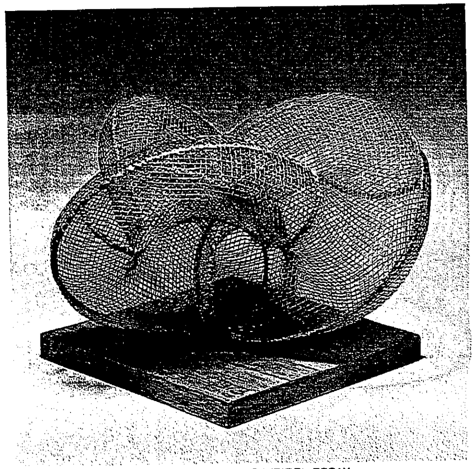
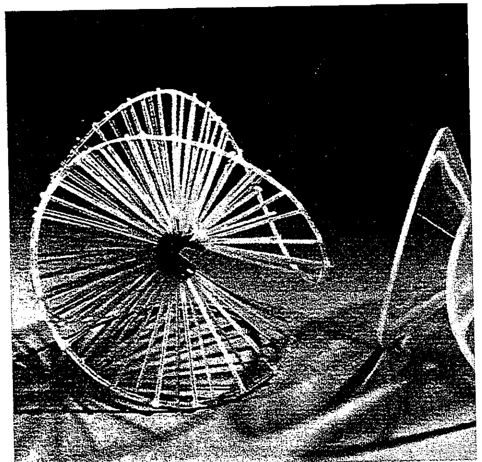
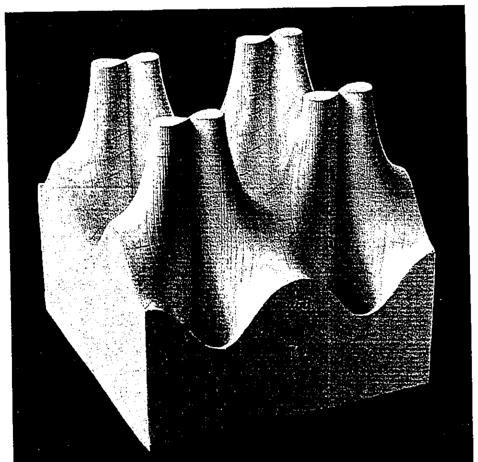
Ruth Vollmer 1961–1978. Thinking the Line: Nadia Rottas, Peter Weibel (Hrsg.), Hatje Cantz, Ostfildern 2006



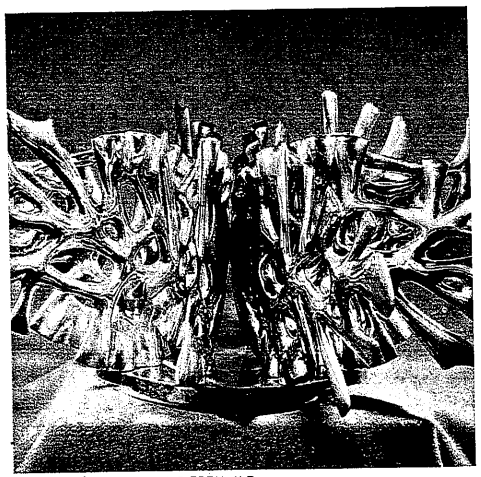
BOY'S SURFACE, WIRE MODEL IN PETER WEIBEL ESSAY
MATHEMATICAL INSTITUTE, UNIVERSITY OF GÖTTINGEN



NAUM GABO, MODEL FOR SPHERICAL CONSTRUCTION: WELL, 1937/38,
AND MODEL FOR SPHERICAL THEME, 1936/37
FROM MICHAEL SCHWARZ, ED., LICHT UND RAUM (1998)



PLASTER MODEL OF THE P-FUNCTION, ONE OF KARL WEIERSTRASS'S
HIGHLY "UNINTUITABLE" MATHEMATICAL CREATIONS
FROM GERD FISCHER, "MATHEMATISCHE MODELLE" (1986)



ETIENNE BÉOTHY, NUCLEAR FORM, N.D.
FROM PETER WEIBEL, ED., JENSEITS VON KUNST (1997)

RUTH VOLLMER'S "MATHEMATICAL MODELS": SCULPTURES BETWEEN ABSTRACTION AND ANSCHAUUNG BY PETER WEIBEL

(2006)

S. 29–75

Mathematics possesses not only truth but supreme beauty, a beauty cold and austere, like that of sculpture, sublimely pure and capable of a stern perfection, such as only the greatest art can show. —Bertrand Russell

Around the time Ruth Vollmer (born Landshoff) and her husband, Hermann, had to leave Germany in 1935 because of her Jewish faith, two important books concerning the crisis of *Anschauung*, or sense-perception, were published. The one was by David Hilbert, in 1932, and the other by Edmund Husserl, in 1936. In his *Die Krise der europäischen Wissenschaften und die transzendentale Phänomenologie* (The Crisis of the European Sciences and the Transcendental Phenomenology), Husserl identified this crisis with the rationalization of the sciences, especially with the "Galilean mathematization of nature," in which "the latter itself became reduced to mathematical diversity." During the industrial and political revolutions that took place in Europe after 1800, rationalization and the tenets of the Enlightenment dominated scientific thought, which bid farewell to political and ideological absolutism in the name of progress. But Husserl claimed that science, in abandoning experience and history for the purely abstract, had instituted its own crisis. Against this formulation of the modern world as "more geometrico" and against the "non-visual symbolism" of mathematics, he proposed *Anschauung*, or contemplation, intuition, and visualization: "In the current act of measuring of visual objects of experience all we gain are empirical-inexact variables and figures." Husserl evidently disliked variables and numbers, formulae and figures—in short, mathematics—because of their abstract, rational character and their lack of visual symbolism. For him, only *Anschauung*, with its visual character and as a visual experience of the world, encompassed the historical experience. This reduction to a mathematical diversity of nonvisual character and to a mere science of fact constituted the crisis in the European sciences, as it led to science losing its "significance for life." Precisely at this point, the crisis of science became a crisis of life, and only a return to history and the "lifeworld" (*Lebenswelt*) could free us. Like the Romantics, Husserl evoked history as the highest authority for our actions. With history, he proposed a determinism that excluded free will—the ability to choose.

F.W.J. Schelling, the philosophical champion of Romanticism, had already claimed, in his *System des transzendentalen Idealismus* (System of Transcendental Idealism) of 1800, that only through "intellectual contemplation" and "congenial intuition"—that is, *Anschauung*—could one grasp the absolute, the highest form of knowledge. This romantic program was in sharp contrast to the philosophy of the Enlightenment, which rested on the power of rational thought. Therefore, G.W.F. Hegel, in his *Die Phänomenologie des Geistes* (Phenomenology of Spirit), which he penned in Jena in 1806, saw himself in opposition to the Romantics, whom he accused of "not construing, but feeling and contemplating the Absolute, and it is not the concept thereof, but the emotion and contemplation of it that are meant to lead the way to be expressed." Hegel stated that the

Absolute could not be gained through *Anschauung* (contemplation and intuition) but only through the labor of the "concept" (*Begriff*). For him, Romanticism marked the end of art, because philosophy, in the guise of self-awareness, had taken the place of religion and art in the search for absolute truth. In the battle between *Anschauung* and abstraction, Hegel (and Immanuel Kant as well) voted clearly for abstraction. Abstraction, the Enlightenment, and rationalization formed the block against *Anschauung* and experiential evidence in the search of truth. The legitimacy of modern science was founded on abstract concepts and mathematical formulae. That a formula like $e=mc^2$ could become so famous shows the culmination of this tendency, which started in sync with the beginning of the industrial, technical, and political revolutions around 1800.

The great eighteenth-century mathematician Joseph Louis Lagrange wrote in the preface to his influential book *Mécanique analytique* (Analytical Mechanics; 1788): "One will not find figures in this work. The methods that I expound require neither constructions, nor geometrical or mechanical arguments, but only algebraic operations, subject to a regular and uniform course." Lagrange expressed most radically the conviction of his time, that only mathematical rationalization could explain the world correctly. Only a mathematical analysis of the mechanics of the world could give us the absolute truth. Any trace of *Anschauung* had to be expelled as a possible contamination of the pure "construction of the Absolute," as Hegel defined it around the same time. Lagrange's rejection of any image or graphical construction, even of a geometrical proof, in order to achieve the ideal mathematical form was the climax of the "mathematization of nature" that Husserl bemoaned and that the scientific community acclaimed.

Lagrange had the reputation of being Europe's best mathematician. In 1766, he followed Leonhard Euler as president of the Berlin Academy, where he worked until 1786. In his books *Théorie des fonctions analytiques* (1799) and *Leçon sur le calcul des fonctions* (1801), Lagrange gave mathematics its strength by assiduously avoiding the use of visual materials, *Anschauung*, or "intuition," using only algebraic tools and operations. Classical mechanics was given mathematical form by Euler and Lagrange. Lagrange not only influenced later mathematicians such as Carl Friedrich Gauss and Bernhard Riemann, but also the nineteenth-century physicist Hermann von Helmholtz and even philosophers like Kant and Hegel in their fight for analyticity and rationality instead of *Anschauung* and intuition.

Coincidentally, in 1790 Lagrange also formulated a mathematical problem commonly known as "Plateau's problem," after Joseph Plateau. Plateau solved it experimentally using soap films on wire frames—those same soap films that would later fascinate Ruth Vollmer. Lagrange's problem was to fit a minimal surface to the boundary of any given closed curve in space. A surface may be "minimal" in respect to the area occupied or to the volume enclosed, the area being the surface that the film creates when it fills up a ring, whether a plane or not. The geometers are apt to restrict the term "minimal surface" to forms such as these, or, more generally, to all cases where the mean curvature is nil; the others, being only minimal with respect to the volume contained, are called "surfaces of constant mean curvature." If we limit ourselves to surfaces of revolution—that is to say, to surfaces symmetrical about an axis—we find that there are six in all: the plane, the sphere, the cylinder, the catenoid, the unduloid, and a curious surface Plateau called the nodoid. The sphere is, of all possible figures, that which encloses the greatest volume with the least area of surface (see Jacob Steiner's *Einfache Beweise der Isopermetrischen Hauptsätze* [Simple Proofs of the Isopermetric Axioms; 1836]). As such, the sphere is not only an ideal body mathematically, but also biologically. Oil globules and soap bubbles are wonderful examples of the sphere in nature, a model for the organic cell as being in a "steady state" simulating equilibrium. In 1930, Jesse Douglas and Tibor Rado would prove Plateau's problem mathematically with the help of the Dirichlet principle, for which Douglas was awarded the Fields Medal, the "Nobel Prize" of mathematicians, in 1936.

It is evident that Ruth Vollmer knew this history of *minimae areae*, as the titles of some of her works, like *Steiner Surface* (1970), suggest. Her interest in soap bubbles, demonstrated by the film *Soap Film Forms* in 1974, is also well known. It is interesting and evident that the concept of minimal surfaces in connection with volume and space played a central role in the paintings of modernism and in the minimal and conceptual art of the sixties—more than 150 years later. Vollmer's interest in these mathematical objects, more than the artistic atmosphere of New York in the sixties, provided the context for the evolution of her sculptures. She realized, in a very original way, that the problems and descriptions of surfaces of revolution, viewed through the lens of modern art, could be reinterpreted and constructed as aesthetic problems of contemporary sculpture. Her focus on these surfaces of revolution, on minimal surfaces, reveals her exceptional understanding of sculptural issues of the twentieth century. Questioning and defining the boundaries of closed curves in space is the last moment of modern sculpture, still treated as a volume, before it dissolved into acts of enactment (the "happenings" of the Fluxus group) or acts of naming (conceptualism's embrace of the idea as the real substance of art). At the same time, this interest in spheres, cylinders, undoloids, and catenoids shows Vollmer's awareness of the kinetic aspects of sculpture, expressed through the search for thermodynamic equilibrium. Therefore, Vollmer was interested not only in Platonic (idealized) mathematical objects, but also in how the constraints of nature shape biological forms after these mathematical and thermodynamic laws. Her sculptures are sites of both abstraction as ideal mathematical models (like Pascal's spiral) and *Anschauung* as concrete biological organisms (like a shell).

One of the founders of statistical mechanics and thermodynamics, Josiah Willard Gibbs, was equally interested in this equilibrium of abstraction and *Anschauung*, in the sense of visualization, in dynamics and geometry. In two papers of 1873, "Graphical Methods in the Thermodynamics of Fluids" and "A Method of Geometrical Representation of the Thermodynamic Properties of Substances by Means of Surfaces," Gibbs illustrates the problem of surfaces, of thermodynamically stability, using graphical means. A sculptural model of this graphical presentation of fluids in motion exists, and is a wonderful demonstration of the possible mix of abstraction and *Anschauung* that would also be realized by Vollmer.

Underlying the dichotomy of abstraction and *Anschauung*, we find a much deeper opposition that is between theory and experience, as hinted at by Husserl. Before the successful mathematization of nature by modern physics, experience came before theory. In modern science, theory comes before experience. This triumph of theory over experience further aggravated the conflict between abstraction and *Anschauung*. Abstraction has advanced to such a high complexity that modern mathematics and physics now go far beyond *Anschauung*, becoming not only the languages of the *Unanschauliche*—the unintuitable—but also the languages of the incomprehensible. But this is precisely the reason why we construct these mathematical models, because they help us to understand the laws of nature better than our sense-perception could ever do. The "labor of concept" (Hegel) turned the world of experience into a world of mathematical formulae on paper, and these formulae in turn have transformed the real world.

Theoretical physicist James Clerk Maxwell, in his seminal paper "A Dynamical Theory of the Electromagnetic Field" (1865), used the dynamics of Lagrange and his analytical methods to postulate the existence of electromagnetic waves, giving mathematical expression to Michael Faraday's 1821 discovery of electromagnetism. In 1887, Heinrich Hertz succeeded in proving that the postulated electromagnetic waves did indeed exist. Hertz turned theory into experience, providing an experimental proof—by showing that electrical signals can travel through open air—for Faraday's and Maxwell's theory. The physics of the nineteenth and twentieth centuries declared clearly the primacy of theory over experience. As a result, Hans-Jörg Rheinberger and Michael Hagner could even speak of *Experimentalsysteme in den biologischen Wissenschaften 1850/1950* (Experimental Systems in the Biological Sciences 1850/1950; 1993).

Around 1800, pictures were strictly forbidden in mathematical books if their authors wanted to be taken seriously. These books of science were what Husserl had in mind when he blamed the crisis of European science on the loss of experience and history. But one hundred years later, around 1900, pictures triumphantly returned, in two ways: first, as *Veranschaulichung des Unanschaulichen* (visualization of the abstract); and second, as the revaluation of intuition—*Anschauung*.

So we see on the one side the triumph of theory and abstraction, the explanation of mechanics and motion in mathematical terms. The description of the world in mathematical expressions has as its result the technical revolution of the nineteenth and twentieth centuries. This school of thinkers was opposed to *Anschauung* and pictures, because pictures deceive and are only valid for specific cases. Formulae describe laws and ideas beyond particularities. This approach could be described as Platonic.

On the other side we have mathematicians and physicists like Henri Poincaré, who did not dismantle visually oriented work in mathematics and even supported intuition. In his 1899 paper "La logique et l'intuition dans la science mathématique et dans l'enseignement" (Logic and Intuition in Mathematical Science and Teaching), he wrote: "And even though pure mathematicians could do without intuition, it is always necessary to come back to intuition to bridge the abyss which separates symbol from reality." Even pure mathematicians need intuition to create new theorems. Poincaré even drew pictures and figures to illustrate his ideas. And Dutch mathematician Luitzen Egbertus Jan Brouwer, around 1911, established a doctrine of intuitionism that viewed the nature of mathematics as mental constructions governed by *self-evident* laws.

In the early nineteenth century, pictures, diagrams, and figures took a three-dimensional turn as mathematical models, used by Gaspard Monge, in France, and in the latter part of the century by Alexander Brill, Karl Weierstrass, and Felix Klein, in Germany. Klein wrote the influential book *Lectures on the Icosahedron* (1913), and he promoted the use of mathematical models in teaching. Built from wood and plaster, wire and paper, glass and brass, they looked like objects made by artists, and therefore like modern sculptures; they were widely used, particularly at the mathematics institute of the University of Göttingen, where they served not only to teach "spatial intuition" to students, but also to support progress in abstraction. Their aim, finally, was to picture the *Unanschauliche*—the unvisualizable. It is evident that these models, especially those from the Göttingen institute, served as one of the starting points for the abstract sculpture of the early avant-garde in the twentieth century, and especially for Ruth Vollmer. In art movements such as constructivism and abstraction-création, and in the work of Naum Gabo, Antoine Pevsner, Etienne Béothy, and Georges Vantongerloo, among others, you can see these influences of the "mathematical sensibility" the futurists spoke of in their 1914 manifesto, "Geometric and Mechanical Splendour and the Numerical Sensibility," written by Filippo Tommaso Marinetti. This interest in mathematics by the early avant-garde was also continued in the neo-avant-garde, from Max Bill to Mario Merz, and influenced the development of both minimal and conceptual art.

Central to the visualization approach—to make the unintuitable intuitable—was the chair of the mathematics department at the University of Göttingen, the eminent mathematician David Hilbert, who was known as a formalist. In his book (with Stephan Cohn-Vossen) *Anschauliche Geometrie* (1932; published in English as *Geometry and the Imagination* in 1952), Hilbert embraced the *Anschauliche* (the intuitable, the visual), as the title already suggests. In the preface to the book, he writes:

> In mathematics, as in any scientific research, we find two tendencies present. On the one hand, the tendency toward abstraction seeks to crystallize the logical relations inherent in the maze of material that is being studied, and to correlate the material in a systematic and orderly manner. On the other hand, the tendency toward intuitive understanding fosters a more immediate grasp of the objects one studies, a live rapport with them, so to speak, which stresses the concrete meaning of their relations.
>
> As to geometry, in particular, the abstract tendency has here led to the magnificent systematic theories of Algebraic Geometry, of Riemannian Geometry, and of Topology; these theories make extensive use of abstract reasoning and symbolic calculation in the sense of algebra. Notwithstanding this, it is still as true today as it ever was that intuitive understanding plays a major role in geometry. And such concrete intuition is of great value not only for the research worker, but also for anyone who wishes to study and appreciate the results of research in geometry.
>
> In this book, it is our purpose to give a presentation of geometry, as it stands today, in its visual, intuitive aspects. With the aid of visual imagination we can illuminate the manifold facts and problems of geometry, and beyond this, it is possible in many cases to depict the geometric outline of the methods of investigation and proof, without necessarily entering into the details connected with the strict definitions of concepts and with the actual calculations.

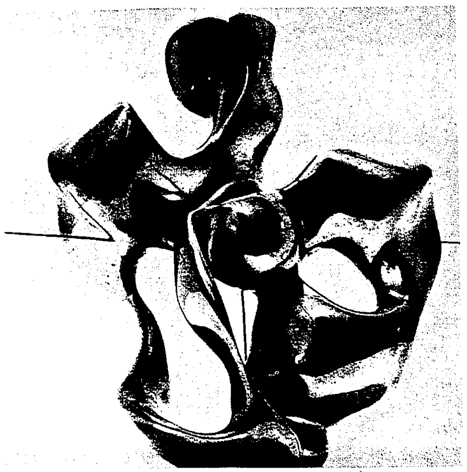
Hilbert would even go so far as to say that the propositions of geometry would be just as true if one took the terms "line," "point," "place," and replaced them with "table," "chair," "mug." For him, there was no gap between symbol and reality, between abstraction and concretion, between Platonism and realism. Also, his friend Hermann Minkowski, who, like Klein and Hilbert, taught in Göttingen, reconceptualized pure number theory in visual terms in *Geometrie der Zahlen* (The Geometry of Numbers; 1896).

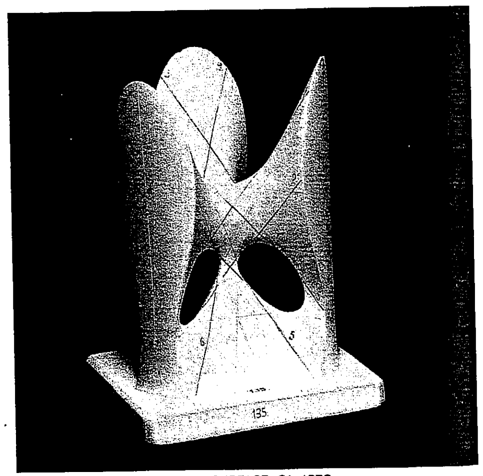
So we could say that the Göttingen School was the site for the *Anschauliche* in mathematics, and that Ruth Vollmer was its artistic heir. What does this mean? Precisely that her position, too, resided between abstraction and *Anschauung*, between the mathematical modeling of space and the *Anschauung* of space, between spheres of numbers and spheres of life, between topology and biology. Therefore, Vollmer could exercise influence on Eva Hesse, who had close contact with her, and on Sol LeWitt.

Like the Bauhaus School, Vollmer transported the European tradition of the mathematical mentality in the arts and in design (for example, the early "abstract ornaments" of the Wiener Werkstätten) to North America. Her work did not derive from that of R. Buckminster Fuller or from architecture generally. Rather, it is closer to instruction manuals like *Mathematical Models* (1961) by H. Martyn Cundy and A.P. Rollett, or *Polyhedron Models* (1971) and *Spherical Models* (1979) by Magnus J. Wenninger, who cites the mathematician and logician Bertrand Russell: "Mathematics possesses not only truth but supreme beauty, a beauty cold and austere, like that of sculpture, sublimely pure and capable of a stern perfection, such as only the greatest act can show." Russell connected mathematics to sculpture because of its purity and cold perfection—its sublimity. This, too, could have been a source of Vollmer's fascination with "mathematical forms," as LeWitt called her sculptures, denying their sculptural status in favor of describing them as "ideas made into solid forms. The ideas are illustrations of geometric formulae; they are found ideas." Minimalist sculptures, too, are sublimely pure and capable of a stern perfection, and certainly owe a lot to the problems of surface, *minimae areae*, and space anticipated by the mathematics of the nineteenth century. But the case of Vollmer is more complex. The art world has the tendency to accept natural forms like human bodies, flowers, animals, et cetera, and even models of natural forms, which are, essentially, what figurative sculptures are. Models of natural forms are accepted as self-sustaining works of art due to the romantic tradition of *Anschauung*, which still dominates the art world. A marble sculpture of a person's body, being in fact a model of that person in three dimensions, is not questioned as a work of art. But a marble sculpture of a mathematical object or a Platonic body like a regular polyhedron, being equally in fact a model (of a Platonic idea), is, strangely enough, not readily accepted as a work of art. Just as shells, as models of natural forms, are accepted as artworks, so should spirals as models of mathematical forms, especially those created in the age of minimalist sculpture. This might have been what was in LeWitt's mind when he spoke of "mathematical forms" in relation to Vollmer's sculptures instead of the dominant anthropomorphic and biological forms of traditional sculpture. Therefore, it is interesting to see Vollmer situated between LeWitt, Walter De Maria, Carl Andre, and Robert Mallary in the chapter "Systems Elementary and Complex" of Nicolas and Elena Calas's *Icons + Images of the Sixties* from 1971.

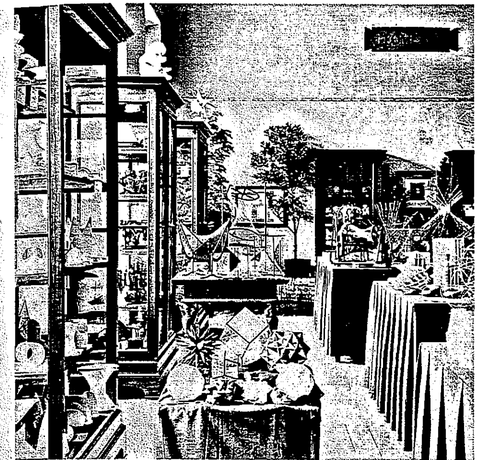
Because of the status of Vollmer's sculptures—as lying somewhere between abstraction and *Anschauung*, between topology and biology—her work is closer to more contemporary sculptural practices, like that of Olafur Eliasson, for example, than to the works of the minimalists with whom she is often aligned. On the one hand, one can reference her work in the images of the nine regular solids, from Platonic (five) to Kepler-Poinset (four), and the various polyhedra in physicist Alan Holder's *Shapes, Space, and Symmetry* (1971), which, indeed, look very similar to some works by Robert Smithson and Donald Judd. The same is even more valid for John Borrego's *Space Grid Structures: Skeletal Frameworks and Stressed Skin Systems* (1968), an overview of international architecture and design, since systems, structures, and grids played a central role in the conceptual and minimal art of the sixties. But, on the other hand, one can refer Vollmer's work to the biological interpretation of mathematical models and ideas that started for artists with the magnificent work *On Growth and Form* (1917), by D'Arcy Wentworth Thompson, which was followed in 1933 by George D. Birkhoff's *Aesthetic Measure* and in 1952 by Hermann Weyl's *Symmetry*. These interpretations culminated in papers like "Patterns of Growth of Figures: Mathematical Aspects" (1962) by the Polish mathematician Stanislaw Ulam, in *Module, Proportion, Symmetry, Rhythm* (1966), edited by Gyorgy Kepes (the successor of László Moholy-Nagy as director of the Chicago Bauhaus or School of Design); and in genetic algorithms developed, for example, in *The Algorithmic Beauty of Plants* (1990) by Przemyslaw Prusinkiewicz and Aristide Lindenmayer, and *Digital Design of Nature* (2005) by Oliver Deussen and Bernd Lintermann. (Vollmer was familiar with an earlier volume, *Patterns in Nature* by Peter S. Stevens, which was published in 1974.) Today, after the triumphant return of the visual with the invention of fractals by Benoit Mandelbrot (see his *The Fractal Geometry of Nature* of 1982), the sciences, from medicine to astronomy, are using visualization methods in perfect legitimization, and three-dimensional visualizations are popular like never before.

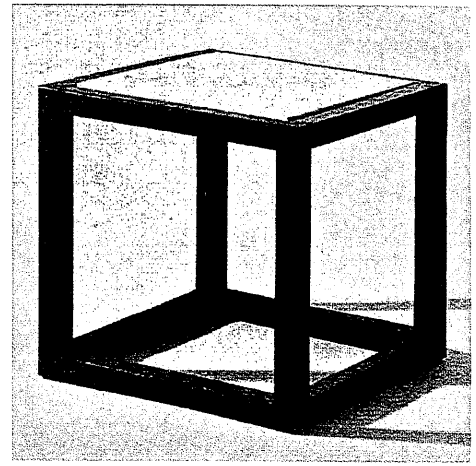
Between 1998 and 2004, the German philosopher Peter Sloterdijk published three volumes with the title *Sphären* (Spheres): *Blasen* (Bubbles), *Globen* (Globes), and *Schäume* (Foams). Here, again, we encounter the terminology of Plateau's problem and the conflict between abstraction and *Anschauung*. In these books, which center around the sphere as ideal mathematical and biological form, Sloterdijk develops a history of mankind as the evolution and construction of spheres, from mother's womb to Fuller's geodesic dome. The history of human housing as the artificial control of natural atmospheres builds the horizon in which being is not defined in relation to time, as Martin Heidegger did in *Sein und Zeit* (Being and Time; 1935), but in relation to space; we could, therefore, paraphrase Heidegger's title as *Sein und Raum* (Being and Space) or *Sein und Sphäre* (Being and Sphere). This biological and anthropological interpretation of mathematical models resides precisely in the German tradition of the opposition between abstraction and *Anschauung*, but it has the virtue of dedefining established positions and giving them a much deeper foundation. Sloterdijk gives an old philosophical problem a new reading by turning the sphere into the focus of being. Vollmer's achievement as an artist, her concentration on spheres and polyhedra, can be seen as a step toward Sloterdijk's philosophy of spheres: sculpture as a biological and mathematical form, as a model of both mankind and mathematics, *Anschauung* and abstraction. Art, for many, resides in the domain of intuition (*Anschauung*), and mathematics, in the domain of abstraction. But as the title of a wonderful book of 1973 by the great Hungarian mathematician Rényi Alfréd shows, a combination and convergence of the two is possible: *Ars Mathematics*. This could also serve as the inscription on the gate to the territory of Vollmer's art.

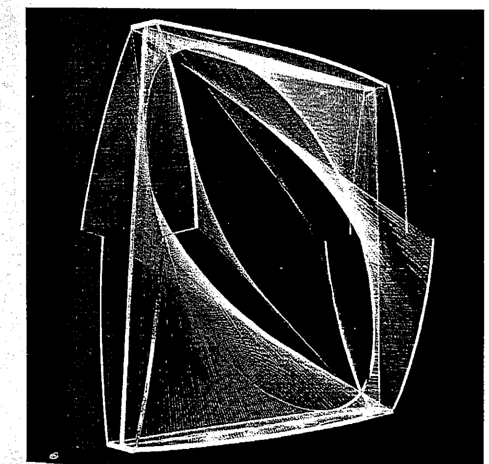

GEORGES VANTONGERLOO, CONSTRUCTION DANS LA SPHÈRE, 1918
FROM ANGELA THOMAS, DENKBILDER (1987)

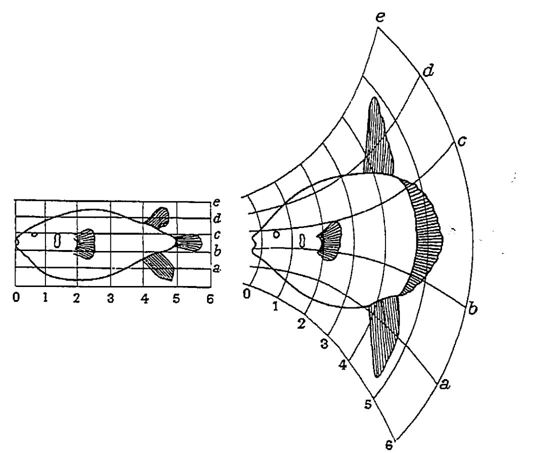


MODEL OF CLEBSCH DIAGONAL SURFACE, CA. 1870
MATHEMATICAL INSTITUTE, UNIVERSITY OF GÖTTINGEN


THE GEOMETRY ROOM, PART OF THE MODEL EXHIBITION AT THE TECHNISCHE HOCHSCHULE, MUNICH, HELD IN CELEBRATION OF THE THIRD ANNUAL MEETING OF THE GERMAN MATHEMATICAL UNION, 1893
PHOTO ©ARCHIVE DEUTSCHES MUSEUM, MUNICH


JOSEF HOFFMAN, CUBICAL TABLE, CA. 1904
FROM PETER WEIBEL, ED., JENSEITS VON KUNST (1997)


NAUM GABO, LINEAR CONSTRUCTION IN SPACE NO. 1, 1943
THE PHILLIPS COLLECTION, WASHINGTON, D.C.
PHOTO HERBERT MATTER



LEFT: DIODON, OR COMMON PORCUPINE FISH
RIGHT: ORTHAGORISCUS MOLA, OR SUNFISH. THE VERTICAL CO-ORDINATES WERE DEFORMED INTO CONCENTRIC CIRCLES AND THE HORIZONTAL COORDINATES INTO A SYSTEM OF CURVES. THE NEW OUTLINE SHOWS THE SUNFISH, WHICH IS CLOSELY ALLIED TO THE PORCUPINE FISH. FROM D'ARCY WENTWORTH THOMPSON, ON GROWTH AND FORM (1917)