(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
22 December 2011 (22.12.2011)

PCT

(10) International Publication Number
WO 2011/159808 A2

(51) International Patent Classification:
E02D 29/02 (2006.01) *E02B 3/12* (2006.01)
E02D 17/20 (2006.01)

(21) International Application Number:
PCT/US2011/040541

(22) International Filing Date:
15 June 2011 (15.06.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
12/818,011 17 June 2010 (17.06.2010) US
12/837,437 15 July 2010 (15.07.2010) US

(71) Applicant *(for all designated States except US)*: **T & B STRUCTURAL SYSTEMS LLC** [US/US]; 6800 West Manhattan Boulevard, Suite 304, Ft. Worth, Texas 76118 (US).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **TAYLOR, Thomas P.** [US/US]; 2301 Poplar Lane, Colleyville, Texas 76034 (US).

(74) Agents: **NOLTE, N. Alexander** et al.; Edmonds & Nolte, PC, 10411 Westheimer Road, Suite 201, Houston, Texas 77042 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) **Title**: MECHANICALLY STABILIZED EARTH WELDED WIRE WALL FACING SYSTEM AND METHOD

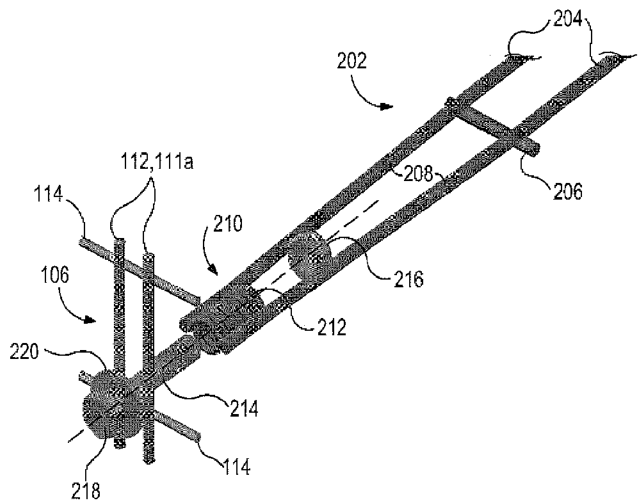

FIG. 3

(57) Abstract: A system and method of constructing a mechanically stabilized earth (MSE) structure. A wire facing is composed of horizontal and vertical elements. A soil reinforcing element has a plurality of transverse wires coupled to at least two longitudinal wires where the longitudinal wires are coupled to a coil and a threaded rod is configured to extend through both the vertical facing and the coil. A washer engages the vertical facing and prevents the threaded rod from passing completely through the vertical facing and a nut is threaded onto the threaded rod to prevent its removal from the coil. Multiple systems can be characterized as lifts and erected one atop the other to a desired MSE structure height.

WO 2011/159808 A2

MECHANICALLY STABILIZED EARTH WELDED WIRE WALL FACING SYSTEM AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to U.S. Pat. App. No. 12/837,437, entitled "Mechanically Stabilized Earth Welded Wire Facing Connection System and Method," which was filed July 15, 2010 and is a continuation-in-part of co-pending U.S. Pat. App. No. 12/818,011, entitled "Mechanically Stabilized Earth System and Method," which was filed on June 17, 2010. The contents of each priority application are incorporated herein by reference in their entirety.

BACKGROUND OF THE DISCLOSURE

[0002] Retaining wall structures that use horizontally positioned soil inclusions to reinforce an earth mass in combination with a facing element are referred to as mechanically stabilized earth (MSE) structures. MSE structures can be used for various applications including retaining walls, bridge abutments, dams, seawalls, and dikes.

[0003] The basic MSE implementation is a repetitive process where layers of backfill and horizontally-placed soil reinforcing elements are positioned one atop the other until a desired height of the earthen structure is achieved. Typically, grid-like steel mats or welded wire mesh are used as soil reinforcing elements. In most applications, the soil reinforcing elements consist of parallel, transversely-extending wires welded to parallel, longitudinally-extending wires, thus forming a grid-like mat or structure. Backfill material and the soil reinforcing mats are combined and compacted in series to form a solid earthen structure, taking the form of a standing earthen wall.

[0004] In some instances, the soil reinforcing elements can be attached or otherwise coupled to a substantially vertical wall either forming part of the MSE structure or offset a short distance therefrom. The vertical wall is typically made either of concrete or a steel wire facing and not only serves to provide tensile resistance to the soil reinforcing elements but also prevents erosion of the MSE. The soil reinforcing elements extending from the compacted backfill may be attached directly to a vertical wall of the facing in a variety of configurations.

[0005] Although there are several methods of attaching soil reinforcing elements to facing structures, it nonetheless remains desirable to find improved attachment methods and systems that provide greater resistance to shear forces inherent in such structures.

SUMMARY OF THE DISCLOSURE

[0006] Embodiments of the disclosure may provide a system for constructing a mechanically stabilized earth structure. The system may include a wire facing having a bend formed therein to form a horizontal element and a vertical facing, the horizontal element having initial and terminal wires each coupled to a plurality of horizontal wires, and the vertical facing having a plurality of vertical wires coupled to a plurality of facing cross wires and a top-most cross wire. The system may further include a soil reinforcing element having a plurality of transverse wires coupled to at least two longitudinal wires having lead ends that converge, and a connector having a coil coupled to the lead ends of the longitudinal wires and a threaded rod configured to extend through both the vertical facing and the coil, wherein a washer engages the vertical facing and prevents the threaded rod from passing completely therethrough and a first nut is threaded onto the threaded rod to prevent its removal from the coil.

[0007] Another exemplary embodiment of the disclosure may provide a method of constructing a mechanically stabilized earth structure. The method may include providing a first lift comprising a first wire facing being bent to form a first horizontal element and a first vertical facing, the first horizontal element having initial and terminal wires coupled to a plurality of horizontal wires, and the first vertical facing having a plurality of vertical wires coupled to a plurality of facing cross wires including a last facing cross wire and a top-most cross wire. The method may further include extending a first threaded rod through the first vertical facing and a first coil coupled to converging lead ends of longitudinal wires of a first soil reinforcing element, and engaging the vertical facing with a first washer disposed radially about the first threaded rod, the first washer being configured to prevent the first threaded rod from passing completely through the first vertical facing. The method may further include securing the first threaded rod to the first coil with a first nut, placing a screen on the first wire facing whereby the screen covers at least a portion of the first vertical facing and first horizontal element, and placing backfill on the first lift to a first height Y above the last facing cross wire of the first vertical facing.

[0008] Another exemplary embodiment of the disclosure may provide another system for constructing a mechanically stabilized earth structure. The system may include first and second lifts. The first lift may include a first wire facing having a first horizontal element and a first vertical facing, the first horizontal element having initial and terminal wires coupled to a plurality of horizontal wires, and the first vertical facing having a plurality of vertical wires coupled to a plurality of facing cross wires including a last facing cross wire and a top-most cross wire. The first lift may further include a first soil reinforcing element coupled to the first wire facing, the first soil reinforcing element having converging lead ends coupled to a first coil, and a first threaded rod extended through the first vertical facing and the first coil, wherein a first washer disposed radially about the first threaded rod engages the first vertical facing and prevents the first threaded rod from passing completely therethrough and a first nut is threaded onto the first threaded rod to prevent its removal from the first coil. The first lift may further include backfill disposed on the first wire facing to a first height above the last facing cross wire of the first vertical facing. The second lift may be disposed on the backfill of the first lift and may include a second wire facing having a second horizontal element and a second vertical facing, a second soil reinforcing element coupled to the second wire facing, the second soil reinforcing element having converging lead ends coupled to a second coil, and a second threaded rod extended through the first and second vertical facings and the second coil, wherein a second washer disposed radially about the second threaded rod engages the first vertical facing and prevents the second threaded rod from passing therethrough and a second nut is threaded onto the second threaded rod to prevent its removal from the coil.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Figure 1 is an isometric view of an exemplary system of constructing a mechanically stabilized earth structure, according to one or more aspects of the present disclosure.

[0010] Figure 2A is an isometric view of an exemplary wire facing element, according to one or more aspects of the present disclosure.

[0011] Figure 2B is a side view of the wire facing element shown in Figure 2A.

[0012] Figure 3 is an isometric view of a soil reinforcing element used in the system shown in Figure 1, according to one or more aspects of the present disclosure.

[0013] Figure 4 is a plan view of the system of constructing a mechanically stabilized earth structure, according to one or more aspects of the present disclosure.

[0014] Figure 5 is a side view of the connection apparatus for connecting at least two lifts or systems, according to one or more aspects of the present disclosure.

[0015] Figure 6A is an isometric view of another system of constructing a mechanically stabilized earth structure, according to one or more aspects of the present disclosure.

[0016] Figure 6B is a side view of a soil reinforcing element used in the system shown in Figure 6A, according to one or more aspects of the present disclosure.

DETAILED DESCRIPTION

[0017] It is to be understood that the following disclosure describes several exemplary embodiments for implementing different features, structures, or functions of the invention. Exemplary embodiments of components, arrangements, and configurations are described below to simplify the present disclosure, however, these exemplary embodiments are provided merely as examples and are not intended to limit the scope of the invention. Additionally, the present disclosure may repeat reference numerals and/or letters in the various exemplary embodiments and across the Figures provided herein. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various exemplary embodiments and/or configurations discussed in the various Figures. Moreover, the formation of a first feature over or on a second feature in the description that follows may include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which additional features may be formed interposing the first and second features, such that the first and second features may not be in direct contact. Finally, the exemplary embodiments presented below may be combined in any combination of ways, *i.e.*, any element from one exemplary embodiment may be used in any other exemplary embodiment, without departing from the scope of the disclosure.

[0018] Additionally, certain terms are used throughout the following description and claims to refer to particular components. As one skilled in the art will appreciate, various entities may refer to the same component by different names, and as such, the naming convention for the elements described herein is not intended to limit the scope of the invention, unless otherwise specifically defined herein. Further, the naming convention used herein is not intended to distinguish between components that differ in name but not function. Further, in the following discussion and in the claims, the terms "including" and "comprising" are used in an open-ended fashion, and thus should be interpreted to mean "including, but not limited to." All numerical values in this disclosure may be exact or approximate values unless otherwise specifically stated. Accordingly, various embodiments of the disclosure may deviate from the numbers, values, and ranges disclosed herein without departing from the intended scope. Furthermore, as it is used in the claims or specification, the term "or" is intended to encompass both exclusive and inclusive cases, *i.e.*, "A or B" is intended to be synonymous with "at least one of A and B," unless otherwise expressly specified herein.

[0019] Referring to Figure 1, illustrated is an isometric view of an exemplary system 100 for erecting an MSE structure. In brief, and as will be described in more detail below, the system 100 may include one or more wire facings 102 stacked one atop the other and having one or more soil reinforcing elements 202 coupled thereto and extending into the backfill 103 area. One or more struts 118 may also be coupled to each wire facing 102 and adapted to maintain the wire facings 102 in a predetermined angular configuration with respect to horizontal. The backfill 103 may be sequentially added to the system 100 in a plurality of layers configured to cover the soil reinforcing elements 202, and thereby provide tensile strength to the wire facings 102 and prevent the wire facings 102 from bulging outward. A more detailed discussion of these and other elements of the system 100 now follows.

[0020] Referring to Figures 2A and 2B, the wire facing 102 of the system 100 may be fabricated from several lengths of cold-drawn wire welded and arranged into a mesh panel. The wire mesh panel can then be folded or otherwise shaped to form a substantially L-shaped assembly that includes a horizontal element 104 and a vertical facing 106. The horizontal element 104 may include a plurality of horizontal wires 108 welded or otherwise attached to one or more cross wires 110, such as an initial wire 110a, a terminal wire 110b, and a median wire

110c. The initial wire 110a may be disposed adjacent to and directly behind the vertical facing 106, thereby being positioned inside the MSE structure. The terminal wire 110b may be disposed at or near the distal ends of the horizontal wires 108. The median wire 110c may be welded or otherwise coupled to the horizontal wires 108 and disposed laterally between the initial and terminal wires 110a,b. As can be appreciated, any number of cross wires 110 can be employed without departing from the scope of the disclosure. For instance, in at least one embodiment, the median wire 110c may be excluded from the system 100.

[0021] The vertical facing 106 can include a plurality of vertical wires 112 extending vertically with reference to the horizontal element 104 and laterally-spaced from each other. In one embodiment, the vertical wires 112 may be continuous, vertically-extending extensions of the horizontal wires 108. The vertical facing 106 may also include a plurality of facing cross wires 114 vertically-offset from each other and welded or otherwise attached to the vertical wires 112. A top-most cross wire 116 may be vertically-offset from the last facing cross wire 114 and also attached to the vertical wires 112 in like manner.

[0022] In at least one embodiment, each vertical wire 112 may be separated by a distance of about 4 inches on center from adjacent vertical wires 112, and the facing cross wires 114 may also be separated from each other by a distance of about 4 inches on center, thereby generating a grid-like facing 106 composed of a plurality of square voids having about a 4" x 4" dimension. As can be appreciated, however, the spacing between adjacent wires 112, 114 can be varied to more or less than 4 inches to suit varying applications and the spacing need not be equidistant. In one embodiment, the top-most cross wire 116 may be vertically-offset from the last facing cross wire 114 by a distance X, as will be discussed in more detail below.

[0023] The wire facing 102 may further include a plurality of connector leads 111a-g extending from the horizontal element 104 and up the vertical facing 106. In an embodiment, each connector lead 111a-g may include a pair of horizontal wires 108 (or vertical wires 112, if taken from the frame of reference of the vertical facing 106) laterally-offset from each other by a short distance. The short distance can vary depending on the particular application, but may generally include about a one inch separation. In one embodiment, each connector lead 111a-g may be equidistantly-spaced from each other along the horizontal element 104 and/or vertical facing 106, and configured to provide a visual indicator to an installer as to where a soil reinforcing element 202 (Figures 1 and 3) may be properly attached, as will be described in greater detail below. In at least one embodiment, each connector lead 111a-g may be spaced from each other by about 12 inches on center. As can be appreciated, however, such relative distances may vary to suit particular applications.

[0024] In one or more embodiments, the cross wires 110a-c of the horizontal element 104 may be larger in diameter than the cross wires 114 and top-most cross wire 116 of the vertical facing 106. In at least one embodiment, the cross wires 110a-c of the horizontal element 104 may have diameters at least twice as large as the facing cross wires 114 and top-most cross wire 116 of the vertical facing 106. In other embodiments, however, the diameter of wires 110a-c, 114, 116 may be substantially the same or the facing cross wires 114 may be larger than the cross wires 110a-c of the horizontal element 104 without departing from the scope of the disclosure.

[0025] Still referring to Figures 2A-2B, one or more struts 118 may be operatively coupled to the wire facing 102. As illustrated, the struts 118 may be coupled to both the vertical facing 106 and the horizontal element 104 at predetermined locations. Each strut 118 may be prefabricated with or include a connection device 120 disposed at each end of the strut 118 and configured to fasten or otherwise attach the struts 118 to both the horizontal element 104 and the vertical facing 106. In at least one embodiment, and as can best be seen in Figure 5, the connection device 120 may include a hook that is bent about 180° back upon itself. In other embodiments, the connection device 120 may include a wire loop disposed at each end of the struts 118 that can be manipulated, clipped, or otherwise tied to both the horizontal element 104 and the vertical facing 106. As can be appreciated, however, the struts 118 can be coupled to the horizontal element 104 and the vertical facing 106 by any practicable method or device known in the art.

[0026] Each strut 118 may be coupled at one end to at least one facing cross wire 114 and at the other end to the terminal wire 110b. In other embodiments, one or more struts 118 may be coupled to the median wire 110c instead of the terminal wire 110b, without departing from the scope of the disclosure. As illustrated, each strut 118 may be coupled to the wire facing 102 in general alignment with a corresponding connector lead 111a-g. In other embodiments, however, the struts 118 can be connected at any location along the respective axial lengths of any facing cross wire 114 and terminal wire 110b, without departing from the scope of the disclosure. In yet other embodiments, the struts 118 may be coupled to any one of the vertical wires 112 of the vertical facing 106 and/or any one of the horizontal wires 108 of the horizontal element 104, respectively, without departing from the scope of the disclosure.

[0027] The struts 118 are generally coupled to the wire facing 102 before any backfill 103 (Figure 1) is added to the respective layer of the system 100. During the placement of backfill 103, and during the life of the system 100, the struts 118 may be adapted to prevent the vertical facing 106 from bending past a predetermined vertical angle, and thereby collapsing the wire facing 102. For example, in the illustrated embodiment, the struts 118 may be configured to maintain the vertical facing 106 at or near about 90° with respect to the horizontal element 104. As can be appreciated, however, the struts 118 can be fabricated to varying lengths or otherwise attached at varying locations along the wire facing 102 to maintain the vertical facing

106 at a variety of angles of orientation. The struts 118 may allow installers to walk on the backfill 103 of the MSE structure, tamp it, and compact it fully before adding a new lift or layer, as will be described below.

[0028] Referring now to Figure 3, illustrated is an exemplary soil reinforcing element 202 that may be attached or otherwise coupled to a portion of the wire facing 102 (Figures 2A and 2B) in the construction of an MSE structure. The soil reinforcing element 202 may include a welded wire grid having a pair of longitudinal wires 204 that extend substantially parallel to each other. In other embodiments, there could be more than two longitudinal wires 204 without departing from the scope of the disclosure. The longitudinal wires 204 may be joined to one or more transverse wires 206 in a generally perpendicular fashion by welds at their intersections, thus forming a welded wire gridworks. In one or more embodiments, the spacing between each longitudinal wire 106 may be about 2 inches, while the spacing between each transverse wire 206 (see also Figure 4) may be about 6 inches. As can be appreciated, however, the spacing and configuration of adjacent respective wires 204, 206 may vary for a variety of reasons, such as the combination of tensile force requirements that the soil reinforcing element 202 must endure and resist. In other embodiments, the soil reinforcing element 202 may include more or less than two longitudinal wires 204 without departing from the scope of the disclosure.

[0029] In one or more embodiments, lead ends 208 of the longitudinal wires 204 may generally converge and be welded or otherwise attached to a connector 210. In at least one embodiment, the connector 210 (shown in an exploded view) may include a coil 212, a threaded rod 214, such as a bolt or a length of rebar, and a nut 216. As illustrated, the coil 212 may include a plurality of indentations or grooves defined along its axial length which provide a more suitable welding surface for attaching the lead ends 208 of the longitudinal wires 204 thereto. As can be appreciated, such indentations and/or grooves can result in a stronger resistance weld. In one embodiment, the coil 212 can be a coil or helical spring. In other embodiments, the coil 212 can be another nut or a coil rod that is welded to the longitudinal wires 204. Other exemplary embodiments of the connector 210 contemplated herein are described in co-owned U.S. Pat. No. 6,571,293, entitled "Anchor Grid Connector Element," issued on February 11, 2003 and hereby incorporated by reference to the extent not inconsistent with the present disclosure.

[0030] To secure the soil reinforcing element 202 to a portion of the wire facing 102 (Figure 2B), or more particularly the vertical facing 106, the head 218 of the threaded rod 214 may be disposed on the front side of at least two vertical wires 112, such as at a connector lead 111a. The body of the threaded rod 214 can be extended through the vertical facing 106 and coil 212 and secured on the opposite side of the coil 212 with the nut 216. As illustrated, the head 218 may be prevented from passing through the vertical wires 112 or connector lead 111a by employing a washer 220 disposed radially about the threaded rod and adapted to bias the vertical wires 112 or connector lead 111a. As the nut 216 is tightened, it brings the coil 212 into engagement, or at least adjacent to, the back side of the vertical facing 106.

[0031] In embodiments where the lateral spacing of adjacent vertical wires 112 is such that the connector 210 and a portion of the soil reinforcing element 202 may be able to extend through the vertical facing 106, it is further contemplated to employ secondary washers or bearing plates (not shown) on the inside or back side of the vertical facing 106. For instance, at least one secondary washer or bearing plate may extend radially around the threaded rod and be disposed axially adjacent the coil 212 and large enough so as to bear on at least two vertical wires 112 and prevent the connector 210 from passing through the vertical facing 106. Accordingly, the soil reinforcing element 202 may be secured against removal from the wire facing 102 on both front and back sides of the vertical facing 106.

[0032] Referring to Figure 4, depicted is a plan view of the system 100 where at least four soil reinforcing elements 202 have been coupled to a wire facing 102. As illustrated, the soil reinforcing elements 202 may be attached to the wire facing 102 at one or more connector leads 111a-g of the horizontal element 104. In one or more embodiments, soil reinforcing elements 202 may be connected to each connector lead 111a-g, every other connector lead 111a-g, every third connector lead 111a-g, etc. For instance, Figure 4 depicts soil reinforcing elements 202 connected to every other connector lead 111a, 111c, 111e, and 111g.

[0033] In one or more embodiments, the terminal wire 110b and/or median wire 110c may be located a predetermined distance from the initial wire 110a to allow at least one transverse wire 206 of the soil reinforcing element 202 to be positioned adjacent the terminal and/or median wires 110b, 110c when the soil reinforcing element 202 is tightened against wire facing 102 with the connector 210. Accordingly, corresponding transverse wires 206 may be coupled or otherwise attached to the terminal and/or median wires 110b, 110c. In at least one embodiment, the transverse wires 206 may be positioned directly behind the terminal and/or median wires 110b, 110c and secured thereto using a coupling device (not shown), such as a hog ring, wire tie, or the like. In other embodiments, however, the transverse wires 206 may be positioned in front of the terminal and/or median wires 110b, 110c and similarly secured thereto with a coupling device, without departing from the scope of the disclosure. In yet other embodiments, the soil reinforcing element 202 is secured to only one or none of the terminal and/or median wires 110b, 110c.

[0034] In embodiments where the soil reinforcing element 202 is not coupled to the terminal or median wires 110b, 110c, the soil reinforcing element 202 may be free to swivel or otherwise rotate in a horizontal plane as generally indicated by arrows A. As can be appreciated, this configuration allows the soil reinforcing elements 202 to swivel in order to avoid vertically-disposed obstructions, such as drainage pipes, catch basins, bridge piles, or bridge piers, which may be encountered in the backfill 103 (Figure 1) field.

[0035] As shown in both Figures 1 and 4, the system 100 may further include a screen 402 disposed on the wire facing 102. In one embodiment, the screen 402 can be disposed on portions of both the vertical facing 106 and the horizontal element 104. As illustrated, the screen 402 may be placed on substantially all of the vertical facing 106 and only a portion of the horizontal element 104. In other embodiments, however, the screen 402 may be placed in different configurations, such as covering the entire horizontal element 104 or only a portion of the vertical facing 106. In operation, the screen 402 may be configured to prevent backfill 103 (Figure 1) from leaking, eroding, or otherwise raveling out of the wire facing 102. In one embodiment, the screen 402 may be a layer of filter fabric. In other embodiments, however, the screen 402 may include construction hardware cloth or a fine wire mesh. In yet other embodiments, the screen 402 may include a layer of cobble, such as large rocks that are large enough so as to not advance through the square voids defined in the vertical facing 106, but small enough to prevent backfill 103 materials from penetrating the wire facing 102.

[0036] Referring again to Figure 1, the system 100 can be characterized as a lift 105 configured as a layer for building an MSE structure wall to a particular required height. As illustrated in Figure 1, a plurality of lifts 105a, 105b may be required to reach the required height. Each lift 105a, 105b may include the elements of the system 100 as generally described above in Figures 2A, 2B, 3, and 4. While only two lifts 105a, 105b are shown in Figure 1, it will be appreciated that any number of lifts may be used to fit a particular application and reach a desired height for the MSE structure. As depicted, the first lift 105a may be disposed generally below the second lift 105b and the horizontal elements 104 of each lift 105a, 105b may be oriented substantially parallel to each other but vertically-offset. The angle of orientation for the vertical facings 106 of each lift 105a, 105b may be similar or may vary, depending on the application. For example, the vertical facings 106 of each lift 105a, 105b may be disposed at angles less than or greater than 90° with respect to horizontal.

[0037] In at least one embodiment, the vertical facings 106 of each lift 105a, 105b may be substantially parallel and continuous, thereby constituting an unbroken vertical ascent for the facing of the MSE structure. In other embodiments, however, the vertical facings 106 of each lift 105a, 105b may be laterally offset from each other, and generate a "stepped" facing. For example, the disclosure contemplates embodiments where the vertical facing 106 of the second lift 105b may be disposed behind or in front of the vertical facing 106 of the first lift 105a, and so on until the desired height of the MSE wall is realized.

[0038] In one or more embodiments, because of the added strength derived from the struts 118, each lift 105a, 105b may be free from contact with any adjacent lift 105a, 105b. Thus, in at least one embodiment, the first lift 105a may have backfill 103 placed thereon up to or near the vertical height of the vertical facing 106 and compacted so that the second lift 105b may be placed completely and entirely on the compacted backfill 103 of the first lift 105a therebelow. Whereas conventional systems would require the vertical facing 106 of the first lift 105a to be tied into the vertical facing 106 of the second lift 105b to prevent its outward movement, the present disclosure allows the components of each lift 105a, 105b (excepting the backfill 103) to be physically free from engagement with each other. This may prove advantageous during settling of the MSE structure. For instance, the system 100 may settle without causing adjacent lifts 105a,b to bind on each other, which can potentially diminish the structural integrity of the MSE structure.

[0039] Referring now to Figure 5, other embodiments of the disclosure include coupling or otherwise engaging the first and second lifts 105a,b in sliding engagement with one another using the connector 210 of the soil reinforcing elements 202. As shown in Figure 5, each lift 105a, 105b may have a corresponding vertical facing 106a, 106b, respectively. The first lift 105a may be disposed substantially below the second lift 105b, with its vertical facing 106a being placed laterally in front of the vertical facing 106b of the second lift 105b. Backfill 103 may be added to at least a portion of the first lift 105a to a first height or distance Y above the last facing cross wire 114. The second lift 105b may be disposed on top of the backfill 103, thereby being arranged a distance Y above the last facing cross wire 114. As will be appreciated, the first height or distance Y can be any distance or height less than the distance X. For example, the distance Y can be about, but less than, the distance X, thereby leveling the backfill 103 up to but just below the top-most cross wire 116 of the vertical facing 106a.

[0040] In order to bring the vertical facings 106a,b of each lift 105a,b into engagement or at least adjacent one another, the threaded rod 214 of the connector 210 may be configured to extend through each vertical facing 106a,b and be secured thereto with the nut 216. In order to ensure a sliding engagement between the first and second lifts 105a,b, the nut 216 may be "finger-tightened," or tightened so as to nonetheless allow sliding, vertical movement of either the first or second lift 105a,b with respect to each other. Tightening the nut 216 may bring the coil 212 into engagement with the vertical facing 106b of the second lift 105b, having the coil rest on the initial wire 110a, and also bring the washer 220 into engagement with the vertical facing 106a of the first lift 105a. In at least one embodiment, tightening the nut 216 may also bring the top-most cross wire 116 into engagement with the vertical facing 106b and thereby further prevent the outward displacement of the vertical facing 106a. However, in other embodiments, the top-most cross wire 116 is not necessarily brought into contact with the vertical facing 106b, but the vertical facing 106b may be held in its angular configuration by the strut 118 and connection device 120 disposed on the upper facing cross wire 114.

[0041] Placing the second lift 105b a distance Y above the upper facing cross wire 114 allows the second lift 105b to vertically shift the distance Y if necessary in reaction to backfill 103 settling or thermal expansion/contraction of the MSE structure. Accordingly, the distance Y can be characterized as a settling distance over which the second lift 105b may be able to traverse without binding on the first lift 105a and thereby weakening the structural integrity of the system 100.

[0042] Referring now to Figures 6A-6B, depicted is another exemplary embodiment of the system 100 depicted in Figure 1, embodied and described here as system 600. As such, Figures 6A-6B may best be understood with reference to Figures 1-5, where like numerals correspond to like elements that will not be described again in detail. Similar to the system 100 generally described above, system 600 may include one or more lifts 105a,b stacked one atop the other and having one or more soil reinforcing elements 202 coupled the wire facings 102. The soil reinforcing elements 202 may extend into the backfill 103 and the backfill 103 may be sequentially added to the system 600 in a plurality of layers configured to cover the soil reinforcing elements 202 and provide tensile strength to each corresponding wire facing 102.

[0043] The soil reinforcing elements 202 in system 600, however, may include a different type of connector 210 than described in system 100. For example, any type of threaded rod can be extended through the coil 212 and secured thereto with a nut 216, thereby replacing the threaded rod 214 as generally described with reference to Figure 3. Referring to the exploded view of the connector 210 in Figure 6B, a threaded eye-bolt 602 with a head 604 may be employed. As illustrated, the head 604 may be a loop in one or more embodiments.

[0044] To secure the soil reinforcing element 202 to a portion of a wire facing 102, or in particular the vertical facing 106, the head 604 of the eye-bolt 602 may be disposed on the front side of at least two vertical wires 112, such as at a location of a connector lead 111a, such that the elongate body of the eye-bolt 602 can be extended through the coil 212 and secured thereto on its opposite end with the nut 216. As illustrated, the loop or head 604 may be prevented from passing through the vertical wires 112 or connector lead 111a by employing a washer 220 adapted to bias the vertical wires 112 or connector lead 111a. As the nut 216 is tightened, it brings the coil 212 into engagement with or at least adjacent the back side of the vertical facing 106, and the washer 220 into engagement with the vertical wires 112 or connector lead 111a.

[0045] In one or more embodiments, the elongate body of the eye-bolt 602 may also be threaded through a second nut 606 disposed against the washer 220 on the front side of the vertical facing 106. As illustrated, the body of the eye-bolt 602 can have a non-threaded portion 603 configured to offset the second nut 606 from the head 604 a distance Z when the second nut 606 is fully threaded onto the body. The distance Z may allow the head 604 to be laterally-offset from the vertical facing 106, as shown in Figure 6A.

[0046] As can be appreciated, having the head 604 offset from the vertical facing 106 may provide a location to attach or otherwise form a facing (not shown) to the system 600. For example, rebar may be passed through or otherwise coupled to the heads 604 of each connector 210, thereby providing a skeletal rebar structure prepared to be formed within a facing structure, such as being cast within a concrete skin. Moreover, lengths of rebar may be used to attach turnbuckles or other connection devices configured to couple the vertical facing 106 to a laterally-adjacent facing. As illustrated, the loop or head 604 may be horizontally-disposed, but may also be vertically-disposed without departing from the scope of the disclosure. Consequently, rebar may be passed either vertically or horizontally through adjacent loops or heads 604 in various embodiments of the system 600. Exemplary connective systems that may be used in conjunction with the present disclosure can be found in co-pending U.S. Pat. App. No. 12/132,750, entitled "Two Stage Mechanically Stabilized Earth Wall System," filed on June 4, 2008 and hereby incorporated by reference to the extent not inconsistent with the present disclosure.

[0047] The foregoing disclosure and description of the disclosure is illustrative and explanatory thereof. Various changes in the details of the illustrated construction may be made within the scope of the appended claims without departing from the spirit of the disclosure. While the preceding description shows and describes one or more embodiments, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the present disclosure. For example, various steps of the described methods may be executed repetitively, combined, further divided, replaced with alternate steps, or removed entirely. In addition, different shapes and sizes of elements may be combined in different configurations to achieve the desired earth retaining structures. Therefore, the claims should be interpreted in a broad manner, consistent with the present disclosure.

CLAIMS

I claim:

1. A mechanically stabilized earth structure, comprising:

a wire facing having a bend formed therein to form a horizontal element and a vertical facing, the horizontal element having initial and terminal wires each coupled to a plurality of horizontal wires, and the vertical facing having a plurality of vertical wires coupled to a plurality of facing cross wires and a top-most cross wire;

a soil reinforcing element having a plurality of transverse wires coupled to at least two longitudinal wires that have lead ends that converge; and

a connector having a coil coupled to the lead ends of the longitudinal wires and a threaded rod configured to extend through both the vertical facing and the coil, wherein a washer engages the vertical facing and prevents the threaded rod from passing completely therethrough and a first nut is threaded onto the threaded rod to prevent its removal from the coil.

2. The structure of claim 1, wherein the wire facing further comprises a plurality of connector leads extending from the horizontal element and up the vertical facing, the connector leads providing a location to connect the soil reinforcing element to the wire facing.

3. The structure of claim 1, wherein the threaded rod is a bolt.

4. The structure of claim 1, wherein the threaded rod is an eye-bolt having a non-threaded portion extending a distance Z from a head of the threaded rod.

5. The structure of claim 4, wherein the connector further comprises a second nut threaded onto the eye-bolt up to the non-threaded portion and configured to laterally-offset the head of the eye-bolt at least the distance Z from the vertical facing.

6. The structure of claim 5, wherein the head is a loop configured to receive a length of rebar configured to form part of a facing structure.

7. The structure of claim 1, further comprising a strut having a first end coupled to the vertical facing and a second end coupled to the horizontal element, the strut being configured to maintain the vertical facing at a predetermined angle with respect to the horizontal element.

8. The structure of claim 7, wherein the first end of the strut is coupled to one of the plurality of facing cross wires disposed below the top-most cross wire and the second end of the strut is coupled to the terminal wire.

9. A method of constructing a mechanically stabilized earth structure, comprising:

providing a first lift comprising a first wire facing being bent to form a first horizontal element and a first vertical facing, the first horizontal element having initial and terminal wires coupled to a plurality of horizontal wires, and the first vertical facing having a plurality of vertical wires coupled to a plurality of facing cross wires including a last facing cross wire and a top-most cross wire;

coupling a first soil reinforcing element to the first lift by extending a first threaded rod through the first vertical facing and also through a first coil coupled to a pair of longitudinal wires of the first soil reinforcing element;

engaging the vertical facing with a first washer disposed radially about the first threaded rod, the first washer being configured to prevent the first threaded rod from passing completely through the first vertical facing;

securing the first threaded rod to the first coil and first soil reinforcing element with a first nut;

placing a screen on the first wire facing to cover at least a portion of the first vertical facing and at least a portion of the first horizontal element; and

placing backfill on the first lift to a first height above the last facing cross wire of the first vertical facing, the first height being vertically below the top-most cross wire.

10. The method of claim 9, further comprising coupling a first end of a strut to the first vertical facing and a second end of the strut to the first horizontal element.

11. The method of claim 10, wherein the first end of the strut is coupled to the last facing cross wire and the second end of the strut is coupled to the terminal wire.

12. The method of claim 11, further comprising placing a second lift atop the backfill of the first lift, the second lift comprising a second wire facing being bent to form a second horizontal element and a second vertical facing.

13. The method of claim 12, wherein the second lift is not in contact with the first lift but is completely supported by the backfill of the first lift.

14. The method of claim 12, further comprising:

extending a second threaded rod through the first and second vertical facings and a second coil coupled to longitudinal wires of a second soil reinforcing element;

engaging the first vertical facing with a second washer disposed radially about the second threaded rod to prevent the second threaded rod from passing through both the first and second vertical facings; and

securing the second threaded rod to the second coil with a second nut such that the second lift is able to slidingly engage the first lift for at least the first height.

15. A mechanically stabilized earth structure, comprising:

a first lift comprising:

a first wire facing having a first horizontal element and a first vertical facing, the first horizontal element having initial and terminal wires coupled to a plurality of horizontal wires, and the first vertical facing having a plurality of vertical wires coupled to a plurality of facing cross wires including a last facing cross wire and a top-most cross wire;

a first soil reinforcing element coupled to the first wire facing, the first soil reinforcing element having converging lead ends coupled to a first coil;

a first threaded rod extended through the first vertical facing and the first coil, a first washer being engageable with the first vertical facing to prevent the first threaded rod from passing completely therethrough and a first nut is threaded onto the first threaded rod to prevent its removal from the first coil; and

backfill disposed on the first wire facing to a first height above the last facing cross wire of the first vertical facing; and

a second lift disposed on the backfill of the first lift, the second lift comprising:

a second wire facing having a second horizontal element and a second vertical facing;

a second soil reinforcing element coupled to the second wire facing, the second soil reinforcing element having converging lead ends coupled to a second coil; and

a second threaded rod extended through the first and second vertical facings and the second coil, a second washer being engagable with the first vertical facing to prevent the second threaded rod from passing therethrough and a second nut is threaded onto the second threaded rod to prevent its removal from the coil.

16. The structure of claim 15, wherein the first and second threaded rods are eye-bolts having a head and a non-threaded body portion extending a distance Z from the head.

17. The structure of claim 16, wherein each eye-bolt includes a third nut threaded onto the eye-bolt up to the non-threaded portion, the third nut being configured to laterally-offset the head of the corresponding eye-bolt the distance Z from the first and second vertical facings.

18. The structure of claim 17, wherein the head is a loop configured to receive a length of rebar for forming part of a facing structure.

19. The structure of claim 15, wherein the first lift further comprises a strut having a first end coupled to the first vertical facing and a second end coupled to the first horizontal element.

20. The structure of claim 15, wherein the top-most cross wire of the first vertical facing is slidably engaged with second vertical facing.

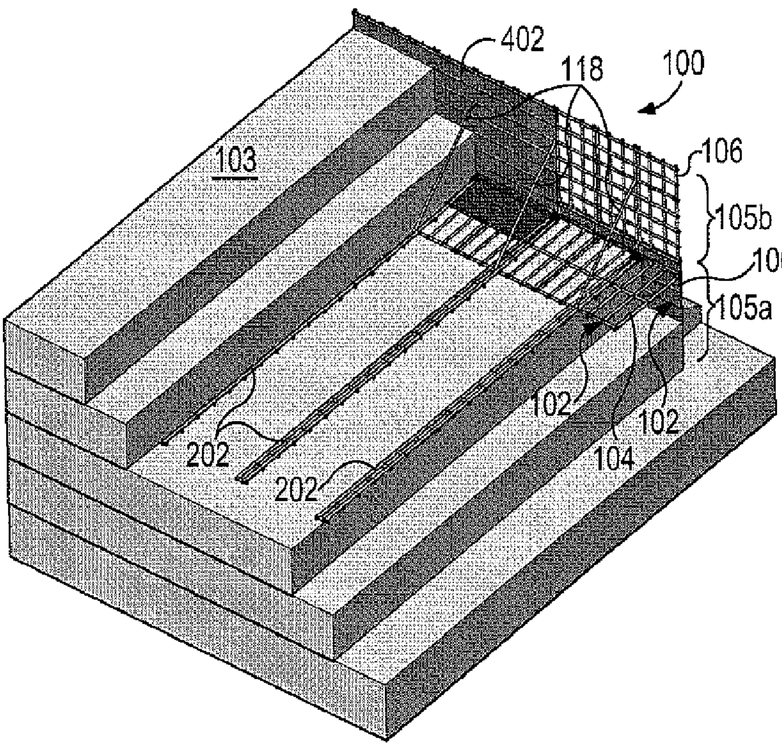
402
118
100
103
106
105b
106
105a
202
102
102
104
202

FIG. 1

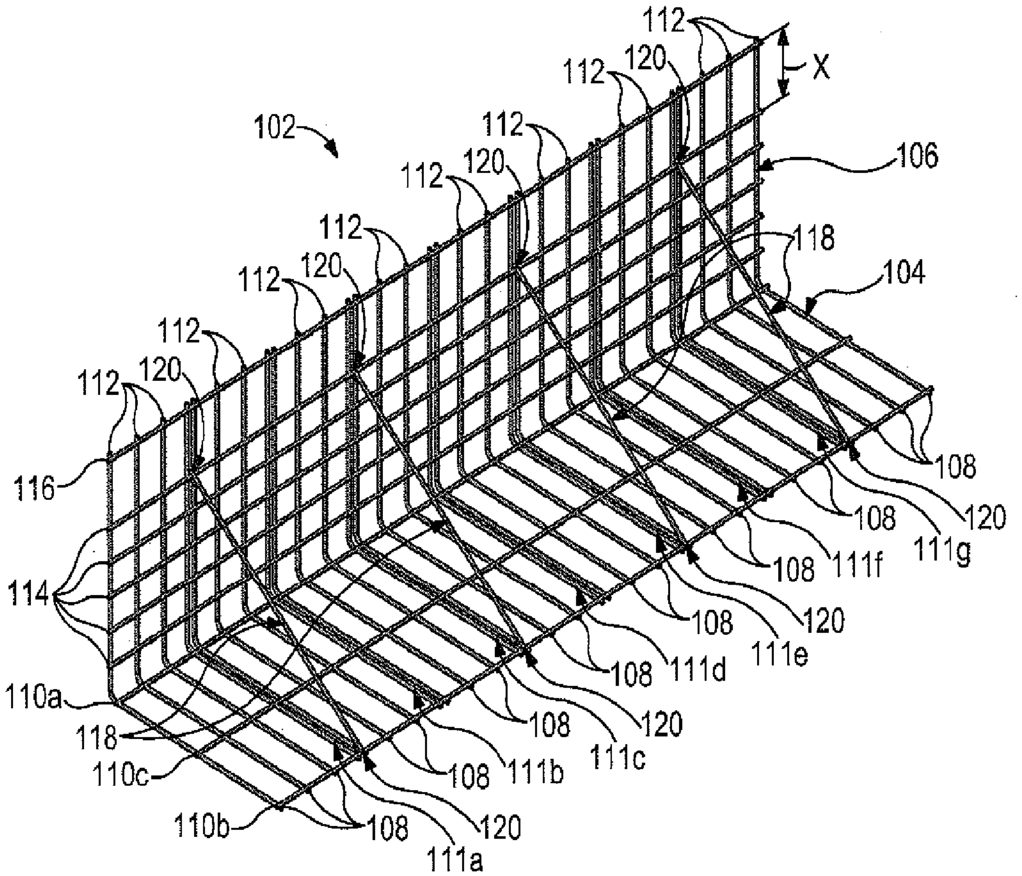
112
120
112
X
102
112
106
112
120
112
112
118
120
104
112
120
112
112
120
116
108
114
108
120
111g
108
111f
108
120
111e
108
111d
110a
108
120
111c
118
108
111b
110c
110b
108
120
111a

FIG. 2A

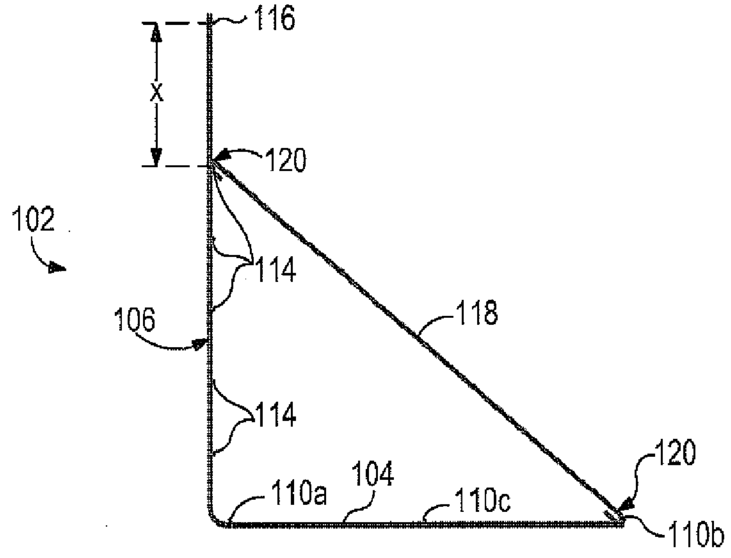
116
X
120
102
114
118
106
114
120
110a
104
110c
110b

FIG. 2B

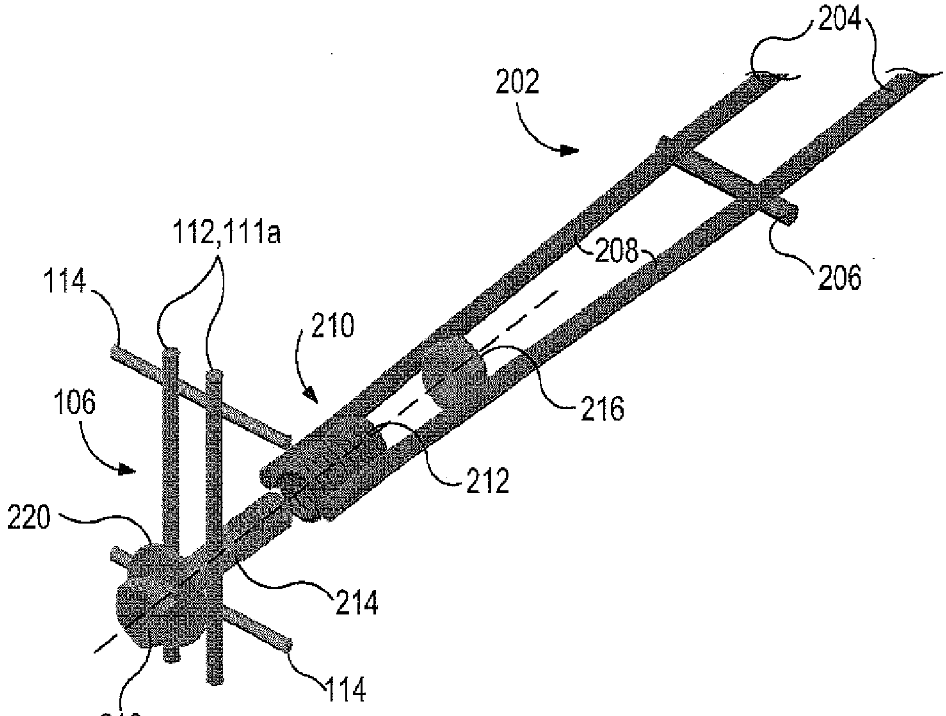
204
202
112,111a
208
206
114
210
216
106
212
220
214
114
218

FIG. 3

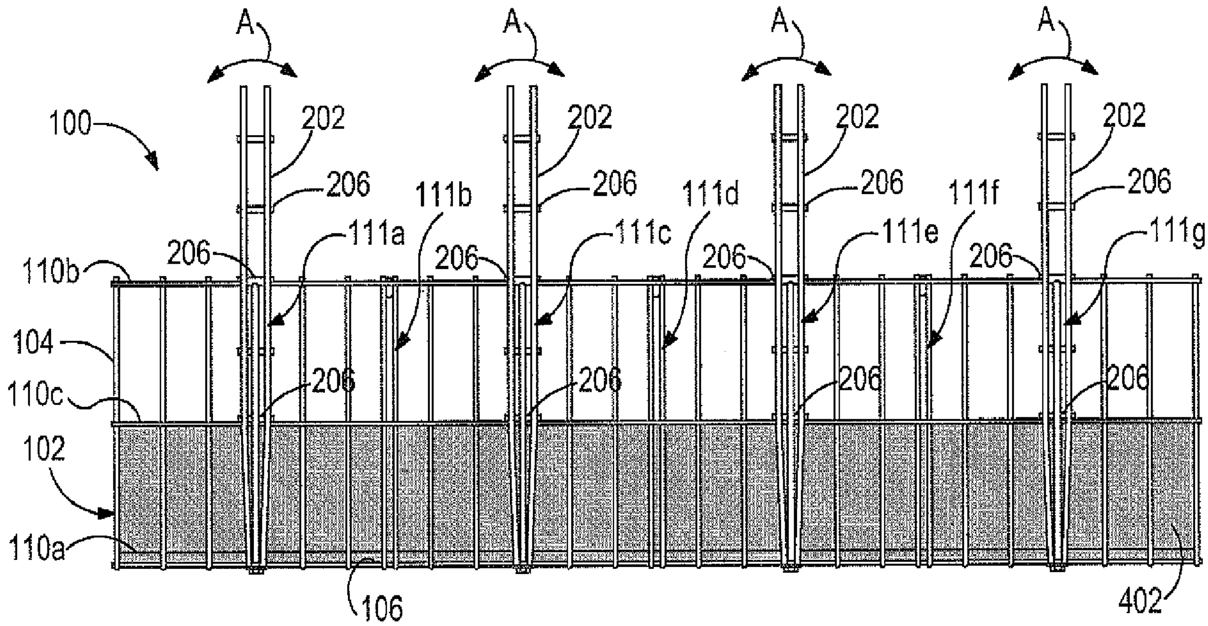
A
A
A
A
100
202
202
202
202
206
206
206
206
111b
111d
111f
206
111a
206
111c
206
111e
206
111g
110b
104
110c
206
206
206
206
102
110a
106
402

FIG. 4

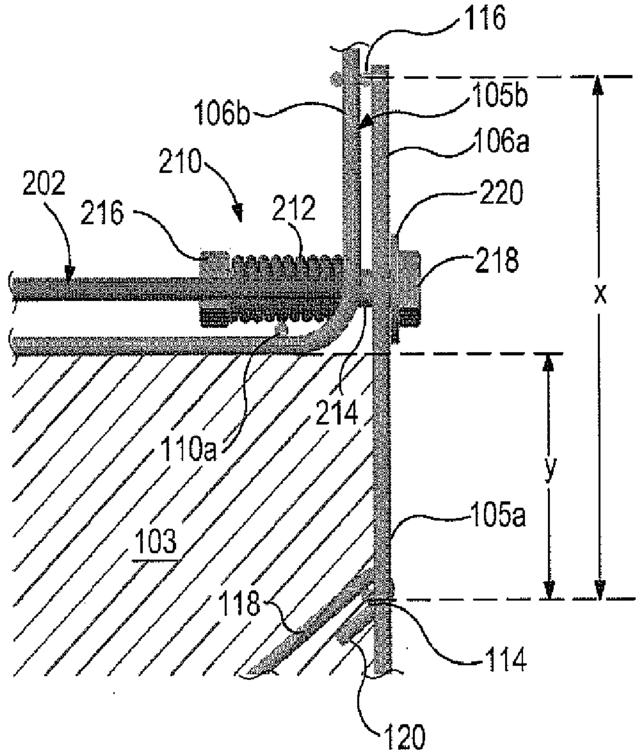
116
106b
105b
106a
210
202
216
212
220
218
x
214
110a
y
103
105a
118
114
120

FIG. 5

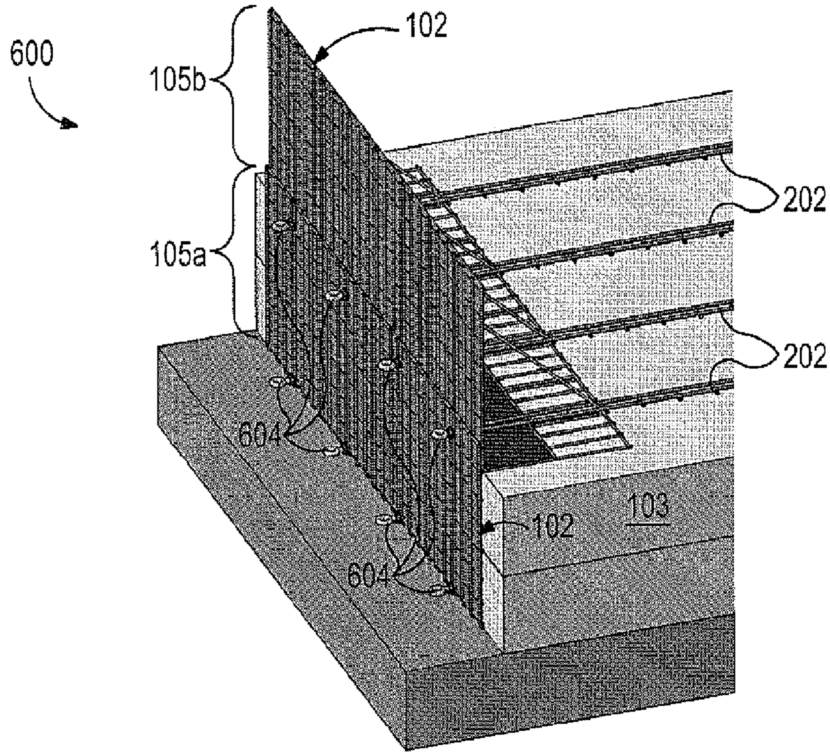
600
102
105b
105a
202
202
604
102
103
604

FIG. 6A

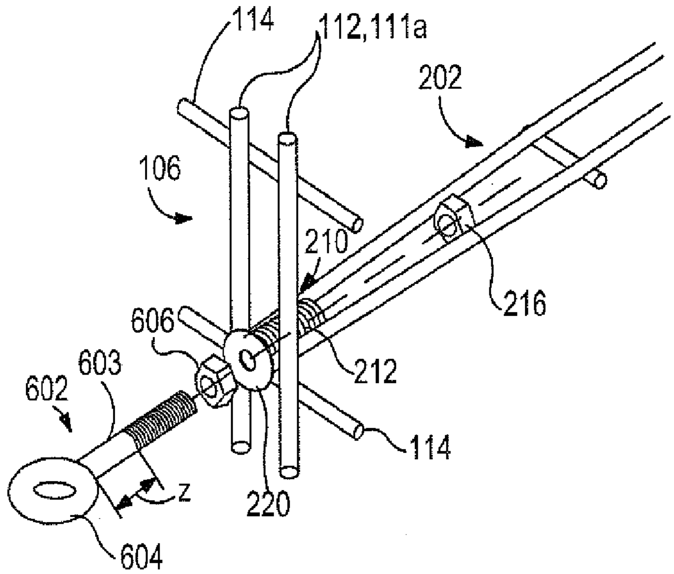
114
112,111a
202
106
210
216
606
603
212
602
114
z
220
604

FIG. 6B