United States Patent [19]

Hubbard, Jr.

[11] **3,913,333**

[45] **Oct. 21, 1975**

[54] **MEANS AND APPARATUS FOR CONTROLLING FLUID CURRENTS AND SELECTIVELY PRESERVING AND MODIFYING TOPOGRAPHY SUBJECTED THERETO**

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[22] Filed: **Sept. 18, 1973**

[21] Appl. No.: **398,305**

[52] **U.S. Cl.** **61/4**
[51] **Int. Cl.**^{2} **E02B 3/06**
[58] **Field of Search** 61/2, 3, 4, 5, 1, 37

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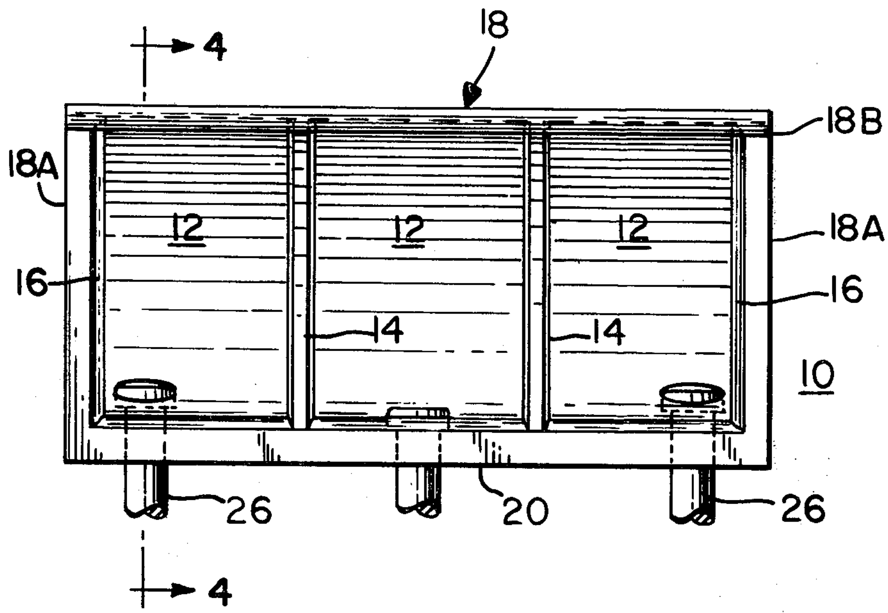
Primary Examiner—Philip C. Kannan
Attorney, Agent, or Firm—Birch and Birch

[57] **ABSTRACT**

Modular units are provided for utilizing the kinetic energy in waves, tides and winds to effect deposits of fluid entrained alluvium. The modules have front and rear surfaces so structured that arrays of the modules can effect shaped alluvial deposits or selective entrainment of alluvium to maintain or modify the topography at the situs of the arrays.

5 Claims, 14 Drawing Figures



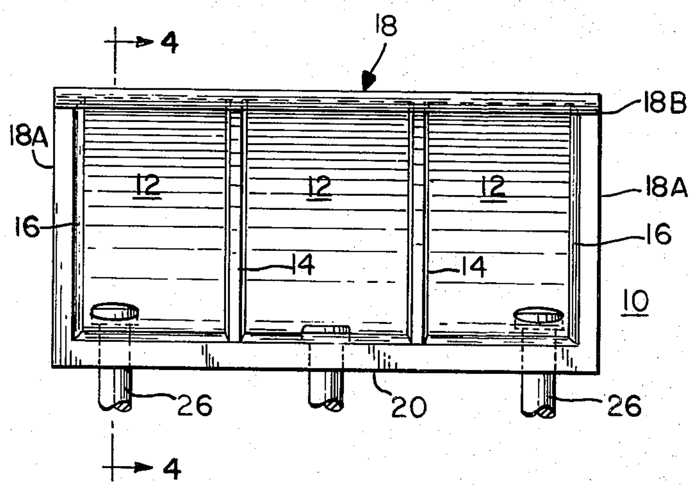


FIG. 1

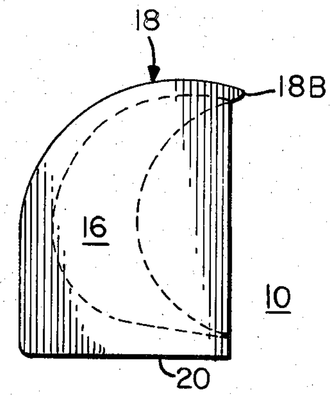


FIG. 3

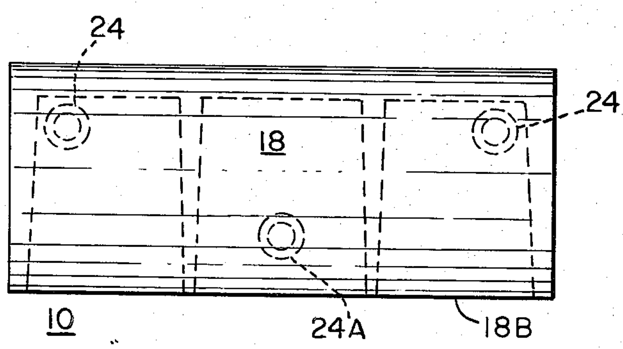


FIG. 2

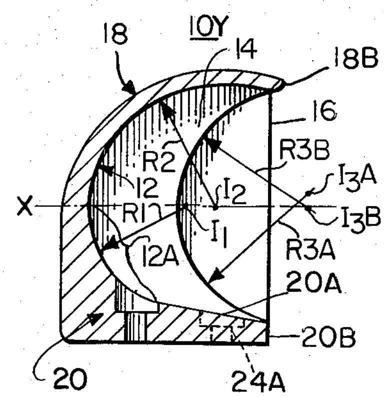


FIG. 4

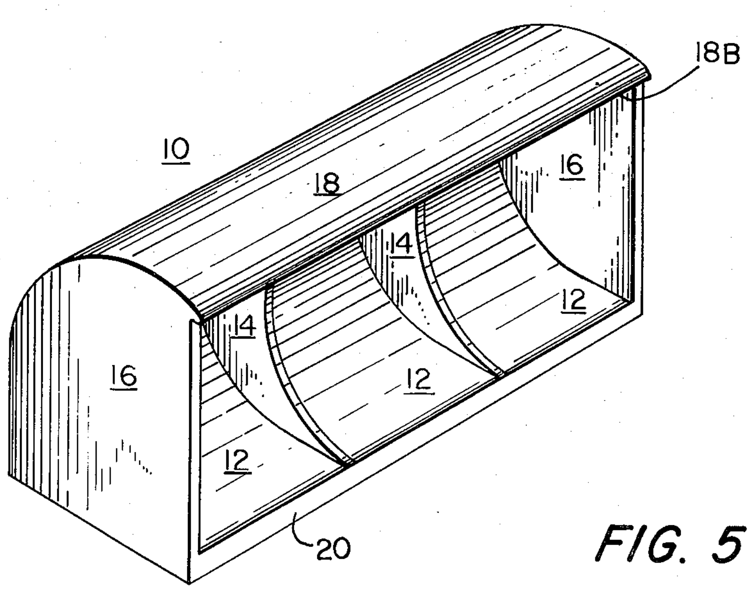


FIG. 5

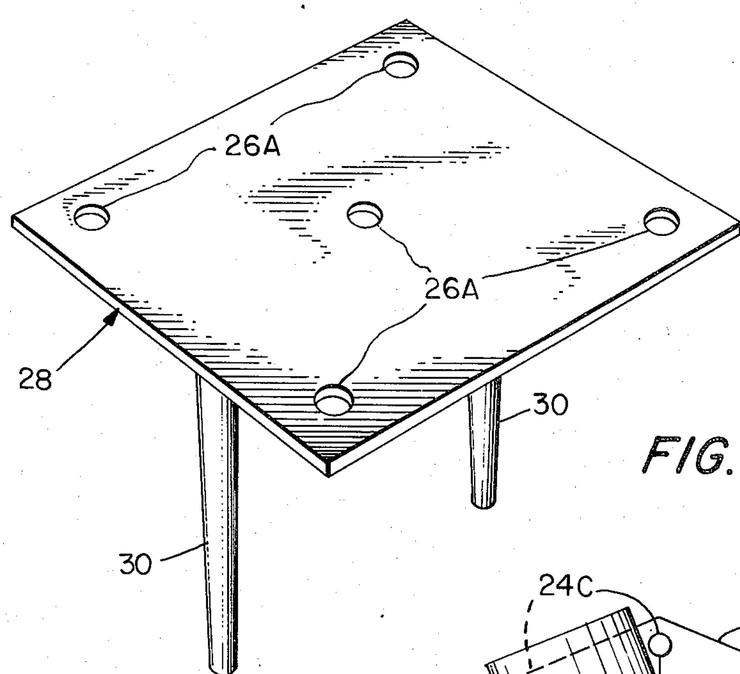


FIG. 6

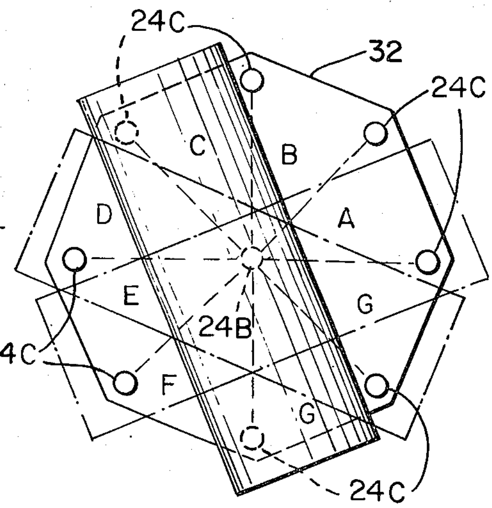
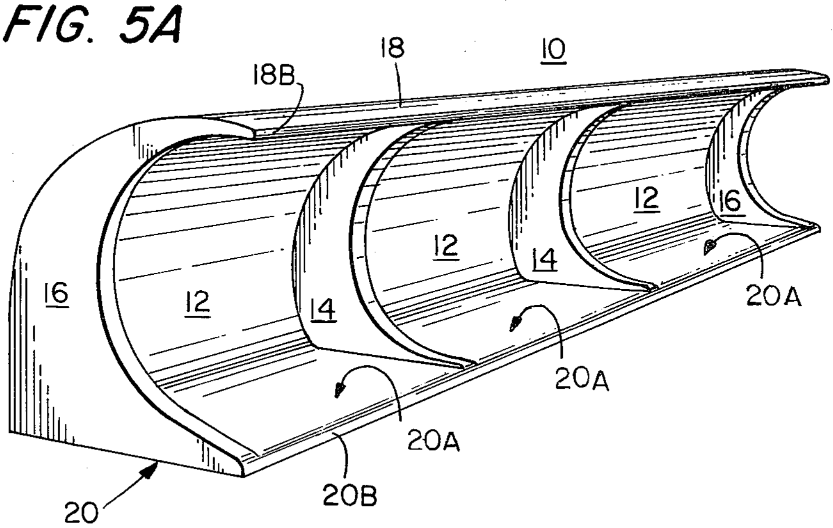


FIG. 7

FIG. 5A



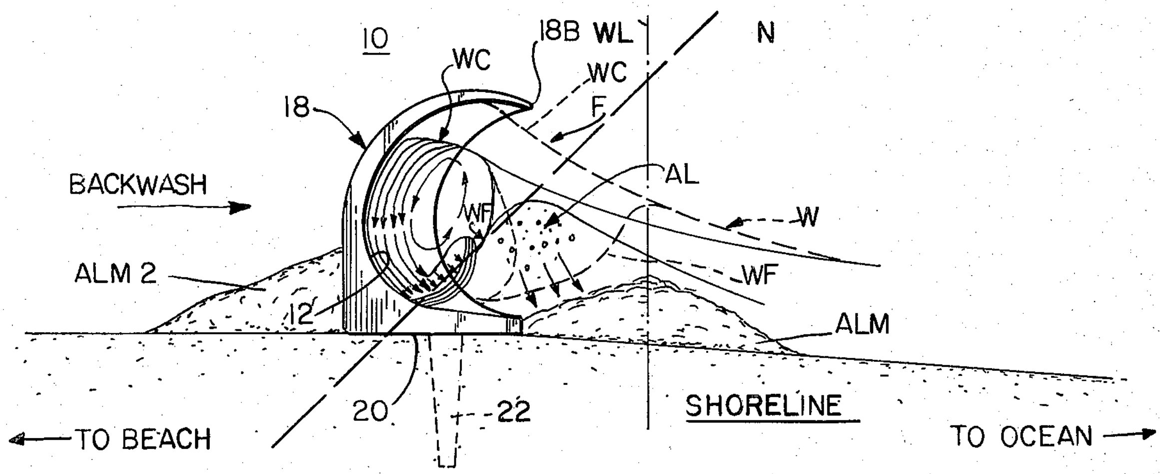


FIG. 8

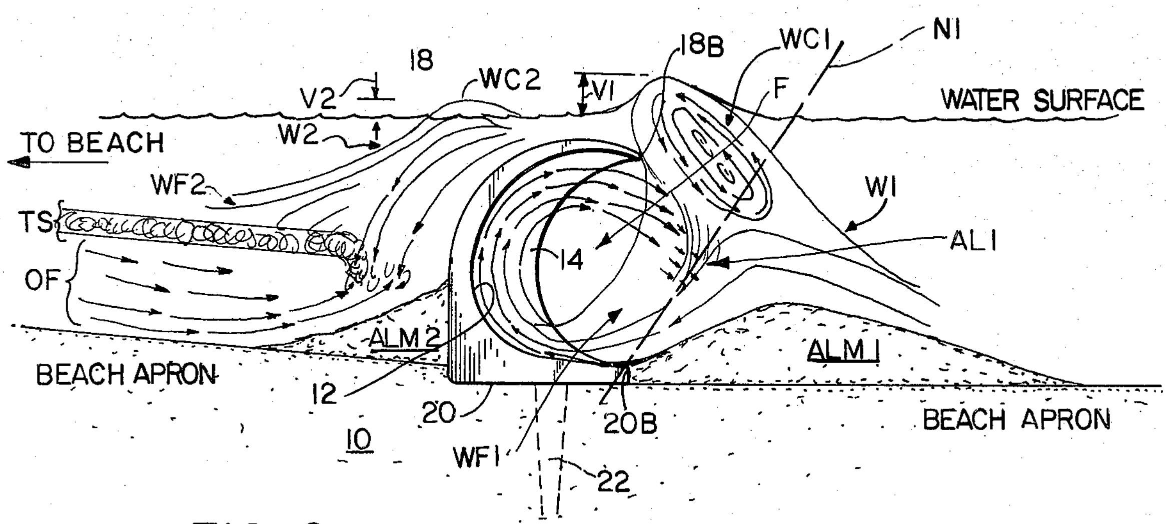


FIG. 9

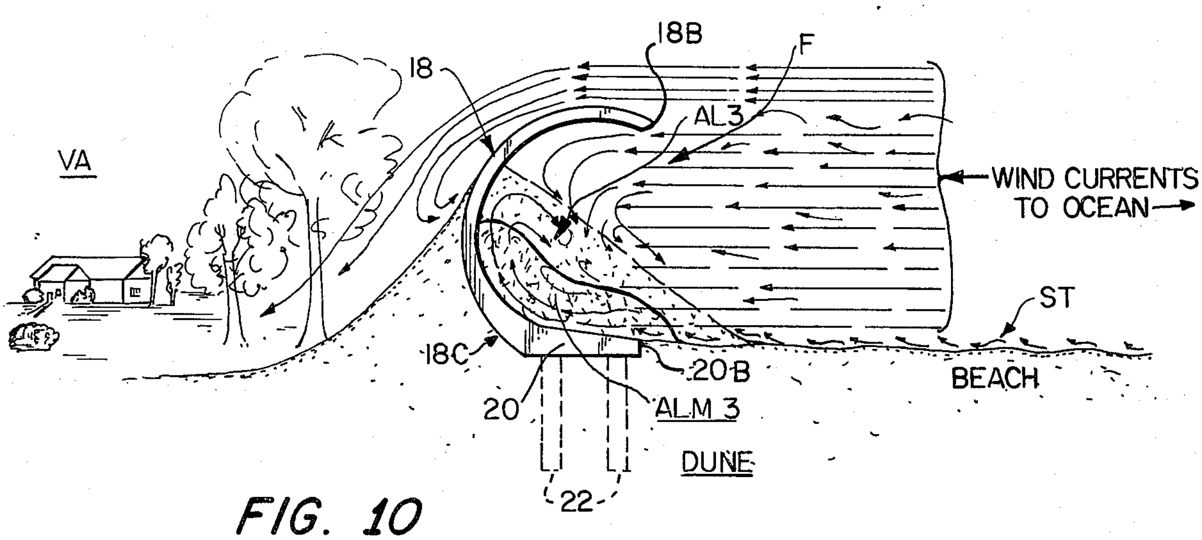


FIG. 10

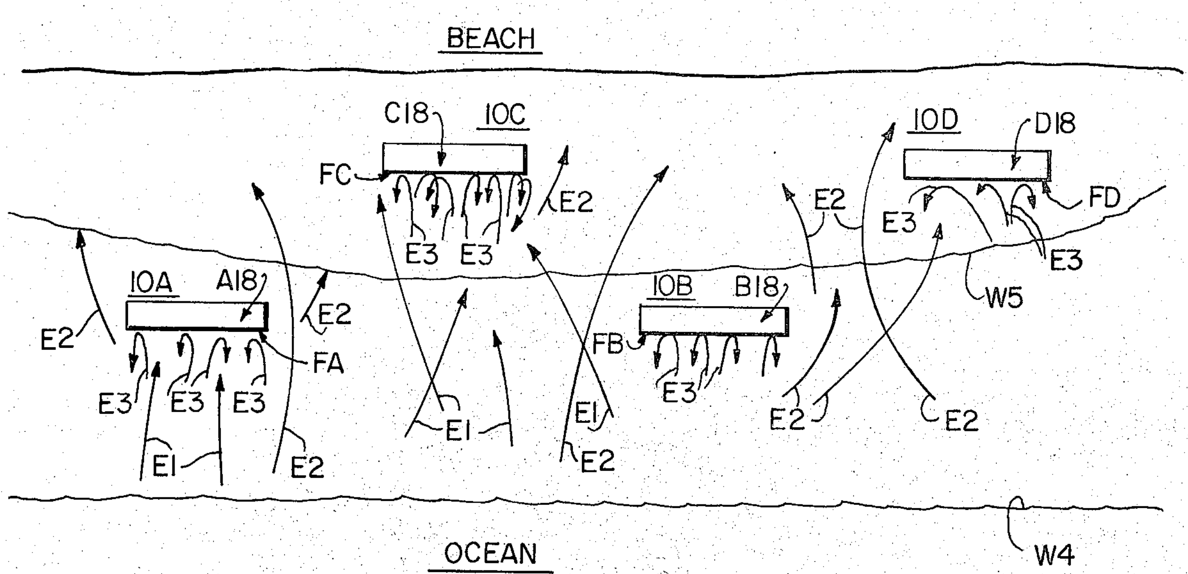

BEACH
C18
10C
10D
D18
FC
E2
FD
E3
E3 E3
E3
10A
A18
10B
B18
W5
E2
FA
FB
E3
E3 E3 E3
E1
E1
E2
E2
E1
E2
E2
OCEAN
W4

FIG. 11

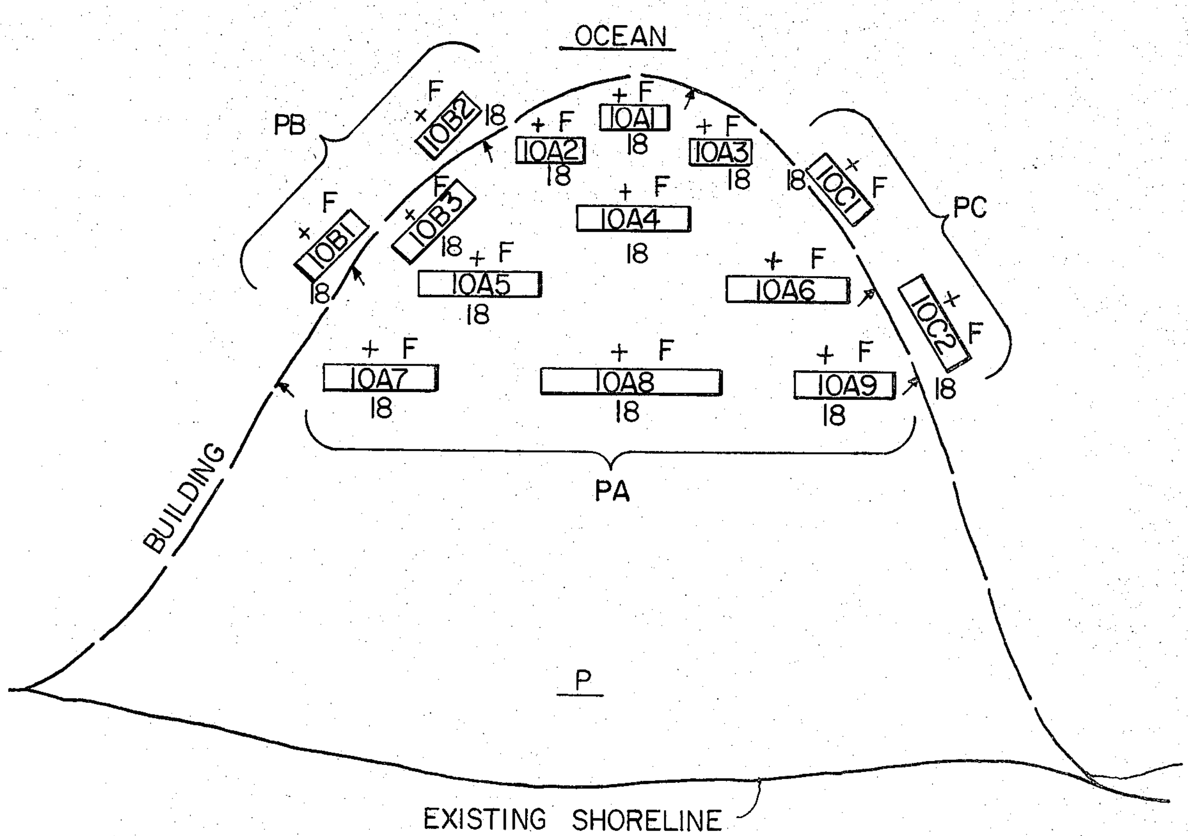

OCEAN
PB
F
10B2
18
10A1
10A2
10A3
10C1
PC
10B1
10B3
10A4
10A5
10A6
10C2
10A7
10A8
10A9
PA
BUILDING
P
EXISTING SHORELINE

FIG. 12

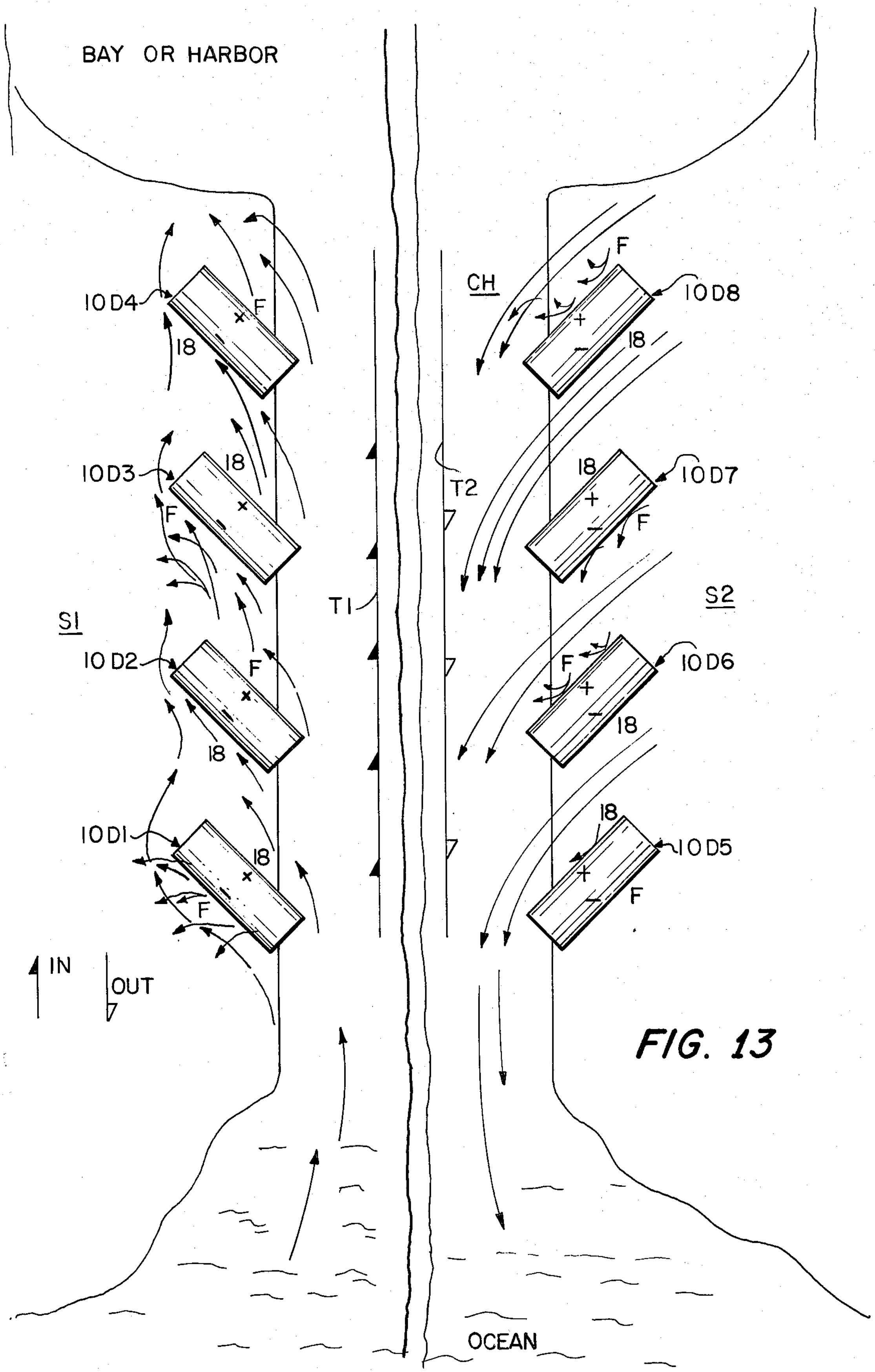

BAY OR HARBOR
10D4
10D3
10D2
10D1
10D8
10D7
10D6
10D5
18
F
S1
S2
CH
T1
T2
IN
OUT
OCEAN

FIG. 13

MEANS AND APPARATUS FOR CONTROLLING FLUID CURRENTS AND SELECTIVELY PRESERVING AND MODIFYING TOPOGRAPHY SUBJECTED THERETO

This invention relates to means and apparatus for modifying the effect of fluid currents such as winds, tides and the like to selectively enhance, modify or reverse the natural erosion processes effected by such currents.

BACKGROUND OF THE INVENTION

The effects of winds, tides and other fluid currents on beaches, shorelines, channels and the like is a long standing and serious problem.

The erosion of beaches, silting of navigation channels, destruction of natural barriers such as sand dunes and other deleterious effects causing untold financial losses, destruction of natural environs and continuing large expenditures of funds for corrective action has been and still is a dilemma that is only solvable on a temporary and frequently recurring basis. A substantially permanent solution to such problems or even a relatively long term solution has not yet been devised.

The prior art is replete with groins, jitties, weirs, breakwaters and the like which serve only specific functions against prevailing conditions and which, unfortunately, have not been satisfactory for preserving shorelines, dunes and/or navigational channels under either prevailing or variable ambient conditions.

Furthermore, no prior art devices are know which can serve all of these functions and in addition actually increase the size of shorelines, dunes and channels or selectively create same in a predetermined configuration and location.

Because of the tremendous energies involved in preventing damage by winds, tides and currents, the prior art approach to erosion control has necessitated unwieldly, large and aesthetically displeasing structures in order to provide sufficient strength and sustainability to such structures.

Furthermore, such structures have been for the most part merely passive devices which are directed to impeding the action of fluid currents, disrupting wave action and/or creating eddy current action.

Accordingly, means and apparatus which can convert such tremendous available energy to corrective and beneficial use are sorely needed.

OBJECTS OF THE INVENTION

It is an object of the present invention to provide a new and novel means for utilizing the energy and/or wave action in fluid currents to selectively modify or preserve the topography of the situs of that means.

Another object of the present invention is to provide a new and novel module for systems having selective interaction and control of fluid currents and/or wave motions for preserving or modifying the topography of the situs of a given one of said systems.

Another object of the present invention is to provide new and novel beach erosion control devices which are aesthetically acceptable and which are capable of complimentary uses and functions.

Still another object of the present invention is to provide new and novel systems and components for same for selectively building land from alluvial material transported by fluid currents reacting with such systems and components.

Still another object of the present invention is to provide new and novel systems and components for same for preserving and/or creating navigational channels.

Yet another object of the present invention is to provide new and novel fluid current modifying and control systems and components for same which are selectively adjustable in situs to compensate for variation in otherwise prevalent ambient conditions of fluid currents and/or wave action.

These and other objects of the present invention will become more fully apparent with reference to the following specification and drawings, which relate to several preferred embodiments of the invention.

SUMMARY OF THE INVENTION

The basic modular components of the present invention are basically elongated shells having a flat base; a convexly curved outer face coterminate with the base at one edge thereof; a complimentary concave inner surface opposite and coeterminate with the convex face; a pair of flat end walls supporting the curved faces and forming therewith an integral structure with the base and partially enclosing said inner face; and one or more internal planor ribs substantially parallel to the said end walls and having, preferably, a relieved leading edge outboard of said inner face and having a generally complimentary radius of curvature, in the plane of said rib, to the said concave inner face of the module.

In erosion control situations for enhancing the deposition of alluvial material entrained in fluid currents and/or waves on shorelines, dunes and the like, the module is oriented such that incoming force of the current is directed into the open side (against the concave inner surface) of the module with the base preferably set laterally of the incoming flow direction and the said end walls and internal ribs substantially parallel to said flow direction. In this configuration, for example, the base of an incoming wave is turned against the crest and at least components of the crest against the base, nullifying or severely attenuating the wave energy in certain strata and causing entrained alluvial material to be deposited in front of the module. This creates a buildup of this material which increases or at least preserves the level of the bottom or shoreline on which the module is situated.

Reverse (outgoing) wave action coming from the rear of the module is forced up and over the convex outer face causing further energy reduction and resulting in additional deposition of alluvial material on the back side of the module. The front and back sides are defined in relation to the incoming wave action in the foregoing description.

Predetermined arrays of these modules can be utilized to maintain navigational channels by selective angular placement of both the outer and inner surfaces of various modules to localize tides into rips in the channel and create bottom holding tide attenuating affects adjacent the existing channels.

Other arrays of the present invention can build up or create shoreline areas using wind, wave, tide and/or current actions. Conversely, other arrays can remove or alter shorelines and cut or form channels and the like by control of these natural forces.

Representative preferred embodiments of arrays for performing these functions will be discussed in more detail hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front view of a control module of the present invention;

FIG. 2 is a top plan view of FIG. 1;

FIG. 3 is an end view of the module of FIGS. 1 and 2;

FIG. 4 is a cross-section taken along line 4—4 of FIG. 1;

FIG. 5 is a perspective of the module of FIG. 1 and includes integral mounting means;

FIG. 5A is a perspective of another embodiment of the control module of the present invention;

FIG. 6 is a perspective of a separable mounting means for the module of FIG. 1;

FIG. 7 is a diagrammatic representation of an multidirectional mounting means for the control module of the present invention;

FIG. 8 is a functional diagram of a control module of the present invention in a beach mounted erosion control mode wherein the module can extend above the water surface;

FIG. 9 is a functional diagram of a control module of the present invention in a subsurface or reef building erosion control mode;

FIG. 10 is a functional diagram of a control module of the present invention reacting with winds or air currents in a dune erosion control mode;

FIG. 11 is a functional diagram of a beach erosion control array of control modules of the present invention;

FIG. 12 is a functional diagram of a shoreline modifying array of control modules of the present invention; and

FIG. 13 is a functional diagram of a navigational channel modifying, creating or preserving array of control modules of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring in detail to the drawings and with particular reference to FIGS. **1, 2, 3, 4,** and **5,** the flow control module **10** of the present invention is shown as comprising an elongated molded solid having one of its longitudinal faces open to expose an interior concave wall or surface **12.**

In the embodiment as shown for the control module **10,** the concave inner face **12** is selectively partitioned along its length by a plurality of substantially equally spaced internal ribs **14,** located between first and second end walls **16** which close the extreme ends of the module **10.** Also, as shown in FIG. **1,** the end wall **16** may be disposed slightly inboard of the extremities of the closed longitudinal top and rear surface **18** of the module **10** which is a convex surface extending from the top front of the module **10** all the way down to the rear of a flat base portion **20** of the said module. The said surface **18** is substantially conformally shaped with the concave inner surface **12.**

Thus, in the embodiment as shown in FIG. **1,** the convex rear surface **18** of the module **10** can be said to have a slight outboard lateral extension **18A** overhanging the end walls **16** of the module as well as an overhanging front lip portion **18B** at the upper edge of the open side of the module **10.**

FIGS. **3** and **5** represent another embodiment of the module **10** of the present invention in that the lateral overhang **18A** are not included and the end walls **16** of the module **10** thereby form the terminal ends thereof.

The inner face **12** of the module **10** can best be described with reference to FIG. **4** in which the module **10** is shown in cross section as disposed about a horizontal (x) and vertical (y) coordinate axis, with the x axis passing a substantially centrally through the cross sectional plane of the module **10** and the y axis being positioned more towards the open edge thereof.

The leading edge **20B** of the base **20** of the module **10** extends inwardly over a rising surface **20A** into a tangential transition with the lowermost portion **12A** of the inner surface **12.** This portion **12A** of the inner surface **12** is defined by a first radius of curvature **R1** over approximately 90° arc which extends from the said tangential transition with the surface **20A** to the intercept of the x-axis and the inner surface **12.**

The radius **R1** commences from an x-axis index point **I1** in-board of the x–y intercept **I2.** The said surface portion **12B** extends from the intercept of the x-axis and surface **12** to the underside of the front lip **18B** of the convex outer surface **18** at which point it makes a smooth transition outward and upward to the outermost edge of the said lip **18B.**

One preferred embodiment of the inner ribs **14** of the module **10** is also shown in FIG. **4,** wherein the concave contour of the leading edge of the said ribs **14** is shown as including a lower curve **14A** with a radius of curvature **R3B** greater than the lower radius **R3A.** The lower radius **R3A** extends from a first index point **13A** on the x-axis outboard of the x–y intercept **I2** to the front edge **20B** of the base **20,** and then defines the lower curve **14A** from that point up to the x-axis.

From the x-axis up to a smooth transition into the outer lip **18B** of the convex surface **18,** the radius **R3B** defines the upper curve **14B** of the inner ribs **14.** The upper radius **R3B** extends from an index **13B** on the x-axis outboard of the index **13A.**

This compound curvature to produce a concave leading edge on the ribs **14** of a compatible configuration with the inner surface **12** can also be imparted to the leading edges of the end walls **16** as shown in perspective in FIG. **5A** which illustrates another preferred embodiment of the module **10.**

At this point it should be understood that the compound curvatures described above are examples of preferred embodiments of the invention and are not intended to limit the scope thereof.

In short, the modules **10** resemble elongated scoops of crescent shaped cross-section with an open front F and a smooth closed back or rear surface **18.**

For impeding fluid flow, the open front F of the module **10** is basically facing the flow of fluid current or incoming wave motion.

For channeling or directing fluid flow the smooth rear surface **18** of these modules **10** is disposed at various angles to the direction of flow or wave action to modify the behavior and direction of such natural forces.

Thus, the mounting of the module **10** at its operating situs is preferably multidirectional if variable affects are desired or if ambient conditions are subject to substantial variation.

Examples of installations for a fixed direction of the modules is shown in FIGS. **8–10** and **6;**

In FIGS. **8–10**, the module **10** is cast or formed with two or three integral piles **22** (shown in dotted lines) depending beneath the base thereof. When the piles **22** are driven into place beneath the soil, either above or below water as the case may be, the module **10** is thus mounted in a fixed directional orientation.

Referring to FIGS. **1, 2** and **4**, the modules **10** are shown as including three triangularly arranged hold-down sockets **24** in which anchor pins **26** or the like are placed.

One of the sockets **24** comprises a master socket **24A** for the purpose of multidirectional orientation of the module **10** as will be hereinafter more fully described with reference to FIG. **7**.

In FIG. **6** is shown a mounting platform or bed **28** which includes land anchors or piles **30** therebeneath to provide a fixed platform for removably mounting the module **10** thereon. Mounting parts **26A** are provided in the platform **28** to receive the anchor pins **26** described in connection with FIG. **1.**

For multidirectional mounting of a module **10**, reference is now made to FIG. **7** wherein there is shown a mounting platform **32** provided either with suitable dependent land anchors or with sufficent weight in and of itself to stay in place.

The platform **32** is substantially symmetrically formed, such as in a square or octagonal top planal configuration.

A central socket **24B** is provided in the platform **32** which is adapted to be in registry with the master socket **24A**.

A plurality of mounting ports **24C** are also provided in the platform **32** in a symmetrical peripheral array which are selectively aligned in pairs with the remaining mounting ports **24** in the module **10** to cause the open front F and rear surface **18** of the module **10** to face in various desired directions. The central mounting port **24C** and the master port **24B** are adapted to mutually receive an anchor pin (such as the anchor pins **26** of FIG. **1**) and thereby provide a central pivot in the mounting platform **32** about which the module **10** can be rotated to place its mounting ports **24** into registry with any desired pair of mounting ports **24C** on the platform **32.**

Alternatively the mounting ports **24B** and **24C** can be located each on one land anchor or pile of an array equivalent to the platform **32.** Thus, a preset array of piles or a mounting platform **32** can be provided at each modular situs in a given array of modules to permit all of the modules in that array to be selectively oriented to effect desired constraints on ambient currents and/or wave motions.

OPERATION OF INDIVIDUAL MODULES TO HARNESS WAVE AND/OR WIND ACTION FOR TOPOGRAPHICAL RETENTION AND/OR ACCRETION

For the protection, retention and accretion of beaches, by controlling wave action the operation of a typical module **10** will now be described with reference to FIG. **8.**

A module **10** is shown anchored to the shoreline by land anchors or pilings **22** at or immediately adjacent to the mean average water line or breaking surf line WL characteristic of the situs.

In the configuration shown in FIG. **8** it will be assumed that an incoming wave W from the ocean will have its crest portion WC and its foot portion WF breaking into the open front face F. of the module **10** against the concave inner surface **12.**

The breaking crest WC of the wave W, as it enters the open front F of the module **10** beneath the lip **18B** reacts with the concave inner surface **12** between adjacent ribs **14** or a rib **14** and an end wall **16** to create a counter-clockwise circulation as shown.

While this action is occurring, the energy in the rising foot WF of the breaking wave W is reacting with the inner bottom surface **20A** and concave inner surface **12** of the module **10** such that a clockwise circulation is created.

Accordingly, approximately in a plane defined by the broken line N, the energies of the crest WC and the foot WF are in opposition, thereby causing a great dissipation or mutual suppression of the energy of both components of the wave W and causing entrained alluvium AL therein to sink or fall to the shoreline or ocean bottom immediately in front of the module **10** where it tends to form a mound ALM of such material.

During sufficiently high water conditions, the rear surface **18** of the module also reduces the energy of backwash from the beach and causes further deposition of alluvium at the rear of module as illustrated by the mound ALM **2.**

In a subsurface mode of operation, the module **10** performs a similar function to build up alluvium on the underwater apron of the beach as will now be described with reference to FIG. **9.**

A standing wave pattern W1 is shown approaching the module **10** and immediately adjacent the open front F thereof, said wave pattern W1 including a crest portion WC1 and a foot portion WF1 which by the nature of such standing wave patterns leads the crest WC1 into the module **10.**

Thus, the energy of the foot WF1 reacts with the concave inner surface **12** to create a clockwise circulation which opposes the energy in the remainder of the foot portion WC1 substantially, the position of a plane defined by the broken line N1 immediately in front of the module **10.**

As a result, with the kinetic energy of the foot portion WF1 turned on itself and the kinetic energy of the crest WC1 dissipated, the amplitude of the standing wave W1 is materially reduced from an above-surface amplitude V1 adjacent the open front F of the module **10** to a reduced abovesurface amplitude V2 adjacent the rear surface **18** of the module **10** as shown by the wave W2 and crest WC2.

The convex rear surface **18** materially contributes to this reduction in kinetic energy and attendance reduction in amplitude crest WC2 and instead directing it downward against the top of the foot portion WF2 of the reduced amplitude wave W2.

Because of the backwash or outflowing current OF from a shoreline located to the rear of the module **10,** there is a stratification of the outflowing current OF and the incoming wave W2 at the rear of the module which creates a turbulent strata or barrier layer TS therebetween, the latter having a substantial entrained alluvium content.

As shown by suitable flow arrows adjacent the convex rear surface **18** of the module **10,** the downwardly directed energy of the modified crest WC2 and the energy of the outflowing current OF are opposed at and below the turbulent layer TS, causing a marked reduction in kinetic energy at that point and a release of the entrained alluvium AL2 in the turbulent layer TS, causing it to be deposited at the base of the rear surface **18** to form a mound ALM2 of alluvium.

The deposition of alluvium AL1 in front of the module **10** to form another mound ALM1 of alluvium adjacent the front edge **20B** of the base **10** of the module **10.** This mount ALM1 is created by the reduction in kinetic energy in the wave foot WF1 in the vicinity of the plane N1 which causes entrained alluvium to be released from the wave W1.

The severe loss in kinetic energies from the wave W1 (WC1, WF1) to the modified or attenuated wave W2 (WC2, WF2) results in a corresponding reduction in forward velocity of the wave W1 such that the wave W2 approaches the beach at a markedly reduced velocity.

Air entrained alluvium and reduction of wind energies can also be effected by the module **10** as will now be described with reference to FIG. **10.**

Assuming, for example, a module **10** located on a sand dune or the like between a beach and a vegetated and/or structurally developed area VA, with the open face F of the module **10** facing the prevailing wind direction coming off the ocean, then surface turbulence ST will cause asportation and entrainment of alluvium from the surface of the beach or the like into the wind currents.

As the airborne alluvium gaians altitude its velocity increases which would normally carry it far inland and cause wind erosion of the dunes and beach and unwanted deposition of the alluvium over inland areas.

As the wind currents enter the front F of the module **10,** however, the various currents over the altitude between the forward edge **20B** of the base **20** and the overhanging lip **18B** of the convex rear surface **18** counter-react with the concave inner surface **12** to oppose one another within the module **10,** thereby substantially reducing the kinetic energy of the said wind currents. This causes the entrained alluvium AL3 therein to form a mound ALM3 of such material in and to the front of the module **10.**

The airfoil action of the rear surface **18** of the module **10** acts to constrain the force of some of the wind currents downwardly therealong and into an area between the said rear surface **18** and the protected area VA.

This redirection of the wind forces air entrained alluvium down toward the ground surface causing a mound ALM4 of alluvium to build up immediately behind the module **10.**

Also, in the embodiment shown, because of the lack of backwash in the wind current mode of operation, the rear surface **18** can continue its curvature as at **18C** so as to provide an undercut behind the base **20** of the module **10.**

Thus, the curvature **18c** and the resulting undercut assist in trapping alluvium at the rear of the module **10** and the dune on which the said module is situated is both preserved and caused to build up under the prevailing wind conditions shown.

Also, the protective function of the dune to the area VA is materially enhanced by the attenuation affects of the module **10** on these wind currents.

Further, in the event of severe storms, waves cresting over the dune will be substantially attenuated by the module **10** and the resulting action of the module to accrete fluid entrained alluvium will continue to preserve the dune regardless of the fluid medium to which the dune is subjected.

SHORELINE EROSION CONTROL

The operation of the individual control modules **10** of the present invention having been described under various ambient conditions, several systems of such modules will now be described to illustrate the versatility and adaptability of these modules in predetermined combinations, to effect specific control functions.

A system of the modules **10** providing a beach and shoreline erosion control function is shown in FIG. **11.**

Assuming fixed conditions for the sake of example in which the wave motion from the ocean is substantially normal to the beach and shoreline, a plurality of control modules **10A, 10B, 10C** and **10D,** the former pair (**10A, 10B**) comprising a first row of spaced modules parallel to the beach and the latter pair (**10C, 10D**) comprising a second row of spaced modules parallel to the beach with the modules in one row respectively staggered between the modules of the other laterally along the said beach.

The open fronts FA – FD, respectively, of the modules **10A – 10D** face the ocean and the back surfaces **A18 – D18** thereof face the beach.

In this configuration, the modules **10A – 10D** selectively impede the incoming wave action and no given row in the array is exposed to the full force of the incoming waves. Also, while only four modules are shown, it is to be clearly understood that both rows of modules can include as many modules as desired to protect any given extent of beach and shoreline. Also, additional rows of the modules **10** can be added so long as a staggered configuration and spacing is maintained.

The operation of each of the individual modules **10A – 10D** in the protective array of FIG. **11** is as described in either of FIGS. **8** and **9** depending upon the depth of the water in which they are placed.

Assuming that the modules **10A** and **10B** (and others in the row defined thereby) are beneath the surface (as in FIG. **9** and that the modules **10C** and **10D** are at the mean average water line or breaking surf line (as in FIG. **8**) the action of the row **10A–10B** is to attenuate an incoming wave W4 to create a modified wavefront W5 which is attenuated by the second row of modules **10C – 10D.**

The direct action of the incoming wave W4 is indicated by the flow paths E1 in FIG. **11**; secondary diverting affects of the modules **10** are indicated by the flow paths E2; and the reverse reaction affects of each of the modules **10A – 10D** on a given portion of the waves W4, W5 are shown by the flow paths E3.

Thus, it can be seen that certain portions of the wavefront W4 impinge directly on the modules **10A–10B** in flow paths E1, are diverted between the said modules **10A–10B** in the first row to the modules **10C–10D** in the paths E2 and counter-react to attenuate energy from the wave W4 and cause accretion of alluvium via the paths E3.

Certain direct components E1 of the wave W4 passing between the modules **10A–10B** in the first row impinge directly on the modules **10C–10D** in the second row resulting in the attenuation and accretion flow paths E3 at the latter modules.

The secondary flow paths E2 are caused to criss-cross and interfer with normal wave motion by both rows of the modules **10A – 10B, 10C – 10D** to further break up the wavefronts **W4** and **W5** and preclude the establishment of normal flow and rhythm of the waves impinging on the beach.

Backflow from the beach is handled by the modules **10A – 10D** in a similar manner and causes accretion of alluvium as previously described with reference to FIGS. **8** and **9.**

It is also contemplated that an additional row of modules **10** can be placed on the beach itself to compensate for both wind and high water conditions if desired.

All of the foregoing actions of wave energy attenuation, alluvium accretion (and hence, retention of alluvium to preserve the beach) and the creation of attenuating crosscurrents to disrupt the normal flow and rhythm of incoming waves are accomplished without subjecting any given module **10A – 10D** or row of modules to the full force and effect of an incoming wave **W4.** The staggered arrangement of the modules **10A – 10D** in their respective rows effectively accretes alluvium from the incoming wave W4 (and its backwash from the beach) in increments of a size determined by the size of the said modules and the spacing therebetween.

If conditions warrant, there can be additional rows of modules **10** places in the configuration of FIG. **9** to provide additional attenuation to incoming waves W4 in the manner of a protective reef.

CREATION OF SHORELINE, IN PREDETERMINED TOPOGRAPHICAL CONFIGURATIONS

The modules **10** of the present invention can also be arranged in arrays which tend to accumulate alluvium to modify existing shorelines by the creation of sandbars, shoals or peninsula type extensions of the said shorelines in topographical configurations determined by the configuration of a given array of the modules **10.**

Such a system or array of the modules **10** is shown in FIG. **12** in which the topographical shape to be created is an accumulation or accretion of alluvium in the form of a peninsula or spit extending from an existing shoreline out into the ocean.

Referring now to FIG. **12,** an existing shoreline is shown by a solid line and a building shoreline shape is shown by a broken line in the general configuration of a peninsula or spit P extending out into the ocean from the shoreline.

The array of modules **10** comprises a major array PA, and either or both of two minor arrays PB and PC symmetrically disposed with respect to the major array PA as follows:

The major array PA is in a Christmas tree shape and includes an outmost point module **10A1** outboard of the gap between first row of modules **10A2** and **10A3;** a further inboard module **10A4** parallel to and in registry with the point module **10A1** on the shoreline side of the first row; a second row of modules **10A5** and **10A6** spaced shoreward from the module **10A4** on either side thereof; and a third row of modules **10A7,** 10A8 and **10A9** spaced shoreward of the second row and staggered in position with respect to the modules **10A5** and **10A6** with the central module **10A8** in registry with the point module **10A1** and inboard module **10A4.**

This staggering of modules **10A1 – 10A9** and additional rows thereof extending to the shoreline can be continued over the entire area P if desired.

The minor arrays PB and PC are shown arranged on the left and right flanks of the major array PA.

At this point is should be understood that the open front F of each module in the major array faces the ocean and the closed rear face **18** thereof faces the beach.

The minor array PB comprises a first pair of modules **10B1** and **10B2** spaced apart to form a row and arranged substantially tangentially of the desired building line outboard thereof. In other words, the length of the closed rear forces **18** of the modules **10B1** and **10B2** are disposed outboard of the building line parallel to a tangent thereto.

The minor array PB is completed by a module **10B3** disposed in the gap between the modules **10B1** and **10B2** as well as across the gap between the first and second rows **10A2 – A3** and **10A5 – A6** of the major array PA, substantially parallel to the row **10B1 – B2.**

An alternative minor array PC is shown as comprising first and second modules **10C1** and **10C2** arranged outboard of the desired building line, with the rear surfaces **18** substantially tangential thereto and disposed, respectively across the gap between the first and second rows **10A2 – A3, 10A5 – A6** and the gap between the second and third rows **10A5 – A6, 10A7 – A8 – A9** in the major array PA. The open fronts F of the modules **10C1** and **10C2** are disposed toward the ocean side of the desired building line.

Thus, the array PA can be combined with a plurality of the minor arrays PB or a plurality of the minor array PC disposed substantially symmetrically on its flanks.

The minor arrays serve to both divert incoming currents and waves tangentially of the desired boundary or building line of the area P and also preclude side currents and varying wind and wave directions from direct access to the flanks of the major array PA.

By closely spacing and staggering the modules **10A1 – A9, 10B1 – B3** and/or **10C1 – C2,** the rapid accretion of alluvium is accomplished to raise the level of the ocean floor in the desired shape of the area P.

The staggered arrangement of the said modules **10** and the flanking disposition of the minor arrays PB and PC provides a like reaction to both backwash and incoming currents and waves in shaping the area P.

NAVIGATIONAL CHANNEL ENHANCEMENT

Another erosion problem of great concern is that of preventing the closure of navigational channels such as those between bays, harbors or backwaters and the ocean.

These channesl fill with silt and require periodic and expensive dredging operations to maintain them in a navigable condition.

An array or system of the modules of the present invention for maintaining such channels free of silting will now be described with reference to FIG. **13.**

In FIG. **13,** a channel CH is shown between two shoals or banks **S1, S2** and extends from the ocean to a bay or harbor as shown. Thus, the tidal action of the ocean flows in and out of the bay or harbor through the channel CH and over the banks or shoals **S1, S2.** This tidal flow in the channel CH is indicated by half-arrows **T1** and **T2,** designating, respectively, incoming and outgoing tidal flow.

For the sake of example, FIG. **13** is drawn to show array of modules **10D1 – 10 D4** on the shoal S1 acting on and modifying the incoming tidal currents T1 and a like array of modules **10D5 – 10D8** on the shoal S2 acting on and modifying the outgoing tidal currents T2. These arrays are mirror images of each other and in actual practice, both arrays act on and modify both the incoming and outgoing tidal currents T1 and T2 as will be more fully described hereinafter.

Without the presence of the modules **10D1 – D8**, the tidal action on the shoals **S1, S2** entrains alluvium therefrom and erodes the channel adjacent edges of the shoals, depositing the resulting alluvium in the channel CH and thus filling the said channel until it tends to become unnavigable.

The modules **10D1 – D4** are all set on the channel adjacent edge of the shoal S1 at like angles to the center of the channel CH with the channel adjacent ends thereof pointed towards the ocean.

Likewise, the modules **10D5 – D8** are all set on the channel adjacent edge of the shoal S2 at respectively reflected angles to the modules **10D1 – D4**, resulting in the channel adjacent ends of the former also pointing towards the ocean.

The two outermost pair of modules D1 and D5 have their open faces F on the ocean side and their convex rear faces **18** facing inward of the channel to form a first opposed pair of modules. A second apposed pair of modules **10D2, 10D6** are reversed from the first, the rear faces **18** facing outboard of the channel CH towards the ocean and the open faces F thereof facing inboard of the channel CH away from the ocean.

A third opposed pair of modules **10D3, 10D7** is oriented like the first pair of modules **10D1, 10D5** and a fourth (adjacent) opposed pair of modules **10D4, 10D8** is oriented like the second pair **10D2, 10D6.**

Accordingly, the preferred array of modules for channel erosion control comprises opposed pairs of modules anchored along the sides of the channel CH with adjacent pairs being in mutually reversed orientation, i.e., the open front faces F are in opposition and the convex rear faces **18** are in opposition alternately down the entire line thereof on each of the shoals **S1, S2** and this alternation is also a mirror image in the array on opposite sides of the channel CH.

In operation, the shoal **S1** and the array **10D1 – D4** is diagramed to show the action of the array to incoming tidal currents **T1.**

The first module **10D1** receives the current T1 on its front face F and through the action described in FIG. **9** and the additional attenuation or current impeding affects of the internal ribs **14** and end walls **16** to current components flowing laterally of the concave inner surface **12**, (see FIGS. **5** and **5A**, depending upon the embodiment used for the system of FIG. **13**) the energy of the incoming tide T1 and its wave action is turned back upon itself and alluvium is accreted, the shoal S1 preserved and the current T1 diverted outboard of the channel CH at the first module **10D1.**

Between the first and second modules **10D1** and **10D2,** the smooth convex rear faces of the modules form an unimpeded passageway for the current T1 constraining an outboard flow of the current T1 from the channel CH over the shoal **S1.** This tends to carry entrained alluvium onto the shoal S1 rather than into the channel CH and the harbor bay.

The third module **10D3** has its open face F reacting against the incoming tide T1 and its rear surface **18** coacting with that of the fourth module **10D4.** This accretes alluvium on the shoal S1 at the front face F of the third module **10D3** and diverts incoming current T1 outboard of the channel CH between the said third and fourth modules **10D3** and **10D4.**

The net result of the array **10D1 – D4** and its mirror image array **10D5 – D8** on the shoal **S2** is to attenuate the incoming current **T1,** entrain alluvium at the edges of the channel CH and divert much of the incoming tidal current **T1** onto the shoals **S1, S2** and away from the channel CH.

This precludes silting of the channel CH and the bay or harbor by the incoming tide **T1** and tends to preserve the boundaries of the channel CH.

The affect of the array **10D1 – D8** on the outgoing tidal current **T2** (or a predominantly one way outflow such as in a river) is illustrated in connection with the array **10D5 – D8** on the second shoal **S2.**

Instead of diverting the outflowing current T2 from the channel CH, the action of the modules **10D5 – D8** is to concentrate the outgoing tidal flow T2 into a tide rip in the channel CH by the angular placement of the modules **10D1–D8** as shown by the flow arrows in the modules **10D5 – D8** on the second shoal **S2.**

The inboard end of the channel CH is preserved by the accreting and attenuating action of the eight module **10D8** (and its mirror image **10D4**) in reaction to the outflow **T2.** Accretion of alluvium is also effected by the sixth module **10D6** (and its mirror image **10D2**) in reaction to the outflow **T2.**

Entrained alluvium in the outflow **T2** is accelerated by the convergent action of the array **10D1 – D8** such that the channel CH is purged of silt in the direction of outflow **T2,** thereby maintaining the channel CH navigable and carrying entrained alluvium (silt,etc.) out into the ocean.

Thus, certain modules (**10D1, 10D5, 10D3, 10D7**) attenuate incoming tidal action **T1** and accrete alluvium therefrom while all the modules **10D1 – D8** cause divergence and attenuation of the incoming tide rip **T1** in the channel CH.

On outflowing currents **T2,** the other modules (**10D2, 10D6, 10D4** and **10D8**) attenuate the outgoing tidal action and accrete alluvjum therefrom while the net effect of the modules **10D1 – D8** is to augment the outgoing tide rip **T2** in the channel CH and scavenge same to maintain it in a navigable condition.

The alternate accretion effects of the various modules **10D1 – D8** serve to preserve the boundaries of the channel CH by preserving the channel adjacent edges of the shoals **S1** and **S2.**

Where substantial tidal currents exist and if the shoals **S1** and **S2** of FIG. **13** were continuous, a channel CH could be carved out of the said shoals by the action of the array **10D1–10D8.**

The foregoing specification and drawings illustrate the ability of the present invention to harness the tremendous energies present in the tides and control the effects thereof to desired useful results in the preservation, creation and maintenance of shorelines, navigational channels and the like.

Therefore, the present invention solves long standing problems in the art and satisfies the attendant long felt need for straightforward relatively economical solutions to the problems of shoreline and navigational channel erosion and maintenance.

The present invention may be modified as would occur to one of ordinary skill in the art without departing from the spirit and scope of the present invention.

What is claimed is:

1. Reaction means for fluid currents to selectively modify the action of such currents on the topography of a given situs and accrete alluvium entrained therein comprising:

securing means mounting said reaction means at said situs in the path of said currents;

an elongated curvilinear surface concave on a first face thereof defining an open face for said reaction means for receiving first currents and convex on the opposite face thereof for impingement by second currents opposed to said first and deflection of laterally directed currents; and

at least two partitions substantially normal to said concave first surface and extending outward therefrom toward said open face;

said concave surface reacting with impinging currents to create opposing currents attenuating the energy of said incoming currents and causing accretion of alluvium suspended therein adjacent said open face; and said partitions providing structural rigidity to said curvilinear surface and acting to impede the flow of current laterally of said concave surface;

wherein said securing means includes a base on said reaction means and hold-down means selectively interconnected with said base to selectively orient said curvilinear surface and said faces thereof with reference to a given direction of fluid current;

wherein said base includes first, second and third mounting ports defined in said base and disposed in a triangular array, one of said ports being centrally located on said base adjacent said open face and said base being substantially coterminate with the length and breadth of said reaction means; and

wherein said hold down means includes pivot means securing said base at said situs through said one of said ports and an array of ground anchor means positioned about said pivot means selectively engageable with remaining respective ones of said ports.

2. A protection array for preserving navigational channels and the like against the alluvial action of incoming and outgoing tidal currents, said channel having first and second lateral boundaries extending from a backwater to a main body of water, comprising:

a first row of spaced apart, mutually parallel modules anchored adjacent the first boundary of a said channel; and

a second row of spaced apart modules anchored adjacent the second boundary of said channel in a substantially mirror image relationship with said first row of modules;

each of said modules comprising a reactive surface which when impinged by tidal currents directs said currents back on themselves and attenuates lateral flow thereof over the length of said module to attenuate the kinetic energy therein and thereby constrain accretion of entrained alluvium from said currents adjacent said module and a fluid diverting surface contiguous over the rear face of said reaction surface;

the said modules in each said row having their reaction and fluid diverting surfaces alternately disposed; and

said surfaces being oriented with said channel to constrain a convergent flow in said channel for outgoing tidal currents and divergent flow from said channel for incoming tidal currents.

3. The invention defined in claim 2, wherein said modules at the extreme ends of each said row adjacent said main body of water have said reaction surfaces facing outboard of said channel.

4. The invention defined in claim 2 wherein said modules at the extreme ends of each said row adjacent said backwater have said reaction surfaces facing inboard of said channel.

5. The invention defined in claim 2, wherein said modules at the extreme ends of each said row adjacent said main body of water have said reaction surfaces facing outboard of said channel; and

wherein said modules at the extreme ends of each said row adjacent said backwater have said reaction surfaces facing inboard of said channel.

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