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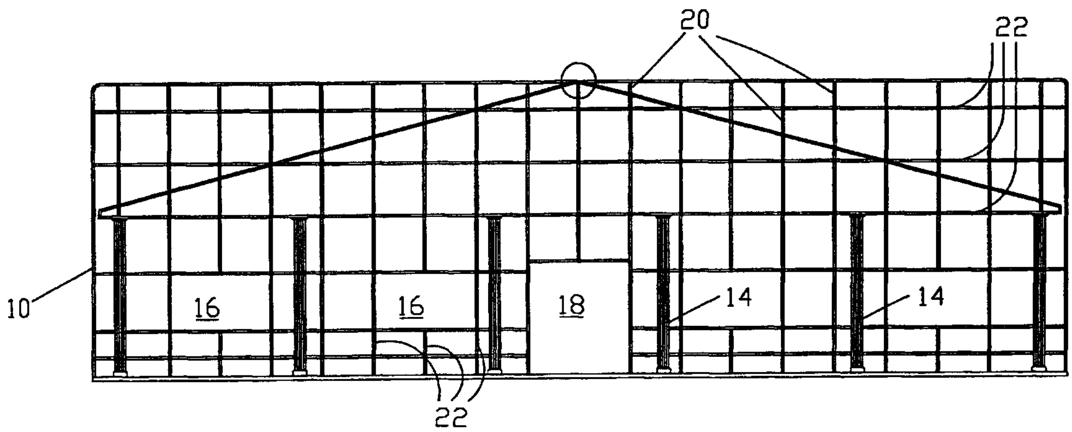
(54) Title: BUILDING SYSTEM



(57) Abstract: Load bearing panels and walls for habitable shelters (10) are formed from a matrix of relatively thin-wall metallic tubing (20, 22) on widely spaced centers joined by a multiplicity of joint systems (26, 23). Individual tube lengths are axially extended by lap splice joints (32) with internal splicing pin (30) that is secured with a shrink fit to each of abutting tube ends (20a, 20b). Tube intersections within a wall matrix are secured without welds or shear fasteners by diametric penetration of one tube by the other through a punched and stretched aperture (23). Tube intersections in a wall matrix can also be secured by mutually clasping saddles (26) that are formed in each of the intersecting tubes at standardized positional increments. Discreet interference fit tolerances facilitate the construction of a non-welded, stress distributing structure highly suitable for earthquake resistance and fire survival.

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BUILDING SYSTEM

TECHNICAL FIELD

The present invention relates to habitable structure construction systems and articles for assembling structural framing components. More particularly, the invention pertains to methods and apparatus for erecting habitable structures that are particularly resistant to failure and collapse due to seismic events.

BACKGROUND ART

Western construction methods are not particularly tolerant of seismic vibration. These methods of construction are characterized by assemblies of rigid but friable materials such as brick, stone and mortar. Although modern commercial construction usually relies upon a steel superstructure that is paneled with masonry and plaster, the steel load bearers are heavily stressed and joined by welded or riveted shear joints. When whipped by the high amplitude, low frequency ground movement of a seismic disruption, welds are broken and rivets are sheared. Upon failure of the assembly fasteners, the joints separate and the steel superstructure collapses.

Others have observed that construction methods and materials used by native cultures of the Pacific Rim are very earthquake tolerant. Significant characteristics of this technology include the use of wood and bamboo assembled by leather thongs, grass and leaves. Timbers are joined without nails or pegs. Rather than rupture, such joints merely slip in their lashings or sockets.

The central essence of these earthquake resistant construction methods is not so much in the indigenous materials used but in the absence of rigidly joined points of high load and stress concentration. It is in the capacity of the structural joints to yield, slip and twist without stressing the fasteners or load bearers beyond the point of failure that distinguishes the primitive Pacific construction methods for being earthquake proof.

It is, therefore, an object of the present invention to provide some construction assembly methods and techniques that adopt the primitive low stress joint technology to modern, high strength materials.

Another object of the present invention is to provide methods and apparatus for erecting habitable structures with relatively thin wall tubing construction elements but without rigid joint fasteners such as welding, nails, rivets or threaded sockets.

DISCLOSURE OF INVENTION

These and other objects of the invention are accomplished by a habitable structure construction system of thin-wall tubing wherein load bearing walls are formed as a woven fabric or matrix of tubing having compliant joints at critical points of tube length intersection. The intersecting tubes are structurally independent at least along one tubular axis. Relative movement between the tubes along that axis is permitted without structural failure of a fastener or assembly element. However, such movement is attended by considerable friction.

In one specific embodiment, the intersection comprises the diametric penetration of one tube by the other. Distinctively, the penetration aperture through the receptacle tube is mechanically punched. Substantially no tube wall material is removed or separated from the receptacle tube. For an intersection of tubes having substantially the same size and sectional geometry, the receptacle tube walls are stretched around the aperture therebetween to accomodate the internal penetration of the intersecting tube. The wall material displaced by the aperture punch remains around the aperture to resiliently bear upon the internal tube wall with great frictional force.

In another assembly embodiment, the intersecting tubes are locally deformed into respective saddle shapes at points of intersection along the tube lengths. The saddle seats respective to each tube of an intersection joint are oppositely facing whereby each seat receives the seat of the other in the manner of a mutual handclasp. Additionally, the orientation of the saddle seats alternates along the axial length of a single tube whereby the structural continuity of a single tube meshes with serially intersecting tubes. Sloping sides to the joint saddles and the resilient properties of the tubing material impose a bias on the clasping saddle seats to restore and return the seats to a stable assembly position whenever displaced by a high amplitude shock wave.

. Collectively, the structure is assembled with the strength and compliance of a woven wire cage or basket wherein dynamic loads are absorbed as frictional heat and spring stress. Standardized blocks, preferably of a ferrous material, are bored along mutually perpendicular axes to receive the end of a joint pin. The internal diameter dimensions of the joint block bores are formed smaller than the outside diameter of respective pins. A joint is made by heating or cooling one member of the joint and quickly inserting one joint element coaxially within the other.

Alternatively, the pin surfaces and block bores may be turned to low, 5% or less, taper angles and driven together with shock force.

Continuous length tube elements are formed similarly by joining short lengths of tubing with an internal, tubular lap splicing pin. Such internal lap splice pins correspond to the pins that are joined in the bores of corner blocks.

Joist and sill joints also are formed by interference fitting splice pins.

Suitable applications of the invention may include site constructed residential dwellings, factory constructed mobile homes, industrial workplace shelters, truck bodies and agriculture out-buildings such as barns and implement shelters

BRIEF DESCRIPTION OF DRAWINGS

The preferred embodiments and best modes of practicing the invention are described in further detail with reference to the drawings wherein:

FIG. 1 is a front elevation of a rectangular structure constructed according to the present invention;

FIG. 2 is an end elevation of the FIG.1 structure;

FIG. 3 represents an initial step in the construction sequence of a foundation;

FIG. 4 represents vertical tube erection from the foundation line in an end wall construction sequence;

FIG. 5 represents the position of horizontal tubes in the construction sequence of an end wall;

FIG. 6 represents the completed end wall matrix of the invention;

FIG. 7 represents the roof construction of the invention;

FIG. 8 represents a foundation section for the invention;

FIG. 9 illustrates the sequence of a lap splice procedure for axially extending the length of a tube;

FIG. 10 illustrates the sectioned elevation of a 90° intersection joint for the invention;

FIG. 11 illustrates the plan of the intersection joint of FIG. 10;

FIG. 12 illustrates the end elevation of the intersection joint of FIG. 10;

FIG. 13 illustrates the sectioned elevation of a punctured tube intersection embodiment of the invention;

FIG. 14 illustrates the plan view of the FIG. 13 intersection;

FIG. 15 illustrates the front elevation view of a woven wall matrix of the invention;

FIG. 16 illustrates the end elevation view of the woven wall matrix;

FIG. 17 is a sectioned view of an intersecting saddle joint;

FIG. 18 is a sectional view of the saddle joint along cutting plane 18-18 of FIG. 17;

FIG. 19 is a sectional view of the saddle joint along cutting plane 19-19 of FIG.17;

FIG. 20 is an elevation view of a circular plan structure according to the invention;

FIG. 21 is a plan view of the circular structure of FIG. 20;

FIG. 22 is a sectional elevation of a yoke joint as viewed along cutting plane 22-22 of FIG. 23;

FIG. 23 is a sectional plan of a yoke joint as viewed along cutting plane 23-23 of FIG. 22;

FIG. 24 is a side elevation view of a yoke joint;

FIG. 25 is an end elevation view of a yoke element;

FIG. 26 is a plan view of a yoke element;

FIG. 27 is a side elevation view of an eye element;

FIG. 28 is an end elevation view of an eye element;

FIG. 29 is a plan view of an eye element;

FIG. 30 is a plan view of a clevis element;

FIG. 31 is a sectional elevation view of a clevis element as viewed along cutting plane 31-31 of FIG. 32;

FIG. 32 is an end view of a clevis element;

FIG. 33 is a sectional elevation of a tongue element;

FIG. 34 is a plan view of a tongue element;

FIG. 35 is an end view of a tongue element.

FIG. 36 is a sectional elevation of a lap joint connector.

FIG. 37 is a top view of a lap joint connector.

FIG. 38 is a sectional end view of a lap joint connector.

BEST MODES FOR CARRYING OUT THE INVENTION

Relative to the drawings wherein like reference characters designate like or similar elements throughout the several figures of the drawings, FIGs. 1 and 2 illustrate a western style rectangular structure 10 having a covered porch 12 along the entire front length dimension. The porch roof overhang is supported by columns 14. Windows 16 and doors 18 are openings in the vertical load bearing wall panels. Additional load bearing panels for support of roof, floor and ceiling loads are positioned internally of the outer walls. These load bearing walls and panels are constructed as substantially uniform, orthogonal distributions of vertical and horizontal structural tube elements, 20 and 22, respectively. The preferred cross-sectional geometry of such transversely intersecting tube elements 20 and 22 is circular. However, the invention features may be readily adapted for other cross-sectional shapes such as square or rectangular. As tubes, the cross-sectional geometry of elements such as 20 and 22 comprises a relatively thin perimeter wall about an internal void space. Definitively, a "tube", as the term is applied to this invention, is not a structural member having a solid material cross-section. In the case of a circular tube 20 or 22 for the present invention, the perimeter wall cross-section is substantially annular, e.g. the material substance of the tube wall occupies the space between substantially concentric inside and outside circular diameters.

Another characteristic of the tube elements 20 and 22 is that both elements of a transversely intersecting group are preferably of substantially the same size and shape. For example, circular tubes 20 and 22 preferably have substantially the same outside dimension and substantially the same inside diameter dimension. This characteristic substantially simplifies the construction site logistics of material supply.

It will be appreciated by those having skill in the art that a load bearing panel must also include a defining or delineating perimeter whereat the panel is joined to one or more other panels. In the case of a wall, for example, the panel perimeter may include a floor perimeter line, a ceiling perimeter line and usually a vertical corner perimeter line. Accordingly, a group of parallel tube elements 20 and 22 will be secured, at least at one end thereof, at substantially uniform separation increments along a perimeter line common to the respective group. Hence, the plane and shape of a load bearing panel is substantially defined by at least a pair of mutually intersecting perimeter lines.

From the perimeter line of structural attachment, longitudinal or axial extensions of the structural tube elements 20 and 22 make a matrix of substantially coplanar intersections of the tubular axes without a rigid connection therebetween. The respective tubes may slide from these intersection points, at least along one axis, without a structural failure of the joint: albeit, such sliding is attended by considerable friction. FIGs. 13 and 14 illustrate one embodiment of such a joint wherein a receptacle tube of the intersection, in the horizontal run 22, for example, is penetrated by the continuous cooperative tube 20. Since both tubes are of substantially the same diameter, the girth of the receptacle tube 22 is expanded to accommodate the penetrant 20. Preferably, the receptacle aperture is formed by mechanical puncture as distinguished from boring. Boring forms an aperture by material removal. Puncture, on the other hand, forms the receptacle aperture by piercing and stretching the tube wall material away from the aperture axis.

Puncture apertures are formed by sharply pointed punch tools having an outside diameter shank corresponding to the desired diameter of the aperture. Advancement of the punch tool through the wall of tube 22 stretches and rolls tube wall material from the punch path into a friction flange 23. At the same time, the inside diameter of the receptacle tube 22 is stretched in a direction transverse to the penetrant tube 20 axis. Accordingly, the receptacle tube 22 outside diameter is deformed to bulge around the penetrant tube 20 by the approximate tube wall thickness on diametrically opposite sides as best illustrated by FIG 14.

As another form of matrix intersection joint consistent with the objectives of this invention, FIGs. 15 and 16 illustrate a woven wall, roof or floor load panel of circular cross-section stringers 20 and longerons 22. These stringers and longerons are, for example, round, thin-wall, architectural steel tubing of 2 in. nominal diameter. Both stringers and longerons are formed to a saddle profile 26 (FIG. 17) at each matrix intersection. Along each tube element, the saddle seat surfaces 27 are sequentially turned in oppositely facing directions. This alternating saddle seat orientation sequence of one element is orthogonally coordinated with the cooperative tube elements also having alternately facing saddle seats 27. In mutual assembly after the manner of a simple basket weave, the saddle socket 29 of one element is detent confined within the saddle socket 29 of the cooperative element.

These intersecting saddles may be field formed with relatively light weight hydraulic forming equipment. Preferably, however, such saddle shapes are formed on continuous production equipment that automatically maintains the spacing and alternating orientation of all saddles in a tube length.

With particular reference to FIGs. 17, 18 and 19, each saddle 26 is shown to include a flattened seat surface 27 that is essentially square having an axial length dimension corresponding to a transverse width dimension. Broadly, the circular perimeter of a tube wall is reconfigured to a rectangular prism having a depth that is substantially equal to the outside radius of the undistorted tube circle. Shoulders 28 axially delineate the seat surface 27 to bias and confine the cooperative tube saddle that is seated therewith. From the outer elements of the tubes, each shoulder 28 is sloped funnel a cooperative saddle into an appropriate intersection and confine it there without the rigid, unyielding attachment of rivets, bolts or welds, for example. Even when a pair of saddles is separated, the statically standing, stable bias of the assembly induces a return to the preferred, mutually clasping alignment.

As primary structural elements of the present invention, a length of preformed tubing may be selectively trimmed in the traditional manner of sawing or roll cutting. Unconventionally, however, thin wall steel tubing may be axially extended by means of an internal lap splice joint in the manner of FIG. 9. With the objective of axially extending the length of tubing joint 20a, the end of a metallic joint 20a is heated by means of a portable torch or furnace to enlarge the tubing inside diameter. While the end of tube 20a is hot, approximately half of a lap splice pin 30, at ambient temperature, is inserted coaxially into the open-ended bore of the hot tube end as shown by FIG 9A. When cooled, the internal bore surface of the tube end shrinks upon the external surface of the pin 30 for a constrictive, interference fit therebetween.

Unstressed or free dimensions of the tube ends 20a at ambient temperatures necessitates an inside diameter that is less than the outside diameter of a splice pin 30. In assembly, such a dimensional relationship is characterized as an interference fit. Both elements of the joint thermally stabilize to respective states of prestress with the tube 20a in tensile hoop stress and the pin 30 in compressive hoop stress. Preferably, such stress is substantially balanced. The degree of prestress in the respective elements is predominately controlled by the percentage of diameter differential. A standardized interference fit stress calls for an inside interference diameter difference of 0.6% to 1.0%. Assuming a 2.0 in. ambient interference fit diameter, the ambient inside diameter of the tube 20a end may be, for example:

$$2'' - (2'' \times 0.006) = 2'' - 0.012'' = 1.988''$$

A corresponding ambient outside diameter for the pin 30 may be:

$$2'' + (2'' \times 0.001) = 2'' + 0.002 = 2.002''$$

In total, therefore, the interference fit differential is:

$$2.002'' - 1.988'' = 0.014''$$

Interference fit dimensions may be established for 0.002" to 0.015" interference differentials.

Duplicating the foregoing assembly of tube 20a with pin 30, tubing element 20b is heated and quickly pushed upon the projecting half of lap pin 30. Preferably, the two tube ends 20a and 20b are pushed into coaxially abutting union as at joint 32 of FIG. 9B. A conservative empirical lapping dimension could be a pin 30 axial penetration depth into the ends of tubes 20a and 20b of about three to four pin diameters.

Although the preferred embodiments of my invention utilize a heated interference fit as described for steel, ferrous alloys, aluminum, brass and other metallic tube forming materials, other coaxial joint techniques may be satisfactorily employed. For example, a slip fit joint of fiberglass and plastic tubing as well as metallic tubing may be axially secured by polymer bonding agents such as epoxies and polyester resins. Also, an axial slip fit joint of metallic tubing may be positionally secured after assembly by staking or beading. Staking is a procedure whereby a dull pointed tool is struck against the outer element wall of a coaxial assembly to dimple the outer wall into the inner wall. Depending on the degree of security required between the two coaxial elements, numerous dimples may be struck around the tube perimeter.

Beading may be considered a circumferentially continuous form of staking whereby a circumferential bead is rolled into the outer assembly element wall of such depth as to form a radially aligned bead into the wall of the inner assembly element.

Coaxial joints may also be secured by a tapered pin and socket assembly whereby an internal surface of a tube socket is formed with a smooth, low angle, tapered face. Taper angles of five degrees or less have been used. A corresponding taper angled surface on the pin element of an assembly is forcefully mated into the socket.

There are numerous construction circumstances that require abrupt, 90° planar intersections. To facilitate these construction circumstances, the present invention provides appliances such as those illustrated by FIGs. 10, 11, and 12 that are based upon an elbow block 34 having bores 36a and 36b with mutually perpendicular axes 38a and 38b, respectively. Lap splice pins 30a and 30b are mated to the respective block 34 bores with an interference fit. Also, panel tubes 20 or 22 are secured to the lap splice pins 30a and 30b by interference fit.

The same principle of an elbow block may be further developed to additional configurations not illustrated such as a tee having a lap splicing length of lap pin 30a projecting from both axial ends of bore 36a.

Those of ordinary skill in the art will recognize that the construction principles embodied in the elbow block and lap pin corner assembly appliance may be expanded to include axial projections in 3, 4, 5, and 6 directions. A particular application of the appliance is illustrated by FIG.8 as a foundation interface for the shelter superstructure. Lap pins 30a and 30b are interference fitted to a common elbow block 34. The projected ends of the lap pins receive and secure the lower ends of vertical tubes 20 along a first, vertical plane and the ends of slab panel tubes 22 in the horizontal plane. The horizontal plane includes a multiplicity of parallel aligned horizontal tubes 22 that are cast in concrete for a reinforced slab 40.

With reference to the construction sequence of FIGs. 3 through 7, FIG. 3 illustrates a foundation slab 40 from which vertical lap pins 30a project along the lines of the load bearing vertical walls and partitions. FIG.4 illustrates the vertical tubes 20 to form an outside load bearing wall erected over the lap pins 30a in free-standing, vertical alignment. At positions along the wall corresponding to the location of windows and doors in the wall panels, the vertical tubes 30a are shortened as those represented by 42 or eliminated.

Referring to FIG.5, the horizontal tubes 22 are matrix mated to the vertical tubes 20. In the case of a penetrated intersection matrix as shown by FIG. 14, a single horizontal tube length 22 may include several penetration points to be mated by an overlay procedure with corresponding vertical tubes 20. For convenience, the vertical tubes 20 may be extended axially by relatively short sections joined by lap pins 30. As a section of vertical tube is extendeed, lengths of punctured horizontal tube 22 are impaled upon the free-standing vertical joints.

A woven intersection matrix as represented by the clasp saddle intersections of FIGs. 15 through 19, may be constructed with the vertical tubes erected to their upper terminus. Appropriate care should be taken, however, to horizontally align the adjacent saddles 26.

The assembly components illustrated by FIGs.22 through 29 are constituents of a first panel joint embodiment whereby the planar intersections of different panels are secured together along the common perimeter line. For example, corner tube 60 may be temporarily secured along a line of intersection 68 common to panels that include horiontal tubes 22a and 22b, respectively. The distal ends of the tubes 22a telescopically receive, with a sliding fit, shanks 64 respective to a yoke joint 62. Shown by FIGs. 24 and 25, a pair of collars 66 are rigidly integral with each yoke joint 62. The collars 66 are internally bored to a diameter corresponding to a slip fit around outside diameter of the corner tube 60. Set screws not shown are turned througn the collars 66 into the corner tube 60 to secure an axial location thereon.

Referring to FIGs. 26 and 29, eye joints 70 also have a shank 72 sized for a telescopically sliding fit into the end of a panel tube 22a. The eye 74 of the joint is also bored to a sliding fit over the outside diameter of the corner tube 60. The width of the eye 74 is also coordinated to the gap between the yoke collars 66 for caged confinement therebetween when in mutual embracement around the corner tube 60. If desired, the eye joint could also be secured to an axial position along the corner tube 60 by set screws not shown.

Although the yoke and eye joints are secured to axial positions along the corner tube 60, the individual horizontal tubes 22a and 22b are given compliance from the corner tube 60 along the horizontal axis.

Another panel joint embodiment of the invention is represented by FIGs.30 through 35 and comprises clevis joints 80 and 90. The clevis yoke joint 80 includes a sleeve 82 with a slip fit internal bore for telescopic receipt of a tubing 22a end. A pair of clevis yokes 84 extend rigidly from the sleeve 82. The clevis tongue joint 90 comprises a sleeve 92 having a sliding fit bore to receive the end of tubing 22b. From the sleeve 92, a clevis tongue 94 is projected with a width corresponding to the gap between the yokes 84., Both of the yokes 84 and the tongue 94 have cooperative pin bores to receive a common fastener therethrough such as a pin or bolt shank.

FIGs. 36-38 illustrate a simple lap joint 100 formed from a substantially square or rectangular billet section. A cylindrical pin 102 is turned from one end of the square billet to serve as a male insert into a tube end 22b. The other end of the billet is shaped as one cheek 104 of a lap joint. The inside face of the cheek 104 is illustrated to be substantially parallel with the tube 22b axis but it should be understood that the face may be formed to any angle that is appropriate for the joint. As in the case of the clevis joint 90, a pair of cooperative cheeks 104 are joined by a link pin not shown through cheek apertures 106.

As the matrix grows vertically, window and door frames are positioned and secured by traditional means and procedures. Matrix tubing upper ends are terminated by appropriate elbow blocks 34 into either roof rafters 44 or stringers 46. The potential for extremely rapid construction progress using the above described erection system will be apparent to those of ordinary skill in the art. Common construction materials such as low carbon steel are substantially stable dimensionally over temperate climatic conditions. Consequently, well known prefabrication techniques permit considerable off-site material cutting and forming without concern for humidity changes.

At the construction site, large numbers of tubing ends may be simultaneously heated in portable furnaces and selectively withdrawn for socketing upon a corresponding pin 30a. It is necessary to plumb only a select few of the vertical "studs" 20 due to the resilient nature of the material. The ordered spacing of the matrix intersections on the horizontal longerons 22 tends to correct any vertical misalignments relative to the plumbed tube element 20.

The shelter of FIGs 20 and 21 is constructed to a circular plan form having no inside or outside corners. In lieu of elbow blocks 34, short radius bends 50 are formed in short lengths of tubing and arced by a hydraulically powered tube bending machine. Lap pins 30 are inserted in both ends of the tubing arc to axially add length extensions from the bend 50. Horizontal ring tubes 52 may be joined with the riser tubes 20 and rafter tubes 54 by either the punctured apertures of FIG.13 or the clasp saddle means of FIG. 17.

The foregoing description of my invention has been of a structural skeleton assembly. Those of ordinary skill in the art, however, will understand that most if not all traditional enclosure materials such as brick, stone, tile, wood and plaster may be integrated with the present invention by means of appropriate ties and /or clamps to the structural tubing. In doing so, however, due consideration should abe given to the structural properties and characteristics of the facade material. For example, brick ties between a tube wall of the present invention and a veneer wall of brick are of poor risk for holding the brick facade together during a major earthquake. Conversely, exterior plaster secured by metal lathing at densely distributed tie points represents a wall that will maintain its essential structural integrity notwithstanding cracking and small particle dislodgment.

Having fully disclosed my invention, those of ordinaty skill in the art will perceive obvious variations and alternatives to combine with the invention. As my invention, however, I CLAIM:

CLAIMS

Claim 1. A method of constructing habitable structures comprising a plurality of load bearing panels, each panel being delineated within a perimeter defined by a plurality of perimeter lines, respective to a first load bearing panel, said construction method including the steps of: securing a first line of parallel aligned tubing elements at least at one end thereof and at substantially uniform increments of separation therebetween along a first perimeter line length for said first load bearing panel, securing a second line of parallel aligned tubing elements at least at one end thereof and at substantially uniform separation increments along a second perimeter line length for said first load bearing panel whereby length extensions of said second line of tubing elements meet transversely at points of intersection with length extensions of said first line of tubing elements, said tubing elements in said first and second perimeter lines having substantially the same transverse sectional geometry and dimension with a relatively thin wall structure, tubing element wall structure corresponding to said first line tubing elements being structurally deformed at substantially uniformly separated positions along the length extensions thereof corresponding to said points of intersection, said second line of tubing elements being non-structurally secured to said first lineof tubing elements at said points of intersection by frictional engagementwhereby said tubing elements may be nondestructively displaced from and returned to said points of intersection along a length direction of at least one of such intersecting tubing elements without structural failure of an assembly element.

Claim 2. A method as described by claim 1 wherein the tubing element wall structure respective to said first line of tubing elements is formed at respective points of intersection to possess a greater dimension than the corresponding transverse dimension of tubing element wall structure in said second line of tubing elements, said deformed tubing element wall structure having punctured apertures along axes substantially perpendicular to said one transverse sectional dimension, said apertures being penetrated by tubing elements respective to said second line of tubing elements with a sliding friction fit therebetween.

Claim 3. A method as described by claim 1 wherein tubing element wall structure respective to tubing elements in both of said first and second tubing element lines are coopetatively deformed at said points of intersection to clasp the other.

Claim 4. A method as described by claim 3 wherein said tubing element wall structure is deformed at said points of intersection to mutually engaging saddle profiles.

Claim 5. A method as described by claim 4 wherein saddle deformations are formed with alternately facing seat portions along a tubing element length.

Claim 6. A method as described by claim 1 wherein lengths of said tubing elements are axially extended by lap splicing pins.

Claim 7. A method as described by claim 6 wherein outside diameter surfaces of said lap splicing pins coaxially engage internal diameter surfaces of said tubing elements.

Claim 8. A method as described by claim 7 wherein unstressed outside diameters of said lap splicing pins are greater at the same temperature than unstressed inside diameters of said tubing elements.

Claim 9. A method as described by claim 8 wherein end portions of said tubing elements are heated to enlarge said inside diameter dimensions and said pins are partially inserted axially therein while said tubing elements are hot.

Claim 10. A method as described by claim 1 including the steps of setting anchor blocks in a castable foundation material at said substantially uniform increments along said first perimeter line, said anchor blocks having splice pins projecting up from a surface of said foundation, said splice pins coaxially receiving said tubing elements thereabout with an interference fitting relationship.

Claim 11. A method as described by claim 10 wherein at least two splice pins project from each of said anchor blocks along mutually perpendicular axial directions.

Claim 12. A method as described by claim 10 wherein a second of said splice pins is set within said castable foundation materials.

Claim 13. A method as described by claim 10 wherein said first perimeter line is curvilinear.

Claim 14. A method as described by claim 1 wherein at least one line of parallel aligned tubing elements are secured along the length of the corresponding perimeter line at substantially fixed separation increments and with sliding axial compliance transversely from said perimeter line.

Claim 15. A method as described by claim 14 wherein said corresponding perimeter line is common to a second load bearing panel.

Claim 16. A method as described by claim 15 wherein said corresponding perimeter line common to said first and second load bearing panels is formed by a length of tubing, each first panel tubing element secured to the common perimeter line tubing is telescopically assembled with a yoke collar.

Claim 17. A method as described by claim 16 wherein each second panel tubing element secured to the common perimeter line tubing is telescopically assembled with an eye collar, said eye collar being meshed with said yoke collar in mutual embracement of said common perimeter line tubing.

Claim 18. A method as described by claim 15 wherein each first panel tubing element secured to said common perimeter line is telescopically assembled with a clevis joint and each second panel tubing element secured to said common perimeter line is telescopically assembled with a tongue joint, said clevis joint and tongue joint being assembled by a common shear pin.

<u>Claim 19.</u> A habitable structure comprising a geometric assembly of load bearing panels, said load bearing panels comprising an assembly of relatively thin walled tubes that includes:

a first row of parallel aligned tubes secured at one end thereof and at substantially uniform separation increments along a first perimeter increment of a load bearing panel, tubes in said first row having substantially the same transverse sectional shape and dimension;

a second row of parallel aligned tubes secured at one end thereof and at substantially uniform separation increments along a second perimeter increment of said load bearing panel;

said first and second rows being relatively aligned whereby axial extensions of tubes in said second row meet at points of intersection with the axial extensions of tube in said first row;

tubes in said second row having substantially the same transverse sectional shape and dimension as tubes in said first row except for tube wall deformations in the proximity of said points of intersection;

the walls of tubes in at least one of said rows being structurally deformed proximate of said points of intersection to mesh with tubes in the other of said rows and substantially align the axes respective to said tubes in a common plane of intersection;

the material substance of tube walls respective to tubes in both of said rows being continuous through said intersections with an enhanced frictional engagement between said tubes.

<u>Claim 20.</u> A structure as described by claim 19 wherein tubes in said first row penetrate the tubes in said second row through punched apertures in said second row tubes.

Claim 21. A structure as described by claim 19 wherein said tubes are deformed into saddle shapes at said intersection points, mutually engaging saddles at an intersection point having oppositely oriented seats.

Claim 22. A structure as described by claim 21 wherein the seats of successive saddles along the length of a tube are alternately oriented in oppositely facing directions.

Claim 23. A structure as described by claim 19 wherein said tubes are axially extended by lap splicing pins inserted axially within the tube walls of abutting tube ends.

Claim 24. A structure as described by claim 23 wherein said lap splicing pins have outside diameters that are dimensionally greater at ambient temperature than inside diameters respective to said abutting tube ends for an interference fit therebeween.

Claim 25. A structure as described by claim 24 wherein said abutting tube ends are heated to increase the respective tube inside diameters for partial length insertion of a respective lap splice pin.

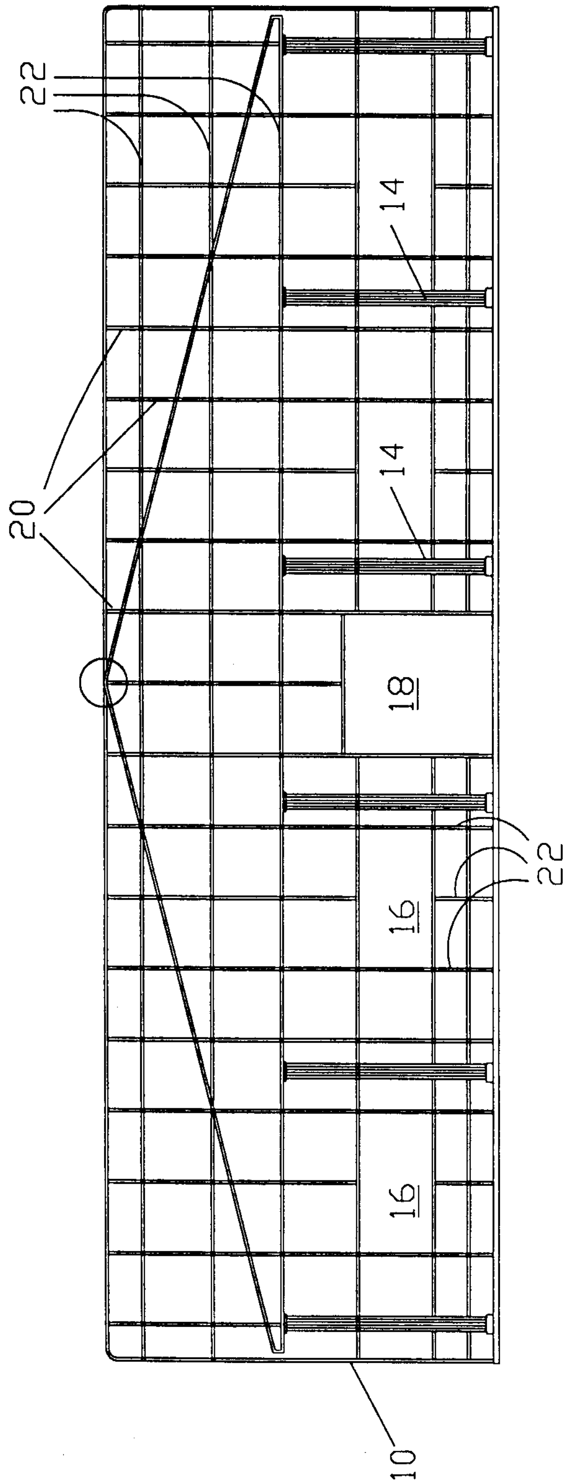

FIG. 1

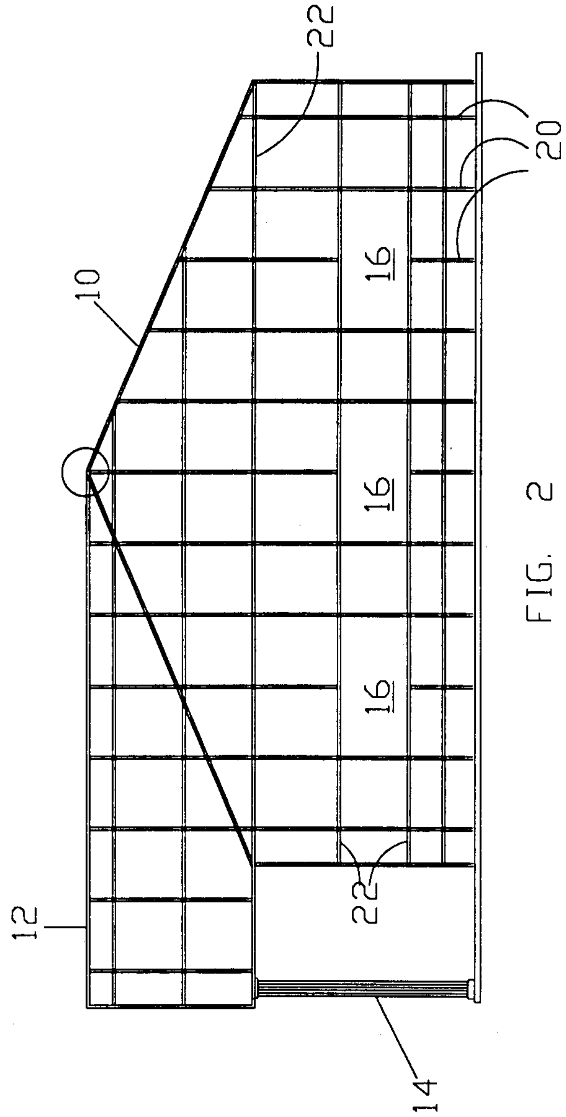

FIG. 2

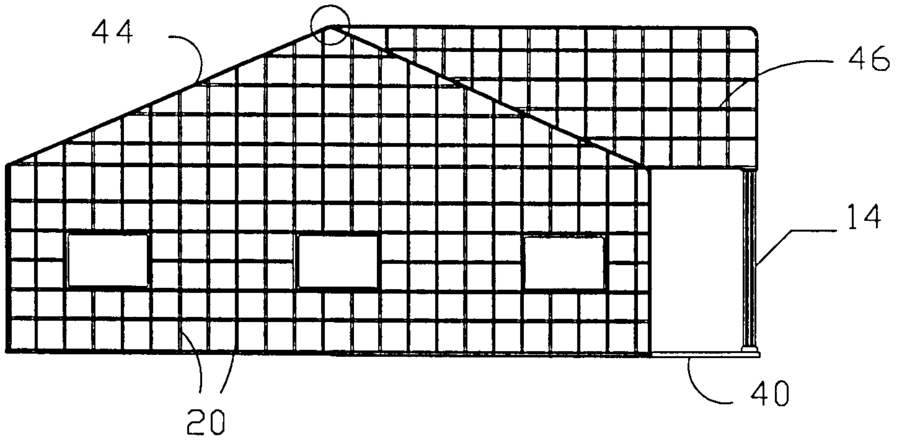

FIG. 7

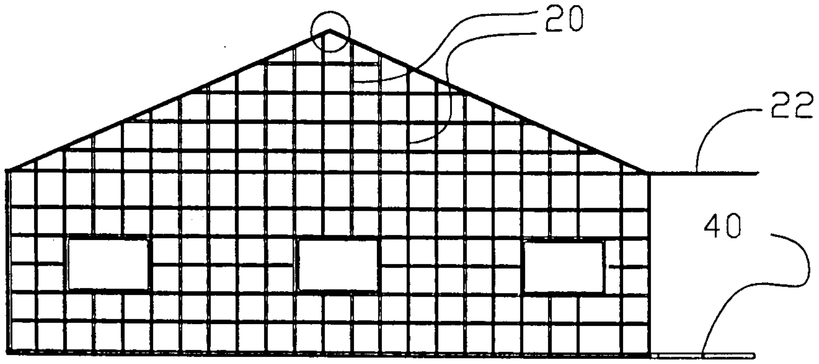

FIG. 6

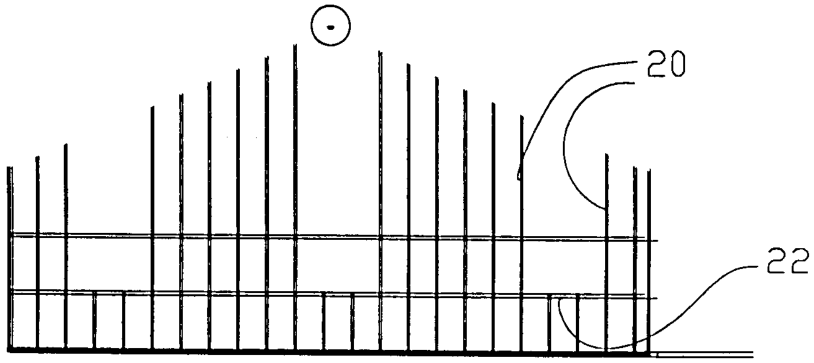

FIG. 5

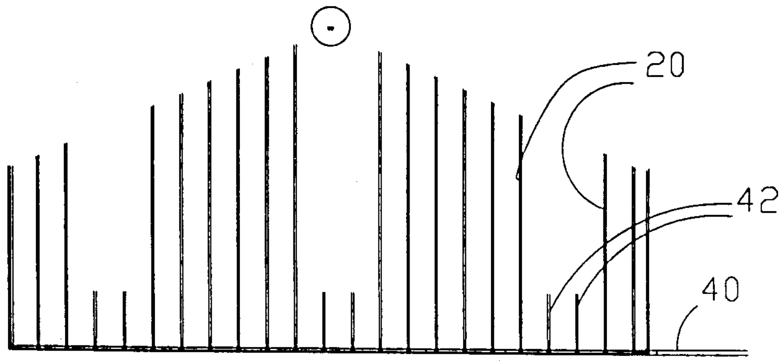

FIG. 4

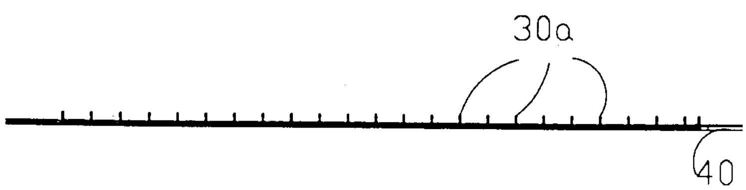

FIG. 3

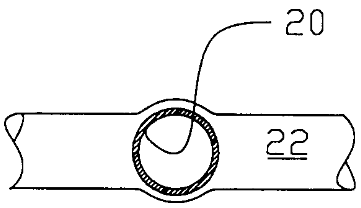

FIG. 14

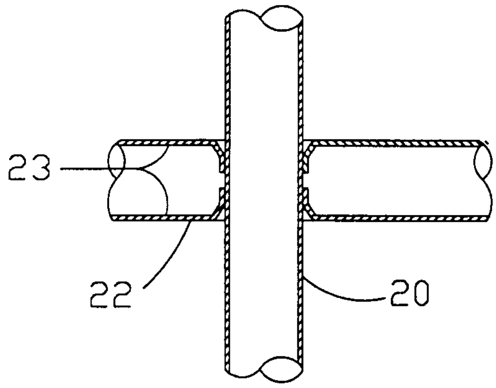

FIG. 13

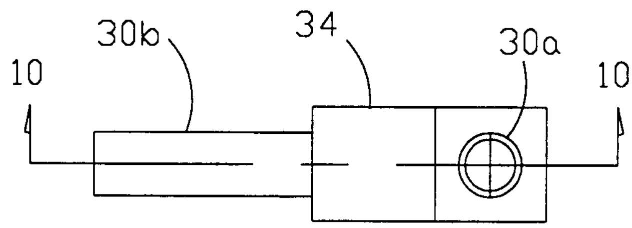

FIG. 11

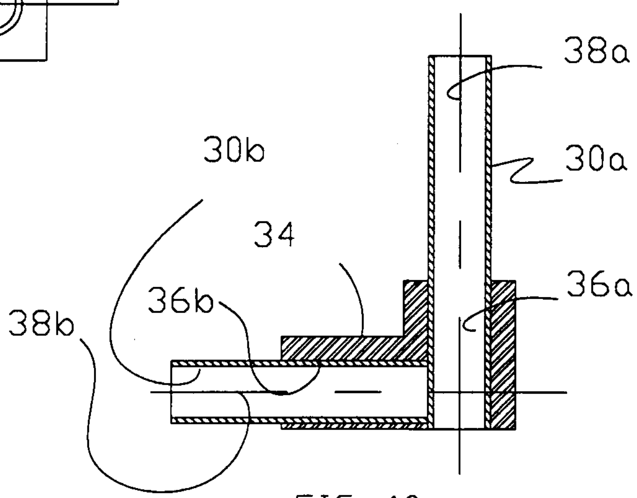

FIG. 10

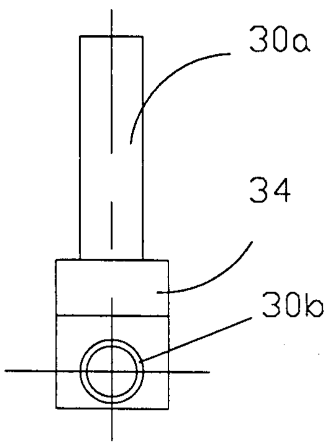

FIG. 12

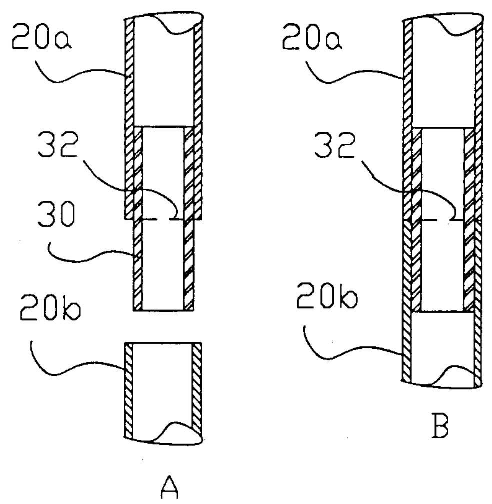

FIG. 9

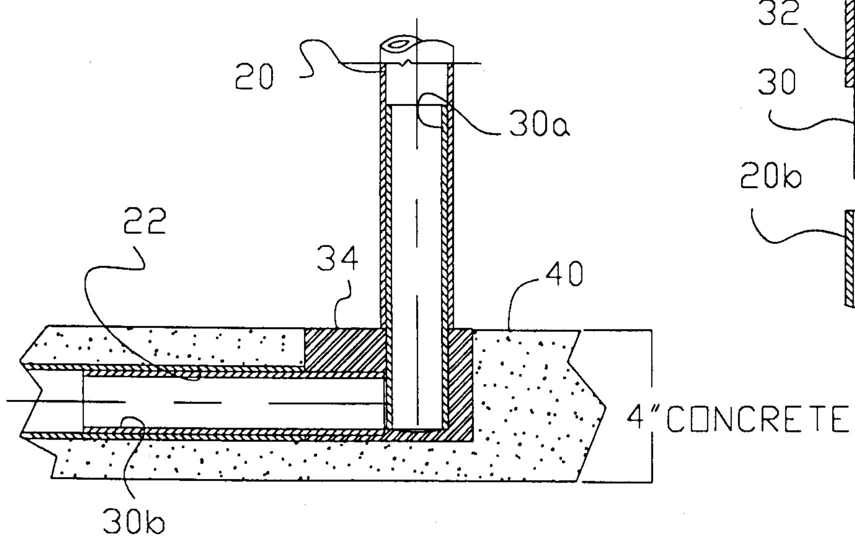

FIG. 8

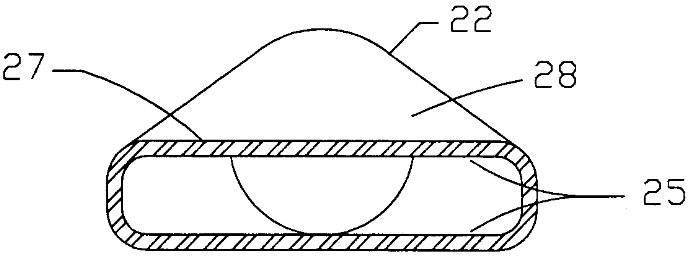

FIG. 18

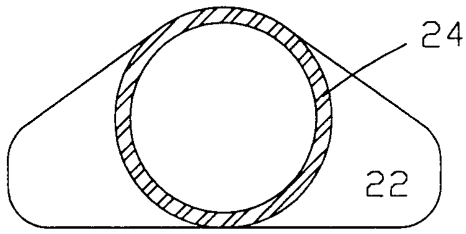

FIG. 19

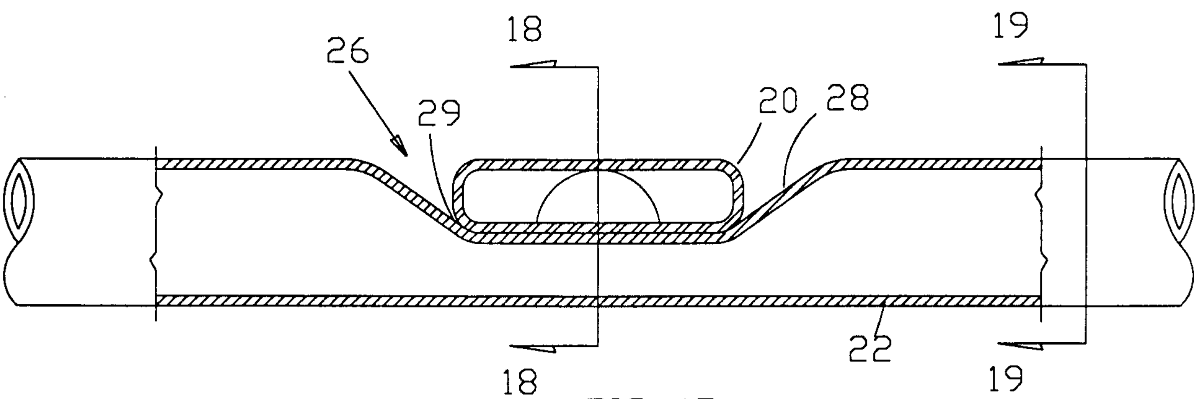

FIG. 17

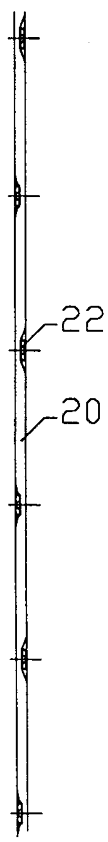

FIG. 16

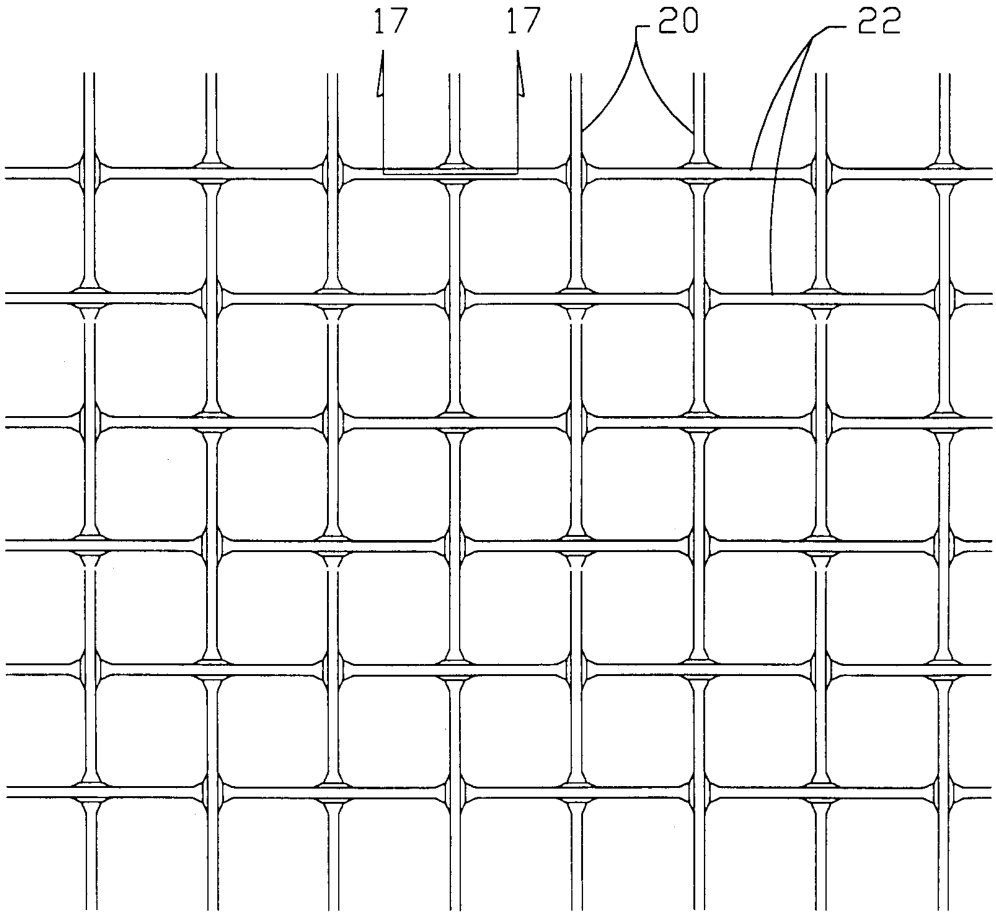

FIG. 15

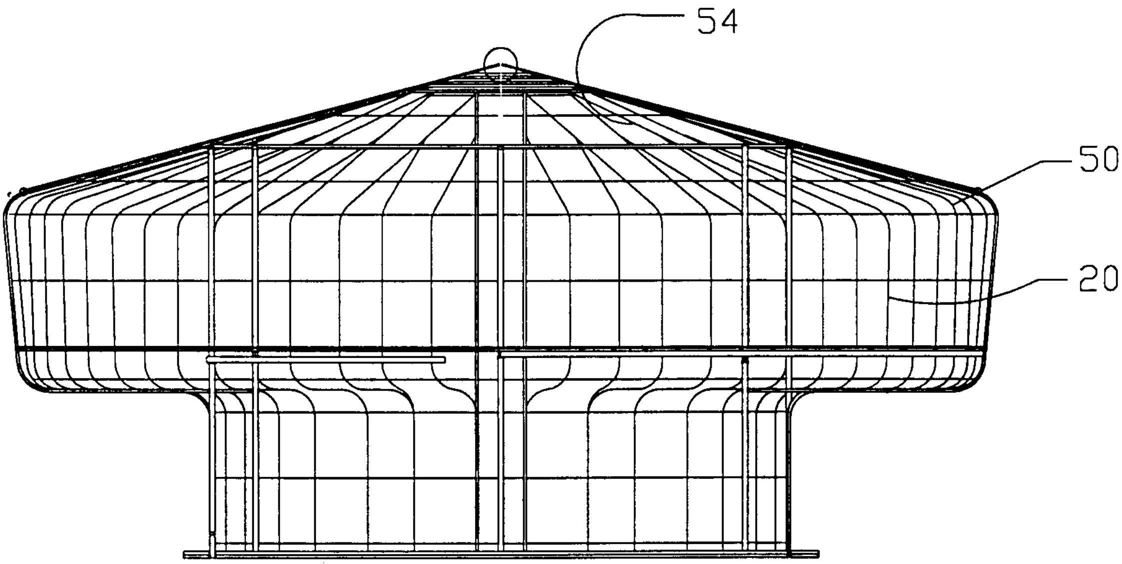

FIG. 20

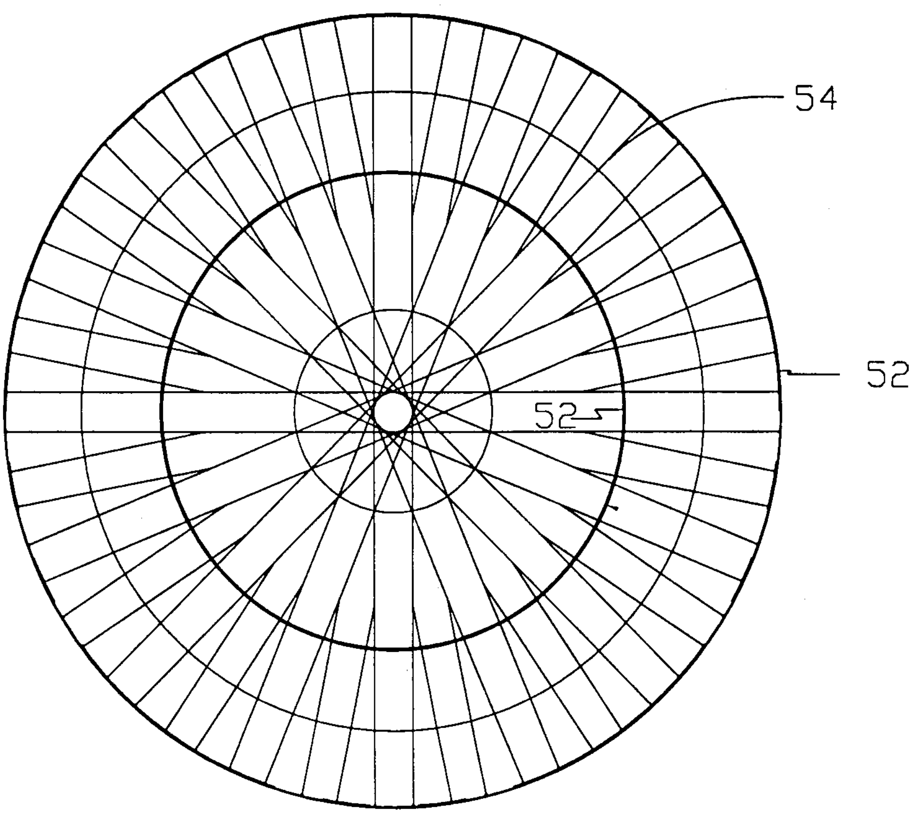

FIG. 21

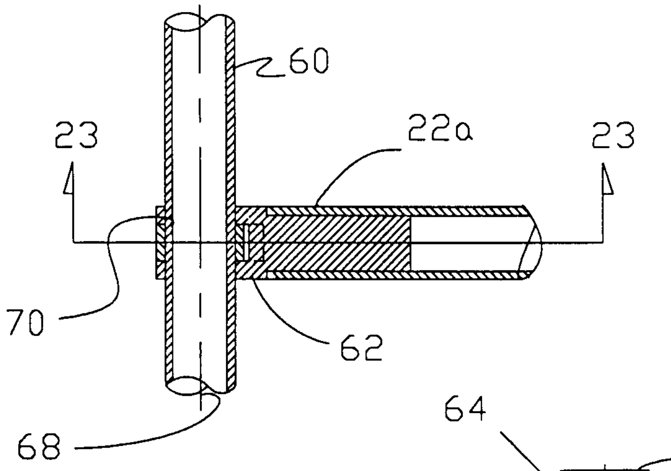

FIG. 22

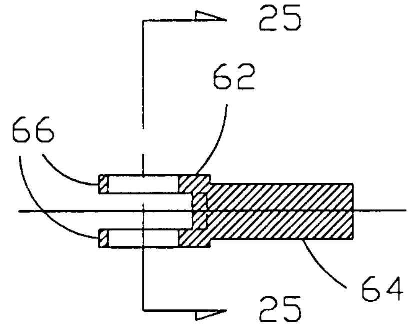

FIG. 24

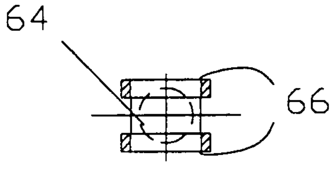

FIG. 25

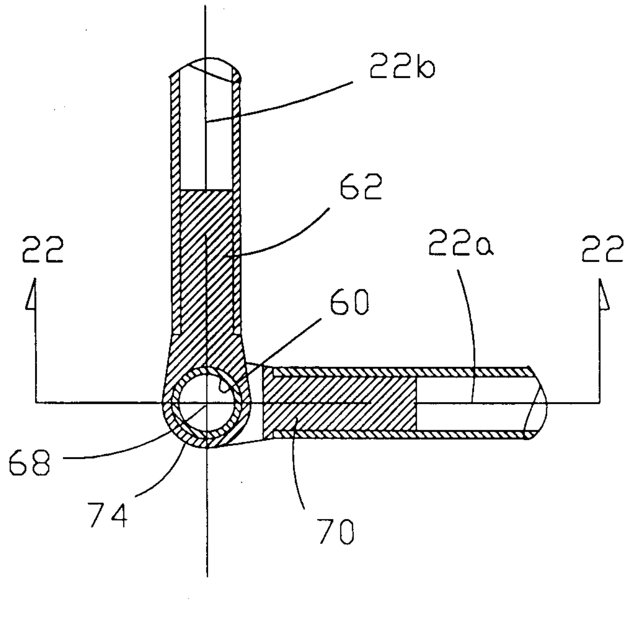

FIG. 23

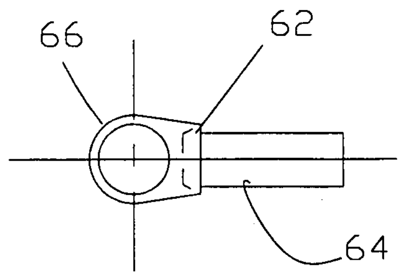

FIG. 26

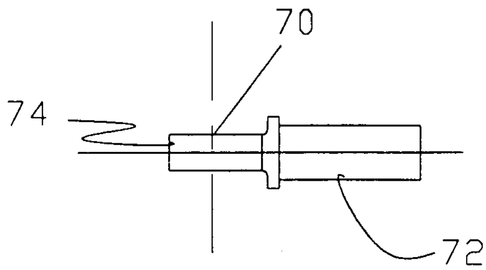

FIG. 27

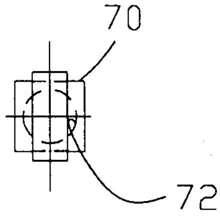

FIG. 28

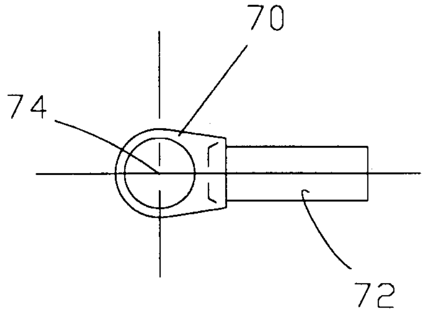

FIG. 29

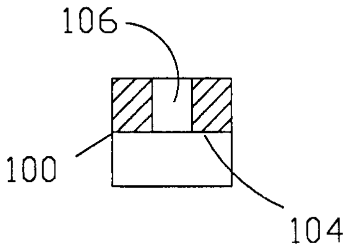

FIG. 38

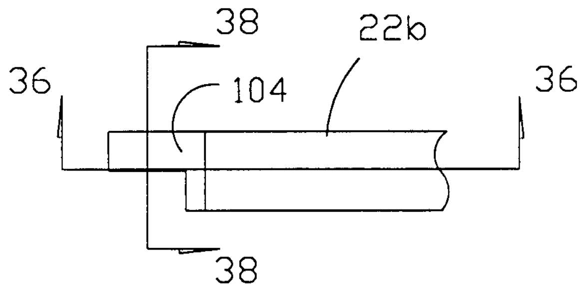

FIG. 37

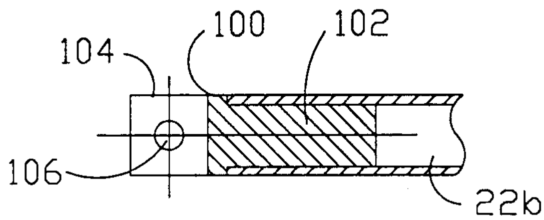

FIG. 36

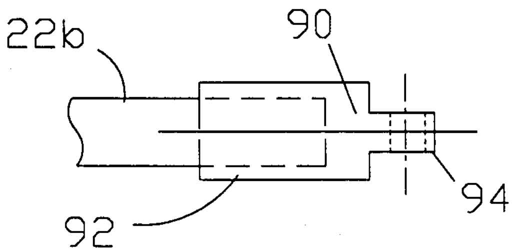

FIG. 34

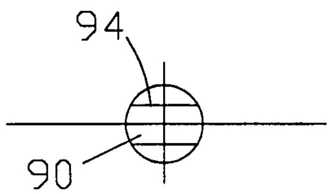

FIG. 35

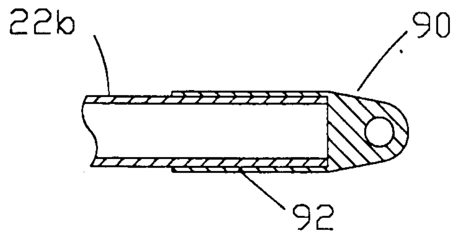

FIG. 33

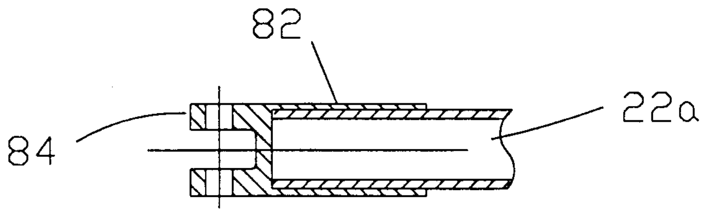

FIG. 31

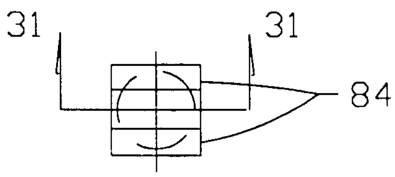

FIG. 32

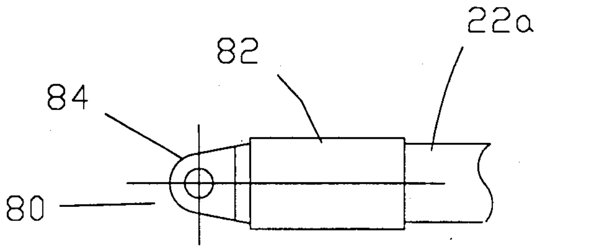

FIG. 30

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/27416

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :E04C 2/42
US CL :52/264, 274, 295, 298, 662, 745.09; 403/346
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 52/262, 264, 274, 295, 296, 298, 656.1, 662, 664, 666, 667, 669, 745.05 745.09; 403/346, 347, 400

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 1,581,487 A (KOHLER) 20 April 1926 (20/04/26), Figs. 1 and 5.	6-13, 23-25
Y	US 2,001,215 A (RUPPEL) 14 May 1935 (14/05/35), Figs. 1, 3, and 8.	6-13, 23-25
X	US 3,849,013 A (BIBB) 19 November 1974 (19/11/74), Figs. 1 and 2.	1, 3, 4, 19, 21
X ---------- Y	US 4,179,858 A (GRAHAM et al.) 25 December 1979 (25/12/79), Figs. 1, 3, 5, and 6.	1, 2, 6 ---------- 7, 8, 10, 12

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
24 MARCH 2000	19 APR 2000

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Authorized officer
MICHAEL SAFAVI
Telephone No. (703) 308-2168

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/27416

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---------- - Y	US 4,466,600 A (TUTTLE) 21 August 1984, Figs. 1 and 4.	1, 2 ------- 6-8, 10, 12