United States Patent [19]

Hamy

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[45] **Mar. 18, 1975**

[54] **CONSTANT MODULE SYSTEM**

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[73] Assignee: **Trebron Holdings Ltd.,** Regina, Saskatchewan, Canada

[22] Filed: **Mar. 13, 1974**

[21] Appl. No.: **450,745**

Related U.S. Application Data

[63] Continuation of Ser. No. 276,163, July 28, 1972, which is a continuation-in-part of Ser. No. 44,012, June 8, 1970, abandoned.

[52] **U.S. Cl.** **52/79,** 52/228, 52/236, 52/606, 52/610

[51] **Int. Cl.** **E04b 1/348,** E04f 17/08

[58] **Field of Search** 52/79, 220, 221, 264, 236, 52/475, 495, 606, 610, 656, 236, 228, 230

[56] **References Cited**

UNITED STATES PATENTS

861,572	7/1907	Budd	52/475
890,769	6/1908	Hewett	52/227
1,886,962	11/1932	Roche	52/236
2,877,508	3/1959	Ewart	52/125
2,996,161	8/1961	Etling	52/475
3,314,200	4/1967	Schuster	52/227
3,367,063	2/1968	Bondesen	52/228
3,455,075	7/1969	Frey	52/606
3,500,595	3/1970	Bennett	52/79
3,526,067	9/1970	Furter	52/79
3,564,795	2/1971	Henton	52/236

FOREIGN PATENTS OR APPLICATIONS

684,712	3/1967	Belgium	52/79
6,804,097	10/1967	Netherlands	52/236

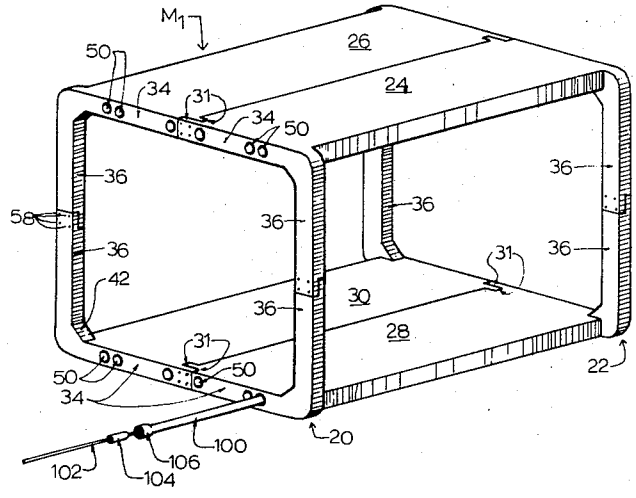
Primary Examiner—Henry C. Sutherland

Attorney, Agent, or Firm—Young & Thompson

[57] **ABSTRACT**

A modular construction system comprised of a plurality of modular constructional units which are capable of being linked to similar modules in order to form a chain or constructed assembly thereof. The modular units are formed or constructed with similar modular segments each having a pair of opposed frame-like members with a connecting substrate extending therebetween. End and side enclosure panels may be connected to the constructed unit. These units may be used in the construction of structural members such as buildings or bridges, or as containers for transport of cargo or in other applications.

16 Claims, 14 Drawing Figures



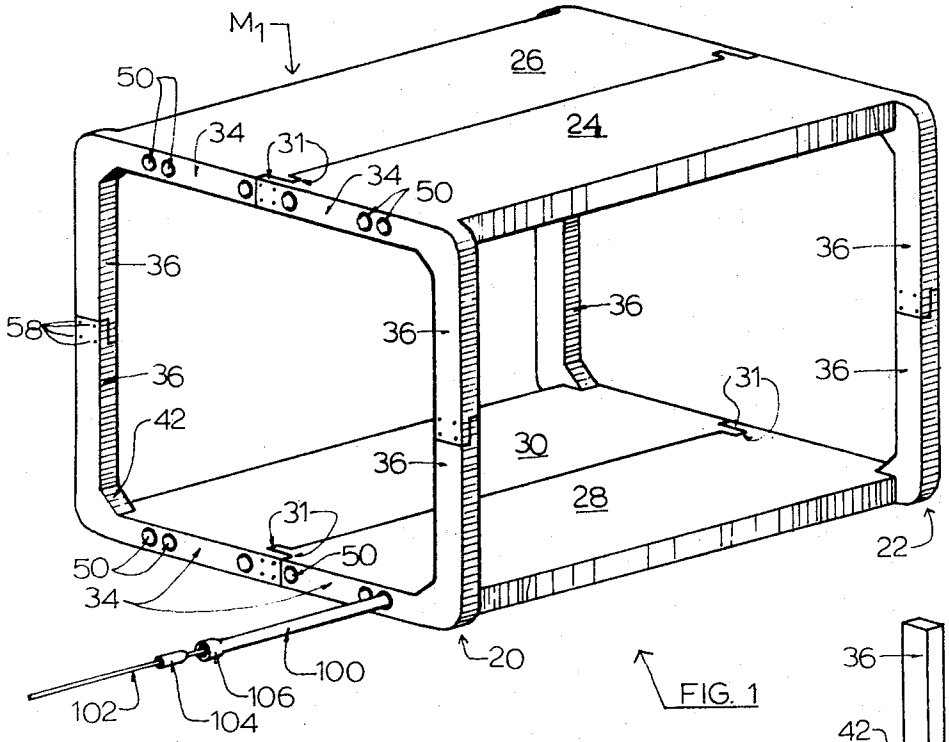


FIG. 1

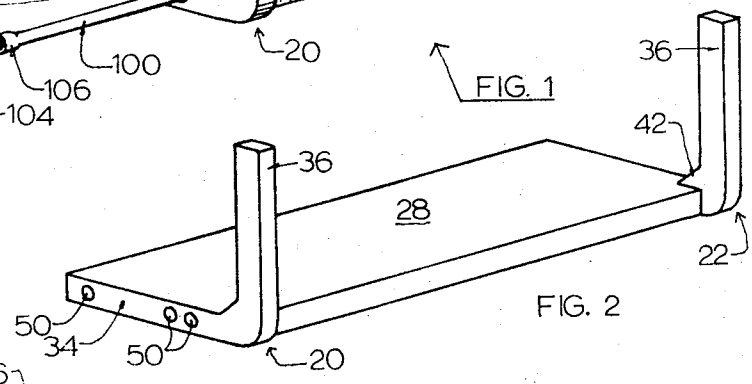


FIG. 2

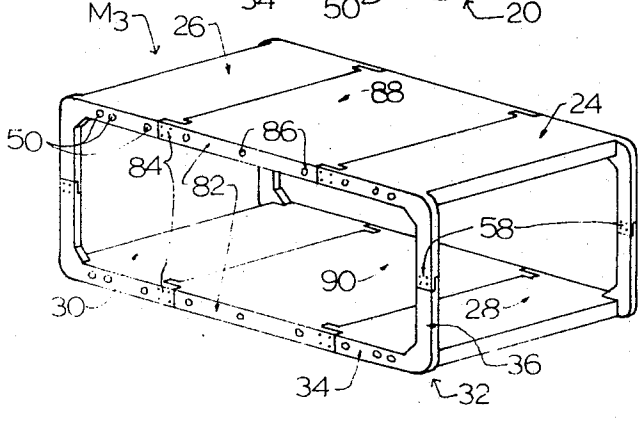
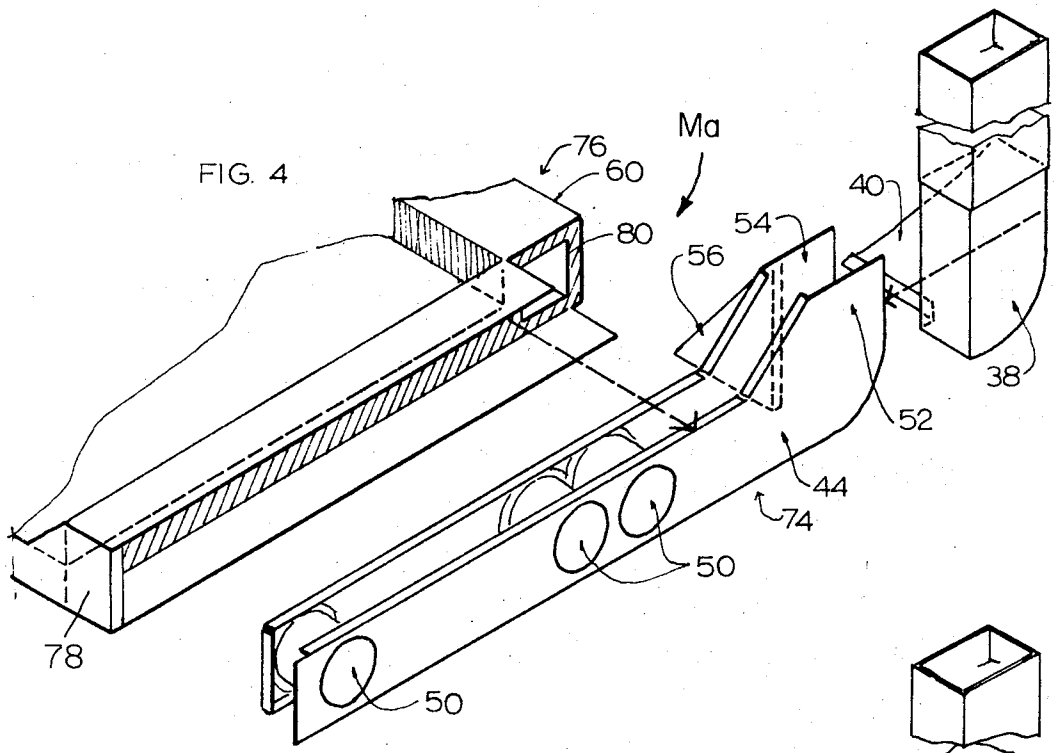


FIG. 5

FIG. 4


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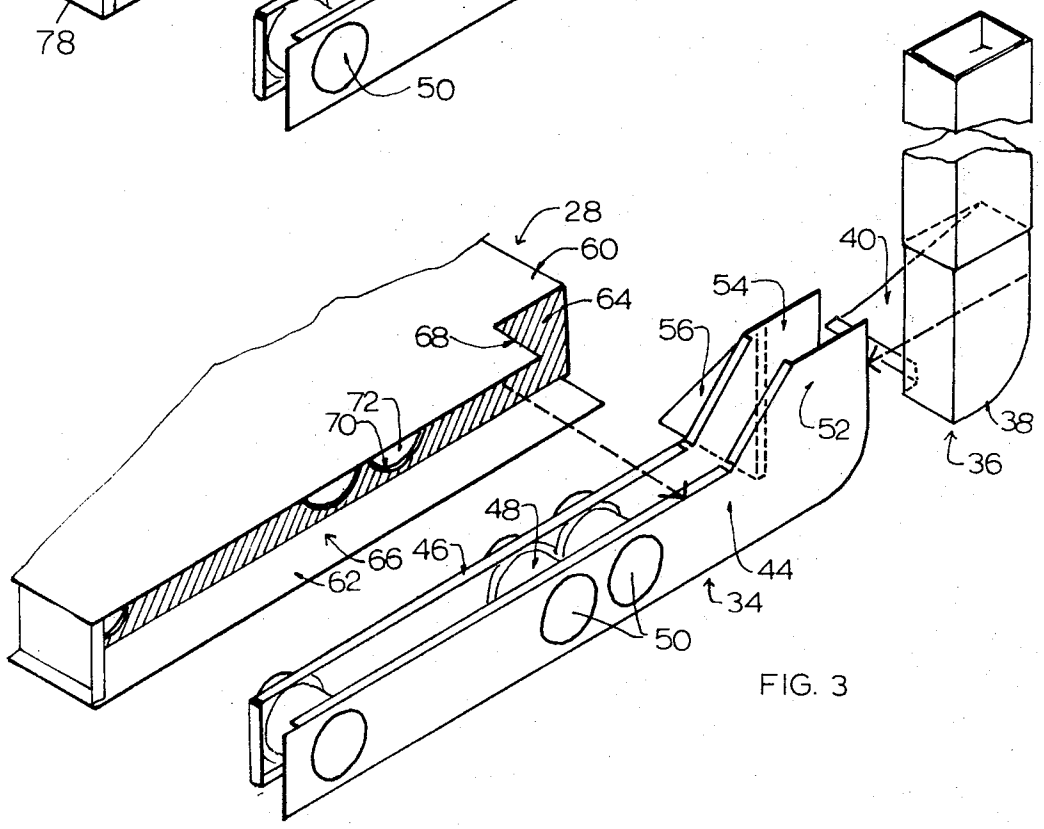

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FIG. 3

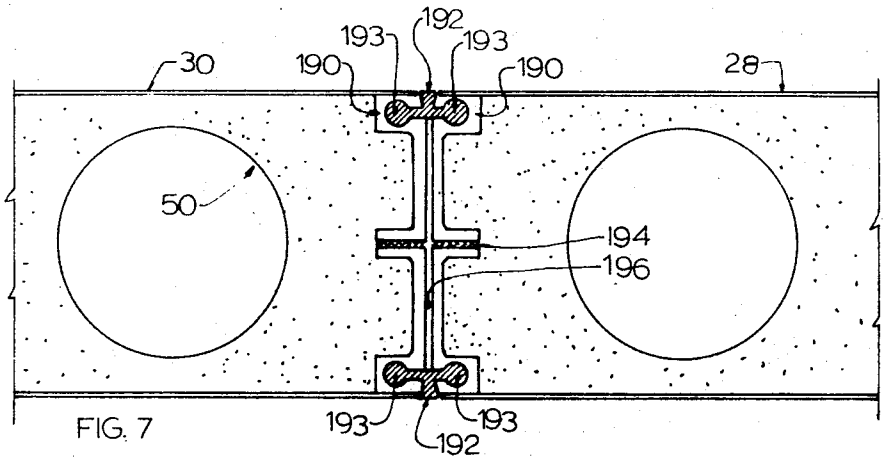


FIG. 7

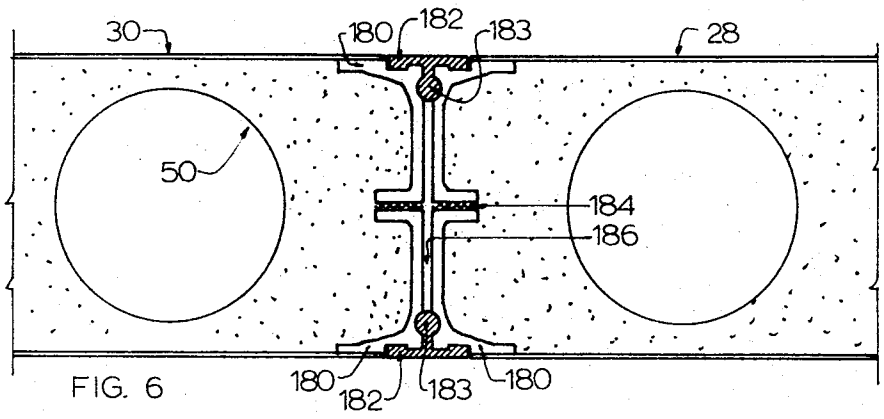


FIG. 6

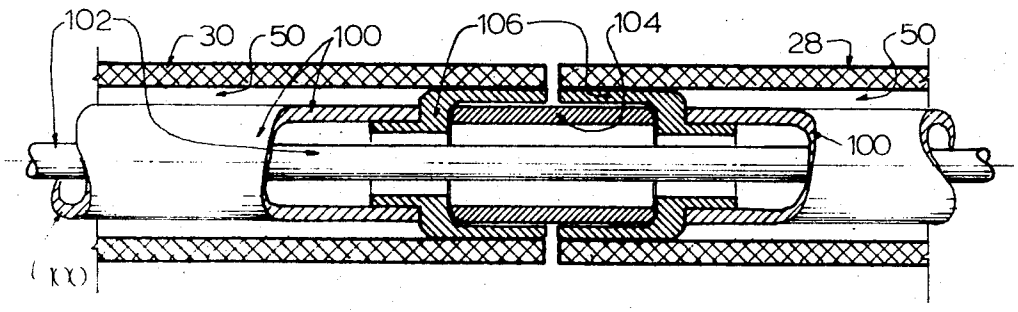


FIG. 8

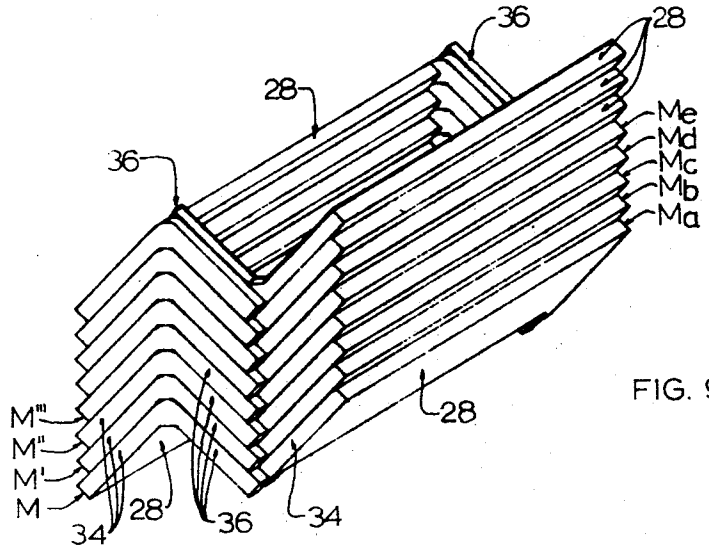


FIG. 9

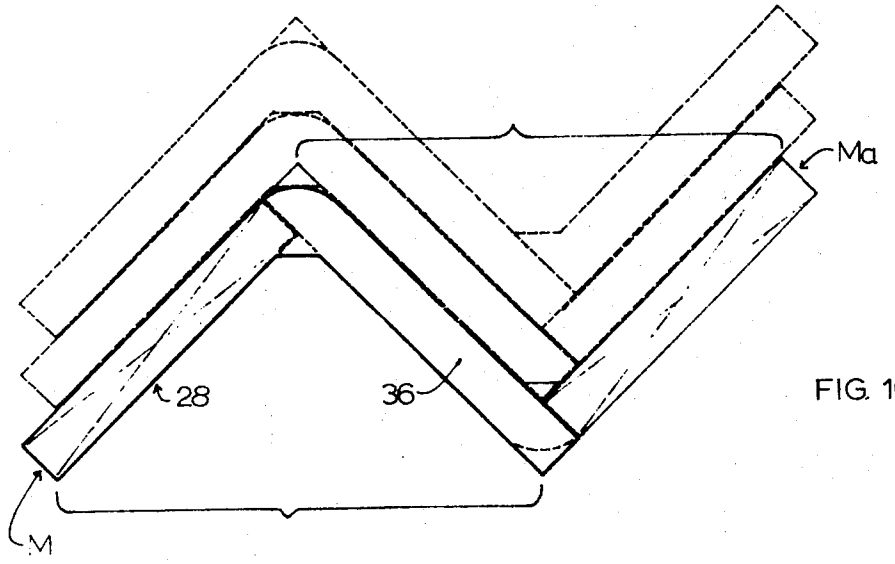


FIG. 10

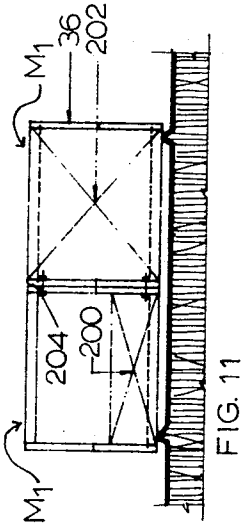


FIG. 11

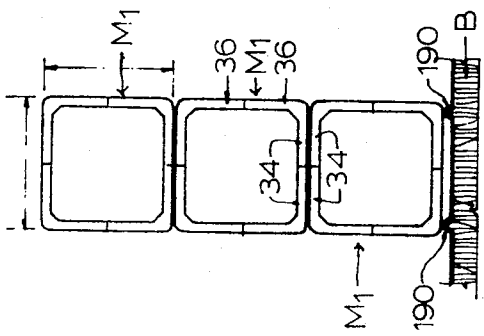


FIG. 13

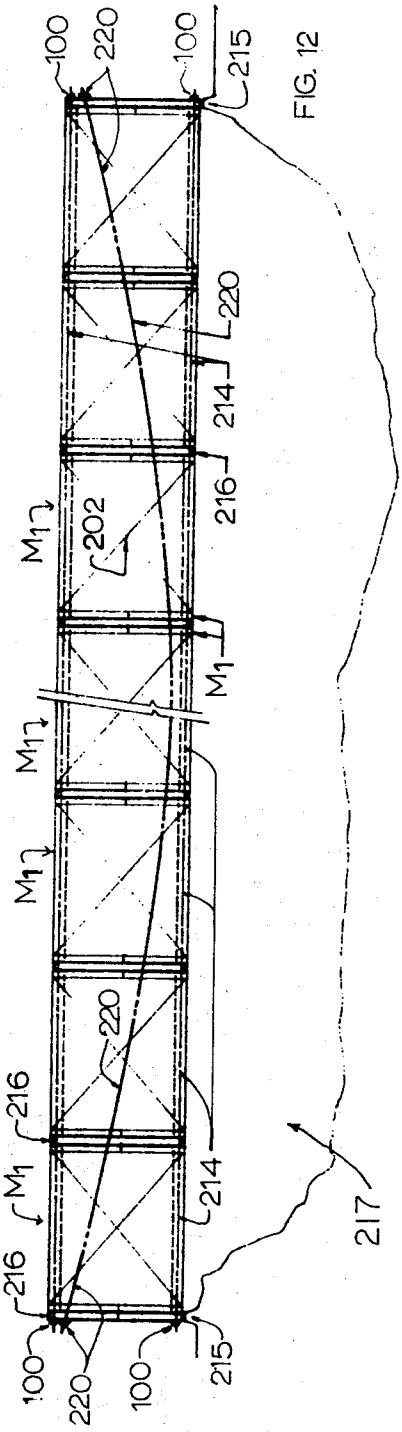


FIG. 12

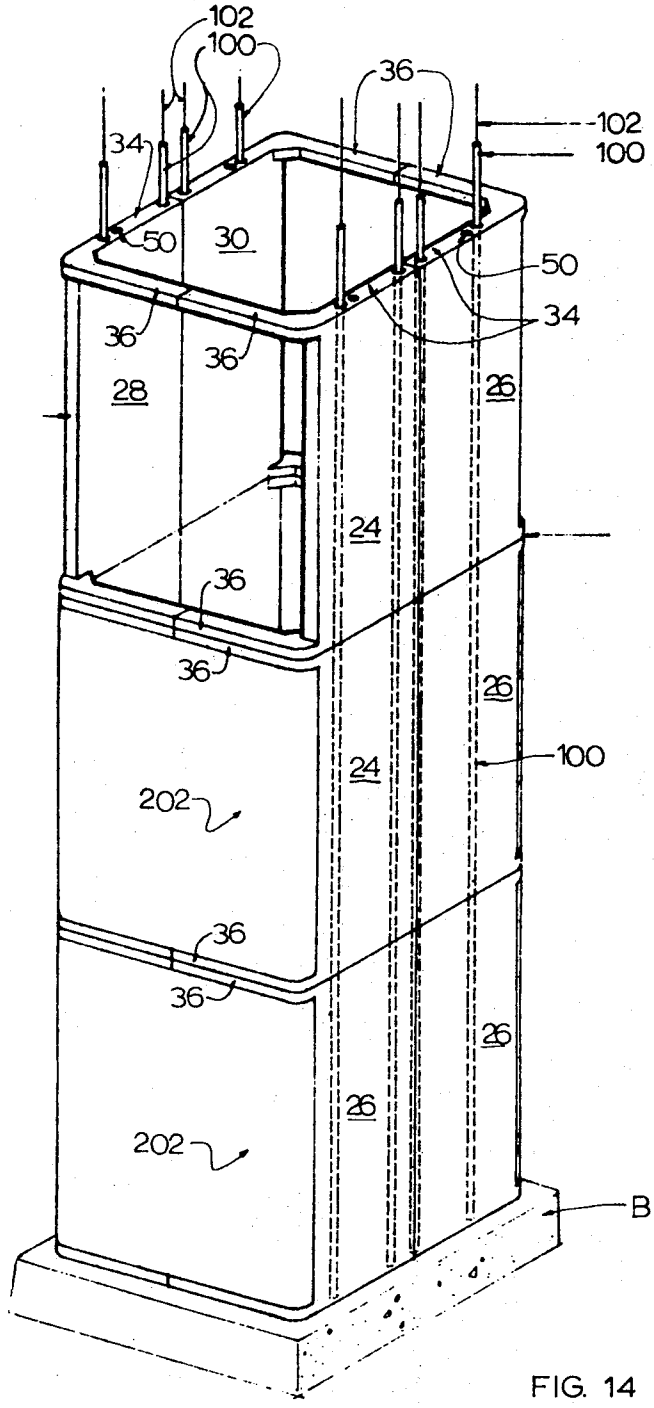

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FIG. 14

CONSTANT MODULE SYSTEM

This a continuation of application Ser. No. 276,163, filed July 28, 1972 which is a continuation-in-part of my co-pending application Ser. No. 44,012, filed June 8, 1970, for a constant module container system (now abandoned).

This invention relates in general to certain new and useful improvements in modular construction systems and more particularly, to systems which employ a plurality of similar connectable modular units.

In recent years, there has been an increased tendency to employ modular construction units in the assembling and construction of various structures, as well as an increased interest in the use of modules for containerization and the like. Many of the modern buildings are being constructed with modular units, which greatly facilitates the construction of the building by reducing costly amounts of skilled and unskilled labor as well as reducing the amount of construction time. In fact, many modern hotels and similar buildings which are provided with substantially similar units or rooms are constructed in the form of a shell, such as from prestressed concrete sections and modular rooms are thereafter inserted into the structural shell.

While the use of modular construction units is highly advantageous in many applications, these units are quite costly and furthermore, each of the units in any modular construction system must be uniquely designed for the intended application. Accordingly, the various known modular construction units are not universally adaptable to a wide variety of applications.

In recent years, the advantages of containerization for the storage and transporting of cargo and other freight forms has also become widely recognized in many industries. The utilization of containers for both storage and transport readily facilitates handling of the cargo and thereby provides a substantial economic advantage which is not otherwise available.

Containerization of freight, that is the employment of fairly rigid self-supporting containers for the storage and transport of cargo, has not been completely adopted inasmuch as other forms of capital equipment are normally required for handling of the freight bearing containers. In many cases, lift-forks, cranes and other form of powered lift equipment is required for purposes of moving the containers laden with cargo due to the substantial weight and bulk. This type of equipment is not normally required for freight forms which are not containerized. Furthermore, the various containers available for the storage and transport of freight are not generally cooperative with the possible exception of the ability to be stacked. Therefore, the containers must be individually handled, and this function is generally performed with the lift equipment described above.

The present invention obviates these and other problems by the provision of a modular construction system which employs modules as a basic unit for construction and for storage and transport and which modules may serve as an active element in various unique transport configuration and in various construction configurations. Those modules are highly effective in that they can be constructed with a plurality of similar segments in a basic external dimension and which are easily assembled with such other modular units. The modules when in the form of containers can be used efficiently

in the storage of cartage and then rapidly connected together for transport without loading or unloading. In this way, the modular system of the present invention enables the storage and transport of cargo with a minimum amount of manual labor and a reduction in the need of costly capital equipment, thereby providing a high degree of economy and efficiency.

In general terms, the present invention may be described as a modular unit construction comprising a pair of spaced-apart end frames and where each of the end frames are comprised of a plurality of substantially similar frame-forming sections. Each of these frame-forming sections comprise a first limb with means forming a slot in the first limb. The frame-forming sections also comprise a second limb, projection means on the second limb fitted into the slot on the first limb and retentively held therein, so that the second limb extends upwardly from the first limb at a mutually angled relationship thereto. Means are also provided for securing at least two opposed members of said frame-forming sections together to form each of said pair of spaced-apart frames of generally rectangular shape. The constructions unit also includes a first planar member extending between and being secured to each of the spaced-apart frames, and a second planar member extending between and secured to said spaced-apart frames and being spaced from said first planar member.

In further detail, the modular unit construction of the present invention may be characterized in that four of said frame-forming sections are joined together to form each of said pair of spaced-apart frames. A third planar member also preferably extends between and is secured to said spaced-apart frames and lies in general coplanar relationship with the first planar member. A fourth planar member extends between and is secured to said spaced-apart frames and lies in general coplanar relationship with the second planar member. Preferably, projection and slot means are formed in the first and third planar members and in the second and fourth planar members to hold such pairs of respective members in abutting relationships. In actual construction, the first and third planar members constitute the upper wall of the modular construction unit and the second and fourth planar members constitute the lower wall of the modular construction unit.

The basic external dimensions of the module may be increased by insertion of splicing elements between the limbs of adjacent frame-forming sections. In addition, splicing planar members which are coplanar to the first-named planar members may also extend between the opposed frame members and the splicing elements.

With respect to the frames, at least one of the mutually angled limbs in each of the frame-forming sections is comprised of a pair of spaced-apart plate elements with connecting elements therebetween. In a preferred aspect, these connecting elements are tubular duct elements. The other of these mutually angled limbs in each of the frame-forming sections comprises a stressed hollow box-shaped member. Again, it is preferable to introduce a fairly rigid plastic or similar material into the hollow box-shaped member for additional reinforcement thereof. With further regard to the planar members, at least one of the planar members and preferably all of the planar members comprises a pair of opposed sheets with a filler material extending between these sheets. These sheets are preferably upper

and lower stressed sheets with a fairly rigid plastic filler material extending therebetween. Extensions of the tubular duct connecting elements on the frames are provided in the filler material and mate with the tubular duct on the frame members so that the tubular duct elements extend through the module and open on opposite sides thereof.

In general terms, the present invention may also be described as a module having a bases external size and basic external dimensions and comprising a pair of opposed frame members. A plurality of substantially planar members extends between and connects the frame members and forms an interior cavity in the module. At least one removable wall closure panel is removably connected to the frame members and enables access to the interior cavity. Coupling means is formed on the modules adapted for mating with cooperative coupling means to permit a plurality of similar modules to be joined.

In a preferred aspect of the present invention, each of the modules is characterized in that the frame members are comprised of a plurality of mutually angled limbs which are joined to form a frame of rectangular shape. Furthermore, each of the frame members are actually formed of a plurality of frame-forming sections and each of the frame-forming sections are comprised of these pairs of mutually angled limbs, so that the limbs of one frame-forming section are connected to the limbs of another frame-forming section to thereby form the frames of rectangular shape.

The basic external dimension of the modules can be increased by insertion of splicing elements between the limbs of the adjacent frame-forming sections to thereby increase the overall size of the frames. In this connection, the addition of splicing planar members which are coplanar to the first named planar members will also extend between the opposed frame-forming members as splicing elements. The mutually angled limbs of each of the frame members are provided with mating elongated slots, and projections on each set of the mutually angled limbs so that the projections on one limb of the mutually angled limbs extends into an elongated slot on the other limb of a set of mutually angled limbs.

In the frame construction, certain of the mutually angled limbs are comprised of a pair of opposed spaced-apart plate elements with connecting elements extending therebetween. Preferably, these connecting elements are tubular duct connecting elements. Certain other of the mutually angled limbs comprise a stressed hollow box-shaped member. Extensions of the tubular duct connecting elements formed in the frame members may be provided in at least one of the planar members and in a preferred embodiment of the present invention, these tubular duct elements extend through the entire module and open on opposite sides thereof. The planar members used in the construction of a module preferably comprise a pair of opposed sheets with a filler material extending between these sheets. These plate members are preferably upper and lower stressed sheets and the filler material is preferably a fairly rigid plastic filler material.

In another respect, the present invention can be described in general terms as a modular container system comprising a plurality of similar container modules, each of which have a basic external size and shape. Each of the modules have at least one wall which matches a common wall of another of the container modules. Furthermore, each of the modules are entirely closed except for at least one access opening and the modules have an internal cavity communicating with the access opening. At least one removable closure panel is removably disposed over the associated access opening and can provide access to the interior cavity when removed. Finally, each of the container modules are provided with connection means on one wall thereof and mating connecting means on the common wall of another of said modules for connection therebetween.

In accordance with the present invention, these modules can be constructed in a wide variety of structural forms. These modules can be connected together in the form of a building construction. In like manner, the modules can be coupled end to end to form a transport system. Furthermore, the modules may be coupled together in the form of a bridge construction.

Having thus described the invention in general terms, reference will now be made to the accompanying drawings in which:

FIG. **1** is a perspective view of a module according to the present invention;

FIG. **2** is a perspective view of one of the segments of the module illustrated in FIG. **1**;

FIG. **3** is an exploded fragmentary perspective view similar to FIG. **2** and showing one end of one type of a segment suitable for use in the modular system of the present invention;

FIG. **4** is a fragmentary perspective view similar to FIG. **3** showing a further form of a segment;

FIG. **5** is a perspective view of a module with splicing elements included therein;

FIG. **6** is a fragmentary vertical section taken through a segment showing one form of interconnecting adjacent segments together;

FIG. **7** is a view similar to FIG. **6** showing a modified form of coupling for joining two adjacent segments in a module together.

FIG. **8** is a fragmentary vertical section taken along a pair of modules aligned end to end showing the tensioning feature in detail;

FIG. **9** is a perspective view of one form of stacking the segments of the present invention;

FIG. **10** is an enlarged view similar to FIG. **9** showing the stacking arrangement in greater detail;

FIG. **11** is a schematic side elevational view showing a pair of the modules of the present invention joined together;

FIG. **12** is a side elevational schematic view showing a plurality of the modules joined together spanning a distance;

FIG. **13** shows a schematic side elevational view of a plurality of the modules of the present invention joined together in a vertically aligned manner;

FIG. **14** is an enlarged view similar to that of FIG. **13** but showing in greater detail the joinder between vertically aligned modules.

Referring now in greater detail to the drawings, illustrating practical embodiments of the present invention, M_1 designates a module of four generally similar segments each comprising a pair of spaced-apart elongated rectangularly shaped frames **20** and **22**, each having an intervening rectangularly shaped panel — which in the respective panel segments, are designated by the reference numbers **24, 26, 28** and **30.** In the module M_1, and with the four segments joined together, the

module includes (in the configuration in FIG. 1) a top panel and an opposed spaced-apart bottom panel; to this end, the respective rectangularly shaped panels **24** and **26** of one pair of segments matingly engaged by means of notches and flanges **31**, for alignment — in a like manner, the panels **28** and **30** of the other pair of segments are likewise joined in mating and engaging relationship by means of notches and flanges **31**.

The end frames **20** and **22** of each segment are generally identical in their construction and one construction of such end frames is illustrated in FIGS. **1, 3** and **4**. Inasmuch as one frame **20** is a mirror image of the other frame **22**, only one of these frames **20** will be described and illustrated in greater detail — see FIGS. **3** and **4**. To this end the frame **20** generally includes a pair of mutually angled limbs **34** and **36** which are preferably perpendicular with respect to each other. In this embodiment as illustrated, the frame **20** comprises a limb **34** which is a stressed hollow box-shaped section and which is preferably constructed from a suitable structural material including metals such as iron, steel, aluminum or the like, or any of a number of known plastic materials such as polystyrene, several of the vinyl chlorides, several of the polyacrylates and polymethacylates, and the like. The limb **36** may be filled, or at least partially filled, with a fairly rigid filler material, such as several known plastics, or the like. In addition, several fairly rigid open-celled materials or foam materials, such as polyurethane, may be introduced into the hollow interior of the limb **36**. The limb **36** is integrally formed with an arcuately shaped outwardly presented lower edge **38** and on one of the interiorly presented faces is integrally provided with a projection **40** for attachment to the limb **34** in a manner to be hereinafter described in more detail. The limb **36** is also provided with an abutment shoulder **42**, (FIG. **2**) the latter being adapted to engage the upper surface and the transverse margin of one of the planar walls, such as wall **28** in the manner as illustrated in FIGS. **1, 2** and **4**.

The limb **34** is formed from a pair of opposed side plates **44** and **46** which may be constructed of any of the materials used in the construction of the hollow box-shaped section forming the limb **36**. The side plates **44** and **46** are rigidly connected by cylindrical tubes **48** extending therebetween and which internally from ducts **50** for reasons which will presently more fully appear. The plates **44** and **46** are parallel to and spaced-apart from each other and are provided with enlarged end flanges **52** in the region proximate the limb **36** to form an elongated slot or recess **54**, the latter being sized to receive the box-shaped section of the limb **36** and adapted to cooperate with the projection **40**. In this way, the limbs **34** and **36** may be rigidly connected to form a frame section. Furthermore, strengthening webs **56** may be integrally formed with the flanges **52** so as to provide increased rigidity.

As indicated previously, only one of the frame sections has been illustrated and described in detail herein, it being understood that each of the other frame sections forming the entire frame **20** or the frame **22** are substantially identical in their construction. Furthermore, each of the frame sections in the form of segments may be secured to each other by means of e.g. bolts **58** or similar mechanical fasteners in the manner as illustrated in FIG. **1**, to form the module M_1.

The planar members, such as the top walls **24** and **26** and the bottom walls **28** and **30** are again similar in their construction. Accordingly, only one of the bottom walls **28** is more fully illustrated in detail in FIGS. **2** and **3**. It should again be understood that the top walls **24** and **26** and the other bottom wall **30** are substantially identical in their construction. The bottom wall **28** generally comprises top and bottom sheets **60** and **62** which are preferably formed of stressed metal, such as stressed steel, or molded from plastic materials of the type mentioned above. Interposed between the spaced-apart top and bottom sheets **60** and **62** is a filler layer **64** preferably formed of a plastic material or an open-celled foam material of the type introduced into the box-shaped structure forming the limb **36**; or in other cases, concrete or other cementitious material. In this connection, for most uses of the module M_1, the filler material must be fairly rigid in its construction and must also be capable of supporting a fairly substantial load when the module is used to contain load-bearing contents therein or in construction application. The filler layer **64** should have essentially the same thickness in the vertical dimension as the limb **34** and a recess **66** is formed in the filler layer **64** between the top and bottom sheets **60** and **62** to connect the limbs such as the limb **34** to the planar members such as the bottom wall **28**. A cut-out **68** is also provided in the top sheet **60** to accommodate the limb **36**.

Cylindrical extension tubes **70** are also set into the filler layer **64** and form extensions of the cylindrical tubes **48**. The extension tubes **70** also form tubular ducts **72** which are in communication with the tubular ducts **50** in the tubes **48**. The tubes **70** extend transversely across the entire module and communicate through the ducts **50** so that these ducts open at a pair of opposite ends of the modules. These ducts are highly desirable in that they can be used as guides in facilitating alignment of the various modules for ultimate connection, and in this connection they can also be used for retention of coupling mechanisms or post tensioning means which could engage compatible and cooperating coupling mechanisms located on a next adjacent module. Furthermore, the tubular ducts are highly useful in that they are capable of carrying fluid which may be desirable when the modules are used in the construction of buildings, or the like. Furthermore, the ducts are also suitably designed to carry electrical conductors or the like, which again is highly advantageous in various forms of construction.

Thus, in the above-described embodiments, it will be seen that the invention provides for four substantially identical segments each of which constitutes one quarter of the module M_1 and which can be used most readily and conveniently to construct a module M_1 using interchangeable components. Each of these four segments is characterized by having a pair of spaced-apart frame members with an intervening substantially flat planar panel whereby two of such panels, when the frame members are arranged so that such panels are in face-to-face relationship form a closed supporting or like surface so that when four such segments are joined, opposed top and bottom walls may be formed in a spaced-apart relationship thus providing a multipurpose module M_1. Still further, with the preferred construction of the base panels, there is also provided conduits for the passage of electrical conductors, post tensioning means, joining means and the like.

The open-sided construction of the module M_1 of the present invention may be further modified to provided

side-closure panels as described hereinafter in greater detail.

Referring now to FIG. 4, M_2 designates a modified form of module as illustrated, and a portion of a further type of segment according to a further embodiment of this invention, as an alternative to FIG. 3. In this case, the segment is generally similar to that of FIG. 3 and like reference numerals have been used to designate like parts. In this case, the segment comprises a pair of spaced-apart rectangular frames (a portion of one of which only is illustrated) and indicated generally by reference number **74.** This embodiment, has provided a panel extending between the opposed frame sections indicated generally by reference number **76.** This panel **76** in this embodiment may have a reduced thickness compared to the panel **28** of FIG. **3,** since in this case, the extension tubes **50** and **70** have been eliminated which for various uses of the module formed from four such segments, may not be necessary depending on its intended utility. Thus, for example, when the module made from four such segments and as such, is intended as a simple container, the extension tubes **50** and **70** may be eliminated if and as desired. In order to accommodate the reduction in thickness of the floor and of the top wall so that these walls may be connected to the frames in the manner as described above, a junction plate **78** is provided on the end of the planar member **76** and a box-beam **80** is provided along its outer edge. It can be observed that the junction plate is retentively secured with respect to the box-beam **80** and furthermore, the box-beam **80** may be hollow in its construction, as illustrated in FIG. **3.**

The basic external dimensions of the modules used in the system of the present invention may be fairly constant and hence, the modules are often referred to as "constant modules." Nevertheless, the size of the modules may be changed in either the longitudinal dimension, the transverse dimension, or the height or otherwise any or all of these dimensions may be altered. Generally, it is preferable to alter only by a multiple of the constant modules. In some cases, the overall dimension in both the transverse and longitudinal dimension are altered in order to achieve what is often referred to as a "super constant module." Notwithstanding, many of the constant modules are typically constructed with a size of approximately 8 feet by 8 feet by 10 feet. However, any of these basic dimensions of the module may be extended by the insertion of splicing members.

Referring to FIG. **5,** a module M_3 is illustrated which is substantially identical in its construction to the module M_1. The module M_3 includes frame extension members **82** which are used to connect two frame sections forming the upper portion and lower portion of the transversely opposed frames **20** and **22.** It can be observed that these frame extensions **82** are bolted or otherwise rigidly secured to the frame section **32** by means of bolts **84** or similar forms of mechanical fasteners. Furthermore, the frame extensions **82** may also be provided with cylindrical tubes **86** forming tubular ducts which extend transversely through the modules in the manner as illustrated in FIG. **5.**

An extension planar member **88** is also fitted between the top walls **24** and **26** and extends between the two frames **20** and **22.** In like manner, a lower extension planar member **90** is fitted between the bottom walls **28** and **30** and also extends between and is connected to the two opposed frames **20** and **22.** Furthermore, the planar members **88** and **90** may be similar in their construction to any of the planar members previously described, such as the planar member **28,** or they may have a different construction if desired. It should be recognized in connection with the present invention, that a number of frame extensions **82** could be used so that two frame extensions, such as the extensions **82** in the upper wall, are connected to each other and to the respective frame sections, as well as a similar extension combination in the bottom portion of the frame. In like manner, these extensions may also be used in the vertical legs of the respective frames **20** and **22** in order to increase the overall dimension of these frames. Furthermore, the width of the module may be increased by employing planar members which have a longer transverse dimension.

It should also be understood that the modules M_1–M_3 as described herein are only three embodiments of modules which can be employed in accordance with the present invention. A number of modifications can be made to these modules in order to alter the modules in such a manner as to accomplish a certain intended use function.

In use, four such similar segments may be assembled together to form a module and, a plurality of such modules may be joined together in a side to side relationship, end to end relationship and/or a vertical relationship to form a larger unit. The ducts **50** formed in the base member of each segment may be used for joining adjacent modules in an end to end relationship; when the module is joined in a side to side relationship or in a vertically "stacked" relationship (in which the panels of the segments of one module are in face to face relationship with panels of other segments of a vertically stacked module), conventional techniques may be used for joining such modules including, for example, use of bolts or like fasteners passing through or around adjacent pairs of side frame members **36** (in the case of a side to side relationship of adjacent modules) or, when vertically aligned, by using of fastening elements or brackets again according to conventional technology.

In the embodiment where the modules are joined in an end to end relationship, for the purposes of joining the same — or for placing the modules under tension as decribed hereinafter in greater detail, and reference may be had to FIGS. **1** and **8** showing the post tensioning and connecting means.

More particularly, in a preferred construction, one or more of the conduits of each panel **24, 26, 28** or **30** is provided with the tensioning means in the form of an elongated compression tube **100** — the tube being made of suitable rigid material such as, for example, various types of metals, etc. The tube **100,** being hollow, is generally sized to be of a length slightly shorter than the overall length of the respective base panels **24** to **28** and thus, each such conduit **50** in each of the panels is sized to receive the compression tube **100.** At either end of the tube **100,** at its terminal end portion **106,** there is provided a compression tube collar fixedly secured thereto by, for example, threading the former to the latter. The collar **106** in the embodiment illustrated outwardly flares and generally snugly fits the conduit **50** and positions the tube **100** therein. In joining adjacent segments together of modules placed in an end to end relationship (a cross-section of which is shown in FIG. **8**), a compression junction sleeve **104** will be mounted between the collars **106** of the respec-

tive tubes **100** of each segment. Sleeves **104** thus share a common position between end to end segments of the respective frame members.

A tie rod, connecting rod **102,** or like joining member, sized to be mounted in the compression tube **100,** is provided to form the connecting member between adjacent modules. To this end, connecting rod **102** may be a continuous one-piece tie rod or the like extending through a plurality of such units and fixedly secured at its respective ends by means of a threaded nut or the like relative to the modules; alternately, the tie or connecting rod may extend only the length of a single module with the sleeve **104** acting to secure pairs of the connecting rods **102** together. To this end, in the latter embodiment, the sleeve **104** may be internally threaded and dimensioned so as to mate with external threads adjacent the end of the connecting rod **102** to thread the sleeve onto opposed adjacent tie rod ends. In this arrangement, the modular units may be separated by a gap as shown in FIG. **8,** so that the tensioning means does not place the units per se under tension.

In FIG. **8,** the connecting rod **102** is of an extended type whereby several modules may be connected together using a single tie rod in each channel **50,** as opposed to the above embodiment where individual tie rods are used for individual modules.

Referring to FIGS. **6** and **7,** two different alternatives of joining the adjacent panels **28** and **30** (or the like panels **24** and **26**) of two adjacent modular segments together are shown in contrast to that of FIG. **1.** In FIG. **6** each of the adjacent segments are provided with a female extrusion **180** of suitable material, e.g. a metal or rigid plastic material (for example, aluminum, polypropylene, etc.). Each extrusion preferably has side edges on the upper and lower faces of the respective segments located interiorly of the outer skin or layer of the members **28** and **30.** The extrusions may also be formed integrally with the construction of members **28** and **30** or they may be secured thereto by use of fastening means 3.g. screws, bolts, adhesives, etc. Preferably each extrusion **180** forming the vertical interior edge of panels **28** and **30** actually comprises two such extrusions of similar shape terminating short of the midhorizontal point of the panels **28** and **30,** (FIGS. **6** and **7**), with a thermal barrier bonded shear strip **184** in between.

In the embodiment of FIG. **6,** there is provided joining means in the form of a tension and shear plate indicated generally by reference numeral **182,** which has a configuration such that it includes a substantially flat top portion with enlarged lateral side portions fitting into appropriate recesses in the female extrusion **180.** Connected to the shear plate **182** is a downwardly extending bulbous member **183** which is adapted to fit between the respective female extrusions **182** of adjacent segments to provide a seal which is adapted to prevent undesired foreign matter from coming between the two segments (and the space **186** therebetween). A thermal barrier bonded shear strip **184** also extends between the two extrusions **180** for each segment.

In FIG. **7,** there is illustrated an alternate arrangement in which there are provided a pair of female extrusions **190** connected to each segment with a thermal barrier bonded shear strip **194** betwewen the two extrusions for each segment. A tension and shear plate **192** is provided to join the respective segments; the plate **192** includes a pair of spaced-apart generally circular members **193** connected thereto and adapted to seat in a recess in the respective extrusions **190.**

In FIGS. **6** and **7,** there is illustrated a further type of core construction for the panel members **28** and **30.** Thus, for example, the panel members **28** and **30** may include an outer stressed skin surrounding and encasing a rigid core of, for example, foam or cementitious material.

Referring now to FIGS. **9** and **10,** there is illustrated one method of stacking the individual segments, four of which form a module of the present invention, for transporting or storing the same. To this end, as will be seen from FIGS. **9** and **10,** the segments may be stored so that one such segment is initially placed in a face-downward position with, as viewed in FIGS. **9** and **10,** the base panel **28** being on the left-hand side, with a subsequent segment placed between the opposed frame members **36** in an "upright" position. In this manner, and by repeating this arrangement, it will be seen that the segments of the present invention can be readily transported and stored in a very easy manner. Thus, an initial segment M can be placed in a "downwards" position with a subsequent segment M*a* placed in an "upright" position with the frame members **36** of each panel being centrally located relative to the base panels **28** of stacked segments. In like manner, by alternating the mounting of segments M′ – M‴ with segments M*b* – M*e*, the arrangement of FIGS. **9** and **10** provides a very simple and expedient method for transporting and storing the segments.

Referring now to FIGS. **11** to **14,** there are illustrated various uses of the modules of the present invention. As shown in FIG. **11,** a pair of such modules may be joined together by bolts **204** extending through the respective vertical frame members of the respective modules M_1. The units thus secured together may form a suitable enclosure for various types of uses, such as storage facilities, etc. They may be mounted on appropriate piers or foundations of a base B, which may for example, be the ground, etc.

In FIG. **11,** there is illustrated a further feature of the versatility of the modules M_1 of the present invention. Thus, in the right-hand module, the normally open side walls of the module M_1 may be encloed by means of a closure panel **202** (which may form an end and/or side closure panel for the module M_1). These closure panels may be formed of any suitable material such as wood, steel or plastic. The panel **202** may be secured to the frame members of the respective segments by suitable means, such as fastening means comprising screws, bolts, etc. If it is desired to make the module M_1 airtight and/or watertight, then appropriate sealing means may also be employed to seal the same to the frame members of the segments. Alternately, the closure panels **202** may be removably attached to the side walls of the module M_1 and removed only when access to the interior of the module M_1 is desired (such panels being mounted by hinge means or the like).

Also, if desired in the arrangement such as illustrated in FIG. **11,** the post tensioning means may also be employed (as described above); the ducts **50** may likewise be utilized for various other functions depending on the intended utility of the modules M_1 which are bolted together.

In the left-hand module of FIG. **11** there is illustrated a further embodiment wherein there is included only a

half or partial panel **200** which may turn the module M_1 into a type of storage container.

Referring now to FIG. **12,** there is illustrated a further version of an arrangement similar to that of FIG. **1** but in which a plurality of the modules M_1 are used to span a gap **217,** and hence form a bridge or the like. To this end, piers **215** may be provided on either side of the gap **217** with a plurality of modules M_1 joined together and separated by means of buffer elements **216.** Buffer elements **216** can be utilized in various embodiments of the present invention and function in this embodiment as a bulkhead for the catenary system used in forming the bridge type construction illustrated in FIG. **11.** In this respect, the modules M_1 are joined together by means of two systems — a tension/— compression system utilizing the arrangement illustrated in FIGS. **1** and **8** relative to the tie or connecting rods **100** mounted in the ducts **50** passing through aligned end-to-end modules M_1; and a catenary tension system indicated generally by reference numeral **200** (which may be constructed according to conventional technology). The modules M_1 forming the bridge system may be provided with side panels **202.**

In the above described arrangement of FIGS. **11** and **12,** it will be understood that the width direction of the system may include two or more such modules M_1 with the module being joined in the transverse direction by conventional fastening means.

Referring now to FIGS. **13** and **14,** there is illustrated a further embodiment of the present invention wherein the modules M_1 may be horizontally and vertically stacked. In FIG. **13,** the modules may form apartment buildings or the like; in the case of FIG. **14,** vertically aligned modules M_1 may form elevator shafts, etc. In the case of FIG. **13,** the modules may be mounted on a suitable base B with piers **190** supporting the same and with conventional fastening means extending between the base panels of the juxtaposed modules M_1 to firmly secure the same. If desired, the modules M_1 of FIG. **13** may be separated by suitable spacing means such as that described with respect to FIG. **12.**

In like manner, the modules of the present invention as shown in FIG. **14** in an end-to-end relationship may be secured together by the system described in FIGS. **1** and **8.** Thus, the post tensioning means **100** and tie rods **102** may be employed. Also, the modules may be enclosed with panels **202** to form a complete enclosure if desired. As illustrated in FIG. **14,** the modules may be mounted on a suitable foundation B of cementitious material or the like.

As will be seen from the above-described embodiments the modules of the present invention provide many advantageous features other conventional prior art constructions. Thus, for example, the modules comprised of four generally identical segments find use in a wide variety of applications; moreover the modules are capable of being constructed from four identical segments which provide a very easy system of manufacturing individual segments and permitting ready assembly into larger units (i.e. the modules). In a further embodiment of the present invention, the modules may be constructed as a one-piece monolithic unit of appropriate material, such as for example, cast cementitious material, rather than being comprised of individual members as illustrated in FIGS. **2** and **3.** The use of a cast or monolithic system has several advantages in terms of manufacturing steps employed, equipment required, etc. and may be preferred for certain circumstances.

As will also be evident from the above-described embodiments, the use of the post tensioning means of the present invention does not import post tensioning factors into the system per se as do the prior art arrangements. Thus, by use of the present invention and with buffer or bulkheads, the post tensioning system may be employed whereby the modules M_1 per se are not under tension.

Having regard to the above description, it will be appreciated that various modifications can be made to the above described embodiments without departing from the spirit and scope of the invention.

I claim:

1. A hollow generally rectangular modular construction unit constructed with a plurality of generally similar end frames which are joined together to form the generally rectangular modular construction unit, said modular construction unit comprising:

a. a first pair of opposed spaced-apart generally parallel end frame segments,

b. a second pair of opposed spaced-apart generally parallel end frame segments,

c. each of the end frame segments in said first pair of segments being substantially identical in construction to the end frame segments in said second pair of end frame segments,

d. each of said end frame segments comprising;

1. a first limb,

a. said first limb having a pair of spaced-apart plates,

b. extension means connecting said plates together in said spaced-apart relationship,

c. means forming an elongated slot at one end of said first limb between said plate,

d. one of said spaced-apart plates having an outwardly presented first connecting end wall,

e. the other of said second-apart plates having an outwardly presented second end wall,

2. a second limb at a mutually angled relationship with respect to said first limb,

a. said second limb having a plurality of angularly located side walls forming a hollow tubular member,

b. projection means extending outwardly from the plane of one of said side walls and being sized for snug fitting disposition within the slot in said first limb,

e. said first pair of said end frame segments being capable of being joined together to form a first end frame,

f. first connecting means for connecting the first pair of end frame segments together to form the first end frame,

g. said second pair of end frame segments being capable of being joined together to form a second end frame,

h. second connecting means for connecting the second pair of end frame segments together to form the second end frame,

i. said first and second end frames capable of being joined together to form a generally rectangular modular unit,

j. third connecting means for connecting the first end frame to the second end frame to thereby form said generally rectangular modular unit,

k. a first generally rectangular base member for use with said first end frame,
l. a second generally rectangular base member for use with said second end frame,
m. each of said base members being substantially identical in construction and
1. each said base member having first and second pairs opposed and generally side margins,
2. each said base member also having a first generally planar major surface,
3. each said base member further having a second generally planar major surface opposed to said first major surface,
n. first securement means for connecting each of the first pair of side margins of the first base member to the respective connecting end walls of the first pair of end frame segments in the first end frame,
o. second securement means for connecting each of the first pair of margins of the second base member to the respective connecting end walls of the second pair of end frame segments in the second end frame,
p. the connecting walls of the end frame segments in each said pair of end frames being located in abutting engagement with each of the respective first pair of side margins of the associated base members,
q. the end frame segments in each of said pair of end frames extending outwardly and in generally perpendicular relationship to the opposed planar major surfaces of the associated base members,
r. said first and second base members each having one of their margins in the second pair of parallel side margins in juxtaposed abutting engagement when the first and second end frames are connected together, and
s. the first generally planar surface of each of said first and second base members are coplanar and generally coextensive when the first and second end frames are connected together.

2. The modular construction unit of claim **1**, wherein the extension means connecting together said spaced-apart plates of said first limb are tubular extension means.

3. The modular construction unit of claim **1**, wherein said second limb is provided with four angularly located side walls to form a rectangularly shaped hollow tubular member.

4. The modular construction unit of claim **1**, wherein each of said end frame segments is comprised of a pair of first limbs and a pair of second limbs.

5. The modular construction unit of claim **1**, wherein a first planar member similar in construction to said first base member extends between and is secured to the first and second end frame segments of said first end frame, and wherein said first planar member is spaced from and lies in generally parallel relationship to said first base member, and a second planar member similar in construction to said second base member extends between and is secured to the first and second end frame segments of the second end frame, and wherein said second planar member is spaced from and lies in generally parallel relationship to said second base member.

6. The modular construction unit of claim **1**, wherein the basic internal dimensions of said modular units are altered by insertion of splicing elements between the base members associated with adjacent end frame segments.

7. The modular construction unit of claim **1**, wherein at least the first pair of said end frame segments includes at least one aperture extending therethrough and the first base member includes at least one aperture extending between said opposed pair of major surfaces of said first base member, and which apertures are in communication with each other.

8. A combination of a plurality of the modular construction units of claim **1** being assembled and secured together in an end to end relationship, and means for fixedly securing said units together.

9. The combination of claim **8**, wherein at least one pair of end frame segments and the associated base member of the first end frame in each modular construction unit includes at least one axially extending aperture between said opposed pair of major faces in the base member, and tensioning means extending between adjacent joined modular construction units, said tensioning means being adapted to tension said combination of units without placing said modular construction units under tension.

10. The modular construction unit of claim **5**, wherein the first planar member associated with one of the first end frame lies in juxtaposed butting side-to-side relationship with the second planar member associated with the other of the second end frame when the first and second end frames are joined together.

11. A one-piece segmented base unit suitable for forming a modular construction unit with generally similar base units when assembled together, each said one-piece base unit comprising:
a. a generally planar substrate member,
1. said substrate member having first and second pairs of opposed generally parallel side margins,
2. said substrate member also having a first major planar surface,
3. said substrate member further having a second major planar surface opposed to said first major planar surface,
b. a pair of opposed spaced-apart generally parallel end frame segments,
c. each of said end frame segments comprising:
1. a first limb,
a. said first limb having a pair of spaced-apart plates,
b. extension means connecting said plates together in said spaced-apart relationship,
c. means forming an elongated slot at one end of said first limb between said plates,
d. one of said spaced-apart plates having an outwardly presented first connecting end wall,
e. the other of said spaced-apart plates having an outwardly presented second end wall,
2. a second limb at a mutually angled relationship with respect to said first limb,
a. said second limb having a plurality of angularly located side walls forming a hollow tubular member,
b. projection means extending outwardly from the plane of one of said side walls and being sized for snug fitting disposition within the slot in said first limb,
c. said pair of said end frame segments being capable of being joined together to form an end frame,

d. connecting means for connecting the pair of end frame segments together to form the end frame,

e. securement means for connecting each of the first pair of side margins of the substrate member to the respective connecting end walls of the first limbs forming part of the pair of end frame segments,

f. the connecting end walls of the first limb in each end frame segment being located in abutting engagement with each of the first pair of side margins of the substrate member,

g. the end frame segments extending outwardly and in generally perpendicular relationship to the opposed planar major surfaces of the substrate member, and

h. said substrate member extending for substantially the greater portion of the length of said first limb on each end frame segment, so that when two base units are assembled together, the substrate member of one base unit will be coplanar with and will have one side margin of the second pair of side margins in juxtaposed abutting relationship to a like side margin of the planar substrate member associated with the other base unit.

12. The one-piece segmented base unit of claim **11**, wherein the extension means connecting together said spaced-apart plates of said first limb are tubular extension means.

13. The one-piece segmented base unit of claim **11**, wherein said second limb is provided with four angularly located side walls to form a rectangularly shaped hollow tubular member.

14. The one-piece segmented base unit of claim **11**, wherein each of said end frame segments is comprised of a pair of first limbs and a pair of second limbs.

15. The one-piece segmented base unit of claim **11**, wherein a second substrate member similar in construction to said first named substrate member extends between and is secured to the end frame segments, and wherein said second substrate member is spaced from and lies in generally parallel relationship to said first named substrate member.

16. The one-piece segmented base unit of claim **11**, wherein said end frame segments include at least one aperture extending therethrough, and the substrate member includes at least one aperture extending between said opposed pair of major surfaces of said substrate member, and which apertures are in communication with each other.

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