

MACHINE DESIGN

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from Hewlett-Packard. They give me first crack at going through the stuff and buying items individually.” Recently, for example, he found a top-of-the-line sublimation printer, complete with 48 Mbytes of RAM and a full suite of Ethernet equipment. He bought the \$9,000 device for \$250, and plans to sell it for \$2,500. “Buying and selling like this just doesn’t take up that much time,” he says. “And it lets me make enough money to pay the rent and buy parts for SRL.”

MECHANICAL MENAGERIE

In any given SRL show, up to two dozen large machines perform, each controlled by trained SRL technicians. Granted, the training might only last a day or two, but the technicians still take their jobs seriously. Wearing the prerequisite earplugs and sound-muffling headsets, they use radio controllers to manipulate the machines. “We build the controllers ourselves,” says Pauline. “There are lots of channels available, up to 30, and we use both the FM and AM band, together with PCM radios, to avoid interference



An SRL show put on in Seattle carried the title “A Carnival of Mismatched Devotion: Calculated to Arouse Resentment for the Principles of Order.”

An SRL crew tests a flame-throwing jet engine prior to a show.



issues. We also use noise-resistant, custom-built boards inside metal enclosures to stop RF interference. Since we use them around huge Tesla coils and actually arc the coils to the machines themselves, we really need that protection.”

Some devices use controls that operators actually wear. In one, for example, the machine’s articulated arm mimics the arm motions of the operator. And in a device that fires concrete-filled cans, a person wearing a special headset aims at an object merely by looking at it. Other, less lethal machines crawl and lurch across the performing area on their own. Ever-alert SRL staffers keep them from going astray or into the audience.

“At one time, we experimented with artificial life and A-life algorithms to construct a show in which the machines would operate and interact automatically,” recalls Pauline. “But we ran into problems with time and money. It takes some serious funding to integrate the sensor technology and keep it all safe. So I decided there was no way we could continue to do those things on a large scale

without more money.”

SRL machines are powered by a variety of sources, everything from gas-powered motorcycle engines and full-sized V8s to lead/acid batteries and compressed air. “We try to stick with high-density energy sources,” explains Pauline. “The batteries, for example, are deep-cycle versions from Panasonic. They each hold about 20 amp-hr at 20 volts, and they can be recharged relatively quickly.”

He also has about eight jet engines, including a pair of Boeing 502, 175-lb thrust, 200-hp turbojets and a 10-year-old, 900-lb thrust engine from an Exocet cruise missile. “The manufacturers are usually more than happy to send you maintenance manuals on these engines,” says Pauline. “They figure if you have an engine, they don’t want you to kill yourself with it, so they’re pretty forthcoming with information, except for the military companies. I’m not too sure I could’ve gotten the manual on the Exocet motor. But I got my hands on one anyway.”

Pauline and his crew are using jet engines to move machinery, like the jet-powered go-kart that has appeared in several shows, and to just create noise, smoke and flame. His crew consists of about two-dozen hard-core volunteers

and another eighty or so who do much of the manual labor and thousands of other small but necessary jobs that must be done to stage an SRL event.

In return for their work and know-how, volunteers get a crash course in machine shop practices and access to SRL's shop and stockpiles. Many SRL volunteers are scientist and engineers who bring their own skills to the job. For example, SRL staffer and electronic whiz Greg Leyh works at SLAC where he specializes in power conversion and is building the power supplies for a new accelerator. He also claims to have designed the world's largest Tesla coil, a 45-ft-tall, 150-kW model, for a wealthy New Zealand man who enjoys watching it arc.

SRL has literally built a cast of machines, some dating back almost 15 years, available to star in upcoming shows. "Once you build these machines, they just don't go away," says Pauline as he points out the Inch Worm, the Shock Cannon, and other SRL creations. "The names are mostly perfunctory. I like to stay away from the artworld convention of precious naming."

The machines, some in pieces, some huddled under plastic sheets, litter the

area in and around SRL's building. They include:

- The Running Machine, a six-legged affair powered by a small gas engine, a Vickers piston pump, and a wicked-looking chain drive. A moving, articulated arm on the front of the machine carries a cutter which severs cables holding heavy objects aloft during the shows. "With a top speed of 6 miles per hour, this is the fastest leg-powered machine in the world, and it has the longest range, about 40 miles," notes Pauline.

He got the idea for the drive from articles on Hughes' gatling-gun loading system. They were having problems making parts strong enough to handle the high peak loads of moving ammo at 600 rounds/sec and still small enough to fit into an aircraft-sized system. Hughes' engineers decided to use a chain and spread the loads over the complete cycle time. "I looked at that and said, Wow, that's the real problem

A V-1 rocket creates smoke, flame and noise to announce an upcoming show in Austria.



on machines with legs," recalls Pauline. "Peak loads make the linkages fail and limit the speed the legs can move. So I came up with this chain drive. It's reliable, runs for hours, and because the chains are strong, it's efficient. Plus, if the chain breaks, it's easy to get another one. It's not a complicated linkage that takes weeks to machine."

- The High Pressure Air Launcher was originally developed by NASA for avalanche control. It uses gas pressure to automatically load and fire up to 26 concrete-filled cans at 500 ft/sec. The "ammo" can hit targets a mile away. The device uses CO₂ and circumvents existing Federal Firearms Laws. In recent shows, SRL has let people on the Internet aim and fire the Launcher, making them the first organization to let the public operate potentially lethal machines over the Net.

- The Hand-O'-God is a giant spring-loaded hand mounted on a remote-controlled wheeled platform. The hand is made of several hollow metal cylinders that serve as fingers and are attached by steel cables to a set of giant springs. The hand weighs 1,500 lb and is cocked by an air-cylinder with 8 tons of pressure. When the springs are released, the hand flexes forward with a considerable amount of force. The hand

SRL turned a machine used to shoot explosives and trigger avalanches into the High Pressure Air Launcher, a device that fires concrete-filled cans.



KEEPING TRACK OF SRL

For more information on Survival Research Laboratories, updates on shows, and an opportunity to buy SRL paraphernalia, check out the Web site at <http://www.srl.org/>

is held aloft on four spindly metal arms and a set of brackets taken from a military loading system. “The chrome-moly alloy is incredibly strong and can easily hold the 1,500 pounds,” says Pauline.

• The Taser is a 20-kV rail gun used to fire molten metal comets across the stage. It’s based on plans Pauline found that could’ve been for a propulsion system for submarines or ships. Originally, the rail gun would fire capacitive energy into seawater and propel the water out like an underwater jet engine. “We built one intending to shoot napalm or gasoline out of it, but water worked best,” says Pauline, noting that it would shoot a ball of water about 100 ft. “But it wasn’t that interesting, so I tried some other things.”

He added heavy copper rails, fiddling with their length and width to focus the magnetic field in the barrel of the device. He wanted the field to force the metal into a tight ball. Eventually he came up with a design that uses an air cylinder to slam high-



A flamethrower and several smaller SRL machines perform in the show “The Unexpected Destruction of Elaborately Engineered Artifacts: A Misguided Adventure in Risk Eradication, Happening Without Known Cause, in Connection With Events That Are Not Necessarily Related.”

carbon steel “shots” into the copper bars or rails, which are charged from a 20-kJ capacitor bank. The steel sparks and is liquefied and ejected practically simultaneously. “At first I used an ignitron to supply the spark, but they’re expensive and finicky and have a limited number of shots, so I came up with the idea of using the metal slamming in there to create a spark.”

• The Jet-Engine Powered Wheeled Vehicle uses a simple jet engine fabricated from a modified high-pressure axial turbocompressor-driven furnace burner with a Lear Jet combustor can. It uses a Kawasaki 750 motorcycle engine to power the turbine and associated pumps. A B-29 turbo compressor is being installed to add more thrust.

• The Shockwave Generator harnesses explosions of propylene and oxygen to create a powerful vortex ring.

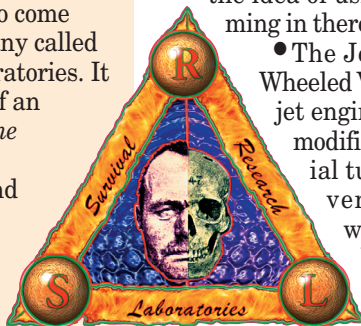
The vortex is strong enough to break windows from 700 ft away and has been known to damage roofs on buildings 50 yd or more away from SRL’s impromptu testing grounds (i.e., right outside the machine shop).

• The portable Foam Generating Machine takes standard high-expansion fire-fighting foam and generates 1,500 ft³ of thick, free-standing foam/min. It’s primarily intended for use on audiences. Another device that has been morphed into an audience misery enhancer is one of the Boeing jet engines. It gets set up on a pivoting frame, turned on, and swung to and fro at the nearby crowd. A strong-smelling chemical added to the diesel fuel amplifies the desired effect. An afterburner fuel-injection system added by SRL lets it also operate as a huge blowtorch.

SRL assaults audiences, like those in Austria, with extreme noise. Inspiration for many of the noisemakers comes out of military research. The Spinning Machine that twirls a cable at supersonic speed, for example, is

WHAT’S IN A NAME?

When Mark Pauline was first putting together his performance-art group he happened to come across an ad for a company called Survival Research Laboratories. It was buried in the back of an issue of *Soldier of Fortune* magazine, a publication ostensibly for hit men and mercenaries. Though he doesn’t remember what the company was selling, he liked the name and appropriated it for his organization. In the twenty or more years since he grabbed the name, he’s never heard from the SRL that took out the ad.



sort of a twisted spin-off of U.S. research done on supersonic prop-driven planes. Seems at some point, any more energy used to turn a prop gets transformed into noise. An enterprising SRL worker realized that they could spin a steel cable instead of a prop and put together a relatively inexpensive noise machine.

Pauline's collection of air raid sirens and whistles stems from work done by the French in the 50s and 60s on noise weapons for crowd control. "I've copied some of their designs for crowd-control whistles and we have one hooked up to a three-stage turbocompressor," he says. "The literature documents some of the effects sound can have and they're rather disturbing."

While SRL was building ever larger turbocompressors to power ever louder whistles, a physicist at SLAC caught wind of their pursuit of noise. A collector of military documents, he happened to have complete plans for a V-1 rocket. "That guy knew we would get more low-frequency sound out of the V-1 than we ever could out of a whistle," says Pauline, who modified the plans a bit and built one. The original engine used valves with a 40-hr life, not enough for SRL's purposes. "So I made the valves out of Inconel 750, a spring material, and gave them basically an infinite life," says Pauline. He uses an eight-stage Spencer turbocompressor as a starter and a 454-cu-in. V8 to run the compressor. Depending on how rich they run the fuel, SRL technicians can coax the V-1 to belch smoke clouds, shoot 40-ft flames, or put out a roaring 40-Hz buzz.

"That V-1 really has an effect on people. It makes them feel like they're drunk. Their IQ drops, along with their ability to operate in a test envi-

ronment," says Pauline, drawing on more French research.

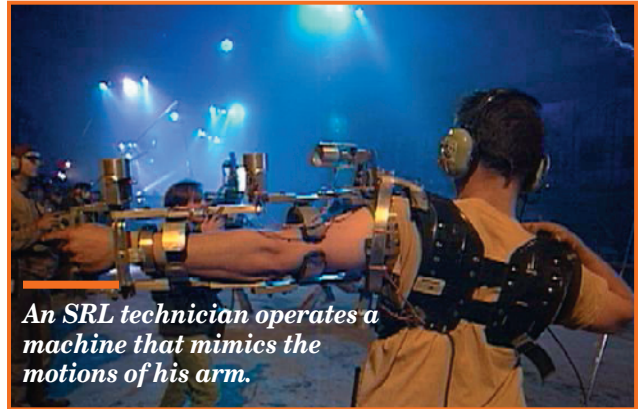
Does he have any compunctions about exposing his audiences to sounds that might have effects they're unaware of? "Our machines aren't going to damage anyone's hearing necessarily, and no one has really complained. We give everybody earplugs. But by the time someone leaves a show, they could feel pretty thoroughly thrashed," says Pauline. "Besides, I think it's really fun.

"Some people leave the shows very upset because they found themselves in the wrong place or a smoky machine invaded their space," Pauline says. "Others go away with a much more positive memory of the experience. But we're trying to do things that are memorable, though some might call it traumatic instead."

ON THE DRAWING BOARD

Pauline and his crew are busy in the workshop turning out machines and exploring new frontiers in technology while planning the next SRL event. They are broadcasting shows and events on the Web to widen their audience. They also use the Web to encourage interaction with the audience, letting them control machines from a distance. And they're working on some more contraptions like the Pitching Machine and the Flying Platform.

The Pitching Machine uses a V8 engine hooked via an inverted chain drive to a custom-built gearbox to spin two large car wheels at 125 mph. The wheels are mounted only inches apart and turning in opposite directions. Two-by-four sections of board fed into it come flying out at about 120 mph to arc 900 ft through the air. Pauline describes it as a weapon for the 21st century; even if there's no more gunpowder, there will always be methane



An SRL technician operates a machine that mimics the motions of his arm.

to burn and leftover two-by-fours to shoot. "At shows it will be like 2-ft clubs flying through the air," imagines Pauline. "And we'll have a 7-ft pneumatic cylinder feeding boards in one by one."

The Flying Platform, so far, is only a small, round aluminum hovercraft fairing and some designs in Pauline's head. He plans to power it with a small motorcycle engine turning a lifting blade designed to handle 20 hp. A 6-lb pulse jet engine putting out 70 lb of thrust will provide steering and rotation. The finished machine should weigh about 350 lb and be able to lift a few thousand pounds, according to his rough calculations.

For the immediate future, SRL will be trying to set up more complicated contraptions that use sophisticated controllers, along with more devices that fly and other extreme machines. "The machines look very odd, and that's part of the psychology of creating an event," explains Pauline. "We couldn't have just wheeled vehicles. Everybody's already seen that. But having machines with legs, some with square wheels, or running on steel screws, keeps the attention of the audience and gives them an experience more like a performance than an exhibition." ■



Machines and audience interact at an SRL show in Phoenix entitled "A Million Inconsiderate Experiments."

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