Bridges
Mathematical Connections
in Art, Music, and Science

Intersecting Cylinders and the Jitterbug

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Abstract

Five art sculpture pieces are presented that compliment the paper *"A Search in Progress: Polyhedra from Intersecting Cylinders."* The double face connection of the tetrahedron, hexahedron, octahedron, dodecahedron, and icosahedron are constructed from laser cut exotic wood. Each piece can be transformed from one polyhedron into another by a screw axis transformation. The transformation path of each vertex lies on the line of intersection of cylinders.

1. Background

R. Buckminster Fuller first proposed the 'Jitterbug' motion in 1948. The 'Jitterbug' "... oscillates, expanding and contracting over tetrahedrons, octahedrons, icosahedrons, to again end with the cuboctahedron." [1] Duncan Stuart extended the 'Jitterbug' concept to include face, edge, and vertex connected transformations of the regular and semi-regular polyhedra. His work began in the early 1950's. while working with Fuller on his "energetic/synergetic geometry". [2] Stuart independently published his work in 1963. [3] Ronald D. Resch was independently studying the transformation concepts also in the early 1960's. [4] During the same time period, under NASA sponsorship, Joseph D. Clinton further expanded the system proposed by Stuart. The first dual face polyhedral transformation model was made by Clinton in 1965 and is located in the Fuller archive at Stanford University. A computer model of the transformations was published in several interim research reports between 1965 and 1971 with the final research report being published in 1971.[5] Further research has continued with the published work by Hugo F. Verheyen in 1996 and a private internet publication by Robert W. Gray, 199?. [6] [7]

2. Description of the sculptures

The five regular polyhedra with doubled faces, one face exterior and one face interior to the polyhedron are connected to adjacent faces through their vertices. The vertex connections are alternated interior to exterior. Each face is allowed to rotate about a central face axis while translating along the axis. The interior faces rotate in the opposite direction of the exterior faces thus showing the clockwise and counterclockwise symmetry relationships of the 'Jitterbug' transformation. The path followed by a transforming vertex is along an elliptical line of the intersection of cylinders with their axes being coincident with the axis of translation of the connected faces of the polyhedron. Each of the polyhedral transformations may pass through a rotation of 360° thereby cycling from a closed state, open state, and an enfold state. The elliptical path may be defined as follows:

$$b^2x^2 + c^2y^2 = c^2b^2$$

where: b = ½ minor axis of the ellipse (the radius of the cylinder)
c = ½ major axis of the ellipse

and: $c = b/(2\cos\alpha)$
where: $\alpha = \frac{1}{2}$ dihedral angle of the original polyhedron
$a = \frac{1}{2}$ the extent of translation

The five models are constructed from laser cut exotic hardwoods. They are displayed on an 18" dia. glass table top supported by a 6" high tensegrity X-brace space truss. The overall size of the sculpture is 18" diameter in plan and 15" height in elevation.

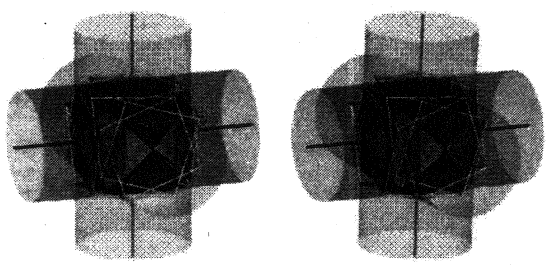

Figure 1: *Hexahedron 'Jitterbug' and its cylinders*

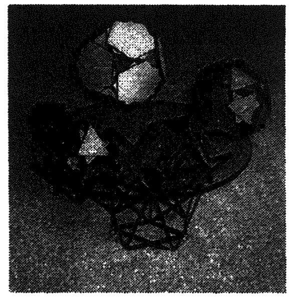

Figure 2: *Hexahedron 'Jitterbug'*

Figure 3: *Hexahedron 'jitterbug' motion animation frames*

References

[1] Krausse, Joachim and Lichtenstein, Claude eds., Your Private Sky, Lars Müller Publishers, Baden, Switzerland, 1999, pp286.
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[4] Resch, Ronald R., *The topological design of sculptural and architectural systems*, FAIPS-Conference Proceedings, AFIPS Press, Montvale, N.J., 1973, Vol. 42, pps 643-650.
[5] Clinton, Joseph D., *Advanced Structural geometry Studies: Part II – A Geometric Transformation Concept for Expanding Rigid Structures*, NASA CR-1735, NASA, Washington D.C., 1971.
[6] Verheyen, Hugo F., Symmetry Orbits, Birkhäuser, Boston, Massachusetts, 1996,
[7] Gray, Robert, W., *The Jitterbug Motion*, http://www.rwgrayprojects.com/rbfnotes/toc.html