(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 707 117 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
17.04.1996 Bulletin 1996/16

(51) Int. Cl.[6]: **E02D 29/00**, E02D 29/02

(21) Application number: **95117143.8**

(22) Date of filing: **21.03.1994**

(84) Designated Contracting States:
AT BE CH DE DK ES FR GB GR IE IT LI NL PT SE

(30) Priority: **31.03.1993 US 40904**
18.08.1993 US 108933
14.02.1994 US 192801

(62) Application number of the earlier application in accordance with Art. 76 EPC: **94913930.7**

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Remarks:
This application was filed on 31 - 10 - 1995 as a divisional application to the application mentioned under INID code 62.

(54) Modular block retaining wall construction and components

(57) A modular block wall includes dry cast, unreinforced modular wall blocks (40,80,116,340,480,550) with anchor type, or frictional type or composite type soil stabilizing elements (42,44,280,300,302,312,324,506) recessed therein and attached thereto by vertical rods (46) which also connect the blocks together. The soil stabilizing elements are positioned in counterbores or slots (62,64,100,554,555) in the blocks and project into the compacted soil behind the courses of modular wall blocks.

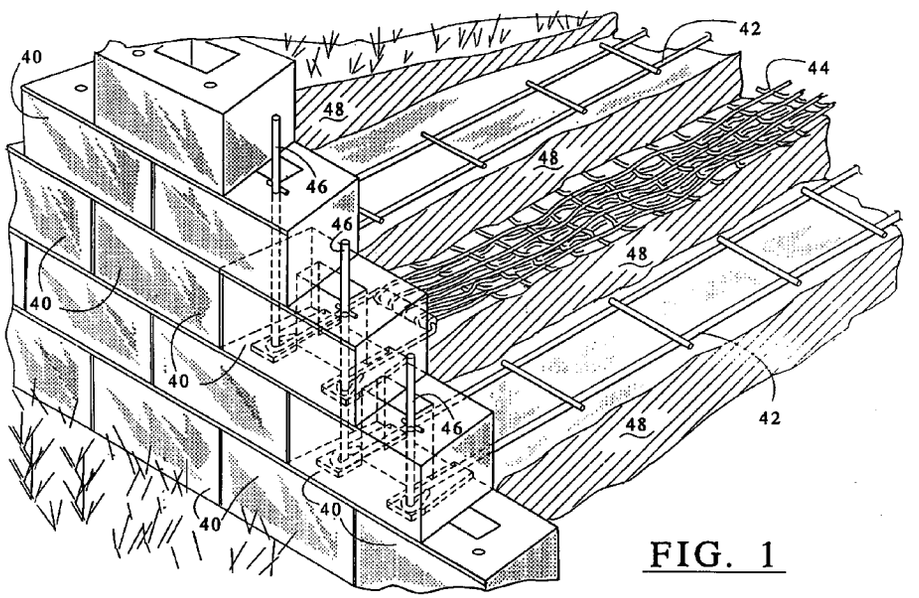


FIG. 1

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Description

BACKGROUND OF THE INVENTION

This invention relates to an improved retaining wall construction and, more particularly, to a retaining wall construction comprised of modular blocks, in combination with tie-back and/or mechanically stabilized earth elements and compacted particulate or soil.

In U.S. Patent No. 3,686,873 and No. 3,421,326, Henri Vidal discloses a constructional work now often referred to as a mechanically stabilized earth structure. The referenced patents also disclose methods for construction of mechanically stabilized earth structures such as retaining walls, embankment walls, platforms; foundations, etc. In a typical Vidal construction, particulate earthen material interacts with longitudinal elements such as elongated steel strips positioned at appropriately spaced intervals in the earthen material. The elements are generally arrayed for attachment to reinforced precast concrete wall panels and, the combination forms a cohesive embankment and wall construction. The longitudinal elements, which extend into the earthen work, interact with compacted soil particles principally by frictional interaction and thus mechanically stabilize the earthen work. The longitudinal elements may also perform a tie-back or anchor function.

Various embodiments of the Vidal development have been commercially available under various trademarks including the trademarks, REINFORCED EARTH embankments and RETAINED EARTH embankments. Moreover, other constructional works of this general nature have been developed. By way of example and not by way of limitation, Hilfiker in U.S. Patent No. 4,324,508 discloses a retaining wall comprised of elongated panel members with wire grid mats attached to the backside of the panel members projecting into an earthen mass.

Vidal, Hilfiker and others generally disclose large precast, reinforced concrete wall panel members cooperative with strips, mats, etc. to provide a mechanically stabilized earth construction. Vidal, Hilfiker and others also disclose or use various shapes of wall panel members. It is also noted that in constructions disclosed by Vidal and Hilfiker, the elements interactive with the compacted earth or particulate behind the wall panels or blocks, are typically rigid steel strips or mats which rely upon friction and/or anchoring interaction with the particulate, although ultimately, all interaction between such elements and the earth or particulate is dependent upon friction.

It is sometimes difficult or not practical to work with large panel members like those disclosed in Vidal or Hilfiker inasmuch as heavy mechanical lifting equipment is often required to position such panels. In such circumstances, smaller blocks rather than panels may be used to define the wall. Forsberg in U.S. Patent No. 4,914,876 discloses the use of smaller retaining wall blocks in combination with flexible plastic netting as a mechanically stabilizing earth element to thereby provide a mechanically stabilized earth retaining wall construction. Using flexible plastic netting and smaller, specially constructed blocks arranged in rows superimposed one upon the other, reduces the necessity for large or heavy mechanical lifting equipment during the construction phase of such a wall.

Others have also suggested the utilization of facing blocks of various configurations with concrete anchoring and/or frictional netting material to build an embankment and wall. Among the various products of this type commercially available is a product offered by Rockwood Retaining Walls, Inc. of Rochester, Minnesota and a product offered by Westblock Products, Inc. and sold under the trade name, Gravity Stone. Common features of these systems appear to be the utilization of various facing elements in combination with backfill, wherein the backfill is interactive with plastic or fabric reinforcing and/or anchoring means which are attached to the facing elements. Thus, there is a great diversity of such combinations available in the marketplace or disclosed in various patents and other references.

Nonetheless, there has remained the need to provide an improved system utilizing anchoring and/or frictional interaction of backfill and elements positioned in the backfill wherein the elements are cooperative with and attachable to facing elements, particularly blocks which are smaller and lighter than large facing panels such as utilized in many installations. The present invention comprises an improved combination of elements of this general nature and provides enhanced versatility in the erection of retaining walls and embankments, as well as in the maintenance and cost of such structures.

SUMMARY OF THE INVENTION

Briefly, the present invention comprises a combination of components to provide an improved retaining wall system or construction. The invention also comprises components or elements from which the improved retaining wall is fabricated. An important feature of the invention is a modular wall block which is used as a facing component for the retaining wall construction. The modular wall block may be unreinforced and dry cast. The block includes a front face which is generally planar, but may be configured in almost any desired finish and shape. The wall block also includes generally converging side walls, generally parallel top and bottom surfaces, a back wall, vertical throughbores or passages through the block specially positioned to enhance the modular character of the block, and counterbores associated with the throughbores having a particular shape and configuration which permit the block to be integrated with and cooperative with various types of anchoring and/or earth stabilizing elements. Special corner block and cap block constructions are also disclosed.

Various earth stabilizing and/or anchor elements are also disclosed for cooperation with the modular wall or face block and other blocks. A preferred embodiment of the earth stabilizing and/or anchoring elements includes

first and second generally parallel tensile rods which are designed to extend longitudinally from the modular wall block into compacted soil or an earthen work. The ends of the tensile rods are configured to fit within the counterbores defined in the top or bottom surface of the modular wall or facing block. Angled or transverse cross members connect the parallel tensile rods and are arrayed not only to enhance the anchoring characteristics, but also the frictional characteristics of interaction of the tensile rods with earth or particulate material comprising the embankment. The described wall construction further includes generally vertical anchoring rods that interact both with the stabilizing elements and also with the described modular blocks by extending vertically through the throughbores in those blocks while simultaneously engaging the stabilizing elements.

An alternative stabilizing element cooperative with the modular blocks comprises a harness which includes generally parallel tension arms that fit into the counterbores in the blocks and which cooperate with the vertical anchoring rods so as to attach the tension arms to the blocks. The harness includes a cross member connecting the opposite tension arms adjacent the back face outside of the modular block. The cross member of the harness may be cooperative with a geotextile strip, for example, which extends into the earthen work behind the modular wall block. Again, the harness cooperates with vertical anchoring rods which extend into the passages or throughbores defined in the modular blocks. Various other alternative permutations, combinations and constructions of the described components are set forth.

Thus it is an object of the invention to provide an improved retaining wall construction comprised of modular blocks and cooperative stabilizing elements that project into an earthen work or particulate material.

It is a further object of the invention to provide an improved and unique modular block construction for utilization in the construction of a improved retaining wall construction.

Yet another object of the invention is to provide a modular block construction which may be easily fabricated utilizing known casting or molding techniques.

Yet a further object of the invention is to provide a substantially universal modular wall block which is useful in combination with earth retaining or stabilizing elements as well as anchoring elements.

Yet another object of the invention is to provide unique earth anchoring and/or stabilizing elements that are cooperative with a modular wall or facing block.

Yet a further object of the invention is to provide a combination of components for manufacture of a retaining wall system or construction which is inexpensive, efficient, easy to use and which may be used in designs susceptible to conventional design or engineering techniques.

Another object of the invention is to provide a design for a modular block which may be used in a mechanically stabilized earth construction or an anchor wall construction wherein the block may be unreinforced and/or manufactured by dry cast or pre-cast methods, and/or interactive with rigid, metal stabilizing elements as well as flexible stabilizing elements such as geotextiles.

These and other objects, advantages and features of the invention will be set forth in the detailed description which follows.

BRIEF DESCRIPTION OF THE DRAWING

In the detailed description which follows, reference will be made to the drawing comprised of the following figures:

FIGURE 1 is an isometric, cut away view of an embodiment and example of the modular block retaining wall construction of the invention incorporating various alternative elements or components;
FIGURE 2 is an isometric view of the improved standard modular wall block utilized in the retaining wall construction of the invention;
FIGURE 3 is an isometric view of an earthen stabilizing and/or anchor element which is used in combination with the modular block of Figure 2 and which cooperates with and interacts with earth or particulate by means of friction and/or anchoring means or both;
FIGURE 4 is an isometric view of a typical anchoring rod which interacts with the wall block of Figure 2 and the earth stabilizing element of Figure 3 in the construction of the improved retaining wall of the invention;
FIGURE 4A is an alternate construction of the rod of Figure 4;
FIGURE 5 is a bottom plan view of the block of Figure 2;
FIGURE 6 is a rear elevation of the block of Figure 5;
FIGURE 7 is a side elevation of the block of Figure 5;
FIGURE 8 is a top plan view of a corner block as contrasted with the wall block of Figure 5;
FIGURE 9 is a rear elevation of the block of Figure 8;
FIGURE 10 is a side elevation of the block of Figure 8;
FIGURE 11 is a top plan view of an alternative corner block construction;
FIGURE 12 is a rear elevation of the block of Figure 11;
FIGURE 13 is a side elevation of the block of Figure 11;
FIGURE 13A is a top plan view of an alternate throughbore pattern for a corner block;
FIGURE 14 is a top plan view of a typical earth stabilizing element or component of the type depicted in Figure 3;
FIGURE 15 is a top plan view of a component of an alternative earth stabilizing element;
FIGURE 15A is an isometric view of an alternative component for the element of Figure 15;

FIGURE 16 is a bottom plan view of the element shown in Figure 14 in combination with a block of the type shown in Figure 2;

FIGURE 17 is a bottom plan view of the component or element depicted in Figure 16 in combination with a flexible geotextile material and a block of the type shown in Figure 2;

FIGURE 18 is a front elevation of a typical assembly of the modular wall blocks of Figure 2 and corner blocks such as shown in Figure 8 in combination with the other components and elements forming a retaining wall;

FIGURE 19 is a sectional view of the wall of Figure 18 taken substantially along the line 19--19;

FIGURE 20 is a sectional view of the wall of Figure 18 taken along line 20--20 in Figure 18;

FIGURE 21 is a cross sectional view of the wall of Figure 18 taken substantially along the line 21--21;

FIGURE 22 is a side sectional view of a combination of the type depicted in Figure 17;

FIGURE 23 is a side sectional view of a combination of elements of the type depicted in Figure 16;

FIGURE 24 is a top plan view of a typical retaining wall construction depicting the arrangement of the modular block elements to form an outside curve;

FIGURE 25 is a top plan view of modular block elements arranged so as to form an inside curve;

FIGURE 26 is a front elevation depicting a typical retaining wall in accord with the invention;

FIGURE 27 is an enlarged front elevation of a retaining wall illustrating the manner in which a slip joint may be constructed utilizing the invention;

FIGURE 28 is a sectional view of the wall shown in Figure 27 taken substantially along the lines 28--28;

FIGURE 29 is a sectional view of the wall of Figure 27 taken substantially along the line 29--29;

FIGURE 30 is a bottom plan view of the modular facing block of the invention as it is initially dry cast in a mold for a pair of facing blocks;

FIGURE 31 is a bottom plan view similar to Figure 30 depicting the manner in which the cast blocks of Figure 30 are separated to provide a pair of separate modular facing blocks;

FIGURE 32 is a top plan view of the cast formation of the corner blocks;

FIGURE 33 is a top plan view of the corner blocks of Figure 32 after they have been split or separated;

FIGURE 34 is a plan view of an alternative casting array for corner blocks;

FIGURE 35 is a plan view of corner blocks of Figure 24 separated;

FIGURE 36 is a front elevation of a wall construction with a cap block;

FIGURE 36A is a top plan view of cap blocks forming a corner;

FIGURE 37 is an isometric view of an alternative stabilizing element;

FIGURE 38 is a bottom plan view of an alternative stabilizing element and wall block construction;

FIGURE 39 is a plan view of another alternative stabilizing element and wall block construction;

FIGURE 40 is a side elevation of an alternative wall construction utilizing anchor type stabilizing elements;

FIGURE 41 is a bottom plan view of the wall construction of Figure 40 taken along the line 41--41;

FIGURE 42 is a top plan view of an alternative stabilizing element construction;

FIGURE 43 is a top plan view of another alternative stabilizing element construction;

FIGURE 44 is a top plan view of another stabilizing element construction;

FIGURE 45 is a bottom plan view of an alternative cap block construction;

FIGURE 46 is a cross-sectional view of the alternative cap block construction of Figure 45 taken along the line 46--46;

FIGURE 47 is a sectional plan view of an alternative construction incorporating modular facing blocks and a rigid grid;

FIGURE 48 is a side sectional view of the construction of Figure 47;

FIGURE 49 is a top plan sectional view of another alternative construction utilizing modular facing blocks in combination with a wire grid;

FIGURE 50 is a side section view of the construction of Figure 49;

FIGURE 51 is a side sectional view of an alternative to the construction of Figure 50;

FIGURE 52 is a side sectional view of a further alternative to the construction of Figure 50 depicting an alternative facing block construction;

FIGURE 53 is a top sectional view of the construction of Figure 52;

FIGURE 54 is a side sectional view of alternatives to the construction depicted in Figure 52;

FIGURE 55 is a top plan sectional view of an alternative construction depicting an alternative facing block construction which is similar to the construction of Figure 49;

FIGURE 56 is a side sectional view of another alternative construction utilizing a modified facing block configuration;

FIGURE 57 is a top plan view of the facing block used in the construction of Figure 56;

FIGURE 58 is a top plan sectional view of yet another alternative construction utilizing a modular facing block in combination with a wire mesh;

FIGURE 59 is a side sectional view depicting various alternative combinations of a wire mesh and block as depicted in Figure 58;

FIGURE 60 is a top plan view of another modification of the construction depicted in Figure 58;

FIGURE 61 is a top plan sectional view of another alternative embodiment of the invention utilizing tension arms and tension members in combination with facing blocks and various connector pins and a cast in place counterfort;

FIGURE 62 is a side sectional of the construction depicted in Figure 61;

FIGURE 63 is a top plan view of an alternative design and the form for the cast in place counterfort similar to the construction shown in Figure 61; and

FIGURE 64 is a side elevation of the forms of Figure 63.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

General Description

Figure 1 generally depicts the combination of components or elements which define the modular block retaining wall construction of the invention. Modular blocks 40 are arranged in courses one upon the other in an overlapping array. Generally rigid earth retaining or stabilizing elements 42 and/or flexible stabilizing elements 44 are cooperative with or interact with the blocks 40. Also, anchoring elements such as tie back elements may be utilized in cooperation with blocks 40. The stabilizing or anchoring elements 42, 44 are attached to blocks 40 by means of vertical anchoring rods 46. The elements 42 and/or 44 project from the back face of blocks 40 into compacted soil 48 and interact with the soil 48 as anchors and/or frictionally.

It is noted that interaction between the elements 42 and 44 and soil or particulate 48 depends ultimately upon frictional interaction of particulate material comprising the soil 48 with itself and with elements, such as elements 42 and 44. Conventionally, that interaction may be viewed as an anchoring interaction in many instances rather than a frictional interaction. Thus, for purposes of the disclosure of the present invention, both frictional and anchoring types of interaction of compacted soil 48 with stabilizing and/or anchor elements are considered to be generally within the scope of the invention.

The invention comprises a combination of the described components including the blocks 40, stabilizing elements 42 and/or 44, anchoring rods 46 and soil 48 as well as the separate described components themselves, the method of assembly thereof, the method of manufacture of the separate components and various ancillary or alternative elements and their combination. Following is a description of these various components, combinations and methods.

Facing Block Construction

Figure 2, as well as Figures 5 through 13, 13A, 30 through 36A, 44 and 45 illustrate in greater detail the construction of standard modular or facing blocks 40 and various other blocks. Figure 2, as well as Figures 5 through 7, depict the basic modular block 40 which is associated with the invention. Figures 30 and 31 are also associated with the basic or standard modular block 40 in Figure 2. The remaining figures relate to other block constructions.

Standard Modular Block

As depicted in Figures 2 and 5 through 7, the standard modular block 40 includes a generally planar front face 50. The front face 50, in its preferred embodiment, is typically aesthetically textured as a result of the manufacturing process. Texturing is, however, not a limiting characteristic of the front face 50. The front face 50 may include a precast pattern. It may be convex or concave or some other desired cast or molded shape. Because the block 40 is manufactured principally by casting techniques, the variety of shapes and configurations, surface textures and the like for the front face 50 is not generally a limiting feature of the invention.

The front face 50, however, does define the outline of the modular blocks comprising the wall as shown in Figure 1. Thus, the front face 50 defines a generally rectangular front elevation configuration, and because the blocks 40 are typically manufactured by means of casting techniques, the dimensions of the perimeter of front face 50 are typically those associated with a standard concrete block construction. The size or dimension, however, is not a limiting feature of the invention.

Spaced from and generally parallel to the front face 50 is a back face 52. The back face 52 is connected to the front face 50 by means of side walls 54 and 56 which generally converge towards one another from the front face 50. The convergence is generally uniform and equal on both sides of the block 40. Convergence may commence from front edges 51, 53, or may commence a distance from front face 50 toward back face 52. Convergence may be defined by a single flat side surface or multiple flat or curved side surfaces. The convergence angle is generally in the range of 7° to 15°, in the preferred embodiment of the invention, though, a range of convergence of 0° to about 30° is useful.

The thickness of the block 40, or in other words the distance between the front face 50 and back face 52, may be varied in accord with engineering and structural considerations. Again, typical dimensions associated with concrete block constructions are often relied upon by casters and those involved in precast or dry cast operations of block 40. Thus, for example, if the dimensions of the front face 50 are 16 inches wide by 8 inches high, the width of the back face would be approximately 12 inches and the depth or distance between the faces 50, 52 would be approximately 8, 10 or 12 inches.

In the embodiment shown, the side walls 54 and 56 are also rectangular as is the back face 52. Parallel top and bottom surfaces 58 and 60 each have a trapezoidal configuration and intersect the faces 50, 52 and walls 54, 56. In the preferred embodiment, the surfaces 58, 60 are congruent and parallel to each other and are also at generally right angles with respect to the front face 50 and back face 52.

The block 40 includes a first vertical passage or throughbore 62 and a second vertical passage or throughbore 64. Throughbores 62, 64 are generally parallel to one another and extend between surfaces 58, 60.

As depicted in Figure 5 the cross-sectional configurations of the throughbores 62 and 64 are preferably uniform along their length. The throughbores 62, 64 each include a centerline axis 66 and 68, respectively. The cross-sectional shape of each of the throughbores 62 and 64 is substantially identical and comprises an elongated or elliptical configuration or shape.

Each of the throughbores 62 and 64 and, more particularly, the axis 66 and 68 thereof, is precisely positioned relative to the side edges 51 and 53 of the front face 50. The side edges 51 and 53 are defined by the intersection respectively of the side wall 54 and front face 50 and side wall 56 and front face 50. The axis 66 is one-quarter of the distance between the side edge 53 and the side edge 51. The axis 68 is one-quarter of the distance between the side edge 51 and the side edge 53. Thus the axes 66 and 68 are arrayed or spaced one from the other by a distance equal to the sum of the distances that the axes 66, 68 are spaced from the side edges 51 and 53.

The throughbores 62 and 64 are positioned intermediate the front face 50 and back face 52 approximately one-quarter of the distance from the front face 50 toward the back face 52, although this distance may be varied depending upon engineering and other structural considerations associated with the block 40. As explained below, compressive forces on the block 40 result when an anchoring rod 46, which fits within each one of the throughbores 62 and 64, engages against a surface of each throughbore 62 or 64 most nearly adjacent the back face 52. The force is generally a compressive force on the material comprising the block 40. Thus, it is necessary, from a structural analysis viewpoint, to ensure that the throughbores 62 and 64 are appropriately positioned to accommodate the compressive forces on block 40 in a manner which will maintain the integrity of the block 40.

A counterbore 70 is provided with the throughbore 62. Similarly, a counterbore 72 is provided with the throughbore 64. Referring first to the counterbore 70, the counterbore 70 is defined in the surface 58 and extends from back face 52 over and around the throughbore 62. Importantly, the counterbore 70 defines a pathway between the throughbore 62 and the back face 52 wherein a tensile member (described below) may be placed in a manner such that the tensile member may remain generally perpendicular to an element, such as rod 46, positioned in the throughbore 62.

In a similar fashion, the counterbore 72 extends from the back face 52 in the surface 58 and around the throughbore 64. In the preferred embodiment, the counterbores 70 and 72 are provided in the top face 58 uniformly for all of the blocks 40. However, it is possible to provide the counterbores in the bottom face 60 or in both faces 58 and 60. Note that since the blocks 40 may be inverted, the faces 58 and 60 may be inverted between a top and bottom position. In sum, the counterbores 70 and 72 are aligned with and constitute counterbores for the throughbores 62 and 64, respectively.

In the preferred embodiment, a rectangular cross-section passage 74 extends parallel to the throughbores 62 and 64 through the block 40 from the top surface 58 to the bottom surface 60. The passage 74 is provided to eliminate weight and bulk of the block 40 without reducing the structural integrity of the block. It also provides a transverse counterbore connecting counterbores 70 and 72. The passage 74 is not necessarily required in the block 40. The particular configuration and orientation, shape and extent of the passage 74 may be varied considerably in order to eliminate bulk and material from the block 40.

The general cross-section of the throughbores 62 and 64 may be varied. Importantly, it is appropriate and preferred that the cross-sectional shape of the throughbores 62 and 64 permits lateral movement of the block 40 relative to anchoring rods 46, for example, which are inserted in the throughbores 62 and 64. Thus the dimension of the throughbores 62 and 64 in the direction parallel to the back face 52 in the embodiment shown is chosen so as to be greater than the diameter of a rod 46. The transverse (or front to back) dimension of the throughbores 62 and 64 more closely approximates the diameter of the rod 46 so that the blocks 40 will not be movable from front to back into and out of a position. That is, the front face 50 of each of the blocks 40 in separate courses and on top of each other can be maintained in alignment because of the size and configuration of throughbores 62, 64. Consequently, the blocks 40 can be preferably adjusted from side to side as one builds a wall of the type depicted in Figure 1, though the blocks 40 are not adjustable inwardly or outwardly to any great extent. This maintains the planar integrity of the assembly comprising the retaining wall so that the blocks 40 will be maintained in a desired and generally planar array. Side to side adjustment insures that any gap between the blocks 40 is maintained at a minimum and also permits, as will be explained below, various adjustments such as required for formation of inside and outside curvature of the wall construction.

The depth of the counterbores 70 and 72 is variable. It is preferred that the depth be at least adequate to permit the elements 42 and/or 44 to be maintained below or no higher than the level of surface 58, so that when an additional course of blocks 40 is laid upon a lower course of blocks 40, the elements 42 and/or 44 are appropriately and properly recessed so as not to interfere with an upper course of blocks 40.

Referring briefly to Figures 30 and 31, there is illustrated a manner in which the standard modular blocks of Figures 2 and 5 can be manufactured. Typically, such blocks may be cast in pairs using dry casting techniques with the front face of the blocks 40 cast in opposition to each other with a split line such as split line 75 as depicted in Figure 30. Then after the blocks 40 are cast, a wedge or shear may be utilized to split or separate blocks 40 one from the other revealing a textured face such as illustrated in Figure 31. Appropriate drag and draft angles are incorporated in the molds with respect

to such a casting operation as will be understood by those of ordinary skill in the art. Also note, the dry cast blocks 40 are not typically reinforced. However, the dry cast blocks may include reinforcing fibers. Lack of reinforcement and manufacture by dry casting techniques of a block 40 for use with metallic and/or generally rigid stabilizing elements is not known to be depicted or used in the prior art.

Corner and/or Spilt Face Blocks

Figures 8 through 13A, and 32 through 36A depict blocks that are used to form corners and/or caps of the improved retaining wall construction of the invention or to define a boundary or split face in such a retaining wall. Figures 8, 9 and 10 disclose a first corner block 80 which is similar to, but dimensionally different from the corner blocks of Figures 11, 12 and 13 and the corner block 110 of Figure 13A.

Referring, therefore, to Figures 8, 9 and 10, corner block 80 comprises a front face 82, a back face 84, a finished side surface 86 and a unfinished side surface 88. A top surface 90 is parallel to a bottom surface 92. The surfaces and faces generally define a rectangular parallelpiped. The front face 82 and the finished side surface 86 are generally planar and may be finished with a texture, color, composition and configuration which is compatible with or identical to the surface treatment of blocks 40. The corner block 80 includes a first throughbore 94 which extends from the top surface 90 through the bottom surface 92. The throughbore 94 is generally cylindrical in shape; however, the throughbore 94 may include a funnel shaped or frusto-conical section 96 which facilitates cooperation with a rod, such as rod 46, as will be explained below.

The cross-sectional area of the throughbore 94 is slightly larger than the cross-sectional area and configuration of a compatible rod, such as rod 46, which is designed to fit through the throughbore 94. Importantly, the cross-sectional shape of the throughbore 94 and the associated rod, such as rod 46, are generally congruent to preclude any significant alteration and orientation of a positioned corner block 80 once a rod 46 is inserted through a throughbore 94.

The position of the first throughbore 94 relative to the surfaces 82, 84 and 86 is an important factor in the design of the corner block 80. That is, the throughbore 94 includes a centerline axis 98. The axis 98 is substantially an equal distance from each of the surfaces 82, 84 and 86, thus rendering the distances **x**, **y** and **z** in Figure 8 substantially equal, where **x** is the distance between the axis 98 and the surface 82, **y** is the distance between the axis 98 and the surface 84, and **z** is the distance between the axis 98 and the surface 86.

The corner block 80 further includes a second throughbore 100 which extends from the top surface 90 through the bottom surface 92. The second throughbore 100 may also include a funnel shaped or frusto-conical section 104. The cross-sectional shape of the throughbore 100 generally has an elongated or elliptical form and has a generally central axis 102 which is parallel to the surfaces 82, 84, 86 and 88. The longitudinal dimension of the cross-sectional configuration of the second throughbore 100 is generally parallel to the front face 82. The axis 102 is specially positioned relative to the side surface 88 and the front face 82. Thus the axis 102 is positioned a distance **w** from the front face 82 which is substantially equal to the distance **w** which axis 66 is positioned from front face 50 of the block 40 as depicted in Figure 5. The axis 102 is also positioned a distance **v** from the unfinished side surface 88 which is substantially equal to the distance **c** which the axis 62 is positioned from the edge 53 of the front face 50 of the block 40 as depicted again in Figure 5. A counterbore 103 may be provided for throughbore 100. Counterbore 103 extends from back surface 84 and around bore 100. The counterbore 103 may be provided in both top and bottom surfaces 90 and 92.

The distance **u** between the axis 102 and the axis 98 for the corner block 80 is depicted in Figure 8 and is equal to the distance **u** between the axis 66 and the axis 68 for the block 40 in Figure 5. The distance **u** is substantially two times the distance **v**. The distance **v** between the axis 102 and the side surface 88 is substantially equal to the distance **z** between the axis 98 and the side surface 86. The correlation of the various ratios of the distances for the various blocks 40, 80 and 110 set forth above is summarized in the following Table No. 1:

TABLE 1

For Block 40	-	$2v = u$
For Corner Block 80	-	$x = y = z$
	-	$x + y = u$
	-	$v + z = u$
For Corner Block 110	-	$a = b = c$
		$d = v + c$

It is to be noted that the corner block 80 of Figures 8, 9 and 10 is a corner block 80 wherein the perimeter of the front face 82 is dimensionally substantially equal to the front face 50 of the block 40. Figures 11, 12 and 13 illustrate an alternative corner block construction wherein the front face and finished side face or surface are different dimensionally from that of the corner block 80 in Figures 8, 9 and 10.

Referring therefore to Figures 11, 12 and 13, a corner block 110 includes a front face 112, a back face 114, a finished side surface 116, an unfinished side surface 118, top and bottom parallel surfaces 120 and 122. The

block 110 has a rectangular, parallelpiped configuration like the block 80. The block 110 includes a first throughbore 124 having a shape and configuration substantially identical to that of the first throughbore 94 previously described including the frusto-conical section 126, and an axis 128. Similarly, the block 110 includes a second throughbore 130 having an axis 132 with a cross-sectional configuration substantially identical to that of the second throughbore 100 and also including a frusto-conical or funnel shaped section 134. Also, counterbores 131 may be provided in the top and bottom surfaces 120, 122. The front face 112 and finished side surface 116 are finished, as previously described with respect to front face 50, in any desired fashion. The front face 112 has a height dimension as illustrated in Figure 13 as height **h** which is substantially equal to the height **h** of the block 40 in Figure 7, as well as the height **h** of the block 80 as illustrated in Figure 10.

The axis 128 is again equally spaced from the face 112, surface 116 and surface 114 as illustrated in Figure 11. Thus, the distance **a** from the surface 112 to axis 128 equals the distance **b** from the face 114 to the axis 128 which also equals the distance **c** from the surface 116 to the axis 128. The axis 132 is spaced from the front face 112 by the distance **w** which again is equal to the distance **w** of spacing of axis 66 from face 50 of block 40 as shown in Figure 5. Similarly, the axis 132 is spaced a distance **v** from the unfinished side surface 118 which is equal to the distance **c** associated with the block 40 as depicted in Figure 5. The distance between the axis 132 and the axis 128 represented by **d** in Figure 11 equals the distance **v** between axis 132 and surface 118 plus distance **c**, the distance between axis 128 and finished side surface 116. Again, these dimensional relationships are set forth in Table 1.

Figure 13A illustrates the configuration of a corner block which is reversible and includes throughbores 99, 101 which are shaped with an L shaped cross section so as to function as though they are a combination of throughbores 124, 130 of the embodiment of Figure 11. Thus, bores 99 and 101 each include an axis 128a which is equivalent to axis 128 of the corner block of Figure 11 and a second axis 132a which is equivalent to the axis 132 of the block of Figure 11.

Other alternative block constructions are possible within the scope of the invention and some modifications and alternatives are discussed below. However, the aforedescribed block 40 as well as the corner blocks 80 and 110 are principal modular blocks to practice the preferred embodiment of the invention.

Stabilizing Elements

The second major component of the retaining wall construction comprises retaining elements which are interactive with and cooperate with the blocks 40, 80, and 110, particularly the basic block 40. Figures 14 through 17 illustrate various stabilizing elements. Referring first to Figure 14, there is illustrated a stabilizing element 42 which is comprised of a first parallel reinforcing bar 140 and a second parallel reinforcing bar 142. The bars 140 and 142 each have a loop 144 and 146 respectively formed at an inner end thereof. Typically, the bars 140 and 142 are deformed to form the loops 144, 146 and the ends of the loops 144, 146 are welded back onto the bar 140 and 142.

Importantly, each loop 144 and 146 is connected to a tension arm 148 and 150 defined by the bars 140 and 142. The tension arms 148 and 150 are parallel to one another and are of such a length so as to extend beyond the back face of any of the blocks previously described. A cross member 152, positioned beyond the back face of the block 40, connects the arms 148 and 150 to ensure their appropriate spacing and alignment. A second cross member 154 ensures that the arms 148 and 150, as well as the bars 140 and 142, remain generally parallel.

There are additional cross members 154 and 156 provided along the length of the bars 140 and 142. The spacing of the cross members 154 and 156 is preferably generally uniform in accordance with the principles of mechanically stabilized earth structures essentially based on friction. However, this is not a limiting feature and cross members 156 may preferably be uniformly spaced from the other at generally closer intervals in a so called passive or resistive zone, than the cross members 154 in front, if the stabilizing elements are rather considered as anchors. In this case, the bars and cross members 154, as well as cross members 152, are not necessarily closely spaced or even required so long as the bars 140 and 142 are maintained in a substantially parallel array.

It is noted that in the preferred embodiment, that just two bars 140 and 142 are required or are provided. However, stabilizing elements having one or more longitudinal members (e.g. bars 140, 142) may be utilized. The stabilizing element depicted and described with respect to Figure 14 relies upon frictional interaction but could be configured to rely, as well, upon anchoring interaction with compacted soil. The cross members 156, thus, could be configured to act as a collection of anchors. The bars 140 and 142 and cross members 156 in the preferred embodiment provide frictional interaction with compacted soil.

Figure 15 illustrates a component of a further alternative stabilizing element 44. Specifically referring to Figure 15, the element depicted includes a harness or connector 160 which includes a first tension bar or arm 162 and a second bar or arm 164. Arms 162 and 164 are generally parallel to one another and are connected by a cross member 166, which in this case also includes a cylindrical, tubular member 168 retained thereon. Alternatively, as depicted in Figure 15A, a C-shaped clamp member 167 may be fitted over the cross member 166.

Each of the parallel tension arms 162 and 164 terminate with a loop 170 and 172. The loops 170 and 172 are arranged in opposed relationship and aligned with one another as depicted in Figure 15. The ends of the

loops 170 and 172 are welded at welds 174 and 176, respectively to the arms 162 and 164, respectively.

The harness or connector 160 is cooperative with the blocks, most particularly block 40, as will be described in further detail. That detail is illustrated, in part, in Figures 16 and 17. Referring first to Figure 16, there is depicted a stabilizing element 42. Figure 17 illustrates the stabilizing element 44. Referring to Figure 16 the element 42 and more particularly the tension arms 148 and 150 are positioned in the counterbores 70 and 72 of block 40 with the loops 144 and 146 positioned over the throughbores 64 and 62, respectively.

Referring to Figure 17, the connector 160, which comprises a portion of the stabilizing element 44, includes arms 162 and 164 which are fitted into the counterbores 70 and 72, respectively of block 40 with loops 170 and 172, respectively fitted over the throughbores 62 and 64. Note that connector 160 is sufficiently recessed within the block 40 so as to be below the plane of the top surface 58 thereof. Similarly, the tension arms 148 and 150 of the element 42 are sufficiently recessed within the counterbores 70 and 72 to be below the plane or no higher than the plane of the top surface 58 of the block 40.

Referring again to Figure 17, the element 44 further includes a geotextile material comprising a lattice of polymeric strips, such as strip 180, which is generally flexible and wherein an elongated length thereof is wrapped around or fitted over the tube or cylinder 168 or clamp 167 so that the opposite ends of the strips 180 extend outwardly and away from the block 40. Thus, Figure 16 illustrates a generally rigid element. Figure 17 illustrates a generally flexible element. In each event, the elements 42 and 44 are cooperative with a block 40 as described.

Connectors

Depicted in Figure 4 is a typical connector which comprises a reinforcing rod or bar, normally a steel reinforcing bar 46, which is generally cylindrical in shape and which is fitted through loops, for example loops 170 and 172 in Figure 17 and associated throughbores 62 and 64 of block 40 to thereby serve to retain the element 44 and more particularly the connector 160 cooperatively engaged with block 40. The rod 46, which is depicted as the preferred embodiment, is cylindrical as previously mentioned. However, any desired size may be utilized. It is to be noted that the steel reinforcing bars, which are recommended in order to practice the invention, are also utilized in cooperation with the specially configured first throughbores 94, 124 of the corner blocks 80, 110. For example first throughbore 124 of the corner block 110 illustrated in Figure 12 cooperates with a rod such as rod 46 illustrated in Figure 4. The rods 46 are of a sufficient length so that they will project through at least two adjacent blocks 40 which are stacked one on top of the other thus distributing the compressive forces resulting from the elements 44 interacting with the blocks 40 to blocks of adjacent courses forming a wall.

As depicted in Figure 4A, the rod 46 may include a small stop or cross bar 47 welded or attached at its midpoint. Cross bar 47 insures that the rod 46 will be positioned properly and retained in position to engage blocks 40 above and below the block 40 in which rod 46 is positioned to cooperate with elements 42, 44. Thus, the rod 46 will not fall or slip downward into throughbores 62, 64.

Retaining Wall System

Figures 18 through 29 illustrate the manner of assembly of the components heretofore described to provide a retaining wall. Referring first to Figure 18, there is depicted an array of three courses of modular blocks 40 and corner blocks 80 to define a section or portion of a wall using the components of the invention. Note that each of the courses provide that the blocks 40 are overlapping. Note further that the front face dimensions of the corner block 80 are equal to the front face dimensions of the modular blocks 40. The side face or surface dimensions of the corner blocks 80 are equal to one half of the dimensions of the basic blocks 40.

Figure 19, which is a sectional view of the wall of Figure 18, illustrates the manner of positioning the corner blocks 80 and modular basic building blocks 40 with respect to each other to define the first course of the wall depicted in Figure 18. Note that elements 42, which are the rigid stabilizing elements, are cooperatively positioned for interaction with the blocks 40. In the preferred embodiment, stabilizing elements 42 are provided for use in association with each and every one of the modular blocks 40 and the elements 42 include only two parallel reinforcing bars. It is possible to provide for constructions which would have a multiple number of reinforcing bars or special anchoring elements attached to the bars. The preferred embodiment is to use just two bars in order to conserve with respect to cost, and further, the two bar construction provides for efficient distribution of tensile forces and anchoring forces on the element 42, and torsional forces are significantly reduced.

Figure 20 illustrates the manner in which the corner block 80 may be positioned in order to define an edge or corner of the wall depicted in Figure 18. Thus, the block 80, which is a very symmetrical block as previously described, may be alternated between positions shown in Figures 19 and 20. Moreover, the corner blocks 80 may be further oriented as depicted and described with respect to Figures 27 through 29 below. The element 44, which is a stabilizing element utilizing a flexible polymeric or geotextile material, is depicted as being used with respect to the course or layer of blocks 40 defining or depicted in Figure 20.

Figure 21 is a side sectional view of the wall construction of Figure 18. As known to those of ordinary skill in the art, construction of such walls and the analysis thereof calls for the defining of a resistive zone 190 and an active zone 192. As explained above, in some cases

the cross members 156 are preferably closer in the resistive zone; however, this is not a limiting feature.

Figure 21 illustrates also the use of the polymeric grid material 180. It is to be noted that all of the elements 42 and/or 44 are retained in a compacted soil or compacted earth in a manner described in the previously referenced prior art patents.

In Figure 21, there is illustrated the placement of a stabilizing element, such as elements 42 or 44, in association with each and every course of blocks 40, 80. In actual practice, however, the stabilizing elements 42 and/or 44 may be utilized in association with separate layers or courses, eg. every second, third or fourth course of blocks 40, 80 and/or at separate blocks, eg. every second or third block horizontally in accord with good design principles. This does not, however, preclude utilization of the stabilizing elements 42, 44 in association with each and every course and each and every block 40, 80. Thus, it has been found that the mechanically stabilized earth reinforcement does not necessarily require stabilizing elements at every possible block position. Again, calculations with respect to this can be provided using techniques known to those of ordinary skill in the art such as referenced herein.

During construction, a course of blocks 40 are initially positioned in a line on a desired footing 200, which may consist of granular fill, earthen fill, concrete or other leveling material. Earthen backfill material 202 is then placed behind the blocks 40. An element, such as stabilizing element 42, may then be positioned in the special counterbores 70, 72 in a manner previously described and defined in the blocks 40, 80. Rods 46 may then be inserted to maintain the elements 42 in position with respect to the blocks 40. The rods 46 should, as previously described, interact with at least two adjacent courses of blocks 40. A layer of sealant, fabric or other material (not shown) may be placed on the blocks. Subsequently, a further layer of blocks 40 is positioned onto the rods 46. Additional soil or backfill 202 is placed behind the blocks 40, and the process continues as the wall is erected.

In practice, it has been found preferable to orient the counterbores 70, 72 facing downward rather than upward during construction. This orientation facilitates keeping the counterbores 70, 72 free of debris, etc. during construction.

Figures 22 and 23 illustrate side elevations of the construction utilizing a flexible stabilizing element 44 in Figure 22 and a rigid stabilizing element 42 in Figure 23. In each instance, the elements 42 and/or 44 are cooperative with blocks 40, rods 46 and compacted soil 202 as previously described.

Referring next to Figures 24 and 25, as previously noted, the throughbores 62, 64 in the blocks 40 have an elongated cross-sectional configuration. Such elongation permits a slight adjustable movement of the blocks 40 laterally with respect to each other to ensure that any tolerances associated with the manufacture of the blocks 40 are accommodated. It was further noted that the blocks 40 are defined to include converging side surfaces 54, 56. Because the side surfaces 54, 56 are converging, it is possible to form a wall having an outside curve as depicted in Figure 24 or an inside curve as depicted in Figure 25. In each instance, the mode of assembly and the cooperative interaction of the stabilizing elements 42, 44 and rods 46 as well as blocks 40 are substantially as previously described with respect to a wall having a flat front surface.

Figure 26 illustrates the versatility of the construction of the present invention. Walls of various shapes, dimensions and heights may be constructed. It is to be noted that with the combination of the present invention the front face of the wall may be substantially planar and may rise substantially vertically from a footing. Though it is possible to set back the wall or tilt the wall as it ascends, that requirement is not necessary with the retaining wall system of the present invention. Also, the footing may be tiered. Also, the block 40 may be dry cast and is useful in combination with a rigid stabilizing element, such as element 42, as contrasted with geotextile materials.

Figures 27, 28 and 29 illustrate the utilization of corner blocks to provide for a slip joint in a conventional wall of the type depicted in Figure 26. As shown in Figure 27, a slip joint or vertical slot 210 is defined between wall sections 212 and 214. Sectional views of the walls 212 and 214 are depicted in Figures 28 and 29. There it will be seen that the corner blocks 80, which may be turned in either a right handed or left handed direction, may be spaced from one another or positioned as closely adjacent as desired or required. A fabric or other flexible material 216 may be positioned along the back side of the blocks 80 and then backfill 202 positioned against the flexible material 216.

Figure 29 illustrates the arrangement of these elements including the flexible barrier 216 and the blocks 80 for the next course of materials. It is to be noted that the first throughbore 94 of the corner blocks 80 as well as for the corner block 110 always align vertically over one another as each of the courses are laid. Thus, a rod 46 may be passed directly through the first throughbores 94 to form a rigidly held corner which does not include the capacity for adjustment which is built into the throughbores 62, 64 associated with the blocks 40 or the second throughbore 100 associated with corner blocks 80. The positioning of the throughbores 94 facilitates the described assembly. The blocks 80 may include a molded split line 81 during manufacture. The line 81 facilitates fracture of the block 80 and removal of the inside half 83 as shown in Figure 28.

Figures 32, 33 and 34 illustrate a possible method for casting corner blocks 80. Corner blocks 80 may be cast in an assembly comprising four corner blocks wherein the mold provides that the faces 82, 85 of the corner blocks 80 will be in opposition along split lines 182, 185 so that, as depicted in Figure 32, four corner blocks 80 may be simultaneously cast, or as shown in Figure 34, two corner blocks 80 may be cast. Then as depicted in Figure 33, the corner blocks may be split from

one another along the molded split lines to provide four (or two) corner blocks 80.

The stabilizing elements 42, 44, may also be cooperative with the counterbores 103, 131 of the corner blocks 80, 110. In practice, such construction is suggested to stabilize corners of a wall. The elements 42, 44 would thus simultaneously cooperate with counterbores 103, 131 of a corner block 80, 110 and counterbores 70 or 72 of a modular block 40.

The described components and the mode of assembly of those components constitutes a preferred embodiment of the invention. It is to be noted that the corner blocks 80 as well as the standard modular blocks 40 may be combined in a retaining wall having various types of stabilizing elements and utilizing various types of analysis in calculating the bill of materials. That is, the stabilizing elements have both anchoring capabilities as well as frictional interactive capabilities with compacted soil or the like. Thus, there is a great variety of stabilizing elements beyond those specifically described which are useful in combination with the invention.

For example, the stabilizing elements may comprise a mat of reinforcing bars comprised of two or more parallel bars which are designed to extend into compacted soil. Rather than forming the loops on the ends of those bars to interact with vertical rods 46, it is possible to merely bend the ends of such rods at a right angle so that they will fit into the throughbores 62, 64 through the blocks 40 thereby holding mats or reinforcing bars in position. Additionally, the rods 46 may be directly welded to longitudinal tensile arms in the throughbores, thus, eliminating the necessity of forming a loop in the ends of the tension arms.

Though two tensions arms and thus two reinforcing bars are the preferred embodiment, a multiplicity of tension arms may be utilized. Additionally, as pointed out in the description above, the relative size of the corner blocks may be varied and the dimensional alternatives in that regard were described. The shapes of the rods 46 may be varied. The attachment to the rods 46 may be varied.

Also, cap blocks 250 may be provided as illustrated in Figure 35 and 36. Such blocks 250 could have a plan profile like that of modular blocks 40 but with a longer lateral dimension and four throughbores 252, which could be aligned in pairs with throughbores 62, 64. The cap blocks 250 may then be alternated in orientation, as depicted in Figure 35, with rods 46 fitting in proper pairs of openings 252. Mortar in openings 252 would lock the cap blocks 250 in place. Cap blocks 250 could also be split into halves 254, 256, as shown in Figure 35, to form a corner. An alternative cap block construction comprises a rectangular shaped cap with a longitudinal slot on the underside for receipt of the ends of rods 46 projecting from the top course of a row of blocks 40. Other constructions are also possible.

Another alternative construction for a stabilizing element is illustrated in Figure 37. There, tension arms 260, 262 and cross members 264 cooperate with a clamp 266 which receives a bolt 268 to retain a metal strip 270. Strip 270 is designed to act as a friction strip or connect to an anchor (not shown).

Figure 38 depicts another alternative construction for a stabilizing element 280 and the connection thereof to block 40. Element 280 includes parallel tension arms 281, 283 with a loop 282 which fits in the space between counterbores 70, 72 defined by passage 74. The shape of the walls defining the passage 74 may thus be molded to maximize the efficient interaction of the stabilizing element 280 and block 40.

Figure 39 depicts yet another alternative construction wherein block 40 includes a passage 290 from internal passage 74 through the back face 52 of block 40. A stabilizing element such as a strip 292 fits through passage 290 and is retained by a pin 294 through an opening in strip 292. Strip 292 may be tied to an anchor (not shown) or may be a friction strip. Rods 46 still are utilized to join blocks 40.

Figures 40 and 41 depict a wall construction comprised of blocks 40 in combination with anchor type stabilizing elements. The anchor type stabilizing elements are, in turn, comprised of double ended tensile elements 300 analogous to elements 42 previously described. The elements 300 are fastened to blocks 40 at each end by means of vertical rods 46. The blocks 40 form an outer wall 302 and an inner anchor 304 connected by elements 300. Anchors 304 are imbedded in compacted soil 305. The inside surface of the outer wall 302 may be lined with a fabric liner 306 to prevent soil erosion. This design for a wall construction utilizes the basic components previously described and may have certain advantages especially for low wall constructions.

Figures 42, 43 and 44 illustrate further alternative constructions for a stabilizing element 302 and a connection thereof to block 40. Reference is also directed to Figure 38 which is related functionally to Figures 42, 43, and 44. Referring to Figure 42, there is depicted a block 40 with a stabilizing element 302 comprised of first and second parallel arms 304 and 305 which are formed from a continuous reinforcing bar to thereby define an end loop 306 which fits over a formed rib 308 defined between the connected counterbores 70 and 72. This is analogous to the construction depicted in Figure 38. The parallel arms or bars 304 and 305 are connected one to the other by cross members 307 and 303 which are connected to the arms 304 and 305 at an angle to thereby define a truss type construction. The ends of the arms 304 and 305 may be connected by a transverse, perpendicular cross member or cross brace 310.

Referring to Figure 43, there is illustrated yet another alternative construction wherein a stabilizing element 312 is again comprised of parallel arms 314 and 316 which form a symmetrical closed loop construction including an end 318 having a generally V shape as depicted in Figure 43 cooperative with a rib 320 defined in the block 40. Note that the cross members 322 are at an angle to define a truss type configuration. Further note that the V-shaped end 318 includes an opposite end

counterpart 328 so that the entire stabilizing element 312 is generally symmetrical. It may or may not be symmetrical, depending upon desires.

Figure 44 illustrates a variation on the theme of Figure 43 wherein a stabilizing element 324 is comprised of arms 326 and 327 which cooperate with reinforcing bars 46 positioned in block 40 in the manner previously described. Crossing members 329 are again configured to define a generally truss shaped pattern analogous to the construction shown in Figures 42 and 43. Thus it can be seen that the construction of the stabilizing element may be varied significantly while still providing a rather rigid stabilizing element cooperative with blocks 40 and corner blocks as previously described.

Figures 45 and 46 illustrate an alternative to the cap block construction previously described. In Figure 45, the bottom plan view of the cap block has substantially the same configuration as a face block 40. Thus cap block 340 includes counterbores 70 and 72 which are designed to be cooperative with stabilizing elements in the manner previously described. The passageways through the cap block 340, however, do not pass entirely through the block. Thus, as illustrated in Figure 46, the cap block 340 includes counterbores 72 and 70 as previously described. A passageway for the reinforcing bars 46; namely, passage 342 and 344 extends only partially through the block 340. Similarly, the passage 346 extends only partially through the cap block 340. In this manner, the cap block 340 will define a cap that does not have any openings at the top thereof. The cap block 340 as depicted in Figures 45 and 46 may, when in a position on the top of the wall, have gaps between the sides of the blocks because of their tapered shape. Thus it may be appropriate and desirable to mold or cast the cap blocks in a rectangular, parallelpiped configuration as illustrated in dotted lines in Figure 45. Alternatively, the space between the blocks 340 forming the cap may be filled with mortar or earthen fill or other fill.

Alternative Wall Constructions

Referring next to Figure 47, there is depicted a further alternative embodiment of the invention. In this embodiment, facing blocks 400 include a front face 402 converging side walls 404 and 406 and a back face 408. The front face 402 may be textured, etc. in the manner previously described. A series of counterbores 410, 411 and 412 are arranged in parallel array and extend from adjacent the front face 402 and project through the back face 408. The counterbores 410, 411 and 412 are parallel and are defined in a bottom surface 414 in Figure 48 or a top surface 416 in Figure 48. The counterbores 410, 411 and 412 are interconnected by a cross counterbore 418 which is generally perpendicular to the counterbores 410, 411 and 412 and which is positioned adjacent to and parallel to the front face 402. Vertical throughbores 420 and 422 are defined through the block 400 and extend into the cross counterbore 418.

In a wall construction, a series of the blocks 400 are arrayed in horizontal layers. The blocks 400, thus, define courses which are arranged in horizontal layers with one row upon the other. The blocks 400 preferably overlap one another. That is, vertically adjacent blocks 400 overlap one another. The throughbores 420 and 422 are preferably arranged in the modular array previously disclosed. That is, the spacing of the throughbores 420 and 422 is equal to one half the width dimension of the front face 402. The throughbores 420 and 422 are set inwardly from the vertical side edges of the front face 402 one quarter of the width dimension of the front face between the side edges. In this manner, the throughbores 420 and 422 can serve as passages for receipt of connector pins or rods 424 as shown in Figure 48 to connect the facing blocks 400 which are vertically adjacent and over lapping one another.

Coacting with the array of facing blocks 400 is a continuous wire mesh or wire sheath comprised of tension arms or tension members 428 which extend Generally from adjacent the front face 402 into compacted soil 429 behind the back face 408. Cross members 430 interconnect the tension members 428. An outside cross member 432 connects the tension arms or tension members 428 and fits within the cross counterbore 418. Cross member 432 extends along the length of that counterbore of adjacent facing blocks 400. In this manner, the facing blocks 400 are generally interconnected by means of a rigid cross member 432. Typically, the cross member 432 will be welded to the tension members 428 as depicted in Figure 48.

Alternatively, as depicted in Figure 48, the end 436 of the tension arms 428 may be formed as a loop which is retained in the cross counterbore 418. A cross bar 438 will then fit through the end loop 436 and serve to retain the tension rods 428 in the block 400. Note that in Figure 48 there is depicted the positioning of the counterbore 410 vertically upward as well as vertically downward. Either orientation may be utilized when building a wall utilizing the components of the present invention.

Figure 49 illustrates another variation of the invention. Referring to the top plan view in Figure 49, a facing block 450 includes a front face 452, a back face 454, side walls 456 and 458, and parallel counterbores 460, 462 and 464 extending from adjacent front face 452 through the back face 454. Cross counterbore 466 extends between the sidewalls 456 and 458. As a result of this configuration of counterbores 460, 462, 464 and 466, defined in either the top or bottom parallel face of block 450, there is provided a series of channels which are adapted to receive a grid wire comprised of grid tension members 468 and cross members 470. This particular construction is useful for building lower gravity type walls inasmuch as there is no specific vertical interconnection of the facing blocks 450.

Figure 50 illustrates, in cross sectional view, the position of the wire grid in the channels defined by the counterbores 460 and 466 of block 450. Figure 51 illustrates an alternative construction for the wire grid. Ten-

sion members 472 are provided. A loop 474 is formed at the end of the tension members 472, and a cross bar 476 is fitted through that loop. The construction fits into the counterbores 460 and 466 in a matter similar to that depicted in Figures 49 and 50.

Figures 52, 53, 54 and 55 illustrate another variation of the wall construction utilizing horizontal rows of facing blocks 550 which are offset inwardly one with respect to the other. As depicted in Figure 52, blocks 550 include a lower depending lip 552 adjacent to the back face or wall 553 of the block 550. The blocks 550 also include a first set of vertical throughbores 554 and a second set of vertical throughbores 555 behind the first set 554. As shown in Figure 53, the throughbores 554 and 555 are arranged in position within counterbores 556 and are arranged one behind the other between the front wall 551 and the back wall 553. As in any of the blocks which are described herein, a throughbore or core 558 may be provided to reduce the weight of the block.

In any event, the lip 552 associated with the blocks 550 necessitates offsetting the horizontal rows of blocks 550 as the horizontal courses are laid one upon the other. The offset associated with the lip 552 equals to the offset of the centers of the vertical throughbores 554 and 555. In this manner, vertical pins or rods 562 may be inserted through the first throughbore 554 of a block 550 and downwardly into the second throughbore 555 of the next lower block 550. This will lock the blocks 550 together and also hold a horizontal stabilizing element, such as element 564, in position. The stabilizing element 564 is similar to that depicted in Figure 14, for example, although numerous types of stabilizing elements as described herein may be utilized in combination with the block 550.

As illustrated in Figure 54, blocks 570 may be provided with counterbores 572 and cross counterbores 574 for cooperation with a wire mesh mat 576 in a fashion similar to that previously described with respect to Figures 47 and 49. Again note that the facing block 570 includes a depending lip or rib 577 for block offset and may also include a center throughbore opening 580 to reduce block weight. Also, note that the side walls 579, 581 of the block 570 are converging to permit formation of various kinds of curves although such convergence is an optional feature of the block 570.

Figures 56 and 57 depict a variation of a facing block construction wherein facing blocks 590 are provided with lips 592 along the front edge thereof to effect horizontal offset. The blocks 590 are otherwise configured to include counterbores 594 and cross counterbores 596 for cooperation with mats, such as mats 598 or 600, in the manner described herein.

Figures 58 and 59 illustrate yet another variation of a wall block and wall construction. Here, standard dry cast concrete block 480 of the type having a generally flat front wall 482, a back wall 484, and side walls 486, 488 are cast in the form of rectangular parallelpiped having a top surface 490 and throughbores 492 and 494. A wire mesh comprised of tension members 496 and cross members 498 is held in position on the face 490 of the block 480 by means of vertical reinforcing bars 500. The reinforcing bars 500 may be extended through vertically adjacent blocks 480 inasmuch as the throughbores 492, 494 of such blocks 480 will overlap one another. The reinforcing bars 500 may be typical steel reinforcing rods. Fill material may be used such as sand or gravel. Alternatively, concrete or mortar may be inserted into the throughbores 492 and 494. The bars 500 capture or retain the cross bars 498. The adjacent horizontal rows of blocks 480 are typically separated by a mortar joint so as to provide spacing for receipt of members 496.

Side elevation, Figure 59, illustrates various alternative constructions for connection of the wire grid to the blocks 480. The upper part of Figure 59 has the construction described and depicted by Figure 58. Alternatively tension members 496 have loop ends 504. The loop ends 504 coact with cross bars 505. As another alternative, a stabilizing element 506 in Figure 59 is depicted in greater detail in Figure 60 and is actually the same as the stabilizing element depicted in Figure 14. In other words, numerous types of stabilizing elements may be used in combination with the block 480 arrangement depicted in Figures 58 and 59 including an arrangement as depicted in Figure 60 wherein the block 480 cooperates with the stabilizing element 506 and vertical reinforcing bars 500 which are imbedded preferably in concrete which fills the throughbores such as throughbore 492 in the block 480.

Reference is next directed to Figures 61, 62, 63 and 64 wherein the concepts of the invention are incorporated with and combined with a cast in place counterfort. Thus, referring to these figures, there is depicted a wall in Figure 61 having a series of facing blocks 620 which are arrayed in horizontal layers one over the other with the blocks being offset with respect to each other. The blocks 620 may be any one of the particular constructions heretofore described. The block described and depicted in Figure 2, for example, may be used along with stabilizing members 622 of the type depicted in Figure 14. The stabilizing member 622 includes tension arms 624 and 626 which are positioned within counterbores in the manner previously described to cooperate with vertical pin members again in the manner previously described. As shown in Figure 61, the stabilizing members 622 may be used to connect the horizontally adjacent blocks 620 or may be connected to one of such blocks 620. The stabilizing members 622 include a connecting cross member 628 which is positioned some distance from the back of the blocks 622.

To construct a counterfort, a series of the stabilizing elements 622 are arrayed vertically one over the other in the manner depicted in Figure 62. The entire assembly is preferably positioned on a precast footing 630 having reinforcing bars 632 projecting from the footing 630 upwardly and retained between the loops or bars forming the stabilizing elements 622. It should be noted that, with respect to the counterfort construction of Figures 61 through 64, the vertical reinforcing members 632 which

extend upwardly into the cast in place counterfort member are preferably included and are preferably connected with the cast in place footing 630.

A concrete form such as the form 634 depicted in Figures 63 and 64 is fitted over the stabilizing elements 622 and against the back side of facing blocks 620. Form 634 includes a back wall 631, side walls 633, 635 and block engaging ends 637, 639. A cast in place counterfort 638 is then cast. The form 634 may have the width of a single facing block 620 to provide a counterfort 633, or the width of more than one block 620. Inasmuch as the facing blocks 620 overlap one another in vertically adjacent rows, the form 634 of Figure 63 will, in fact, engage with and interact with single and adjacent facing blocks 620 at different vertical elevations of the counterfort 638.

Additionally, it should be noted that the facing block 620 may interact with and be utilized with all of the various types of stabilizing and anchor elements heretofore described. For example, a ladder reinforcing element 640 may include tension rods 642 and cross members 644 which extend laterally beyond the generally parallel tension rods 642. The stabilizing member may also be, as depicted in Figure 61, a member 650 which includes a single tension arm 652 having cross members 654 attached thereto.

Still another form of stabilizing element used in combination with blocks 620 is depicted in Figure 61. Specifically, one or more concrete blocks 658 are connected, end to end, to the back side of a facing block 620. Metal clips or other fasteners 660 connect the blocks 658 together as depicted.

Thus, there are numerous variations of the construction. The invention, therefore, has many variations and is only to be limited by the following claims and equivalents.

Claims

1. A wall construction comprising a facing assembled from a plurality of facing elements (40;80;116;340;480;550), compacted particulate material (48;202;305) behind the facing, and a plurality of stabilizing elements (42;44;280;300;302;312;324;506) extending rearwardly into the particulate material to stabilize said material, each stabilizing element comprising first and second tensile portions (140,142;162,164;260,262;281,283;304,305;314,316;326,327) and being formed at a forward end thereof into at least-one substantially horizontal loop (144,146;170,172;282;306;318) which engages a retaining portion (46;308;320) of a respective facing element, thereby forming a connection between the stabilizing element and the facing element, characterised in that the first and second tensile portions are laterally spaced apart from each other by a cross member (152;166;307;322;329) disposed in the particulate material, the stabilizing element extending rearwardly from the cross member into the particulate material.

2. A wall construction as claimed in claim 1, wherein each of the first and second tensile portions is formed into a substantially horizontal loop (144,146;170,172), and wherein a pair of laterally spaced vertical pins (46) project from a pair of laterally spaced bores (62,64;94,100;554,555) in the facing element, each pin being engaged by a respective horizontal loop.

3. A wall construction as claimed in claim 2, wherein the pins (46) engage in a pair of laterally spaced bores (62,64;94,100;554,555) in a vertically adjacent facing element.

4. A wall construction as claimed in claim 2 or 3, wherein each bore (62,64;100;554,555) is vertical and has a horizontal cross-sectional shape which is elongate in the lateral direction of the facing.

5. A wall construction as claimed in claim 2, 3 or 4, wherein one bore (555) is arranged behind another bore (554).

6. A wall construction as claimed in claim 1, wherein the first and second tensile portions are each part of a continuous member which forms the substantially horizontal loop (282;306;318).

7. A wall construction as claimed in claim 6, wherein the loop (318) formed by the continuous member is generally V-shaped.

8. A wall construction as claimed in any preceding claim, wherein the stabilizing elements have a plurality of longitudinally spaced cross members (154,156;303,310;322,328;329).

9. A wall construction as claimed in claim 8, wherein the cross members (154,156) are perpendicular to the longitudinal direction.

10. A wall construction as claimed in any of claims 2 to 5, wherein a separate tensile member (180;270) is attached to the cross member (166;264) to extend rearwardly therefrom.

11. A wall construction as claimed in claim 10, wherein the separate tensile member is a flexible tensile member (180) wrapped over the cross member.

12. A wall construction as claimed in claim 10, wherein the separate tensile member is a metal strip (270).

13. A wall construction as claimed in any preceding claim, wherein the first and second tensile members are parallel.

14. A wall construction as claimed in any preceding claim, wherein the facing elements (40;340;550) comprise facing block members arranged in overlapping courses one upon the other, each block member having a front face (50), side faces (54,56), a back face (52) and generally parallel top and bottom surfaces (58,60), and each block member having a pair of laterally spaced counterbores (70,72;556) in the top or bottom surface each extending through the back face to define channels in which the first and second tensile portions are received.

15. A wall construction as claimed in claim 14, wherein the block members (40) are narrower at the back than at the front.

16. A stabilizing element (42,44;280;300;302;312;324;506) for use in combination with a facing element (40;80;110;340;480,550) of a mechanically stabilized earthen work, the stabilizing element comprising first and second tensile portions (140,142;162,164;260,262;281,283;304,305;314, 316;326,327) and being formed at a forward end thereof into at least one substantially horizontal loop (144,146;170,172;282;306;318) for engaging a retaining portion (46;308;320) of the facing element to connect the stabilizing element and the facing element, characterised in that the first and second tensile portions are laterally spaced apart from each other by a cross member (152;166;307;322;329) rearwardly spaced from the loop so as to be disposed, in use, in the earth of the earthen work, the stabilizing element extending rearwardly from the cross member.

17. A stabilizing element as claimed in claim 16, further comprising the stabilizing element features mentioned in any of claims 2 or 6 to 13.

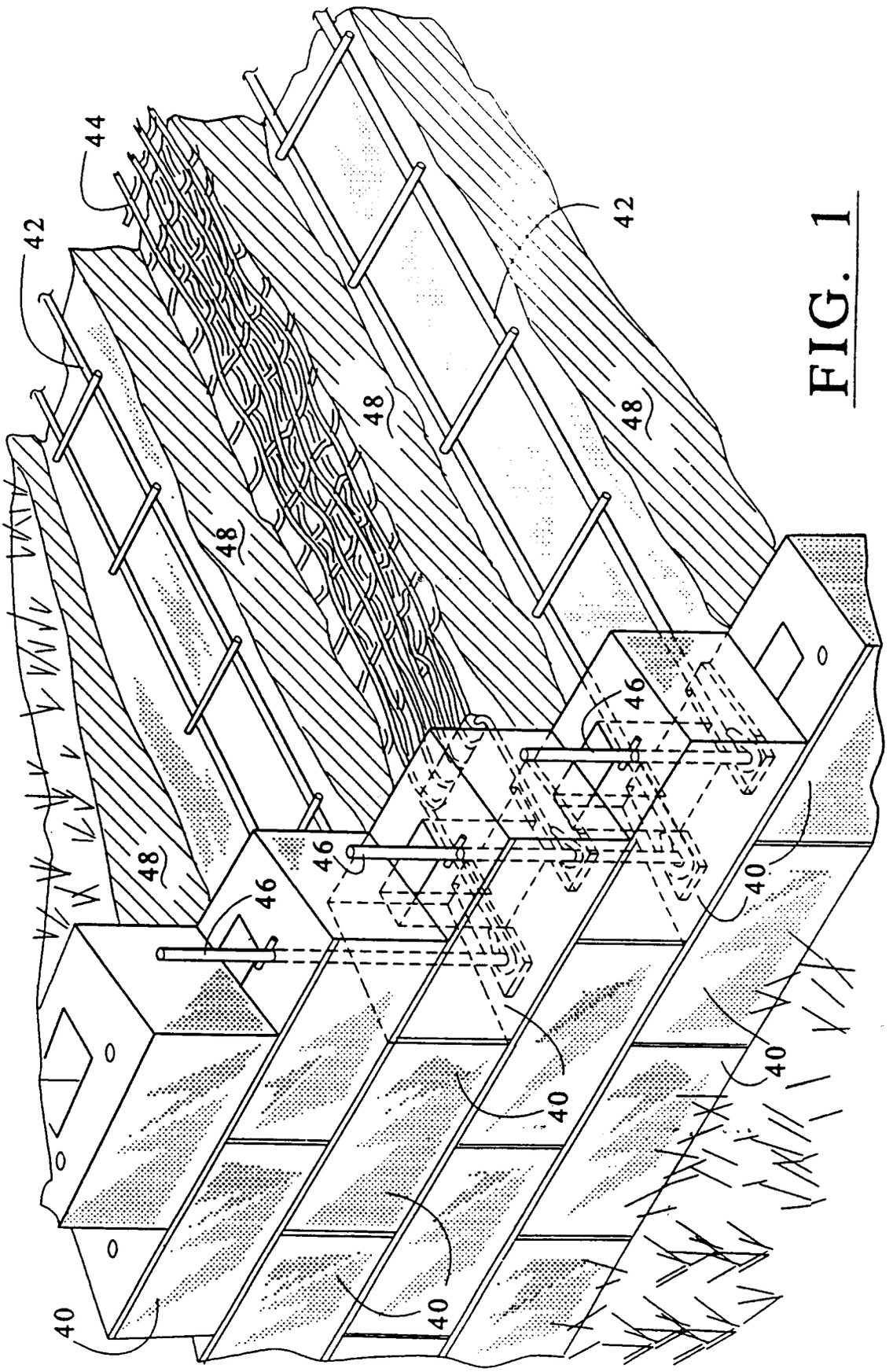


FIG. 1

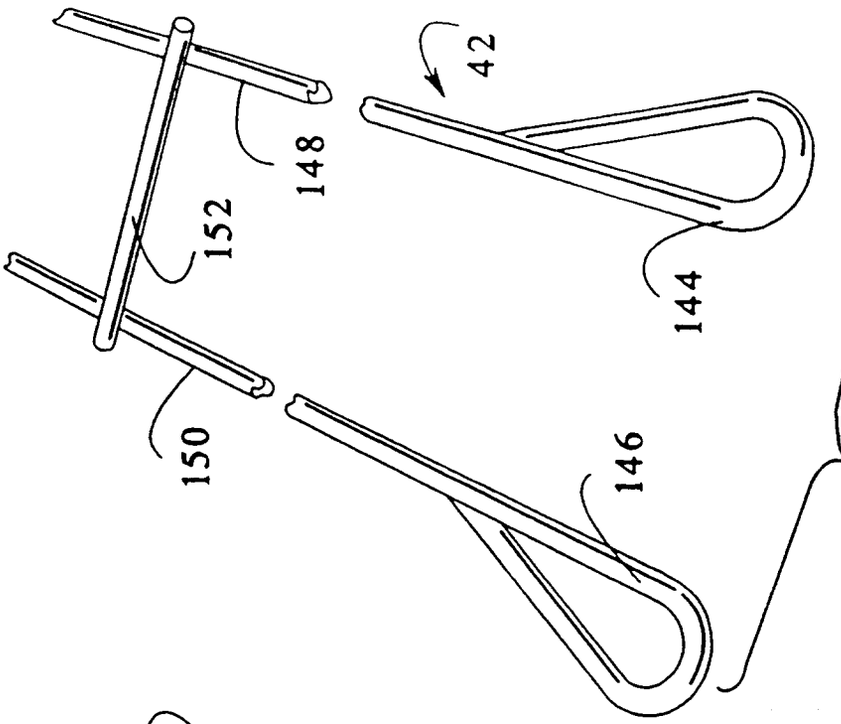


FIG. 3

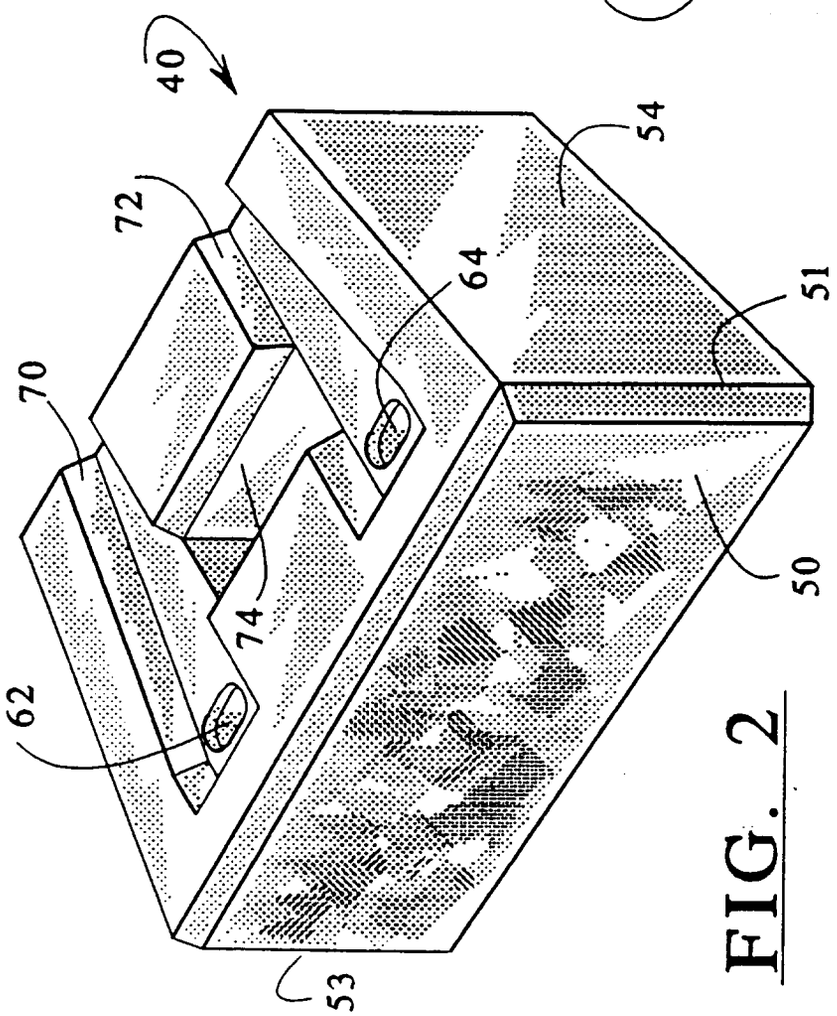


FIG. 2

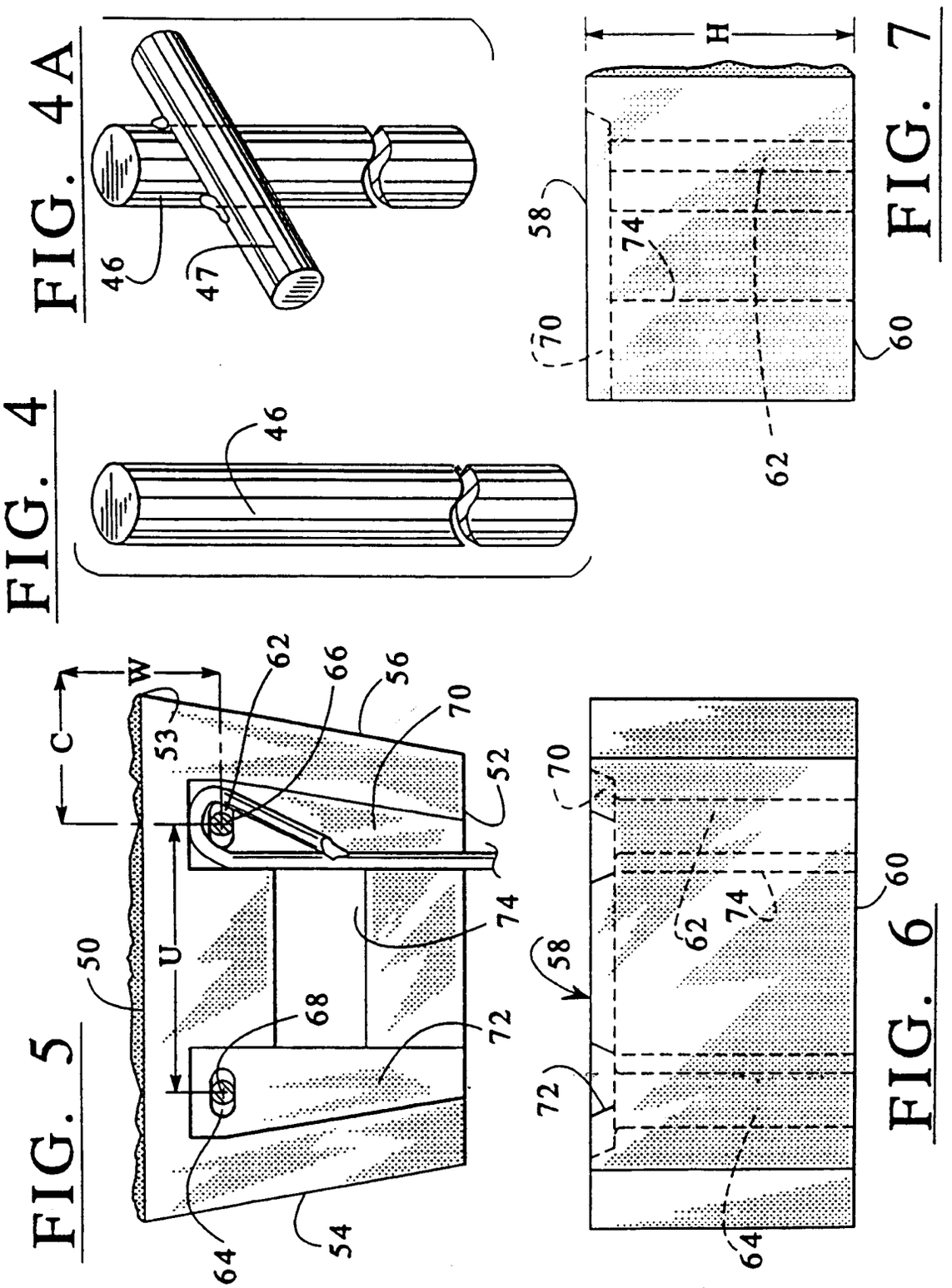

FIG. 4A
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FIG. 4
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FIG. 7
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FIG. 5
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FIG. 6
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FIG. 10

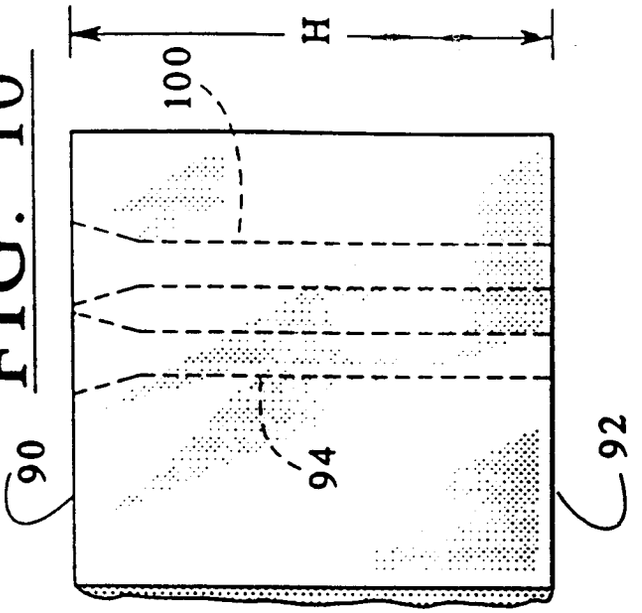


FIG. 8

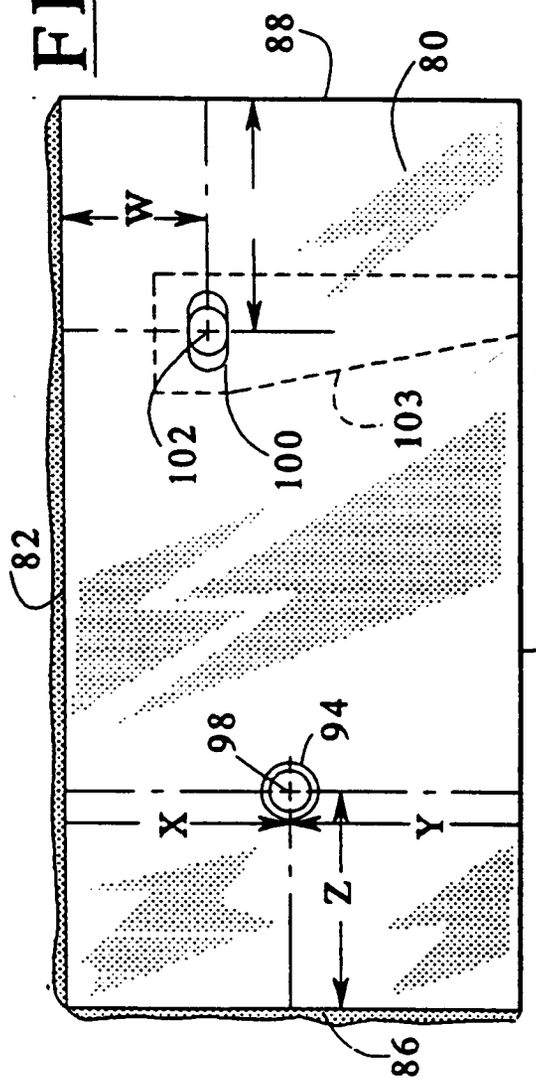


FIG. 9

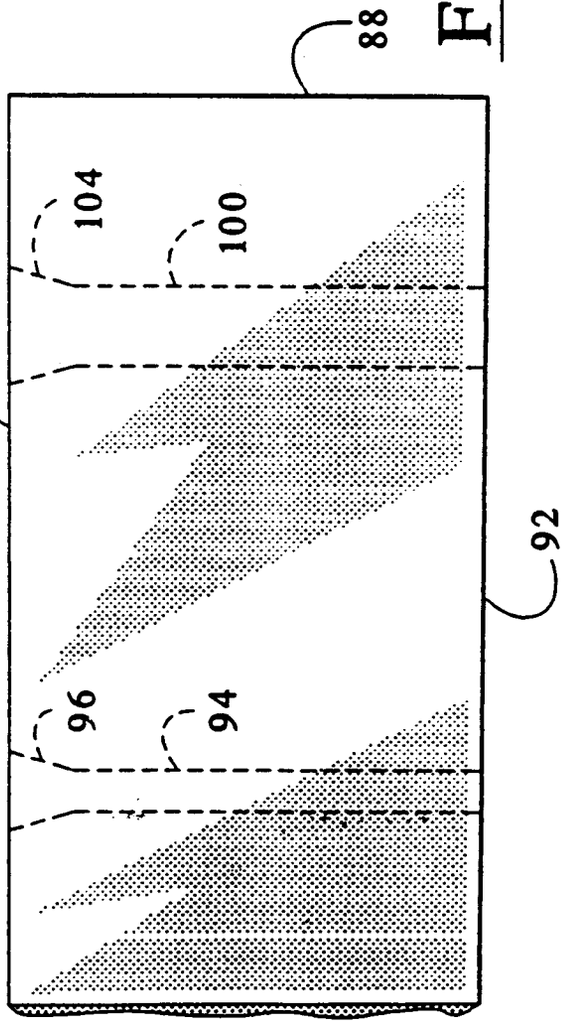


FIG. 13

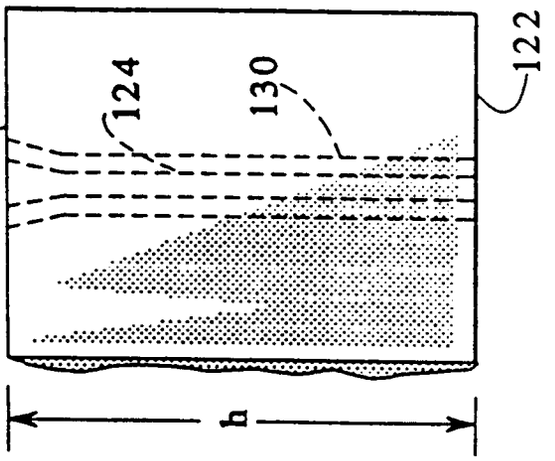


FIG. 11

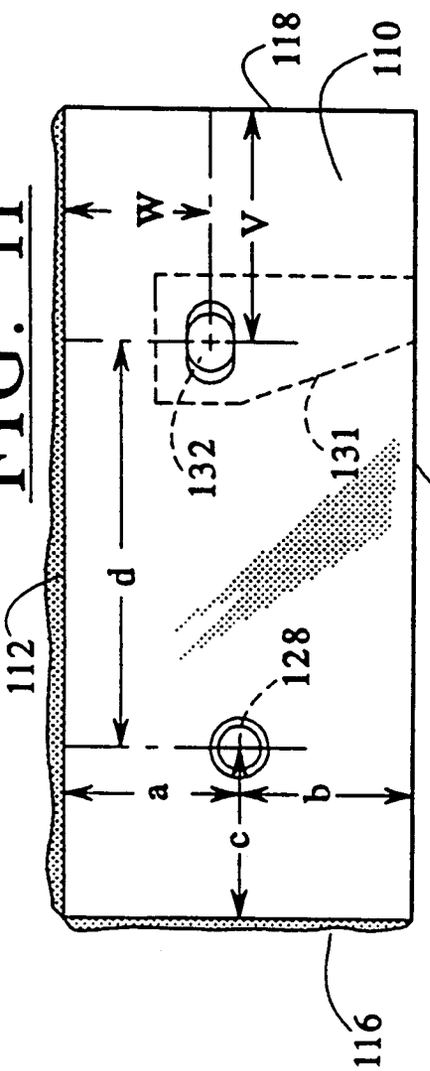


FIG. 12

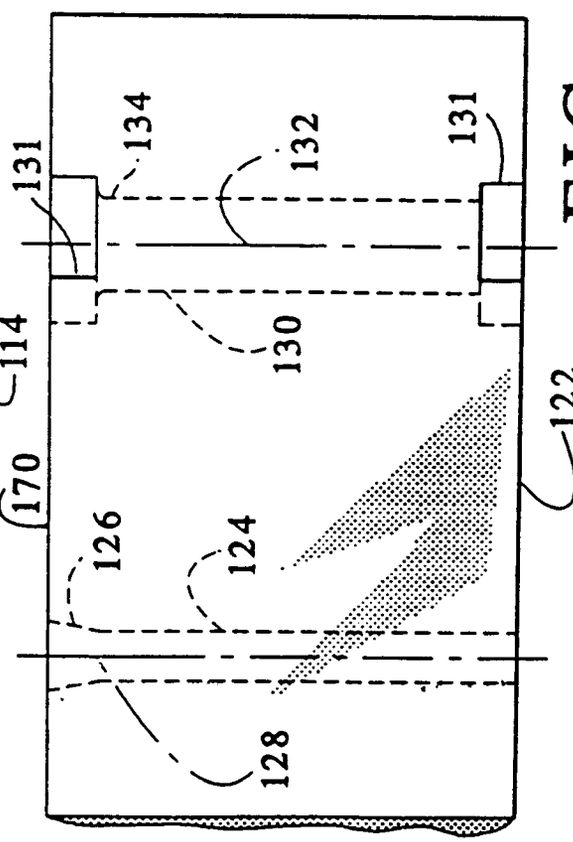


FIG. 15

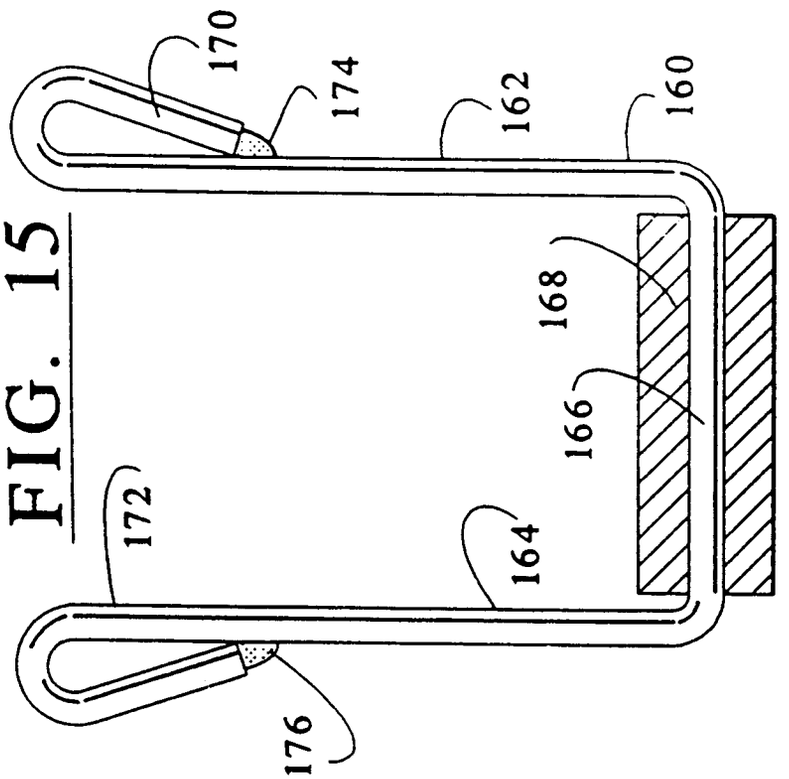


FIG. 15A

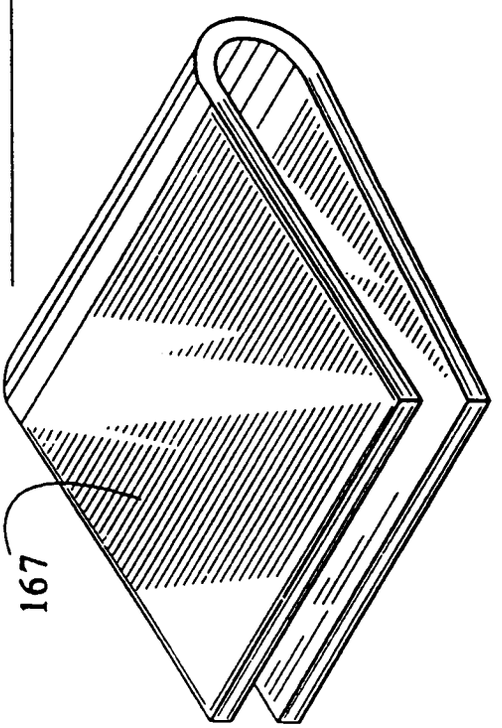
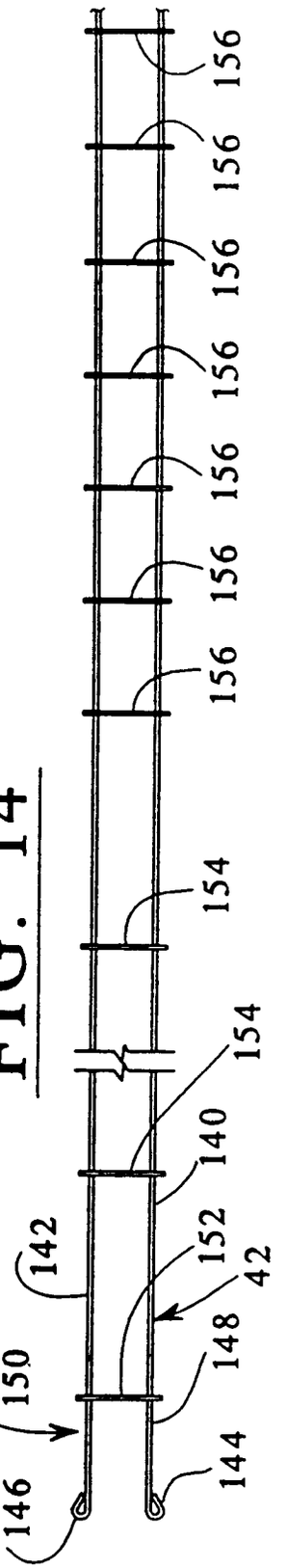


FIG. 14



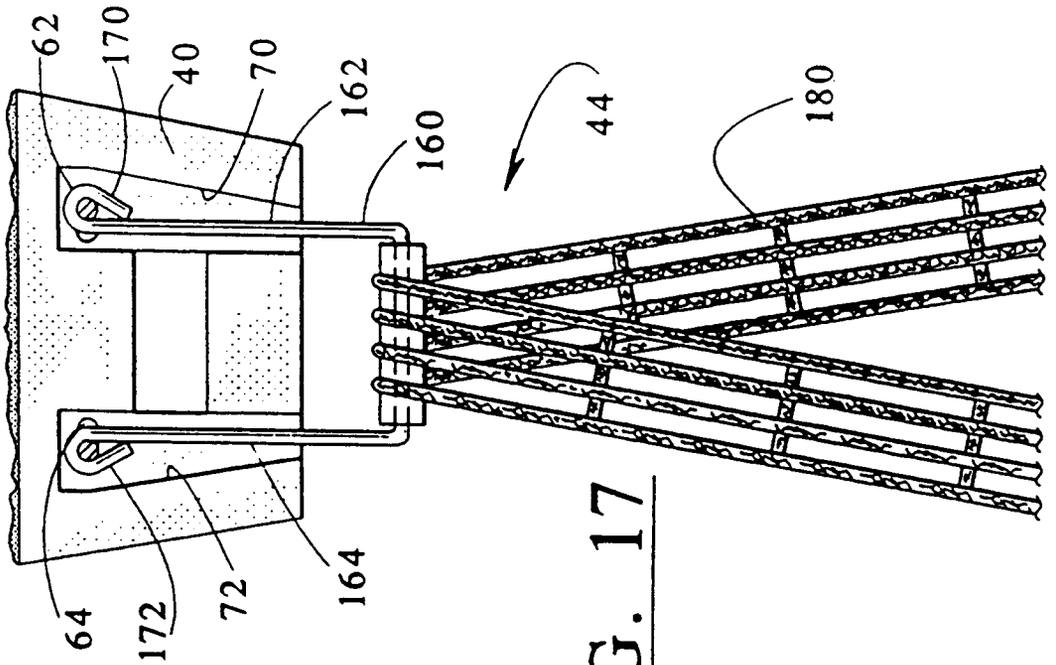

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FIG. 17

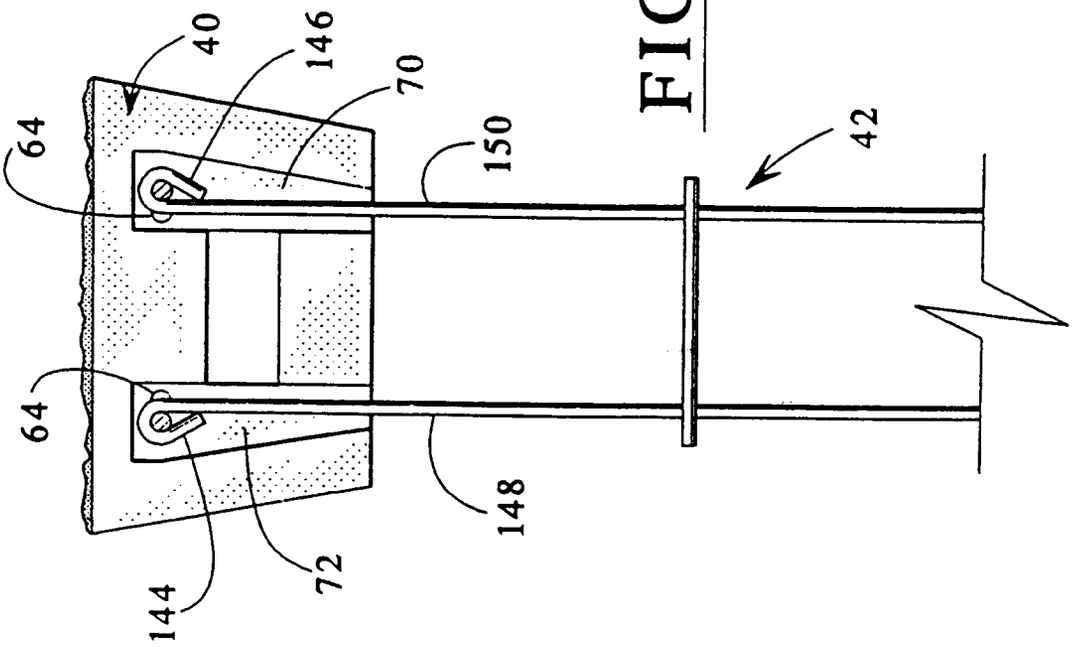

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FIG. 16

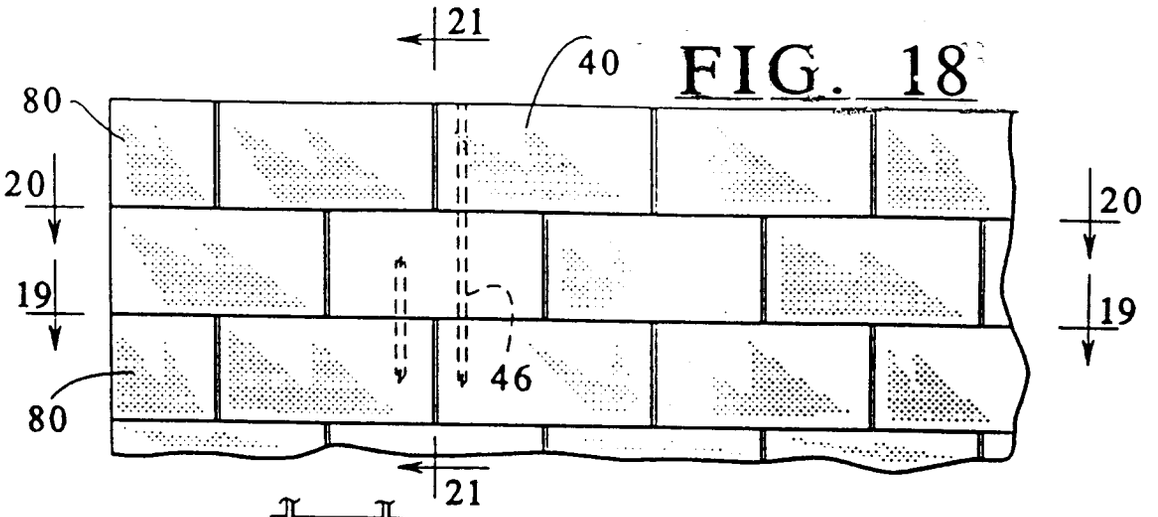


FIG. 18

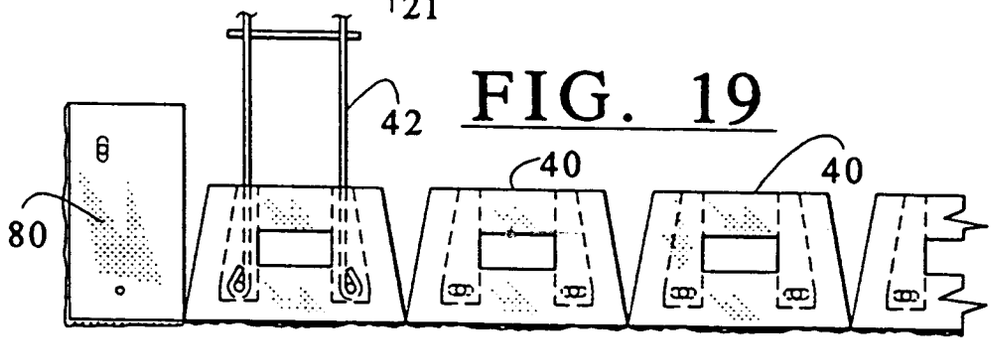


FIG. 19

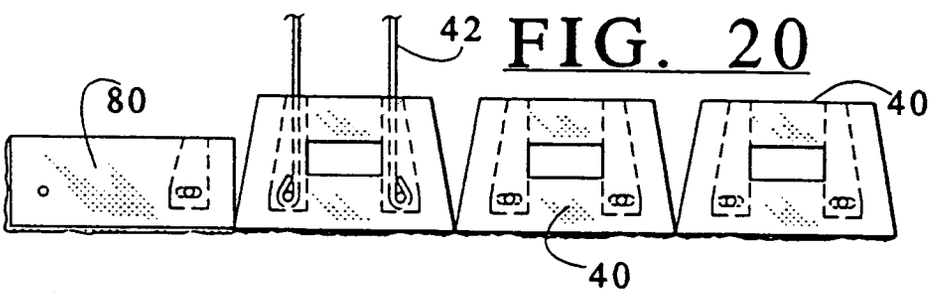


FIG. 20

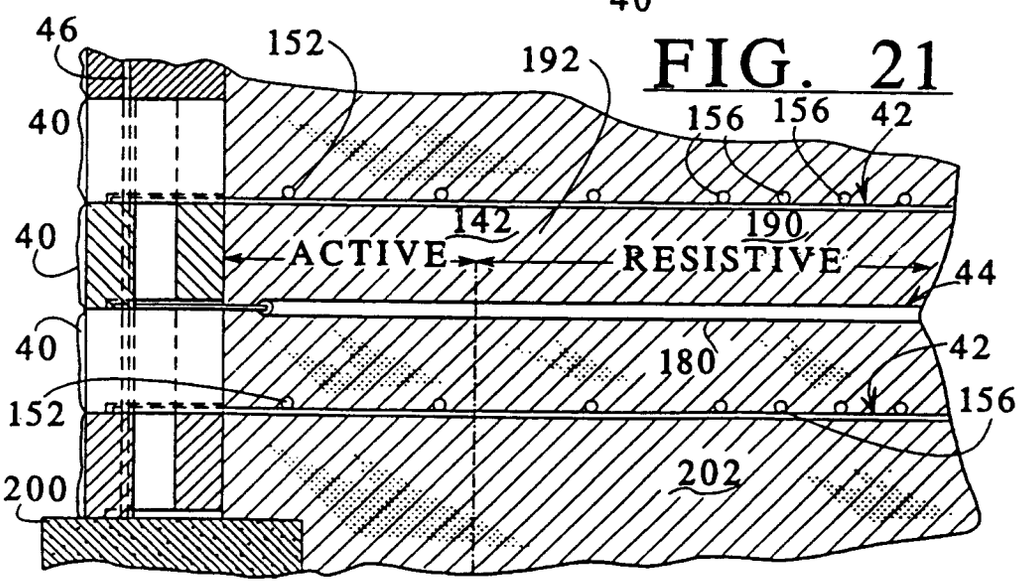


FIG. 21

FIG. 23

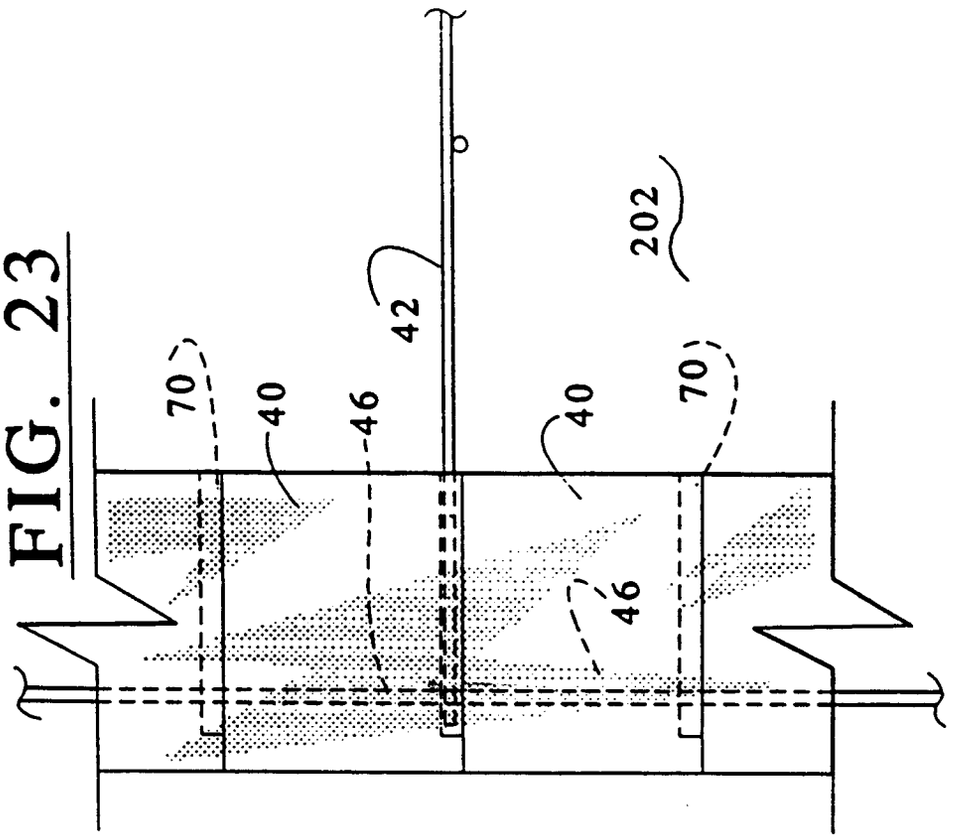


FIG. 22

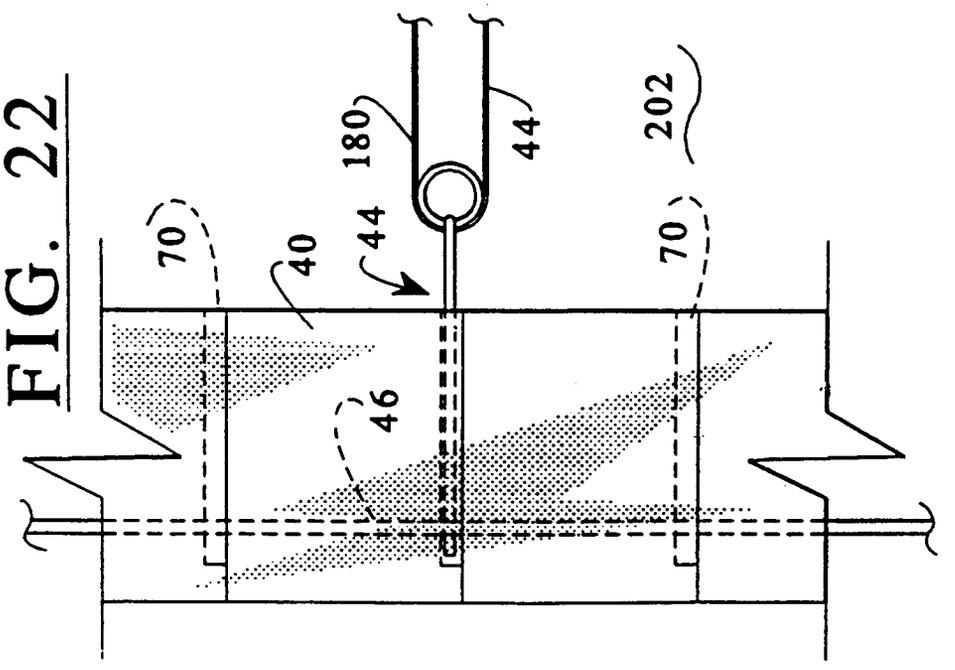
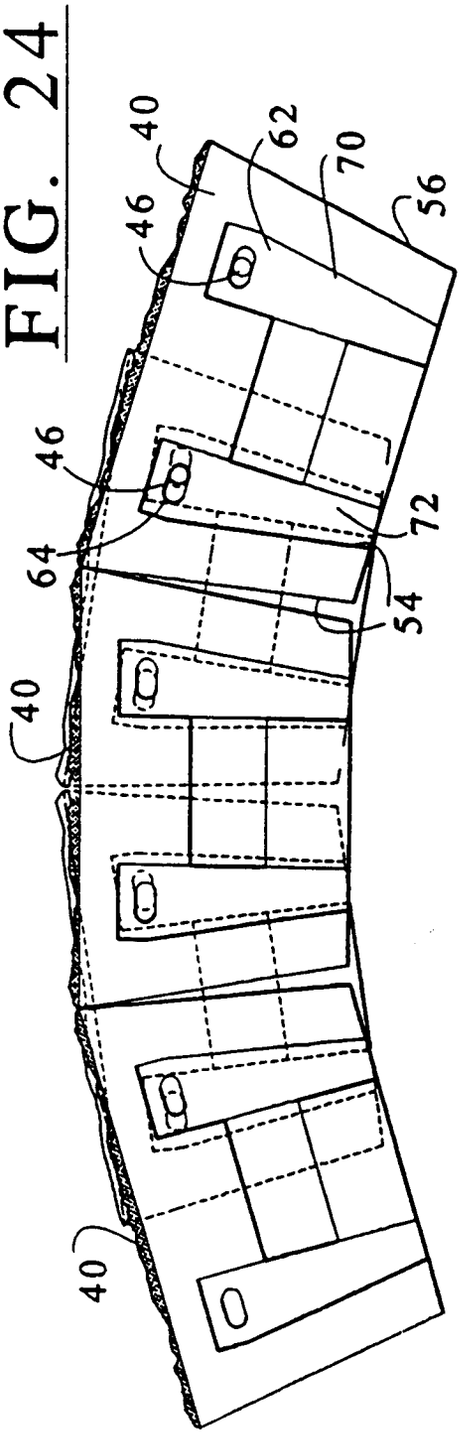


FIG. 24



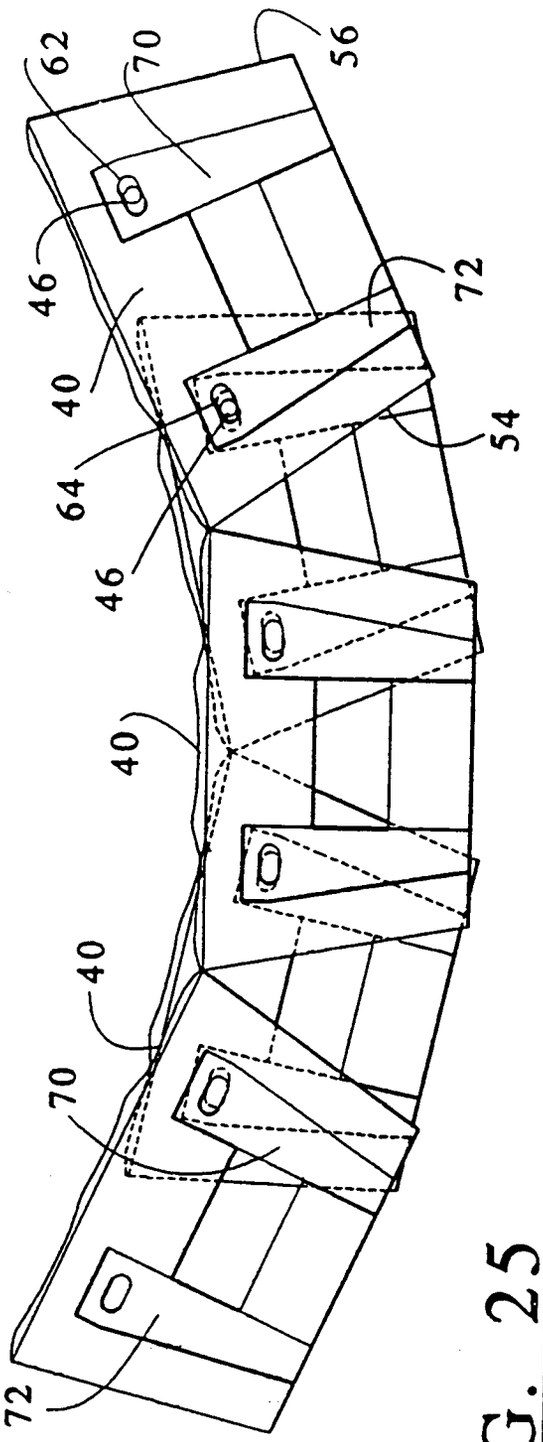


FIG. 25

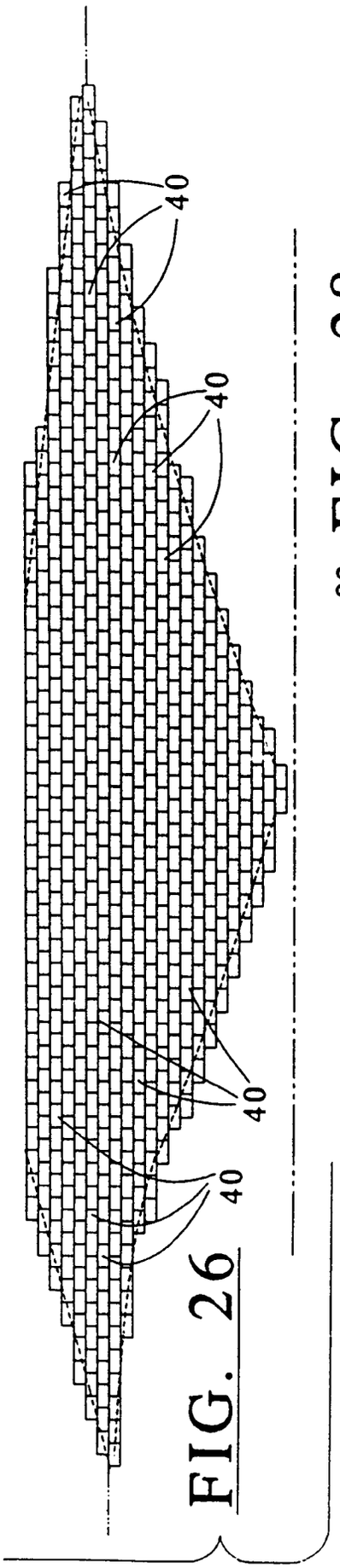


FIG. 26

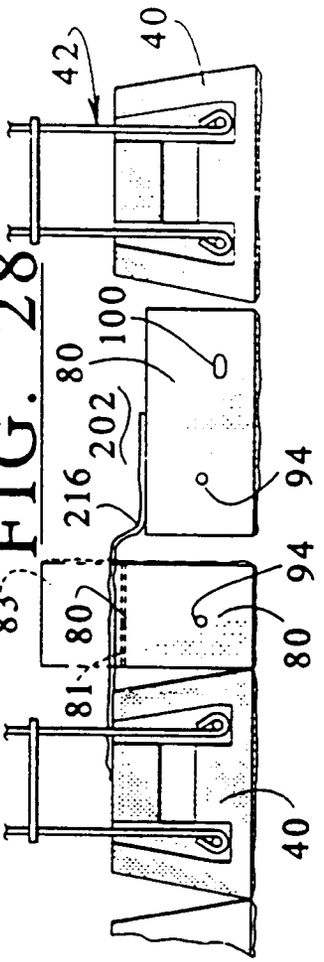


FIG. 28

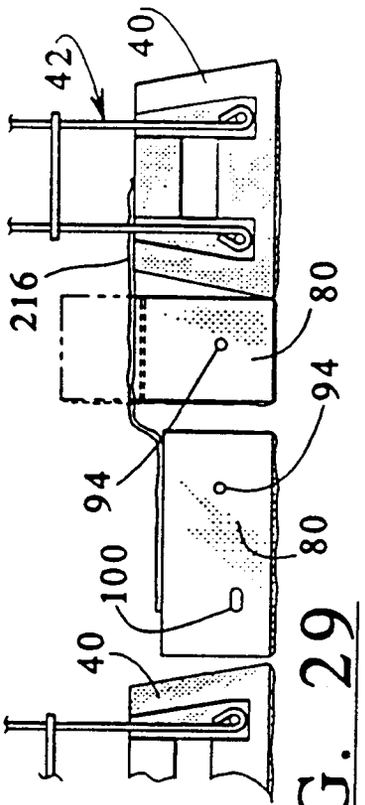


FIG. 29

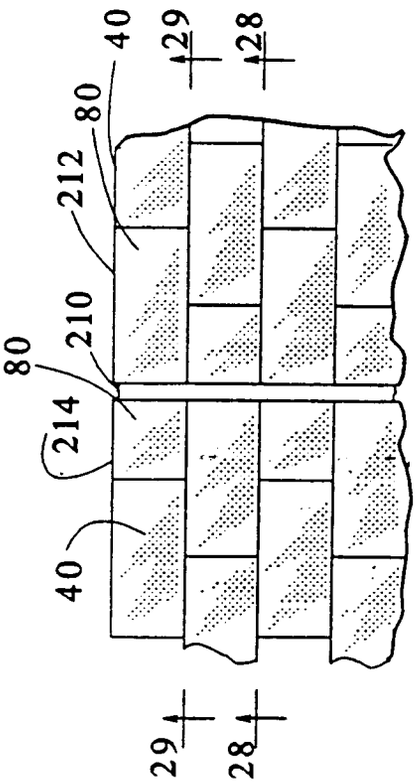


FIG. 27

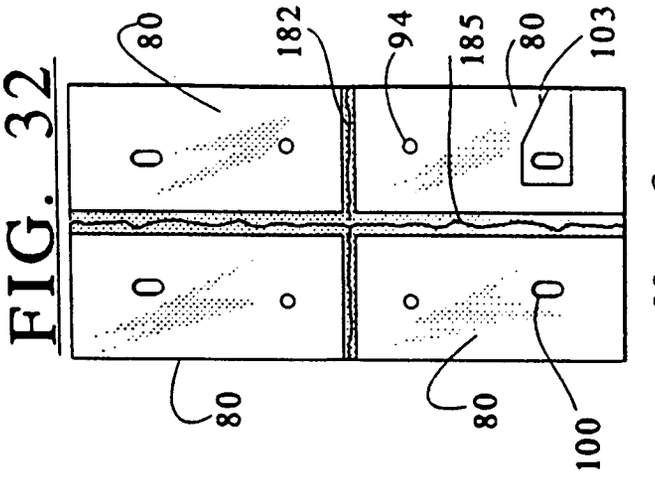


FIG. 32

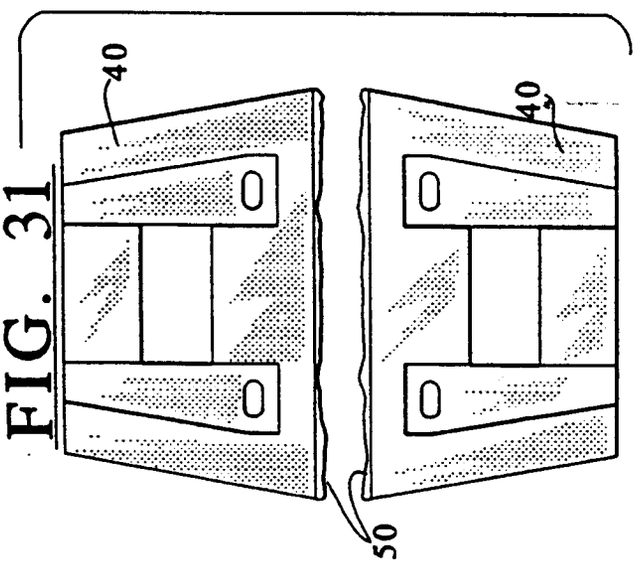


FIG. 31

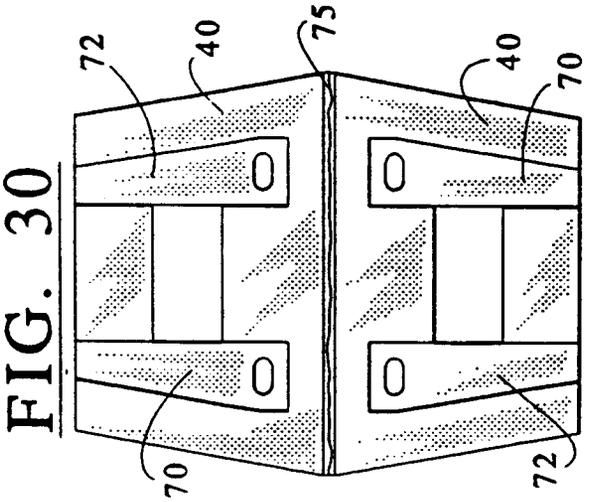


FIG. 30

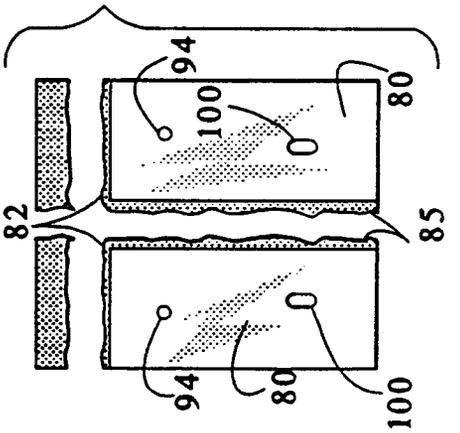


FIG. 35

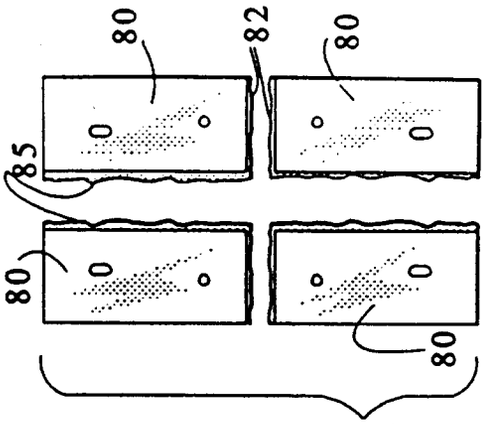


FIG. 33

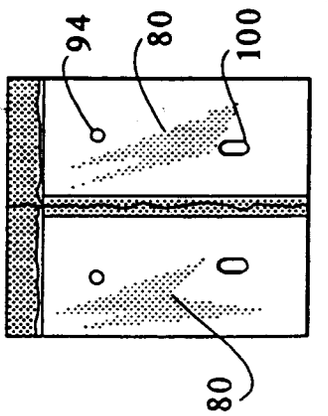
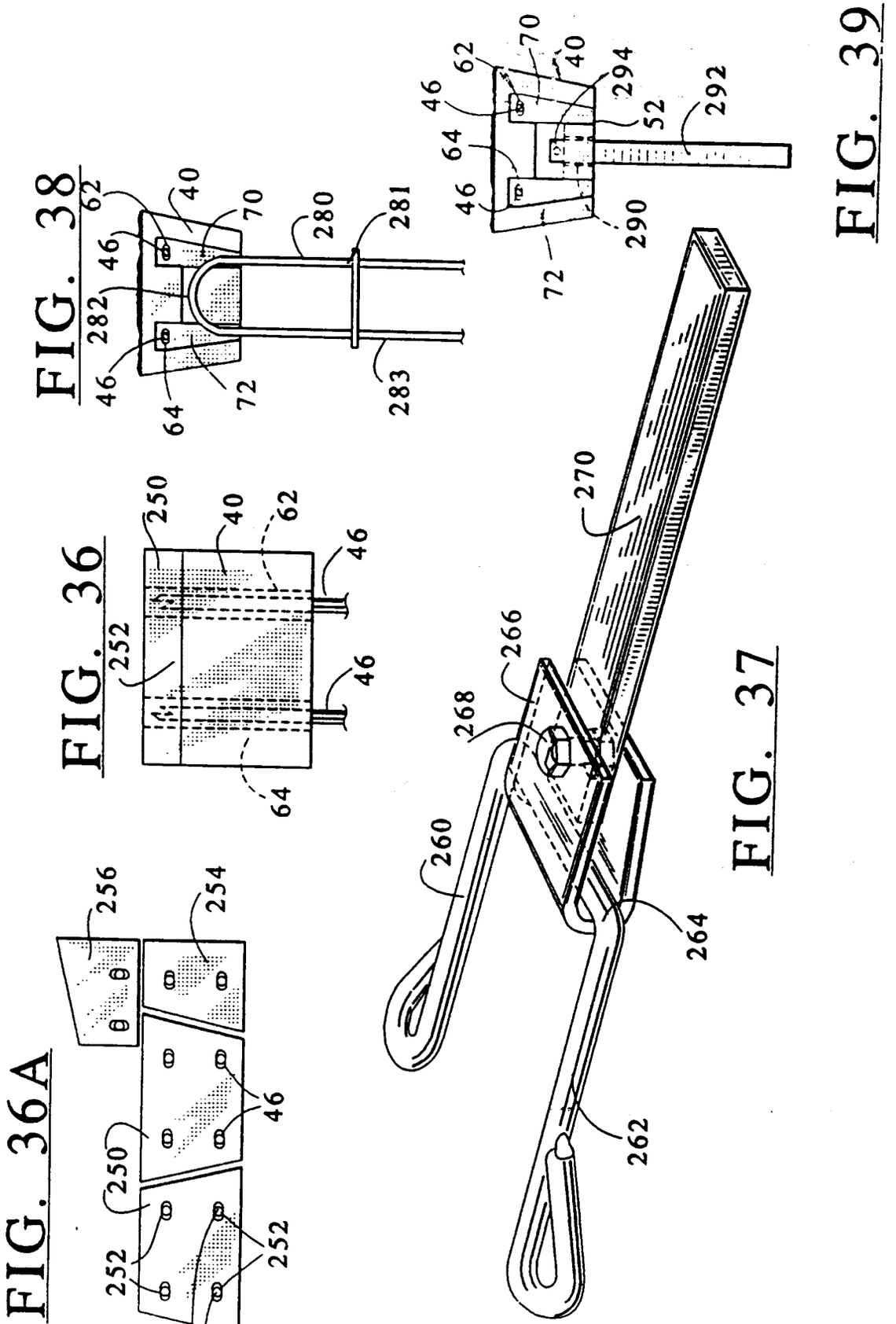


FIG. 34


FIG. 36A
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FIG. 36
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FIG. 39
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FIG. 37
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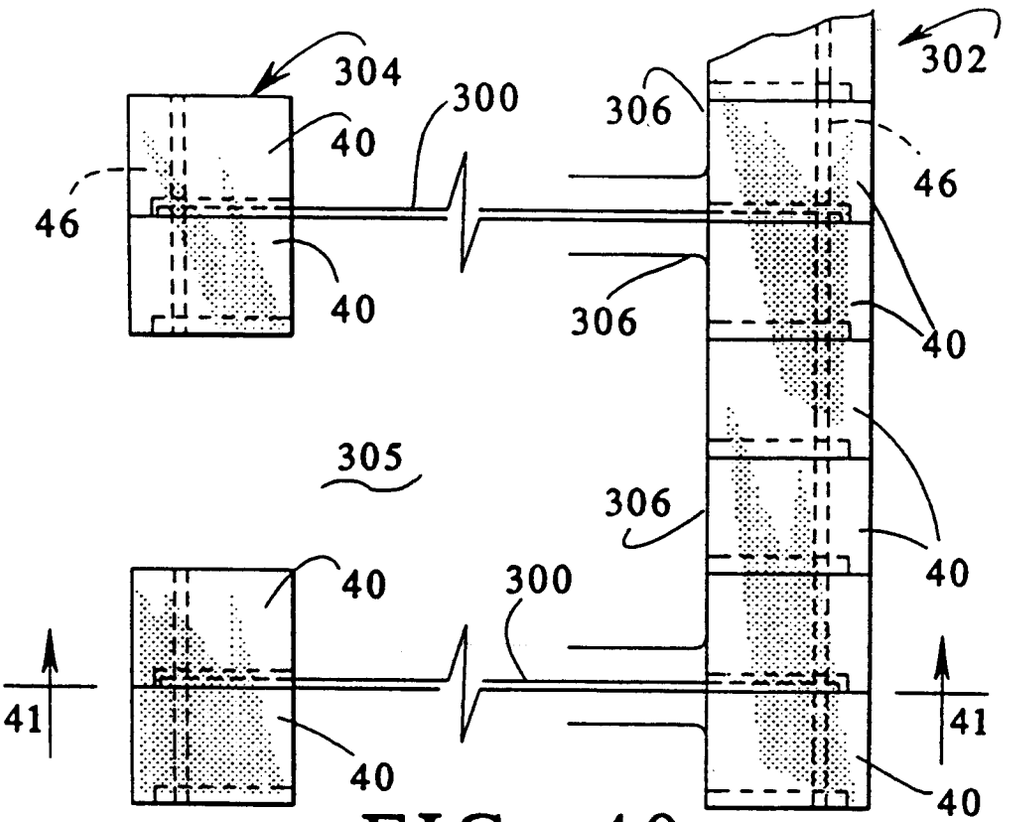
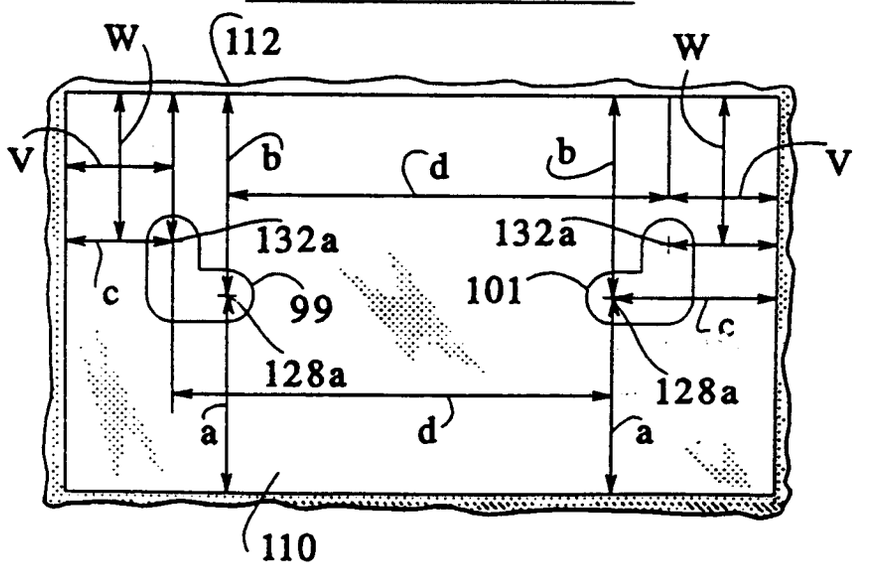


FIG. 40

FIG. 13A



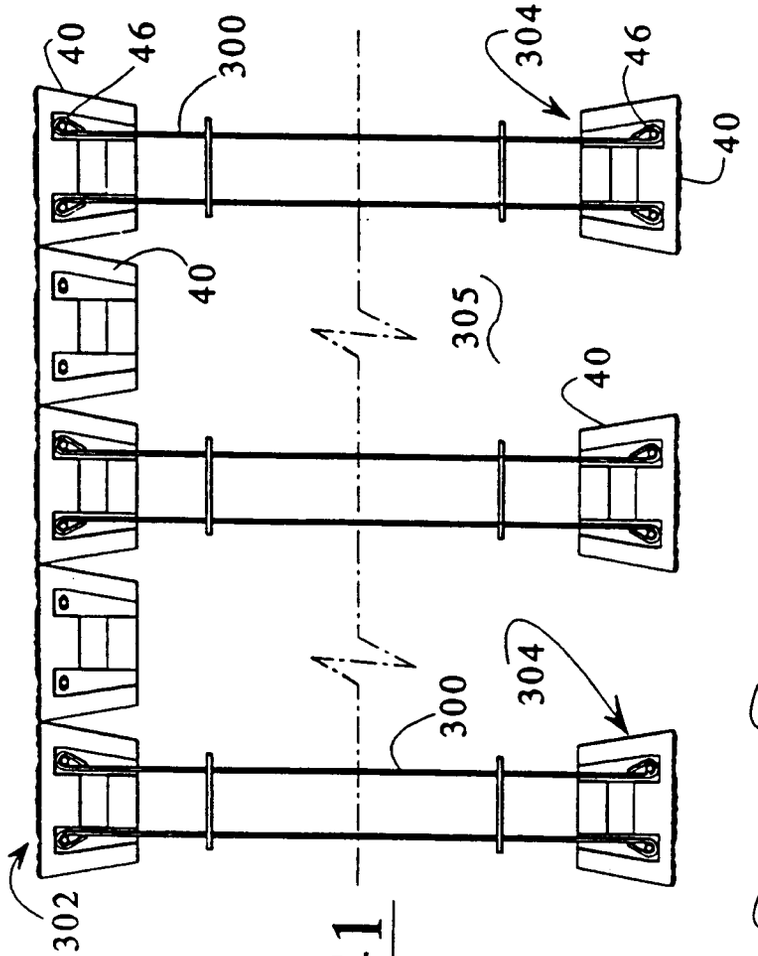


FIG. 41

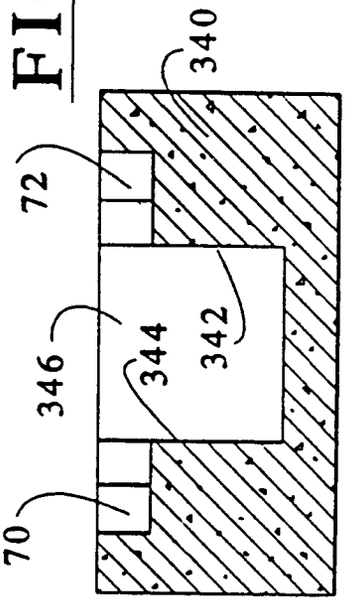


FIG. 46

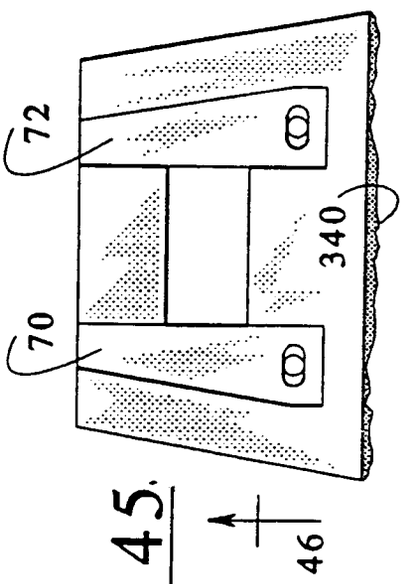


FIG. 45

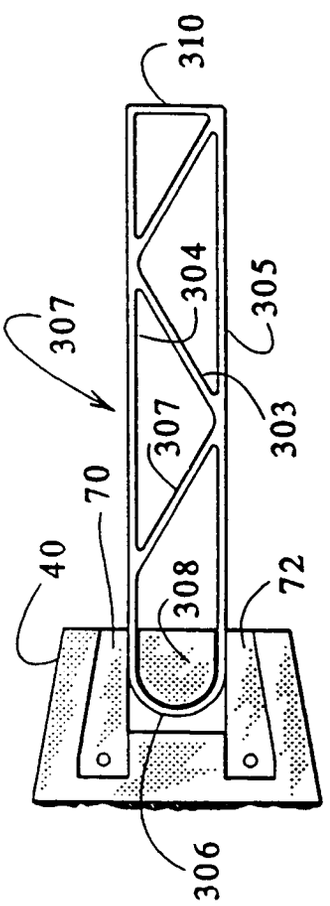


FIG. 42

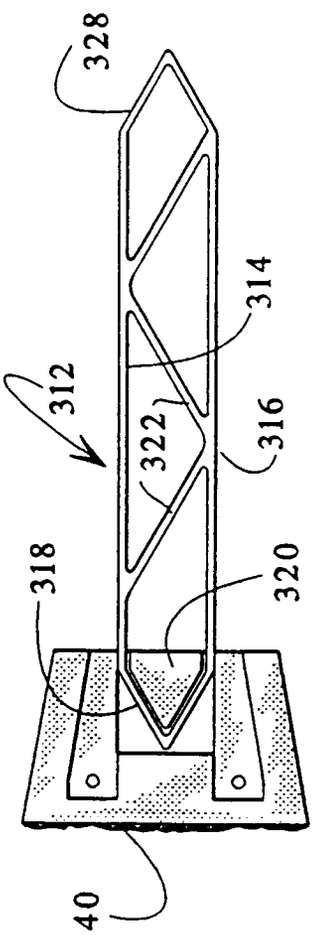


FIG. 43

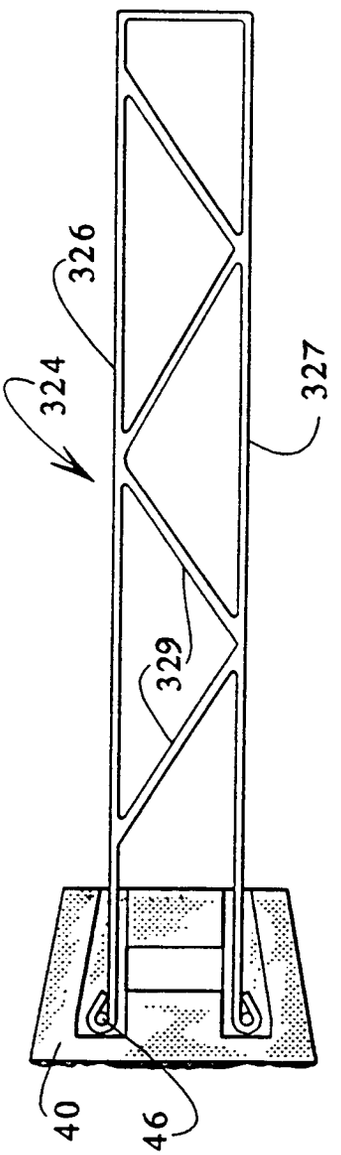
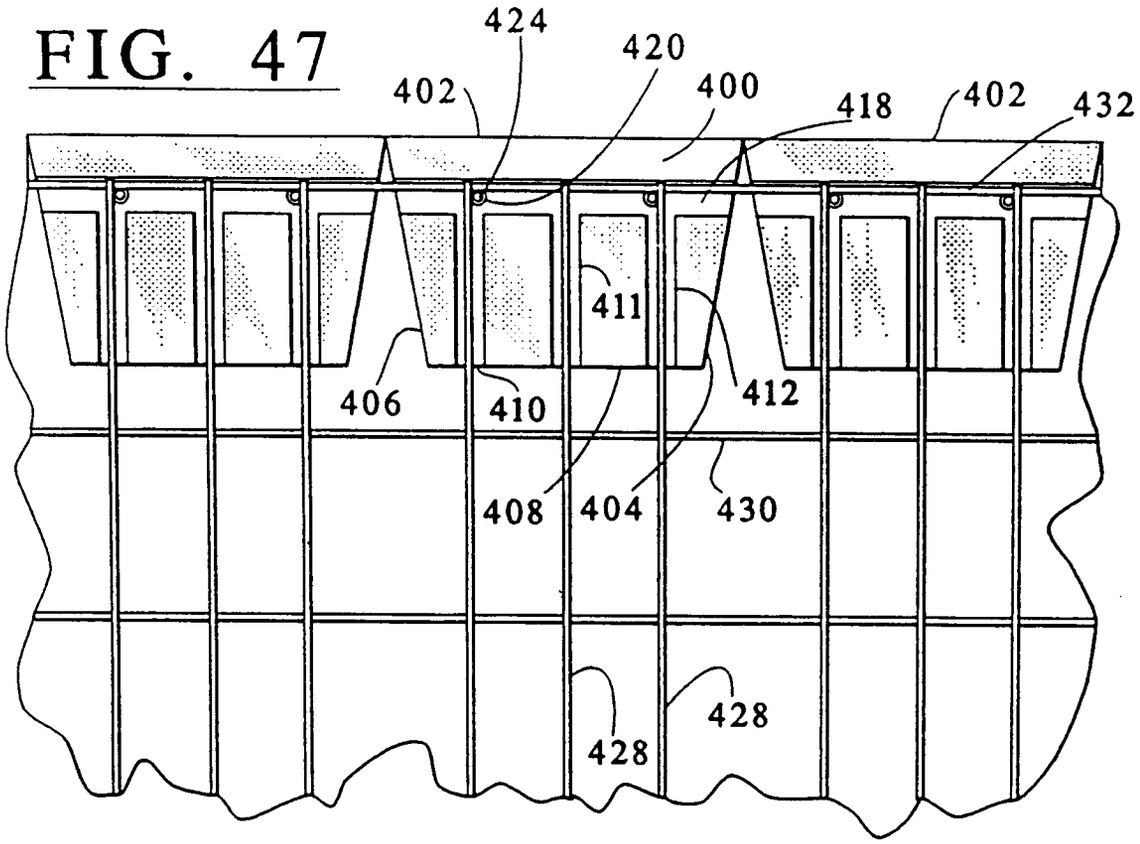


FIG. 44

FIG. 47


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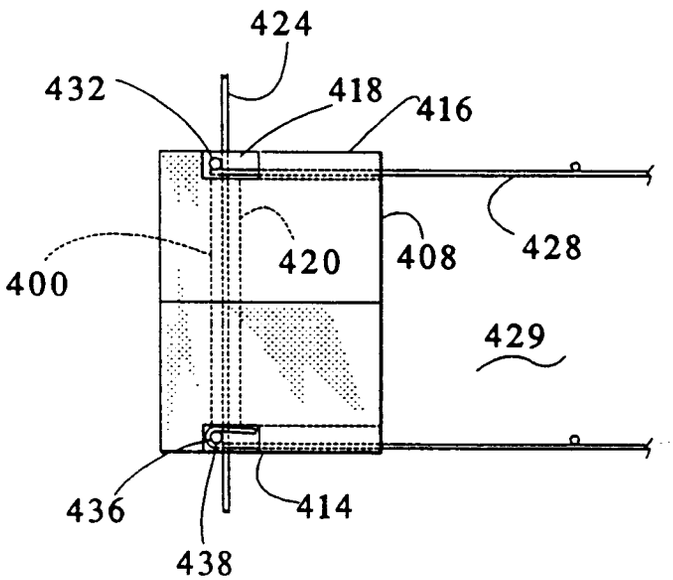

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FIG. 48

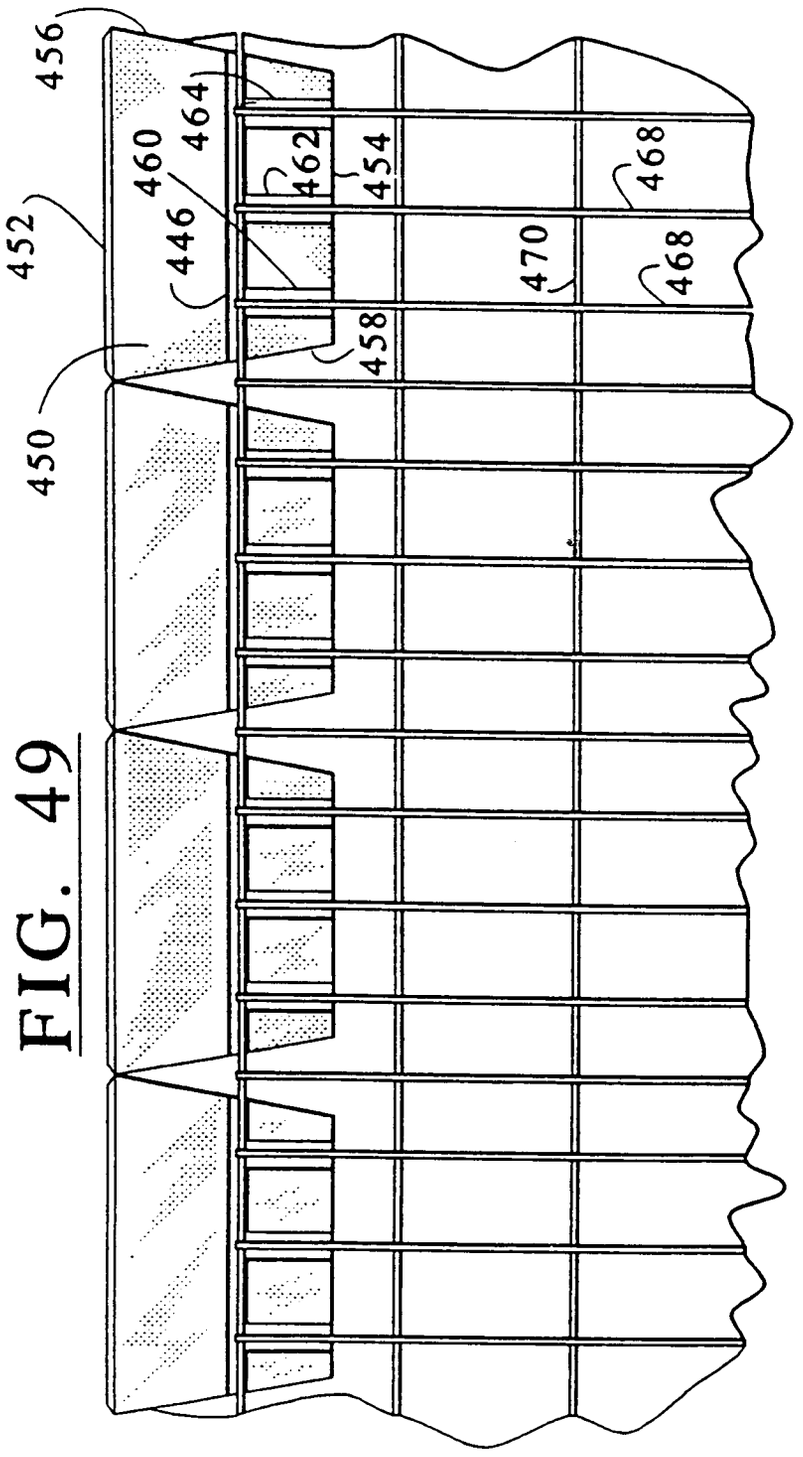


FIG. 49

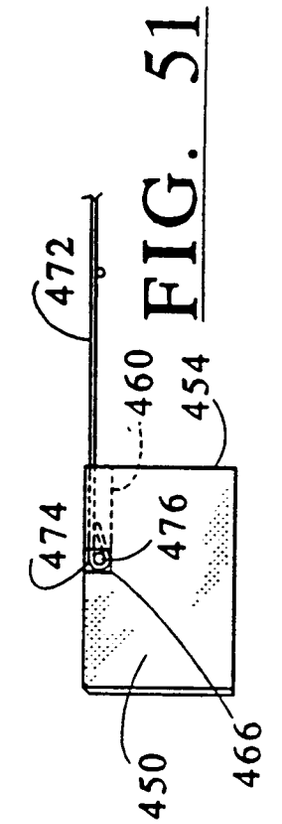


FIG. 51

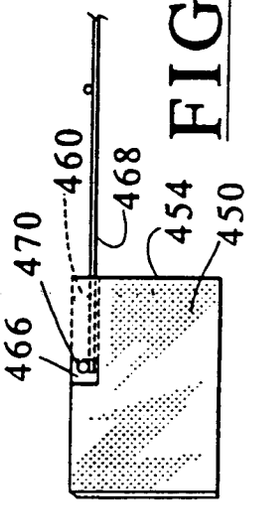


FIG. 50

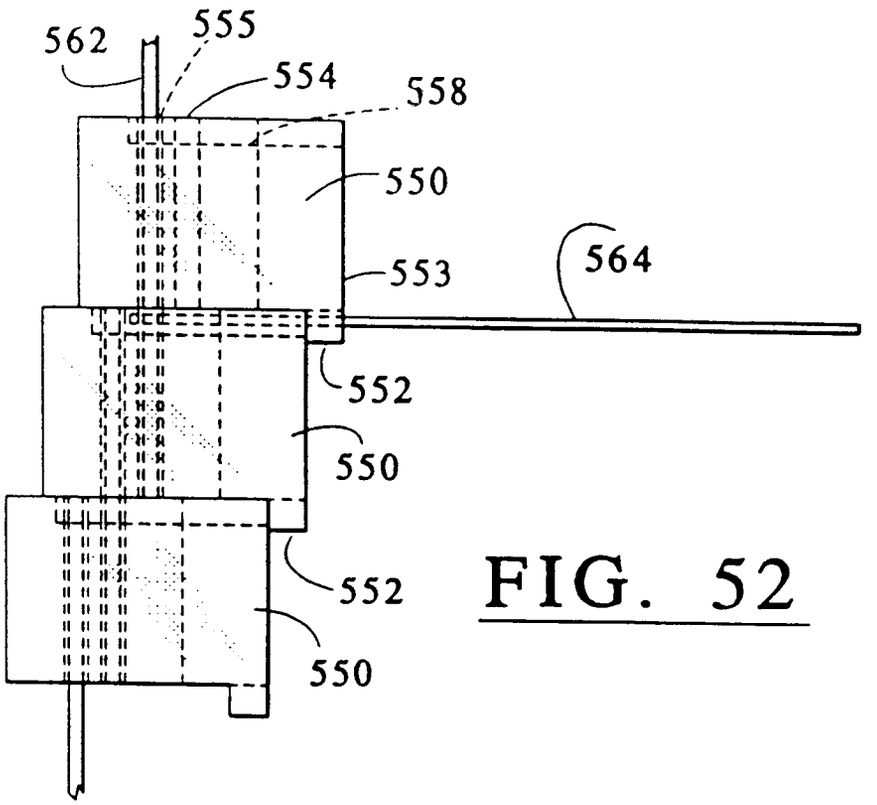
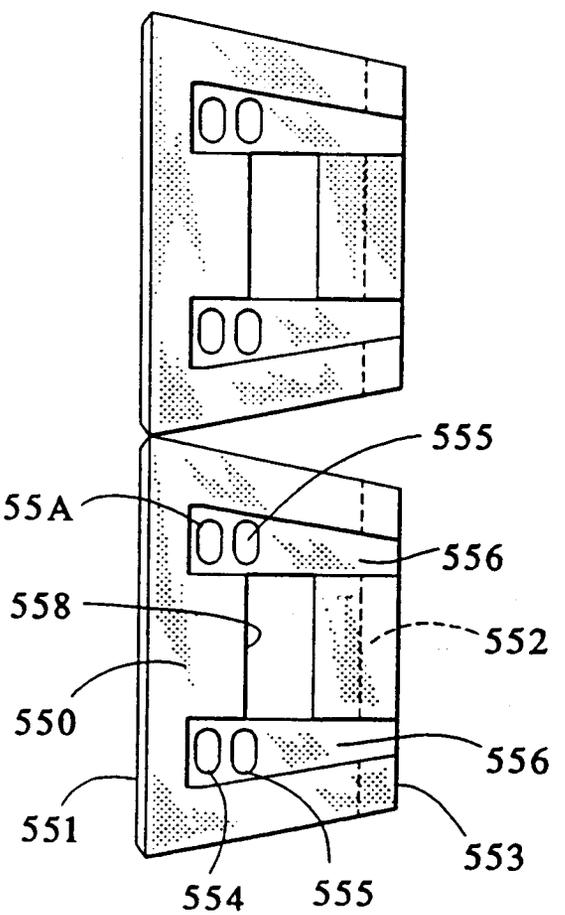

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FIG. 52

FIG. 53


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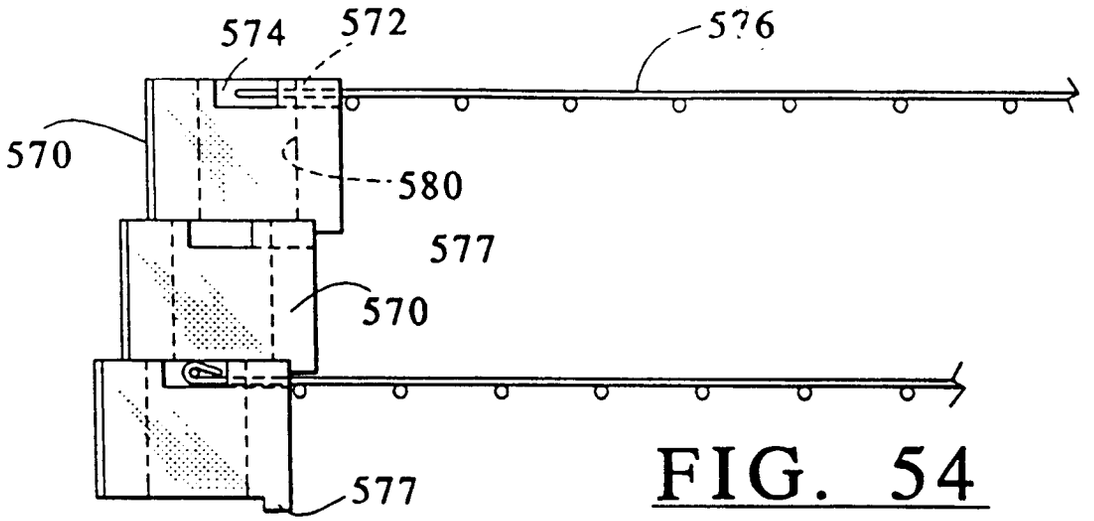


FIG. 54

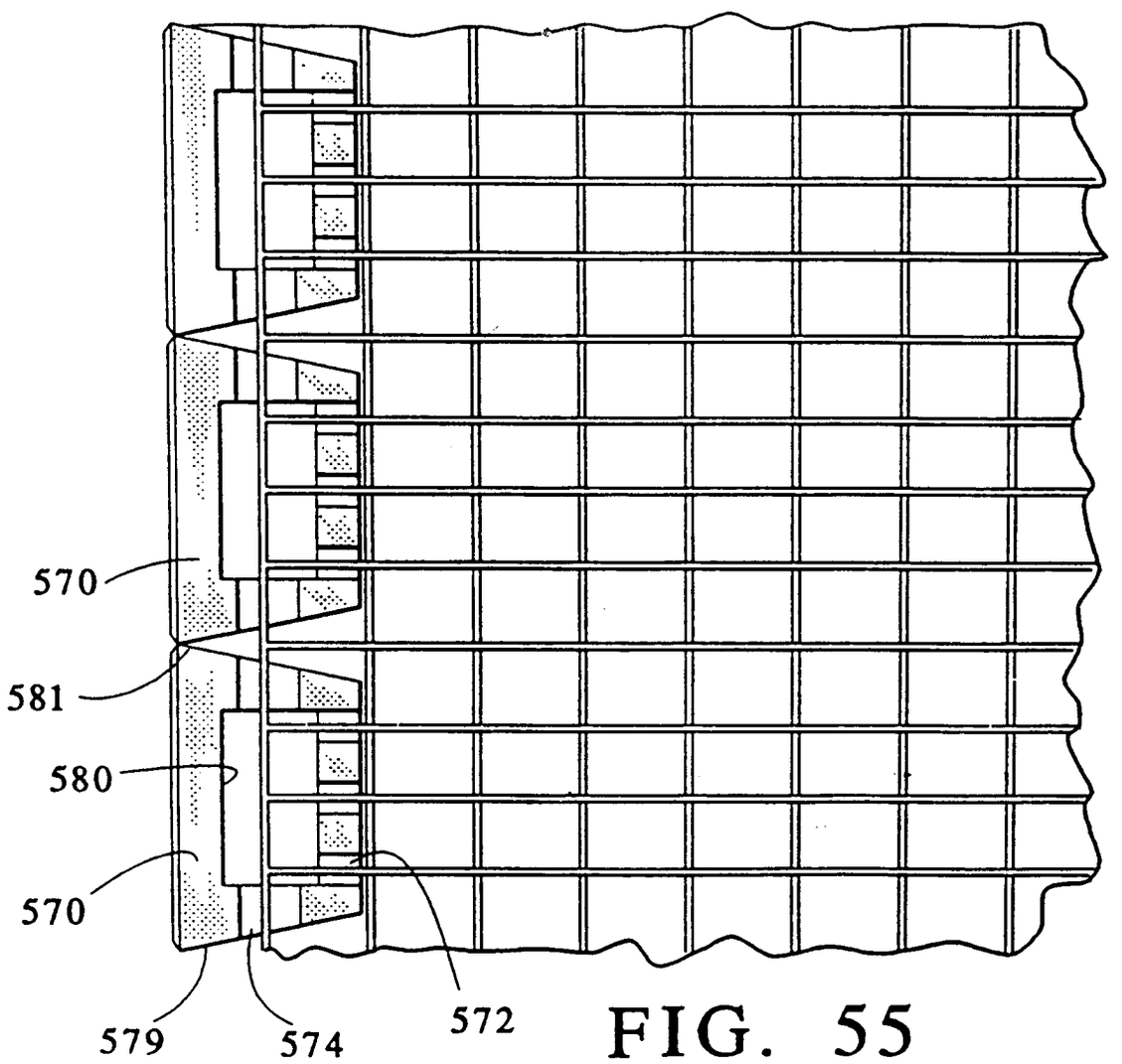


FIG. 55

FIG. 56

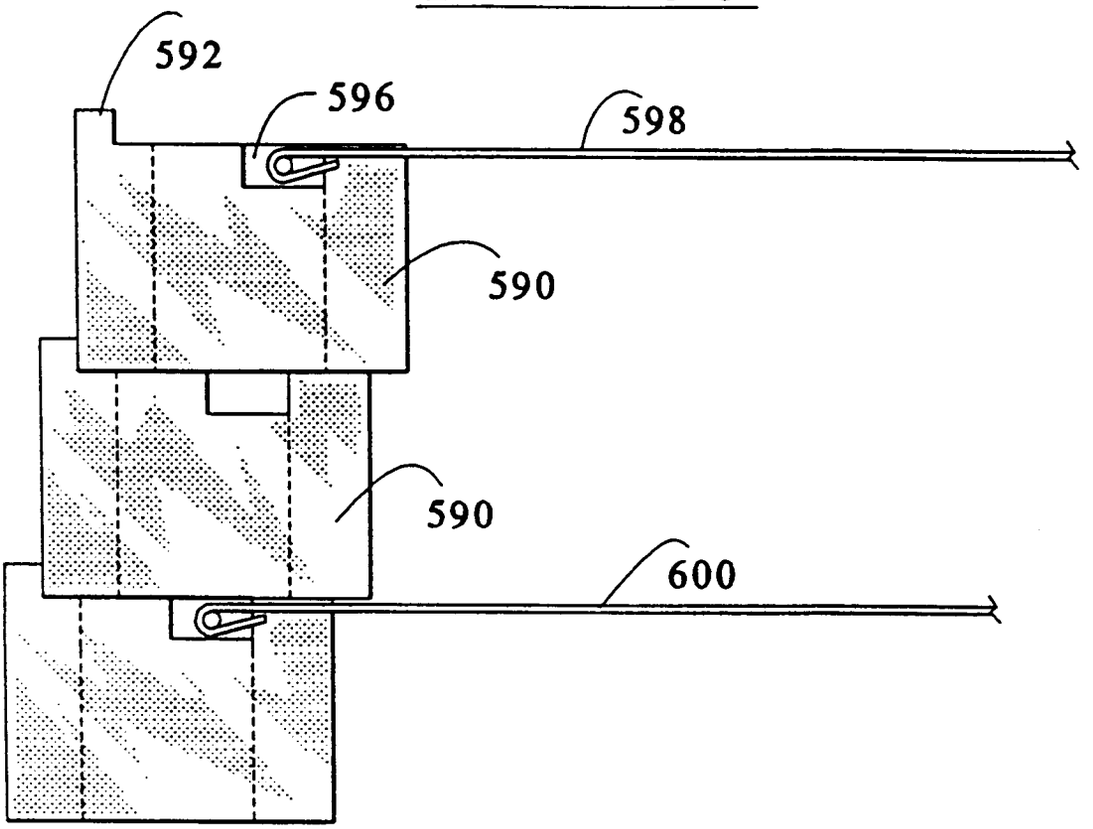


FIG. 57

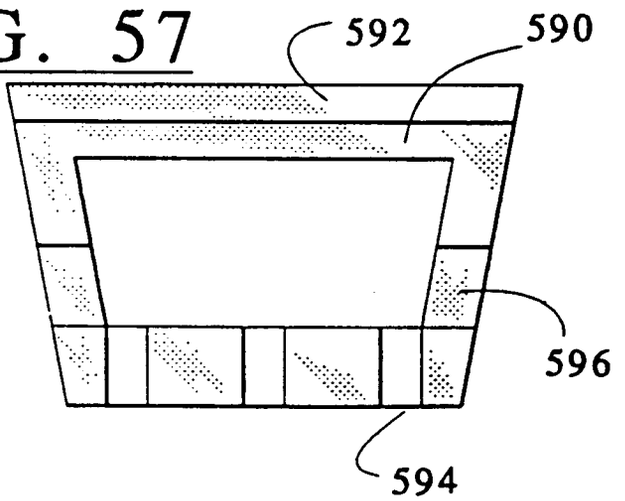
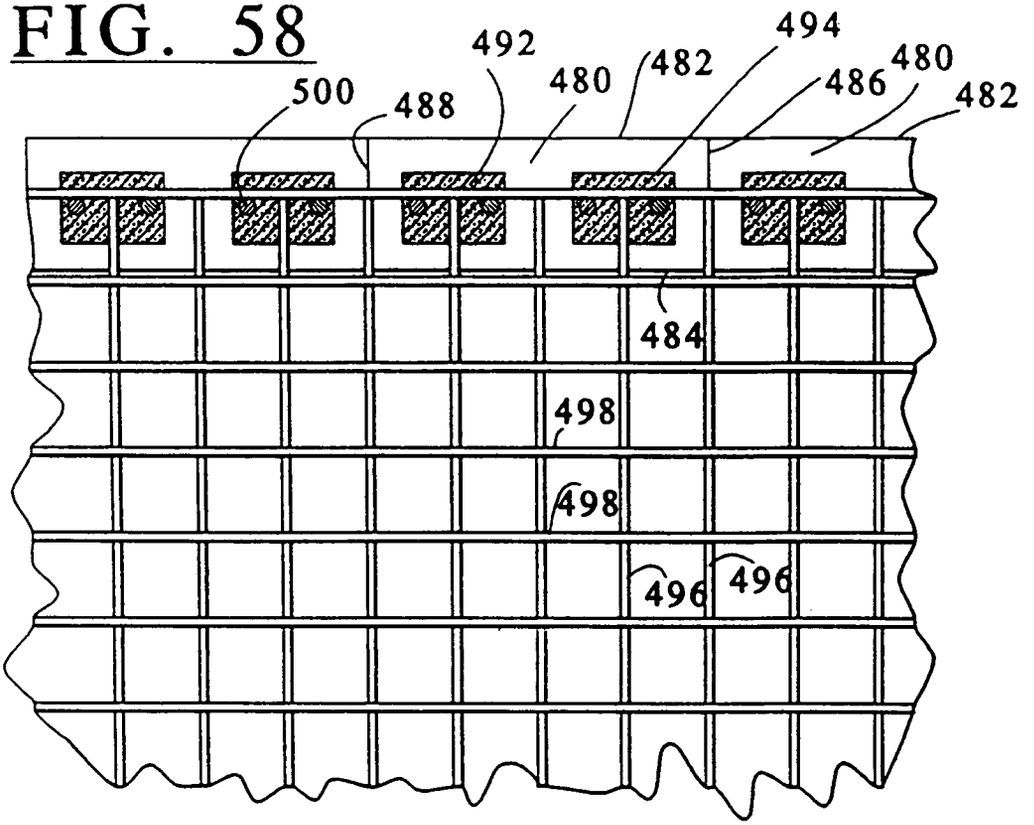


FIG. 58


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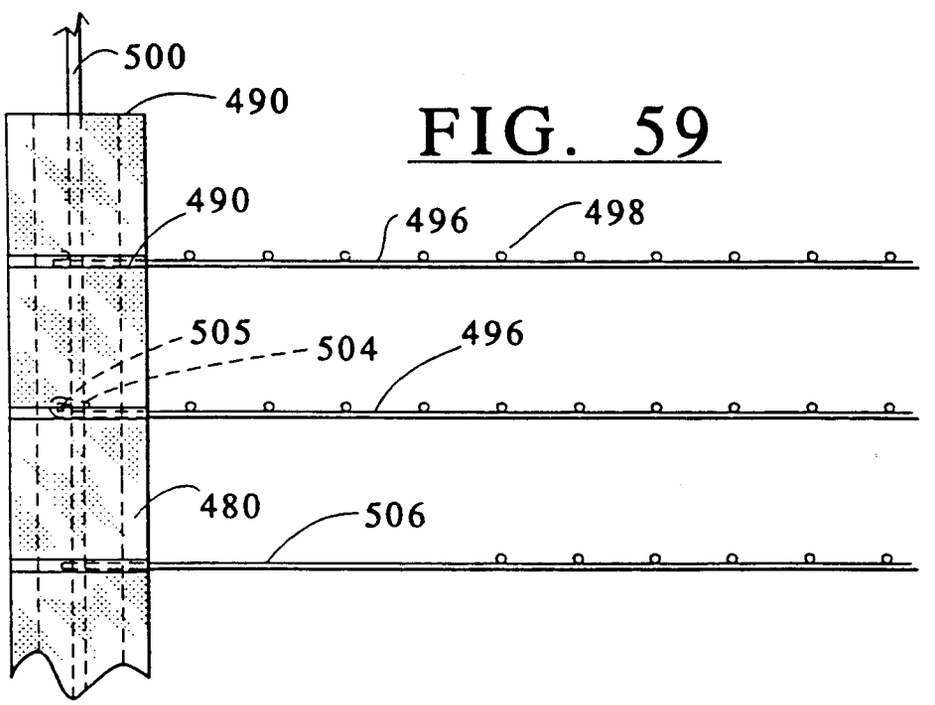

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FIG. 59

FIG. 60

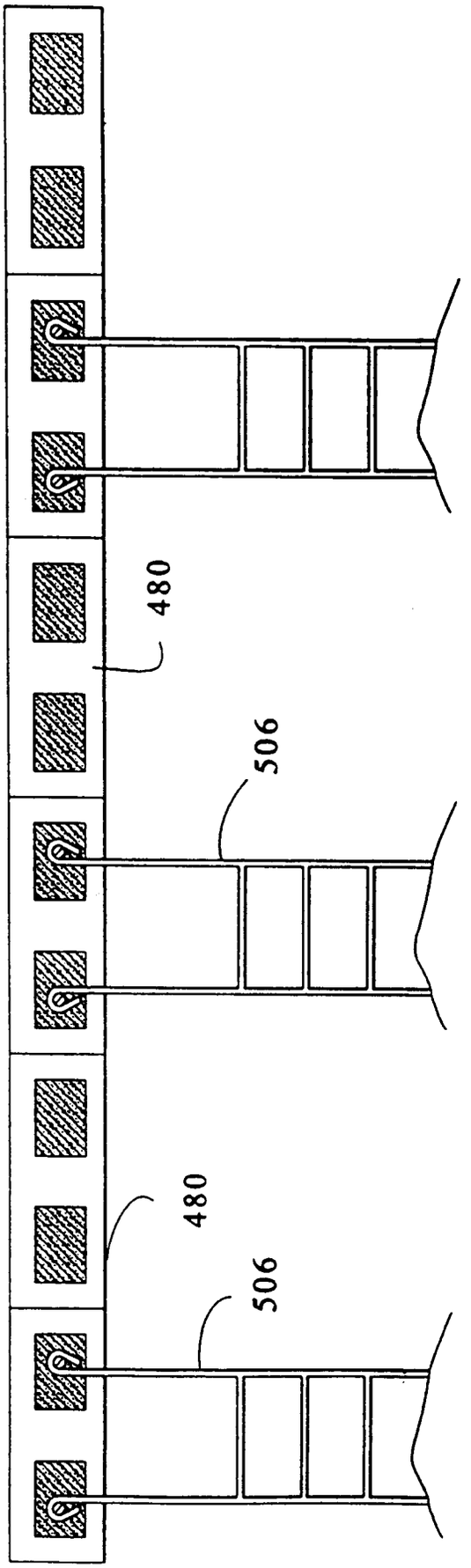


FIG. 61

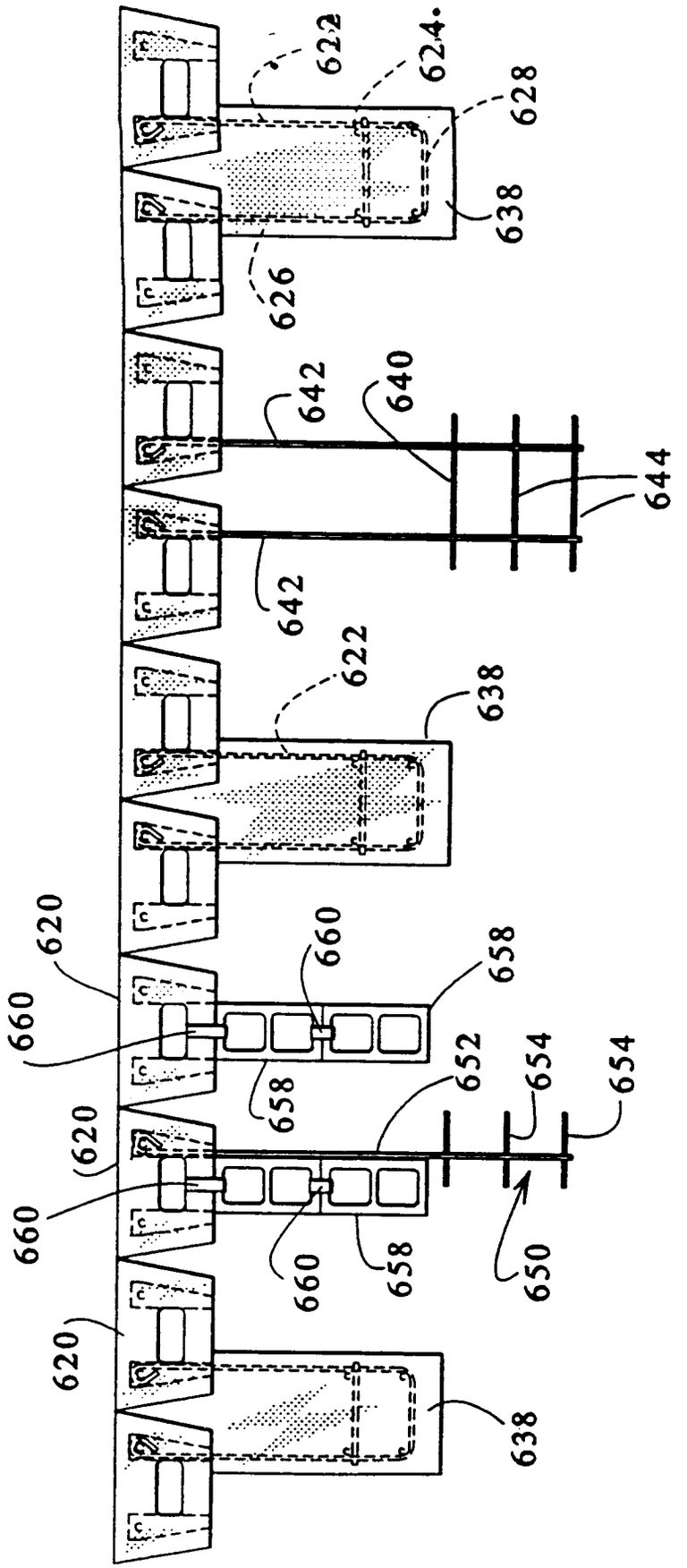
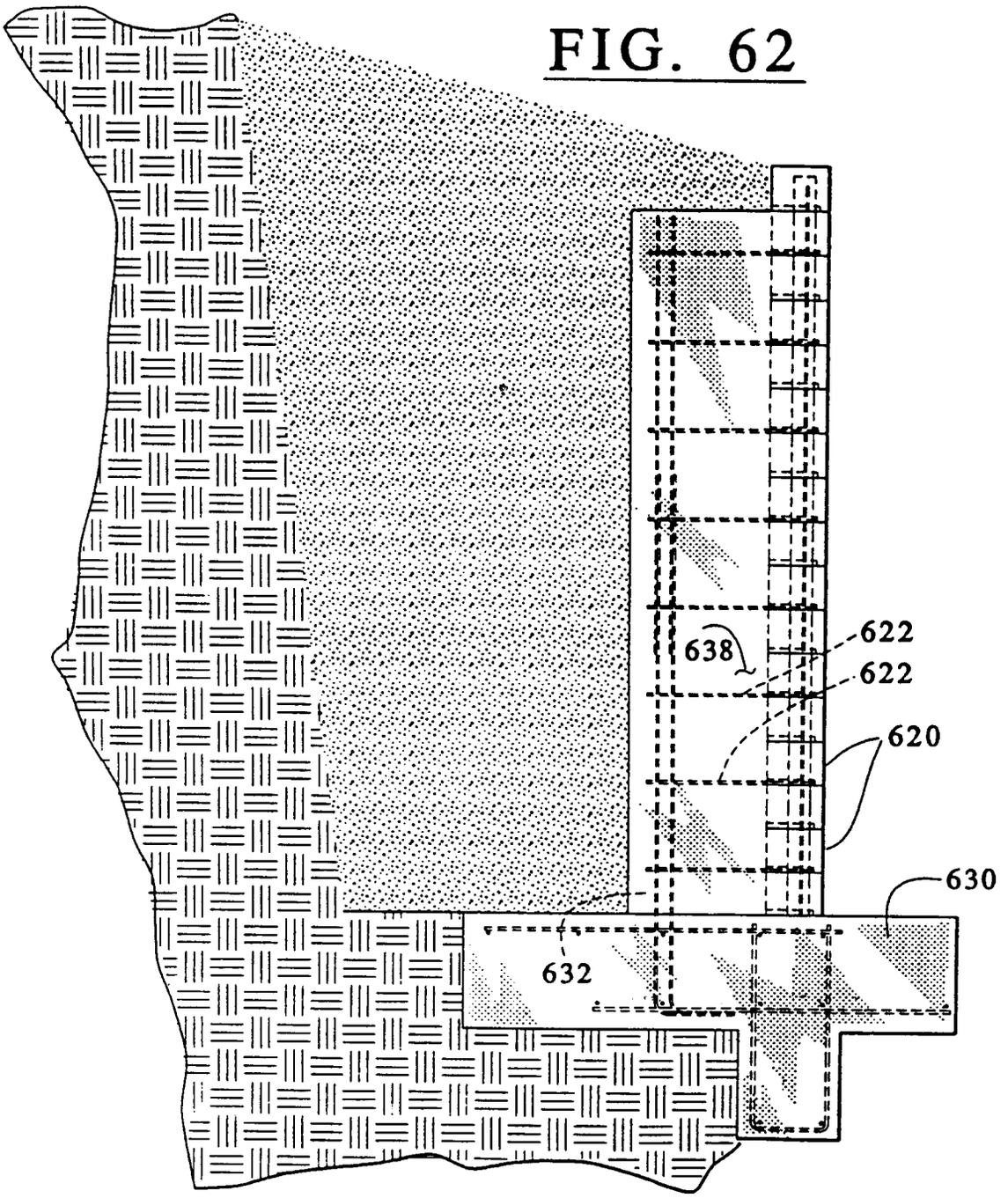

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FIG. 62



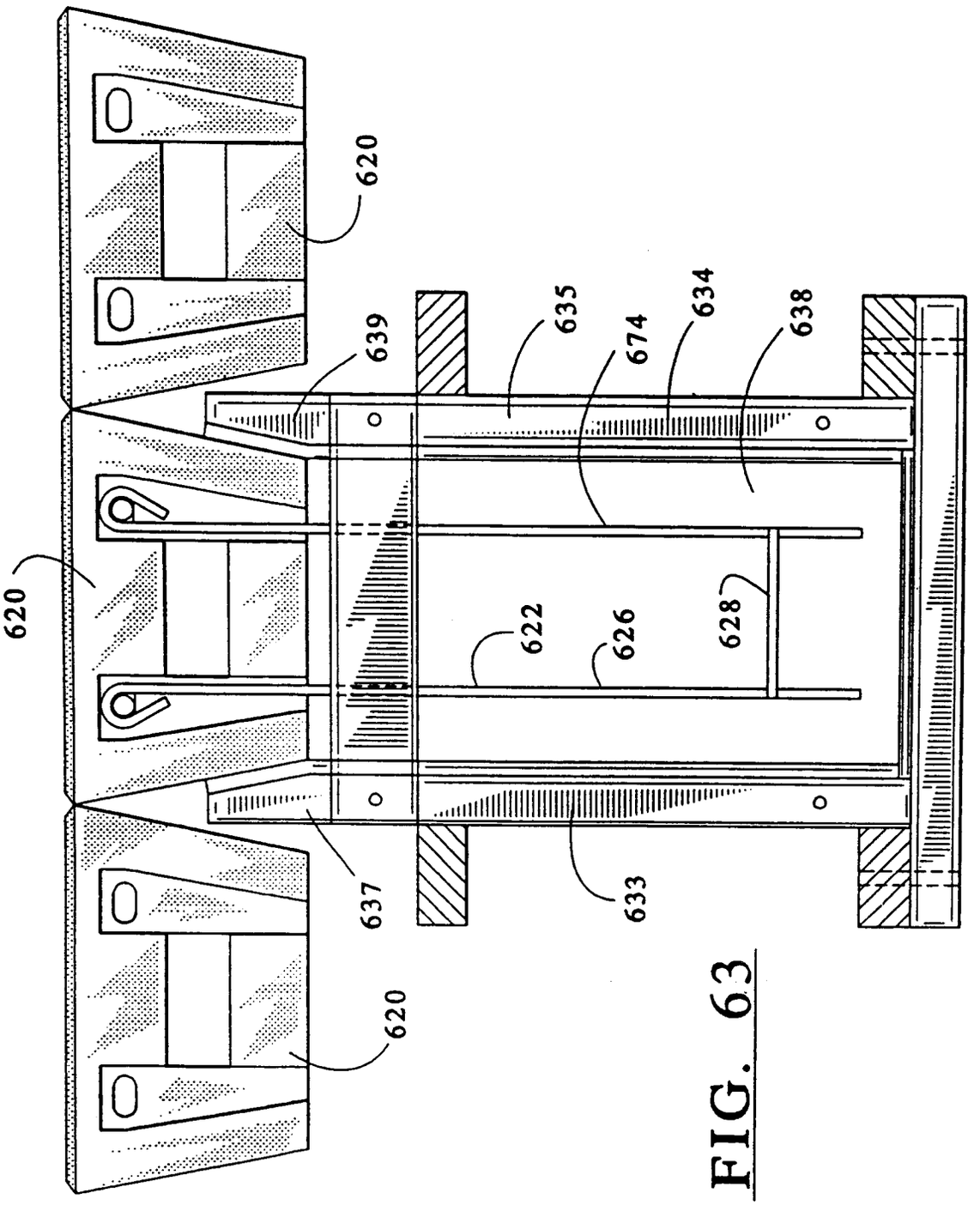


FIG. 63

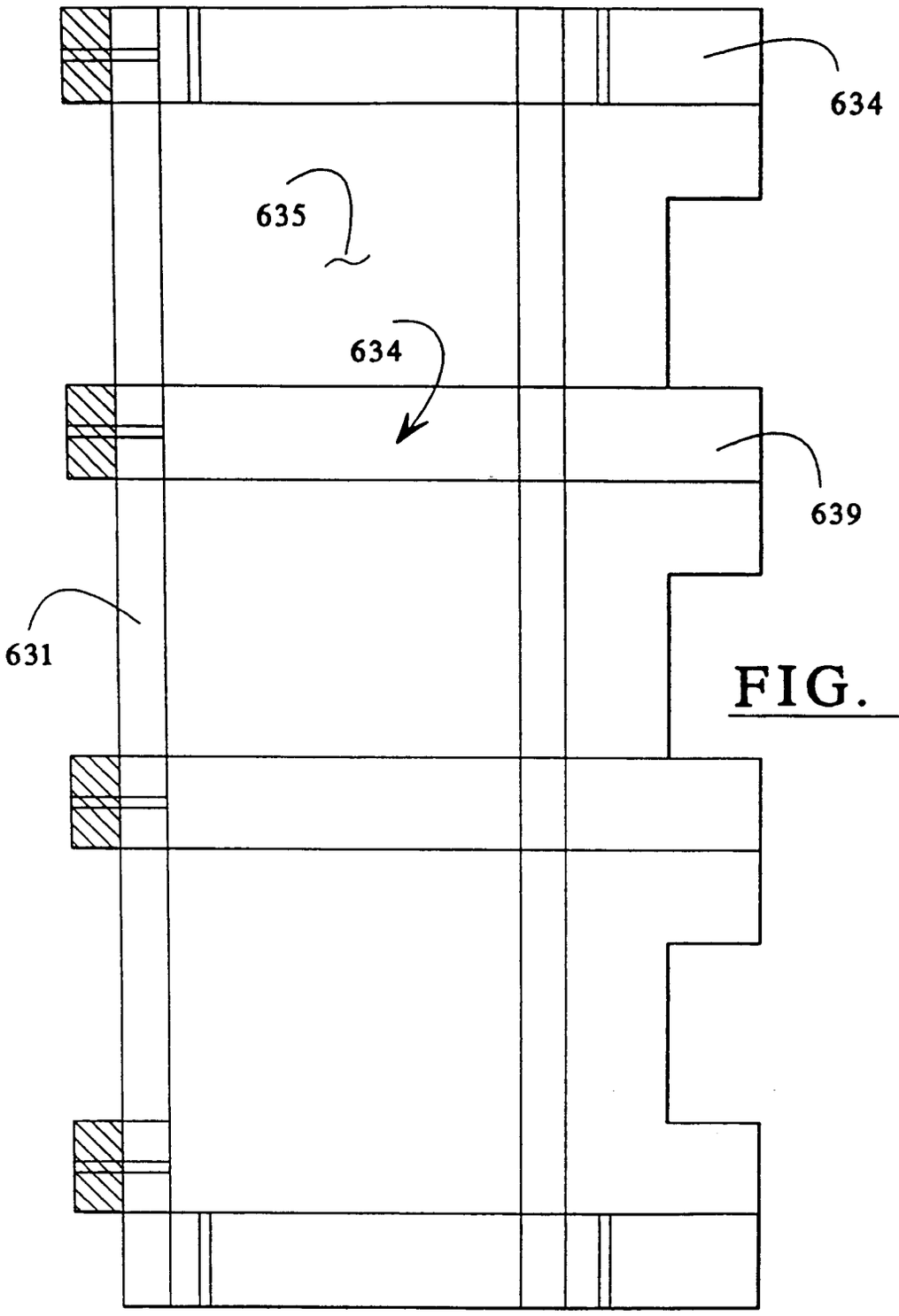


FIG. 64

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 11 7143

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
Y,D	US-A-4 324 508 (HILFIKER WILLIAM K ET AL) 13 April 1982 * column 3, line 3 - column 7, line 10; figures 1-10 *	1-4,8,9, 13,14, 16,17	E02D29/00 E02D29/02
Y	US-A-1 762 343 (MUNSTER) 10 June 1930 * the whole document *	1-4,8,9, 13,14, 16,17	
A	EP-A-0 427 221 (IMPRESA CONCARI PREFABBRICATI) 15 May 1991 * column 2, line 32 - column 3, line 35; figures 1-7 *	1,12,14, 16,17	
A	EP-A-0 351 229 (HELIX REINFORCEMENTS) 17 January 1990 * the whole document *	11,12, 16,17	
A	EP-A-0 002 216 (BAYER AG ;STRABAG BAU AG (DE)) 13 June 1979 * page 7, line 1 - page 9, line 5; figures 1-7 *	1,6,7, 10-12, 16,17	TECHNICAL FIELDS SEARCHED (Int.Cl.5) E02D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26 January 1996	Tellefsen, J

CATEGORY OF CITED DOCUMENTS

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