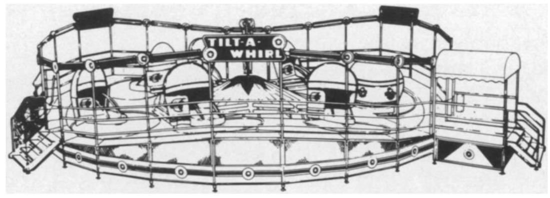
Chaos for fun and profit



Sellner Manufacturing

Experiencing chaos by riding the Tilt-A-Whirl.

Much of the fun of an amusement-park ride arises from its stomach-churning, mind-tingling unpredictability. The Tilt-A-Whirl, for example, spins its passengers in one direction, then another, sometimes hesitating between forays and sometimes swinging them abruptly from one motion to another. The rider never knows exactly what will come next.

Yet these complicated, surprising motions result from a remarkably simple geometry. A passenger rides in one of seven cars, each mounted near the edge of its own circular platform but free to pivot about the center. These platforms, in turn, move at a constant speed along an undulating circular track consisting of three identical hills separated by valleys, which tilt the platforms in different directions. The movements of the platforms are perfectly regular, but the cars independently whirl around in an irregular manner.

Intrigued by the possibility that the motion of the Tilt-A-Whirl cars may represent an example of chaotic behavior, Richard L. Kautz of the National Institute of Standards and Technology in Boulder, Colo., and Bret M. Huggard of Northern Arizona University in Flagstaff worked out a mathematical equation to describe the forces acting on each car. Solving this equation to determine how a car would move, they obtained results that closely mimicked the Tilt-A-Whirl's actual behavior. The researchers describe their results in the January AMERICAN JOURNAL OF PHYSICS.

The mathematical model developed by Kautz and Huggard suggests that when the platforms travel at very low speeds along the track, the cars complete one backward revolution as their platforms go over each hill. In contrast, at high speeds, a car swings to its platform's outer edge and stays locked in that position. Chaotic motion occurs at intermediate speeds, close to the 6.5 revolutions per minute at which the ride actually operates.

"In spite of its limitations, our idealized model seems to capture the essence of this ride," the researchers say. At intermediate speeds, the jumbled mixture of car rotations never repeats itself exactly, which gives the Tilt-A-Whirl its lively and unpredictable character.

Tilt-A-Whirl fanatics also know that they can affect the motion of a car by throwing their weight from side to side at crucial moments, turning cycles with little or no rotation into good whirls. "Thus, it would seem that aficionados of the Tilt-A-Whirl have known for some time that chaotic systems can be controlled using small perturbations, a principle that has recently been applied by scientists to the less frivolous task of suppressing chaotic behavior," Kautz and Huggard remark.

It's probably safe to assume that the Tilt-A-Whirl's inventor, Herbert W. Sellner, discovered his ride's unpredictable dynamics not through mathematical analysis but by building one. In 1926, dynamical chaos had not yet attained the notoriety it now enjoys.