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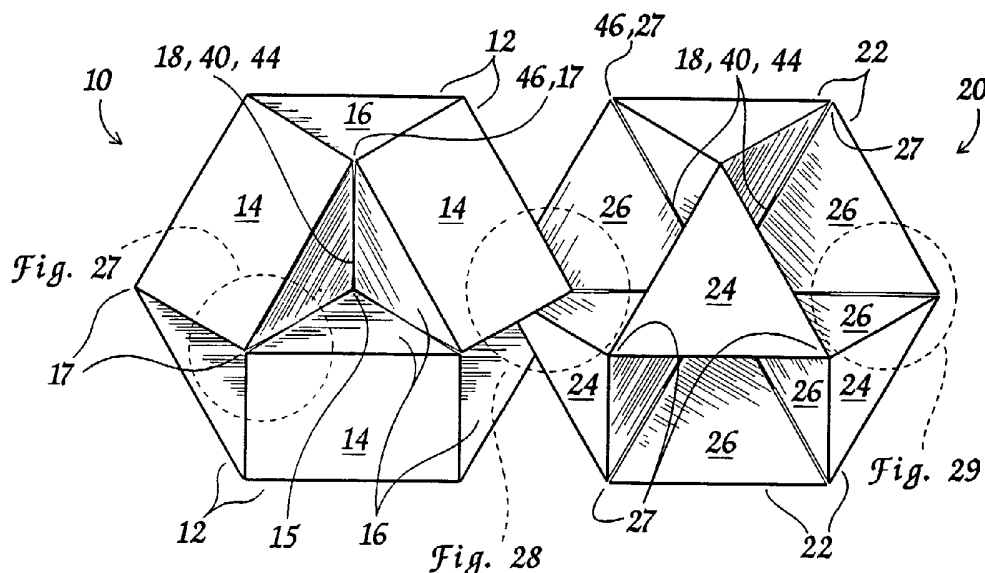
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(54) Title: A SYSTEM AND SET OF INTERCLEAVING DICHOTOMIZED POLYHEDRAL ELEMENTS AND EXTENSIONS



(57) Abstract: A set of intercleaving (interfitting and adhering/clinging) toy or actual construction elements may be used as structural elements, constructions components, building blocks, modeling elements. Elements (10, 20, 70) are composed of a plurality of pyramids (12, 22) or other polyhedral members, clustered around a central point such that the resulting cluster or clusters form a discrete member. Polyhedral members may be joined only partially along coincident edges (18, 28) for maintaining the structural stability. A portion of the joining coincident edges (18, 28) are slotted or not completely joined (difurcated) on the outer half of the joining edge to facilitate interfitting of a first element with a second (10, 20, 70). The above may be implemented in a virtual reality by use of appropriate software in a general purpose or dedicated computer system.



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**A SYSTEM AND SET OF INTERCLEAVING DICHOTOMIZED
POLYHEDRAL ELEMENTS AND EXTENSIONS**

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DESCRIPTION

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15 **Technical Field**

The current invention relates to a system for toy or real construction elements, as well as molecular and crystal modeling tools, which may be implemented either directly in a physical form or indirectly in a virtual reality which is physically provided for by the hardware of a general purpose or dedicated computer system. The goals of the current
20 invention are: 1) to provide educational, entertaining, and constructional value while providing a means of visualizing and exploring the principles and realms of space filling, space sharing, three dimensional tiling, and three dimensional fractals, as well as crystalline, quasi-crystalline, and other chemical compounds and/or structures; 2) to provide a new form of construction toy based on a new form of building blocks; 3) to provide the basis
25 of a new genre of logic puzzles and 4) to provide an entertaining metaphor for many of life's challenges.

Background Art

Prior to the current invention, most construction elements of any similar nature could be placed into one or more of four categories:

- 5 1) Stacking Blocks - which provide no means for self-retention of assembled structures, other than gravity; but require some form of bonding material if they are to be secured in their relative positions;
- 2) Member Suspended Interconnected Elements - which require rods or other secondary connective devices to determine and/or secure their relative
10 positions in space;
- 3) Slotted Circular or Polygonal Discs - while interfitting or intercleaving, their teachings do not lend themselves to producing the non-planar elements required to emulate real world, molecular building blocks. Assemblies produced with such planar elements are not substantially space filled; and
- 15 4) Interfitting Surface Indentations - where complimentary patterns of protrusions and indentations provide for the alignment and mating of the surfaces of the generally polyhedral forms in a manner/direction which is orthogonal with respect to those mating surfaces.

No prior art has attempted to produce self-interfitting, self-retaining construction
20 elements which produce substantially space-filled structures/assemblies. Most construction elements of prior design attempt to make their use more obvious and easy; while a significant portion of the current invention's value as an entertainment device and educational tool is the mystery, puzzlement, and challenges it presents due to the tendency of its various embodiments to retain the natural restraints associated with real-world
25 elemental building blocks. Some examples of these natural restraints demonstrated by the elements of the current invention are as follows:

- 1) the restricted intercleaving nature of the elements may be used to demonstrate the intercleaving nature of covalent chemical bonds;
- 2) some of the required assembly and disassembly methods for the elements are
30 analogous to thermal contraction and expansion in solids;

- 3) other assembly and disassemble methods emulate crystal growing and cleaving;
- 4) the natural inclination for the elements to produce mirror image (enatiomorphic) structures may be used to demonstrate and better understand both right-handed rotating (dextrorotary) and left-handed (levorotary) formations, such as during growth of organic substances or crystals;
- 5) the self-similar nature of assembled supersets of the elements of the invention may be used to emulate the development of polymer compounds from smaller polymer and monomer building blocks;
- 6) the self-similar nature of the assembled elements may also be used in creating complex embodiments and assemblies, enabling a new means of representing the fractal nature of the physical world; and
- 7) the ability of select embodiments of the invention to more naturally implement assemblies with five-fold symmetry may assist in demonstrating recently discovered chemical compounds with similar symmetries.

Accordingly, the building blocks (construction elements) of the invention are capable of not only modeling the net results of molecular and crystal formation, but also of simulating the nature of the difficulties and processes involved in forming such chemical assemblages. Part of the challenge associated with the use of the current invention is that once one has determined which elements are needed and where each element must be placed, the user must still determine how to get them there; once again simulating the challenging nature of creating assemblies of chemical elements.

In summary, although many prior teachings demonstrate the combining of polyhedral elements into larger assemblies, each of these require some form of adhesive or secondary connection device or mechanism to implement the connection or to retain their interconnected alignments. Although most of the manufactures defined by the invention do not result in fully space filled assemblages, all assemblies resulting from the use of the present invention are substantially more space-filling than any of the planar intercleaving manufactures of any prior art. No prior art provides generally polyhedral construction elements which non-perpendicularly mate, with respect to engaging surfaces, via

interpenetrating vertices and/or edges. Finally no prior art provides the ability to produce the uniquely elegant assemblies enabled by the current invention.

Disclosure of the Invention

5 The invention is a system and set of intercleaving (interfitting and adhering/clinging) elements which may be used as structural elements, building blocks, construction elements, modeling elements, or the like. Each of these discrete structural elements is comprised of a plurality of pyramids, or other polyhedral members, clustered around at least one central point in such a manner that the resulting cluster or clusters form a discrete structural
10 element. The polyhedral members may be joined at least partially along coincident edges for maintaining the structural stability of the element. A portion of the joining coincident edges of the polyhedral members are slotted or not completely joined ("difurcated") on the outer half of the joining edge to facilitate interfitting of a first element with a second element.

15 Accordingly, each element of the invention has the ability to be interfitted with other complimentary elements in a mutually interfitting and adhering manner (i.e., "intercleaving") along the coincident edges of sets of diagonally adjacent polyhedral members (such as pyramids) which have been difurcated along an outermost portion of their coincident edges which radiate from their coincident central point. The primary mechanism
20 for the mutual cleaving or adherence of the interfitted elements is friction, enhanced by wedging forces, due, in part, to the relatively narrow nature of these provided clefts, slots, or slits (collectively or interchangeably referred to as "difurcations") formed in the coincident edges of the polyhedral members which make up each element. However, the effectiveness of their intercleaving properties may be enhanced by the addition of a variety
25 of standard techniques for increasing their resistance to disassembly, including locking mechanisms or other protrusions or undulations.

 Consequently, the present invention provides a unique structural element, building block, modeling element, construction component, or the like (These terms are used
30 synonymously and interchangeably throughout this document and none is not intended to be exclusive of any of the others.). The elements of the invention may be interfitted into a

variety of configurations and arrangements. Thus, the present invention effectively combines a plurality of polyhedral members into discrete elements, and enables those elements to interfit with and adhere to complementary elements also formed of a plurality of polyhedral members. Accordingly, it will be apparent that the present invention provides a novel, aesthetic, and unconventional structural element.

Brief Description of the Drawings

FIG. 1 illustrates a first embodiment 10 of a pentahedral-comprised structural element of the invention interfitting with a complimentary second embodiment 20 of a tetrahedral-comprised structural element of the invention.

FIG. 2 illustrates a pentahedral equilateral square based pyramid.

FIG. 3 illustrates a tetrahedral equilateral triangular based pyramid.

FIG. 4 illustrates a reduced-size view of the pentahedral-comprised structural element 10 of the first embodiment of the invention.

FIG. 5 illustrates a plan view of the structural element 10 of FIG. 4.

FIG. 6 illustrates a front view of the structural element 10 of FIG. 5.

FIG. 7 illustrates a bottom view of the structural element 10 of FIG. 5.

FIG. 8 illustrates a rear view of the structural element 10 of FIG. 5.

FIG. 9 illustrates a left side view of the structural element 10 of FIG. 5.

FIG. 10 illustrates a right side view of the structural element 10 of FIG. 5.

FIG. 11 illustrates a Left-Front orthographic view of the structural element 10 illustrated in Figure 6, rotated 45 degrees to the right.

FIG. 12 illustrates a Right-Front orthographic view of the structural element 10 illustrated in Figure 6, rotated 45 degrees to the left.

FIG. 13 is an orthographic view of the structural element 10 depicted in FIG. 11 rotated front-down approx. 35.25 degrees, doubling as an isometric view.

FIG. 14 is an orthographic view of the structural element 10 depicted in FIG. 12 rotated front-down approx. 35.25 degrees, doubling as an isometric view.

FIG. 15a illustrates an orthographic view of a cuboctahedron space definition

perpendicular to one of its eight triangular surfaces.

FIG. 15b illustrates an orthographic view of the reverse of the cuboctahedron space definition of FIG. 15a, with the cuboctahedron having been flipped left to right.

5 FIG. 16 illustrates a reduced-size view of the tetrahedral-comprised structural element 20 of the second embodiment of the invention.

FIG. 17 illustrates a plan view of the structural element 20 of FIG. 16.

FIG. 18 illustrates a front view of the structural element 20 of FIG. 17.

FIG. 19 illustrates a bottom view of the structural element 20 of FIG. 17.

FIG. 20 illustrates a rear view of the structural element 20 of FIG. 17.

10 FIG. 21 illustrates a left side view of the structural element 20 of FIG. 17

FIG. 22 illustrates a right side view of the structural element 20 of FIG. 17.

FIG. 23 illustrates a Left-Front orthographic view of the structural element 20 illustrated in Figure 18, rotated 45 degrees to the right.

15 FIG. 24 illustrates a Right-Front orthographic view of the structural element 20 illustrated in Figure 18, rotated 45 degrees to the left.

FIG. 25 is an orthographic view of the structural element 20 illustrated in FIG. 23 rotated front-down approx. 35.25 degrees, doubling as an isometric view.

FIG. 26 is an orthographic view of the structural element 20 illustrated in FIG. 24 rotated front-down approx. 35.25 degrees, doubling as an isometric view.

20 FIG. 27 illustrates an enlarged view of a slit-implemented edge set difurcation of first element 10 of FIG. 1.

FIG. 28 illustrates an enlarged view of intercleaving diagonally adjacent pyramids of complimentary elements of FIG. 1.

25 FIG. 29 illustrates an enlarged view of a slot-implemented edge set difurcation of second element 20 of FIG. 1.

FIG. 30 illustrates an intercleaving complimentary pair of structural elements 10,20, similar to FIG. 1, with a fully filleted pentahedral-comprised structural element 10 and partially filleted tetrahedral-comprised structural element 20.

30 FIG. 31 illustrates an enlarged view of a fully filleted edge set and the resulting cleft and webbing.

FIG. 32 illustrates a schematic diagram depicting/suggesting an approach to a four-piece molding system for producing structural element 10, shown in closed/engaged position.

FIG. 33 illustrates a schematic diagram of the four-piece molding system of FIG. 32 shown releasing a molded structural element 10.

FIG. 34a illustrates an enlarged top view of one of the four identical molding dies depicted in Figs. 32 & 33, shown disengaging the newly formed structural element 10.

FIG. 34b illustrates a side view of the die and manufacture depicted in FIG. 34a.

FIG. 35 illustrates a pattern for producing a sheet material blank used to produce pentahedral-comprised structural element 10 of the first embodiment of the invention.

FIG. 36 illustrates a pattern for producing a sheet material blank used to produce a tetrahedral-comprised structural element 20 of the second embodiment of the invention.

FIG. 37a illustrates a perspective side view of a third embodiment of a combined structural element 70, which combines the first and second structural elements 10,20.

FIG. 37b illustrates a bottom view of the structural element 70 of FIG. 37a..

FIG. 37c illustrates a top view of the structural element 70 of FIG. 37a.

FIGS. 38a -38c, illustrate three views of a Non-Cuboctahedral Quadecahedron (14-faceted) Space Definition which provides the basis for the third embodiment 70.

FIG. 39 illustrates a pattern for producing a sheet material blank used to produce structural element 70 of a third embodiment of the invention,

FIG. 40 illustrates a reduced-size perspective view taken from FIG. 1 of structural elements 10 and 20 of the first and second embodiments, respectively, fully mated

FIG. 41 a illustrates a plan view of an assembly of three structural elements 10, 20, prior to the addition of a fourth tetrahedral-comprised structural element 20 to the assembly.

FIG. 41b illustrates a perspective view of the assembly and element 20 of FIG 41a.

FIG. 42a illustrates a plan view of the assembly process for adding an element 20 to the assembly of FIG. 41a.

FIG. 42b illustrates a perspective view of the assembly method of FIG 42a.

FIG. 43a illustrates a plan view of a fourth structural element 20 added to the assembly of FIG. 41a.

FIG. 43b illustrates a perspective view of the assembly of FIG 43a.

FIG. 44 illustrates a view depicting the challenge of adding a sixth element to an assemblage of five.

FIGS. 45a & 45b illustrate views of two mutually enantiomorphic hexagonal assemblages, with 45a being the goal of the challenge of FIG. 44.

FIG. 46 illustrates one of three methods of accomplishing one of the goals of FIG. 44.

FIG. 47 illustrates two emulated ring compounds interfitted to form a larger structure.

FIG. 48 illustrates a geodic assemblage of twenty-four elements, twelve elements and twelve elements.

FIG. 49 illustrates two of the geodic assemblages of FIG. 48 interfitted as they function as fractalized intercleaving building blocks.

FIG. 50a thru FIG. 53b illustrate pairs of views of four examples of the further subdividing of the cuboctahedron space definition into additional embodiments of the current invention.

FIG. 54a & FIG. 54b illustrate two views of an Intercleaving Building Block based on, or extended/projected to, an Octahedron Space Definition, illustrating both peripherally based and radially based pyramid clustering.

FIG. 55 illustrates a view of the most basic (first-order) embodiment of an octahedron space definition.

FIG. 56a & 56b illustrate two views of the element depicted in FIG. 52a & 52b after being projected to an octahedron space definition.

Figs. 57a thru 57d illustrate views of four Intercleaving Building Blocks based on an Icosahedron Space Definition, demonstrating more generalized definitions of an edge set, diagonally adjacent and facially adjacent polyhedrons, and complex/composite polyhedrons.

Figs. 58a thru 58c illustrate three views of an Intercleaving Building Block based on a quindecahedron (15-faceted) space definition.

Figs. 59a thru 59c illustrate three views of an Intercleaving Building Block based on a cubic (hexahedron) space definition.

Figs. 60a thru 60c illustrate three views of an Intercleaving Building Block based on a rhombic dodecahedron space definition, which may be also viewed as an extension from the embodiment of Figs. 59a thru 59c into a rhombic dodecahedron space definition.

5 FIG. 61 illustrates a fractalized octahedral assemblage of seven of the first-order octahedral embodiment depicted in FIG. 55.

FIG. 62 illustrates a fractalized octahedral assemblage of seven of the seven-element octahedral macro-embodiment depicted in FIG. 61.

10 FIG. 63a illustrates an embodiment based upon fusing the assembly illustrated in , FIG. 40, comprised of a first embodiment element 10 interfitted with a second embodiment element 20, which are fused together to for a single contiguous element.

FIG. 63b illustrates a view of the element of FIG. 63a rotated 180 degrees.

FIG. 63c illustrate a bottom view of the element of FIG. 63a.

FIG. 64 illustrates an embodiment based on a fusing of three first embodiment elements 10 with a single centrally-located second embodiment element 20.

15 FIG. 65 illustrates an embodiment based on a fusing of three second embodiment elements 20 with a single centrally-locate first embodiment element 10.

FIG. 66 illustrates the embodiment of FIG. 64 with the tetrahedral voids filled in.

FIG. 67 illustrates the embodiment FIG. 65 with the central tetrahedral void filled in.

20

Best Modes for Carrying Out the Invention

Definition of Terms

The following generalized terms are here defined.

25 **Blending of Surfaces** - any smoothing deviation from the angular intersection of the planar polyhedron surfaces, or the increasing of intersection angles via the truncation of said intersections to form one or more additional planar facets or otherwise smooth surfaces.

Cell, Cell Definition - any defined portion of a space definition which is potentially physical/material (filled, occupied) or spatial (empty, unoccupied).

Cleaving - refers simultaneously or individually to both literal senses of the word, namely
1) to pierce, to split; to separate and 2) to adhere to; to cling to, to grasp.

Cleft - 1) "an opening made by or as made by cleaving; crack; crevice" 2) "a hollow
between two parts" (applied more generally herein as: between two or more parts);
5 although the term cleft might usually imply a visibly noticeable gap, it is used herein
to refer to any *difurcation* including slots or slits which may leave the separated
edges/polyhedrons in contact but unconnected.

Cuboctahedron - a fourteen sided polyhedron whose faces consist of six equal squares and
eight equal equilateral triangles, and which can be formed by cutting the corners off
10 a cube.

Deltohedron - also known as: deltoid dodecahedron, or tetragonal tristetrahedron; a
dodecahedron having twelve quadrilateral/tetragonal surfaces; including the
rhombic dodecahedron.

Diagonally Adjacent - structures or, more specifically, polyhedral elements which adjoin
15 or coexist along generally coincident or overlappingly collinear edge lines, or along
any expansion of that common edge line used to facilitate their connection., but
which share no common sides/surfaces, i.e. have no coincident or overlappingly
coplanar surfaces, are said to be diagonally adjacent.

Difurcations - used herein as a more generalized equivalent of the word "bifurcated",
20 meaning any separation/division of two *or more* elements of a manufacture resulting
in a plurality of branches or peaks, while leaving the separated portions of the
separated elements remaining in the same general proximity of each other; where
said difurcations may include slots or slits which may leave the separated elements
in contact but unconnected. The general use of this term is intended to include
25 *provisional difurcation*. In virtual manufactures, where difurcations may be
infinitely narrow, the term may simply refer to [mean] any portion of the coincident
lines of a manufacture's one dimensional edge set which is allowed to share their one
dimensional space with the virtual difurcation of the one dimensional edge set of a
similar manufacture. Therefore, in virtual reality , any or all edge sets may be
30 thought of as being 100% difurcated.

Dodecahedron - a twelve faceted polyhedron.

Edge Set (Edgeset) - any cluster of two or more coincident polyhedral edges resulting from diagonally adjacent polyhedrons. An edge set is said to have been formed (to exist) if at least two diagonally adjacent material polyhedral elements and at least two spatial polyhedral elements share coincident edge lines.

Ellipsoidal - having the shape of a solid whose plane sections are all ellipses or circles, including spheroids and spheres.

Fillet - a fairing or other smoothing of the outline or shape of an element or structure.

Geodic Macro manufactures - geodic in form; "earthlike"; assemblages of embodiments of the current invention where said assemblages are generally spherical or otherwise ellipsoidal in shape and may encompass a central cavity, even though said ellipsoidal assemblages may also be viewed as being generally polyhedral in shape.

Implied Surface - 1) any surface which is not physically present but whose presence is defined by, or suggested by the logical extension of, bounding and surrounding points, lines, and/or surfaces; i.e.; logically extrapolated from surrounding features. 2) any surface of a specified space definition which limits any further extension of the definition of an otherwise defined spatial polyhedron or cell and, therefore, serves as a defining surface of said spatial polyhedron or cell.

Intercleaving - mutually cleaving elements; two or more elements which simultaneously interfit and/or cling to each other, with each element doing so with two or more protrusions.

Material - when used as an adjective and unless otherwise specified or obvious, its general use refers to being composed of either physical material or virtual material, except where virtual manufactures are not protected by patent law, in which case material becomes synonymous with physical. When used as a noun, its use is believed made clear by the context of each use.

Material/ Physical Polyhedral Elements/Members - see below

Member -

Physical/Material Polyhedral Elements/Members - may be solid, hollow, open faced, or

framed (including wire-framed) in nature. Physical polyhedral elements may also be defined as any substantial occupancy of a polyhedral cell (i.e. subdivision) of a given space definition.

Plane of Inversion - any specified plane section of a three dimensional whole which delineates the portion of that whole which is to be spatially inverted and that portion which is to remain uninverted.

Polyhedron (polyhedrons, polyhedra) - any element/membe which is generally polyhedral in shape, and unless otherwise specified, signifies physical/material polyhedrons as apposed to spatial polyhedrons.

Project - "to transform the points of a geometric figure into the points of another figure; to extend and/or truncate the defining points of a manufacture to conform with the form of another geometric form or space definition. Such projections may be made between concentric space definitions or between space definitions whose centers have been offset. Similarly, the source and target space definitions need not be a synchronized, i.e. symmetrically aligned, but may be rotated with respect to each other in a manner resulting in a projected embodiment which does not retain the symmetry of either of its parent space definitions.

Provisional Difurcations, Provisional Clefts, Slots, and/or Slits - any difurcation provided for, but not implemented during the primary manufacturing phase; where actual implementation of said Difurcations, as a subsequent manufacturing phase to be performed by intermediate or end users, is required, directed, or implied; or when the implementation of the actual difurcation might be reasonably expected to occur from reasonably expected use and/or experimentation; or where an impetus for implementing such difurcations is provided. Such an impetus may merely be a picture or diagram of a structure resulting from, or suggesting the interfitting of, so difurcated embodiments of the current invention. Such provisional difurcations would most often be implemented *as noticeably thinner webbing*, whereby a slit, slot, or wider cleft may be, at a later time, readily implemented, and is therefore facilitated, and thereby *indirectly and/or cooperatively implemented*. Such difurcations, clefts, slots, and/or slits may be said to have been *provisionally*

implemented. If the provisional difurcation is sufficiently thin, the actual difurcation may be produced when complimentary manufactures are first interfitted by the end user during reasonably expected use or experimentation. .

Quadecahedron - a fourteen faceted polyhedron, including the cuboctahedron.

5 **Quindecahedron** - a fifteen faceted polyhedron.

Rhombic Dodecahedron - a dodecahedron whose twelve facets are rhombuses.

Sculpted Surface - any surface which deviates from the theoretical planar or otherwise smooth or continuous surface of a generally defined shape. This term, as used in this document, is not intended to imply any given method of achieving these deviations.

10 **Sculpting** - Any blending or other deviation from the theoretical norm of a line, plane, or surface of a polyhedral or other geometric shape or form. Examples of which would include: undulations, serrations, gougings, dimplings, texturing, truncations, protrusions, projection (extension or truncation), filleting, or shrinking/recession from its theoretical or nominal definition/location. This term, as used in this document, is not intended to imply any given method of achieving these deviations.

15 **Space Definition** - any set of points and resulting peripheral planes defined by these points, or any other specified planar or curved surfaces or geometric form, which define the confines of a limited universe of space/matter under consideration, which in turn defines the basic shape/form of and, therefore, acts as the base/body of a subject manufacture providing the basis by which: 1) the limits of the space within which specified polyhedral elements are positioned is defined; 2) the relative locations of facet-based material and/or spatial pyramidal formations are defined; or 3) the form/limits of the further projection/extension/truncation of an otherwise defined manufacture is/are further defined. An example of a space definition would be the regular cuboctahedron whose twelve peripheral points (vertices) define the
20 fourteen peripheral planar surfaces 30 & 32 (FIG. 15a & 15b) which form the confines of each of the two components of the complimentary pair of preferred embodiments of the current invention described herein as the first and second embodiments 10,20 (FIG.1), and which further defines the bases of the pyramidal
25 elements of each cuboctahedral embodiment.
30

Spatial Dichotomization - dividing or redefining a material or spatial whole into material and spatial elements/sections.

Spatial Inversion - a reversal of the material or spatial specification/definition of one or more elements; changing a portion or the entirety of one or more elements of a material or spatial whole into its material/spatial inverse.

Substantially Complementary - elements which are sufficiently complimentary of each other to allow some portion of themselves to interfit within and/or around each other, i.e., to intercleave. The use of "complementary" throughout this document is intended to be synonymous with "substantially complementary".

Virtual - for practical purposes the same as . . .

Virtual Manufacture - computer generated manufactures/objects for manipulation by a computer or computer operator and/or display on/in any two or three dimensional display or stereo viewer designed to be used by such computers. Virtual reality is no longer merely an academic tool, but has become a very real medium for the manifestation of competitively manipulatable manufactures. Such manufactures, whether viewed on a two-dimensional display, in the perceived space produced by a virtual reality helmet, or manifested in some futuristic three-dimensional display or medium, may be moved across the user's field of vision or interfitted with other such manufactures. The specific computer hardware, software, and algorithms used to dynamically manufacture, manipulate, and/or render a display of a virtual manufacture are as secondary to the resulting virtual manufacture as are the machinery, materials, and manufacturing techniques and processes used are to an otherwise identical physical manufacture.

Virtual Matter - any defined set of points in a *virtual reality* which is not allowed to be or is otherwise restricted in some manner and/or degree from being shared with any similarly defined set of points. (In any given virtual reality it is possible to modify "the laws of physics", as we normally think of them, to allow conditional sharing of space by two or more sets of "matter".) Any such set of points may be moved, modified, or otherwise manipulated in accordance with a set of "laws of physics" as defined for the specific virtual reality in which said virtual matter has been defined.

Virtual Medium - the mechanism by which a virtual reality is effected

Virtual Reality - any manipulatable existence comprised of *virtual space* and *virtual matter/material*.

Virtual Space - any portion of a *virtual reality* which is available for unrestricted occupancy by *virtual matter/material*.

5 **Webbing** - the material provided to connect diagonally adjacent polyhedrons to each other along a portion of their coincident edges. In virtual manufactures, where webbing may be infinitely narrow, the term may simply mean the inner portion of the coincident lines of a manufacture's one dimensional edge set which are not allowed to share their one dimensional space with the virtual webbing of the one dimensional
10 edge set of a similar manufacture.

Description of the Preferred Embodiments

The invention is directed to a set and system of interfitting structural elements which may be used for building structures, creating models, amusing and entertaining people, or
15 the like. FIG. 1 illustrates a first embodiment 10 of a pentahedral-comprised structural element of the invention being interfitted with a second embodiment 20 of a tetrahedral-comprised structural element of the invention. The first and second preferred embodiments of the current invention are a complementary pair of first and second structural elements 10,
20 20, respectively, each being the spatial inverse of the other. Neither of these two embodiments 10, 20 are intended to be interfitted with identical elements, but instead, are paired with each other or with other substantially complimentary embodiments. However, the second embodiment 20 of the two elements *is* capable of being mated with identical elements 20 in a partially complimentary manner, producing some unique capabilities.

For purposes of clear explanation, FIGS. 2 and 3 are provided to illustrate basic
25 shapes used in first pentahedral-comprised structural element 10 and second tetrahedral-comprised structural element 20. FIG. 2 illustrates an equilateral, pentahedral, squared based, pyramid 12 of the invention. Pyramid 12 has a square base 14 and four equilateral triangle radial sides 16 which are joined at their respective edges 18, and which meet at a summit or apex 19. FIG. 3 illustrates an equilateral, tetrahedral pyramid 22 having a
30 triangular base 24 and three identical equilateral triangle radial sides 26 which are joined at

their respective edges 28, and which meet at a summit or apex 29. It will be apparent that the base 24 and sides 26 of tetrahedral pyramid 22 are distinguishable from each other based only upon orientation (i.e., base 24 is identical in size and shape to each of sides 26), whereas the base 14 of pentahedral pyramid 12 is distinguishable from sides 16 based upon size and shape.

FIGS. 4-14 further illustrate pentahedral-comprised structural element 10 of the first embodiment of the invention. Pentahedral-comprised element 10 is comprised of six equilateral pentahedral, square-based pyramids 12a-12f arranged in a clustered manner which results in their six apexes or summits 19 being coincident at a single central point 15, and each of the four radial edge lines 18 of each pyramid 12a-12f being coincident with one edge line 18 of each of four diagonally adjacent pyramids 12a-12f. For example, as illustrated in FIG. 5, four pyramids 12d, 12f, 12b, & 12e, are diagonally adjacent to pyramid 12a, with each pyramid 12d, 12f, 12b, & 12e sharing a single radial edge line 18ad, 18af, 18ab, & 18ae, respectively, with pyramid 12a, as illustrated in FIGS. 4 and 6-14. Furthermore, pyramid 12a is diametrically opposed to a fifth pyramid 12c, and pyramid 12c is also diagonally adjacent to the four pyramids 12d, 12f, 12b, & 12e. Thus, each of the six pyramids 12a-12f is centrally disposed relative to four diagonally adjacent pyramids 12a-12f, and diametrically opposed to a fifth pyramid 12a-12f.

With pyramids 12a-12f so arranged, their six peripherally oriented square bases 14 correspond to six square surfaces or facets 30 of a cuboctahedron space definition, as illustrated in FIGS. 15a & 15b; and as such, these pyramids 12a-12f may be referred to as facet-based pyramids, where a facet of the basic form (space definition) of the structural element functions as the base of each of the subject pyramids 12a-12f. In this case, the basic form of first structural element 10 is a cuboctahedron. A cuboctahedron is a fourteen sided polyhedron whose faces or facets consist of six equal squares and eight equal equilateral triangles, and which can be formed by cutting the comers off a cube. It may be seen from FIG. 1 that structural elements 10,20 are both based upon the cuboctahedron structure/form, but are spatial inverses of each other. Accordingly, portions of element 10 are able to fit into spaces in element 20 and vice versa. Further, it will be apparent that the bases 14 of each pentahedral pyramid 12 are located in accordance with the square facets 30 on the

cuboctahedral space definition, and bases 14 may be described as facets of first element 10. Thus these pyramids are each based at/on the facets of the polyhedral form which the structural element, as a whole, is based upon, and where this polyhedral form may be referred to as the base or body of the structural element, the facets of said polyhedral form/space definition form or provide for the bases of the facet-based pyramids.

Thus, the arrangement of first element 10 includes eight spaces (i.e., voids, recesses, or open areas) in the shape of eight spatial tetrahedral pyramids 22 being interspersed between and defined by the twenty-four radial sides 16 of the six pentahedral pyramids 12a-12f. There are eight implied triangular peripheral surfaces (openings) corresponding to the eight triangular surfaces 32 of the cuboctahedron space definition. Thus these tetrahedral pyramidal voids/recesses (spatial pyramids) are each based at/on an implied facet of the polyhedral form which the structural element, as a whole, is based upon, and may also be referred to as facet-based. (For the sake of clarity, numerical designations or lead lines to define the spatial areas of the current invention are generally not provided in the included drawings. Attempts to point to an open three dimensional space in/on a two-dimensional presentation can prove to be more confusing than clarifying.) Accordingly, first element 10 includes six physical pentahedral pyramids 12a-12f, which are arranged about central point 15, with their edges 18 aligned with adjacent edges 18 of pyramids 12a-12f, so that there are eight voids between pyramids 12a-12f in the shape of eight tetrahedral pyramids 22. These eight pyramidal voids may also be viewed as being pyramidal recesses in the generally cuboctahedral body of the construction element, resulting, effectually, from the recession of the eight triangular facets 32 of the cuboctahedron form/base/body toward their common central point 15. The six physical pentahedral pyramids 12a-12f may also be viewed as resulting, effectually, from the extension the six square facets 30 of the cuboctahedral form/base/body toward their common central point 15 (or as the extension of the edges of those facets, forming hollow pyramids). It can be seen that the natural consequence of these recessions and extensions of the surfaces/facets of a cuboctahedron is the prescribed edge alignments of the resulting diagonally adjacent material pyramids 12a-12f, as well as a similar alignment of the resulting spatial pyramids.

Turning now to the second structural element 20 of the invention, tetrahedral-

comprised structural element 20 of the second embodiment of the invention is illustrated in FIGS. 16-26. Tetrahedral-comprised element 20 is comprised of eight equilateral tetrahedral pyramids 22a-22h arranged in an edge-aligned manner around a single coincident center point 25, with apexes 29 located at center point 25. For example, the edges 28 of tetrahedral pyramid 22a are aligned with the edges 28 of tetrahedral pyramids 22b, 22c, and 22d, and are shown as reference numbers 28ab, 28ac, and 28ad, respectively. Thus, each tetrahedral pyramid 22a-22h has its edges 28 adjacent to and aligned with the edges 28 of three other tetrahedral pyramids 22a-22h.

It will be apparent that tetrahedral pyramids 22a- 22h of element 20 are also arranged within the same cuboctahedron space definition (Figures 15a & 15b) as for pentahedral-comprised structural element 10 of the first embodiment. Thus, the arrangement of second element 20 results in the volume of six spatial pentahedral pyramids 12 being interspersed between and defined by the twenty-four radial surfaces 26 of the eight physical tetrahedral pyramids 22a-22h and the six implied square surfaces (i.e., openings) corresponding to the six square surfaces 30 of the space definition, while the eight peripherally-based triangular surfaces 24a-24h of the tetrahedral pyramids correspond to the eight triangular surfaces 32 of the space definition. Accordingly, any of the tetrahedral pyramids 22a-22h is coincident along its three edges 28 with the edges 28 of three other tetrahedral pyramids 22a-22h, with the apexes 29 of the tetrahedral pyramids 22a-22h located at center point 25, and with six pentahedral voids dispersed between the aligned tetrahedral pyramids 22a-22h. Furthermore, as described above with respect to the first embodiment 10, bases 24 of tetrahedral pyramids 22 correspond to the triangular facets 32 of the cuboctohedral space definition, and may be described as facets of second element 20. Therefore, with the recessions and extensions of the facets 30, 32 of the cuboctahedron space definition reversed, the prescribed edge alignments of the resulting eight diagonally adjacent material tetrahedral pyramids 22a-22h of second structural element 20 are achieved, as well as a similar alignment of the resulting six spatial pentahedral pyramids.

Turning back to FIG. 1, in pentahedral-comprised element 10, each pair of diagonally adjacent pyramids 12 has coincident radial edge lines 18 which form an *edge set* 40 where the edges 18 of pyramids 12 meet. Similarly, in tetrahedral-comprised element 20, each pair

of diagonally adjacent pyramids 22 forms an edge set 40 along their coincident radial edge lines 28. Thus, an edge set 40 may be defined as any cluster of two or more coincident polyhedral edges resulting from diagonally adjacent polyhedrons. An edge set 40 is said to have been formed (to exist) if at least two diagonally adjacent physical polyhedral elements and at least two spatial polyhedral elements share coincident edge lines. In the case of first and second elements 10 & 20, it can be seen that the natural consequence of the previously describe material recessions and extensions of the facets of their cuboctahedron form is the formation of these edge sets at the vertices 17, 27 of their cuboctahedral forms/bases/bodies, i.e. at the vertices 37 of their defining cuboctahedron space definition, and that these edge sets naturally radiate from their central points 15, 25 towards, and terminating at, those vertices 17, 27; or may be otherwise viewed as radiating inward from those vertices 17, 25 toward their common central points 15, 25. Furthermore, and again as a natural consequence of these edge sets radiating from the apexes of these pyramidal extensions and recessions, these edge sets define and lie on a plurality of nonparallel planes. In the case of these cuboctahedral based elements 10, 20, these edge sets 40 define four mutually oblique and non-parallel planes intersecting at their coincident central points 15, 25. Each of their edge sets are, therefore, obliquely noncoplanar with and nonparallel to at least one pair of coplanar edge sets.

It can be seen that this obliquely noncoplanar and nonparallel relationship exists between the radial edges of any pyramid; and that it is this relationship which allows the formation of some of the unique three-dimensional assemblages enabled by the current invention such as the one depicted in Figure 48.

In the embodiments 10,20 of FIG. 1, and as also illustrated in FIGS. 27-29, the diagonally adjacent pyramids 12,22, respectively, are interconnected along an inner portion of edge sets 40 by what will hereinafter be referred to as *webbing* 44 and are separated along an outer portion of these edge sets 40 by *clefts* 46 (also referred to as "difurcations"). Webbing 44 is the connecting material or filleting which is a necessary part of manufacturing a physical element 10, 20, and which are also necessary for maintaining structural integrity of elements 10,20, by holding the polyhedral members in position. Clefts 46 extend inward from the outermost point of the edge sets 40, resulting in what will be referred to as

difurcated edge sets 48. These clefts 46, alternately referred to as difurcations 46, may also be viewed as spatially connecting the diagonally adjacent spatial pyramids.

In each of the two preferred embodiments 10,20, all twelve of the resulting edge sets 40 are equally difurcated to a depth equal to at least fifty percent of the edge set's 40 length.

5 However, as long as structural integrity is maintained, each difurcation 46 may extend along any outer portion of the edge set's 40 length, including its entirety, with a complementary portion of the length of the appropriate edge set 40 of an intended mating element 10, 20 being suitably difurcated. In an extreme example, an edge set 40 of a first element 10 may be 100 percent difurcated, and a complementary edge set 40 on a second element 20 may be 10 undifurcated, and still be able to mate first element 10.

In FIGS. 27-29, it can be seen that it is these clefts 46 which allow a pair of pentahedral pyramids 12 of first element 10, or a portion of them, to protrude into a pair of spatial pentahedral pyramids in second element 20 while the pair of physical tetrahedral pyramids 22 associated with the mating edge set 40 of second element 20 protrude into the 15 pair of spatial tetrahedral pyramids associated with the relevant edge set 40 of the first element 10, in a mutually *cleaving* manner. During insertion, the webbing material 44 connecting the inner portion of the edge sets 40 of each element 10, 20 simultaneously slides into the clefts 46 of the other element 10, 20, as the elements 10, 20 become fully seated within each other. In the preferred embodiments, the webbing material 44 connecting the 20 inner portion of the edge sets 40 is tapered and slightly wider than the clefts 46, providing greater wedging forces, to increase the frictional resistance to disassembly once fully assembled. This may be balanced against similar tapering of the clefts 46, as illustrated in FIG. 27, providing for easier mating and greater angular tolerance when interfitting multiple construction elements.

25 These clefts 46, which can be seen in greater detail in Figures 27-29, may be no more than slits as in FIG. 27, or slots as in FIGS. 28 and 29, or even broader. Clefts 46 are represented in unenlarged drawings, such as Figures 4-14 and 16-26, by broader lines, or not indicated at all, since not all edge sets which may be suitable for difurcation need be difurcated in given manufacture. Furthermore, it will be apparent that each edge set 40 is 30 non-perpendicular (oblique) to the facets (bases 14, 24) which make up the polyhedrons

forming that edge set 40. For example, in first element 10, two pentahedral pyramids 12 have aligned coincident edges 18 which form an edge set 40. However, bases 14 of these two pentahedral pyramids form planar surfaces or facets which are non-perpendicular to the edge set 40, and which are also non-parallel to the edge set 40. This feature contributes to the non-intuitive manner in which the elements 10, 20 of the invention interfit with each other. It can further be seen that this non-orthographic relationship is due to the manner in which these edge sets 40 peripherally terminate at the vertices 17, 27 of the generally polyhedral elements, or, as in the embodiments depicted in FIGS. 54a, 54b, 56a and 56b, may be alternately achieved by edge-terminating edge sets 40b which terminate along the edges of the construction element's generally polyhedral form (space definition). Such references to terminations at or along vertices or edges are irrespective of any truncation or filleting of those vertices or edges.

It should be further noted that the preferred embodiments described thus far have spherical symmetry. Accordingly, edge sets 40 radiate symmetrically in a radial manner from central point 15,25, so that elements 10,20 may be described as being spherically symmetrical. This facilitates connecting elements 10, 20 to other elements 10, 20 from a plurality of sides and angles, thereby increasing the variety of structures which may be formed by elements 10,20.

FIGS. 30-31 illustrate slightly modified elements 10', 20' of FIG. 1, in which substantial filleting is added to the webbing 44 and clefts 46. Pentahedral-comprised element 10' includes a fully filleted webbing 44 and large clefts 46. In addition, all other edges of modified element 10 are rounded off, without changing the essential shape of element 10'. Similarly, modified tetrahedral-comprised element 201 includes fully filleted webbing 44 and large clefts 46, but is not rounded off on the outer edges in the manner of modified first element 10'. The modified elements 101, 20' would be more practical for manufacture by molding or the like, without substantially changing the function or appearance of the elements.

The best method of manufacture of the preferred embodiments is considered to be injection molding of a solid one piece element, where all of the described features are implemented simultaneously. Such an implementation would require molds consisting of at

least four parts as suggested by Figures 32-34b. These diagrams illustrate a set of four identical dies 50 being used to form modified first element 10' with fully filleted features, as depicted in Figure 30; though not all details of such a mold are presented here. For example, the details required to implement the other eight difurcated edge sets which lie along the mating planes 51 of the four dies are not shown, but the manufacturing of the elements 10, 20 is believed to be within conventional skills of those skilled in the art, and, accordingly, no additional description is believed to be required.

A similar system may be employed for the manufacture of the second described embodiment element 20. However, at least two differing pairs of identical dies may be required. Also, the use of more than the minimum number of component dies may be desirable particularly where regular retooling for a variety of embodiments is expected, or to simply minimize the visibility of resulting seams. The molding of any embodiments of the current invention may directly form the required clefts 46, or the clefts 46 may be provided as a subsequent step. This additional step(s) might involve any of a variety of machining processes or a literal cleaving of the edge sets 40.

A forced mechanical cleaving of the edge sets 40 would, assuming that other design characteristics, including webbing thickness and resiliency of used materials, allow the use of slits as clefts 46, provide particularly stealthy difurcations. Also, the resiliency of an appropriate manufacturing material would tend to re-close the formed clefts 46, making them less visible and more puzzling. The central portion of hollow versions of these manufactures may be similarly molded without the peripheral surfaces (e.g., pyramid bases 14 could be left out during the molding process, with pyramids 12 being hollow). These surfaces could be subsequently added using standard techniques. If these peripheral surfaces 14, 24 were not added, the resulting manufacture would be considered to be comprised of open faced pyramidal members.

An alternate method of manufacture would be to use adhesives or other bonding materials or techniques to assemble discrete polyhedral members into the forms described/claimed as the current invention.

Two computer controlled manufacturing techniques which may be particularly valuable for creating prototypes, if not production models, of the numerous possible

variations on the preferred embodiments are: Successive Layer Deposition; and Convergent Beam Polymer Solidification. Similarly, elements 10,20 may be machined from solid stock using automated numerically controlled equipment.

In yet another manufacturing method, prototypes of various embodiments of the current invention have been created from sheet materials using patterned blanks similar to the ones depicted in FIGS. 35 & 36. In brief, the blank of FIG. 35 is comprised of six generally square and 24 generally equilateral triangular panels further provided with a plurality of securing/gluing tabs for securing the panels in position once folded into the spatially dichotomized cuboctahedron which, when provided with difurcated edge sets by the blank's further provided slits/slots, forms first structural element 10. This blank may be alternately viewed as being comprised of six square and eighteen triangular panels distributed about a central, generally equilateral, hexagonal panel. The blank of FIG. 36 is similarly comprised of 32 generally equilateral triangular panels (or 26 distributed about a central hexagonal panel) also provided with a plurality of securing/gluing tabs which, once folded, forms the spatially inversed spatially dichotomized cuboctahedron which, when provided with difurcated edge sets by the provided slits/slots, forms second structural element 20. In both cases, the hexagonal central panel may be viewed as a continuum of six triangular panels which remain coplanar (unfolded) after all folds have been completed.

These blanks have been used to produce prototypes of pentahedral-comprised element 10 and tetrahedral-comprised element 20, respectively. Each of these blanks is cut along the solid lines 58, including the slits 59, but excluding the lines associated with the center reference marking 60; and then folded toward its printed side along the dashed lines 61 and folded toward its unprinted side along the dotted lines 62. The resulting tabs 63 are then glued to appropriate surfaces to create the target manufactures as illustrated in FIG. 1, 4-14 and 16-26.

Up to two optional reinforcements 64 may be added to pentahedral-comprised element 10 after the folding and gluing of the blank of Figure 35 has been otherwise completed. Each reinforcement 64 being glued to three coplanar radial surfaces, one radial surface of each of three of the resulting pentahedral pyramids 12, providing otherwise unprovided webbing 44 for two more (a total of four more) of the resulting twelve edge sets

40. The remaining two unconnected edge sets 40 may be optionally glued along an inner portion of their length.

Up to twelve reinforcements 65 may be added to tetrahedral-comprised element 20 while the blank of Figure 36 is being implemented. After being folded along its dashed line, each of these reinforcements 65 is glued to surfaces internal to the eight resulting tetrahedrons 22 along otherwise unconnected internal edge lines to provide additional support for otherwise unconnected intersecting surfaces which were further weakened by the provided slits 59. Once otherwise completed, the provided slits in any so constructed embodiments may be widened into slots to allow for the thickness of heavier sheet materials, or otherwise provided for with modifications to the basic blanks shown. In fact, if sheet metal, for example, were used to create larger embodiments, standard bend allowances, as appropriate for the materials in use, would have to be added to the patterns. Similarly, once otherwise completed, the outer vertices may be rounded and/or the slots/clefts tapered, as illustrated in FIG. 27, along the edge sets 40 to allow easier mating and assembly.

FIGS. 37a -37c illustrate a third embodiment of a combined element 70 of the invention. Combined element 70 has one half that is comprised of three physical pentahedral pyramids 12 and four spatial tetrahedral pyramids, and a second contiguous half that is comprised of four physical tetrahedral pyramids 22 and three spatial pentahedral pyramids. Thus, while conforming to the noncuboctahedral equilateral quadecahedron (14 faceted) space definition illustrated in FIGS. 38a-38c, combined element 70 may be interfitted with first element 10, second element 20, and/or additional embodiments of third element 70; and may be viewed as seven facet-based material pyramids (pyramidal members) and seven facet-based spatial pyramids (pyramidal recesses) providing for twelve difurcated edge sets which define and lie on seven mutually oblique and non-parallel planes which intersect at the element's central point.

Figure 39 depicts a blank pattern used to create third embodiment combined element 70. Having portions of both of the blanks of Figures 35 and 36, the alphabetic gluing indices provided on the blank of FIG. 39 are also instructional for the use of the blanks of FIGS. 35 and 36. The lower case character indices indicate that the gluing surface is actually a corresponding location on the reverse (unprinted side) of the blank. Upper case indices

indicate that the gluing surface is the location where the index character is actually printed (its obverse). In each case, an indexed tab 63 is mated with a location having the same but opposite case index character. For example, the reverse of tab "a" is glued to the obverse of location "A"; and the obverse of tab "S" is glued to the reverse of location "s". In each case, the tab is placed and glued along the side of the line that the location index indicates. The placement locations of the optional reinforcements 64,65 have not been indicated, but are left to the discretion of the user, one of the first reinforcement 64 and up to six of the second reinforcement 65 may be used. Although some variation is acceptable, implementing the indexed gluing steps alphabetically is recommended. However, two tabs 63 (or even three, if reinforcements 64, 65 are included) must at times be glued simultaneously. Once folded and glued in this manner, the blank of FIG. 39, comprised of 3 generally square panels and 28 generally equilateral triangular panels (or 3 square and 22 triangular panels distributed about a central hexagonal panel) further provided with a plurality of securing/gluing tabs, forms a spatially dichotomized noncuboctahedral quadecahedron which, when provided with difurcated edge sets by the provided slits/slots, forms third structural element 70.

Virtual embodiments of the current invention may be implemented, by those skilled in the art, through the use of standard general purpose computer hardware and one or more readily available 3D modeling and/or rendering software packages or, where deemed desirable, using existing specialized systems designed to produce virtual environments and/or objects. However, no special hardware or software packages are required to produce useable objects/embodiments or to render these virtual embodiments of the invention visible to the computer operator(s). Although the use of a stereo viewing system may enhance the experience and efficiency of using these virtual embodiments, it would be optional. The hardware and software used to make use of these virtual objects/embodiments may be separate and distinct from those used to produce the virtual objects/embodiments. This is particularly true if one of several 3D modeling standards available to produce and transfer such objects is used, where the specifications of a specific object/embodiment are effected in a standard transferable form in a standard storage medium, allowing such objects/embodiments to be moved to/from, and used by/with, a variety of hardware and

software configurations. Such specifications may be alternately effected in proprietary forms and/or mediums. The physical mediums and methods required to implement the virtual reality/environment required and the physical methods required to produce/use virtual objects, in general, or virtual embodiments of the current invention are thoroughly understood by those skilled in the arts of doing so.

The minimal hardware requirements for producing and/or using such virtual embodiments would be:

1. at least one operator-to-computer interface,
 - a. keyboard
 - b. pointing device
 - c. and/or the like
2. at least one central processing unit,
3. at least one data storage medium,
 - a. fixed storage mediums
 - i. RAM/ROM
 - ii. fixed disk drive (optional)
 - iii. and/or the like
 - b. removable/transferrable storage mediums (optional)
 - i. magnetic media
 - ii. optical media
 - iii. and/or the like
4. at least one computer-to-operator interface device,
 - a. standard computer monitor
 - b. stereo viewer (optional)
 - c. virtual reality helmet/visor (optional)
 - d. and/or the like

running computer software comprising: at least one software module designed to provide and control virtual objects in virtual realities, whereby/in these virtual construction elements may be manipulated and/or displayed by a computer operator, and optionally, at least one additional software module, whereby the manner in which said objects may be aligned,

interfitted, and assembled into larger structures is further restricted by at least one software module which restricts the occupancy of any portion of said virtual reality by more than one portion of defined virtual matter.

The use and usefulness of the current invention as both a construction element and as a puzzlement is demonstrated in Figures 40 thru 47. It can be also seen in these drawings that each assemblage of the preferred embodiments creates, in itself, a new larger intercleavable building block which, as an assembly, or fused or blended into a single monoelement as illustrated in FIGS. 63a-67, may be viewed and used as an embodiment of the current invention, as a construction element of yet larger more complex structures. In this respect, it can be said that the manufactures of the current invention form, or can, or may form, self-similar or fractalized structures or manufactures. Again, such assemblages or fusions may be viewed as Macro manufactures, and therefore, as macro-embodiments of the current invention.

Even the geodic assembly of Figure 48, comprised of twelve each of first element 10 and second element 20, is usable as an intercleaving building block to create even larger structures as illustrated in Figure 49.

Figures 50a thru 53b illustrate how the basic use of a space definition can be further subdivided to define additional embodiments of this class of construction elements which is the current invention. In these cases, it is the cuboctahedron as employed by first element 10 and second element 20 which has been further subdivided. These embodiments also serve to further illustrate the three basic classes of edge sets, vertex-terminating 40a, edge-terminating 40b, and facet-terminating 40c. It can be seen that all edge sets 40 illustrated prior to FIG. 50a are, in fact, more specifically, vertex-terminating edge sets 40a.

Figures 54a & 54b illustrate embodiments based on the projection of portions of the defining points of the cuboctahedral embodiment of Figures 50a & 50b into an octahedron space definition. Though not illustrated here, such basic embodiments may, in addition to being projected into other polyhedral space definitions, be projected into spherical or other ellipsoidal embodiments or into any other nonpolyhedral space definition.

It should also be noted that if aforementioned embodiments were projected (extended/truncated) to spherical or other ellipsoidal embodiments, such vertex-terminating,

edge-terminating, or facet-terminating edge sets would then peripherally terminate along the discontinuous curved surfaces of those embodiments; and such edge set termination designations would then be referring to vertices, edges, and/or facets of the underlying polyhedral form which defined the relative positions and orientations of those edge sets. A similar referencing to the underlying/defining polyhedral form may also be appropriate when such embodiments are further defined by their projection to one or more secondary polyhedral forms (or other geometric forms).

Figures 50a thru 56b and 59a thru 60c also demonstrate the more general definition of a facet-base pyramid. While all of the embodiments depicted prior to FIG. 50a are comprised only of full-facet-based pyramidal members and recesses (where an entire facet of the construction element's polyhedral base acts as the base of the corresponding pyramidal member) many embodiments of the current invention may also (or solely) comprise semi-facet-based pyramidal members and/or recesses, where only a portion/subdivision of the facet of the element's polyhedral base acts as the pyramid's base. The prefix "semi" is being used here to mean, more generally, "partly, not fully" rather than strictly as "half". The distinctions between some of these full-facet-based 43a and semi-facet-based 43b pyramidal members are designated in FIGS. 50a thru 56b and 59a thru 60c.

Figure 55 illustrates the most basic octahedral based embodiment of the current invention, where each facet of a polyhedral space definition is viewed as the base of a pyramid whose summit lies at the center of the space definition. These comprising pyramidal members are then alternately defined as either material or spatial. The original polyhedral whole may now be viewed as having been dichotomized into material and spatial elements. The resulting edge sets are then difurcated as earlier described for first element 10 and second element 20. This may be viewed as a first-order embodiment of the current invention based on a first-order dichotomization (spatial dichotomization) of a defined polyhedral object and/or space definition.

Figures 56a & 56b illustrate embodiments derived by further subdividing an octahedron space definition into polyhedral elements which extend to the center of the space definition. This may be viewed as a fifth-order embodiment of the current invention in that it may be viewed as having been formed by starting with the first-order embodiment of FIG. 55 and

then, four times, dividing it into two sections and spatially inverting one of those two sections; with spatial inversion being the conversion of spatial elements into material elements while simultaneously converting material elements into spatial elements. Each successive cycle/phase of division and spatial inversion can be viewed as an additional level or order of *dichotomization, spatial inversion, or spatial dichotomization*. With this in mind, we may now classify the first, second, and third embodiments (10, 20, and 70, respectively) as first-order embodiments, while the two embodiments depicted in Figures 50a & b and 51a & b are second-order embodiments. Figures 52a & b present two views of a fourth-order cuboctahedron based embodiment; and Figures 53a & b are two views of a seventh-order cuboctahedral embodiment of the current invention. These embodiments may also be viewed as resulting from second, fourth, and seventh-order spatial dichotomizations of a cuboctahedron whose resulting edgesets are subsequently difurcated. As an extension of the second-order embodiment of FIGS. 50a & 50b, that of FIGS. 54a & b may also be classified as a second-order embodiment.

Just as the five first-order embodiments depicted in Figures 57a thru 57e have not been uniformly dichotomized, subsequent dichotomizations need not be evenly distributed nor applied to the entirety of the manufacture, but may be applied to any number of or a single element of the previously defined embodiment. Similarly, subsequent dichotomizations need not be based on binary or centered divisions of the space definition, but may be the result of off-centered divisions, or multiple divisions to which spatial inversion is alternately applied.

These icosahedron based embodiments depicted in Figures 57a thru 57e also serve to illustrate the more general definitions of several terms used throughout this document. We first define a *peripheral surface or facet* of a comprising polyhedral element/formation as any of its surfaces which coincides with, forms, or is generally aligned with a portion of one of the peripheral surfaces of the manufacture as a whole and/or the periphery of any confining space definition, and which do not radiate outward from the center of the manufacture. The periphery of the manufacture would include the resulting truncations of the vertices or edges of its primary form once projected/truncated/extended into a secondary form space definition. For example, the base of a facet-based pyramid would also be referred to as a peripheral facet/surface of that pyramid as well as a peripheral facet/surface of the

manufacture (structural/construction element) itself. Similarly, the sides of that facet-based pyramid, which radiate inward toward its apex, centrally located within the manufactures general form, would also be referred to as radial facets/surfaces of both the pyramidal formation/element and of the manufacture as a whole, since those facets/surfaces radiate
5 from the manufactures core toward/to its peripheral surface(s).

In the case of Figure 57a, the surfaces indexed as A thru G identify seven of the peripheral facets of the depicted icosahedron based manufacture/embodiment as well as the seven underlying material tetrahedral elements of the manufacture. (For simplicity, we are here ignoring those tetrahedral elements whose peripheral surfaces are not visible in these
10 views.) Each of these same seven surfaces is also individually referred to as the peripheral facet or surface of each of the corresponding tetrahedral/pyramidal elements of the embodiment. Furthermore, with the peripheral facets of these tetrahedrons designated as the bases of their pyramidal forms, they also become defined as *facet-based* material pyramids.

In the embodiments of Figures 57b thru 57e the depicted sets of material tetrahedrons
15 are subsets of the set of tetrahedrons depicted in FIG. 57a, where one or more of the seven material tetrahedral pyramids have been converted to spatial elements; i.e. removed or *spatially inverted*, which may also be now referred to as *facet-based* spatial pyramids, or pyramidal recesses/voids.

These seven tetrahedral elements of FIG. 57a may also be viewed as forming at least
20 two complex composite polyhedrons composed of facially adjacent tetrahedral pyramids. That is to say that facially adjacent tetrahedral elements A and B may also be viewed as composite polyhedron AB. Tetrahedrons A and B are said to be facially adjacent because they each have a facet which shares a common and, in this case, coincident planar space with the other. Similarly, the continuous string (continuum) of facially adjacent
25 tetrahedrons C through G may be viewed as the complex polyhedron CDEFG; or as any of several sets of smaller composite polyhedra such as (CD, EF, & G); (CDE & FG); & (DEFG); (CD, E, FG); etc. In this sense, a fully physical icosahedron can be viewed as a cluster or closed continuum of twenty facially adjacent tetrahedrons where each tetrahedron is facially adjacent to three surrounding tetrahedrons; and any subset of facially adjacent
30 tetrahedral pyramids may be viewed as a polyhedral element of the icosahedral whole.

If any individual element or set of these tetrahedral elements of the whole are removed and thereby converted to space, bounded by the remaining physical polyhedral elements, they may be similarly viewed as being spatial elements of this new whole. In FIGS. 57a and 57b, the spiritual elements bounded by physical elements A, C, & F and A, C, E, & G respectively can be referred to as spatial elements acf and aceg respectively.

These spatial elements may each be alternately, and more specifically, referred to as a continuum of apex-coincident, facially adjacent, facet-based pyramidal recessions or voids, or facet-based spatial pyramids. Similarly, the continuous structures formed by these tetrahedral elements may each be more specifically referred to as a continuum of apex-coincident, facially adjacent, facet-based material pyramids or pyramidal formations/elements. Any continuum of material pyramids or individual pyramidal member of a material continuum which protrudes sufficiently to allow it to participate in the formation of an edge set may also be referred to as a structural *member* comprised by the manufacture.

The term diagonally adjacent polyhedrons, or more specifically, diagonally adjacent pyramids is also illustrated here most simply in FIG. 57e where tetrahedral pyramids A, C, and F are each diagonally adjacent to the other two across their common edge lines collectively referred to as an edge set, in this case edge set ACF. Again, each tetrahedron can be viewed separately or as a portion of a more complex polyhedron or of a continuum of tetrahedral pyramids. Therefore, in FIG. 57a, individual tetrahedron C can be viewed as being diagonally adjacent to tetrahedrons A and B individually or diagonally adjacent to the compound polyhedron AB across edge set ABC. Similarly, polyhedron AB may be viewed as being diagonally adjacent to compound polyhedron CDEFG at two points, across edge sets ABC and AFG. Similar to FIG. 57e, in FIG. 57c, compound polyhedrons AB, CD, and FG are each diagonally adjacent to the other two. In FIG. 57b, polyhedron CDE is diagonally adjacent to both G and AB, while G is also diagonally adjacent to AB.

The resulting edge sets visible in the dichotomized polyhedra of FIGS. 57a, b, & c have not been difurcated and would, therefore, not qualify as being intercleaving, as defined herein, unless one or more of their edge sets were in fact difurcated.

In FIG. 57d it can be seen that regardless of how one chooses to view elements F and G, element A has been separated, i.e. difurcated, from both F and G individually and as the

composite element FG, producing what is herein referred to as a difurcated edge set. A more generalized example of difurcated edge sets can be seen in FIG. 52a and 56a where edge sets formed by at least three diagonally adjacent material elements have been difurcated, separating each of the elements from each of the others.

5 FIGS. 58a thru 58c provide three different views of a first-order quindecahedron based embodiment of the current invention. FIGS. 59a thru 60c provide three views of each of two seventh-order embodiments based on: 1) a cube space definition (FIGS. 59a-c); and 2) a rhombic dodecahedron space definition (FIGS. 60a-c). The latter may also be viewed as a
10 projection of the cubic embodiment of FIGS. 59a thru 59c into the rhombic dodecahedron space definition.

FIGS. 61 and 62 depict successively fractalized assemblages of the first-order octahedral embodiment presented in FIG. 55. FIG. 61 is the result of six of these FIG. 55
15 embodiments being mated with a centering seventh along its six difurcated edge sets. Similarly, the structure of FIG. 62 is formed when six FIG. 61 macro-embodiments are mated with the six exposed edge sets of a seventh FIG. 61 embodiment.

FIG. 63a illustrates an embodiment based upon fusing the assembly illustrated in FIG. 40, comprised of a first embodiment element 10 interfitted with a second embodiment
20 element 20, which are fused together to form a single contiguous fused element 130. The fused element 130 includes a combination of a first element 10 and a second element 20, but two of the voids of the second embodiment element 20 portion of fused element 130 have been optionally filled, but still leave element 130 with a number of difurcated edge sets capable of intercleaving with additional elements of the invention, as set forth above. FIG. 63b illustrates a reverse-side view of fused element 130 rotated approximately 120 degrees. FIG. 63c illustrates a bottom view of fused element 130.

25 FIGS. 64 thru 67 illustrate additional fused embodiments which may be constructed in accordance with the present invention. FIG. 64 illustrates an embodiment based on a fusing of three first embodiment elements 10 with a single centrally-located second embodiment element 20. FIG. 65 illustrates an embodiment based on the fusing of three second
embodiment elements 20 with a single centrally-located first embodiment element 10.

30 FIG. 66 illustrates the embodiment of FIG. 64 with the tetrahedral voids filled in. FIG.

67 illustrates the embodiment of FIG. 65 with the central tetrahedral void filled in. It will be apparent that a variety of other fused elements may also be constructed based on the structural elements of the invention.

5 The embodiments of FIGS. 63b thru 65 and most obviously in FIGS. 66 and 67 may also be viewed as construction elements comprising intercleaving spatially dichotomized multifaceted protrusions, or in other words, protrusions which have been individually and/or collectively formed/modified to comply with the teachings and specifications of the current invention.

10 In more general discussion, if molded of appropriate materials (including recycled plastics) and in appropriate sizes, various embodiments of the current invention can be used as decorative construction blocks. They can be assembled to function as lawn furnishings, sculptures, climbing structures and play houses, planters and trellises, or as privacy or retaining walls, including unique outdoor staircases which might double as retaining walls.

15 Their intercleaving nature will make them particularly suitable for constructing large retaining or sea walls. A variety of manufacture and assembly techniques can be employed to create unique wave dampening systems/structures, and artificial reefs. These aquatic uses might be most effective if implemented with elements which are at least partially hollowed and provided with appropriately sized portals to control wave and tidal induced water flows, as well as to function as homes and sheltered hatcheries for small to medium sized aquatic
20 life. Geodic assemblies may be useful not only in such aquatic shelters, but also in industrial settings as containment chambers or bunkers.

Constructed of appropriate materials (steel, aluminum, industrial plastics, epoxy/fiber composites, etc.) and in appropriate sizes, these structures may also function as a connection system for structural members/beams. The structural members (rods, I-beams, trusses, etc.)
25 may be attached to a portion of one or more of the outer surfaces of the structures and/or the structures attached to each end of the members. The members may also be extensions of the outer surface of one or more of the physical or spatial polyhedrons. In the latter case, the beam would extend into and fill the spatial polyhedron and, in effect, be permanently attached. Additional threaded or unthreaded receptacles/openings may also be provided to
30 allow for a more permanent assembly of structures via bolts or rivets, or they may simply

be bonded by welds or adhesives. The interfitting nature of these structures will allow the beams to self-align and hold themselves in place while construction crews or do-it-yourselfers complete the assembly and/or the adhesives harden/cure. The manner in which the surfaces of the intercleaving structures interface make these structures particularly effective in amplifying the strength of adhesive bondings.

Rather than having the structural members attached directly to the surfaces of these structures, receptacles may be machined or molded into these surfaces to receive the members. The spatial polyhedrons formed within the basic embodiments may also be used, with or without modifications, as Structural Member receptacles. Manufactured from appropriate materials they may be used for heavy "or light weight real-world construction, or in a recreational construction set. In such construction sets, the basic embodiments would not only serve to interconnect the rods, but would also be able to interact with each other.

In any of the aforementioned real construction systems/uses, care must be taken to provide more than adequate webbing, central point, and reinforcement material to insure structural integrity above and beyond the intended use. Although any stipulated use of mortar or other adhesive or connective systems (collectively referred to here as mortared) would greatly increase the strength of assembled structures, there would be, due to their basic nature, a tendency by end users to use such blocks or construction members in a mortarless manner. In such mortarless assemblies, no matter how tightly fitted and mutually supportive the discrete intercleaving components may be, their primary weakness will, of course, lie along their difurcated edge sets. This weakness is further amplified by the relatively high moments of inertia about these edge sets and their coincident central points due to the inverted pyramidal masses of their comprising polyhedral elements, relative to their coincident central points. These inertial moments may be reduced by making the outermost portions of the polyhedral elements hollow or comprised of light weight aggregates, foam or honeycombed structures. In any case, the final design of discrete components should, both individually and in mortared or unmortared compiled assemblies, be as capable or more capable of enduring the abnormal G forces associated with earth tremors, quakes, or abnormal tidal effects, or waves, as any comparable mortared construction system.

Elements of differing sizes may be interconnected to represent different elements in molecular and crystal models, or to simply allow greater artistic and structural variety in general recreational and construction applications. Individual structures, with or without the interfacing features, and simulated or permanently assembled combinations of structures may also be produced as stand-alone decorative and/or functional products. Such products might include nicknacks, paperweights, ash trays, candle holders/lamps, bookends, Christmas tree ornaments, candy dishes, and trinket boxes. Larger items might include coffee and end tables, magazine racks, stools, benches, lamps, and ottomans. Thus, while preferred embodiments have been described herein, it will be recognized that a variety of changes and modifications may be made without departing from the spirit of the subject invention.

CLAIMS

1. A set of at least two structural elements which may be intercleaved with each other for forming an assembly, said set comprising:

5 a first structural element having at least two diagonally adjacent first physical polyhedral members and at least two first spatial polyhedral members sharing coincident first edge lines for forming a first edge set;

10 a second structural element having at least two diagonally adjacent second physical polyhedral members and at least two second spatial polyhedral members sharing coincident second edge lines for forming a second edge set;

15 wherein said first physical polyhedral members are the same polyhedral shape as said second spatial polyhedral members and said second physical polyhedral members are the same shape as said first spatial polyhedral members, but said first physical polyhedral members are of a different polyhedral shape from said second physical polyhedral members; and

wherein at least one of said first edge set and said second edge set includes a cleft whereby said first structural element may be intercleaved to said second structural element by inserting said first physical polyhedral members into the voids formed by said second spatial polyhedral members.

20 2. The set of claim 1 wherein said first physical polyhedral members are pentahedral square-based pyramids, and wherein said second physical polyhedral members are tetrahedral pyramids.

25 3. The set of claim 1 wherein said first structural element is formed using six pentahedral pyramids as said first physical polyhedral members, and wherein said second structural element is formed using eight tetrahedral pyramids as said second physical polyhedral members.

4. The set of claim 1 wherein said first physical polyhedral members are arranged within a cuboctahedron space definition, and wherein said second physical polyhedral members are arranged in a complementary manner within a cuboctahedron space definition.

5. The set of claim 1 wherein said cleft is formed along at least 50 percent of said first edge set and along at least 50 percent of said second edge set.

6. A set of complimentary elements which may be assembled with one-another for forming a structure, said set comprising:

5 a first element having a plurality of first polyhedron members arranged symmetrically about a central point whereby the edges of said first polyhedron members are aligned with the edges of diagonally adjacent first polyhedron members and connected thereto by a webbing, and wherein a first cleft is formed in a portion of said webbing;

10 a second element having a plurality of second polyhedron members arranged symmetrically about a central point whereby the edges of said second polyhedron members are aligned with the edges of diagonally adjacent second polyhedron members and connected thereto by a webbing, and wherein a second cleft is formed along a portion of said webbing;

15 whereby said first element has voids in the shape of said second polyhedron members, which accommodate portions of said second element, and said second element has voids in the shape of said first polyhedron members which accommodate portions of said first element when said first element is assembled to said second element by inserting the webbing of said first element into said second cleft of said second element and the webbing of the second element into said first cleft of the first element for assembling the first element to the second element.

20 7. The set of claim 6 wherein said first polyhedron members are pentahedral square-based pyramids, and wherein said second polyhedron members are tetrahedral pyramids.

8. The set of claim 6 further including a third element having a combination of said first polyhedron members on one half thereof and said second polyhedron members on the other half thereof for assembly to either of said first elements or said second elements.

25 9. The set of claim 6 wherein said first element is formed using six pentahedral pyramids as said first polyhedron members, and wherein said second element is formed using eight tetrahedral pyramids as said second polyhedron members.

10. The set of claim 6 wherein said first polyhedron members are arranged within a cuboctahedron space definition, and wherein said second polyhedron members are arranged

in a complementary manner within a cuboctahedron space definition.

11. A set of structural elements capable of assembly by interfitting with each other, said set comprising:

5 at least one first element, said first element being composed of six equilateral square based pyramids having their apexes located at a single central point, and an having their edges aligned with the edges of diagonally adjacent said square-based pyramids, with clefts located along the outer portions of said aligned edges;

10 at least one second element, said second element being composed of eight equilateral tetrahedral pyramids having their apexes located at a single central point, and having their edges aligned with the edges of diagonally adjacent said tetrahedral pyramids, with clefts located along the outer portions of said aligned edges; and

15 whereby said clefts permit portions of said square based pyramids to be inserted into spaces between said tetrahedral pyramids, while portions of said tetrahedral pyramids may be simultaneously inserted into spaces between said square-based pyramids for interfitting said first element with said second element.

12. The set of claim 11 wherein said square-based pyramids of said first elements are arranged to correspond with the square surfaces of a cuboctahedral space definition, and wherein said tetrahedral pyramids of said second element are arranged to correspond with the triangular surfaces of a cuboctahedral space definition.

20 13. The set of claim 11 wherein a third element is included, said third element having one half that is comprised of three pentahedral square-based pyramids and an another half that is comprised of four tetrahedral pyramids arranged around a central point, whereby said third element can intercleave with either said first element or said second element.

25 14. The set of claim 11 wherein webbing is included along said aligned edges of said square-based pyramids and said aligned edges of said tetrahedral pyramids for maintaining the structural integrity of said first element and said second element, respectively.

15. A system for assembling a structure of multiple intercleaving elements, said system comprising:

providing a first element, said first element including a plurality of first polyhedral members, said first polyhedral members being clustered about at least one first central point in an edge-aligned fashion so that first voids are located on both sides of any pair of diagonally adjacent polyhedral members whereby the coincident aligned edges of said first polyhedral members create first edge sets, and further whereby a cleft is provided along a portion of at least one said first edge sets;

providing a second element including a plurality of second polyhedral members, said second polyhedral members being of a shape different from said first polyhedral members, said second polyhedral members being clustered about at least one second central point in an edge-aligned fashion whereby the coincident aligned edges of said second polyhedral members create second edge sets, and further whereby a cleft is provided along a portion of at least one said second edge sets, and second voids are located on both sides of any pair of diagonally adjacent said second polyhedral members, whereby, said second element may be assembled to said first element by inserting portions of said first polyhedral members into said second voids, and said second polyhedral members into said first voids by sliding together along said first and second edge sets.

16. The system of claim 15 wherein said first polyhedral members are pentahedral square-based pyramids, and wherein said second polyhedral members are tetrahedral pyramids.

17. The system of claim 15 further including providing a third element having a combination of said first polyhedral members on one half thereof and said second polyhedral members on the other half thereof for assembly to either of said first elements or said second elements.

18. The system of claim 15 wherein said first element is formed having six square-based pentahedral pyramids as said first polyhedral members arranged in a spherically symmetrical pattern about said first central point, and wherein said second element is formed having eight tetrahedral pyramids as said second polyhedral members arranged in a spherically symmetrical pattern about said second central point.

19. The system of claim 15 wherein said first polyhedral members are arranged within a cuboctahedron space definition, and wherein said second polyhedral members are arranged in a complementary manner within a cuboctahedron space definition.

20. The system of claim 15 wherein said first voids are the same shape as said second polyhedral members, and said second voids are the same shape as said first polyhedral members.

21. Construction elements comprising a plurality of generally polyhedral members formed and arranged fully within the confines of, and generally conforming to the shape of, a polyhedral base in a manner whereby:

10 at least one set of at least two diagonally adjacent polyhedral members is formed, where

at least one facet of at least one member of at least one of said at least one set of diagonally adjacent polyhedral members is coplanar with, and coincident with at least a portion of one of the facets of said polyhedral base, and where

15 at least one vertex of said facet of at least one of said member is coincident with a vertex of said facet of said polyhedral base, wherein

an edge set is formed along the coincident edges of said diagonally adjacent polyhedral members of each of said at least one set of diagonally adjacent polyhedral members, and wherein

20 a plurality of polyhedral voids are formed by and interspersed among said polyhedral members in a manner whereby

at least two diagonally adjacent polyhedral voids are formed about each edge set formed by said at least one set of diagonally adjacent polyhedral members, and wherein

25 said polyhedral members of at least one of said at least one set of diagonally adjacent polyhedral members are interconnected along an innermost portion of the length of said formed edge set and where

said polyhedral members of said at least one set of interconnected diagonally adjacent polyhedral members are difurcated along an outermost portion of the length of said formed edge set, thereby

30 forming at least one difurcated edge set, where

at least one of said at least one difurcated edge set radiates inward from a point along an edge of said polyhedral base, where

said edge of said polyhedral base is inclusive of the two vertices of said polyhedral base which define said edge, whereby

5 said at least one difurcated edge set enables the interfitting of a first said construction element along said edge set with at least a second said construction element having a substantially complementarily formed and difurcated edge set; whereby

10 the body of said first construction element penetrates into the body of said second construction element and the body of said second construction element simultaneously penetrates into the body of said first construction element in a mutually intercleaving, mutually interpenetrating, and mutually supporting manner, whereby

the construction of intercleaving assemblages of said construction elements is facilitated, and

15 where said polyhedral base is said to provide the basis of a generally polyhedral body for said construction element, and

where said interfitting of said complimentary construction elements is enabled by the aforementioned formations fully implemented within the confines of said polyhedral body,

said interfitting is thereby fully enabled without an attachment of appendages to said polyhedral body.

20

22. Generally polyhedral construction elements comprising a polyhedral body, within which

a plurality of diagonally adjacent facet-based pyramidal recesses are formed, further forming

5 a plurality of diagonally adjacent facet-based pyramidal members, and

a plurality of difurcated edge sets, where said difurcated edge sets each comprise a plurality of coincident edges of diagonally adjacent facet-based pyramidal members,

a plurality of coincident edges of diagonally adjacent facet-based pyramidal

10 recesses interspersed among said diagonally adjacent members, and

a plurality of clefts each implemented along an outermost portion of one of said coincident edges of said diagonally adjacent members, and where

each of said difurcated edge sets enables the interfitting of a first said construction element along said edge set with at least a second said construction element having

15 a substantially complementarily formed and difurcated edge set; whereby

the body of said first construction element penetrates into the body of said second construction element and the body of said second construction element simultaneously penetrates into the body of said first construction element in a mutually intercleaving, mutually interpenetrating manner.

20 23. Generally polyhedral construction elements of claim 22 where

said facet-based pyramidal recesses are each an effected recession of a *polygonal portion* of one of the facets of said polyhedral body inward toward a central point of the construction element, where

25 said *polygonal portion* of said polyhedral body's facet and said central point serves as the base and apex, respectively, of said facet-based pyramidal recess, and where

said facet-based pyramidal members are each an effected extension of a *polygonal portion* of one of the facets of said polyhedral body inward toward a central point of the construction element, where

30 said *polygonal portion* of said polyhedral body's facet and said central point

serves as the base and apex, respectively, of said facet-based pyramidal member.

24. Generally polyhedral construction elements of claim 22 where at least one of said plurality of recesses is *a continuum of at least one* facet-based pyramidal recess, and

at least one of said plurality of members *a continuum of at least one* facet-based pyramidal member.

25. The construction elements cited in claim 21 wherein at least one of said at least one difurcated edge sets radiates inward from a vertex of said polyhedral base/body.

26. The construction elements cited in claim 21 wherein at least one of said difurcated edge sets is obliquely noncoplanar with and nonparallel to at least one co-planar pair of said difurcated edge sets.

27. The construction elements cited in any one of claims 21 thru 24 wherein said polyhedral members of of said sets of diagonally adjacent polyhedral members are interconnected along an innermost portion of the length of said formed edge sets by webbing, and where said polyhedral members of at least one set of said interconnected diagonally adjacent polyhedral members are difurcated along an outermost portion of the length of said formed edge set by at least one slot, thereby forming at least one difurcated edge set.

28. The construction elements cited in any one of claims 21 thru 26 wherein said polyhedral members of said sets of diagonally adjacent polyhedral members are interconnected along an innermost portion of the length of said formed edge sets by webbing, and where said polyhedral members of at least one set of said interconnected diagonally adjacent polyhedral members is provided with a *provisional difurcation* along an outermost portion of the length of said formed edge set.

29. The construction elements cited in any one of claims 21 thru 26 wherein said polyhedral members of at least one of said at least one set of diagonally adjacent polyhedral members are interconnected along an innermost portion of the length of said formed edge set by webbing, and where said polyhedral members of said at least one set of interconnected diagonally adjacent polyhedral members is provided with a *provisional difurcation* along an outermost portion of the length of said formed edge set, thereby forming at least one

provisionally difurcated edge set, where said at least one provisional difurcation is implemented *as noticeably thinner webbing*, whereby at least one slot may be, at a later time, readily implemented between at least one pair of said diagonally adjacent polyhedral members, whereby said at least one difurcated edge set is facilitated, and thereby *indirectly and/or cooperatively implemented*.

5 30. The construction elements cited in any one of claims 21 thru 24 where said generally polyhedral base is further limited to a convex polyhedral base/body.

 31. The construction elements cited in any one of claims 21 thru 24 where said generally polyhedral base is further limited to a spherically symmetrical polyhedral
10 base/body.

 32. The construction elements cited in any one of claims 21 thru 24 where said generally polyhedral base is further limited to a generally nonprismatic polyhedral base/body.

 33. The construction elements of any one of claims 21 thru 24 wherein said
15 construction elements have a generally polyhedral base/body chosen from the set consisting of cuboids, octahedrons, dodecahedrons (including rhombic dodecahedrons), quadehedrons (including cuboctahedrons), quindecadhedrons, and icosahedrons.

 34. The construction elements cited in any one of claims 1 thru 24 further defined by an effected projection of at least a portion of the peripheral points and surfaces of said
20 construction elements to the surface(s) of a second geometric form.

 35. The construction elements cited in any one of claims 1 thru 24 further defined by an effected projection of at least a portion of the peripheral points and surfaces of said construction elements to the form of a convex polyhedron.

 36. The construction elements cited in any one of claims 1 thru 24 further defined by
25 an effected projection of at least a portion of the peripheral points and surfaces of said construction elements to the form of an ellipsoid, where ellipsoids are inclusive of spheres and other spheroids.

 37. Construction elements comprising a fused and/or blended plurality of the construction elements of any one of claims 21 thru 24.

30 38. Construction elements of any one of claims 21 thru 24 comprising the functional

equivalent of a fused plurality of interfitted construction elements, where

each of said plurality of construction elements is individually a construction element as defined in claims 21 thru 24 respectively based in a convex polyhedral base, and where

5 at least one of said plurality of elements forms a generally convex protrusion, where each of said protrusions comprises at least one of said difurcated edge sets radiating inward from a vertex of said protrusion.

39. The construction elements of claim 38 wherein at least one of said plurality of construction elements has been further defined by the effected projection of at least a portion
10 of its peripheral points and surfaces into the form of a section of a spheroid.

40. The construction elements of any one of claims 21 thru 26 further limited to construction elements produced in a virtual reality provide by a virtual medium for computer manipulation and display, where

15 said virtual medium is physically provided in the form of a general purpose computer hardware system running computer software comprising at least one software module designed to provide and control the objects within virtual realities, such as said virtual reality, whereby said manipulation and display of elements of said virtual reality, such as said construction elements, by a computer operator, are facilitated, and where
20 the specifications of said claims are effected in a standard form in a standard storage medium, where said polyhedral members of said construction elements are formed as virtual matter in accordance with the specifications of said claims, and wherein said polyhedral voids are interspersed among and defined by said virtual matter within
25 said base/body.

41. The construction elements of claim 40 where said computer hardware system had been specifically designed to provide and control virtual realities, such as said virtual reality

42. The construction elements of claim 40 where said computer hardware system comprises at least one operator-to-computer interface, at least one central processing unit,
30 at least one data storage medium, and at least one computer-to-operator interface device,

where said computer-to-operator interfaces are inclusive of a computer monitor.

43 The construction elements of claim 42 where said at least one computer-to-operator interface device comprises at least one stereo viewing system.

5 44. The construction elements of any one of claims 40 thru 43 where the manner in which said construction elements may be aligned, interfitted, and assembled into larger structures is further restricted by at least one software module which restricts the occupancy of any portion of said virtual reality by more than one portion of defined virtual matter.

10 45. A sheet material blanks for folding into the form of a spatially dichotomized cuboctahedron comprised of six material pentahedral pyramids further forming eight spatial tetrahedrons and twelve edge sets, where said blank comprises

a continuum of six (6) generally square panels and

twenty-four (24) generally equilateral triangular panels

further provided with a plurality of securing/gluing tabs for securing the panels in position once folded.

15 46. The sheet material blank of claim 45 further provided with a plurality of slits/slots, where

said slits/slots are located in a manner which provides said dichotomized cuboctahedron

with a plurality of *difurcated* edge sets,

forming said first structural element defined in claim 12.

20 47. A sheet material blank for folding into the form of a spatially dichotomized cuboctahedron comprised of eight material tetrahedral pyramids further forming six spatial pentahedral pyramids and twelve edge sets, where said blank comprises

a continuum of thirty-two (32) generally equilateral triangular panels

further provided with a plurality of securing/gluing tabs for securing the panels in position once folded.

25

48. The sheet material blank of claim 47 further provided with a plurality of slits/slots,

where

said slits/slots are located in a manner which provides said dichotomized cuboctahedron

with a plurality of *difurcated* edge sets,

30

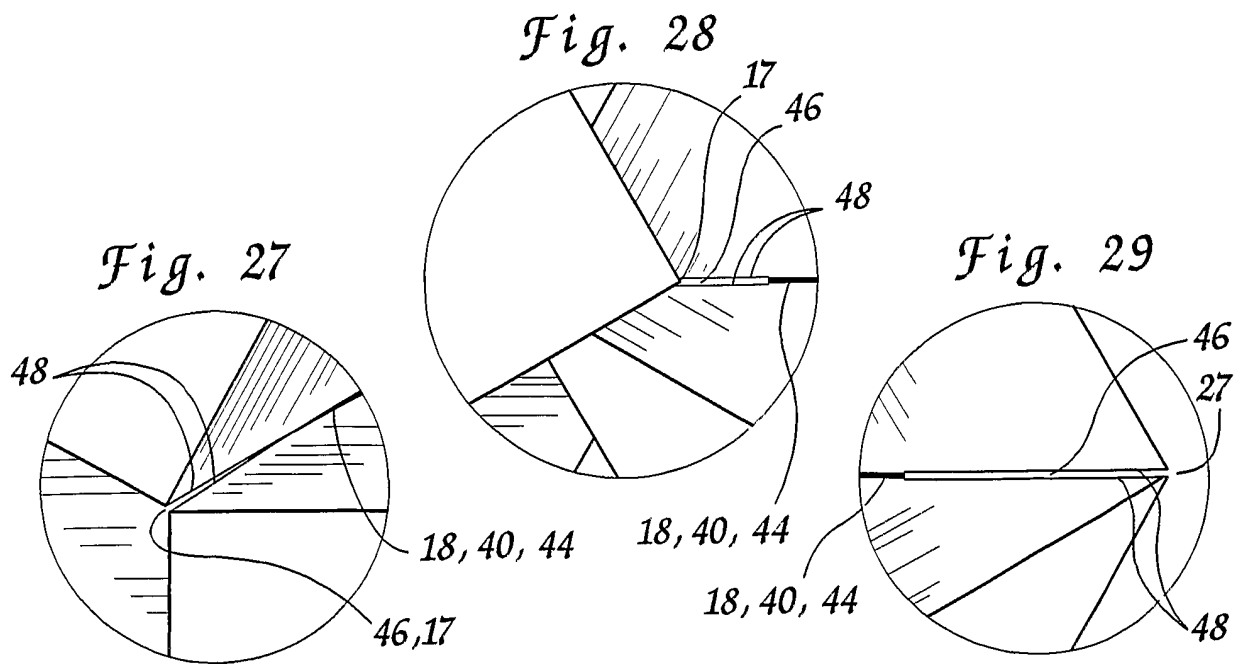
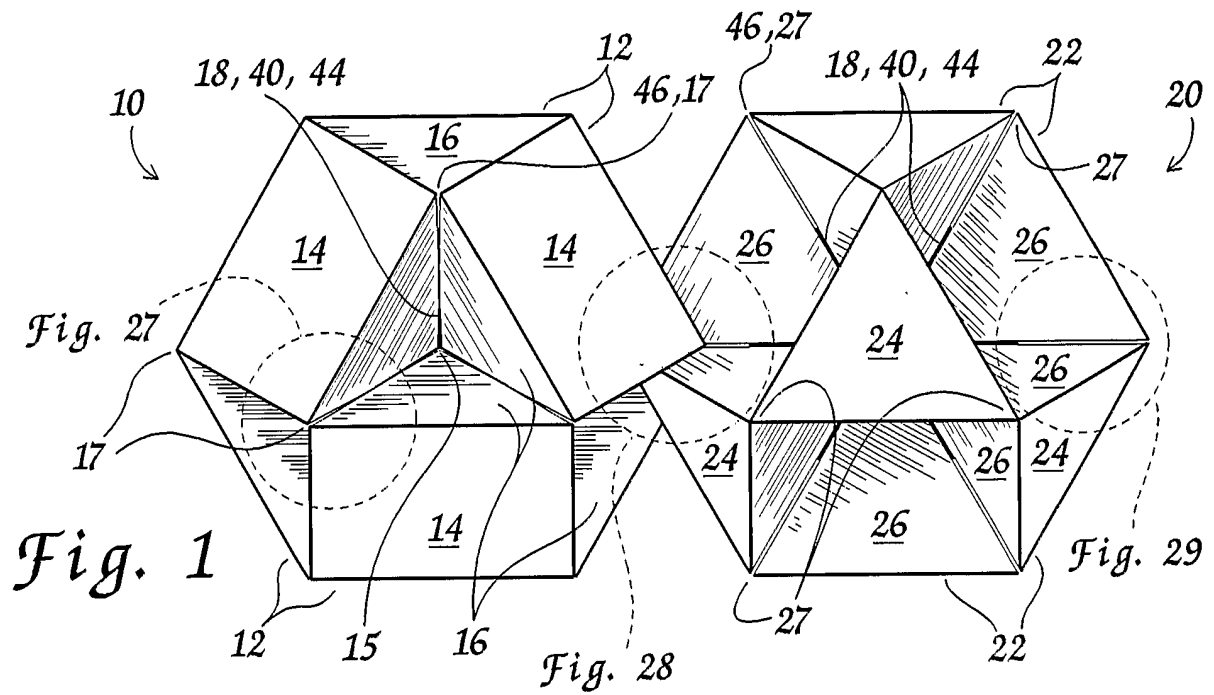
forming said second structural element defined in claim 12.

49. A sheet material blank for folding into the form of a spatially dichotomized quadecahedron comprised of three material pentahedral pyramids and four material tetrahedral pyramids further forming four spatial tetrahedrons, three spatial pentahedral pyramids, and twelve edge sets, where said blank comprises

5 a continuum of three (3) generally square panels and
twenty-eight (28) generally equilateral triangular panels
further provided with a plurality of securing/gluing tabs for securing the panels in
position once folded.

50. The sheet material blank of claim 49 further provided with a plurality of slits/slots,
10 where
said slits/slots provides said dichotomized noncuboctahedral quadecahedron with a
plurality of *difurcated* edge sets,
forming the noncuboctahedral quadecahedron third structural element defined in
claim 13.

15 51. The construction elements of any one of the claims 21 thru 26 wherein said
pyramidal members are limited to physical pyramidal members.



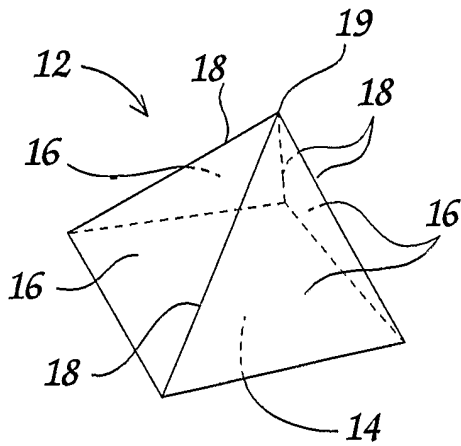


Fig. 2

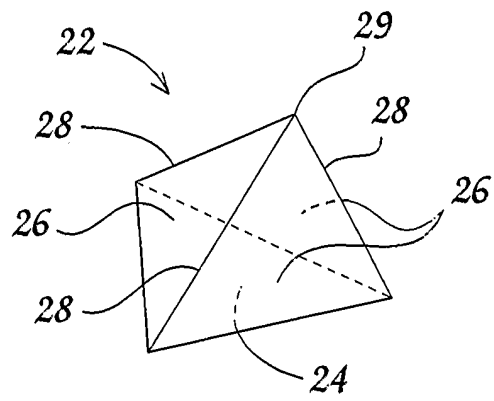


Fig. 3

Fig. 15a

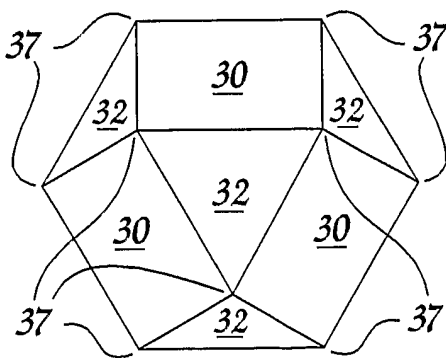
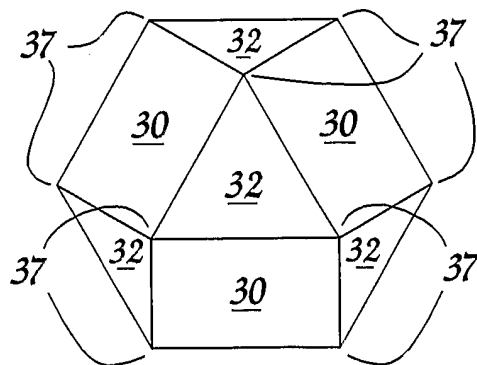


Fig. 15b



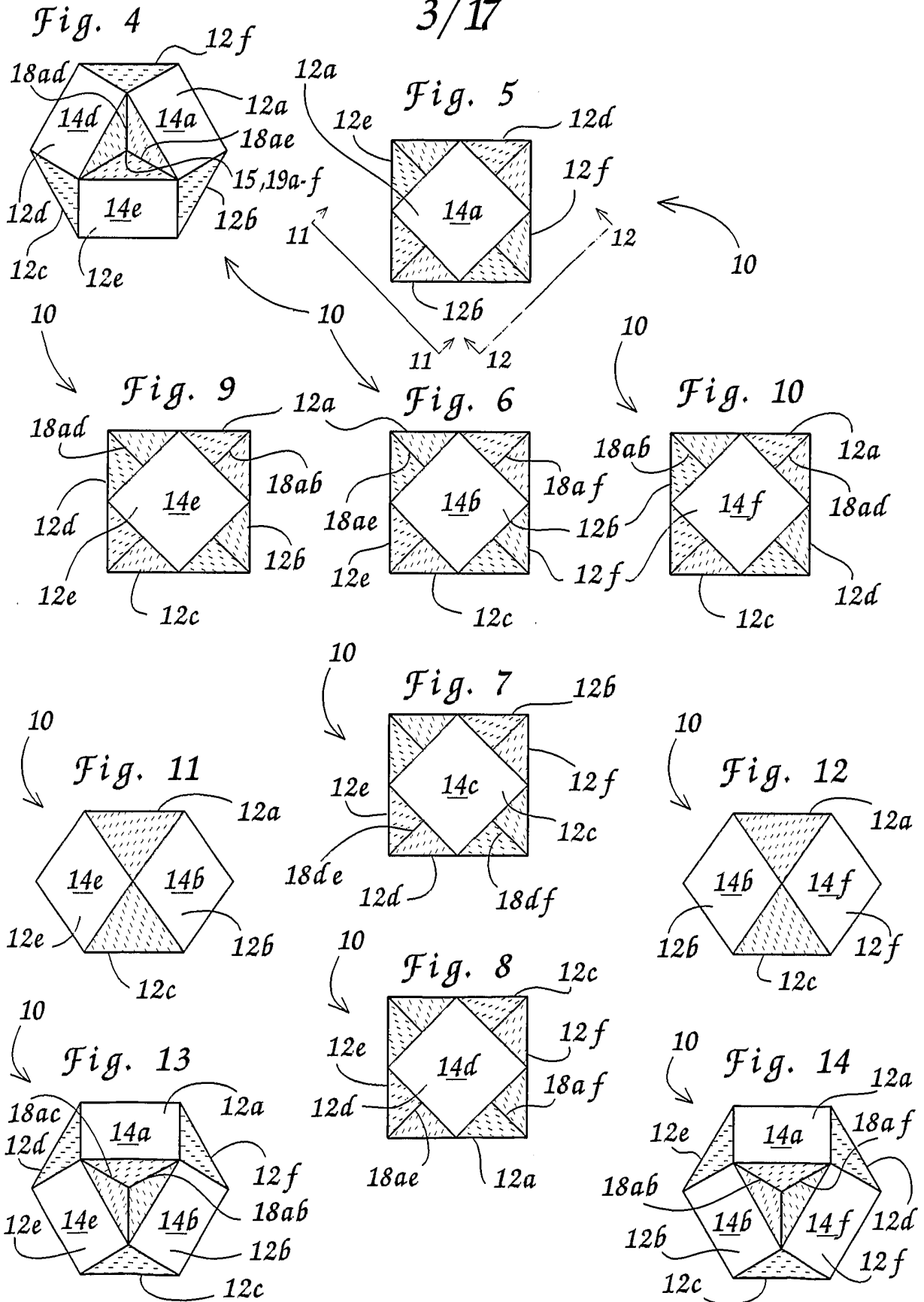


Fig. 16

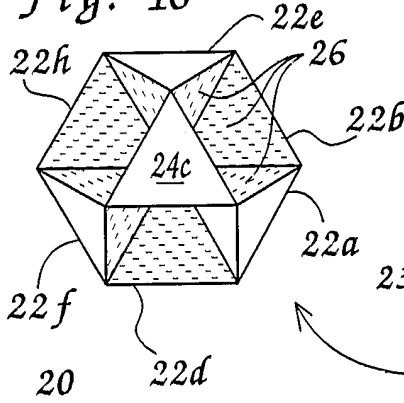


Fig. 17

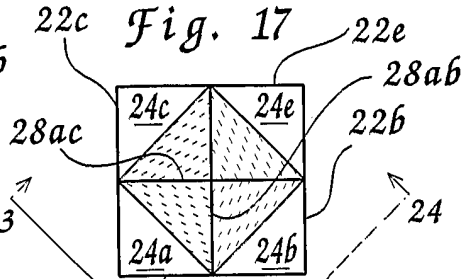


Fig. 21

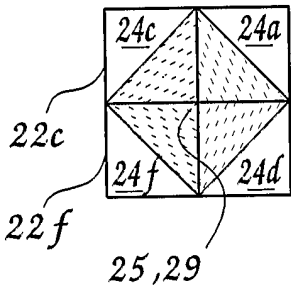


Fig. 18

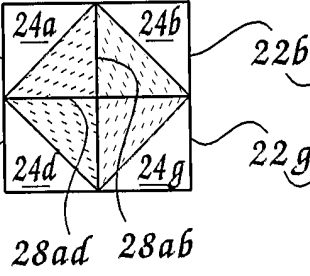


Fig. 22

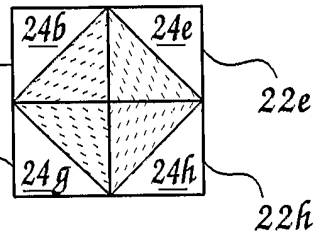


Fig. 23

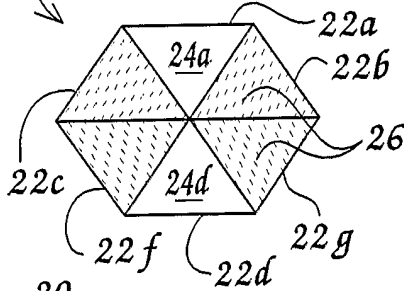


Fig. 19

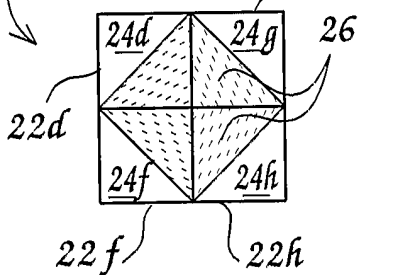


Fig. 24

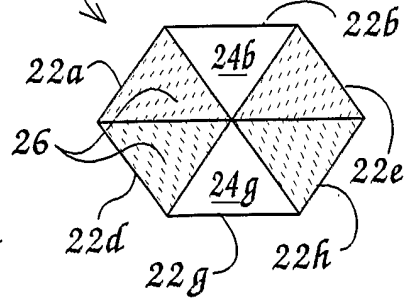


Fig. 25

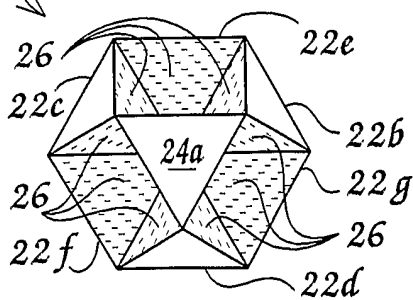


Fig. 20

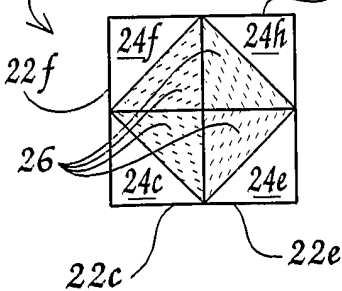
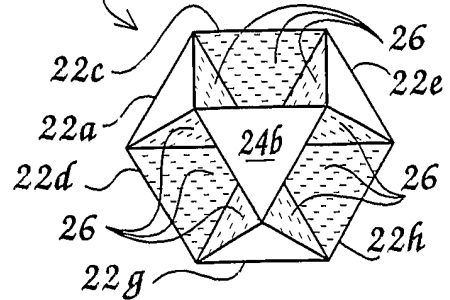
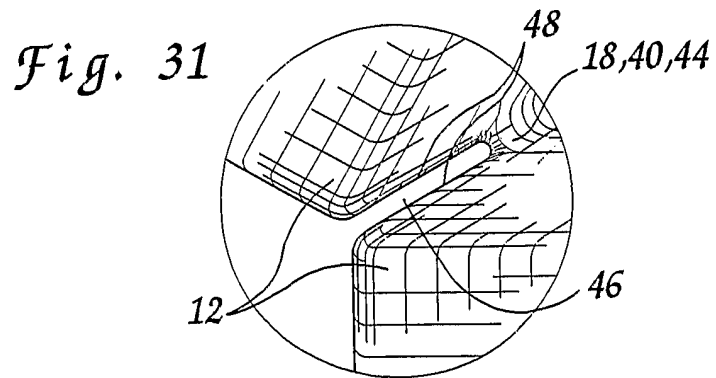
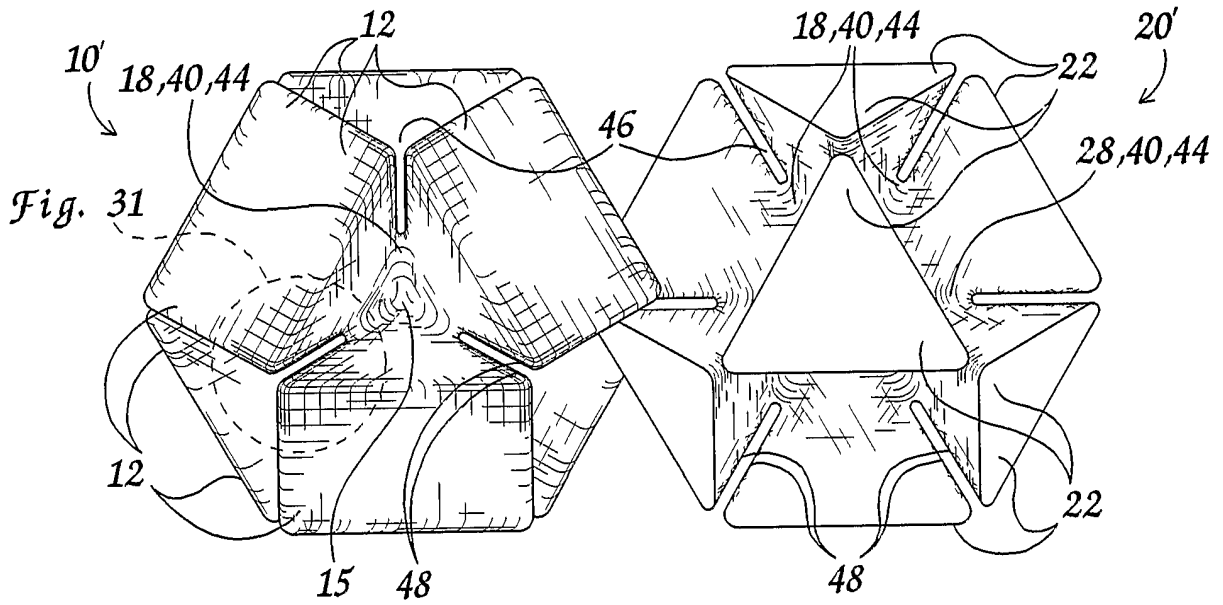


Fig. 26



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Fig. 30



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Fig. 32

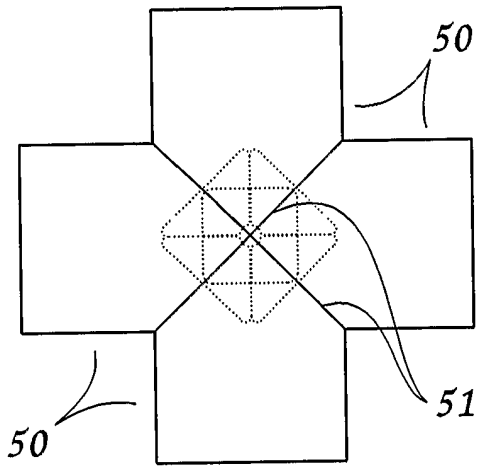


Fig. 33

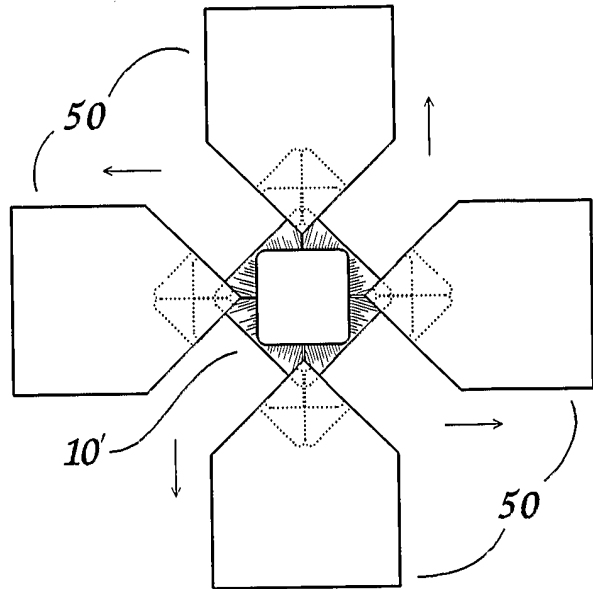


Fig. 34a

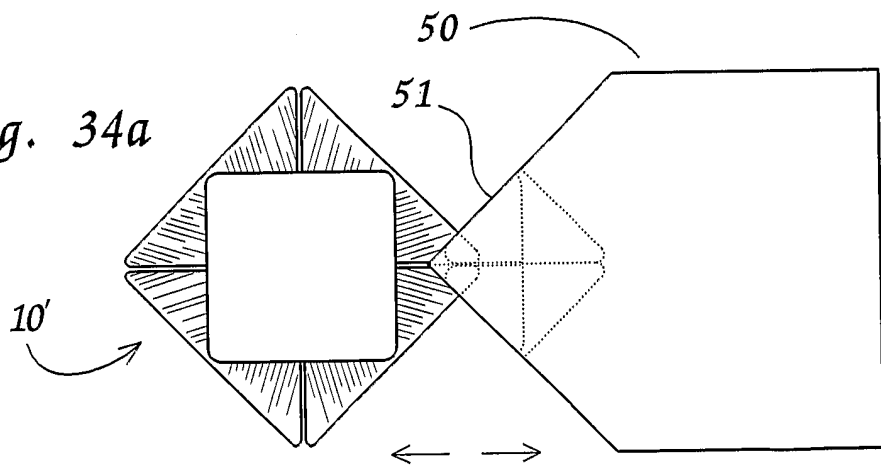
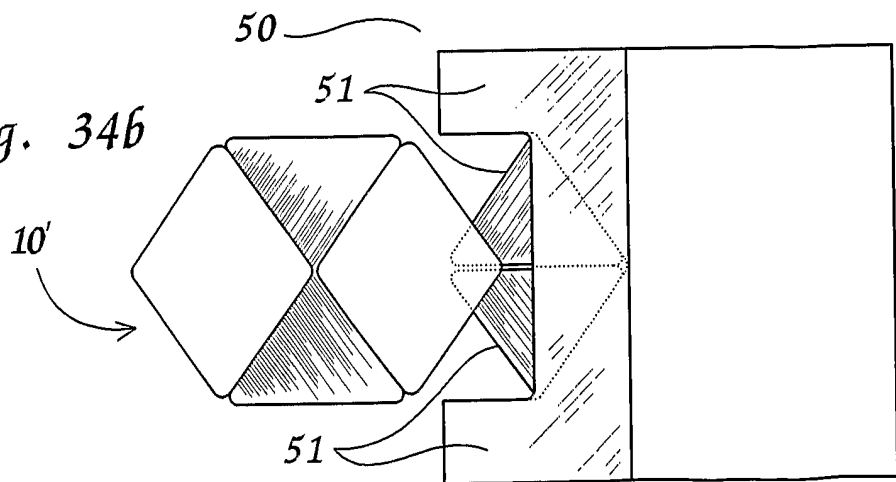


Fig. 34b



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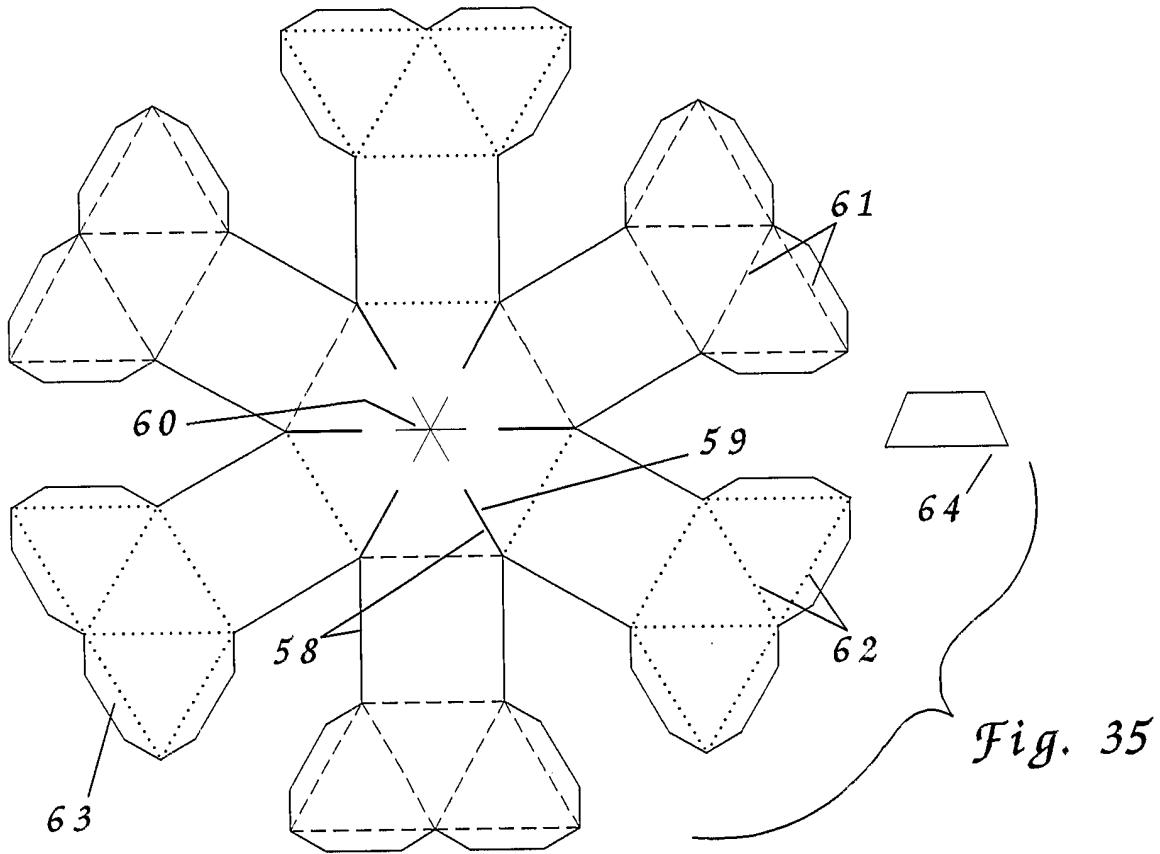
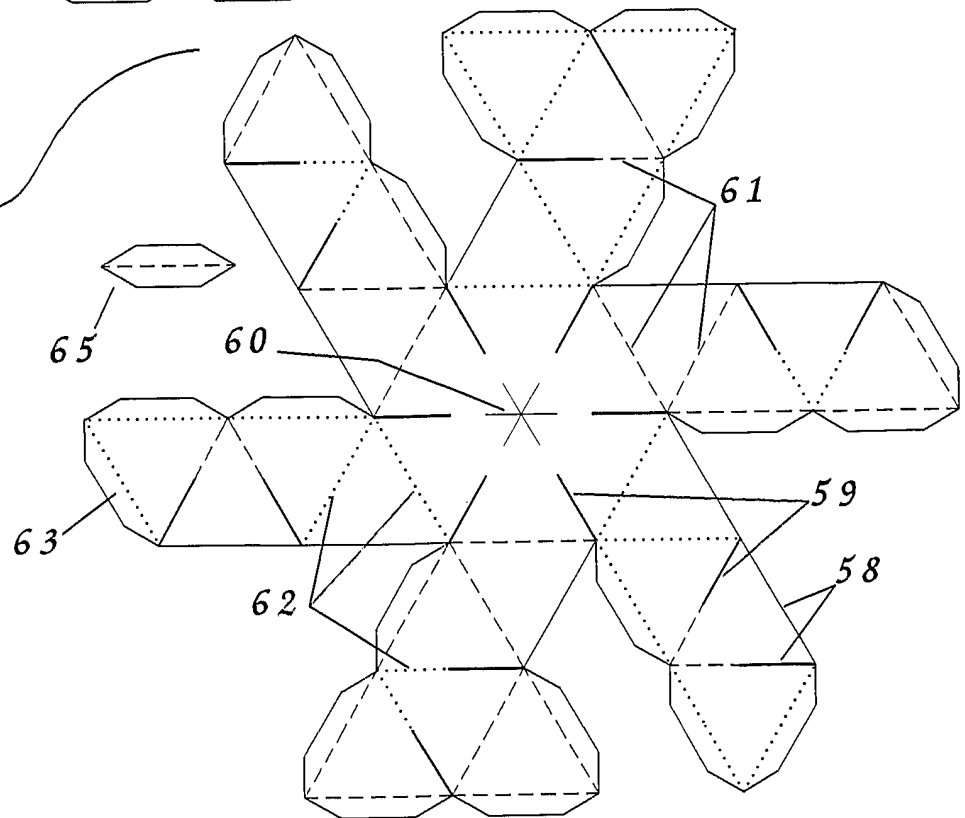
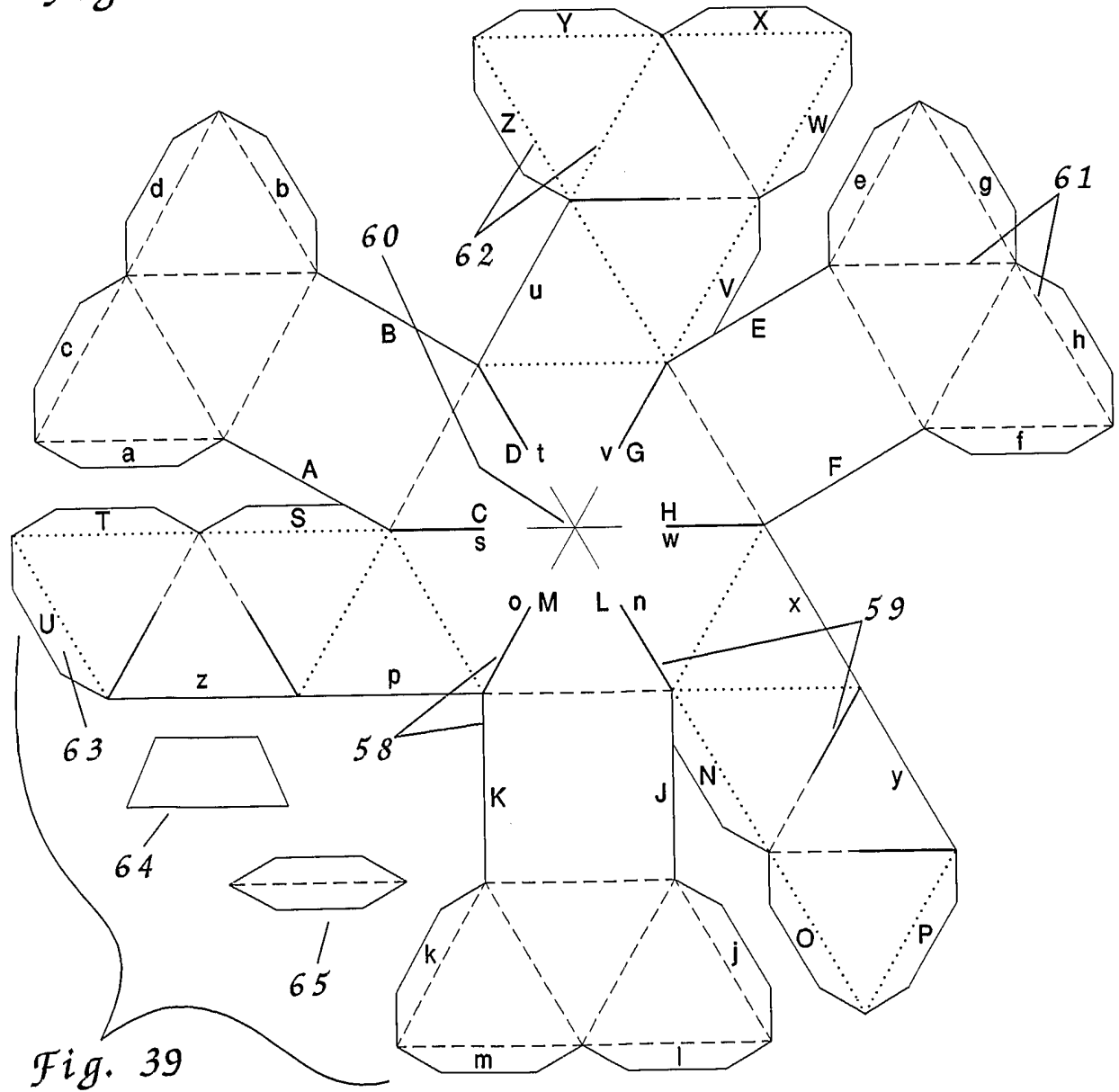
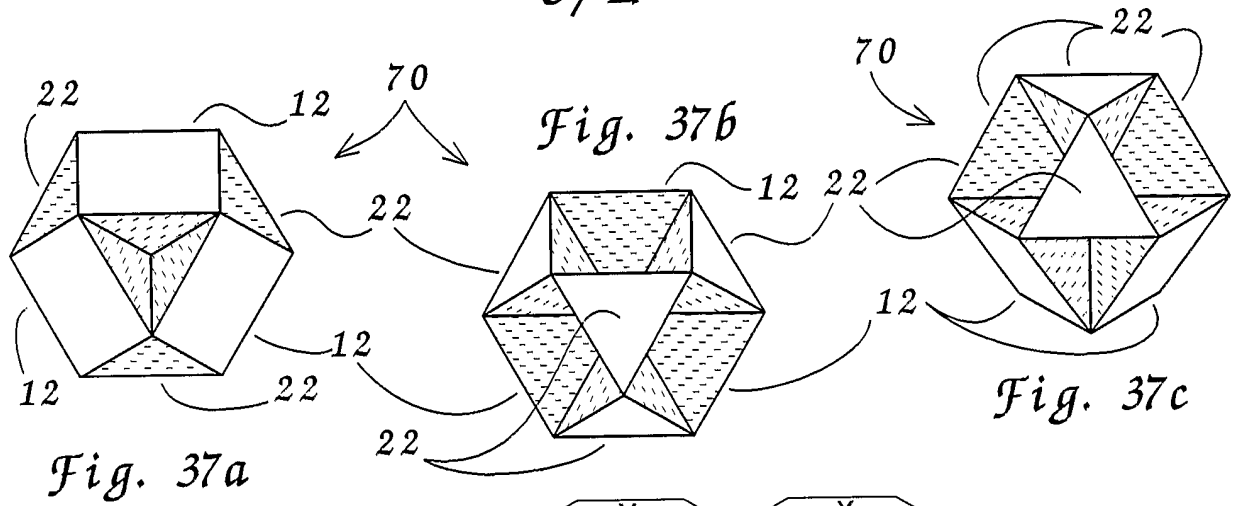


Fig. 35

Fig. 36



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Fig. 38c

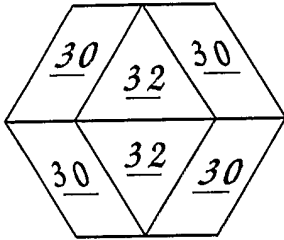


Fig. 38a

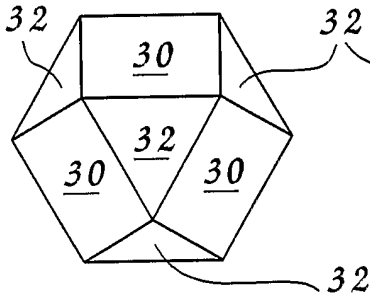


Fig. 38b

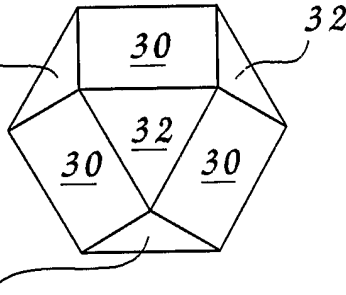


Fig. 40

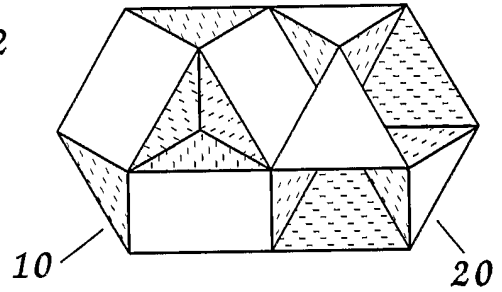


Fig. 41a

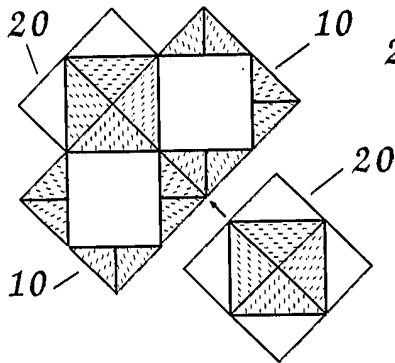


Fig. 43a

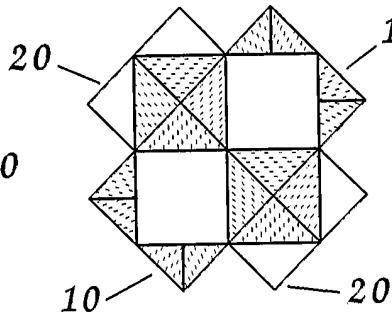


Fig. 42a

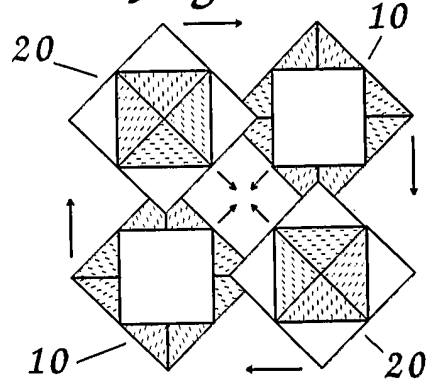


Fig. 41b

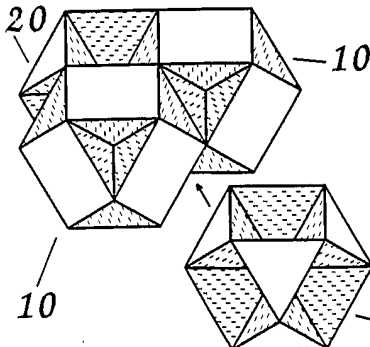


Fig. 43b

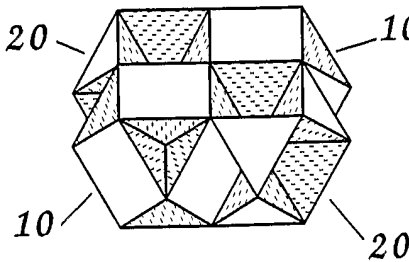
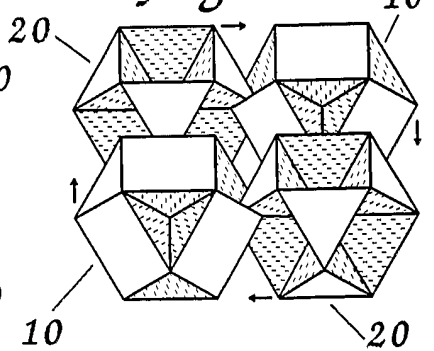


Fig. 42b



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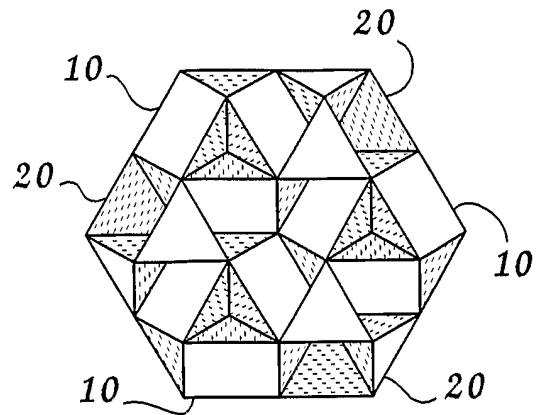
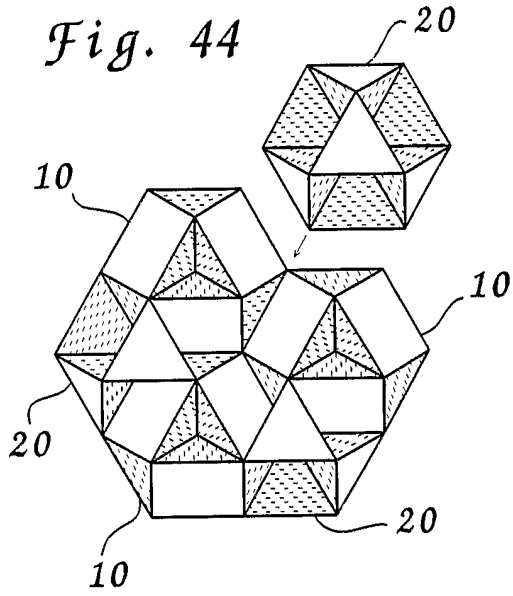


Fig. 45a

Fig. 45b

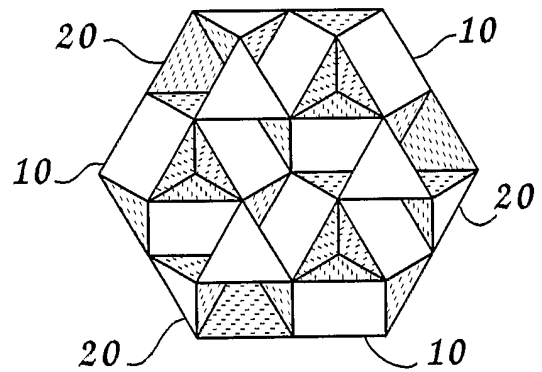
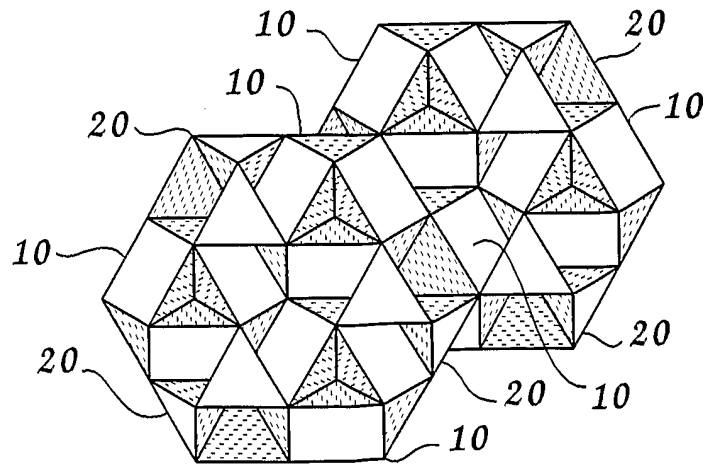
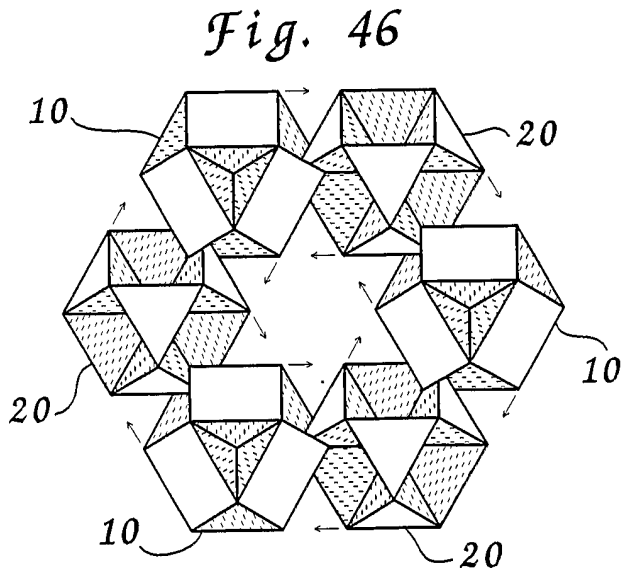


Fig. 47



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Fig. 48

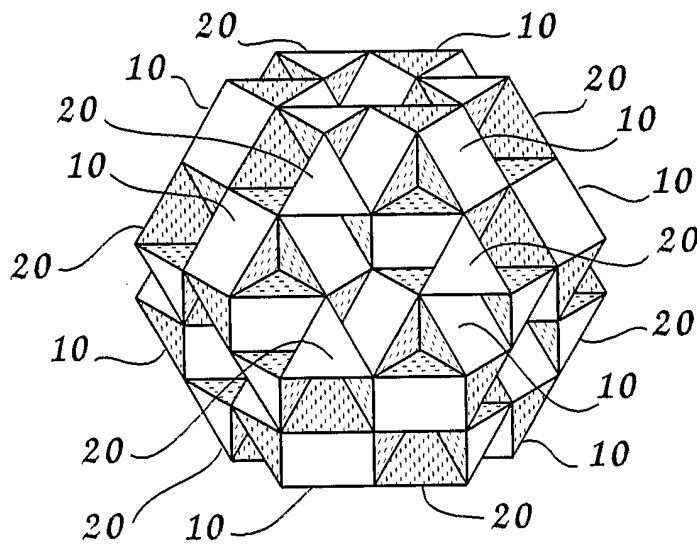
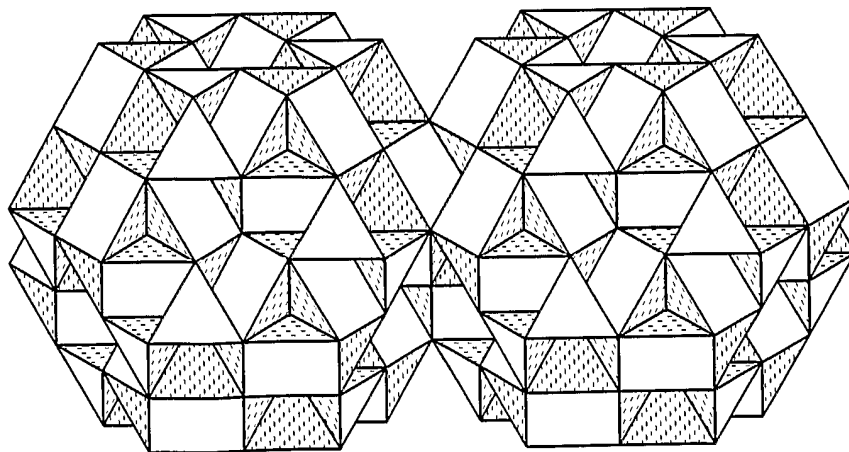


Fig. 49



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Fig. 50a

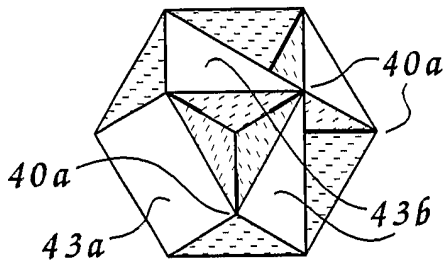


Fig. 50b

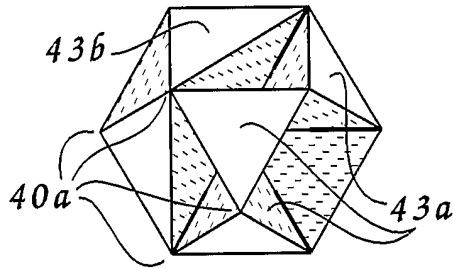


Fig. 51a

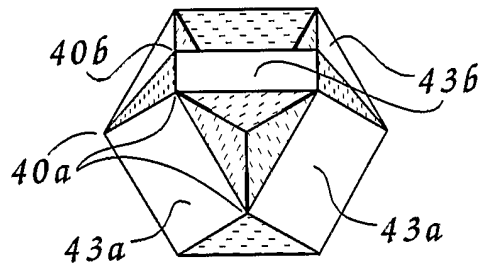


Fig. 51b

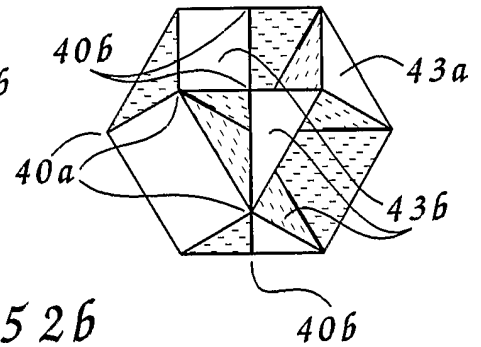


Fig. 52a

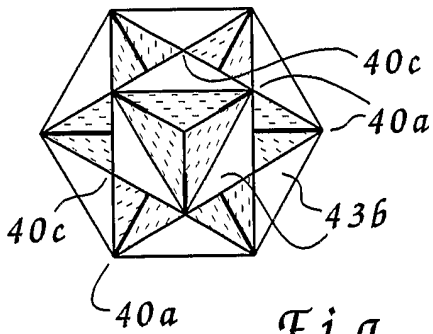


Fig. 52b

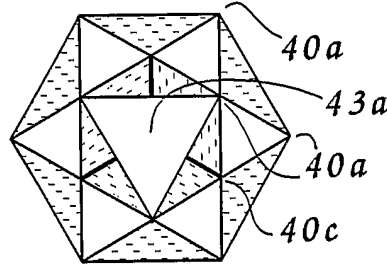


Fig. 53a

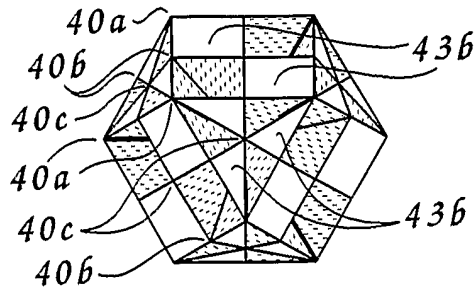


Fig. 53b

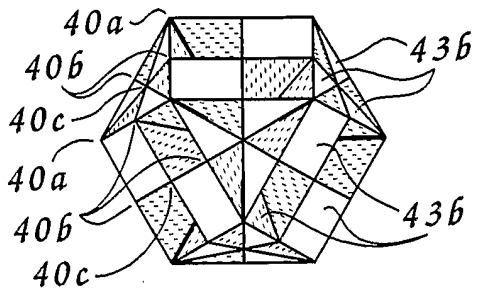


Fig. 54a

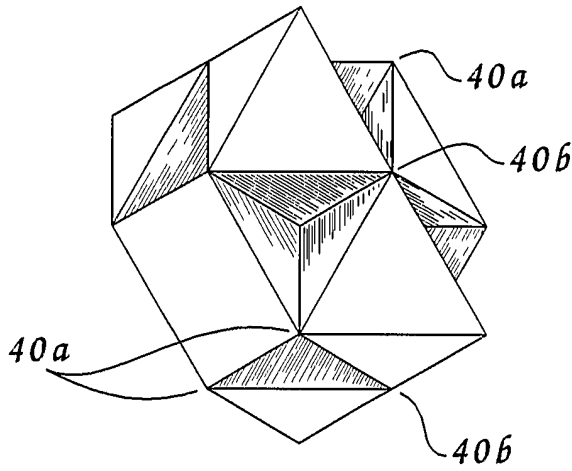


Fig. 54b

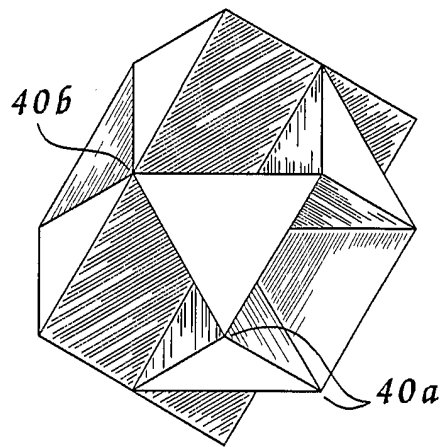


Fig. 56a

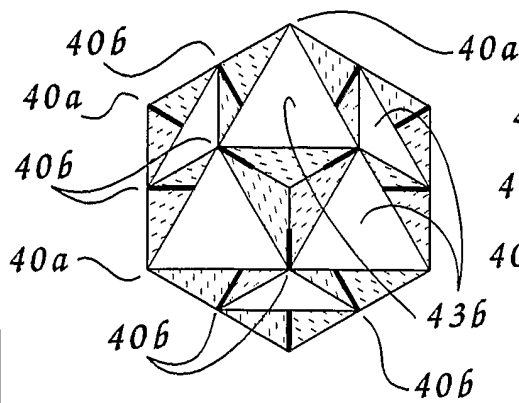


Fig. 56b

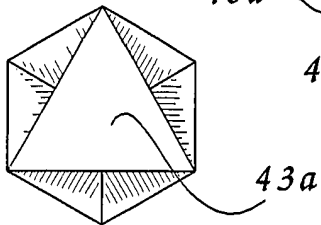
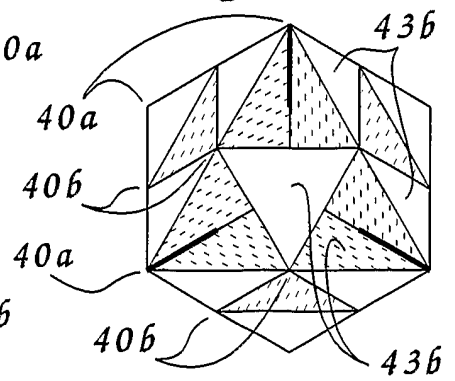


Fig. 55

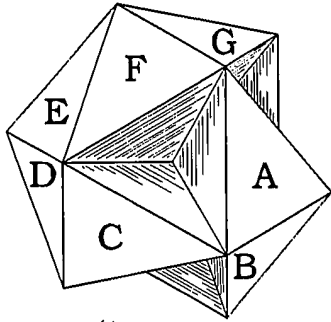


Fig. 57a

Fig. 57b

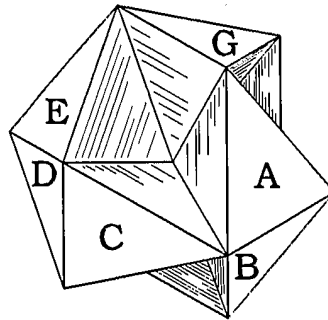


Fig. 57c

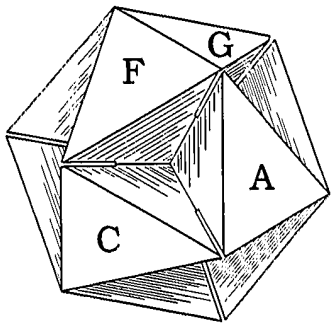
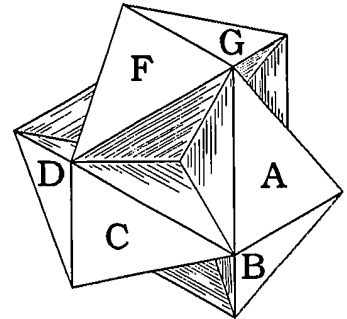


Fig. 57d

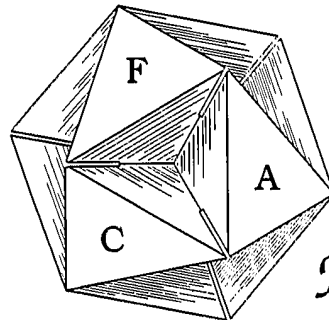


Fig. 57e

Fig. 58a

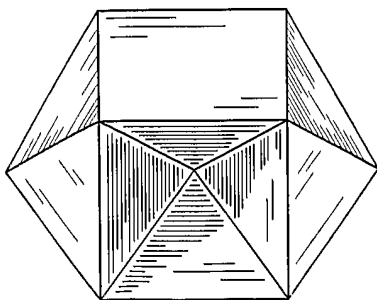


Fig. 58b

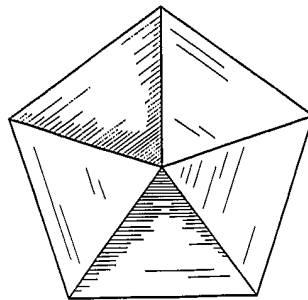


Fig. 58c

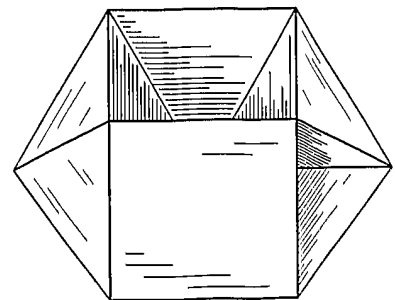
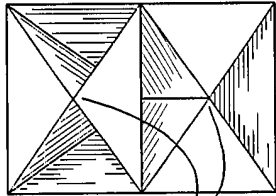
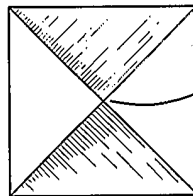


Fig. 59b



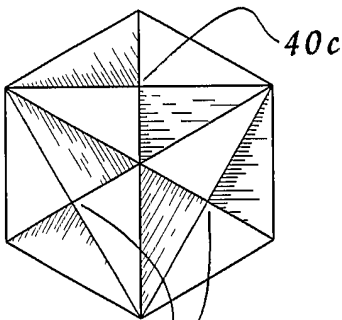
40c

Fig. 59a



40c

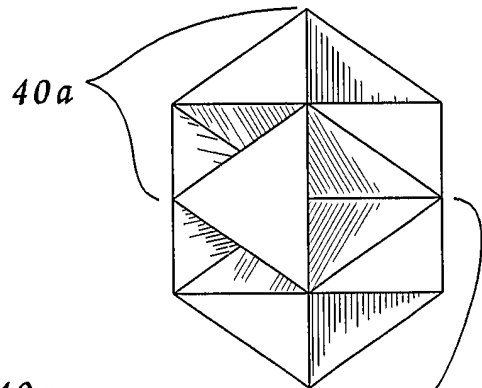
Fig. 59c



40c

40c

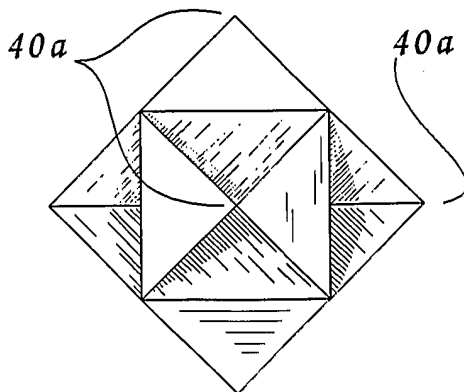
Fig. 60b



40a

40a

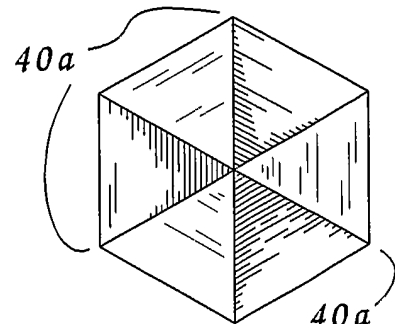
Fig. 60a



40a

40a

Fig. 60c



40a

40a

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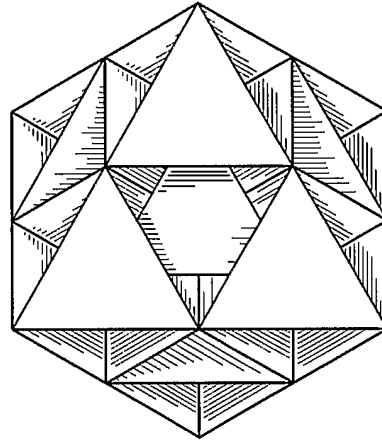


Fig. 61

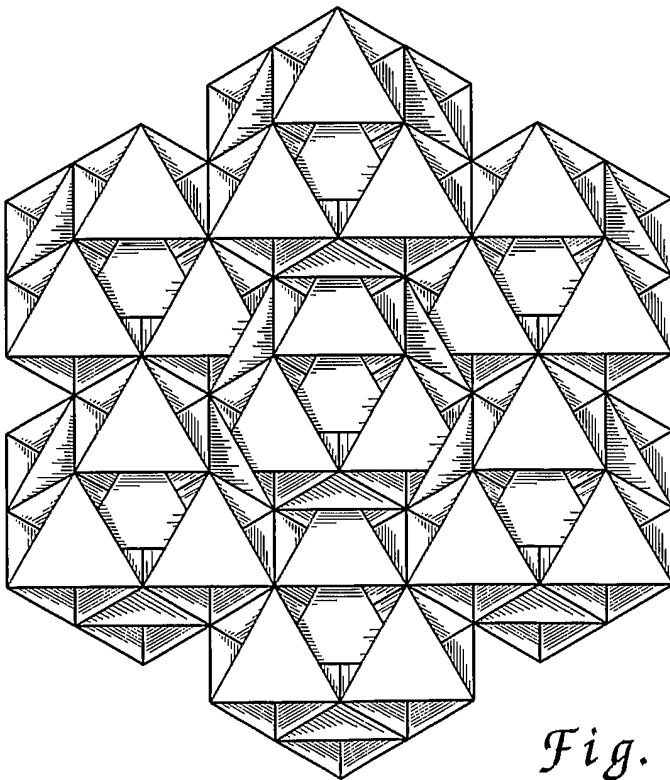


Fig. 62

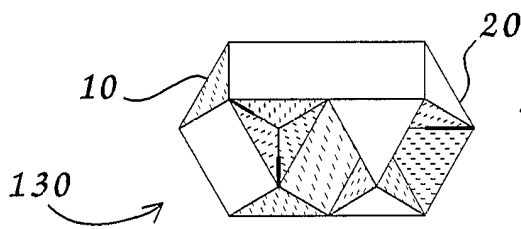


Fig. 63b

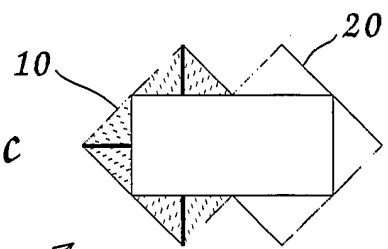


Fig. 63c

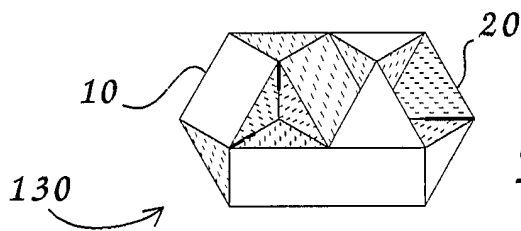


Fig. 63a

Fig. 64

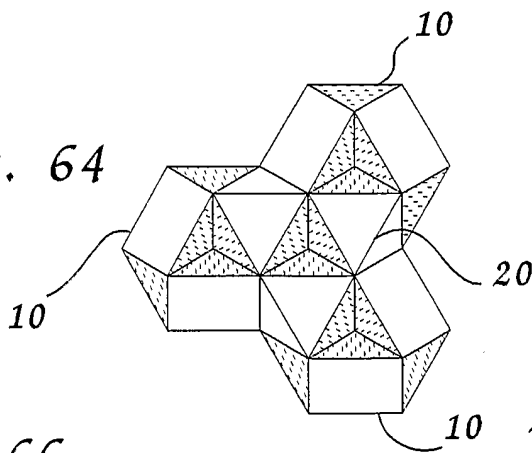


Fig. 66

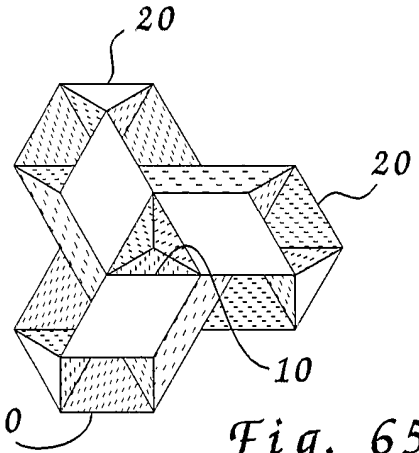
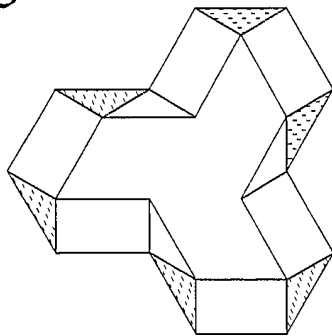
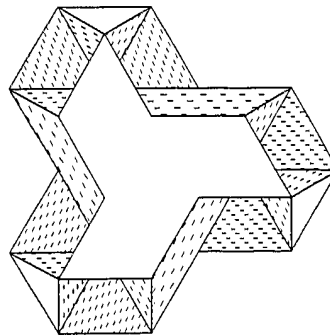


Fig. 65

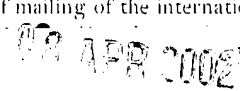
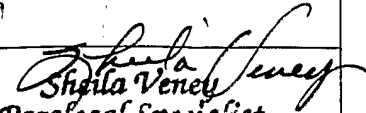
Fig. 67



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/26020

A. CLASSIFICATION OF SUBJECT MATTER IPC(7) : A63H 33/04, 33/08, 33/00 US CL : 446/85, 124, 488 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. : 446/69, 85, 87, 108, 116, 117, 122, 124, 125, 127, 488, 489; 52/Dig 10 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) EAST; construction, interleave(d,ing), difurcate(d), toy or toys		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3,461,574 A (LARSEN et al.) 19 August 1969, see figs 4A-J	47-50
A	US 3,537,706 A (HEAVENER, Jr) 03 November 1970	
A	US 3,545,123 A (MULLER) 08 December 1970	
A	US 3,782,029 A (BARDOT) 01 January 1974	
A	US 4,676,507 A (PATTERSON) 30 June 1987	
A	US 3,785,066 A (TUITT) 15 January 1974	
A	US 5,593,337 A (LAPOINTE) 14 January 1997	
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
+	Special categories of cited documents:	"I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"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
"E"	earlier document published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means	
"P"	document published prior to the international filing date but later than the priority date claimed	
Date of the actual completion of the international search	Date of mailing of the international search report	
13 MARCH 2002		
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer  D. NEAL MUIR Paralegal Specialist Technology Center 3700 Telephone No. (703) 308-1200	