US 20030147696A1

(19) **United States**
(12) **Patent Application Publication** (10) **Pub. No.: US 2003/0147696 A1**
Hulsemann et al. (43) **Pub. Date: Aug. 7, 2003**

(54) **WAVE RAMP**

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(21) Appl. No.: **10/365,972**

(22) Filed: **Feb. 12, 2003**

Related U.S. Application Data

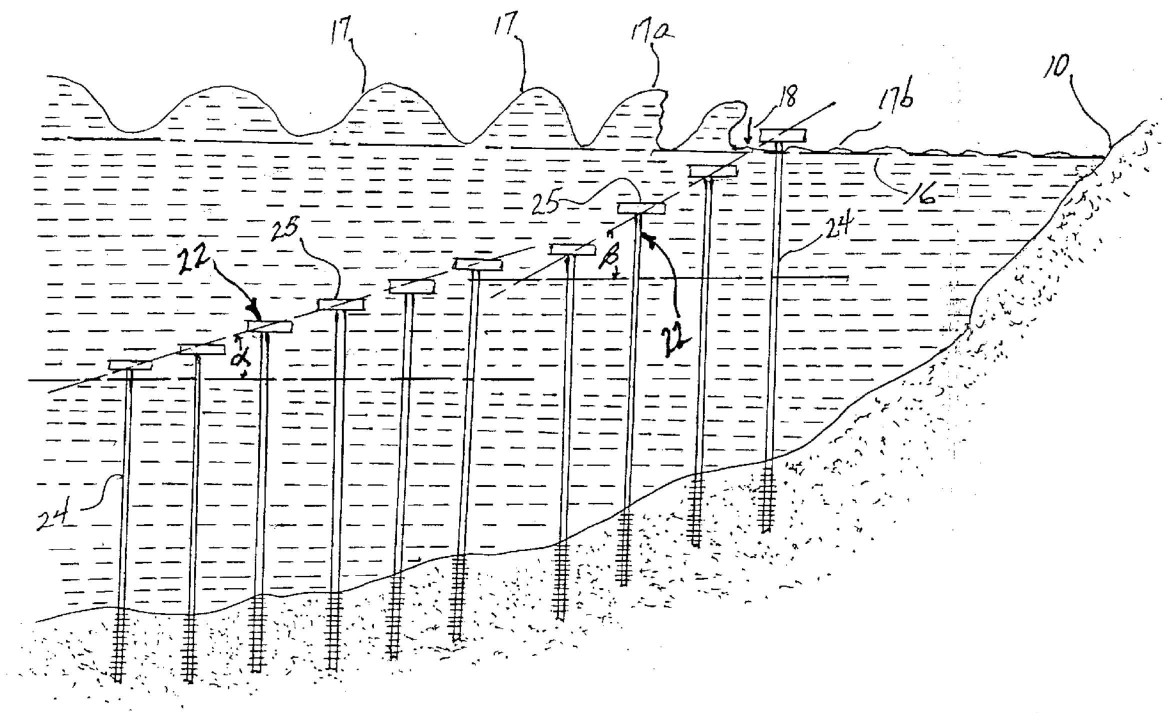
(63) Continuation-in-part of application No. 09/737,247, filed on Dec. 15, 2000, now abandoned.

Publication Classification

(51) **Int. Cl.**^{7} **E02B 3/06**; B63B 35/44
(52) **U.S. Cl.** **405/21**; 405/25; 405/34; 114/267

(57) **ABSTRACT**

The present invention describes an off-shore wave ramp for inducing early cresting of waves to prevent damage and erosion along a shoreline, consisting of at least one platform supported above the natural sea floor by support means firmly affixed to the sea floor, the platform being arranged according to a predetermined regular pattern such that the area of the covers between about 50 and 80 percent of the area of the seal floor under the platform and forming a false sea floor seawardly inclined between the high water level to a selected distance above the sea floor. The wave ramp platform is comprised of an array of a selected spaced-apart, unconnected, rigid, non-bouyant, stationary plate-shaped elements with a seaward inclination of the wave ramp is at a selected angle relative to the floor.



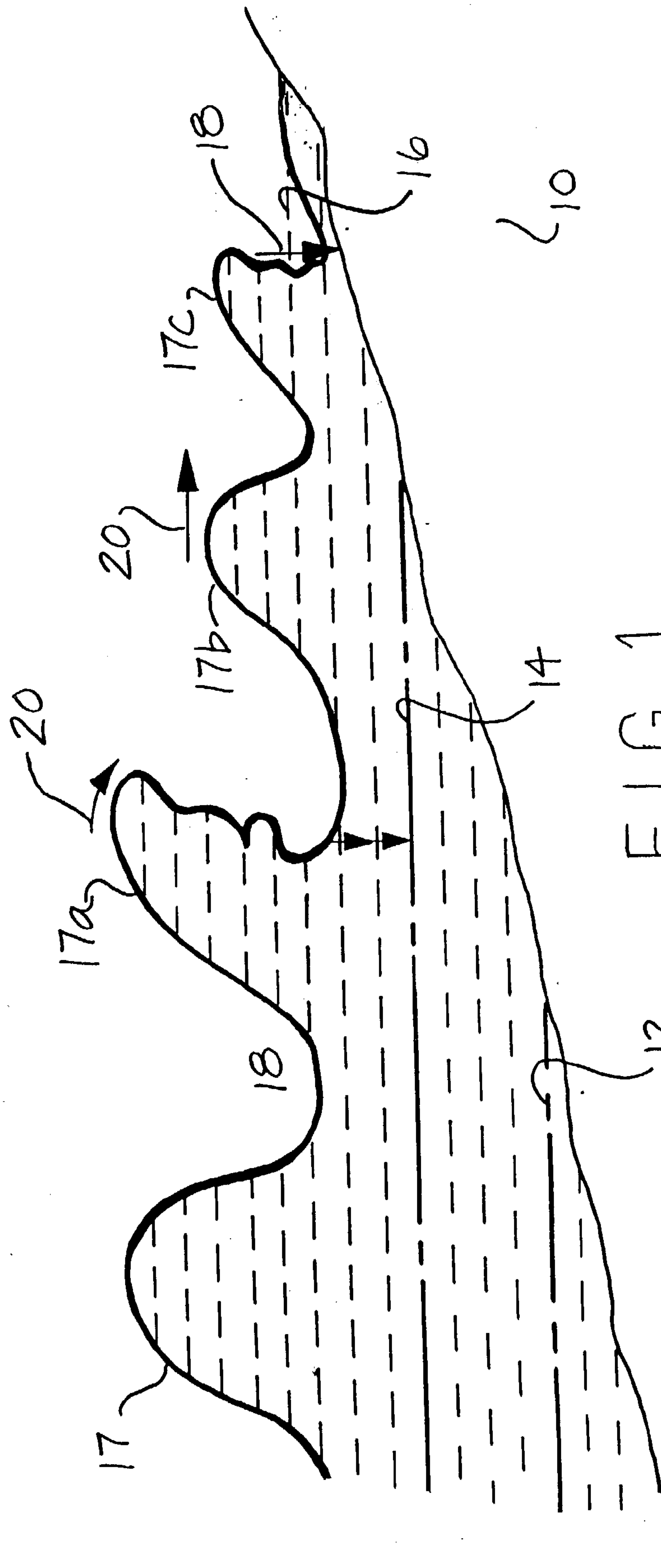


FIG. 1

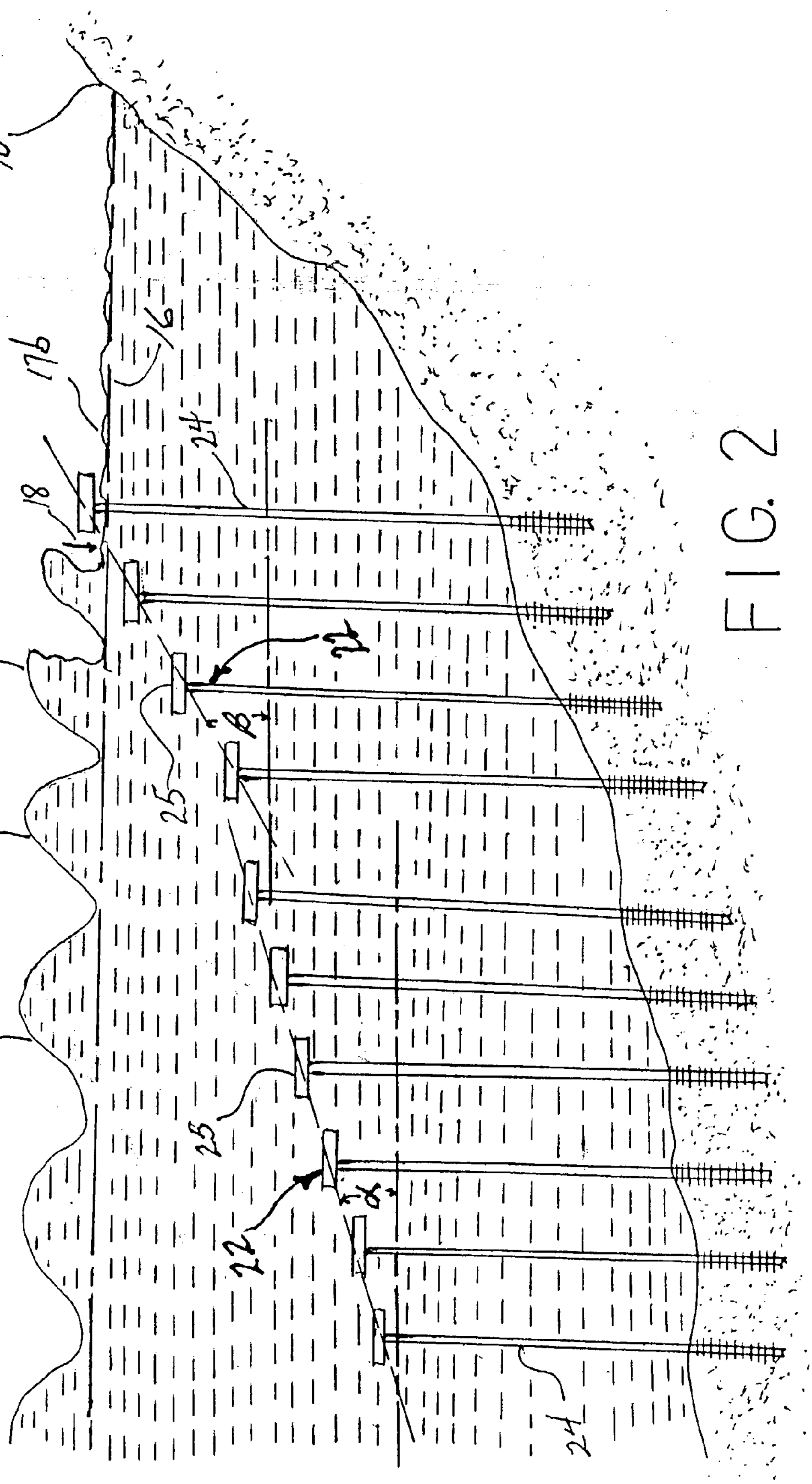


FIG. 2

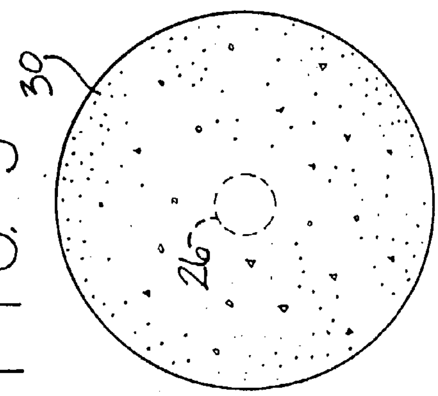


FIG. 5

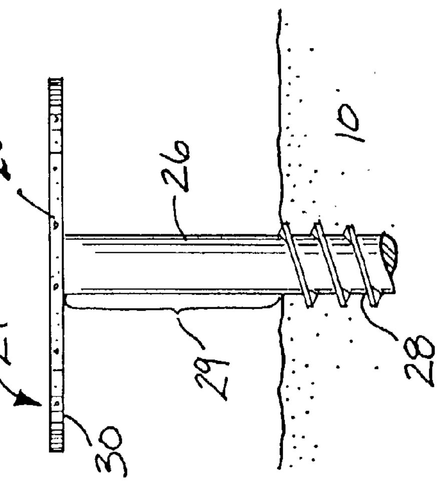


FIG. 4

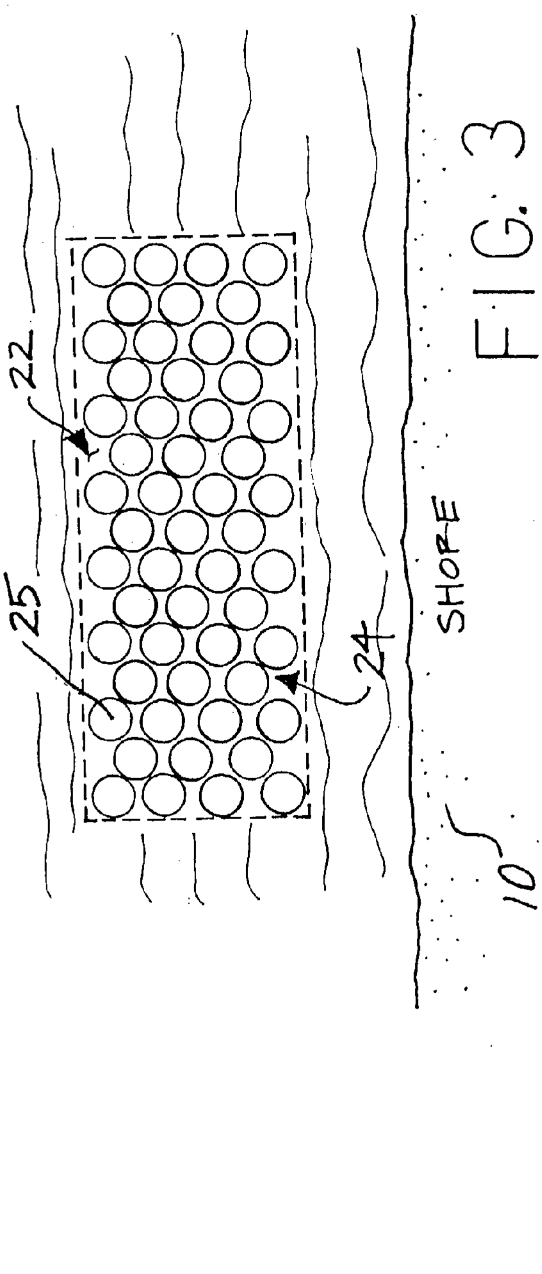


FIG. 3

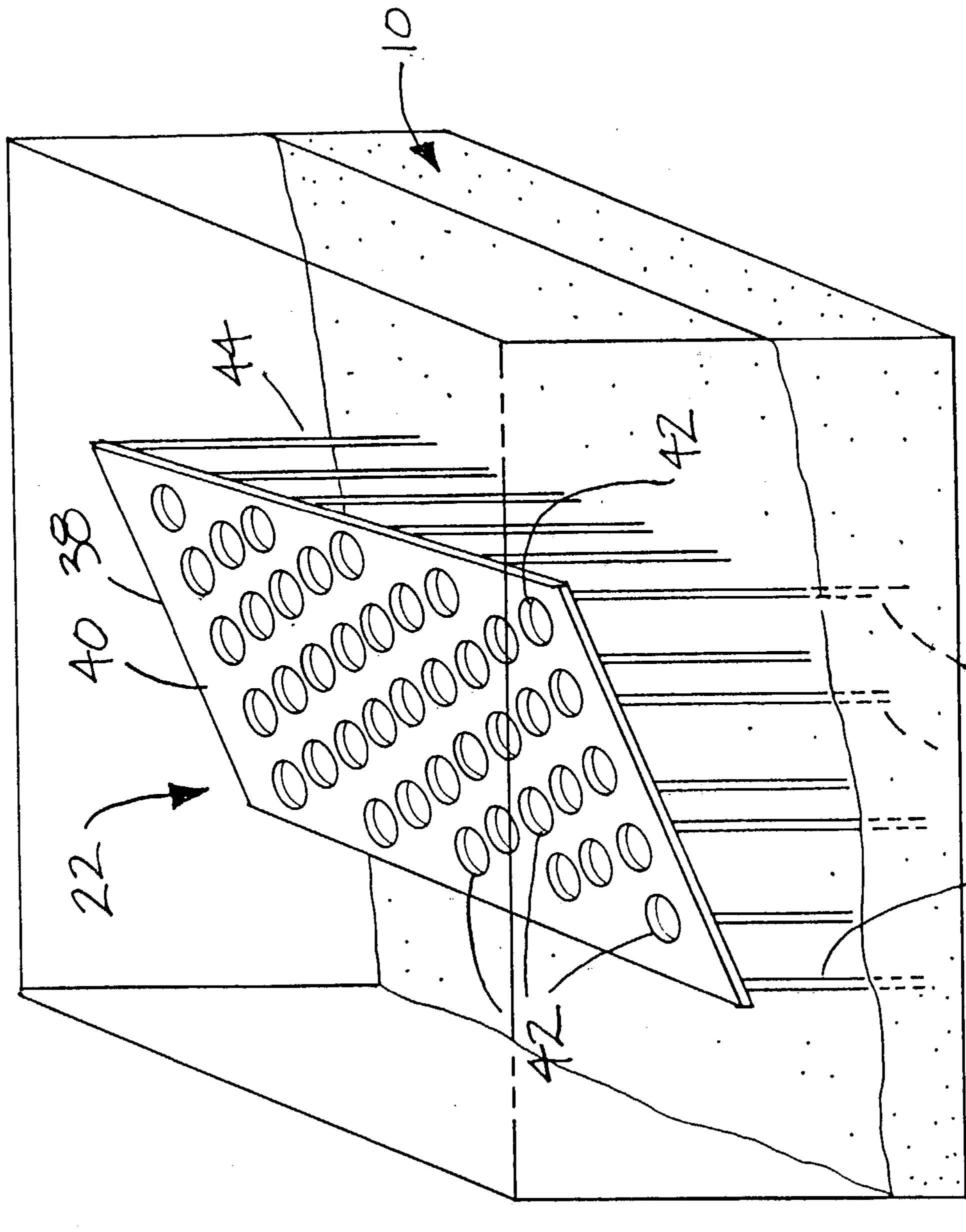


FIG. 6

WAVE RAMP

[0001] This application is a continuation in part of U.S. patent application No. Serial No. 09/737,247 filed Dec. 15, 2000, now abandoned.

BACKGROUND OF THE INVENTION

[0002] This invention relates to coastal breakwaters and more particularly to an improved construction for damping incoming wave energy to reduce harmful effects of incoming waves on the bottom, adjacent shore, and the like.

[0003] The use of a breakwater for the protection of shore areas and the damping of incoming waves is well known in the art. All of the various designs are positioned in the natural breaker zone or closer to shore. The most common breakwater is the barrier type that is in effect a solid wall situated offshore extending from the sea bottom to above the air/water interface. This type of breakwater acts as a wall against which the energy of the incoming waves is expended so that the water area of the shoreward side of the breakwater remains relatively calm and the shore area is relatively protected against the battering and erosion by wave action. This type of breakwater by its very nature interferes with currents which, under the proper circumstances, can result in increased erosion at the margins of the breakwater and may result in undue silting on the leeward side of the breakwater. In addition, breakwaters of this type require constant care and maintenance because of the force of the incoming waves and because the currents acting against the breakwater will in time erode away the base of the breakwater which will result in damage to the breakwater.

[0004] Other types of breakwaters have been devised in an attempt to avoid the massive construction generally required for barrier type breakwaters. These are normally of the floating barrier type in which a buoyant body or a plurality of buoyant bodies acting at or near the air/water interface serve to dampen the wave height, thereby to produce an area of relatively calm water behind the breakwater. Although such devices may operate satisfactorily in moderate seas, they are normally of insufficient strength to withstand very heavy seas, particularly in shallow water where wave action is most severe so that substantial repair and replacement of the buoyant bodies will be required after a period of very heavy seas. In addition, such devices require relatively complex mooring systems to retain the floating breakwater in position. More recently, restoring beaches lost to wave action is done by transporting sand from selected surplus areas to shore. Natural wave action, however, removes this material much like the original sand. Thus, this practice of replenishment is a never-ending procedure, besides it is creating new problems in the reservoir areas.

[0005] The most relevant prior art is U.S. Pat. No. 4,006,598, entitled "Breakwater System," which was granted to the present inventor, Jobst Hulsemann, on Feb. 8, 1977. The Hulsemann '598 patent describes a breakwater system comprising a generally plate-like structure disposed offshore and having an upper face that defined a raised sea floor above the natural bottom. Incoming waves are crested offshore over the breakwater, and subsequently formed waves are smaller because of the reduced water depth afforded by the false sea floor of the breakwater. Open spaces are provided in the upper face of the breakwater so that water pressure on the breakwater is equalized, thereby minimizing the structural requirements of the breakwater. The Hulsemann '598 patent provides for a plurality of false sea floors, each disposed at a different distance from the natural bottom so that the platform created by the plurality of false sea floors is roughly parallel to the surface of the water, and the plurality of false sea floors then forming a breakwater. Thus it can be seen that the Hulsemann '598 patent discloses a method wherein the breakwater system moved the effective area for reducing the damaging forces of breaking waves below the air/water interface, thus simulating a false sea floor during certain conditions of the sea, especially those conditions of different wave heights and different levels of the sea relative to the sea floor. The present invention of a wave ramp, by inherently deviating from the breakwater system of the prior art, overcomes the limitation of the prior art, and, in addition, offers other advantages. The most decisive difference to prior art is the overall inclination of the wave ramp, namely from about the sea floor to or above the surface of the sea, thus replicating more completely the naturally rising sea floor that causes steepening, cresting and breaking of incoming waves over the sandy bottom. The advantage of the continuity of the seaward inclination is that it covers the entire spectrum of incoming waves, regardless of wave height and different levels of the sea relative to the sea floor, in but a single structure, thus rendering the construction of tiered platforms to accommodate waves of different height unnecessary as used in the breakwater system. As a constructional consequence the individual component elements are considerably less massive, rendering a substantially greater ease of handling in placement operations, and require a shorter founding depth into the compacted subsoil of the sea floor. Also, the wave ramp of the present invention has all waves run up from their first encounter with the bottom of the false sea floor as it would be the case with the natural sea floor closer to shore without the wave ramp. Furthermore, the prior art breakwater system has an inherent weakness resting in its beginning in mid-water where parts of larger waves may form smaller waves beneath the structure. Even if these may not be erosive on the bottom their pulsating oscillations exert some stress on the individual elements from below that must be compensated for by the massiveness of the structure. On the other hand, the present invention of the wave ramp offers the advantage of a simple extension above the mean storm level of the sea towards shoreward in case protection is sought from damage of rarer events of exceedingly high stands of sea level. The present invention also overcomes the foregoing deficiencies with the prior art devices and practices and provides a breakwater effective for damping incoming waves, regardless of wave height and different levels of the sea relative to the sea floor, without interfering with the normal tidal and offshore currents.

SUMMARY OF THE INVENTION

[0006] The present invention resides in a wave ramp, a kind of sloping false sea floor, positioned seaward of the natural breakwater zone designed to induce the breaking process of the waves before they interact with the natural bottom. The wave ramp of the present invention is subjected to lower physical stresses as the result of wave encounter since the wave ramp is detached from the bottom, except for piles holding it in position, resulting in little interference with currents; and by acting at the base of incoming waves, well beneath the air/water interface, thereby reducing the height of the waves more shoreward from the wave ramp, and energy components of incoming waves against the wave ramp are significantly reduced. Accordingly, the structural strength of the system is not as critical as for prior art devices which encounter the incoming waves at the air/water interface, the point of greatest wave energy.

[**0007**] In accordance with the present invention, the wave ramp includes a generally plate-like structure having a substantially upper planar face spaced above the natural bottom to define a false sea floor over which the depth is substantially reduced as contrasted to depth of water over the natural bottom. Incoming waves, the sustainable heights of which are a function of water depth, run up over the wave ramp until they break. The energy is released in turbulence dispensed on the solid structure of the wave ramp rather than on the natural sea floor that is composed of readily movable sand. Waves subsequently formed, landward of the wave ramp, are substantially reduced in size due to the reduced distance left to the wind to build up new waves. Because of the shallowness of the water, the waves reaching shore have less force than would be the case without the wave ramp.

[**0008**] The upper face of the plate-like structure is provided with a plurality of spaced-apart apertures or open areas between the constituent numerous individual plate-like elements that extend through the structure to permit the passage of water therethrough, thus equalizing pressure above and below the wave ramp. Because the pressure equalization feature and because the breakwater acts substantially at the wave base rather than at the air/water interface, the stress on the structure is minimized. Consequently, damage to the wave ramp is minimal, and little or no maintenance is required. In addition, the plate-like structure of the breakwater is spaced above the natural bottom so that there is substantially no interference with the normal tidal and other near shore currents as the result of the placement of the wave ramp.

[**0009**] In one embodiment of the invention, the wave ramp defines a generally rectangular shaped sheet or plate in which a plurality of apertures or open spaces are provided so that about 50% to about 80% of the plate upper face is solid. The wave ramp is disposed with the plate spaced above the sea bottom in a gently inclined plane from near the sea floor to near the sea surface and anchored by a plurality of piles directly in the natural bottom.

[**0010**] The wave ramp is positioned offshore adjacent to the area to be protected and normally extends in its longitudinal dimension parallel to the area to be protected. The transverse dimension of the wave ramp, that is the distance from the landward to the seaward edges, is equal to at least 1 ½ wavelengths.

[**0011**] In another embodiment of the invention, the wave ramp is defined by a plurality of generally plate-shaped elements, each one slightly offset from it's neighbors in transverse direction, i.e. seaward and shoreward, which are disposed above the natural sea bottom and in combination define a generally rectangular rising plate-like configuration. The upper surfaces of the plates comprise a substantially planar upper face and the size of the plates and the spacing therebetween is such that not more than about 80% of the upper face area is solid surface. The combination of plates is so arranged as to transversely extend at least a distance of about 1 ½ wavelengths thereby rising from the sea floor to the surface. Whereas the wave ramp in transverse direction always begins near the bottom on it's seaward side it extends on it's shoreward side to above the mean level of the sea surface at regular or extreme stands of sea level. The size of the plates or constituent elements and the spacing therebetween can be varied across the transverse dimension of the wave ramp.

[**0012**] Other features and advantages of the present invention will become apparent from the following detailed description taken in conjunction with the drawings and from the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[**0013**] **FIG. 1** is a sectional side elevation illustrating schematically a section of sea floor and the action of incoming waves.

[**0014**] **FIG. 2** is a side sectional view of the sea floor of **FIG. 1** and showing a wave ramp, constructed in accordance with the invention disposed on the sea bottom for damping incoming waves.

[**0015**] **FIG. 3** is a plan view of the wave ramp of **FIG. 2**.

[**0016**] **FIG. 4** is a side elevation of an individual plate element of the wave ramp of **FIG. 3** showing the plate element secured in its operating position in the sea bottom.

[**0017**] **FIG. 5** is a plan view of the plate element of **FIG. 4**.

[**0018**] **FIG. 6** is a perspective view, partially in section, of a wave ramp constructed in accordance with another embodiment of the invention.

DESCRIPTION OF THE INVENTION

[**0019**] As shown in **FIG. 1 a** section of typical sea bottom **10** adjacent to a shore area is covered by water which normally cycles, because of tides, between a median low water level **12** and a median high water level **14**. During storms, however, the water may reach an even higher level and this level is designated as the mean storm level **16**.

[**0020**] It should be clear, however, that a specific storm water level cannot be precisely defined because of the variations in frequency and intensity of storms, the geography of the shore area, the nature of the body of water and other factors. Accordingly, determination of the mean storm water level can only be made after a period of observations and collection of data at the location.

[**0021**] Incoming waves **17**, generally generated by wind, can occur at any of the aforementioned water levels. These incoming waves, upon reaching the shallow waters adjacent to the shore, crest and break and, depending upon the wave height, may result in erosion of the bottom. In addition, the battering force of the waves, that is the force of the waves applied in a generally horizontal plane, is also largely dependent upon the height of the incoming waves.

[**0022**] Wave height is a factor of both wind velocity and water depth and as an incoming wave **17** approaches the shore, the water depth decreases to a point where the wave height is greater than the water depth can support. As water depth decreases, the front of the wave **17** becomes increasingly steeper until the wave collapses which results in the breaking of the wave, as indicated in **17***a*. The area where the breaking of the incoming waves occurs is commonly called the breaker zone. Typically, the bottom of the breaker zone is characterized by a greatly variable topography, often with holes and rises. It is presently believed that cresting and breaking will occur when the height of the wave, that is, the vertical distance from the trough to the top of the wave, exceeds about 1.5 times the mean depth of the water. Cresting of the wave creates a vertical component of energy **18** due to falling water and the magnitude of the vertical component is related to wave height. If the water is shallow enough and the vertical component **18** sufficiently large, particles from the bottom **10** will be lifted and suspended in the water, where they are eventually carried away by tidal current or near shore currents, if present, and subsequently deposited as silt or sand elsewhere. **FIG. 1** also shows a fairly uniform distance between the crests of waves **17**, such distance known as the period, or periodicity of the waves, which will vary based on wind, storm and tidal conditions.

[**0023**] In addition to the vertical energy component **18**, a horizontal energy component **20**, which is also related to wave height, is generated by the incoming wave **17**, which accounts for the battering force of the wave. The horizontal component **20** is greatest at the air/water interface or surface of the wave **17**.

[**0024**] After cresting fter cresting as at **17***a,* new wave forms **17***b* are generated and cresting is repeated, as at **17***c*. The new wave forms **17***b* are reduced in height as contrasted to the parent wave **17**, because they are formed in shallower water. However, the new wave forms even though of reduced height may still have sufficient vertical and horizontal energy components to be destructive to shore areas and installations located there along.

[**0025**] In accordance with the present invention, it has been found that by raising the sea bottom and reducing the water depth in a selected offshore area, incoming waves are caused to crest offshore in an area where the vertical component **18** can do little or no erosion damage to the sea bottom **10**. The wave ramp of the present invention, in effect, represents an artificially raised sea floor or false bottom. As the waves run up they do crest and break and collapse much like they do in the natural breaker zone without a wave ramp; the decisive difference, however, is that this breaking process occurs over the likewise non-erodable wave ramp **22** (**FIG. 2**) and not over the loose and movable grained sea floor **10**, the natural sea floor. In addition, hydrostatic pressure above and below the wave ramp is always balanced due to the spaced apart arrangement of the individual elements **24** (**FIG. 2**), and there is no interference with normal tidal and near shore currents because of the open spaces between the pilings **24**.

[**0026**] As is more particularly shown in **FIGS. 2 and 3**, a wave ramp (not to scale), shown generally as **22**, comprises a plurality of individual plate units **24** which are arranged in spaced relation off the shore area to be protected, shorewardly inclined from a point above the natural sea floor to a point above the mean storm level **16**. The plate units, even though they may have planar upper faces **25**, are slightly set off to define a generally elongated plate-like structure having a substantially inclined upper face extending between the sea surface and the bottom **10** to define a false sea floor which acts on the incoming waves in the same manner as the natural sea bottom in shallower waters adjacent to the shore. **FIG. 2** shows two wave ramps **22**, eached comprised of a plurality of individual plate units **24** having upper faces **25**, each wave ramp having two different rates of inclination α and β to the horizontal, where α is the angle measured by drawing a line through the midpoints of surfaces **25** for the first segment and β is the angle measured by drawing a line through the midpoints of surface **25** for the second segment. Thus, as the incoming waves **17** pass over the upper faces **25** between the sea surface and the surface of wave ramp **22** the mean depth of the water is substantially decreased, and, should the wave height be less than about 1.5 times the mean depth of the water as now determined by the upper face of the wave ramp **22**, the waves will crest as at **17***a* and break thereby discharging their energy (**FIG. 1**: **18**) on top of the faces **25** or the wave ramp **22**. Because the true bottom **10** is well below the false bottom simulated by the wave ramp **22** the particles will not be lifted by the turbulence at the bottom of the breaking waves **17** and not be suspended and transported as when the breaking occurs in naturally shallower water without a wave ramp. Subsequently formed waves will be of substantially reduced heights so that waves eventually reaching the shore area are of greatly reduced force.

[**0027**] The wave ramp **22** is preferably located in the offshore waters with its longitudinal axis extending substantially parallel to the shoreline, or to the installation being protected. The precise offshore distance of the wave ramp **22** is not critical although it is highly preferred to locate it far enough offshore so that the cresting waves **17***a* which are induced by the wave ramp **22** will have substantially little or no effect on the sea bottom **10**. This is always seaward of the natural breaker zone. Wave ramp **22** is spaced above the sea bottom **10** so that the upper faces **25** will lie substantially in an inclined plane vertically spaced from the bottom **10** rising to above the mean storm level (**FIG. 1**: **16**) over a distance of at least 1.5 times the wavelength. Although the upper faces **25** of the wave ramp **22** are described as substantially planar, the upper faces may be contoured in conformity with the contour of the bottom **10** at the point of installation.

[**0028**] The longitudinal dimension of the wave ramp **22** is not critical and it may be as long as required to protect a particular shore area or installation. The transverse dimension of the wave ramp **22** is selected as to be equal to at least 1 ½ times the wavelength and preferably the transverse dimension is equivalent to three or more wavelengths. As used herein, a wavelength will vary depending upon the location, the depth of the body of water, the slope of the sea bottom and the like. Thus, for example, in North Sea locations the wavelength is relatively short, while on the West Coast of the United States wavelengths are generally longer.

[**0029**] Referring again to **FIG. 1**, one can note that the geography of the sea floor is normally a continuation of the geography of the landmass above the high water line. When there is a gradual slope to the beach, the slope continues at the same relative slope under water. Due to the effects of erosion, the inclination of the sea floor closer to the beach area may be greater than the inclination of the sea floor at a greater offshore location. The geographies of the wave zones can thus be separated by the inclination of the sea floor. Table 1 shows examples of the relationships between the wave zones.

TABLE 1

	Sea Floor			Breaker Zone		Common Beach		Very Steep Beach
Rise:	1–500	1:200	1:100	1:50	1:30	1:30	1:20	1:10
Angle:	0.1°	0.3°	0.6°	1.1°	1.9°	1.9°	2.9°	5.7°
Percent:	0.2%	0.5%	1%	2%	3.3%	3.3%	5%	10%

[**0030**] The inclination of the wave ramp can then be selected based on the inclination of the sea floor. The angle of inclination of the wave ramp structure may be greater or less than the angle of inclination of the sea floor. As an example, a wave ramp structure may be selected wherein the first set of plate units **24** will be placed parallel to the shore such that the upper surface **25** is about 12 meters below the mean level of the sea surface where wave heights may only be 5 meters. As another example, Table 2 shows the approximate transverse width (from shore-side to ocean-side) of the wave ramp based on the length of the wavelength. The first three columns represent wavelengths from about 30 meters to about 80 meters, and the last two columns represent wavelengths from about 30 meters and less.

TABLE 2

Wavelength	80 m	80 m	80 m	30 m	30 m
Inclination:	1:20	1:25	1:30	1:10	1:50
Wave ramp	240 m	300 m	360m	90 m	100 m

[**0031**] Referring again to **FIG. 2**, where the period of the wavelength is about 30 meters, two different sloping segments may be simultaneously employed, based on the inclination of the sea floor having two different rates of inclination α and β to the horizontal. For example, where the inclination is 1:10, the first segment may be placed where the first set of plate units **24** placed parallel to the shore such that the upper surface **25** is about 10 meters below the mean level of the sea surface, and the first set of plate units **24** for the second segment may be placed parallel to the shore such that the upper surface **25** is about 2 meters below the mean level of the sea surface.

[**0032**] As is more particularly shown in **FIGS. 4 and 5**, the plate units **24** each comprise a shall or pile **26**, including preferably a lower threaded end portion **28**, adapted for anchoring in the sea bottom **10**, and an upper end portion **29** extending above the sea bottom and carrying a plate **30** in spaced relation to the sea bottom. The upper surface of the plate **30** in combination with adjacent plates defines the upper face **25** of the wave ramp **22**, which acts on the wave in the manner described to induce early cresting and breaking, thereby discharging the vertical energy component **18** and the horizontal component **20** of the incoming wave **17** on top of the plate units **24**. The plates **24** are preferably constructed of a fairly high strength material and in this connection reinforced concrete has been found to be an excellent construction material in view of its high strength and ready availability. With reinforced concrete it has been found that the preferred proportions of the plate **30** diameter to the diameter of the pile **26** be maintained on the order of about 5:1 to about 7:1. In typical sandy bottom the portion of the pile **26** in the sea bottom **10** rarely needs to extend more than a fixed length into the consolidated bottom, e.g. 5 m, to insure proper anchoring of the plate unit **24**. However, under certain conditions of the sea floor, other ratios between the diameter of plate **30** and pile **26** may be selected. Further, other material for plate **30** and pile **26** may be selected, such as stainless steel, wood, or composites such as carbon or fiber. Any material that can resist the corrosive effects of the environment may be used for plate **30** and pile **26** may be selected.

[**0033**] The spacing between the individual plate units **24** is an important element of the present invention, since, if the units are spaced too far apart, the efficiency of the wave ramp **22** is reduced. On the other hand, if the units are spaced too closely together, the wave ramp **22** will be exposed to undue structural stress due to the force exerted by the water passing over the breakwater system. Accordingly, it has been found that good results are achieved when the units are spaced so that the upper surfaces of the plates **30** comprise between about 50% to about 80% of the total area of the upper face **25** of the wave ramp **22**. In this manner sufticient surface is provided to efficiently induce the cresting and breaking of the waves yet sufficient open space is provided to permit equalization of the pressures above and below the wave ramp **22**.

[**0034**] In some cases it may be desirable to provide a series of wave ramps **22**, in which the upper faces **25** are disposed at different distances from the shore line, so that, for example, an outer wave ramp is followed by a more shoreward wave ramp, as is the case above where the wavelength is about or less than 30 meters.

[**0035**] Although the wave ramp of the present invention has been described in connection with a plurality of plate units **24** which are individually anchored in the sea bottom **10** to define a false sea floor, it should be clear that other structural arrangements can be utilized to induce the early cresting of waves in accordance with the present invention. For example, a platform unit can be utilized in place of the plurality of plate units **24**.

[**0036**] As is more specifically shown in **FIG. 6, a** wave ramp **22'** comprises a unitary rectangular platform **38** having a substantially planar upper face **40** including a plurality of openings **42**, which extend through the platform for the equalization of pressure. The platform **38** is anchored in the sea bottom **10** by a plurality of piles **44** which extend above the sea bottom for carrying the platform **38** substantially between the bottom **10** and the sea surface for the purpose already described. The openings **42** are distributed over the platform **38** and are of sufficient size and number so that the solid portion of the surface of the platform comprises between about 50% to about 80% of the total platform area. The transverse dimension of the platform **38** is equal to between 1 ½ to about three or more wavelengths. In this embodiment, the wave ramp **22'** can comprise sections of the platforms **38** arranged in end to end relation so as to extend parallel to the shoreline or installation being protected.

[**0037**] The operation of the wave ramp **22'** is as described above. That is to say, the upper surface **40** of the platform **38** defines a false sea floor, which causes early cresting and breaking of the larger incoming waves, while waves subsequently formed over the system are substantially smaller because of the reduced water depth provided by the false sea floor, the short distance to the shore, and the length of time the wind operates on the surface of the water.

[0038] From the foregoing it will be seen that the wave ramp of the present invention provides a false sea floor, which is in spaced relation to the natural sea bottom, to act upon the base portions of incoming waves to induce early cresting and breaking of incoming waves at a point offf-shore, where the vertical component of wave energy can do substantially little or no damage to the sea bottom. The transverse dimension of the system is sufficiently large to inhibit the subsequent formation of large waves. The waves that do form shoreward of the wave ramp are of substantially less height than would normally occur in the absence of the wave ramp, and the horizontal components and the vertical components of wave energy are greatly reduced on the shoreward side of the wave ramp. In view of the structural design of the wave ramp and the manner in which it acts on the incoming waves, the forces exerted on the construction are minimized. Moreover, since the wave ramp is raised on pilings above the sea bottom, there is substantially no interference with normal currents.

[0039] While the invention has been described above in connection with certain embodiments thereof, it will be clear that changes and modifications may be made to the wave ramp system of the present invention without departing from the spirit or the scope of the appended claims. For example, the individual plate units **24** of the preferred embodiments have been shown to be disk-shaped, however, plates of any geometric design may be used. In addition, a wave ramp structure may constructed such that plate units **24** may be inclined relative to the general surface of the water.

I claim:

1. An off-shore wave ramp for inducing cresting of incoming waves before they interact with the natural sea floor to prevent damage and erosion along a shoreline, the wave ramp comprising: a plurality of platforms forming a substantially rectangular array of a selected number of spaced-apart, unconnected, rigid, non-buoyant, stationary plate-shaped elements, the array having a seaward side and a shoreward side, each such plate-shaped element having an upper surface substantially planar with the surface of the sea, the plurality of plate-shaped elements supported above the natural sea floor by support means firmly aftixed to the sea floor, said array of platforms being arranged according to a predetermined regular pattern such that the area of the array of platforms covers between about 50 and 80 percent of the area of the sea floor under the array of platforms, the array of platforms arranged such that their upper surfaces are displaced horizontally and vertically shoreward forming a false sea floor inclined between a point at a selected distance above the sea floor at the seaward side to a selected point above the mean storm level at the shoreward side.

2. The wave ramp of claim 1 wherein the shoreward inclination of the wave ramp forms a selected angle relative to the sea floor.

3. The wave ramp of claim 1 wherein the support means consists of a selected number of piles sufficient to bear the weight of the wave ramp under various conditions of wave height and period.

4. The wave ramp of claim 3 wherein the support means consists of a single piling for each plate-shaped element.

5. The wave ramp structure of claim 1, wherein the spaces between said plate-shaped elements vary according to the distance of the plate-shaped elements from the shoreline, the most seaward plate-shaped elements being spaced-apart by the greatest distances.

6. The wave ramp structure of claim 1, wherein the transverse dimension of the platform is from about 1.5 wavelengths to about three or more wavelengths.

7. The wave ramp structure of claim 2, wherein the plate-shaped element is in the shape of a disk.

8. The wave ramp structure of claim 2, wherein the overall inclination of the platform varies from, about 1:50 to 1:30 at the seaward side, to about 1:30 to 1:10 near the shoreward side.

9. The wave ramp structure of claim 1, wherein the ratio of the diameter of each disk to the diameter of its supporting pile is from about 5:1 to about 7:1 and the extension into the sea floor not exceeding the depth of the water.

10. The wave ramp of claim 1, wherein the platform is made of a material selected from the group consisting of reinforced concrete, stainless steel, wood, carbon fiber, plastic and composites.

11. The wave ramp of claim 1, wherein the platform is comprised of two or more successive platforms located substantially between a selected off-shore location and the shore line, each platform extending from the high water level to the sea floor, the high water level side of the platform always located closer to shore than its sea floor side.

12. An off-shore wave ramp for inducing cresting of waves before they interact with the natural sea floor to prevent damage and erosion along a shoreline, the wave ramp comprising:

(a) a substantially rectangular array of a selected number of spaced-apart, unconnected, rigid, non-buoyant, stationary plate-shaped elements, the array having a seaward side and a shoreward side, each such plate-shaped element having an upper surface, the upper surface of each such plate-shaped element substantially planar with the surface of the sea, each of such plate-shaped elements supported above the natural sea floor by support means firmly affixed to the sea floor, the array of elements being arranged according to a predetermined regular pattern such that the area of the array of elements covers between about 50 and 80 percent of the area of the sea floor under the array of elements, the array of elements arranged such that their upper surfaces are displaced horizontally and vertically shoreward forming a false sea floor inclined between a point at a selected distance above the sea floor at the seaward side to a selected point above the mean storm level at the shoreward side, the shoreward inclination of the wave ramp forming a selected angle relative to the sea floor; and

(b) the support means consisting of a selected number of piles sufficient to bear the weight of the wave ramp under various conditions of wave height and period.

13. The wave ramp of claim 12 wherein the support means consists of a single piling for each plate-shaped element.

14. The wave ramp structure of claim 12, wherein the spaces between said platforms vary according to the distance of the platforms from the shoreline, the most seaward platforms being spaced-apart by the greatest distances.

15. The wave ramp structure of claim 12, wherein the transverse dimension of the platform is about 1.5 wavelengths to about three or more wavelengths.

16. The wave ramp structure of claim 12, wherein the plate-shaped element is in the shape of a disk.

17. The wave ramp structure of claim 12, wherein the overall inclination of the platform varies from, about 1:50 to 1:30 at the seaward side, to about 1:30 to 1:10 near the shoreward side.

18. The wave ramp structure of claim 12, wherein the ratio of the diameter of each plate to the diameter of its supporting pile is from about 5:1 to about 7:1 and the extension into the sea floor not exceeding the depth of the water.

19. The wave ramp of claim 12, wherein the material for the platform is selected from the group consisting of reinforced concrete, stainless steel, wood, carbon fiber, plastic and composites.

20. The wave ramp of claim 12, wherein the platform is comprised of two or more successive platforms located substantially between a selected off shore location and the shore line, each platform extending from the high water level to the sea floor, the high water level side of the platform always located closer to shore than its sea floor side.

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