at all since the density of the stretched elements still remains below 500 g./l., and hence much less than that of water. For example, isotactic polypropylene (melt index 8) foam strands having a density after extrusion of 34 g./l. were stretched at a ratio of 13:1 at 164° C. and thereby obtained a final density of 178 g./l. In another case, a polypropylene foam strands with a density of 28 g./l. were stretched at a ratio of 9:1 at 162° C., resulting in a final density of 107 g./l.

The final density of a stretched foam strand was calculated by determining its weight and volume, the latter established by submersion in a water bath. Since the strands have their open net structure surrounded with a predominantly closed skin, little water will penetrate into the strands. However, since the volume measurement was made using a relatively short piece of strand, the water that might enter the strand at the ends thereof, where no protective skin is present, might influence the volume measurement too much, and for this reason, the ends of the sample strand had been sealed.

The foamed strands are suitably in the form of tapes having in cross section a greatest dimension of 2—2.5 mm. and a smallest dimension of 0.5 mm. Generally, satisfactory dimensions for the strands are a width between 1 and 10 mm. and a thickness between 0.25 and 4 mm.

The term "water-decomposable material" as used in this specification and claims refers to material which, in a short period of time relative to the useful like of the seaweed, decomposes under water by chemical, physical or biological action, so that the filaments made of this material will lose their coherence and strength and thereby no longer hold the elongated elements together. As a result, the elongated elements in the underwater seaweed will soon obtain independent mobility relative to the other elements and will then remain connected only at their lower ends near the anchoring means of the seaweed.

Suitable materials are natural or synthetic cellulose fibers, in particular paper, and water-soluble materials, in particular polyvinyl alcohol or alginates.

It is desirable that the filaments decompose as early as possible, and therefore the filaments are normally made so that they will decompose under water within 24 hours.

In general, water-soluble materials have the shortest decomposition time, which may be less than 1 hour. However, in regard of the long useful life of plastic seaweed, which may be many years, a decomposition time of several days or even a few weeks is acceptable. Since thinner filaments will decompose more quickly than thicker ones, the filaments are preferably made as thin as is permissible to keep the strands together during handling, it being understood that little or nor harm is done if a few of the filaments break during this period.

Preferably, the lower ends of the strands are interwoven with other strands or threads of the same or a different nondecomposing, i.e., water-resistant, material to form a fabric strip to which the anchoring means can be connected. This article could be produced on a weaving loom, in which the strands of the seaweed are weft and the threads through the lower ends of the strands are the warp, thus making fast and continuous production possible.

If the strands, as has been heretofore usual, were to be interconnected only at their lower ends, the continuous production of the seaweed on a loom would result in various complications, for example, because the seaweed cannot be woven without a selvage of both ends, so that the selvage at the upper end of the seaweed must be removed later in order that the strands be free.

It would be possible to weave the seaweed on the loom with a selvage at both sides, whereupon the product is cut midway between and parallel to the sides so that two seaweed structures are formed, each with one selvage only. This practice is satisfactory for making seaweed having relatively short strands of, say, 1-meter length. However, the width of the loom imposes restrictions on the length of the strands, and for many applications of the seaweed it is desirable to employ strands which are longer than half the width of the loom.

Furthermore, it is not practical to weave a structure having only its sides formed as a fabric and having a large central area of unwoven parallel strands.

For these reasons, the present invention offers an important advantage because the warp area in the loom can be extended with the decomposable filaments, so that the weft over its entire length (although in general only at intervals thereof) will be woven through the warp. In particularly, a few of the decomposable filaments can be located at the upper ends of the strands forming together with these upper ends a selvage during the weaving operation. Thus, the matlike structure of the seaweed apart from being easier to handle also provides a possibility of producing the seaweed continuously on a loom.

The filaments are woven through the strands at regularly spaced intervals, for example, of 5, 10 or 20 cm. each. The magnitude of the spacing is mainly dependent on weaving requirements. At each interval, one or a few of the filaments are woven through the strands.

If the strands extend parallel to each other, a matlike structure is obtained which is easiest to handle. These mats may be laid one on top of the other during storage and transport without danger of entanglement, or the mat may be made in a continuous length and wound on a roll for storage.

In the preferred mode, the lower end of the mat is made in the form of a woven strip of water-resistant filaments. The woven water-resistant strip can be relatively narrow, a few centimeters width generally being sufficient. The transverse strands, as well as the filamentary elements, are suitably made of extruded foamed and stretched polypropylene as described above, which can be woven to form a strong fabric. In order to maintain the seaweed anchored to a sea floor, the fabric strip may be connected to weights such as blocks of concrete or metal bars, chains, or cables. In a preferred embodiment, the fabric strip is formed as a hollow, tubular seam through which a cable, chain or bar is inserted. In that case, there is no need for additional means for tying the seaweed to the anchoring means. If desired, the seaweed is transported to the water without the anchoring means, and on the working site chains or other elongated anchoring means are inserted into the hollow seams. The tubular seam can be woven tight enough to form a hose able to contain a liquid cement mixture which is poured or pumped into the hoselike seam and is allowed to harden therein to form the anchoring means. For this purpose, the seaweed can be laid on the sea floor in a continuous length with one end thereof terminating on a beach or barge, from where the liquid cement is pumped into the hollow seam of the seaweed over the entire length thereof. Instead of cement, a water/sand mixture can be pumped into the hose, the water escaping through the wall of the hose.

The use of a liquid cement filling for the fabric tube allows the seaweed to be laid continuously and quickly. Moreover, the cement-filled tube of the seaweed easily sets itself in conformity with the profile of the sea floor, and the tube will assume an elliptical cross section with the long axis directed horizontally so that the forces acting upon the tube by underwater currents are relatively small and the tube is less likely to be displaced.

The tubular seam can be formed by first weaving a straight fabric strip, and then laying the longitudinal edges of the strip one on top of the other and fastening them together by sewing or otherwise. However, the fastest and preferable method is to weave the strands directly with a loop at their ends, whereby the seaweed is provided in the weaving operation with a fabric hose at its bottom end.

In the drawing, the seaweed comprises a large number of elongated, thin, flexible elements 10 extending in a substantially parallel arrangement. Preferably the elements 10 are formed from extruded strands of foamed polypropylene having a density of less than 300 g./l. which have been subsequently stretched to at least five times their original length; typically they are 2 to 2.5 mm. wide and from 1 to 3 meters long.

The strands 10 are tied together with polyvinyl alcohol filaments 11 typically having a diameter of approximately 0.2 mm., woven through the strands at intervals of a few centimeters.

The lower ends of the strands are interwoven with other strands 12 identical to strands 10. Thus, a fabric strip 13 is formed at the lower end of the seaweed to which anchoring means can be securely attached which, in the water, hold the vertically extending strands in a regular horizontal spacing with the desired number of strands per unit length horizontally of the seaweed, for example 5 strands per centimeter. The fabric strip 13 is suitably formed as a fabric tube, which when laid flat, has a width of, for example, some 15 cm. In the drawing, a bar **14** of the kind used for reinforcing concrete has been inserted through fabric tube **13**. As stated before, the tube can instead be filled with cement, a cementitious mixture, or sand.

Four bars **14**, having the seaweed connected thereto, may be joined by welding or otherwise to form a horizontal square or rectangular unit in which each of the four sides is provided with seaweed. Larger units may comprise several squares or rectangles, all having seaweed on their sides, encompassing a large area of sea floor. The seaweed may also be formed so that the fabric tubes thereof together form a ladder structure, bars or other anchoring means being inserted in the steps and/or sides of the ladder.

The seaweed before it is laid under water can be handled like a coherent body, but once under water the polyvinyl alcohol filaments **11** will dissolve and thereby release the strands **10**, which then remain connected only at their lower ends.

The seaweed is formed on a loom, whereby at the upper end of the seaweed a salvage **15** is formed by the upper ends of the strands **10** and a series of the filaments **11**. During the weaving of the seaweed structure, the strands **10** are used as the weft, so that the strands **10** are formed by one continuous length of strand. Therefore, in the installed seaweed after the filaments **11** have disappeared therefrom the strands **10**, in fact, are elongated loops. However, if desired, the upper ends of the loops are cut so that each loop will result in two individual strands.

I claim as my invention:

1. An article adapted to be anchored as a means for influencing the migration of material at the bottom of bodies of water, comprising a coherent structure of elongated, flexible, buoyant strands of synthetic water-resistant material interconnected at spaced intervals along their length by filaments of water-decomposable material, said water-resistant strands being, at one of their ends, interwoven with other water-resistant strands to form a fabric strip adapted to be secured to anchoring means.

2. An article according to claim **1** wherein said buoyant strands are polyolefin strands having a tensile strength of at least 1 g./denier and an internal plexiform structure surrounded by a substantially closed, thin skin, and said filaments of water-decomposable material are composed of polyvinyl alchohol or cellulose fibers.

3. An article according to claim **1** in which said buoyant strands are interconnected by said filaments in parallel arrangement to form a matlike structure.

4. An article according to claim **2**, in which said strands and filaments form a woven structure which has been formed on a loom with the filaments being the warp and the strands being the weft.

5. An article adapted to be anchored as a means for influencing the migration of material at the bottom of bodies of water, comprising a coherent structure of elongated, flexible, buoyant strands of synthetic water-resistant material which strands, at one of their ends, form a fabric strip in a tubular form.

6. An article according to claim **5** wherein said water-resistant strands are interconnected at spaced intervals along their lengths by filaments of water-decomposable material.

7. An article according to claim **2** wherein said polyolefin is polypropylene.