Aug. 13, 1968 B. A. LAMBERTON 3,396,542

METHOD AND ARRANGEMENTS FOR PROTECTING SHORELINES

Filed Oct. 5, 1965

FIG. 1

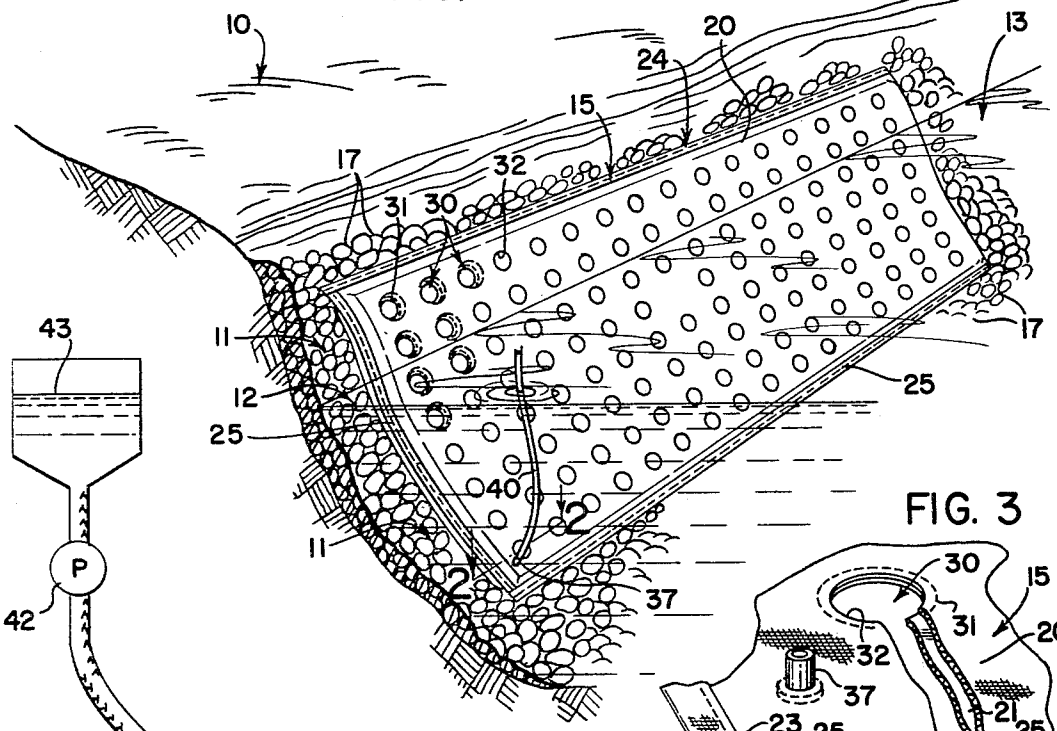
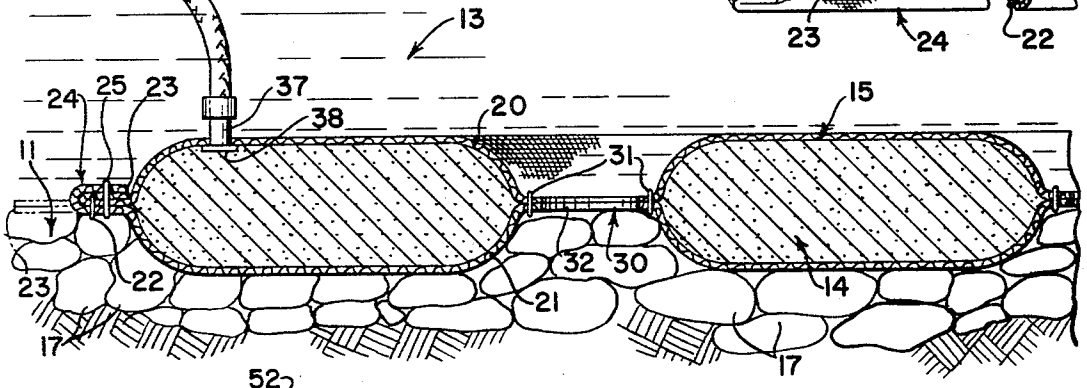


FIG. 3

FIG. 2



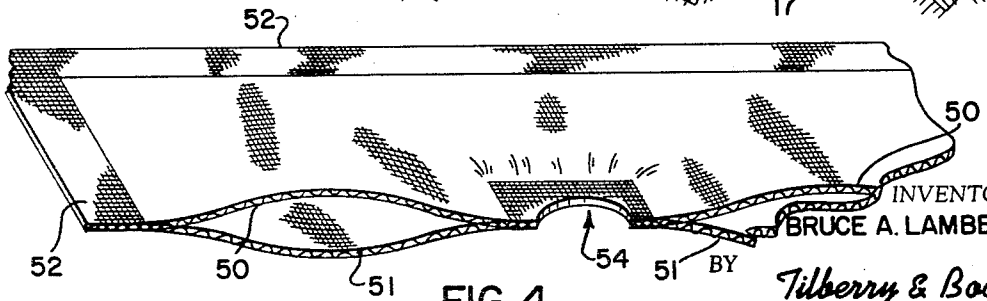


FIG. 4

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METHOD AND ARRANGEMENTS FOR PROTECTING SHORELINES

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ABSTRACT OF THE DISCLOSURE

A pair of large sheets of flexible material at least in part porous are joined around their entire outer periphery. The sheets have a plurality of aligned openings therethrough and the two sheets are joined together around the periphery of the openings thereby to define a fully enclosed interior space. A cementitious slurry is injected into the space between the two sheets.

This invention pertains to the art of protecting shorelines from wave action and more particularly to a mat arrangement for such a shoreline and a method of positioning same.

Heretofore it has been conventional in order to protect the shoreline of a large body of water subject to wave action to place articles or structures along such shoreline of sufficient mass that the maximum wave action, e.g. during a storm or the like, cannot move such structures from their intended position.

One such arrangement is a concrete wall. However, such walls require first the construction of a cofferdam, then the placing of rigid forms, pouring of the concrete, and the removal of the forms and the cofferdam. This is a very expensive operation. Also, such a wall receives the full impact of each wave and must be constructed very ruggedly if it is to withstand repeated wave action without cracking. Further waves tend to undermine and crack such walls.

Another arrangement has been to place a large number of large boulders or concrete slabs each weighing a ton or more in side by side relationship along such shoreline. In the case of large boulders, they are difficult to procure. In the case of concrete slabs, they must be manufactured on the shore, and in either event the boulders or the slabs must be hauled over long distances to the shoreline to be protected and then must be lowered into position and accurately placed. Such an operation is not only expensive but can be extremely dangerous if, for example, there is considerable wave action present at the time that the boulders or slabs are being placed into position.

The present invention contemplates an arrangement for protecting a shoreline subject to wave action which overcomes all of the above referred to difficulties and others and which enables the protection to be placed in position with a minimum of danger, a minimum of cost, and a maximum degree of protection. The invention primarily uses a cementitious slurry and a form at least in part porous.

"Slurry" as used herein means any liquid suspension of solid particles of a size varying from one micron up to and including .005 inch capable of being pumped through pipes or conduits for distances of from one to any number of feet required for the particular operation to be carried out. The slurry may also include various substances for lubricating the particles so that they will slide more easily one over the other or for assisting in maintaining these particles in suspension. The slurry may also contain granules larger than these particles above

referred to, but these will normally be referred to as an aggregate.

A cementitious slurry or grout is one where some of the particles are of a type such as Portland cement, which will react either with other particles or with the liquid or both to form a solid. The grout, when it hardens, is called hardened cement or concrete. Concrete generically includes hardened cement whether or not it contains an aggregate.

Water-cement ratio is the ratio of the weights of the water and all cements used in the slurry. Pozzolans are normally considered equivalents to or substitutes for cement and when employed in the slurry are considered a cement in calculating the water-cement ratio. Sand or aggregate may then be added to the mix in amounts that will be suspended therein but this does not alter the water-cement ratio.

Setting up as applied to a cementitious slurry means where water-cement ratio has either been reduced sufficiently or the cement has hydrated sufficiently or both that the mixture has completely lost any flow characteristics but has little physical strength. The strength is obtained by the ultimate hydration of the cement particles. Setting up may take place in as little as ten minutes, particularly when the water-cement ratio is reduced as with the present invention, while hydration may take days or weeks to go to completion. Grout which has set up and then completed at least a substantial part of its hydration will be referred to as "hardened."

The present invention attempts to make beneficial use of a phenomenon which has long plagued the field of pressure grouting, namely, that when it is attempted to fill cracks and voids below the earth's surface with concrete by using pressure to force a cementitious slurry through the cracks and into the voids, the particles in the slurry block up the cracks even though of a width larger than the largest particle size in the slurry and prevent the further movement of the particles through the cracks into the remote voids. Apparently two or more of the particles in attempting to go through a crack at the same time bridge the crack thus restricting its opening. Thereafter, smaller particles bridge this restricted opening in the same manner until very quickly even the cement particles having a size on the order of 10 microns will not pass through the openings. In effect, the various particles in the slurry form a "filter bed" to prevent the passage of any particles of any size. This filter bed effect can take place quite rapidly and once it starts nothing can prevent its continuing. If the pressure is maintained, however, water will still pass through such filter bed carrying with it an insignificant amount of the cement particles such that the cement particles upon hydration have no or an insignificant strength and no stabilizing effect on the surrounding soil. Heretofore the passage of the water into the voids beyond the filter bed without also carrying sufficient cement particles to improve soil characteristics was considered quite detrimental.

The present invention uses this "filter bed" phenomenon to good advantage. Thus, it is known that the higher the water to cement ratio employed, the easier it is to pump the slurry particularly over long distances.

It is further known that a water-cement ratio below about .35 sets up very rapidly.

It is also known that for most portland cements the final water to cement ratio should not be less than 0.25, which is the minimum required for complete hydration of the cement.

In accordance with the present invention, a large monolithic concrete mat or slab is manufactured in situ using a cementitious slurry along the shoreline to be protected,

such mat or slab having a large number of transverse passages therethrough of a size to allow the moving water in a wave to circulate freely therethrough. Preferably but not necessarily so, the shoreline under such mat or slab is previously lined with a large number of rocks of a size which are easily handled by one man, or as a bulk material, e.g., from 25 to 100 lbs., and which rocks are usually indigenous to the area where the shoreline must be protected, and thus need not be hauled long distance. Further, if desired, grid reinforcing steel members or other tensile members may be embedded in the slab to prevent the slab from breaking apart as a result of stresses induced by extreme forces such as wave action.

Further in accordance with the invention, a form for manufacturing in situ large concrete mats or slabs using a cementitious slurry on the shoreline to be protected is provided, comprised of a pair of large sheets of flexible material at least in part porous joined around the entire outer periphery and having a large number of aligned openings therethrough of a size through which water in a wave can freely move and with the sheets being joined around the periphery of each opening. Normally the sheets are a loose woven or porous fabric of a high strength material such as nylon, orlon or the like. Such a fabric is porous over its entire surface.

Further in accordance with the invention, a long, wide and relatively thin flexible closed form at least in part porous, is transported to the situs of the protection, spread out to its maximum dimensions and sunk into position. Thereafter, a flowable cementitious slurry or grout is pumped into the inside of the form. This pumping is continued until the form is filled. The pumping may then be continued, in which event a pressure builds up on the inside of the form which attempts to force the slurry through the pores thereof. The particles of the slurry quickly block up the pores of the surface sufficient to prevent passage of any substantial amount of the particles through such pores, and thereafter form a filter bed through which the water of the slurry can pass while the particles are retained on the inside of the form. The pumping is continued until sufficient water has passed through the pores such that the water-cement ratio of the cementitious slurry which originally would have been on the order of .45 to .60 is reduced to around .25 to .35. At these water-cement ratios, the slurry is no longer flowable and quickly sets up. Thereafter, the cement can harden in a known manner.

This form may have steel reinforcements placed therein before closing the form or the slurry may contain fibrous material such as nylon strands or both.

A further object of the invention is the provision of a new and improved arrangement for protecting the shores of a water body from wave action which does not require the transporting of large individual masses or the building of cofferdams or the like.

Another object of the invention is the provision of a new and improved concrete mat for protecting the shores of a water body from wave action which enables the moving water or the waves to move freely therethrough but at reduced velocities.

Another object of the invention is the provision of a new and improved method of manufacturing a concrete mat or slab in situ where it is desired to protect a shoreline from wave action, which method is simple, nonhazardous, and economical.

Still another object of the invention is the provision of a new and improved form which enables a concrete slab to be manufactured in situ along the shoreline of a water body.

The invention may take form in certain parts and arrangements of parts, and certain steps and combinations of steps, a preferred embodiment of which will be described in detail in this specification and illustrated in

the accompanying drawings which form a part hereof and wherein:

FIGURE 1 is a fragmentary perspective view of the shoreline of a water body having a slab constructed in accordance with the present invention in position therealong;

FIGURE 2 is a cross-sectional view of FIGURE 1 taken approximately on the line **2—2** thereof;

FIGURE 3 is an enlarged fragmentary view of a corner of the form with portions broken away to show the construction thereof illustrating a preferred embodiment of the present invention; and

FIGURE 4 is a fragmentary perspective view of an alternative arrangement for a form.

Referring now to the drawings wherein the showings are for the purposes of illustration only and not for the purposes of limiting same, the figures shows a fragmentary portion **10** of a shoreline of a water body **13** having a surface **11** sloping downwardly under the surface **12** of the water and having a concrete mat **14** positioned on the sloping surface **11** and extending from a point above the surface **12** to a point therebelow.

It will be appreciated that the surface **12** may vary up and down as, for example, due to tides or as the water is piled up against the bank by means of wave action and the like. Also, the surface **12** is shown as being flat, but it will be appreciated that this surface is subject to being roughened by means of wave action, damage from which the present invention is intended to prevent.

In accordance with the preferred embodiment of the invention, the surface **11** is first covered with a large number of rocks **17** having a weight preferably varying between 10 and 100 lbs. which are transported to the shoreline and positioned by any desired means, e.g., hand placing or dumping from barges or shovels.

The concrete mat **14** of the invention is manufactured in situ by first providing a form **15** comprised of a pair of large sheets **20, 21** of flexible, porous, woven fabric material. These sheets **20, 21** are placed in side-by-side parallel relationship and the entire periphery is stitched together as at **22** along a line spaced slightly inwardly from the outermost edges **23**. This resultant edge is then folded over as at **24** and again stitched with stitching **25**. Obviously other methods of joining the edges **23** of the sheets may be employed. Thereafter, the two sheets **20, 21** have a plurality of aligned openings **30** formed therethrough, and the entire periphery of each sheet defining such openings **30** is then joined together as by stitching **31** spaced slightly outwardly from the edge **32** of the openings **30**. These openings **30** are formed preferably by a punching operation.

Obviously the edges of the shets and the openings may be held together by other means. Thus, as is shown in FIGURE 4, the two sheets making up the form can be woven simultaneously with the center parts **50, 51** of the sheets separated and with the edges **52** integrally joined by weaving together. Periodically the portions of center parts of the two sheets are woven together as at **53**. Subsequently the centers of these portions **53** are cut out as at **54** leaving a border woven together. The strands making up the sheets have maximum stress in the interwoven portion **52, 53** immediately adjacent the closed space defined by the sheets. The strands at these portions are preferably double or triple filament strands to give maximum strength at this point of high stress.

The size of the openings **30** may be as desired, but in accordance with the preferred embodiment the diameter of the opening is 3". With such a size opening, the stitching **31** will be located approximately 1" from the edge **32** of the openings **30**. Any number of openings **30** may be provided in the form **15**, but in the preferred embodiment the openings are located so as to have their centers spaced approximately 13". Obviously other spacings may be employed either greater or less than that specified. In

general, the openings may be from 1" to 10", and the spacing should be such that the distance between the centers is from 3 to 10 times the hole diameter.

The form **15** may have any desired external dimensions, but preferably should be of a dimension which is readily handled, e.g., 50 feet long and 20 feet wide. Obviously if an area larger than one form must be protected, a plurality may be used laid end-to-end or side-by-side. If desired, adjacent forms may be stitched or otherwise fastened together.

The strands of the fabric may be made from any desired material having the requisite strength to withstand the hydraulic pressures ultimately to be used to inflate the form. Obviously, the forces developed will depend upon the diameter of the cross section of the inflated form as well as the hydraulic pressure to be employed. Normally, animal and vegetable fibers do not have adequate strength. Additionally, they are readily wetted by the water of the slurries to be used. Accordingly, the synthetic fibers such as nylon, orlon or other materials are preferred. These materials not only have the characteristic of not being wetted by water, but they have the characteristic of having substantial elasticity and an ability of one strand to slip relative to its cross strands of the weave so that when the strands are placed under tension by the hydraulic pressure, they will slip and form a regular weave and additionally will elongate sufficiently as to distribute the tension equally through all of the strands in the weave.

A nylon fabric is preferred having the following characteristics:

23 x 21 thread count, 840 denier, single ply, plain weave. Such a fabric has rather large pore openings of approximately 1/32 inch and tensile strengths of 393 x 321 pounds per square inch respectively.

The form **15** is also provided with a plurality of conduits through the fabric through which a cementitious slurry can be pumped into the inside of the form. This conduit may take any one of a number of different forms, but in the preferred embodiment is comprised of a tube **37** having a flange **38** on its inner end inserted between the individual strands of the fabric prior to the form **15** being stitched together. This tube **37** may have suitable means not shown for detachably coupling to a hose **40** which extends to a remotely located pump **42** in turn connected to a source of cementitious slurry **43**. This pump **42** and cementitious slurry source **43** may be located on a boat or on the shore.

It will also be appreciated that it is possible to simply have the hose **40** terminate in a smooth pointed nozzle which is inserted between the strands of the fabric and then sufficient force maintained on the nozzle to prevent its being forced out of the fabric due to the hydraulic pressure developed on the inside of the form **15**. The amount of force required will depend upon the amount of pressure required and the area of the nozzle which is inserted between the strands of the material.

To carry out the invention, the stones **17** are first carried to the desired shoreline to be protected and dumped or otherwise placed on the surface **11**. These stones may be placed to any desired depth. Thereafter, the form **15** is spread out to its maximum dimensions and located generally over the desired situ which is to be protected. The form **15** is sunk into place by means of weights or anchoring ropes. Thereafter, a cementitious slurry is pumped into the inside of the form **15**. A preferred slurry is as follows:

Portland cement—2 cubic feet or 188 pounds
Sand—3 cubic feet or 330 pounds
"Intrusion-Aid" manufactured by Concrete Chemicals Co.—2⅝ pounds
Pozzolans in the form of fly ash—1 cubic foot or 75 pounds
Water—15 gallons or 118 pounds

Obviously, other ingredients may be employed.

It will be appreciated that in the trade pozzolans are considered as cementing materials and if pozzolans are omitted, then an equivalent amount of Portland cement should be added. It is known that it is possible to substitute from 15–50% of the pozzolans for the Portland cement without adversely affecting the qualities of the hardened cement.

The Intrusion-Aid contains small amounts of an aluminum powder which reacts with the cement as it hardens to produce minute quantities of gas which result in an expansion action to counteract the normal setting shrinkage of sand-cement slurry. The Intrusion-Aid also contains other ingredients for assisting in maintaining the flow characteristics of the slurry as it is pumped over long distances and also for helping to maintain the particles in suspension.

Such a slurry as above described has a water-cement ratio based on weight of approximately 0.45. Such a slurry in the absence of accelerators will normally require approximately 24 hours to set up.

As will appear, more water, i.e., a higher water-cement ratio may be employed because using the invention this excess water is bled off through the walls of the form leaving a much lower and quicker setting water-cement ratio.

The cementitious slurry is pumped into the form **15** through one or a plurality of points until the entire form **15** is filled with the slurry. Thereafter, the pumping is continued until a pressure is built up. Some of the particles of the slurry are forced through the pores of the fabric. However, the particles of the slurry appear to bridge over the pores and prevent the passage of further particles, and very quickly a filter bed builds up which completely blocks the pores of the fabric against the further passage of the particles of the slurry. Thereafter, the continued pressure forces the water outwardly through this filter bed and outwardly through the pores of the fabric. The result is that the water-cement ratio is quickly reduced and the particles quickly set up into a solid body under pressure. Thereafter, the cement particles hydrate to form a solid monolithic concrete body **14**.

The fabric of the form, particularly if of nylon, tends to resiliently stretch slightly when under tension, and this tension holds the particles within the form under pressure even though the pumping has stopped. The result is that when the cement finally hardens, it hardens to a dense cement body **14** having a much higher strength than it would have if it hardened not under pressure. The fabric also contributes to the strength of the final concrete body and tends to prevent spalling.

While not shown in the drawings, steel reinforcements in the form of wire or rods either parallel or criss-crossing and joined at the cross points may be employed. Alternatively short fibers of nylon or other flexible members having a unit tensile strength greater than that of cement may be pumped into the form along with the slurry.

It is also to be noted that in some instances the openings may be partly closed, e.g., by not cutting away the fabric. However, because the slurry does not enter the space between the fabric closed off by the stitching **31**, or the weaving **53**, this portion remains porous so that water can still pass through, only at a much slower rate.

Using the invention, it will be appreciated that a large mass of concrete may be placed over a bed of rocks each of which is small enough that if exposed to the normal wave action would be moved around and otherwise displaced to expose the soil beneath to the further erosion of the water. However, with the mass of concrete placed thereover having the openings **30** therethrough, the waves can strike the fabric enclosed concrete and some of the energy of the waves will be dissipated by flowing through the openings **30**. It will further be appreciated that the concrete body has been placed in position without the building of cofferdams or the use of rigid heavy forms, and

can be placed in position even when the wave action is severe.

The invention has been described with reference to a preferred embodiment. Obviously, modifications and alterations will occur to others upon a reading and understanding of this specification, and it is my intention to include all such modifications and alterations insofar as they come within the scope of the appended claims.

Having thus described my invention, I claim:

1. A form for shaping a mat to be placed on a shoreline to be protected from wave action, said form comprising two large contiguous sheets of flexible material at least in part porous, said sheets being joined around their entire outer periphery and having a plurality of aligned openings formed therethrough and means joining the sheets around the periphery of each opening thereby defining a fully enclosed empty interior space between the two sheets adapted to reecive a flowable material therein.

2. The form of claim 1 wherein said sheets are of a loose woven fabric material.

3. The form of claim 1 wherein said openings have a diameter of from one to ten inches and the centers thereof are spaced from each other a distance of from three to ten times the diameter of the openings.

4. The form of claim 3 wherein said openings are approximately three inches in diameter and the centers are spaced approximately thirteen inches.

5. The method of protecting a shoreline from wave action comprising the steps of:

laying a long and wide form on the shoreline to be protected, said form being comprised of a pair of generally parallel sheets of flexible material at least in part porous and joined at the edges defining a closed interior, said sheets being joined at a plurality of spaced points over the surface inwardly of the edges;

pumping a cementitious slurry having a water-cement ratio in excess of 0.45 into the inside of such form until the form is filled;

maintaining the pumping until a pressure is created to force the liquid of the slurry outwardly through the pores of the form while retaining the particles of the slurry in the form until the water-cement ratio is between 0.35 and 0.25 and,

allowing the cement to harden.

6. The method of claim 5 wherein prior to the placing of the form the bank is coated with a layer of small stones.

7. A mat for protecting the shores of a water body against wave action, said mat being a large monolithic mat of concrete having substantially greater width and length than thickness and a plurality of openings through said concrete to permit the free movement of water therethrough, said mat being encased in a porous synthetic fabric of substantial tensile strength having openings therethrough corresponding with the openings in the concrete.

8. The mat of claim 7 wherein a plurality of members having a unit tensile strength greater than that of concrete are embedded in the concrete.

References Cited

UNITED STATES PATENTS

Re. 25,614	7/1964	Turzillo	61—35
984,121	2/1911	Condie	61—38
1,187,502	6/1916	Chenoweth	61—38
1,987,150	1/1935	Mason	61—38 X
2,633,441	3/1953	Buttress	161—112 X

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Disclaimer

3,396,542.—*Bruce A. Lamberton,* Berea, Ohio. METHOD AND ARRANGEMENTS FOR PROTECTING SHORELINES. Patent dated Aug. 13, 1968. Disclaimer filed Mar. 17, 1982, by the inventor.

The term of this patent subsequent to Aug. 13, 1985 has been disclaimed.

[*Official Gazette October 26, 1982.*]