

## ATTRACTION SAFETY

### Birket Commissions 7th and 8th LIM Coaster Ride Systems

**K**eep hands and feet inside the ride vehicle at all times. By the end of 2004 theme park Earth will have two new linear induction motor-launched (LIM) roller coasters, bringing the Birket LIM coaster count to 8 and the planet's total to 22.

Instead of the more common chain or friction drive lift systems, the propulsion generated by LIM technology creates a traveling magnetic wave that accelerates the coaster vehicle.

Led by engineers Daniel Birket, Glenn McNair, Zhiyong Mao and Tim Swieter, the Birket installations represent the world state-of-the-art in thrill ride control system technology and safety.

Birket confidentiality agreements require that the new ride installations go unnamed.

For more information see [www.birket.com](http://www.birket.com).



#### LIM Coasters of the World, Spring 2004

1. **Halfpipe**, Six Flags Elitch Gardens, Colorado, USA, 2004
2. **Atlantis Adventure**, Lotte World, Seoul, South Korea, 2003
3. **Steel Venom**, Valleyfair!, Minnesota, USA, 2003
4. **Half Pipe**, Särkänniemi Amusement Park, Hame, Finland, 2003
5. **V2: Vertical Velocity**, Six Flags Marine World, California, USA, 2002
6. **Wicked Twister**, Cedar Point, Ohio, USA, 2002
7. **Vertical Velocity**, Six Flags Great America, Illinois, USA, 2001
8. **Screaming Condor**, Leofoo Village Theme Park, Hsinchu, Taiwan, 2001
9. **Steel Venom**, Geauga Lake, Ohio, USA, 2000
10. **Speed**, Nascar Café, Nevada, USA, 2000
11. **Poltergeist**, Six Flags Fiesta Texas, Texas, USA, 1999
12. **Joker's Jinx**, Six Flags America, Maryland, USA, 1999
13. **Volcano**, The Blast Coaster, Paramount's Kings Dominion, Virginia, USA, 1998
14. **Mr. Freeze**, Six Flags St. Louis, Missouri, USA, 1998
15. **Mad Cobra**, Suzuka Circuit, Mie, Japan, 1998
16. **Batman And Robin; The Chiller**, Six Flags Great Adventure, New Jersey, USA, 1998
17. **Linear Gale**, LaQua, Tokyo, Japan, 1998
18. **Mr. Freeze**, Six Flags Over Texas, Texas, USA, 1998
19. **Flight of Fear**, Paramount's Kings Dominion, Virginia, USA, 1996
20. **Flight of Fear**, Paramount's Kings Island, Ohio, USA, 1996

Source: the Roller Coaster Database, see [www.rcdb.com](http://www.rcdb.com).

### Fire When Ready- A Pyro-Electric Safety Primer

by Daniel Birket, BSE EMCS

**P**yro-technicians are trained to handle pyrotechnic devices with great care in part because "you never know when it might go off." The basis of this prudent uncertainty can be traced in part to a lack of information and sometimes to inappropriate techniques. This article attempts to illuminate some obscure areas of pyrotechnics and list some practices that can reduce the risk of unexpected ignition.

#### To Fire or Not to Fire...

Pyrotechnics are a much-anticipated component of shows at theme parks, theatres, and on tour. When the "fireworks" occasionally fail to fire or work, it disappoints the audience, stirs up the management, and stresses out the pyro crew. But any pyrotechnician (who would like to continue to count to ten on his fingers) knows that the problem of devices that don't ignite when you expect is nothing compared to the hazard of ones that do when you don't. The lack of a pyrotechnic accent may detract from the artistic presentation, but a charge that explodes unexpectedly will shut down the entire show whether or not it harms anyone. This problem of unexpected ignition is the focus of this article.

There is a fairly widespread notion that it's easy to make a system that will ignite pyro-electric devices. After all, you only need a medium-size battery to ignite an electric match (often called a "squib"). Anyone able to fix a flashlight can build a system that fires an electric match. This is true: it *is* easy to ignite pyro. In fact, it's hard to make a system that *won't* light pyro – until you want to – and *that* is the question.

#### Ohms and Amperes and Watts, Oh my!

Voltage, current, resistance, and power determine whether or not an electric match will ignite, and a good engineer will thoroughly analyze these parameters when designing a pyro-electric control system. But it's not necessary to know Ohm's Law to know how to avoid unexpected ignition – just a few rules of thumb.

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This newsletter is provided by Birket Engineering, Inc. as a communications device to current and future customers and friends.

Every control system must be evaluated and designed with consideration for the details of the specific application.

Information in this newsletter is not meant to be an engineering or professional opinion.

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# CONTROL SYSTEM DESIGN

(Fire When Ready, continued from page 1)

An electric match will ignite if enough power is sent through it to heat it to its ignition temperature. A tiny amount of power won't do it. When a pyro controller tests for continuity, it uses extremely low power to safely test for the presence of the match. All commercial pyro controllers take great care with the continuity check circuitry because it is an obvious area of risk – a little too much power during the test might ignite a match instead of just testing it.

## Stopping Unexpected Power

There are two ways to avoid sending unwanted power through the electric match:

- Block any unwanted power from reaching the match, and
- Route any unwanted power away from the match.

Blocking unwanted power involves placing insulators and shields between possible power sources and the match. Similarly, routing unwanted power away from the match involves putting conductors between the match and a safe place to dump the unwanted power. With a little thought, we can usually block the unwanted power sources from reaching the match. For the remaining sources, including those we *don't* expect, we can try to route the unwanted power away to a safe place.

There are several kinds of unwanted electrical power that might find their way to an electric match. Most are fairly obvious and easily avoided, but some are quite devious.

## Unexpected Circuits

While everyone is used to wires guiding electricity along the circuits we want, circuits can and do form anywhere different voltages find a way to connect. Current can flow through catwalks, conduits, pipes, even damp stains on surfaces. Have you ever felt a tingle when touching some equipment? That electrical source might have been able to light an electric match.

Obviously, we don't want the pyrotechnic wiring to come in contact with wiring for lighting, audio, or other power. There is more than enough power in a sound system to light an electric match. Cross-wires between ignition channels are another common cause of unexpected ignition. Cross-wires may occur where there are many channels of pyro or other wiring grouped together. A pyro controller that tests for channel cross-wires as it performs its continuity check will reduce this risk.

## Ground Faults

One unexpected, but very common, route for unwanted power is the *ground* – that is, the dirt under our feet. In almost any electrical power wiring system you'll find "ground" wires that lead ultimately to the earth. Metal frame structures are often tied to the earth with special wiring. "Lightning rods" are wired to the ground with thick cables to dissipate the natural

voltage of passing rain clouds. Practically every electrical system uses "ground" on one side of its circuits. This is a good safe practice for most electrical wiring, but bad news for a pyro-electric system.

Although one connection to ground is harmless, it's then easy for a stray wire strand, a fleck of metal, or even a drop of water to form a second connection somewhere else. A second connection may complete an electric circuit between an unwanted power source (perhaps another ignition channel) and the match *through the ground*. For this reason, good pyro control systems are *isolated* from ground to help prevent ground faults. Regular testing or a *ground fault detection* feature is necessary to insure that the system remains isolated from ground. A ground-fault detection circuit works like a "GFCI" (Ground Fault Circuit Interrupter) safety wall outlet to detect unexpected connections to the earth. (Note: Plugging a pyro controller into a GFCI outlet doesn't work.)

## Electromagnetic Interference

Electric power is able to "side-step" from one circuit into another even when there is no electrical conductor between. Wherever electricity flows there is a magnetic field that can cause current to flow in another circuit without ever touching. Power transformers use this principle. When it happens unintentionally, its called Electromagnetic Interference or EMI. If you have ever heard a 60-cycle "hum" in the audio system when the lighting system turns on you've seen this principle in action.

The high-power lighting circuits can easily jump to unshielded audio wiring anywhere the wires are routed together, for example in a cable tray. High power circuits can have the same effect on unshielded pyro channel wiring.

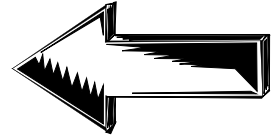
## Insulate, Isolate, Shield, Protect, and Verify

Here are some techniques for keeping these unexpected power sources out of the pyro-electric distribution system:

- **Grounded metal conduit:** In a permanent installation, grounded metal conduit provides excellent physical protection for pyro channel wiring. Wiring is unlikely to be damaged inside the conduit, and grounding the conduit helps to route unwanted power away from the pyro devices. Grounded metal conduit also shields the wire from EMI fields that may induce current in the pyro wiring. Note: If water collects in the conduit, it may eventually break through the wire's insulation and produce a ground fault.
- **Heat and Abuse-Resistant Insulation:** Where pyro wiring is exposed or movable, the wire's insulation should be able to stand up to burning fallout and rough handling. If the insulation melts or scrapes away, it's easy to form an unwanted

Do you have a controls question on a specific ride or show application? Birket Engineering, Inc. invites inquiries. We are fortunate to have a wealth of experience and talent from which to draw in addressing your need.

# ZHIYONG MAO



**C**ongratulations to Zhiyong and wife Jian on the April 19th arrival of their 7lb. 15oz. son, Wesley Mao. Having only arrived at the airport twenty minutes earlier, Zhiyong chased the ambulance carrying Jian on its way to the hospital. Earlier the same day Zhiyong had left Los Angeles, CA, where he is part of the ride system integration team for a soon-to-open LIM-launched thrill attraction.

Zhiyong is a tremendous asset to the software development of current installations in California and Florida. Later this year, Zhiyong will be part of new projects planned for the U.S., Canada, and China.

For more information contact Zhiyong at [zhiyongm@birket.com](mailto:zhiyongm@birket.com).

## The Stats on Zhiyong

### System Engineer, Birket Engineering, FL, 2003-present

Ride Integration team member, confidential LIM project, Los Angeles, CA.

Ride Integration team member, confidential LIM project, Orlando, FL.

### Engineer Supervisor, SIEMENS, Chengdu, China, 1996-1998

System design and integration.

### Electrical Engineer, Chengdu Telecom, China, 1990-1995

System design and integration.

### Master of Science in Electrical Engineering, Systems, 2003

University of Cincinnati, OH

### Bachelor of Science in Electrical Engineering, Controls, 1990

Sichuan University, Chengdu, China



Zhiyong with new arrival Wesley

(Fire When Ready, continued from page 2)

circuit. Teflon is one type of tough insulation.

- **Shielded Wire:** Shielded wire has a web of wire wrapped around the center conductors. When the shield (not the wire) is connected to ground at one end, it will block most Electromagnetic Interference. Note: Take care not to ground the pyro channel wiring by allowing it to touch the shield.
- **Twisted-pair Wire:** When a pair of wires is twisted together, it becomes less susceptible to EMI. This is a good alternative to more expensive shielded wire.
- **NO "Zip Cord":** Un-shielded, un-twisted, "zip" or lamp cord generally has a soft, thin insulation that is neither heat nor abuse resistant. It may be cheap, but it's not suitable for permanent wiring. Zip cord wiring is a common factor in many cases of unexpected ignition. Remove any temporary zip cord with the spent pyro.
- **Isolation Transformers:** If a pyro system uses a low-voltage AC firing current, isolation transformers between zones can help block ground faults and other unwanted circuits from forming. Note: this technique provides only limited protection and is easily compromised unless the isolation is tested regularly.
- **Isolated Firing Circuits:** One excellent way to avoid unwanted circuits from forming between one pyro channel and another is to isolate every circuit from every other. Good pyro control systems use individual firing capacitors to handle each channel independently.
- **Verified Circuits:** To insure that every pyro channel is isolated from ground and from every other pyro channel, use a pyro controller that verifies every circuit during the continuity check. A simple continuity check will insure that a match *will* fire when expected, but ground-fault and cross-wire checks are necessary to insure that no match fires unexpectedly.

## Shunts

After the pyro system designer and the pyro-technician user have taken every reasonable precaution to prevent unwanted power from reaching the electric match, it can still happen. To deal with this problem, pyro control systems "shunt" each pyro channel. The "shunt" is an automatic and/or manual switch on each pyro channel that conducts unwanted power away from the electric match where it will do no harm. This works very well – as long as the channel wiring is heavy enough. If the wiring is too long or too thin, the unwanted power may prefer to flow through the electric match instead of the shunt. It depends on the wire length, but 14-gauge wire is usually heavy enough to insure that channel shunts can provide reasonable protection for the match.

Some pyro systems use a manual shunt that protects the pyro-technician while loading the pyro devices. This is adequate for installations where no one will go near the pyro after the shunt is removed, but inappropriate for a live-action show. Ideally, every pyro channel should be individually shunted up until the moment it is fired. With this style of controller, the entire cast and crew is protected from unexpected ignition at all times.

For more information contact Dan at [danielb@birket.com](mailto:danielb@birket.com).

North America's top 12 best-attended theme parks for 2003, with attendance and percentage change from previous year:

1. WDW Magic Kingdom, 14M, flat
2. Disneyland, 12.7M, flat
3. Epcot, 8.6M, +4%
4. Disney-MGM Studios, 7.8M, -2%
5. Disney's Animal Kingdom, 7.3M, flat
6. Universal Studios Florida, 6.8M, flat
7. Universal's Islands of Adventure, 6M, flat
8. Disney's California Adventure, 5.3M, +13%
9. SeaWorld Orlando, 5.2M, +4%
10. Universal Studios Hollywood, 4.5M, -12%
11. (tie) Busch Gardens Tampa Bay, 4.3M, -4%
12. (tie) Adventuredome at Circus Circus, Las Vegas, 4.3M, -4%

Source: Amusement Business



**Birket Engineering, Inc.**  
provides electrical and  
computer engineering  
services for entertainment  
and industrial  
automation.

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**Luke Zagurski**  
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## Birket Engineering Becomes ICONICS System Integrator Partner

Effective April 2004, Birket Engineering satisfies requirements for the ICONICS System Integrator Partner (SIP) Program. The program gives the SIP access to product and technical support at a deeper level than that of the average user, and provides the integrator with the tools needed to easily develop and maintain systems using ICONICS products.

Founded in 1986, ICONICS is a leader in OPC-based, Web-enabled visualization software for manufacturing, automation and business solutions, and is a Microsoft® Gold Certified Partner. ICONICS products are based on open industry standards. With a single development tool, ICONICS products run on multiple Microsoft Windows® platforms, such as Windows 98, Windows ME, Windows 2000, Windows XP, Windows NT®, Windows CE, Pocket PC, Embedded NT, Embedded XP and Windows 2003 Server.



The SIP partnership is important to Birket's goal to provide support for all of our clients' requirements. As part of the agreement, Electrical Engineer Brian Kuhar successfully completed the three-day GENESIS32 101 training class at the ICONICS headquarters in Foxborough, MA.

Birket continues an over ten-year participation in the Rockwell Automation System Integrator Program.

## Birket Engineering: The Next Generation

Birket Engineering congratulates fourteen-year-old John Charles (J.C.) Birket, son of Vice President Daniel Birket, and Andy Sabis, also fourteen, son of General Manager Ed Sabis upon their acceptance into their respective high schools' Engineering, Science and Technology Magnet (EST) programs.

The prestigious programs provide outstanding students the opportunity to receive diverse exposure to the varied roles of engineers in society. Students are immersed in a rigorous program of college preparatory sciences, math, computer technology and programming courses. EST students are eligible to earn college credit while in high school.

J.C. will enter the EST program in the fall as a freshman at Apopka High School. Andy will continue in his second year of the program at Edgewater High School.

## **BIRKET ENGINEERING, INC. WORK IN PROGRESS NOW**

### Current Projects

- Two new domestic linear induction motor-launched roller coaster control systems are commissioned.
- A control system for US Filter is completed.
- A life-safety stunt show control system is designed for a diversified worldwide entertainment company.

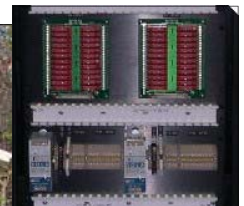
### Strobe-brik™ Systems

- An underwater-use, 250-strobe system for a diversified worldwide entertainment company ships to Japan.
- A 24-strobe system effect opens at the Borg Invasion inside Star Trek: The Experience in the Las Vegas Hilton.

### In Proposal

- Ride system control design for two new roller coasters
- Monitoring hardware and software for a mass-transit ride system.
- Strobe-brik™ systems for international and domestic sites.

For more information see [www.birket.com](http://www.birket.com).



Another beautiful day in Orlando, developing electrical and software systems for the world's finest attractions.