Feb. 3, 1970 E. A. HORSTKETTER ET AL 3,492,826

RETAINING WALL STRUCTURE

Filed Feb. 28, 1968 2 Sheets-Sheet 1

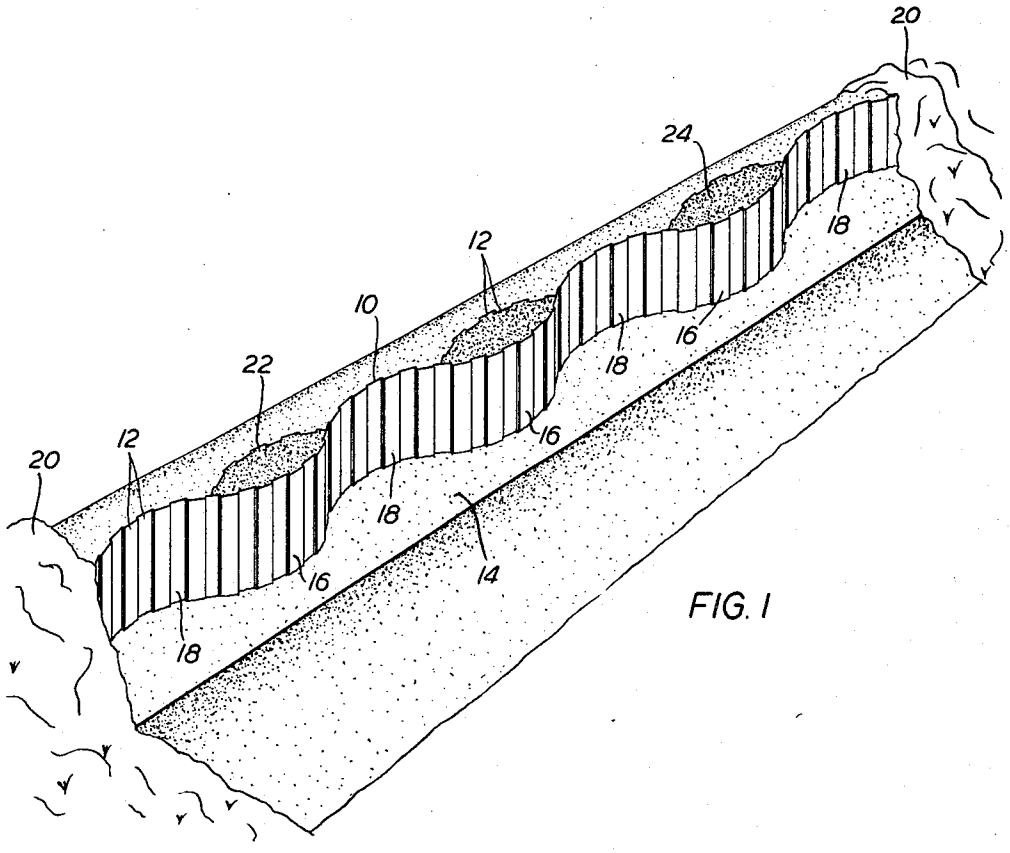


FIG. 1

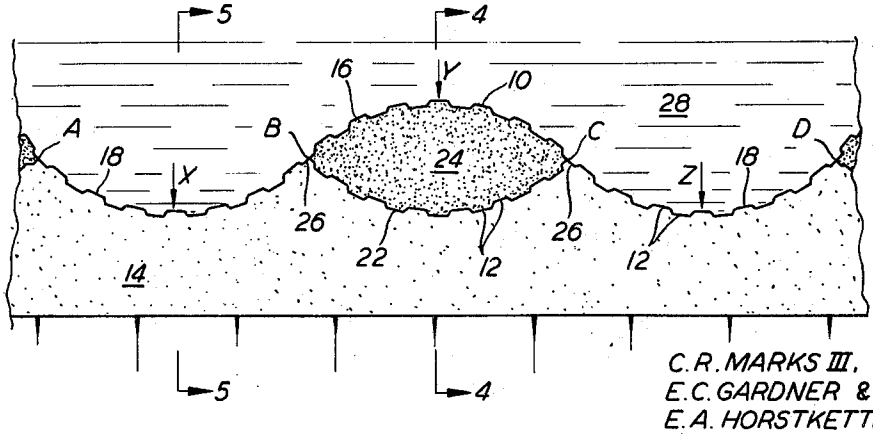


FIG. 2

C. R. MARKS III,
E. C. GARDNER &
E. A. HORSTKETTER
INVENTOR.

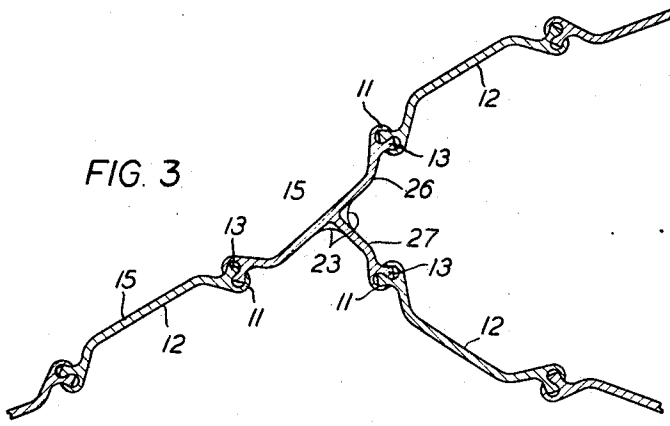
BY Arnold, Roylance, Kruger & Durkee
ATTORNEYS

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Filed Feb. 28, 1968 2 Sheets-Sheet 2

FIG. 3



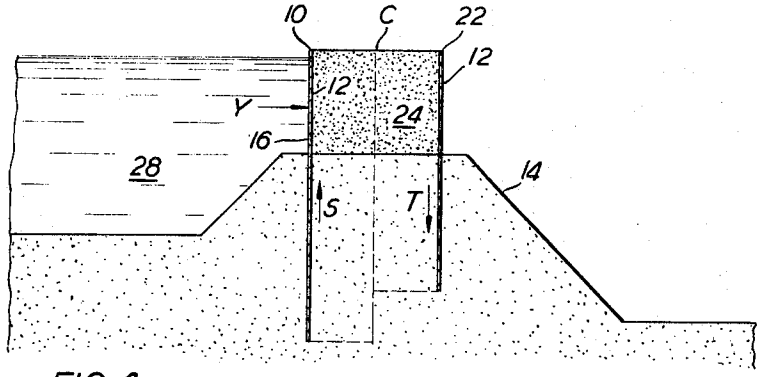


FIG. 4

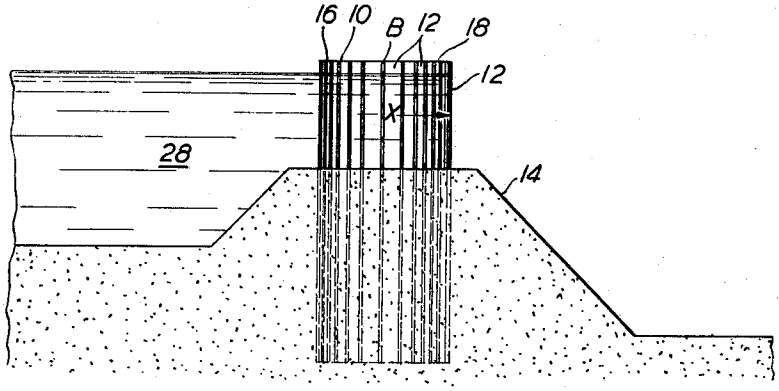


FIG. 5

C. R. MARKS III,
E. C. GARDNER &
E. A. HORSTKETTER
INVENTOR.

BY Arnold, Raylance,
Kruger & Durkee
ATTORNEYS

United States Patent Office

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RETAINING WALL STRUCTURE

Eugene A. Horstketter, Elmer C. Gardner, and Constant R. Marks III, Houston, Tex., assignors to S.O.G. Research and Development Corporation, Houston, Tex., a corporation of Texas

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U.S. Cl. 61—49 12 Claims

ABSTRACT OF THE DISCLOSURE

This application discloses a sheet metal piling retaining wall structure and a method of construction. The retaining wall structure includes a continuous wall member, having no closures, and comprising arcuate wall sections alternately disposed to form a sinuous wall, and arcuate wall members disposed along one side of the continuous wall member to close alternate ones of said arcuate sections for forming regularly spaced cellular enclosures. The cellular enclosures are filled with an unconsolidated aggregate to provide vertical stability to the wall structure.

BACKGROUND OF THE INVENTION

Retaining wall structures utilized in temporary structures such as cofferdams or diversion dams, or in permanent structures such as seawalls or breakwaters, or retaining walls to form docks or wharfs are commonly constructed of edge-interlocking sheet metal piling sections driven into place in the soil. The types of structures heretofore in use have utilized double wall structures with cross-wise interior bracing and truss work to provide the necessary supporting element for preventing undue distortion of the walls, or have used a series of circular cellular enclosures of sheet metal piling sections interconnected by a double wall of arcuate sections of piling. These cellular structures and the space between the double walls are commonly filled with earth, sand or gravel, to provide horizontal tension to the piling sections and to add structural rigidity to the wall. However, these circular cellular structures are expensive and time consuming to build.

When building such cellular enclosures of circular design, one problem encountered is that of "closing" the structure to form a circular enclosure. A closure defined as the point where two series of sheet metal pilings meet, being driven in sequence from different directions. It often occurs that the widths of standard pilings may not coincide with the final space necessary to close the structure and custom-sized pilings must be utilized to close the final space. In addition, the arcuate double-wall structures used to connect the circular cellular enclosures must be closed at each end to connect with the circular enclosures. A substantial amount of time is employed in making each closure, and it can be seen that for a retaining wall structure of considerable length, the number of piling sections required to build the retaining wall can indeed be quite large and a considerable amount of time will be utilized in effecting the various necessary closures.

Accordingly, the disadvantages of the prior art are overcome by the present invention and novel methods are provided for producing a retaining wall structure that is comprised substantially of a single continuously driven wall having no closures and a minimum number of cellular enclosures formed by utilizing a technique that eliminates the need for custom-sized piling sections in the construction of the enclosures.

SUMMARY OF THE INVENTION

In accordance with this invention, a retaining wall structure is provided having a single continuous wall member comprised of arcuate wall sections alternately disposed for forming a sinuous wall undulating along a preselected axis line for the retaining wall structure, and arcuate wall members disposed along one side of the continuous wall member to close alternate ones of the arcuate wall sections for forming regularly spaced cellular enclosures that are filled with earth, sand or gravel. The continuous wall member is driven as a continuous series of interconnected sheet metal piling sections with no closures being effected throughout its entire length. The arcuate wall members that are disposed along one side of the continuous wall member to close alternate ones of the arcuate sections are first placed in an interlocking relationship, fitted within the space necessary to close with the arcuate section of the continuous wall member, prior to the time the pilings of the arcuate wall member are driven. In this way, the closure problem is overcome prior to the time that the piling sections are driven and the radius of the arcuate wall member may be adjusted slightly to close with the arcuate wall section of the continuous wall member utilizing standard widths of piling sections. Only arcuate single walls of piling sections will interconnect the cellular enclosures.

Accordingly, it is the primary feature of the present invention to provide a retaining wall structure that utilizes arcuate wall sections and cellular wall enclosures defined by two arcuate interconnecting wall sections to substantially reduce the number of sheet metal pilings required to construct the retaining wall.

Another feature of the present invention is the simplicity and speed with which the retaining wall structure may be constructed by substantially reducing the number of sheet metal piling sections necessary and in reducing the number of closures necessary to form the cellular enclosures in the wall structure.

Another feature of the present invention is that the principal structural stress advantages of sheet metal pilings are utilized in the construction of the retaining wall structure.

DESCRIPTION OF THE DRAWINGS

The aforementioned features of the present invention will be apparent from the following detailed description wherein reference is made to figures in the accompanying drawings, which drawings form a part of and are incorporated by reference as a part of the specification.

In the drawings:

FIGURE 1 is a pictorial view of a retaining wall structure according to one embodiment of this invention.

FIGURE 2 is a plan view of a portion of the retaining wall structure shown in FIGURE 1.

FIGURE 3 is a detailed view of the interlocking piling sections at the closure of the arcuate wall sections forming a cellular enclosure structure.

FIGURE 4 is a vertical cross-sectional view of the retaining wall structure in accordance with this invention taken along lines 4—4 of FIGURE 2.

FIGURE 5 is a vertical cross-sectional view of the retaining wall structure in accordance with this invention taken along lines 5—5 of FIGURE 2.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to FIGURE 1, a retaining wall structure according to an embodiment of this invention is shown. The structure consists of a continuous wall member **10** comprising a series of edge-interlocking metal piling sections **12** driven into an appropriate earthen

structure **14** which may be the earth's surface or a conventional compacted earthen embankment as illustrated. As may be seen, continuous wall member **10** is made up of a series of arcuate wall sections **16** facing in one direction and interconnected by arcuate wall sections **18** facing in the opposite direction to form a sinuous wall undulating along a known axis line. The ends of wall member **10** are shown conventionally closing with an embankment **20** for forming a continuous retaining wall between the two ends of the embankment as for forming a cofferdam or a diversion dam. Arcuate wall members **22** are composed of edge-interlocking sheet metal piling sections **12** and are disposed opposite arcuate wall sections **16** and interconnected therewith to form a cellular enclosure. Each cellular enclosure, composed of arcuate wall sections **16** and arcuate wall members **22**, is filled with an aggregate material **24**, commonly soil, sand or gravel, to provide a means of stability for continuous wall member **10** and for other reasons to be hereinafter described.

Referring now to FIGURE 2, a plan view of a portion of the retaining wall structure as shown in FIGURE 1 may be seen. A portion of continuous wall member **10** is shown having an arcuate wall section **16** flanked on either side by arcuate wall sections **18** and continuously interconnected therewith. A body of water **28** is shown providing a continuous lateral force against one side of wall member **10** as represented by the force vectors marked X, Y, Z, and representing the force of the restrained water as applied to the arcuate wall sections **16** and **18**. As may be seen, one arcuate wall section **18** is defined by the arcuate section of the continuous wall member **10** between points A and B, arcuate wall section **16** is defined by that portion of continuous wall member **10** between points B and C, and another arcuate wall section **18** is defined by that portion of continuous wall member **10** between points C and D.

Arcuate wall member **22** is shown disposed on the side of continuous wall member **10** opposite the side in resistive contact with water **28**. Wall member **22** is interlocked with arcuate wall section **16** at points B and C to form a cellular wall structure which is filled with an aggregate material **24**. Continuous wall member **10** and arcuate wall member **22** are composed of a series of edge-interlocking sheet metal pilings **12** driven into a retaining surface **14** which may commonly be the earth's surface or an embankment as shown in FIGURE 1. The edge-interlocking sheet metal pilings **12** are conventional interlocking sheet pilings designed to utilize horizontal tension forces to close the interlocking edges to form a water tight retaining wall.

Continuous wall member **10** would be driven as a continuous series of interlocking sheet pilings **12** along a predetermined wall axis as defined by points A, B, C and D in FIGURE 2. Arcuate wall member **22** would first be formed by placing upright in an interlocking relationship the edge-interlocking sheet metal pilings **12** that would be necessary to form arcuate wall member **22** and provide a closure with continuous wall member **10** at points B and C. A closure is defined as the point where two series of sheet metal pilings meet, being driven in sequence from different directions. In other words, the pilings **12** that comprise arcuate wall member **22** are placed in an interlocking relationship and fitted to close with continuous wall member **10** at points B and C prior to the time the pilings **12** are actually driven. This procedure eliminates the conventional closure problem at points B and C where often the width of standard piling sections may not coincide with the amount of space to be filled to effect the closure, necessitating the use of special sizes of sheet pilings at additional cost and the utilization of additional time. It will be noted that since continuous wall member **10** is driven in a continuous series of sheet metal piles it has no closures and hence can be constructed rapidly using standard sizes of sheet metal pilings throughout and with a minimum of delay. It will also be noted that at points A, B, C and D, where a closure will be effected between continuous wall member **10** and arcuate wall member **22**, a special triple edge-interlocking sheet metal piling **26** is utilized.

Aggregate material **24** is used to fill the cellular enclosure defined by the closed portion of continuous wall member **10** and arcuate wall member **22** to apply an outward horizontal pressure for spreading the sheet metal piling sections **12** and placing them in horizontal tension. The piling sections **12** are prevented from slipping in vertical relation to each other by the frictional engagement between the interlocking edges of the sections when the pilings are placed in horizontal tension so that they act in their intended relationship of being a continuous sheet, rather than functioning as individual piling sections. The interlocking edges of piling sections **12** becomes water tight under horizontal tension thus creating a water tight retaining wall. The continuous force exerted against the arcuate surface of wall sections **18** between points A and B, and C and D of continuous wall member **10** is represented by the arrows X and Z, respectively. The force acting against pilings **12** of arcuate wall sections **18** place the sheet metal pilings **12** in horizontal tension forming continuous water tight wall sections.

Arcuate wall section **16** of continuous wall member **10** has a continuous force being applied by the body of water **28** as is shown by the force vector Y. Force Y is exerting pressure against the vertical beam structure formed by the closed wall section **16** of wall member **10** and wall member **22**, tending to push over the vertical beam structure, and placing the sheet metal pilings **12** of arcuate wall section **16** in vertical tension and the sheet metal pilings **12** of the arcuate wall member **22** in vertical compression. The piling sections **12** act as a continuous wall member and do not slip vertically in relation to each other because of the frictional forces caused by horizontal tension as previously described. The structure defined by continuous wall member **10** and arcuate wall members **22**, places the sheet metal pilings **12** either in horizontal tension, vertical compression or vertical tension and therefore utilizes the principal structural advantages of sheet metal pilings.

Referring now to FIGURE 3, a detailed view of the interlocking piling sections **26** at the closure of arcuate wall sections **16** and arcuate wall member **22** are shown. Sheet metal pilings **12** of conventional design are shown, having a channel web section **15** and edge-interlocking means along both longitudinal edges of the piling. The interlocking means are comprised of a thumb **13** and a curved finger **11** which interlock with and grip corresponding thumb and curved finger surfaces of an adjoining piling section. Triple edge-interlocking sheet piling section **26** has the conventional channel web **15** with interlocking thumb **13** and curved finger **11** at either end, and an additional web member **27** terminating in an edge-interlocking surface having an identical thumb section **13** and a curved finger portion **11**. Section **26** has additional built-up web surfaces **23** to add structural strength at the point where web **15** and web **27** are joined.

Referring now to FIGURE 4, a vertical cross-sectional view of a retaining wall structure in accordance with the invention in FIGURE 1 may be seen. Sheet metal piling sections **12** of an arcuate wall section **16** of continuous wall member **10** are shown driven in to an embankment **14**. Sheet piling sections **12** of arcuate wall member **22** are also shown driven into embankment **14**. Point C indicates the point at which continuous wall member **10** and arcuate wall member **22** are closed to form the cellular enclosure structure filled with an aggregate material **24**. A body of water **28** is shown providing a continuous force against the outer surface of arcuate wall sections **16** and

continuous wall member **10** as previously described in FIGURE 2. As earlier mentioned, the force caused by water **28** indicated by force vector Y, is tending to push the cellular enclosure structure filled with unconsolidated aggregate **24** in the direction as indicated at Y. This force, tending to push over the cellular enclosure structure, places the metal pilings **12** of arcuate wall sections **16** in vertical tension, attempting to pull the sheet metal pilings **12** out of the embankment as shown by the arrow indicated at S. The metal piling sections **12** of arcuate wall member **22** are being forced further into embankment **14** as indicated by the arrow T and hence are placed in vertical compression. It will be noted that it is not necessary for the metal piling sections that are in vertical compression to be driven as deeply as those piling sections that are in vertical tension, hence saving the cost of additional lengths of metal pilings and the additional costs of pile-driving operations.

In FIGURE 5 is shown a vertical cross section of a retaining wall structure in accordance with the invention and showing a section of the wall structure taken through arcuate wall section **18** of continuous wall member **10**. A piling section **12** of arcuate wall section **18** of continuous wall member **10** is shown in cross section in its driven position in embankment **14**. The point where piling sections **12** intersect at B indicates the juncture of arcuate wall sections **16** and **18** of continuous wall member **10**. A body of water **28** is shown contacting the outer surfaces of arcuate wall sections **16** and **18** of continuous wall member **10** as previously described in FIGURES 2 and 4. A horizontal force, indicated by the arrow at X, is shown as it is applied against the surfaces of arcuate wall section **18** causing the piling sections **12** to be pushed in the direction shown by arrow X and placing piling sections **12** of arcuate wall section **18** in horizontal tension to form a rigid continuous water tight wall surface.

Referring now to FIGURES 2, 4 and 5, it will be seen that the retaining wall structure formed by continuous wall member **10** and arcuate wall members **22** define an evenly spaced series of embedded vertical beams, represented by the closed semi-circular structures filled with unconsolidated aggregate **24**, between which are suspended water tight continuous retaining wall surfaces as represented by arcuate wall sections **18**. Since the retaining wall structure makes use of only three forces acting on the sheet metal pilings **12**, i.e., horizontal tension, vertical compression and vertical tension, the principal structural advantages of sheet metal pilings are utilized.

It may be seen that as continuous wall member **10** may be driven in a continuous series, having no closures, a considerable amount of time may be saved plus the cost of custom sized sheet piling sections that are normally required to effect the closure. Continuous wall member **10** may be driven utilizing only standard conventional sheet piling sections **12**, employing the use of triple edge-interlocking sheet piling sections **26** at appropriate closure points to form the cellular enclosure structures to be filled with an aggregate material **24**. Further, since wall member **10** is a single wall of arcuate sections, a substantially fewer number of piling sections **12** are needed than are required in conventional double-wall structures having circular enclosures, thus effecting a considerable saving in the cost of the retaining wall structure. By placing the sheet piling sections **12** of arcuate wall member **22** in an interlocking relationship and in their desired positions to effect closure with continuous wall member **10**, prior to the time they are driven, a considerable saving may be made in time and the cost of custom-sized sheet metal pilings to effect closure. It will also be noted that arcuate sections **16** and **18**, and arcuate wall member **22** are of less than semi-circular length for convenience rather than being a critical feature of the invention. The wall sections **16** and **18**, and arcuate wall member **22** could be semi-circular, although a considerable amount of cost advantage through the use of the fewer number of sheet piling sections **12** would be lost. In addition, the radii of arcuate wall sections **16** and **18** need not be of equal length, in fact, it has been found that the radii of arcuate wall sections **18** may conveniently be greater than the radii of arcuate wall section **16**, adding additional savings in the cost of sheet metal pilings required to form continuous wall member **10**. Generally, however, it has been found that the radii of arcuate wall sections **16** and arcuate wall members **22** should be substantially equal.

An embodiment of this invention shown in the previous figures has shown a retaining wall structure to be used as a cofferdam or a diversion dam used in holding back a body of water so that various construction operations may be carried on within or behind the dry area defined by the structure. In addition to its use as a cofferdam, or a diversion dam, the retaining wall structure may also be used in the construction of docks or wharfage. As used for construction of docks or warfage, compacted earth fill would be placed on the side of the structure where the body of water is shown in FIGURES 2, 4 and 5, and the water would be on the opposite side of the retaining wall structure from the earth fill. However, the principal stress forces would still be acting on continuous wall **10** and arcuate wall member **22** as shown in FIGURES 2, 4 and 5, and as hereinbefore described.

Numerous variations and modifications may obviously be made in the structure herein described without departing from the scope of the present invention. Accordingly, it should be clearly understood that the forms of the invention described herein and shown in the figures in the accompanying drawings are illustrative only and are not intended to limit the scope of the invention.

What is claimed is:

1. A retaining wall for resisting a horizontally applied force, comprising

a continuous wall formed of edge-interlocking sheet metal pilings partially driven into the ground, said wall having arcuate wall sections alternately facing in opposite directions for forming a sinuous wall, one side of which is in contact with the horizontally applied force,

arcuate wall members formed of a plurality of edge-interlocking sheet metal pilings partially driven into the ground, said members disposed on the other side of said continuous wall for closing alternate ones of said arcuate sections for forming spaced cell structures, and

aggregate material for filling said cell structures and applying a continuous outward horizontal force on the projecting pilings of said cell structures for placing said walls in horizontal tension and effecting a water tight seal along said interlocking edges of said pilings.

2. The retaining wall structure as described in claim **1**, wherein said arcuate wall sections of each of said cell structures in resistive contact with said force are in vertical tension.

3. The retaining wall structure as described in claim **1**, wherein said arcuate wall members closing each of said cell structures are in vertical compression.

4. The retaining wall structure as described in claim **1**, wherein said alternate arcuate unclosed wall sections of said continuous wall in resistive contact with said force are in horizontal tension for effecting a watertight seal along said interlocking edges of said pilings.

5. A retaining wall for resisting a horizontally directed force, comprising

a continuous wall member having a plurality of arcuate wall sections alternately facing in opposite directions for forming a sinuous wall having one side in resistive contact with the horizontally directed force, each of said arcuate wall sections comprising a plurality of edge-interlocking sheet metal pilings partially driven into the ground,

arcuate wall members formed of a plurality of edge-interlocking sheet metal pilings partially driven into the ground and disposed on the side of the wall opposite the side in resistive contact with the horizontally directed force and adapted for closing with alternate ones of said arcuate wall sections to form spaced cell structures,

aggregate material for filling said cell structures and applying a continuous outward horizontal force on said pilings of said cell structures to place the portion of said pilings above ground in horizontal tension.

6. The retaining wall structure as described in claim **5**, wherein said pilings of said arcuate wall sections in resistive contact with said horizontally directed force are placed in vertical tension by the action of said horizontal force against the portion of said pilings projecting above ground.

7. The retaining wall structure as described in claim **6**, wherein said pilings of said arcuate wall members closing with said alternate arcuate wall sections are placed in vertical compression by the action of said horizontal force against the portion of said cell structures projecting above ground.

8. The retaining wall structure as described in claim **7**, wherein said pilings of said unclosed alternate arcuate wall sections are placed in horizontal tension by the action of said horizontal force against the portion of said pilings projecting above ground.

9. The method of forming a retaining wall structure for resisting a horizontally applied force, comprising the steps of

placing a series of edge-interlocking sheet metal pilings in an interlocking relationship and forming a continuous wall having arcuate wall sections alternately facing in opposite directions for forming a sinuous wall one side of which will be placed in restrictive contact with the horizontally applied force,

placing a series of edge-interlocking sheet metal pilings in an interlocking relationship for forming arcuate wall members disposed along the side of said wall opposite the side to be placed in resistive contact with the horizontally applied force, and positioned to cooperate with alternate ones of said arcuate wall sections to form cell structures,

interlocking said arcuate wall members with said alternate arcuate wall sections for forming spaced cell structures,

partially driving said piling sections into the ground for forming a continuous wall member having spaced cell structures,

filling said cell structures with an aggregate material for applying a continuous outward horizontal force on said pilings of said cell structures for stabilizing said cell structures and said continuous wall, and

applying the horizontally directed force against said one side of said continuous wall.

10. The method of forming a retaining wall structure as described in claim **9**, wherein the step of applying the horizontally directed force against said one side of said continuous wall vertically tensions said pilings of said arcuate wall sections of said cell structures that are in resistive contact with said force.

11. The method of forming a retaining wall structure as described in claim **9**, wherein the step of applying the horizontally directed force against said one side of said continuous wall vertically compresses said pilings of said arcuate wall mmebers closing said cell structures and disposed opposite the side of said wall that is in resistive contact with said force.

12. The method of forming a retaining wall structure as described in claim **9**, wherein the step of applying the horizontally directed force against said one side of said continuous wall horizontally tensions the projecting portion of said pilings of said unclosed arcuate wall sections that are in resistive contact with said applied force.

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JACOB SHAPIRO, Primary Examiner

U.S. Cl. X.R.

52—169; 61—39, 52, 58

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,492,826 Dated February 3, 1970

Inventor(s) E. A. Horstketter et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 7, line 37, "restrictive" should be --resistive--.

Col. 8, line 22, "mmebers" should read --members--.

SIGNED AND
SEALED
JUL 14 1970

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents