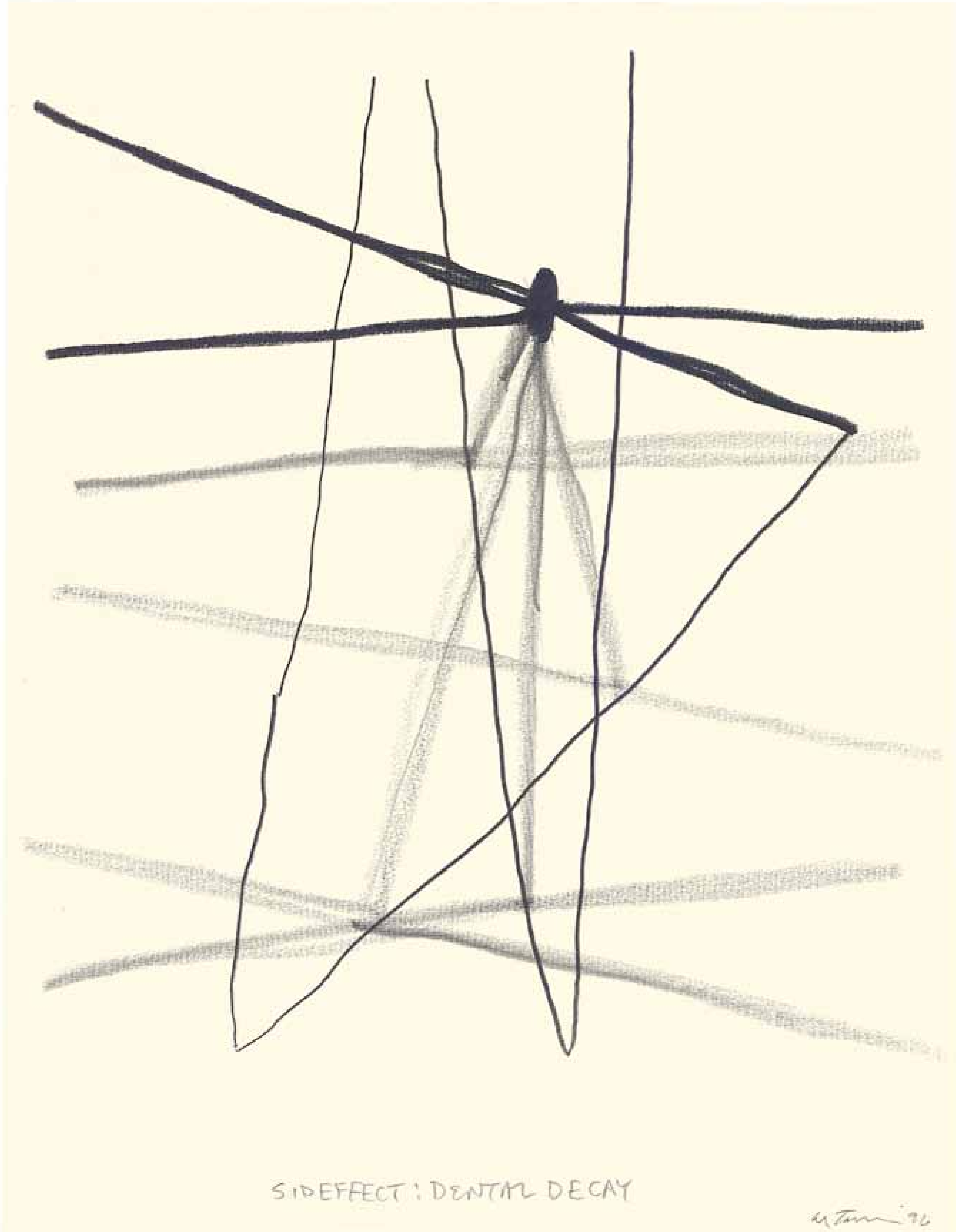


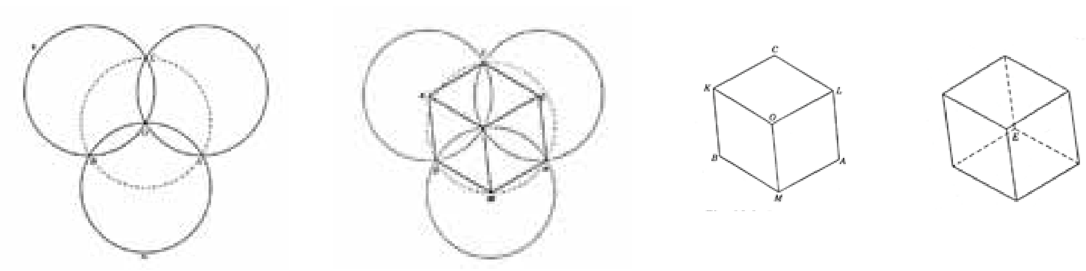
Sideffect: Dental Decay, 1996. Pencil and graphite on paper. 18 1⁄16 × 14 inches (45.9 × 35.6 cm)

MATHEMATICAL SIDE EFFECTS AND THE ART OF AL TAYLOR

by Philip Ording

In the following passage from *Mathematical Discovery*, George Pólya describes the thinking process involved in finding the proof of a theorem of geometry, but he might as well be describing the mental operations that take place when looking at a drawing by Al Taylor:

> The resulting figure is disconcertingly crowded. There are so many lines, straight and circular, that we have much trouble in 'seeing' the figure satisfactorily; it "will not stand still." . . . The drawing is ambiguous on purpose; it presents a certain figure if you look at it in the usual way, but if you turn it to a certain position and look at it in a certain peculiar way, suddenly another figure flashes on you, suggesting a more or less witty comment on the first. Can you recognize in our puzzling figure, overladen with straight lines and circles, a second figure that makes sense? . . . Our theorem is proved, and proved by a surprising, artistic conception of a plane figure as the projection of a solid.[1]



Three circles through one point. Two crowded. It reminds you—of what? Of course!

FIG. 1 Four figures illustrating the path toward proving the theorem "If three circles having the same radius pass through a point, the circle through their outer three points of intersection also has the same radius." Originally published as Figures 10.1–10.4 in Vol. II of *Mathematical Discovery* by George Pólya (New York: Wiley, 1962).

Taylor composes his works from a loosely defined but legible set of elements. The installation *Sideffects* [pp. 94–97] consists of several plastic-coated metal garden stakes capped on each end by a pancake of Bondo and rubbed with graphite. These protrude from both sides of a two-sided gallery wall, where their shadows angle down and onto the floor. In the numerous drawings that constitute the rest of the *Sideffects* series, Taylor maintains in each drawing medium, be it pencil, colored pencil, graphite, ink, or gouache, nearly a one-to-one correspondence with the different components of his subject. The wall protrusions are recognizable among the lines of a *Sideffects* drawing not only by the large circles Taylor draws at each end but also by the dark graphite he uses in opposition to surrounding lines in pencil. Taylor's use of drawing materials is suggestive of a cartographer's use of color. The drawings often appear less drawn than *mapped*. The distribution of his attention to all the individual elements tends to neutralize any hierarchy between figure, shadow, and ground. In some sense, Taylor's drawings are *all* figure. Or all ground.

As a mathematician, I readily accept the elements of a Taylor series to be the given assumptions or axioms from which he draws, but it is interesting to consider the source of the distinctions that he makes. Sometimes the elements are the apparent physical components of his subject. The bicycle wheel divides into hub, spokes, rim, and tire, whether you analyze it in terms of material, structure, or dimension, and these form most of the elements of Taylor's *Rim Job* compositions. Less tangible components are also prominent, such as shadow, which is an element of many Taylor compositions. Other elements are not only intangible, but invisible parts of a subject. Lines of sight, or "sight tubes" make an appearance in several *Sideffects* drawings [pp. 120–121], as though the act of vision itself constitutes a portion of his subject. Similar acts of vision are at work in the grease crayon lines of *X-Ray Tube* [p. 43]. In a more explicitly mathematical turn, Taylor imposes a system of coordinate axes onto the volume of space containing *Dutch Sideffects* [p. 119].

The compositional elements are roughly defined, and this quality emphasizes the relationships between them. Taylor not only uses materials that are malleable, but he handles them in a way that they retain the appearance of being malleable; the rubber and wires of *X-Ray Tube* and (with one exception) the metal in the *Rim Jobs* series are in a state of partial deformation, while the components of *Sideffects* are fashioned to look like metal, though made of Bondo and graphite. Lines may waver, but they always know exactly where they are going. The provisional quality of Taylor's line suggests that, like blackboard figures in a mathematics lecture, their function is to stimulate the imagination and convey truths that do not depend on the skill of the draftsman.[2] A more finished hand would add an unnecessary and distracting degree of specificity. There is rarely a mark that serves to do anything other than represent itself. To translate from the lexicon of the drawing pad to that of the blackboard: each composition (proposition) asserts a specific relationship (conclusion) among its set of variable elements (hypotheses).

In talking to Debbie Taylor about her late husband's art, she said that instead of trying to "figure it out" that I should "just respond to the work." I agree that Taylor's work doesn't require any special knowledge or expertise, and I doubt the value of assigning an explicit mathematical model—an equation or other formulation—for viewers' understanding of an artwork, except where the subject of the work is overtly mathematical. Still, the feeling I get looking at Taylor's work is that I *want* to figure it out.

If there is an apparent logic to the composition of a Taylor drawing, it is not necessarily consistent with a pictorial representation of physical space. If I think I recognize the elements going into a drawing, it does not mean I see how they all fit together. I have no trouble distinguishing the peculiar wall protrusions, the shadows, the floor, and the walls in *Sideffect: Battleship Complex* [FIG.2]. The shadows fall

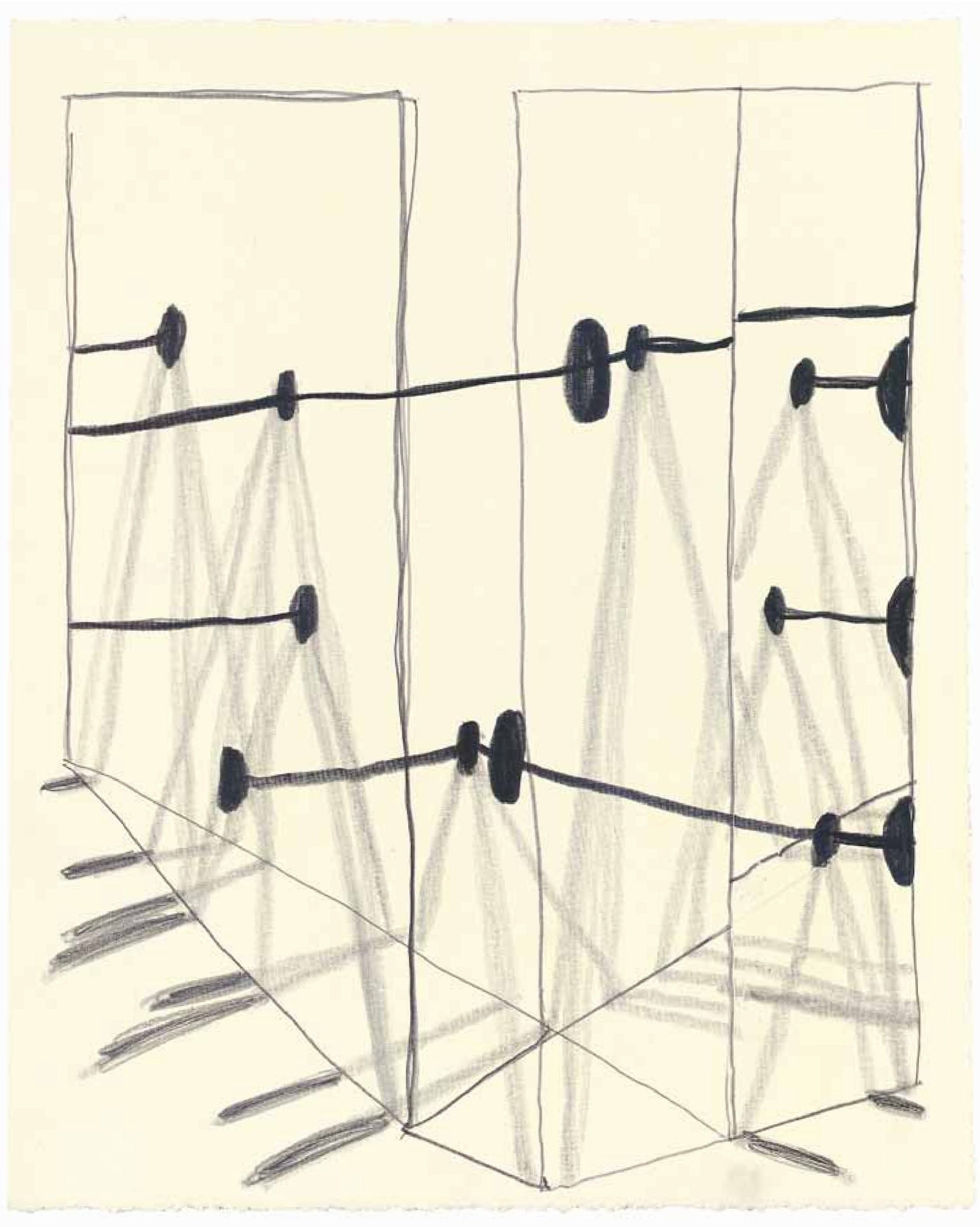


FIG. 2 *Sideffect: Battleship Complex*, ca.1996. Pencil and graphite on paper. 18 3⁄16 × 14 11⁄16 inches (46.2 × 37.3 cm)

FIG. 3 A jungle gym in a twisted Euclidean manifold. (Drawing by Bill Thurston) "… All the bars have the same length, and they all meet at right angles. Some bars appear tilted, because the artist had to distort the twisted Euclidean jungle gym to draw it in ordinary Euclidean space."[3] Originally published as Figure 18.4 of *The Shape of Space: How to Visualize Surfaces and Three Dimensional Manifolds* by Jeffrey Weeks (New York: Marcel Dekker, 1985).

from the protrusions down the wall to the floor and the walls and floors meet each other in corners. But stepping back, I cannot orient myself in the space of the drawing. For example, one place of confusion seems to be the second vertical line from the right that dislocates the picture as if it were a mirror, instead of a wall. The relationship between any one element and another tends to be generic: ends meet, paths cross at visible angles, one thing bounds another, and so forth. In this way, the drawing can read like a schematic, or topological diagram, like the London Underground map, which emphasizes configuration at the expense of scale. There is some local structure in which my eye can navigate the space, but understanding the global picture takes effort. I have to work to make sense of it.

If there is the possibility that the space of the drawing is an abstract space that may not admit any definitive representation, then the problem of visualization deepens. The first time I encountered this kind of problem was in *The Shape of Space: How to Visualize Surfaces and Three Dimensional Manifolds* by Jeffrey Weeks. If the mental optics required to visualize an abstract space like the one illustrated in the figure above [FIG.3] are available, it is difficult not to apply them when looking at a Taylor drawing.

The *Sideffects* drawings point out the unforeseen in Taylor's compositional logic. The pencil-line walls, the graphite wall protrusions, and the graphite shadows of *Sideffect: Dental Decay* [p. 28] meet one another in a way that is more or less typical for the series, but taken as a whole this drawing conspires to form the outline of a tooth with two long roots crisscrossed with gray shadows. The pictorial effect of a rotten tooth is one of the side effects of the compositional system. It may seem silly, but it is no less true for being unexpected. Interpretations of other drawings in the series reveal a battleship cannon, a De Stijl painting, or a cow pie (a foreshortened protrusion), to name a few. The side effects (or perhaps defects?) that Taylor observes in these drawings and other works result from making a survey of viewing angles around his subject, and perspective seems to be at least the primary logic.

The various side effects that Taylor indicates with his titles are reminiscent of counterexamples in mathematics. If a new instance of an abstract object emerges and falsifies a widely accepted conjecture about the nature of the object, then that instance is called a counterexample. By contradicting the mental picture we had (from viewing the three-dimensional construction), the side effect simultaneously refines and expands that mental picture. Occasionally the picture snaps into a new dimension, like the crux of Pólya's proof. In that moment of recognition, our vision changes. Looking at *Sideffect: Dental Decay* for the first time, I could only see the "pictorial logic" of the tooth. But looking at it in terms of the logic of the installation, I recognized the possibility that the roots of the tooth may be walls and the heavy black lines at top are protrusions extending through the walls. Checking the relationships between each of the elements I notice the two groups of parallel shadows. Suddenly, the two walls pitch forward from the page like a pop-up illustration and a space opens out. Taylor's titles invite the viewer into his state of mind, as if we were standing beside him in his studio, sharing the skewed perspective he found, and trying to make sense of it. This generous stance reminds me of the rhetorical use of the first person plural in mathematical exposition: "Our theorem is proved, and proved by a surprising, artistic conception of a plane figure as the projection of a solid."

A new logic can emerge in an instant, from out of the blue. Taylor describes this moment as a "jolt of surprise that has become addictive,"[4] and when his audience figures out a three-dimensional view in one of his drawings they get a sense of what he was after. Similarly, a friend in graduate school once remarked that what attracted her to mathematics was that her thinking changed more often and faster when she studied mathematics than any other subject. To maximize the potential for shifts of perspective, Taylor works with a flexible set of elements and ground rules, all the while showing a healthy disrespect for any explicit interpretation of what it is he is looking at. This is the situation in pure mathematics, where, as Hermann Weyl explains, "The concepts, admittedly, retain a certain range of indeterminacy; but the logical consequences of the axioms are valid, no matter what concrete interpretation may be adopted within this range."[5]

If Taylor's titles appear off-putting, then so much the better; a viewer who is comfortable with the image is less likely to see beyond his or her initial impression. By emphasizing various side effects in this body of work, Taylor manages to slow down the sequence of mental operations that happen between the apprehension of a two-dimensional drawing and a moment of recognition. Taylor noticed that, given a basic set of elements that assemble a scenario with its own rudimentary logic (of incidence and shadow, for example), by gradually shifting your perspective off of center, the scenario opens itself and becomes more visible. These side views may at first appear defective, but they point to the unexpected, but no less truthful, nature of things. When I first encountered the following graph [FIG.4] in the graduate text *Differential Topology*, I was surprised by its playfulness. I think I see a face or maybe two. There's no reason for the graph to be a face, other than that it *can look like a face*. The curve's peculiar motion helps us understand the general nature of the object.

The fact that movement increases visibility finds unusual expression in a news clipping that Taylor kept.[6] In the June 3, 1989, *New York Times* patent report "Frogs' Eyes Inspire Motion Detection System," the inspired inventor explains: "The thing about frogs is that they can see things only if they are in motion. . . . You can starve frogs to death just by putting them in a place filled with nice juicy insects that are motionless."

That *Sideffects* operates as a heuristic device that Taylor used for making art and developing his own mental optics recalls Imre Lakatos' *Proofs and Refutations: The Logic of Mathematical Discovery*. Unlike Pólya's proof, mathematical exposition tends to follow the pattern of deduction starting with axioms and

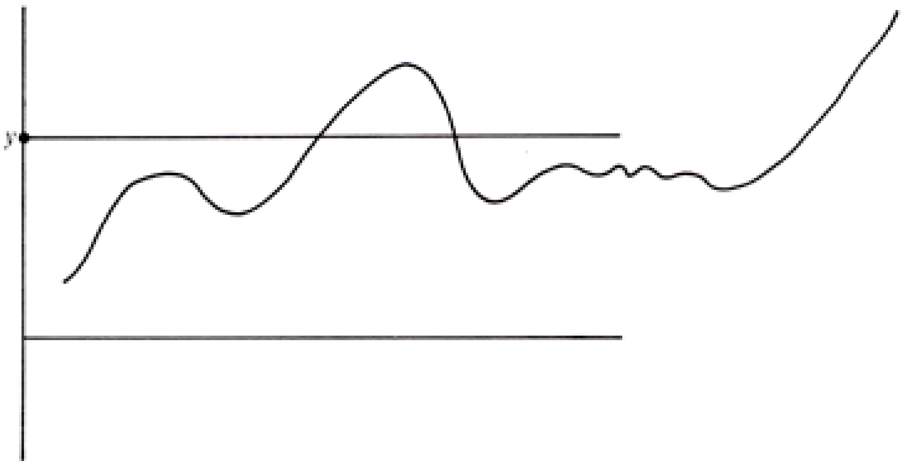


FIG. 4 Graph of a differentiable function illustrating the Morse-Sard Theorem, originally published as Figure 3-1 in *Differential Topology* by Morris W. Hirsch (New York: Springer Verlag, 1976).

concluding with proofs. The "range of indeterminacy" of a mathematical concept is obscured, and the counterexamples that gave it shape are omitted. Lakatos does just the opposite by recapitulating the history of ideas and counterexamples that propelled the development of a (now fundamental) mathematical theorem over the course of its centuries-old life. He argues that the conflict created by an unintended interpretation of a mathematical definition or axiom compels the mathematical community to refine and expand its naïve conception of the objects of study: "Corroborations never compare with counterexamples, or even 'exceptions,' as catalysts for the growth of concepts."[7] Taylor also understood this: "But on another level the work completely contradicts itself. If you have only one point of view that says: This is it, I am searching for this—what good is it when you find it?"[8]

In Taylor's detachment from his own work I recognize mathematical activity, more so than in any formal similarities between his art and mathematical content. For Lakatos, the peculiar distance stems from the logic of mathematical discovery: "Mathematics, this product of human activity, 'alienates itself' from the human activity which has been producing it. It becomes a living, growing organism, that *acquires a certain autonomy* from the activity which has produced it; it develops its own autonomous laws of growth, its own dialectic."[9] Compare this to Taylor's "Instead of forcing myself onto some anonymous objects, I try to find a method that will allow them to form their own logic beyond me."[10]

Taylor seems to have absorbed the lessons of pure mathematics without ever aping the discipline. I don't know how this happened, possibly through his interest in Marcel Duchamp, or perhaps he secretly enrolled in a topology class after hours. Topology can be generally understood as the mathematical study of vague forms. Felix Klein presents the basic question of topology as follows: "Let us think, say, of a surface or a solid made of rubber, with figures marked upon it. What is preserved in these figures if the rubber is arbitrarily distorted without being torn?"[11] Many of Taylor's drawings actually do look remarkably like the diagrams drawn by topologists, at least those that study surfaces and three-dimensional manifolds. But I find it hard to argue that Taylor is using mathematics *per se* or that he is making artistic renditions of any scientific artifact. For his purposes, any system would do, whether the projection of shadows, skid marks from a tire, or the accumulation of pet stains on a sidewalk. There are at least a couple of Taylor drawings that explicitly refer to mathematics, such as *Comforts of Math* (1986) and *Egyptian Progression* (1988) which use Fibonacci numbers. In terms of his oeuvre, these works are isolated; mathematics appears as just one among many found systems, one that I would argue he uses with actually less sophistication than any of the logics explored in this exhibition.

Mathematics and Taylor's artistic process both raise questions about what it is that constitutes the subject of the work and what kind of reality this subject possesses. Try to show that a drawing is a study for sculpture or that a sculpture is a model for drawing, and either analysis turns out, as he would say, "full of holes."[12] Even if I am certain that I recognize the three-dimensional construction *Rim Job* [p. 67] in the two-dimensional drawing, *Untitled (Rim Job)* [p. 65], or vice versa, I can't say what it is that I am recognizing. "If I was forced to try to come up with a category that could encompass Al's work, I would say it's *imaginary realism*," Debbie Taylor told me when I visited the Franklin Street studio. I think Taylor is a *mathematical* realist. To him, as with many working mathematicians, the work constitutes a reality to be discovered. If it happens to reflect a physical reality outside it, so be it, but that interpretation does not limit the territory under investigation.

There is a bust of the mathematician Samuel Eilenberg that dominates the lounge of the Department of Mathematics at Columbia University. I remember sitting there trying to enjoy a break from struggling with his modern axiomatic framework that featured in my topology coursework. It wasn't until later, when I came across this passage in a secondhand-book store, that I began to see the deadpan humor behind his intense gaze: "It is hard to see how a great deal of modern mathematics could be applied to other sciences and human affairs. Most of the men working on the frontiers of pure mathematics don't really care. They are interested primarily in creating ideas. Samuel Eilenberg of Columbia expresses this attitude when he compares himself facetiously with a tailor who makes coats for his own aesthetic satisfaction. 'Sometimes I make them with five sleeves,' he explains, 'other times with seven sleeves. When it pleases me, I make a coat with two sleeves. And if it fits someone, I'm happy enough to have him wear it.'"[13]

Notes

1. George Pólya, *Mathematical Discovery*, Vol. II (New York: Wiley, 1962), 54.
2. Here I am paraphrasing G.H. Hardy's characterization of geometrical figures, see *A Mathematician's Apology* (Cambridge [Eng.]: University Press, 1940), 125.
3. Jeffrey R. Weeks, *The Shape of Space* (New York: Marcel Dekker, 1985), 255.
4. Al Taylor, in *Al Taylor: Drawings/Zeichnungen*, ed. Michael Semff (Ostfildern, Germany: Hatje Cantz Verlag, 2006), 86.
5. Hermann Weyl, *Philosophy of Mathematics and Natural Science* (Princeton: Princeton University Press, 1949), 27.
6. Estate of Al Taylor archives.
7. Imre Lakatos, *Proofs and Refutations* (Cambridge [Eng.]: University Press, 1976), 87.
8. Ulrich Loock and Al Taylor, "A Conversation," in *Al Taylor* (Bern: Kunsthalle Bern, 1992), 36.
9. Lakatos, 146.
10. Ulrich Loock and Al Taylor, "A Conversation," 42.
11. Felix Klein, *Elementary Mathematics from an Advanced Standpoint. Geometry* (New York: Dover, 2004), 105. (Originally published in German as *Elementarmathematik vom höheren Standpunkte aus*, Berlin: Springer, 1924, vol. 2).
12. Ulrich Loock and Al Taylor, "A Conversation," 42.
13. George A.W. Boehm, *The New World of Math* (New York: Dial, 1959), 43.

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