BRIDGES
Mathematical Connections
in Art, Music, and Science

Synetic Structure

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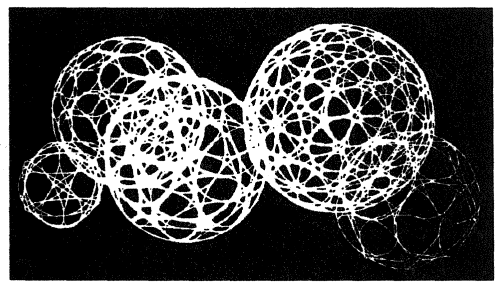
Abstract

This paper presents a new method for the resolution of structure into discrete patterns of tension and compression. Synetic designs are scaleable from atomic through molecular levels, finding many applications in domes and spherical structures. The system also provides a force interaction model that is applicable to a broad range of real and theoretical problems. Synetic principles operate from micro- to macro-scales and in a wide variety of appropriate materials. As energy is increasingly invested along Synetic paths, a structural continuum, a bridge, is established from virtual pattern to strong, resilient construction.



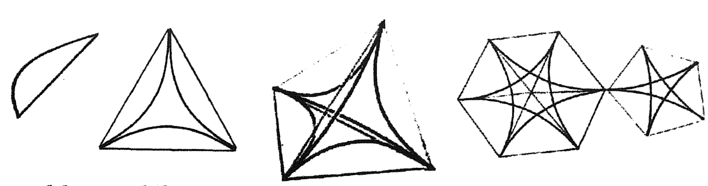
Synetic spheres.

Introduction

Synetics is a flexible yet triangulated structural system, consistently applicable to polyhedral, lattice and manifold geometries. Discrete patterns of tension and of compression act in energetic balance to produce models or structures of unlimited complexity or size. In this system, compressive paths are curvilinear, following the tendency of material to curve under compression, as does a bow. Tensile paths are straight, according to the behavior of material to straighten under tension, as does a bowstring.

In Synetic terms, curvature is the norm and linear is the exception, requiring energy to maintain. In this system, vectors of tension conform to lines of minimum distance, and trajectories of compression follow curves of minimum energy. Reaction and deformation as well as load are efficiently shared throughout Synetic structure. Tension and compression balance in dynamic equilibrium. Forces are resolved through closed circuits of compressive material braced by closed circuits of tensile material. Spheres, domes, tubes and toroids behave as tough pneumatic membranes, bouncy and resilient even at large diameters and capable of rebounding strongly from extreme distortion.

The strung bow represents the first structural differentiation of material into discrete balanced elements of tension and compression. Bows are connected and continued to complete structural circuits in foam-like and bubble-like structure.



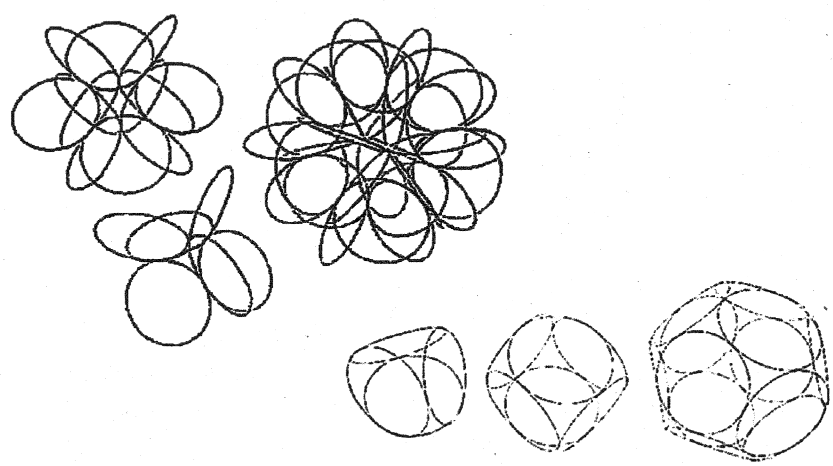
Building with bows.

Designs

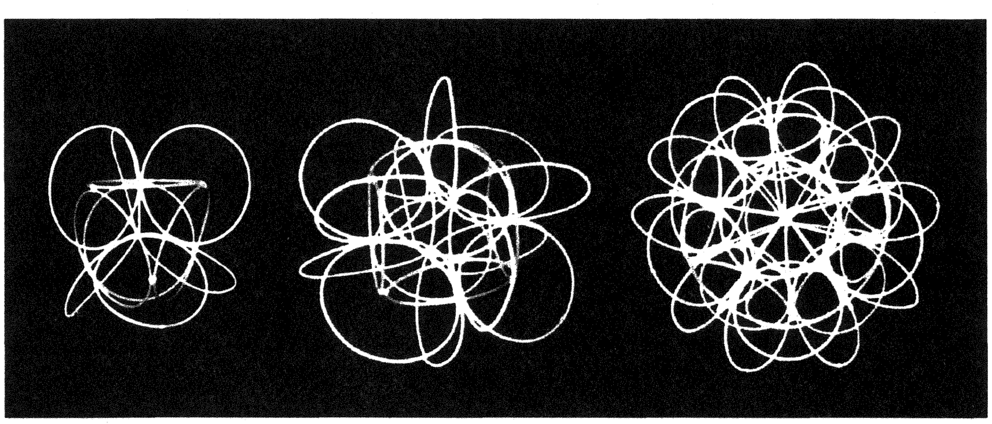
Synetic design utilizes compressive material to the fullest advantage. Tensile elements may be apparent and plainly involved or found to be employed less visibly, as they act to support compressive arcs. Attachment of compressive arcs is entirely by tangency. Operating in simple thrust, tangent articulation provides a structurally integral and uniform connection as the basis for a widely applicable modularity.

Arcs and chords are variously overlapped and systematically joined to form lattices and open arrays or to form closed polyhedral systems and their familiar combinations, distortions and globally symmetric development.

Patterns of tangent circles provide particularly important circuits of compression. Digitally manipulated as circles or built as strong hoops, tangent assemblies react to stress in a predictable hierarchy of transformation. Radial patterns of tangent hoops inscribed in central angles of polyhedra are 'dual' to patterns inscribed in polyhedral faces.



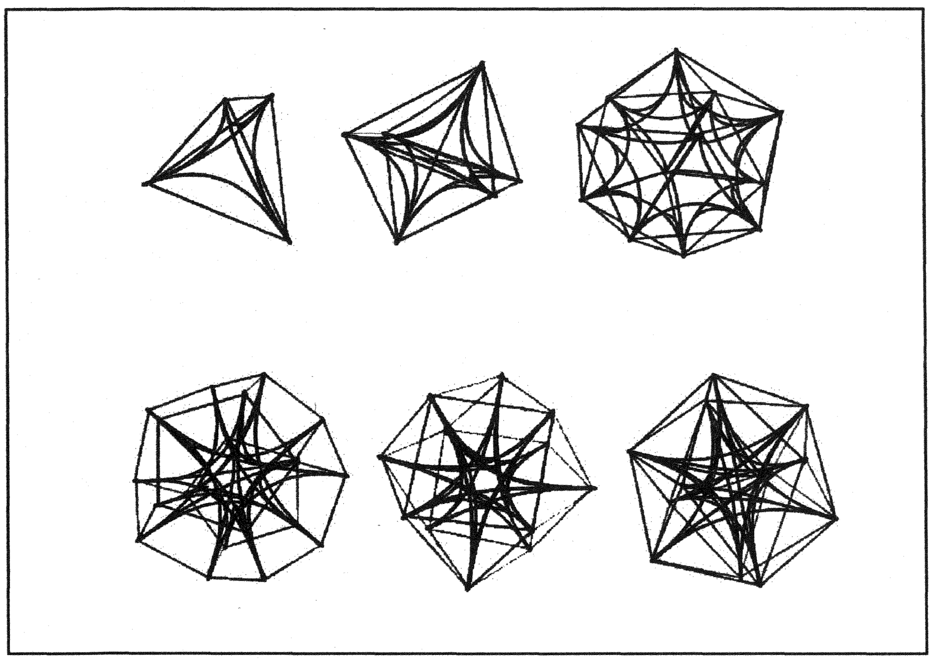
Radial patterns of circles form a tetrahedron, octahedron and icosahedron. Circumferential patterns produce the structurally sound dual figures of tetrahedron, cube and pentagonal dodecahedron. Elements of these patterns are used to develop lattice, radial, or manifold geometries.



Circular duals in combination.

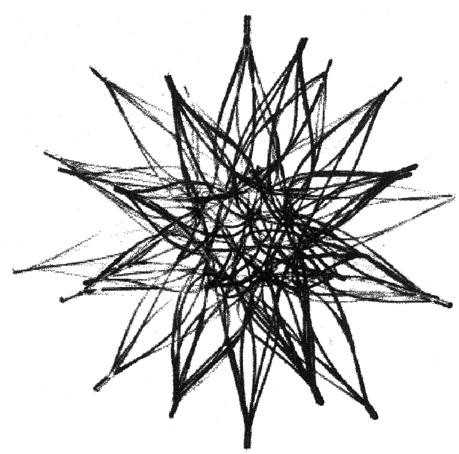
Models

Synetic models demonstrate the dynamic behavior of a particular system as well as its spatial behavior. Tensile paths define linear structures with vertexial or nodal connections. Tension conforms to triangular meshes, to the edges, axes and chords of conventional polyhedra. A lattice node is treated as a polyhedron, through and around which curved compressive paths are taken without particular reference to a central point.

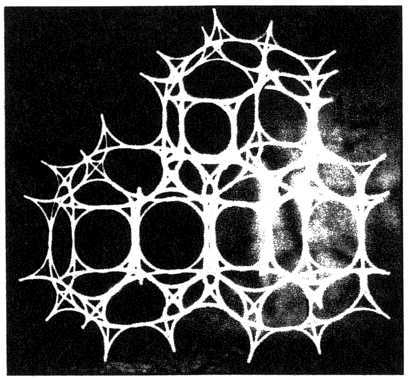


Curved compressive paths in polyhedra defined by linear tensile paths.

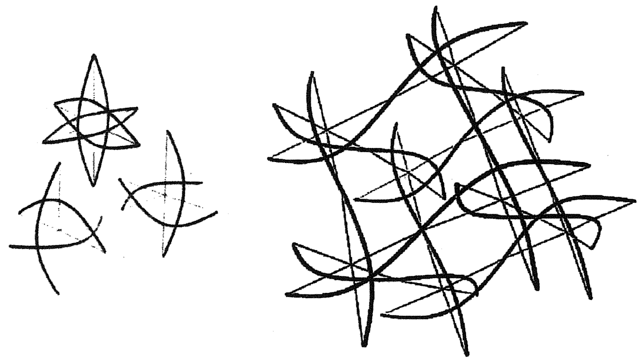
Behaviors of whole systems derive directly from topology and from the periodicity of modular units which self-adjust in angle and distance into structures of increasing complexity.



A stellated icosadocecahedron.



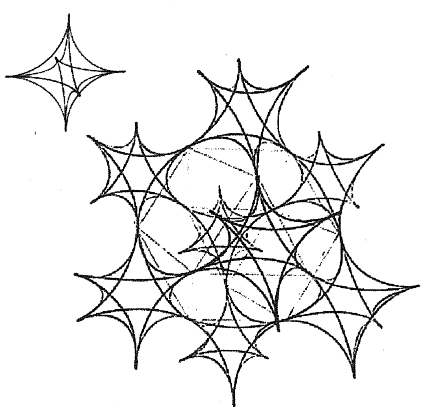
A bubble lattice made of unit tetrahedra.



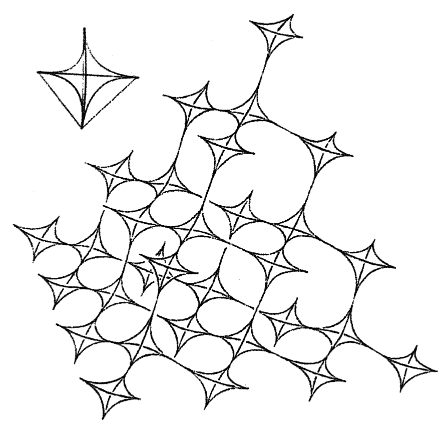
An indefinitely extensible vector matrix made of bows.

A matrix of strung bows might model a vector-field, which is energetically stable, yet fully vibrational in both tensile and compressive components, the nodes being points of no motion. Patterns of tangent circles on a sphere might illustrate standing waves and resonant modes on orbital orientation. In modular sub-units, points of tangent articulation represent sites of connectivity, a system of vectored valence symmetrically disposed by the same dynamic that forms orbital and radial paths.

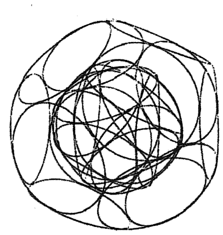
The Synetic system models only angle and energy. Its minimal patterns may be given the various energetic characteristics of fields or bonds or the properties of mass and spring behavior used in molecular modeling. Similarly, they may be assigned features of strong material. Regular arrays have the controlled flexibility to model the pneumatic forms and behavior of nano-scale carbon structure.



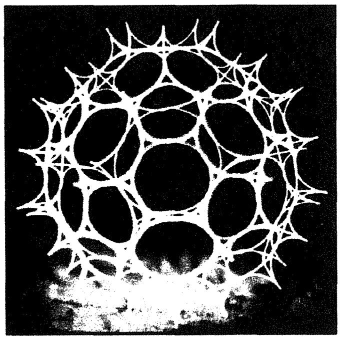
Octahedra form a cubic lattice.



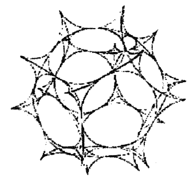
A Synetic diamond lattice.



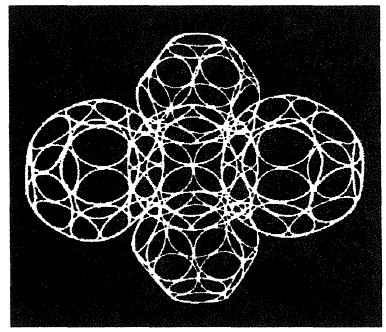
Icosahedron in a dodecahedron:
two ways to arrange the same twelve circles on a sphere.



Synetic tetrahedra model carbon-60.



Twenty tetrahedra form a dodecahedron.

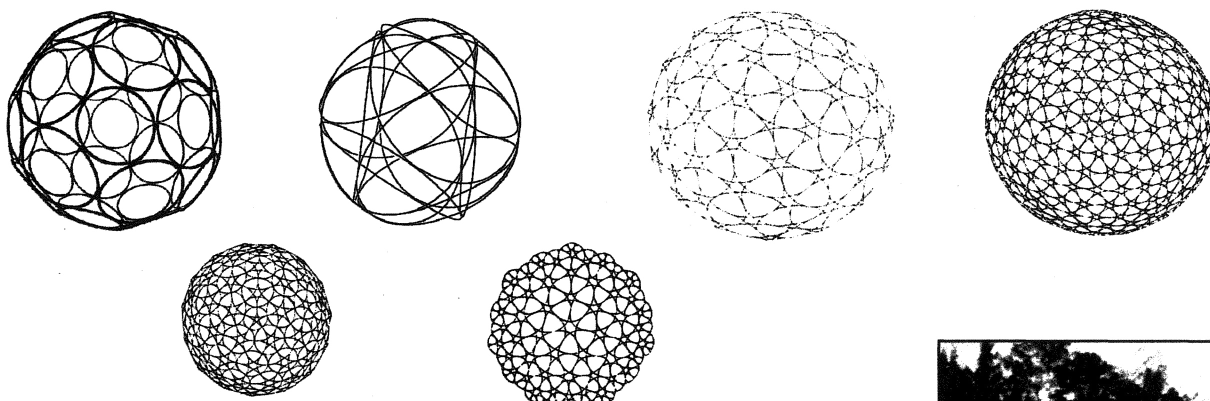


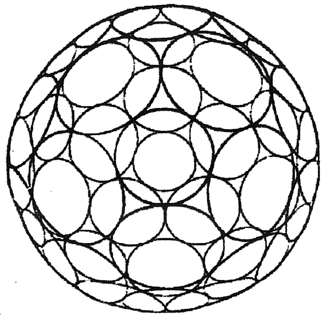
Tetrahedra model a clathrate structure.

The system conforms to the interstitial architecture of packings and to the irregular cellular assemblages of biological structure. It self-adjusts to the fundamental angular characteristics of bubbles and foam, modeling surface-tension phenomena and the relations between membranes. At the macro-scale, tangency appears as the universal cohesive principle in the relation between fiber and membrane, and between fiber and fiber, occurring in minutely accretive structure as well as in branching, tree-like growth.

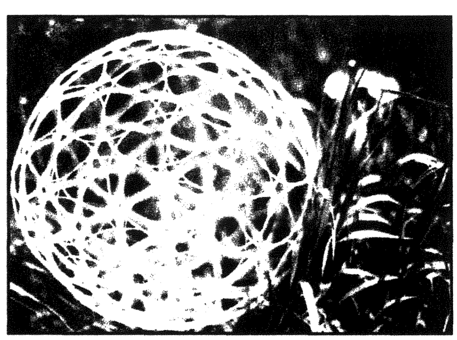
Woven Domes

A Synetic dome framework is an airy and lace-like basketry of thin arcs patterned in curvilinear triangulation. Extremely light in weight, such frames display strength and resilience with minimal material, bounce without much mass, surface tension without much surface.

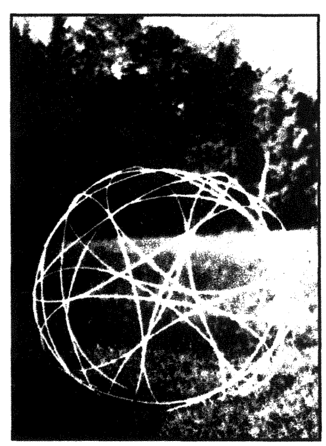




Forty-two hoops on a sphere.

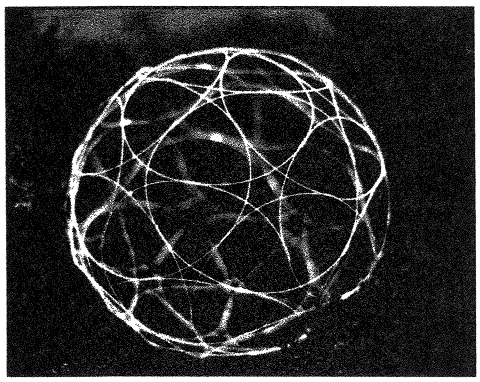


Ninety-two hoops on a sphere.

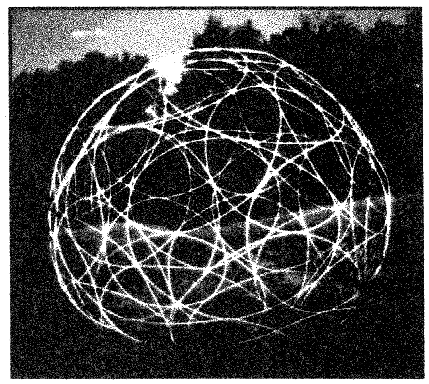


Twelve hoops on a sphere.

Linking and interweaving of compressive paths provides minimal attachment between hoops. The strength and rigidity of frames are increased by further tensile involvement, by lashing and tying of lines and nets, or by attachment of fabric or membrane. Frames stand without the structural aid of a covering, allowing the use of thin fabric or membrane, cut to simple templates or merely wrapped.



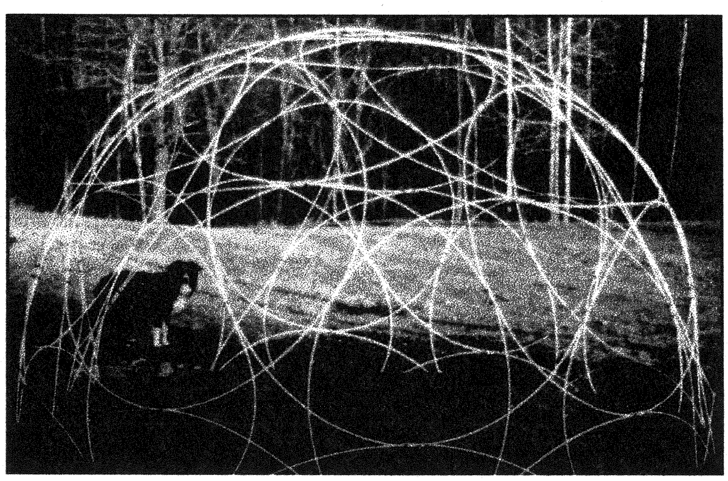
Thirty-two hoops on a sphere.



Forty-two hoops on a sphere.

Curvilinear patterning gives structural advantages to compressive material similar to those conferred on tensile material by fine division, bundling and networking. The compressive function is taken from the single column or spar and spread through a manifold or lattice along continuous networks.

Synetic design is singularly effective in low-tech applications, being tolerant of distortion, inaccuracy and inconsistency of material. An important feature of the system is its potential for strengthening by the incremental addition of compressive as well as tensile materials. Other advantages appear in the modularity and simplicity of the system, and in its low cost.



Hemispherical dome of 3/8" diameter fiberglass rod.

Summary

Synetics offers a new approach to minimal construction with potential application in many fields. It combines rigid triangular connectivity with flexible circular integrity into a strong and useful building system. Synetics provides a bridge of dynamic modeling between virtual design and verifiable structure.