Oct. 20, 1959 R. Q. PALMER 2,909,037

COMPONENT FOR RUBBLE-MOUND BREAKWATERS

Filed Oct. 27, 1958

Fig. 1.

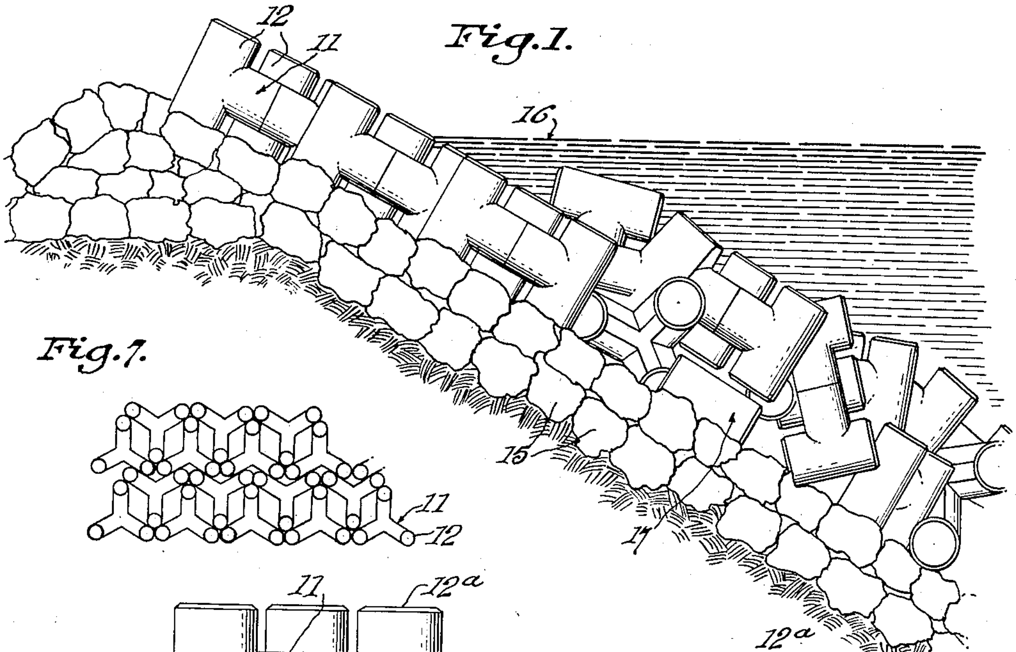


Fig. 7.

Fig. 2.

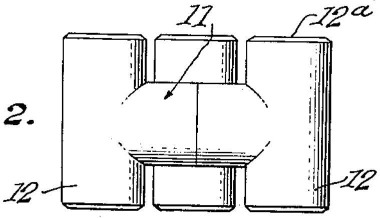


Fig. 5.

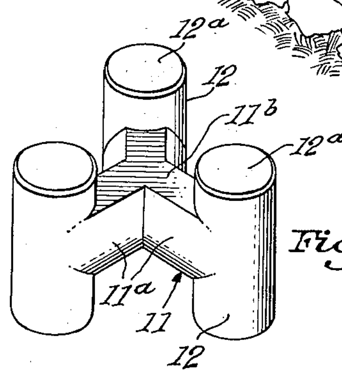


Fig. 3.

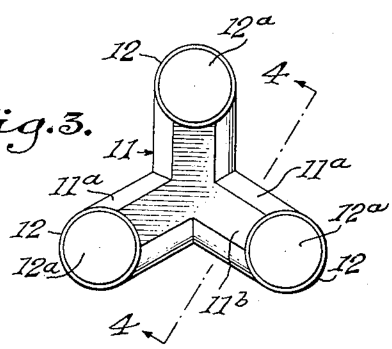


Fig. 6.

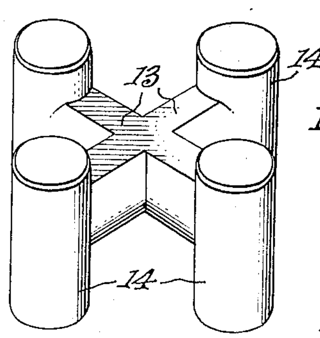
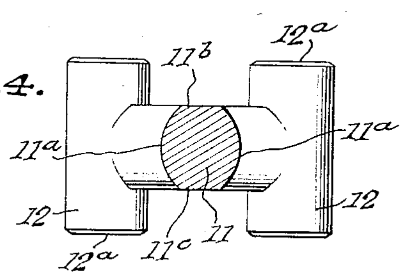


Fig. 4.



INVENTOR.

Robert Q. Palmer

BY Willard J. Hodge Jr.

Boniface Hamilton.

ATTORNEYS

United States Patent Office

2,909,037

Patented Oct. 20, 1959

2,909,037

COMPONENT FOR RUBBLE-MOUND BREAKWATERS

Robert Q. Palmer, Kailua, Oahu, Hawaii

Application October 27, 1958, Serial No. 769,955

16 Claims. (Cl. 61—4)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government, for governmental purposes, without the payment of any royalty thereon.

This invention relates to the construction of components for integration into stable structures to resist kinetic forces of water induced by natural phenomena.

Breakwaters, jetties, revetted slopes and the like, may be exposed to large magnitude kinetic forces resulting from waves, currents, or fluctuations in water levels. These structures may be located in the sea, lakes, artificial reservoirs, or along streams or artificial channels. It is common practice to use natural stones of various sizes for construction and reinforcement of these protective structures which will hereinafter be generically referred to as breakwaters.

In locations where suitable stone of sufficient size is not readily available, it has been the practice to use stone substitutes. The most common substitutes for stone are precast concrete components of various shapes and sizes. Larger and heavier components are used where the largest magnitude kinetic forces are anticipated. Cubicle concrete blocks and modified cubes have been commonly used for this purpose. Tetrahedrons and similar shapes have also been used. Layers of these types of components placed on sloping breakwaters have not been highly stable or economical. This is attributed in part to the relatively large, plane surface areas of these types of components which are exposed to kinetic forces of water, in part to the smooth surfaces of the units on which one unit may slide on another, and in part to the relatively low percentage of voids in layers constructed of these units.

Other improved components have been used in structures exposed to water action. Some of these have overcome the disadvantages of having a relatively large proportion of plane surfaces. The most common form of this type of unit has truncated cones or fingers radiating from a central mass. Layers of these units provide a higher percentage of voids than is usually obtained in layers of cubes, tetrahedrons, and modifications thereof. However, the obtuse angles formed between the projections from the central masses of adjacent units do not provide for positive interlocking of the units. When using components such as the tetrahedrons and other shapes which have four points, the center of gravity is relatively high when the unit is in such a position that one point is down, a position which frequently exists when random placement is employed, and consequently component instability results. The resulting practical disadvantage of all the components described above is that they must be used in multiple layers to be effective.

Extensive tests have been conducted to determine the shape or configuration a component should have for maximum stability and interlocking characteristics, without regard to whether multiple layers of randomly placed components be used or whether a single layer of components arranged in a more or less regular pattern be

used. Based upon the results of these tests, it was determined that the shape should not be spherical because it would tend to roll. Also, it was found that the components should not be wedge-shaped, or have pointed corners or truncated projections radiating from a central mass because it would tend to force itself under adjacent units, thereby lifting them out of position. Nor should the component be shaped so that a position would likely result where three legs would protrude above the surface and thus be exposed to the dynamic force of water action with only one leg embedded in the layer to resist displacement.

Therefore, the principal object of the present invention is to provide an improved component for structures which resist the kinetic forces of water.

Another object of the present invention is to provide a component for use in rubble-mound breakwaters which does not have large, plane surface areas which would be subject to pressure of the fluid acting perpendicular to said plane surfaces, thus concentrating a major force as a single vector tending to displace the component.

A further object is to provide a component for breakwaters which does not have sharp wedge points or other projections which would tend to dislodge adjacent components by wedge or lever action.

Still another object is to provide a component for breakwaters having a relatively great mass, a relatively low center of gravity, and, at the same time, have a relatively high percent of voids.

Another object is to provide a component for breakwaters which has improved interlocking characteristics when used in rubble-mound breakwaters with like components.

Another object is to provide a component for breakwaters having sufficient stability and interlocking ability to be successfully used in a single layer.

Still another object is to provide a substantially symmetrical component for breakwaters which can be successfully used in either a single layer of components placed in a substantially uniform pattern or in a randomly placed or jumbled compound layer.

Additional objects and advantages of the present invention will be obvious to those skilled in the art as the description proceeds, in which—

Fig. 1 is a side view of a breakwater or revetted slope composed of components constructed in accordance with the present invention;

Fig. 2 is a side view of one of the components of Fig. 1;

Fig. 3 is a top view of the component of Fig. 2;

Fig. 4 is a sectional view taken on line 4—4 of Fig. 3;

Fig. 5 is a perspective view of the component of Fig. 2;

Fig. 6 is a perspective view of another embodiment of the present invention; and

Fig. 7 is a plan schematic diagram of a uniformly patterned protective layer of components such as shown in Fig. 2.

Referring to the drawing, Figs. 2, 3, 4, and 5 show what will hereinafter be referred to as a "tribar." Fig. 6 shows another species of the invention hereinafter referred to as a "quadrabar."

The tribar has a central spider having three legs **11**, the central axes of which radiate in a common plane. Attached to the end of each radiating leg is a crossbar **12** having a geometrical axis substantially perpendicular to the plane of the spider. The spider legs **11** are preferably spaced apart at equal angles. The tribar is preferably fabricated of concrete, cast as a single unit, but could be fabricated of any other material having suitable properties of hardness and strength, and having a high specific gravity.

The quadrabar is of the same construction as the tribar except that the central spider has four legs **13** and four crossbars **14**. All statements hereinafter made concerning tribars are equally applicable to quadrabars unless specifically stated otherwise.

Fig. 1 shows a rubble-mound breakwater constructed of tribars. A prepared rock base is shown at **15**. A single layer of tribars arranged in a more or less uniform pattern is shown above and extending slightly below the water line **16**. A randomly placed compound layer of tribars is shown below the water line at **17** where obscured visibility prevents placement of the components in a uniform pattern.

It will be noted that no plane surfaces of any consequence exist on the tribar. The crossbars are cylindrical and the spider legs have arcuate sides **11***a* and flat tops **11***b* and bottoms **11***c*. The ends **12***a* of the crossbars are flat with beveled edges. The spider legs are flattened for convenience in fabrication. The arcuate sides have a radius five-eighths (⅝) the smallest diameter of the spider legs which gives a greater cross-sectional area than a circle and hence greater strength and greater mass.

Although the ends of the crossbars **12***a* may be slightly domed, fully hemispherical ends would adversely affect the interlocking characteristics of the tribar. The crossbars may be slightly tapered or otherwise slightly modified in shape to permit the use of certain types of forms for molding. A series of flat plane surfaces could be used to form crossbars of polygonal cross section to simulate the cylindrical surfaces shown, but should be very narrow in width to as closely approximate a cylindrical surface as possible. Otherwise, a major force due to fluid pressure acting perpendicular to the plane surfaces as a single vector will tend to displace the component.

By positioning the crossbars at right angles to the spider legs, and having blunt ends on the crossbars, no wedges are formed which would tend to work their way under and dislodge adjacent components of the breakwater. The crossbars are sufficiently short and stubby and the overall component is sufficiently compact so that no legs are apt to act as levers to displace adjacent components as frequently happens when components having a central mass and radiating projections are used.

The interlocking characteristics of the tribar are greatly improved over other known types of components due to the right angles formed between the spider legs and the crossbars. When the tribars are placed in a random compound layer, the crossbars will tend to fall over the spider legs and crossbars of adjacent components and will usually be in contact with the overlapped component at substantially right angles, thereby giving greater interlocking than would exist if obtuse angles resulted, as in the case of components having a central mass with radiating projections. The quadrabar has better interlocking characteristics when used in randomly placed layers than the tribar because it has a greater number of crossbars. Continuing on that premise, it would appear that a component having five spider legs and crossbars or an even greater member would provide even better interlocking characteristics. But in order to have spider legs and crossbars of sufficient diameter in relation to the lengths to be sufficiently strong when cast of concrete and of sufficient mass, components having more than four crossbars do not have sufficient space between the crossbars to accommodate the other like parts of adjacent components. Accordingly, except in rare circumstances where it is desired to emphasize the interlocking characteristic at the expense of other characteristics, the invention is restricted to use in the form of tribars or quadrabars. Either form provides a stable, integrated structure having a high percentage of voids and having great resistance to destruction by the forces of water.

When used on the slopes of breakwaters above the water surface and in shallow water where visibility is unobscured, it is preferable to prepare a relatively smooth or even foundation and place the components in an upright position on the ends of the crossbars with the plane of the spider parallel to the base and closely nested together in a pattern such as that shown in Fig. 7, thereby forming a single layer of components as compared to the double or compound layer which is required for randomly placed components to be effective. The tribar is especially adapted for use in a single, patterned layer as shown in Fig. 7. When so placed, the individual components cannot be displaced to any appreciable extent laterally because of the adjacent components. Nor are the tribars subject to being tipped or overturned because of the adjacent, abutting tribars. When used in a single, placed layer, the three-point base of the tribar is always stable and is definitely superior to the four-point base of the quadrabar which would be subject to rocking by wave action and hence more subject to individual component destruction.

In order to have a stable component under all conditions and to have a versatile component which has sufficient mass, sufficient space between the arms and crossbars for interlocking, and which will have a high percent of voids, the proportion of each component or the relationship between the diameter and length of the spider legs and crossbars is critical. It has been found that the spider legs and crossbars should be of approximately the same diameter. From the center of the spider to the center of the crossbar the component should be approximately one and one-fourth diameters. The crossbars should be approximately twice the diameter in length. If the spider legs or the crossbars are made appreciably shorter, the interlocking characteristics are eliminated and the component approaches a solid element which, as stated previously, has proven inferior. If the spider legs or crossbars are lengthened with respect to the diameter, the component can no longer be cast of concrete without internal reinforcement. Even more important, a looser fitting, interlocking pattern results which allows each component to vibrate within the mass thereby promoting individual component disintegration due to impact with adjacent components.

Further, it is desirable that the tribar and quadrabar be constructed substantially symmetrical. That is, the crossbar should be equally spaced apart and of the same length to give the best base. The spider legs should be at the midpoint of the crossbars so that the component can be effectively used either in a random compound layer or in a uniform-patterned single layer, as the circumstance dictates. If the central spider is offset to a position near the ends of the crossbars, the interlocking properties of the component are greatly reduced because one side of the component has no crossbars which project beyond the plane of the spider.

The tribar is especially suitable for casting from concrete. The ends of the crossbars are preferably flat and therefore require no special top-mold. Likewise, the spider legs are flat at top and bottom which also allows an open top-mold to be used for the spider portion of the component. Any number of commonly used methods of forming and working concrete are satisfactory for constructing tribars and quadrabars. If components of unusually large size are required, it may be necessary to reinforce the concrete in spite of the known disadvantages of reinforced concrete when used in sea water.

From the foregoing full and complete disclosure it will be appreciated that a new and novel component for breakwaters has been described. Although the configuration and proportion of the component are critical for a versatile, economical component, it is possible that under unusual circumstances it may be desired to forfeit one desirable characteristic in order to emphasize another.

I claim:

1. A component for breakwaters comprising a central spider having a plurality of legs joined at a common point and radiating therefrom, an elongated crossbar at-

tached to the outer end of each spider leg, the major geometrical axis of each of said crossbars being disposed substantially perpendicular to the geometrical axis of the spider leg to which the crossbar is attached.

2. A component for breakwaters comprising a central spider having a plurality of legs joined at a common point and radiating therefrom with the geometrical axes of said legs lying substantially in a common plane, an elongated crossbar attached to the outer end of each spider leg, the longitudinal geometric axis of each of said crossbars being disposed substantially perpendicular to said common plane.

3. A component for breakwaters as set out in claim 2 wherein the number of spider legs is three.

4. A component for breakwaters as set out in claim 2 wherein the number of spider legs is four.

5. A component for breakwaters as set out in claim 2 wherein said crossbars are cylindrical and portions of the surfaces of said spider legs are arcuate.

6. A component for breakwaters as set out in claim 2 wherein said spider legs are attached centrally of said crossbars, said crossbars being of equal length, and said spider legs radiating from said common point forming substantially equal angles between adjacent spider legs.

7. A component for breakwaters as set out in claim 2 wherein said spider legs and said crossbars have substantially equal diameters, the length of said spider legs being approximately one and one-fourth said diameters, and the length of said crossbars being approximately twice said diameters.

8. A protective covering for breakwaters comprising a plurality of components arranged in interlocking relation in a single layer, each of said components comprising a central spider having a plurality of legs joined at a common point and radiating therefrom with the geometrical axes of said legs lying substantially a common plane, said legs being substantially equally spaced one from the other, an elongated crossbar attached to the outer end of each spider leg, the longitudinal geometric axes of said crossbars being disposed substantially perpendicular to said common plane, each of said components being placed with said common plane substantially parallel to a supporting base and in a close-fitting, interlocking, substantially uniform pattern.

9. A protective covering for breakwaters as set out in claim 8 wherein the number of spider legs for each said component is three.

10. A protective covering for breakwaters comprising a plurality of components, each of said components comprising a central spider having a plurality of legs joined at a common point and radiating therefrom with the geometric axes of said legs lying substantially in a common plane, said legs forming substantially equal angles between adjacent legs, an elongated crossbar attached to the outer end of each spider leg, the longitudinal geometric

axes of said brossbars being disposed substantially perpendicular to said common plane, said components being arranged in a compound layer, randomly placed in jumbled, interlocking relationship to form an integrated protective covering.

11. A protective covering for breakwaters as set out in claim 10 wherein the number of legs in each of said components is four.

12. A component for integration into a protective covering for breakwaters comprising a central spider having a plurality of equal-sized legs joined at a common point and radiating therefrom, the geometric axes of said legs being disposed in a common plane and spaced apart to form equal angles between adjacent legs, said legs having cylindrical sides and plane upper and lower surfaces parallel to said common plane, a cylindrical crossbar attached centrally thereof to the outer end of each spider leg, the geometrical axis of each crossbar being disposed perpendicular to said common plane, said crossbars being of equal length and diameter, the length of said crossbars being approximately twice the diameter of said crossbars, said legs having a minimum diameter approximately equal the diameter of said crossbars and having a length approximately one and one-fourth the diameter of said crossbars.

13. A component as set out in claim 12 wherein the number of said spider legs is three.

14. A component as set out in claim 12 wherein the number of said spider legs is four.

15. A protective covering for structures to resist the kinetic forces of fluids comprised of a plurality of components as set out in claim 12, a first group of said components disposed in a single layer placed upright on the ends of said crossbars in an interlocking, substantially uniform pattern above the water line and for a substantial distance below the water line, and a second group of said components disposed in a compound layer of randomly placed, interlocking components adjacent said single layer forming a continuation of the protective covering further below the water line.

16. A component for breakwaters having a plurality of legs joined at a common point and radiating therefrom, and a single elongated crossbar attached to the outer end of each leg, the major geometrical axis of each of said crossbars being disposed at an angle to the geometrical axis of the spider leg to which the crossbar is attached.

References Cited in the file of this patent

UNITED STATES PATENTS

2,803,113	Hoad	Aug. 20, 1957
2,835,112	Monnet	May 20, 1958

FOREIGN PATENTS

848,624	Germany	Sept. 4, 1952