To all whom it may concern:

Be it known that I, JAMES McGILLIVRAY, a citizen of the United States, residing at Sacramento, in the county of Sacramento, State of California, have invented new and useful Improvements in the Protection of Levees, Embankments, Dams, and other Natural or Artificial Structures, of which the following is a specification.

10 This invention relates to the protection of levees, embankments, dams or other natural or artificial structures, from erosion, wear, damage or injury by the action of water, or other disintegrating or devastating force, and has for its object to render the protection of levees and other structures above mentioned more expeditious, permanent, durable, practicable, efficient and considerably cheaper and more economical.

20 Heretofore levees and embankments constructed of sand, earth or other material have generally been left without any special protection other than the material of which they are constructed. In some places, where unusually exposed, however, the embankment has at times been protected by piling driven into the water at the lower edge of the levee or embankment, or by means of brush strewn along or upon the levee, sometimes by brush packed in behind the piling driven at the base of the levee or embankment; and recently an attempt has been made to protect levees by means of a solid concrete coating or surface on the exposed side of the levee. The method of constructing this solid concrete or monolithic surface is similar to that used in the construction of cement or concrete sidewalks, that is to say: the cement, sand and gravel or crushed rock are taken to the point of intended use, and there mixed and dampened and applied to the side of the levee where desired, in one solid and continuous surface.

30 The present invention contemplates the formation of a revetment from slabs or blocks of concrete or other suitable composition or material, which blocks may be of any suitable size or shape and be made at any convenient place whence to be taken to the place of use and joined together in sufficient numbers to cover the area to be protected.

40 The invention therefore consists in the structure of parts and in their association, combination and arrangement for the purpose specified, substantially as hereinafter set forth and claimed.

That the invention may be fully and concisely disclosed, reference is made to the accompanying drawings, which form a part of this application and in which—

50 Figure 1 represents in vertical section an embankment protected by a revetment or mattress embodying this invention; Fig. 2 is an elevation of a portion of such revetment; Fig. 3 is an edge view of a slab constituting one of the units of said revetment, the manner of joining another unit thereto being also shown therein; Figs. 4 & 5 are face and end views of one of said units; Fig. 6 shows the face of one of such units with only one tie hole in each end; Fig. 7 is an enlarged face view of the tie seen in Fig. 3; Fig. 8 is a like view of the end portion of a unit at the end of a revetment; and Fig. 9 shows an anchor that may be used for any portion of the revetment.

The units of the revetment are preferably in the form of slabs from two (2) inches to six (6) inches in thickness; from one (1) foot to three (3) feet in width and from two (2) feet to ten (10) feet in length. The slabs, constructed at the point of manufacture, are transmitted with the cables and other fastenings to the point of use and secured together and in place by means of the cables and other fastenings, as fully described hereinafter.

The slabs are so constructed as to be placed lengthwise of the levee, that is, a cable is attached to each end of the slab by the means hereinafter indicated and as shown in the drawings. The cables extend from the bottom of the levee, or the lowest point to be protected, up to the upper portion, or top, of the levee, and are fastened to a permanent or artificial anchor, generally a concrete base or dead man sunk into the top of the levee. The lower slab is placed in position at the bottom of the levee and each end of this slab is fastened to the cable adjoining such end. The next slab is then placed immediately above the lower slab and fastened likewise to the same cables. This process is continued until enough slabs have been placed one above another to reach to
the height to be protected, then the next row of slabs is placed in position. The end of
the slab nearest the row of slabs already in place being attached to the same cable and
the opposite end of the slab to another cable. When this row of slabs is completed to the
height desired, the next row of slabs is put in place, fastened to the cables and com-
plete, until there is thus formed one com-
plete mattress covering the space desired.
Each row of slabs is fastened to the adjoin-
ing row of slabs by being fastened to the
same cable and by additional means, if re-
quired; that is, the ends of the two slabs
where they come together, are fastened to
the cable running through the groove in the
ends of the slab, as more fully shown in the
drawings. By this means a pliable mat or
mattress composed of these various units
or slabs, with the cables running between
each set of units, and the various units fas-
tened together as indicated, is formed, and
this mattress thus formed will conform to
any settling and erosion or other changes
in the form of the embankment upon which
it rests. In most instances the weight of
the slabs will be sufficient to hold the entire
structure in place. In some instances where
the current is strong or wash severe, the
lower end of the cables are anchored by
means of cement or granite blocks or other
weights or to cement or other piles driven
into the ground. A large number of slabs
can be assembled at the upper portion of the
embankment or on barges or boats, there
tied to the cables and fastened together and
then lowered to the point to which it is de-
sired to lower them beneath the surface of
the water, and this protection can therefore
be placed in the desired position at any
stage of the water and under any conditions
of weather.
The most practicable slab is one weigh-
ing not to exceed one hundred and fifty
(150) pounds as such a slab is more readily
handled and placed in position. On ordi-
nary work, where there is no unusual ex-
posure or wash or pressure, the slabs are
made thinner than are those used in more
exposed work.
The slabs may be composed of concrete,
made in the usual manner, that is a combi-
nation of cement, gravel and sand in pro-
portion ranging from one of cement to three
or more of gravel or crushed rock and three
more of sand, up to a mixture of one part
of cement to ten or fifteen parts of sand
and gravel as desired. These slabs may also
be made of clay or clay products; they may
be made of asphalt; they may be made of
asphalt macadam, which is a mixture or
combination of asphalt and gravel or
crushed rock; they may be made of crude
oil and crushed rock reinforced with iron
or steel; they may be made of concrete and
steel (or other metal) or asphalt and steel
or other metal (the steel or other metal be-
ing used as a reinforcement or protection
to the asphalt, concrete, and crude oil and
crushed rock; thus—wire mesh coated or
covered with concrete, asphalt, crude oil and
rock screenings, or clay products would
make a cheap and durable slab;) and they
may also be made of steel, iron or other ma-
terials as may be found suitable or adapt-
able to the varying conditions; the idea be-
ing to construct a flexible mattress where
the component parts can be constructed at
a point other than the place of use and put
gether readily at the place of use and
which, when constructed and in place, will
conform to the changing and varying con-
ditions of the levee, embankment, dam or
other structure upon which the same rests.
The slabs may be varied in weight in ac-
cordance with the position in which and the
circumstances under which they are to be
used.
Where the mattress is to be placed be-
neath the surface of the water, it will be
found beneficial to have the mattresses more
flexible, which can be brought about by
changing to some extent the formation of
the slabs, by looser tying and by other means
as hereinafter indicated; and for use be-
nenath the water, instead of placing the sec-
ond slab above the first, it is placed at the
end of the first, that is, several cables are
placed in position, the first slab at the ends
of the first two cables, the second slab be-
tween the second and third cables, the third
slab between the third and fourth cables
and so on until the desired number in length
has been obtained to allow the first slab to
be lowered into the water and still permit
the others, particularly the last, to remain
on the surface. Other slabs are then placed
on top of the first, second and third, and
these gradually lowered into the water, at
the same time the line of slabs being ex-
tended as the work progresses and when the
required number of slabs are beneath the
water the first row of slabs can then be
completed to the height desired and so on
with the other rows.
The slabs may be reinforced by means of
iron, steel or other metal reinforcement.
This reinforcement is arranged in such a
manner that the strain from the attachment
of the slabs to the cable and the slabs to
each other will come on the metal reinforce-
ment and not on the concrete asphaltum or
other material used in the construction of
the slab or unit.
At the lower end of each cable a washer
is used. This washer may be a continuous
washer or chain or cable extending from
the lower end of each cable to the adjoining
cable to form a rest for the lower slab and
to hold each series of slabs in position and

thus release the strain on the various ties and fastenings.

The ties are preferably made by means of separate metal rods and drawn tight or loose, or some tight and some loose as may be desired or required. Ties may be made from the four corners of the slab; from the center of the slab or from whatever positions may be desired or required to conform to conditions.

Referring specifically to the drawings, 10 indicates the unit structure or slab provided with tie holes 11 at the four corners, about which holes and extending from hole to hole is an embedded reinforcing rod or cable 12, Figs. 3, 4 & 5. The ends of the slabs 1 are grooved at 13 for the reception of a cable 14 to which the slabs are connected. A convenient form of this tie is represented at 15. These ties are preferably metal rods, the ends of which may be twisted or hooked together. At the ends of a mattress these rods tie the slabs directly to the cables, Fig. 8, while throughout the body of the mattress, they tie adjacent slabs together with the cable intervening, Fig. 7.

The slabs may be provided with but one tie hole in each end as indicated in the slab 12' encircles the tie holes 11' and extends around the border of the slab as in the first form. Obviously any other form of reinforcement and manner of locating the same may be adopted.

A revetment may be made up of one or more forms of slabs. Fig. 2 shows the two forms above described associated in the same mattress. The washer 16 at the lower edge of the mattress is held in place by a knot or eye in the lower end of the cables 14 and to these eyes may be attached, if desired, suitable anchors such as typified at 17, Figs. 1 & 9, the anchor for the upper end of such cable being indicated at 18, Fig. 1. These anchors may be conveniently made of concrete as indicated.

The mattress as seen in Fig. 1 is applied to a bank or levee 10 and extends below the water as indicated at 20. Obviously to a mattress of this sort anchors 17 may be applied where needed and when needed.

The invention claimed is:

1. A revetment unit of composition provided with tie holes for the purpose set forth and with grooves along its ends for the reception of assembling cables.

2. A slab of reinforced concrete adapted to serve as a portion of a revetment and provided with reinforced tie holes at its ends, and with grooves along its ends for the reception of assembling cables.

3. A revetment unit consisting of a slab of reinforced concrete provided with a cable groove along each end wall thereof and with transverse reinforced tie holes at the corners of said unit.

4. A revetment consisting of a series of slabs provided with grooves in their adjacent ends, cables extending through the channels formed by said adjacent grooves, and means for holding adjacent slabs together, thereby inclosing the cables in said grooves and making close union between the slabs.

5. A revetment consisting of a series of concrete slabs provided with transverse tie holes, cables extending along the ends of said slabs, and means for tying the slabs together whereby to hold them to said cables and close to each other.

6. A revetment consisting of a series of composition slabs provided with transverse tie holes and having metallic reinforcement about each tie hole and extending from tie hole to tie hole, ties extending through adjacent holes for holding the slabs together, and cables confined between the ends of said slabs.

7. A revetment consisting of a series of composition slabs provided with transverse tie holes and having metallic reinforcement about each tie hole and extending from tie hole to tie hole, and also having cable grooves in adjacent ends, anchor cables in said grooves, and ties for joining adjacent slabs together, thereby confining said cables in the grooves and holding the slabs to the cables.

8. A revetment consisting of a number of parallel cables anchored as desired, a series of concrete slabs arranged side-by-side between each two adjacent cables and means for joining said slabs of one series to adjacent slabs of the next series and thereby joining the slabs to the cables.

9. A revetment consisting of a number of upwardly extending cables, a washer joining the lower adjacent ends of the cables, series of concrete slabs arranged one above the other between adjacent cables and provided with tie holes at their ends, and ties extending through said holes whereby to join slabs of adjacent series and bind them together and to the cables.

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Witnesses:

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