# Terror on wheels - by design

A multimillion-dollar theme park is only as good as its hottest thrill ride, which is why screams warm an engineer's heart.

by Robin Nelson

At Kansas City's Worlds of Fun park, the Orient Express coaster dives toward the awesome Kamikaze Kurve (opposite page).

Orient Express coaster's state-of-the-art claim is based mainly on a feature called the "boomerang" by the ride's designer, Arrow Development Co., and the Kamikaze Kurve by the park's thrill marketers. Within 13 seconds the coaster enters (left photo) and leaves (right) a kidney-shaped, double-barrel-roll track section, inverting twice and blasting back out the same way it roared in.

Of the 28 people squirming into the coaster's seats and pulling the padded restraining bars down over their heads, probably two were older than 20. One was an electrical engineer working for Arrow Development Co., which had designed and built Worlds of Fun's Orient Express roller coaster. The other was me. The rest were Kansas City kids lucky enough to win a radio station call-in contest that gave them a free shot at the Midwest's newest new ride on the day before its official opening.

The engineer, who had just finished—hopefully, I should say—the final adjustment on a photocell sensor plus microprocessor control system that would oversee ride braking and interval operation of the three coaster trains, grunted as he lowered himself into the seat. It was snug on me too. "Well," he said, glancing over with an odd, fleeting smile, "guess I ought to ride the thing once, anyway." Taking a last quick glance over the side at the insubstantial-looking polyurethane-tired wheels (photo at left), I felt the brakes let go as we slid into a short, dark tunnel from the station. As we ratcheted up toward the 117-foot-high first drop in a brisk prairie wind, I was prepared for the worst.

Small rollers keep coaster on the tracks.

It was over in two and a half minutes. The first drop was a screamer, like every coaster I've ever been on, and you pulled up into and out of the first loop almost before you knew it was happening. Time for one breath and into the second interlocking loop—even tighter, if a little slower—and then, while you were congratulating yourself on making it this far without letting any shrill, piercing sounds escape the lips of a 44-year-old man wearing a London Fog trenchcoat, it happened. An unusual thrust of sideways pressure threw you smack into the Kami . . . ka . . . ze Kuuurrrve!

It is not possible to remain completely oriented through this 13-second maneuver: An initial barrel-roll shoots you out at right angles to your original course of entry; pulling up sharply, you flip again and come out heading back in the direction from which you came.

The effects of the Kurve were still with me a few seconds later as I pulled into the final braking section, following just one more sharp, but level, turn. The engineer looked relieved, and satisfied. "I think," he said reflectively, pausing to let a surge of giggles from exiting riders die out, "we've got a winner."

Since Worlds of Fun owner Lamar Hunt has invested $4 million in the system, it had *better* be a winner. The park's marketing brains are banking on it, in fact, having hiked the entrance fee to slightly over $10 for the 1980 season. Ten bucks is still considered a never-exceed figure by most people in the theme-park business, but with a draw like the Orient Express—the country's "state of the art" roller coaster—Worlds of Fun made the move with confidence. (With numerous promotional rates and discounts in effect, few customers actually pay full price anyway.)

## It looks steeper than it is

There are probably 20 or more parks in the country today claiming superlative—tallest, fastest, scariest—thrill rides. Yet engineering dynamics confine most amusement rides to limits of about a 55° initial incline and top speed of under 70 mph. It may look straight down when you pitch over the top of that first drop, but 55° is what you're getting. And it doesn't take an engineering degree to figure out that while designers want drops as steep as safely possible for thrill potential, the speed built up must be killed off one way or another before the train completes a circuit.

Make the ride too long and the park can't move enough people through it per hour. Too abrupt a pull-up and you risk back and neck injuries from G-force compression. Carry too much speed into mechanical braking systems and maintenance problems, or something worse, will be the result.

The speed that's a problem to kill off is also expensive to buy: gravity gives it up only as a function of the square root of height. Adding 20 feet to a 120-foot-high coaster, for instance, would only give it about 5 mph more, or about 65 mph at 140 feet, assuming a constant 55° incline. To get to 100 mph, you'd have to build a 400-foot drop. Thus, the promotional claims of highest, fastest and the like, bandied about in theme park advertising these days, are based on such minor-

Heading into loop on the Loch Ness Monster at Busch Gardens, Williamsburg, Va.

crements that they have very little bearing on what the ride does to the pit of your stomach. With height (therefore, speed) bumping up against its practical limits, thrill ride designers have only the geometry of the track as a readily available avenue for pursuing more intentional terror on wheels.

"In the future," says design engineer Ron Toomer, "you'll probably see even more features analogous to high-performance aircraft." Toomer, who works for California's Arrow Development Co., helped conceptualize the "boomerang" feature that Worlds of Fun calls the Kamikaze Kurve (with a potential market in Japan, the designer prefers the former name).

In the past decade, the new geometry of roller coasters has provided a fertile market for both Arrow and West Germany's Schwarzkopf firm (story on opposite page). These two compa dominate the field and compete hea for multimillion-dollar contracts. Inter ingly, in working with gravity and geom try, the two competitors have evol highly differentiated mechanical s tems.

Telephoto lens gives thrill ride a "promotional" perspective; that's only a 55° drop.

## Different brakes and wheels

Take the track: Schwarzkopf tracks bolted together with slip joints to allow hot weather expansion. Arrow welded pipe-type track with no expans joints—the system simply expands as whole.

Wheels: Schwarzkopf uses a prop etary mixture of nylon and other mate for tires; Arrow uses polyurethane like roller skates. Schwarzkopf's thr bearing (one ball, two roller) system sealed and lubricated with molybde disulfide; Arrow's two-roller bearing s tem is lubricated with ordinary crankca oil (as weather warms, heavier oil is ad ed to the system to keep the coast speeds in line).

Both systems use automotive-typ metal-to-metal caliper braking system Arrow's single brake fin (cold-rolled ste extends vertically underneath each ca Schwarzkopf has fins extending horizo tally on each side of the car—and there fore more braking surface to grab. If row's brakes are activated (closed) by pressure, relying on emergency pressu ized tanks in event of compressor failure Schwarzkopf brakes are kept inactiv (open) by air pressure and then are auto matically spring-closed in the event power failure.

Says one park's ride operations ma ager, who has worked with both systems "It's obvious that the European setup more sophisticated—whether that's bet depends on who is going to buy and ru it."

## But are they safe?

Safety questions arose earlier this yea when an electronic malfunction on Schwarzkopf-designed ride at Marriott Great America park at Santa Clara, Cali resulted in a fatal accident. Authorities i the field seem to indicate, however, tha today's system design, including mod and full-scale testing, photocell and mag netic sensors for interval control—eve microprocessors—is resulting in essen tially safer thrill rides than have ever bee built. Yet both the cost and complexity o local maintenance have increased, and the consumer might be guided by the overall appearance of a theme park and the caliber of its employees as well a anything.

Over 100 million Americans visit theme parks each year. Fatalities on all amuse ment rides are averaging less than 10 per year—including ski lifts. Ironically, cable suspended rides, the tamest around, ac count for far more fatalities than the ride designed to scare you to death. PM



## Anton Schwarzkopf—just a simple 'pretzel' merchant

Today's cult of individualized roller coasters, those with names like "The Scream Machine" and "Mindbender," owes more to one man than any other. He is a former cartwright named Anton Schwarzkopf, 56, who employs roughly a third of the work force of the Bavarian town of Munsterhausen (population 1500). Because of Schwarzkopf, Munsterhausen is occasionally called "the Peenemunde of thrill rides."

A. Schwarzkopf

Schwarzkopf was contentedly operating the family cart and wagon business until 1955, when he visited an amusement exposition in Munich, 50 miles away, and got the idea that he could build a better merry-go-round. In a few years, he had worked up to bumper cars, and in 1964, Schwarzkopf designed and built the first roller-coaster system made from steel instead of the usual wooden trusses and supports. Since then, Schwarzkopf has registered 60 patents in the field and has produced upwards of 55 coaster systems that have been sold in countries around the world at prices ranging up to $4 million each.

A number of Schwarzkopf innovations not protected by patent have been adapted by other manufacturers in the field. It makes him reluctant to discuss certain aspects of his designs. He will not disclose, for example, the exact composition of his wheel material—except to say that it includes nylon and Teflon in a combination hard enough to sustain high speeds, but not so brittle that it will crack under stress.

### Perfecting the loop

In 1973, he began research on one of his most important projects: the loop. "We didn't invent it," he concedes, "since there had been a roller coaster with a loop at a Russian amusement park in the late 19th century, and one built at New York's Coney Island in 1901.

But they were too small and coasters going through them were subject to as many as 12 Gs. There were many injuries."

By comparison, astronauts at liftoff pull under 5 Gs. Besides being too small, those early loops were perfectly circular and this, as Schwarzkopf found out through experimentation, is not a good shape for a coaster loop. Trying a number of mathematically correct curves, Schwarzkopf and his associates found that a spiral in which the radius of curvature decreases at a constant rate would provide excellent geometry for a safe loop.

Thus we have the modern, teardrop-shaped loop, in which a coaster can maintain a minimum of 0.6 Gs at the top, keeping riders in their seats, without exceeding 6 Gs—and only approaching that briefly—as it enters and exits.

With his loop tested and proven in 1975, Schwarzkopf further developed cars, undercarriage, tracks and trusses now used every-

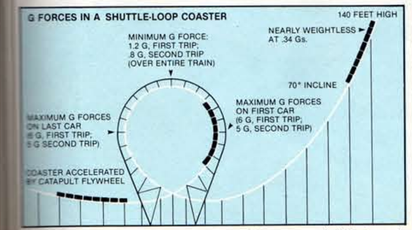
Simple wooden trusses supported test track at Schwarzkopf's works in Bavaria, where the teardrop-shaped loop (above) was perfected in 1975. An outgrowth was the Shuttle-Loop (below), in which counterweight or catapult gets train up to speed for forward/backward runs.

where to support inverted thrill rides. When some American insurance underwriters questioned whether his restraining bar design would be safe under emergency circumstances, he flew them to Munsterhausen, put them on a coaster and had them braked to a stop at the top of a 70-foot loop—where they hung from the restraining bars until they got the point.

Schwarzkopf is exacting in his ideas on safety; if it were up to him, anyone who directly operates a thrill ride would have to be licensed.

For the future, Schwarzkopf envisions extending the inverted regimes on his coasters, with cars hitting 50 mph while suspended in upside-down straightaways.

"To design a coaster," he says, "you just have to think of a pretzel. And we have plenty of pretzels in Bavaria."—*John Dornberg*




Shuttle-Loop schematic shows the "nodes" at each side of the loop, where high-G conditions are encountered. First car of the train gets highest Gs on entry side (right); rear car pulls highest on exit. After incline tower halts the train for the backward run, the situation is reversed. Moral: For least strain, ride mid-train.