BRIDGES
Mathematical Connections
in Art, Music, and Science

Finding an Integral Equation of Design and Mathematics

Brent Collins
90 Railroad Avenue
Gower, MO 64454

Introduction

Though I'm a nonmathematician, the intuitions my work originates in have consistently led to an art of visual mathematics. Such an art obviously has a special resonance for scientists and mathematicians, but being visual, it can be just as immediately engaging for general audiences. Its patterns invite mathematical analysis, but require none, and need only be seen as music need only be heard. The critical measure of their success is the degree to which they are reminiscent of the deep mathematical coherencies found in the forms and dynamics of nature, but again no analysis is necessary for this recognition to be implicitly felt as an aesthetic intuition. In other words, when successful, this art bears a relation to the natural world similar to that of the best pure mathematics where eventually an application is always found. It is after all mathematics as a form of visual aesthetics.

Representative images from some of the earlier and current motif cycles in my work follow in a descriptive survey covering the last eighteen years:

Early Nonorientable Surfaces: 1980-1985

All the works in this cycle have at least one and in many instances several Mobius transitions making the entirety of their surface continuously touchable without crossing an edge (Figures 1 - 5). Some of them have one continuous edge defining a single knot (Figures 1 and 2); while others have multiple edges each discretely traversing a separate knot (Figures 3 - 5). Such topological maneuvers were never intended but always unforeseen revelations emerging as features integral to the holistic coherency of these works. Their Mobius transitions are associated with localized parameters of twist (in contrast to the global twist of a Mobius strip), and it is at these loci of Mobius twist that negative curvatures for the first time appear in my work as dictates of structural logic, though at the time I don't understand their significance as approximations of soap film economy in relation to their immediate edge constraints. And beyond these loci, the surfaces adjoining the edges gravitate to positive curvatures at the ellipsoidal exteriors of these works.

Early Orientable Surfaces: 1985 - 1989

The edge constraints of the works in this cycle from the 1980s are drawn on the convex exteriors of ellipsoids. And peripherally these surfaces retain the positive curvatures of the enclosing ellipsoid (Figures 6 - 10). But the curvatures spanning their edges through their otherwise hollow interiors are negative or hyperbolic . . . Soap film forms hyperbolic curvatures when it spans a sinusoidal wire loop. And elegant economies such as those seen in soap film can be viewed as

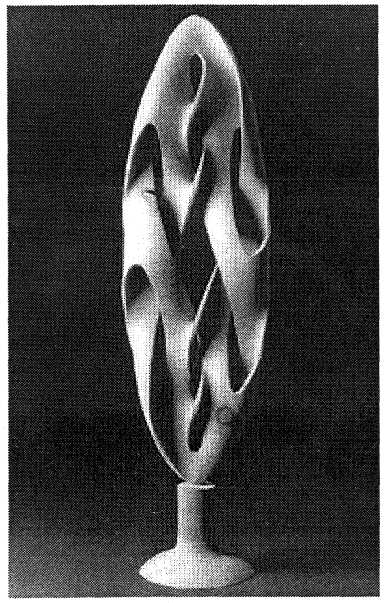

Fig. 1

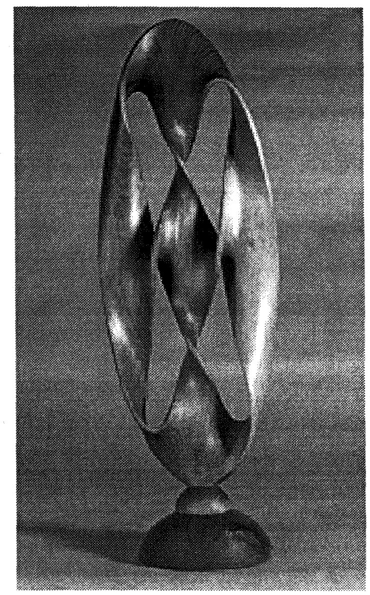

Fig. 2

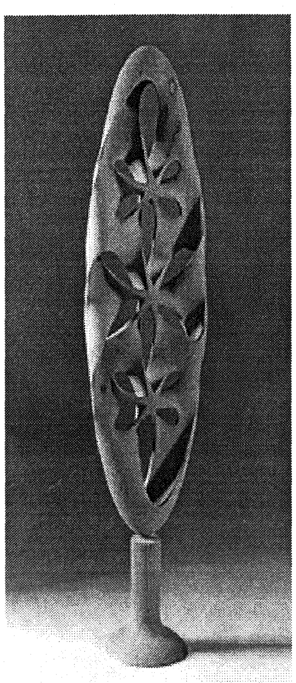

Fig. 3

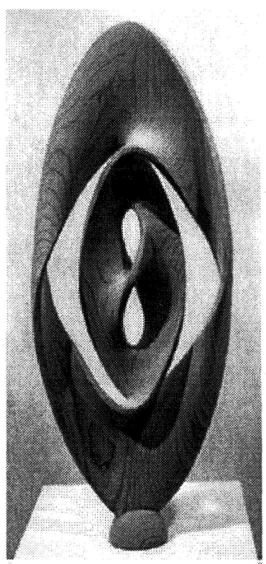

Fig. 4

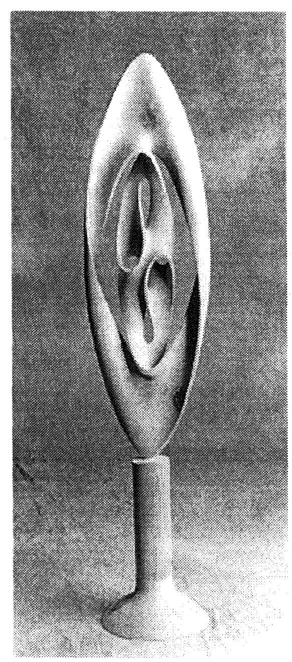

Fig. 5

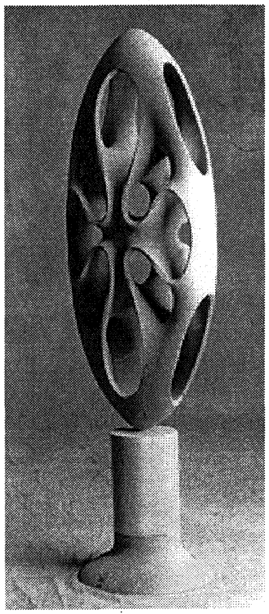

Fig. 6

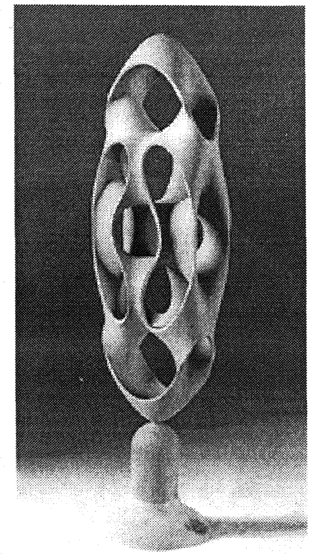

Fig. 7

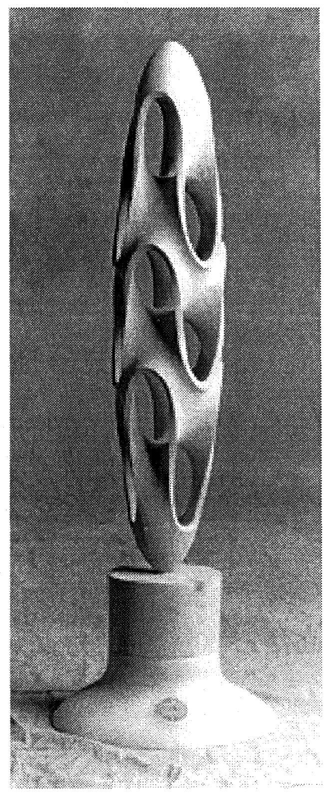

Fig. 9

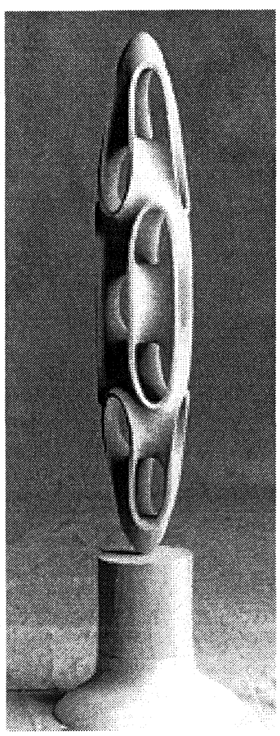

Fig. 8

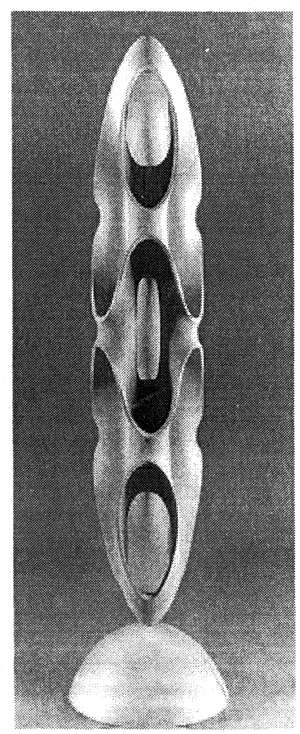

Fig. 10

the aesthetic temper of nature's dynamics. Moreover, their strong intuitive appeal significantly informs our sense of optimum in design and movement. I found them emerging in my own work as though under their own spontaneously self-organizing impetus. When this happens, there is an awareness of something with a mysterious inevitability germinating through you.

Early Modular Surfaces: 1989 - 1990

The edge constraints of these orientable surfaces are integral to the "molecular" articulation of their hyperbolic modules, rather than being in arbitrary conformance to the convex surfaces of ellipsoids as before (Figures 11 and 12). The modules of the surface shown in Figure 12 constellate in an octahedral matrix of hyperbolic curvatures which, as I later learned, is in perfect conformity with the Schwarz minimal surface. Artists and mathematicians, traveling by different though complimentary methods in their sensitivity to a pole of aesthetic and mathematical attraction, can reach the same destination . . . With these and subsequent modular sculptures there is a sense of sometimes being born by the momentum associated with the denouement of their logical schematics. At best this cathartic experience feels like an analogue to the dynamics of replicative synthesis in gene expression, granting the university of creative forces.

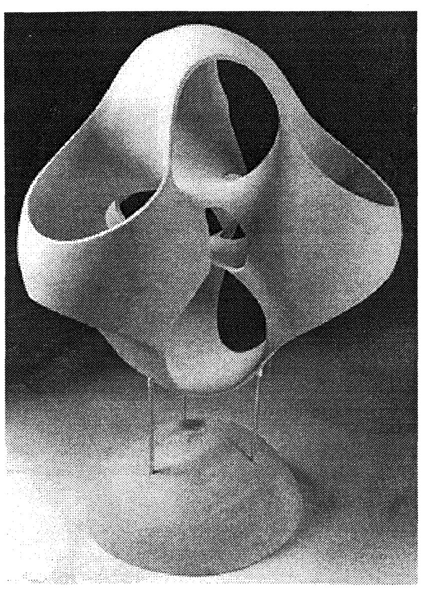

Fig. 11

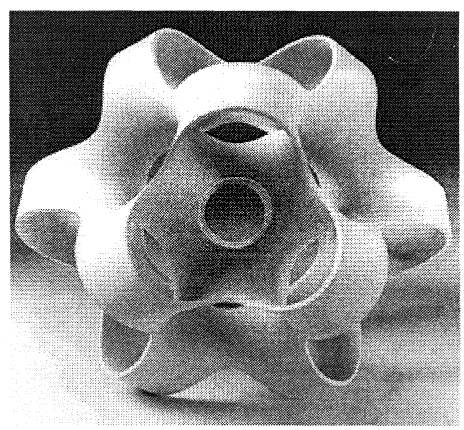

Fig. 12

Modular Spirals: 1990 - 1994

In these orientable surfaces the hyperbolic modules are deployed in an indefinitely extendable spiral progression around their longitudinal axes (Figures 13 and 14). The hyperbolic modules of the two surfaces shown are different, and that of Figure 14 is particularly complex. This surface is also the first to be locally minimal in being pronouncedly hyperbolic throughout. Neither has a precedent known to me, but I imagine that they are in all probability aesthetically evocative of dynamic processes in nature which will yet come to my attention? Interestingly, despite having markedly different modules and schematics for their articulation, each has interior features with a spiral cheirality running counter to those of exterior ones, demonstrating a further affinity underlying their differences which, along with their having been created one after the other, prompts me to group them together.

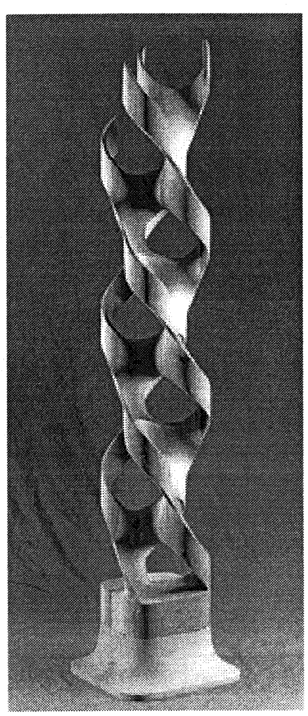

Fig. 13

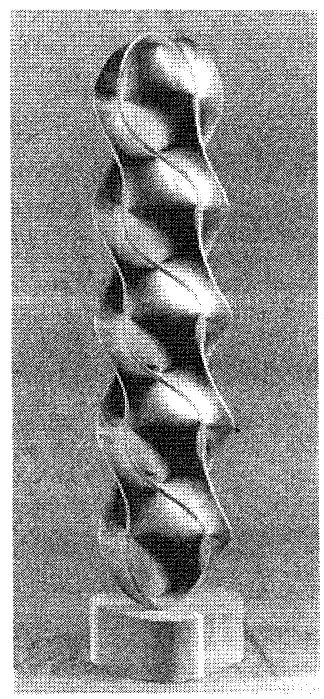

Fig. 14

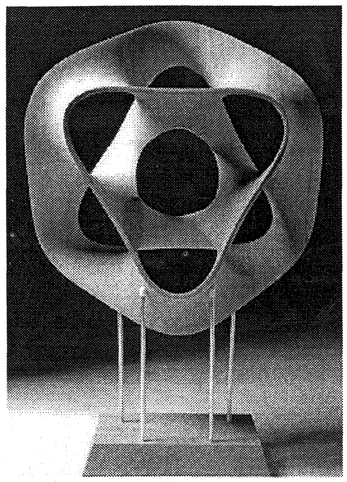

Fig. 15

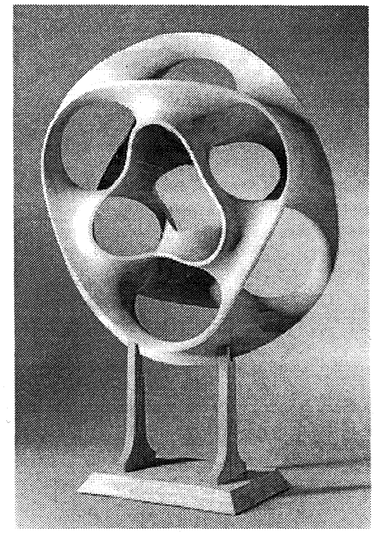

Fig. 16

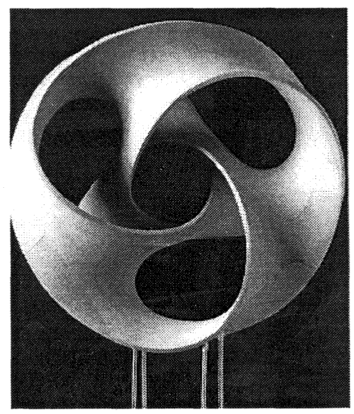

Fig. 18

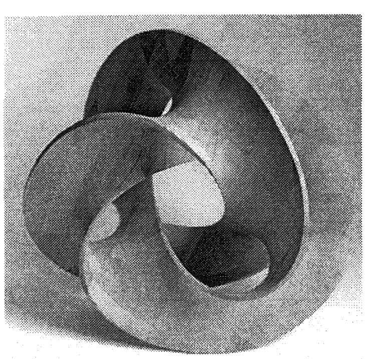

Fig. 17

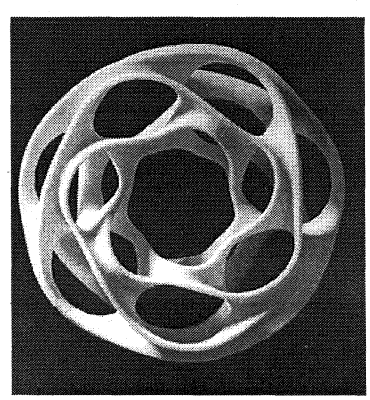

Fig. 19

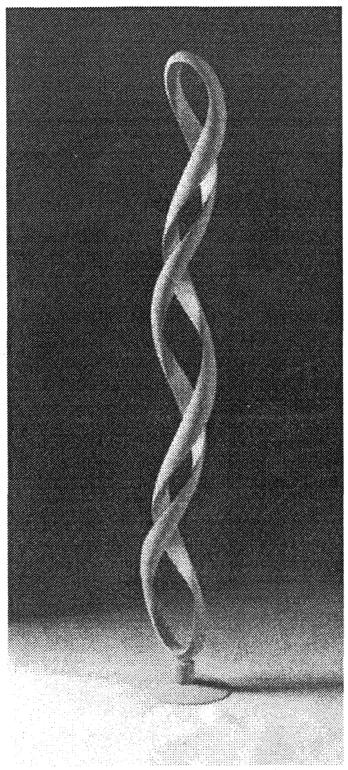

Fig. 20

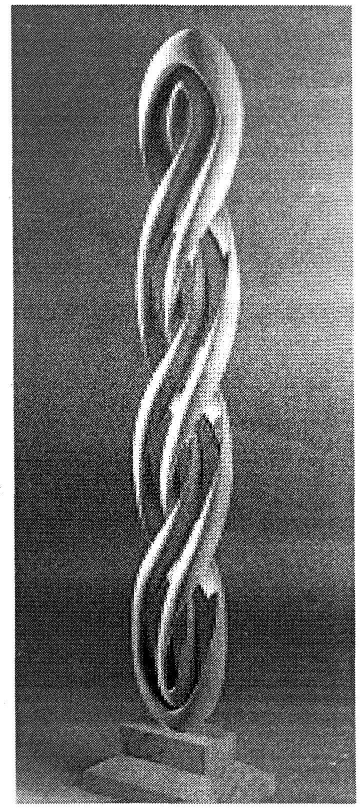

Fig. 21

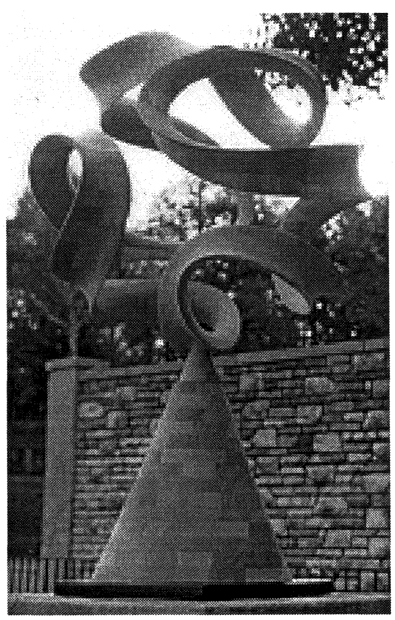

Fig. 22

Modular Toroids: 1994 to Present

These recent sculptures are all locally minimal in having continuously hyperbolic curvatures (Figures 15 - 19). After originating in my work as intuitive inventions, I eventually learned that they can be understood as toroidally warped truncations of Scherk minimal surfaces. Those with an even number of hyperbolic modules or Scherk storeys are orientable and serene in their taut equilibrium (Figures 15 and 16). Toroidal closure of odd numbers of modules requires a twist parameter for their proper orthogonal articulation throughout, however, which makes these variants nonorientable and gives them a dynamic vorticism (Figures 17 and 18). Carlo Séquin, a computer scientist at the University of California, Berkeley has developed a virtual prototyping program for these Scherk toroids systematizing the parameters of all their possible formulations (see URL Homepage:http://http.cs.berkeley.edu/~sequin). The Scherk toroids which I've finished in wood along with Carlo's interactive software and the stereolithographic maquettes (Figure 19) of the surfaces which have been fabricated will be exhibited at *Fermilab* in Batavia, Illinois during April and May of 1998 and at the *America Association for the Advancement of Science* in Washington, D.C. for three months the following autumn. (Stereolithography uses a computer-directed laser to catalyze three-dimensional form layer by layer from a liquid plastic bath; and can be used for Scherk toroids because their mathematics have been compatibly described in three-space by Carlo's program.)

Ribbon Sculptures: 1996 to Present

All these orientable sculptures either spiral or have a twist parameter integral to their design. The earliest ribbons all had the spiral motif most definitely realized in *Genesis* (Figure 20). It is an aestheticized DNA icon whose double helix is optimized for curvilinear grace and systematically modulated to introduce a variable periodicity of more engaging aesthetic interest than the uniform one of textbook schematics. All its curvatures are positive. Bronzes of it can be seen in Washington D.C. at the *American Association for the Advancement of Science* and at Southwestern College in Winfield, Kansas. In another realization of this motif, the ribbons of a quadruple helix fluidly interweave (Figure 21).

The most recent of the ribbon sculptures is *Pax Mundi*, Latin for peaceful world, 1997 (Figures 22 and 23). An image of global integration, its sinusoidal ribbons skirt a two-foot sphere, and have a twist parameter designed to maximize continuous negative curvature in relation to the crescent of their cross section. The laminated mahogany master pattern for an edition of bronzes is shown here.