

# Make:

technology on your time

Mesmerizing  
Jellyfish Tank  
page 82 »



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Page 49

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# Can You Solve This?

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TECHNOLOGY  
(PØT)

NO PØTS!



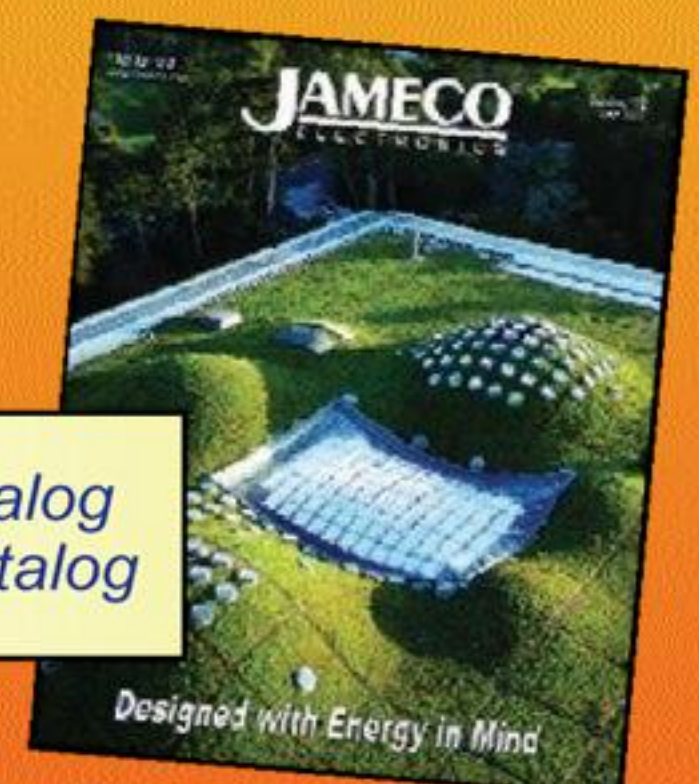
The year is 2021, and the Federal Panel of Obsolete Technology (PØT) has banned the manufacture, sale and use of manually adjustable (analog) potentiometers, trimmers and the like. Only digitally-programmable potentiometer technology may be manufactured and used. Consultant Leo Smith is an analog old timer with a thriving business designing workarounds for circuits that would work much better if "old fashioned" analog components banned by the PØT were still available. How did Leo design a rotary style, continuous (no steps) volume control for a children's portable radio without breaking the law?

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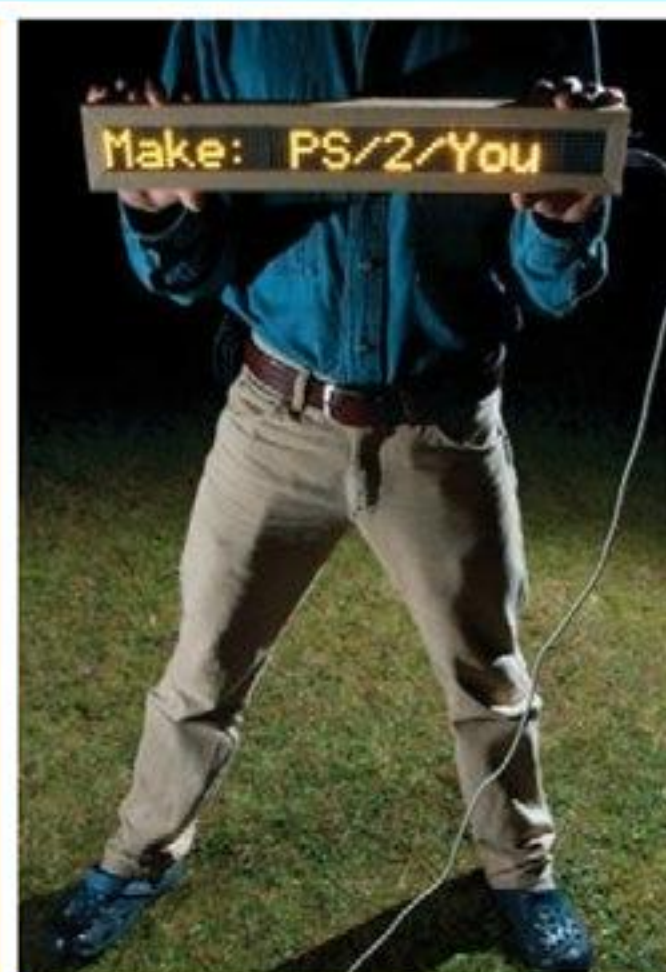


## Jellyfish Tank

Convert a regular aquarium into a jellyfish habitat.

By Alex Andon

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## PS/2/You

Build a go-anywhere, instantly updatable digital message board.  
By Immanuel McKenty

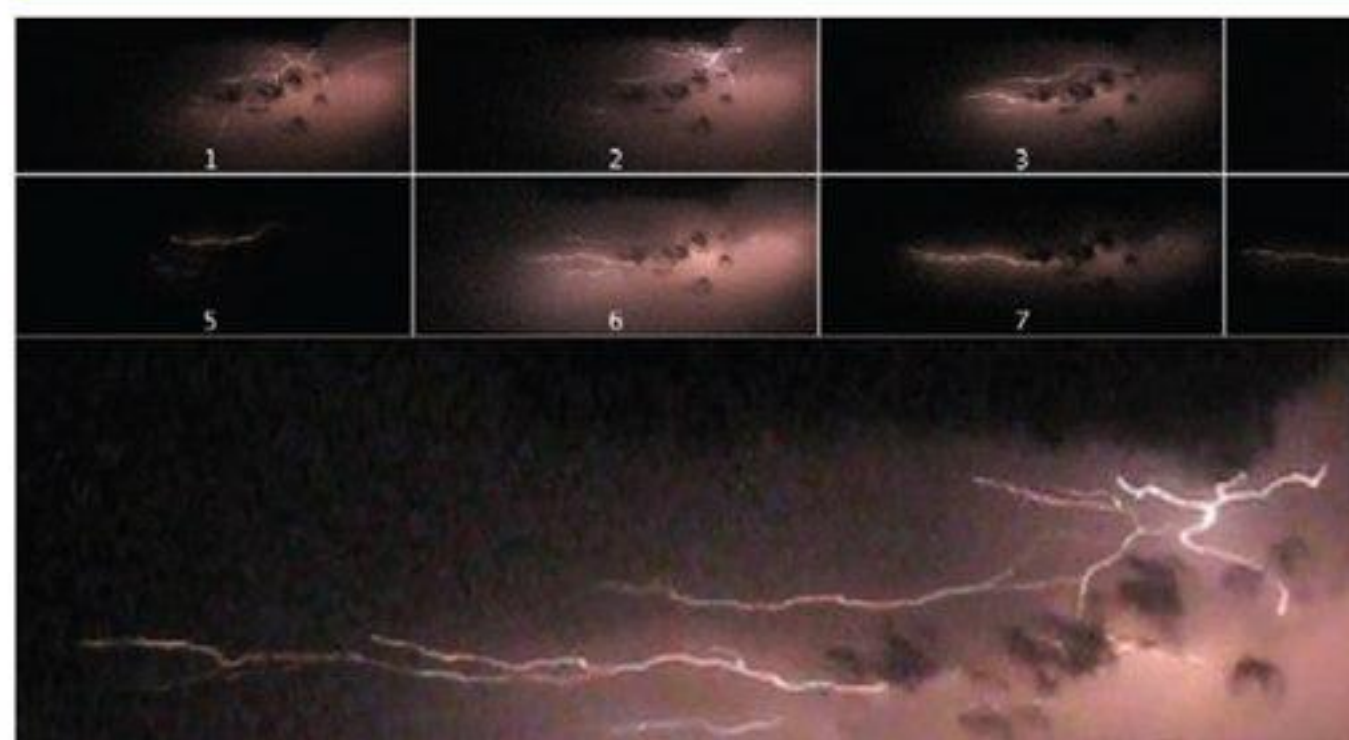
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## Limelight

Experience pre-Edison incandescent lighting.

By Peter Tabur

104



PRIMER

## VISUALIZING WITH IMAGEJ

Use free image/video processing software to create vivid representations of time, movement, and data.

By Bob Goldstein

116

# How to be ready when Hollywood calls?

Work really hard, and use a ShopBot.



**Melissa Jones** from Minnesota, a mother of two, has been diligently building her one-woman sign business for about 5 years. She got a ShopBot CNC router in 2008 to expand her production capability, and that's when the call came from Sony Pictures to make specialized props for "The Green Hornet." And business has been going well ever since.

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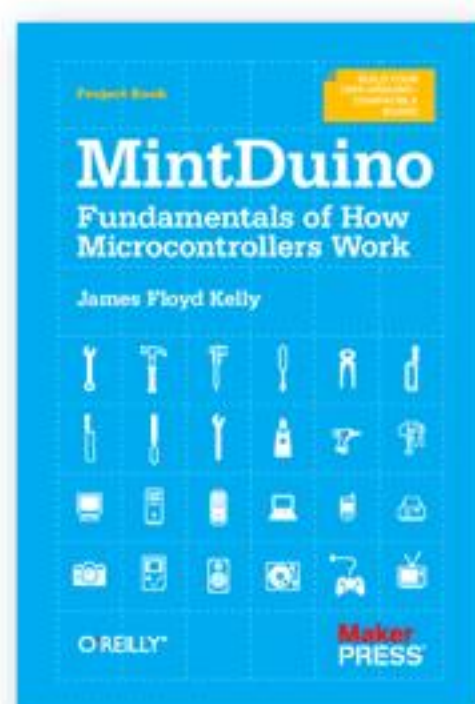
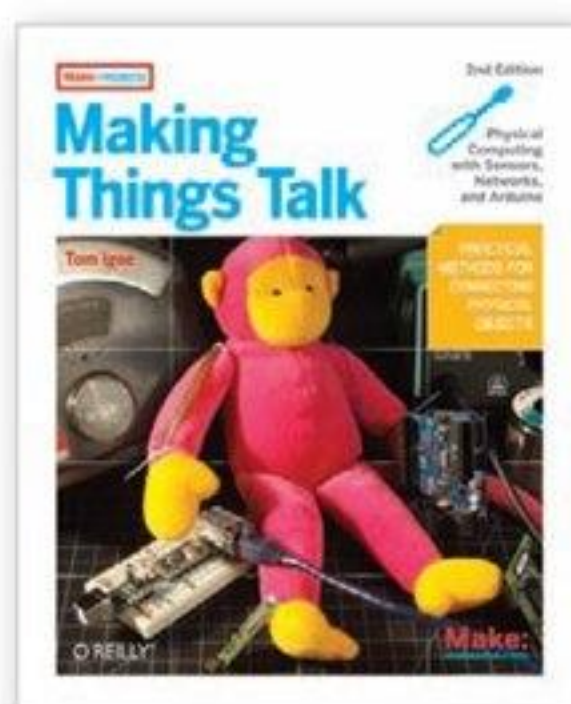
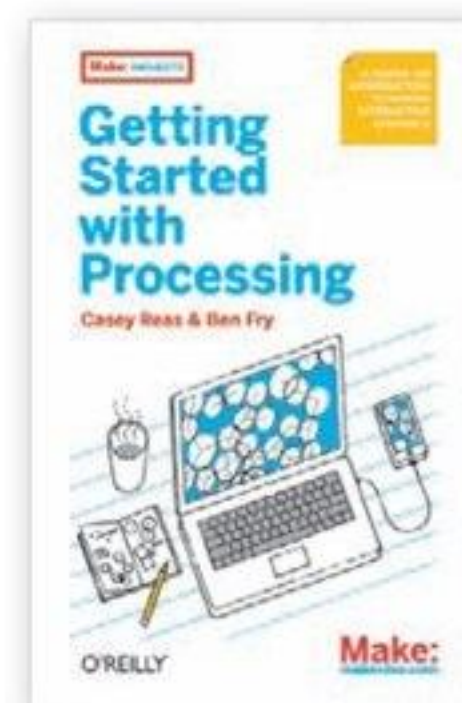
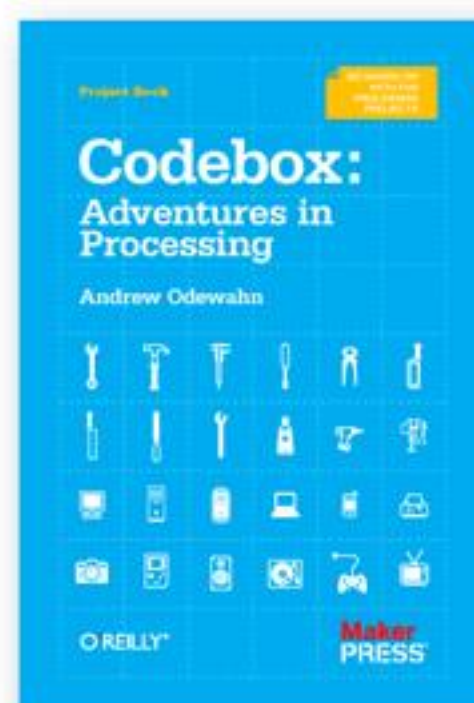
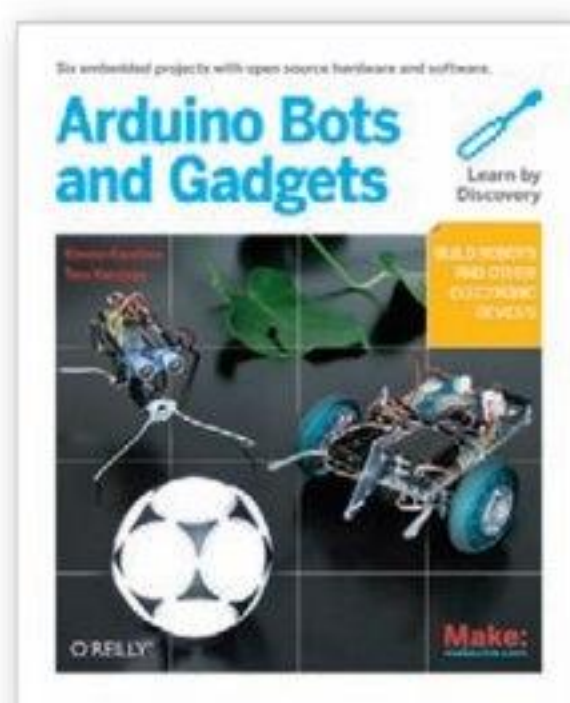
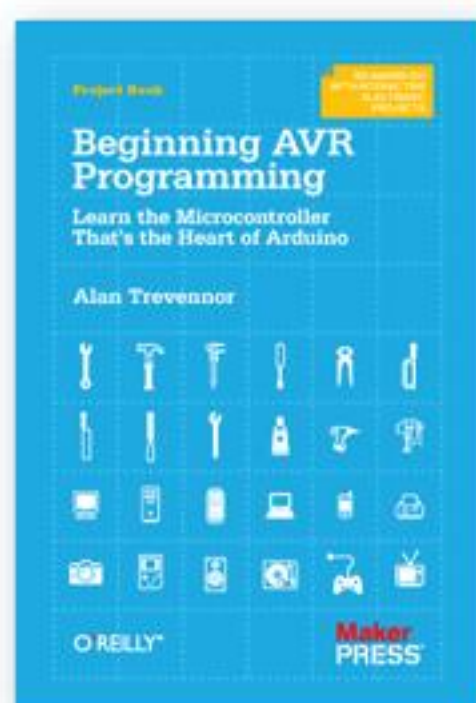
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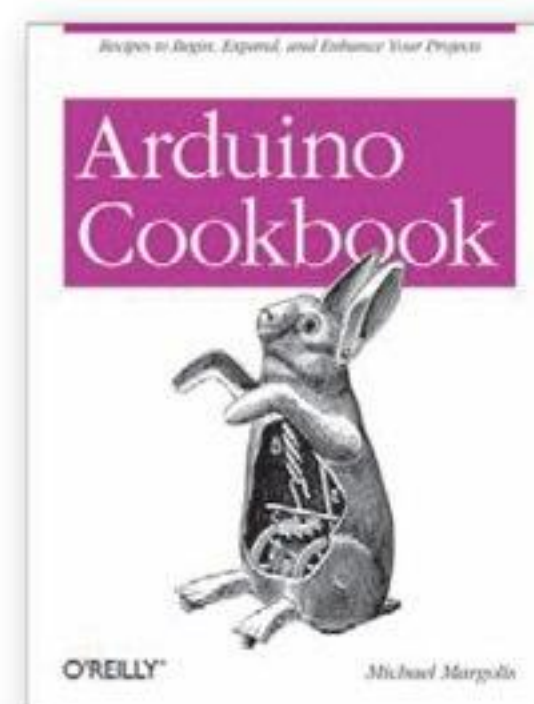


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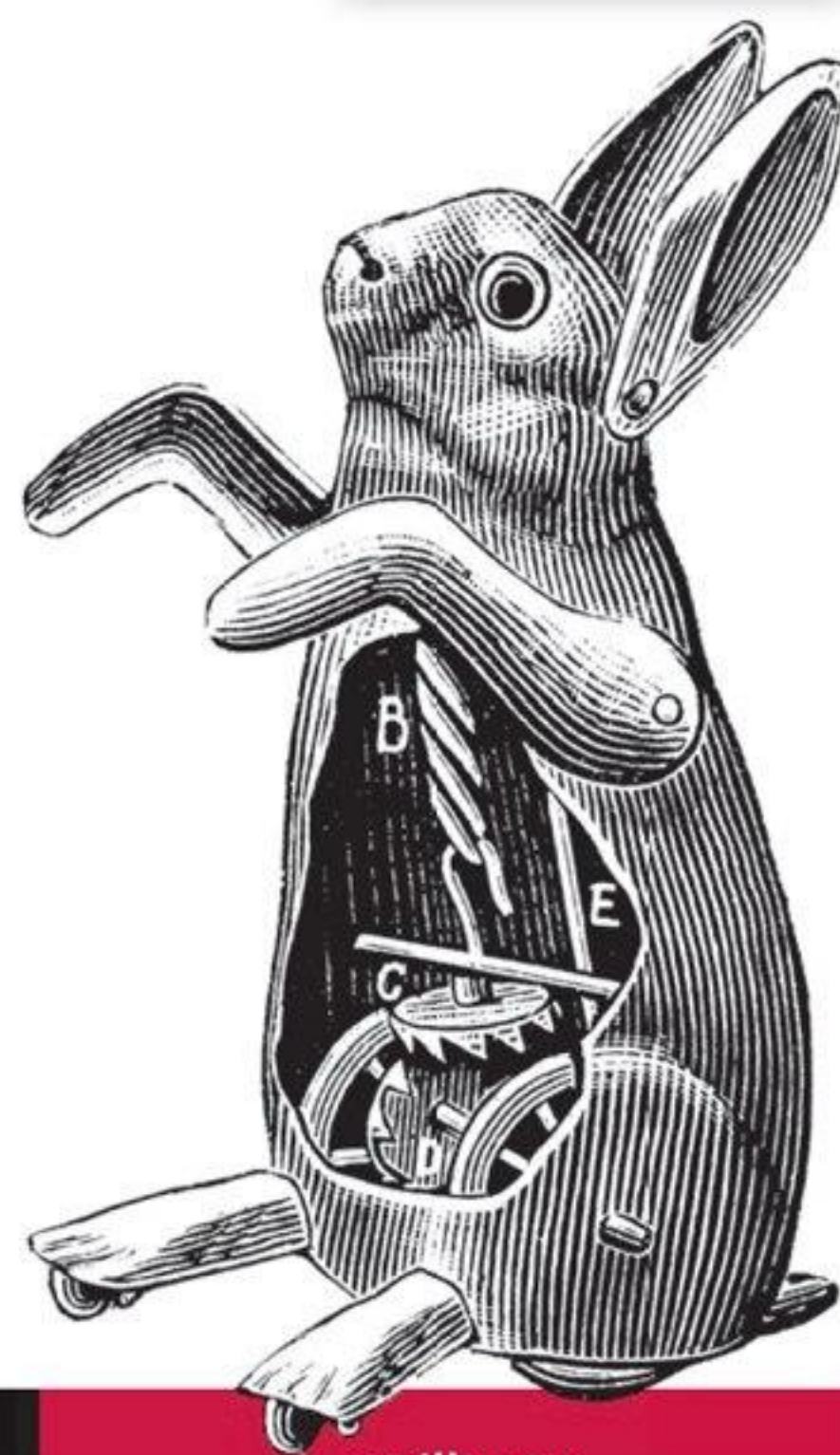
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This summer, have some real fun: learn how to create and operate cool gadgets you design and build yourself. Get into Arduino—the electronics prototyping platform anyone can use—and Processing, an easy-to-learn, easy-to-use programming language. When you combine the two, the possibilities are, well, endless. Just like a great summer.

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# CONTRIBUTORS

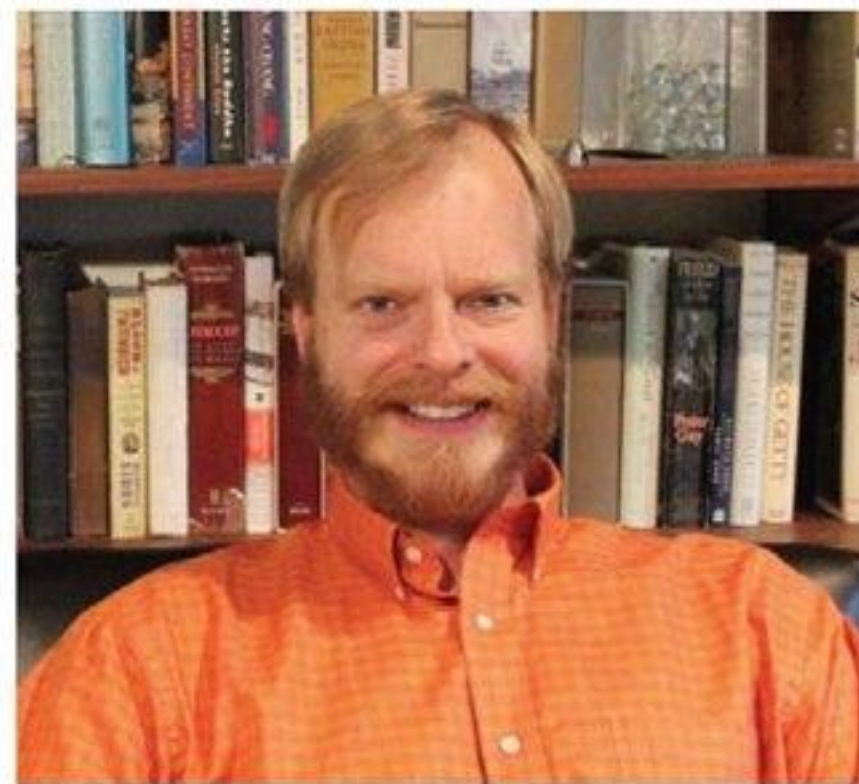
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**Alex Andon's** (*Jellyfish Tank*) fascination with marine animals was sparked on a sail through the British Virgin Islands while free-diving underwater tunnels in coral reefs. He went on to work for the Sea Turtle Protection Society of Greece, camping on beaches in Crete to protect nests and hatchlings. Alex accumulated extensive experience in building aquariums for his own research projects at Duke and the University of Delaware. He founded Jellyfish Art on a platform of cutting-edge jellyfish husbandry techniques that have been developed over the past decade. Alex has a B.S. from Duke in biology and environmental science.



**Marek Michalowski** (*Spazzi: A Solenoid-Powered Dancebot*) has been excited by robots and airplanes since childhood, and things haven't changed much. Together with Hideki Kozima, designer of the robot Keepon, Michalowski co-founded BeatBots LLC in 2007. He's enthusiastic about the growth of desktop fabrication and community hackerspaces, and about their implications for the future of toys, art, and design. In his spare time, he enjoys using his private pilot, scuba, and motorcycle licenses (though never at the same time). Michalowski was born in Poland, grew up in New York, and currently lives in San Francisco.



As a kid, **Peter Tabur** (*Limelight*) had just about every construction set there was, and loved taking broken things apart to figure out how they worked. His love of making, fixing, and building is unabated, so it should come as no surprise that he went to engineering school. He lives in Augusta, Mich., with his wife, Teri, and founding beagle, George. Peter likes to make pizza and furniture and loves his 1950s vintage Rockwell radial arm saw — “a massive cast-iron beauty” he fully restored. He's currently between jobs and is taking advantage of his ample free time to work on his long list of projects.



**Gregory Hayes** (MAKE photo intern) is a California photographer, writer, puppeteer, and handyman, among other things; it's his hope that this rare combination of skills will keep him high on the invite list for off-Earth colonization efforts. In the meantime, he enjoys canoeing, tinkering, cooking, and eating. He lives on the Russian River, throws sticks for his two wonderful dogs (“this never, ever gets old”), likes making tools on the fly (“particularly if I can reuse parts of other projects for new purposes”), and really, really loves artichokes.



**Kathryn Rathke** (MAKE author portraits) is “a practical Wisconsin girl” living in Seattle with her husband and her “gargoyle-faced dog,” Bunny. Her portraits have appeared on the covers of magazines, been projected onto screens, turned into embroidery, and scaled down to fit onto cupcakes. She “treasures wit and absurdity,” took up competitive badminton a year ago, and just had her first Friend Request from one of her subjects. She's learning Flash animation so she can teach her line portraits to blink. [kathrynrathke.com](http://kathrynrathke.com)



If **Colin Way** (*Teaching Old Toys New Tricks* photography) were to describe what he strives for in images, it might sound like this: illustrative and immediate, layered and detailed. Colin has been fortunate to work with a varied client list, including *Chatelaine*, Dell, WestJet, *Canadian Business Magazine*, and *Fashion*. One of the best things about his job is the interesting people he meets along the way (including meeting DJ Sures for this issue). To see more of his work, visit [colinway.com](http://colinway.com).

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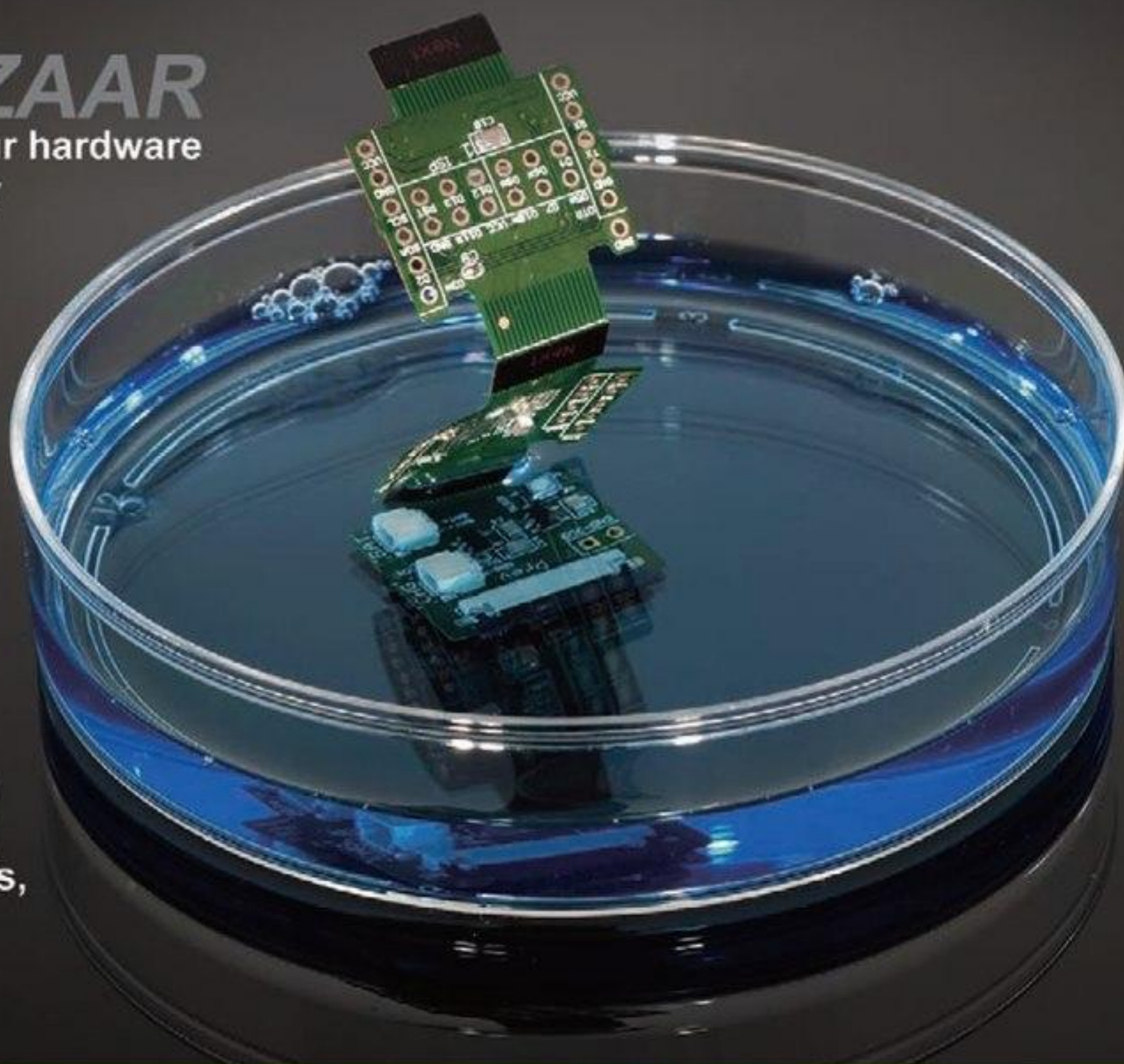
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**WELCOME**

By Dale Dougherty

## Building Robots That Play

### THIS MAY, MAKER FAIRE BAY AREA

brought together 100,000 people for a weekend to celebrate creativity, tinkering, and the DIY spirit. I'm proud to see our event grow so large in just six years. It's a huge indicator that the maker movement continues to broaden by inviting more people to see themselves as makers. Maker Faire is a tremendous outpouring of creative energy: it comes from diverse sources, including very personal motivations, and it goes in all directions.

A reporter at Maker Faire asked me to point out "useful inventions" and "practical applications." I had to think for a moment, but I replied that what dominates Maker Faire are things that are less practical and more playful. It's like seeing the world through the eyes of a kid, where ordinary stuff like cardboard has all kinds of possibilities for playtime. The power lies in your imagination.

We tend to look at invention and innovation as serious business, causing us to miss the bigger picture. In 1876, a committee evaluating Alexander Graham Bell's patent for the telephone dismissed the device as "impractical," "idiotic," "hardly more than a toy." (My favorite reason was that there was no shortage of messenger boys.) We have a hard time predicting how technology creates new opportunities for people to enjoy life.

Robots were conceived as laborers, designed to do the boring, repetitive tasks that humans didn't want to do. In a dystopian vision of the future, the machines rule because they do all the work and there's really no need for humans.


But can a machine be playful? Can it entertain us, even mimic us? Indeed, most of the technology in our lives we use for play, and that play personalizes the technology, whether it's cars or computers. I wonder how long it was before IBM recognized the popularity

of solitaire on PCs.

Nothing could be more mundane than a robot that cleans house, as iRobot's Roomba does. But ever since the debut of the robotic vacuum cleaner, hackers have treated it like a plaything. This issue's "Roomba Recon" project (page 49) starts with a Roomba as a mobile platform, then adds wireless networking and a video camera to create a spy robot with all kinds of potential for mischief. Useful? Maybe. Fun? Definitely.

Our "Spazzi" bot (page 56) is a rhythmic response to the question, "So you think your robot can dance?" Developed by Marek Michalowski of BeatBots, Spazzi amuses us. Yet the thinking behind this toy robot reflects a serious application. BeatBots also developed the Keepon robot, a yellow ball that can produce a range of simple expressions for nonverbal interactions with children. Keepon has been used in studies of autistic children to understand how they react to social cues.

"Teaching Old Toys New Tricks" by DJ Sures (page 66) shows you how to use the Bluetooth EZ-B Robot Controller to transform a dopey Digger the Dog pull-toy into an autonomous robot that can chase a red ball and obey your voice commands. Someone will no doubt program Digger to chase cars as well.

The playful robots we feature in MAKE say a lot about us humans and how we create things in our own image. We've domesticated dogs to do things like play fetch, come when they're called, and lie by our side while we sit in our favorite chair. Like dogs, robots are becoming our companions, demonstrating the ability to learn new routines that make us happy. 

---

Dale Dougherty is the founder and publisher of MAKE.



## READER INPUT

From Makers Like You

# Jacobean Joinery, Zinc Fumes, Space Pods, Stealth Networks

✉ Finally subscribed. (Me cheap, and the cover price put me off for a while.) This community, this attitude has given me a second technical life. I am a controls engineer looking for something after the current career ends.

Your attitude has been a cool spring breeze. It makes me love the basics of my science-fair youth and believe in open-handed sharing for the good of our common future.

I love the hell out of this MAKE thing. I'm on board.

—Dave Weidling, Arcata, Calif.

📷 The pattern for the "Fool's Stool" (Volume 26) repeats a common mistake: cutting notches in the aprons (the horizontal pieces). This creates a high likelihood of short-grain failure (splitting along the grain).

Instead, cut a slot only in the legs, and make it deep enough to accept the apron's full height.

Next, rather than gluing the joint, pin it. Assemble the 4 base pieces and hold them together with tape, clamps, or a helper. Now drill two 1/4" holes through each joint, one high and one low, going from the outside edge of the leg through the apron and at least 1/2" beyond. Pound in a 1/4" oak dowel and cut it off flush (the way the author affixes the seat).

The result will be a rock-solid frame you can expect to hold up a lifetime, if not 500 years! This is how all the surviving boarded stools from the 16th and 17th centuries that I've examined were made.

It's not only more authentic, it's faster, easier (4 slots to cut, not 8, and they needn't fit tightly because they won't be glued), and much stronger. See also: [albionworks.com/Stools/STOOLS.htm](http://albionworks.com/Stools/STOOLS.htm).

—Tim Bray, Albion, Calif.

✉ In "Weekend Warrior Gravity Racer" (Volume 26), author Jeremy Ashinghurst says to "sand off the galvanized surface layer" from EMT tubing before welding, "as it can weaken the joint." The reason it weakens the joint is because burning zinc gives off hazardous gases. The simple answer is: don't weld galvanized steel. There are sources for thin-walled steel tubing without using EMT conduit.

I use a TIG welder, and occasionally I can't avoid welding on galvanized steel. Even after thorough grinding, the weld is never as good as on plain steel. In addition, the torch nozzle and tungsten get contaminated and spoil your next weld on steel or stainless steel.

Otherwise it's a great story — my compliments to Jeremy on an excellent cart design.

—Gord Martin, Mississauga, Ontario

**EDITOR'S REPLY:** Good tip, Gord. MAKE's Technical Advisory Board agrees: welding galvanized metal creates fumes that aren't good for you or your weld. Further, EMT conduit is dip-galvanized, so the zinc coating is also inside, where it's impractical to grind off.

📷 I teach astronomy, physics, and engineering, and I was inspired by one of my students to think about making a device he could use to look at the stars and planets. I hope your readers find it an interesting challenge.

This student is good with a joystick, as he uses one on his wheelchair. I envision an egg-shaped pod (remember the movie 2001?). He could sit in a comfortable (heated?) chair inside the pod away from the cool night air and wind. We have a 40lb, 20x power, 120mm Nikon binocular telescope that could be installed at eye level. The pod would be mounted on a motor-driven gimbal or wheels, controlled by the joystick, to point the student, pod, and telescope at any astronomical object of interest.



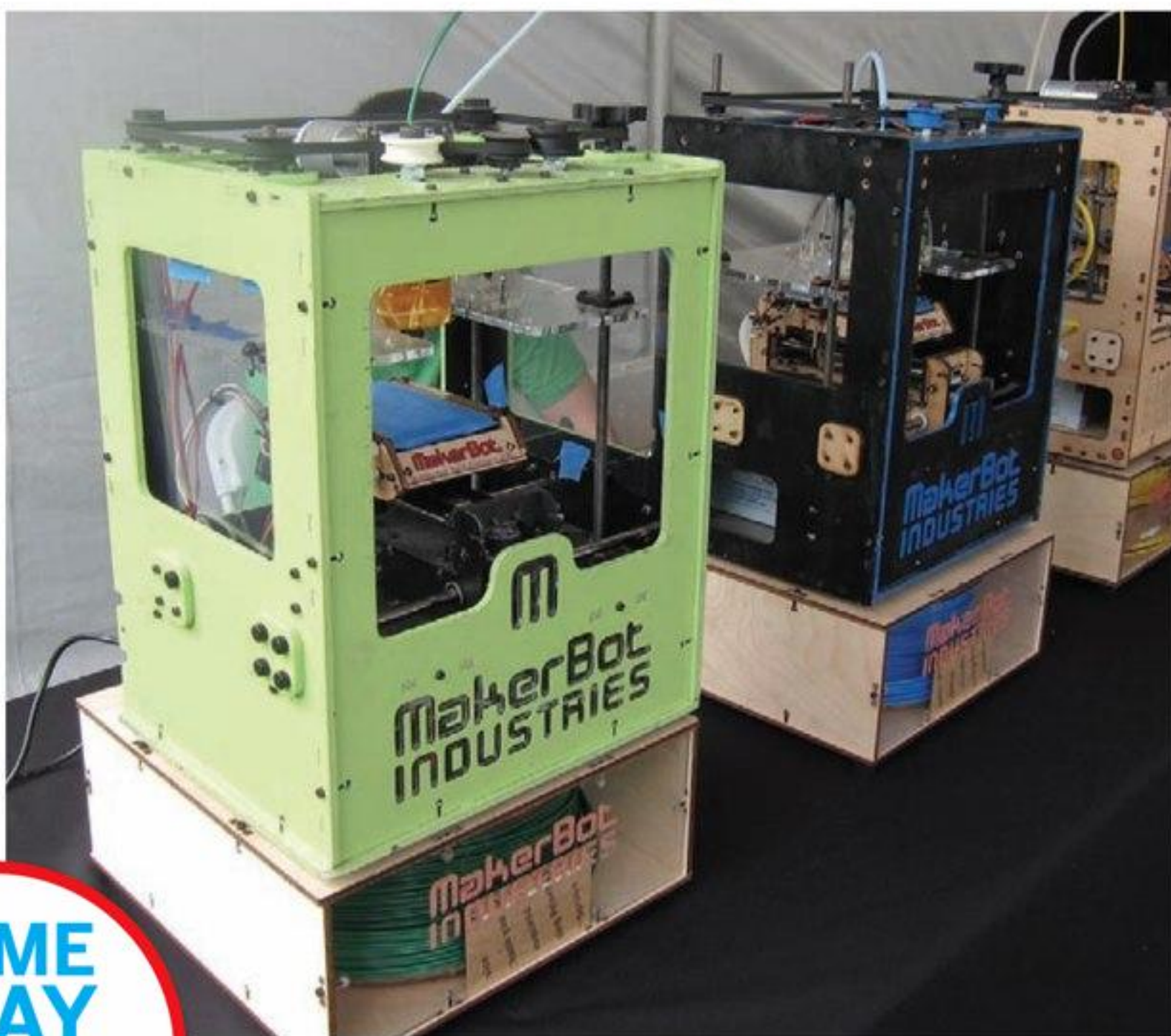
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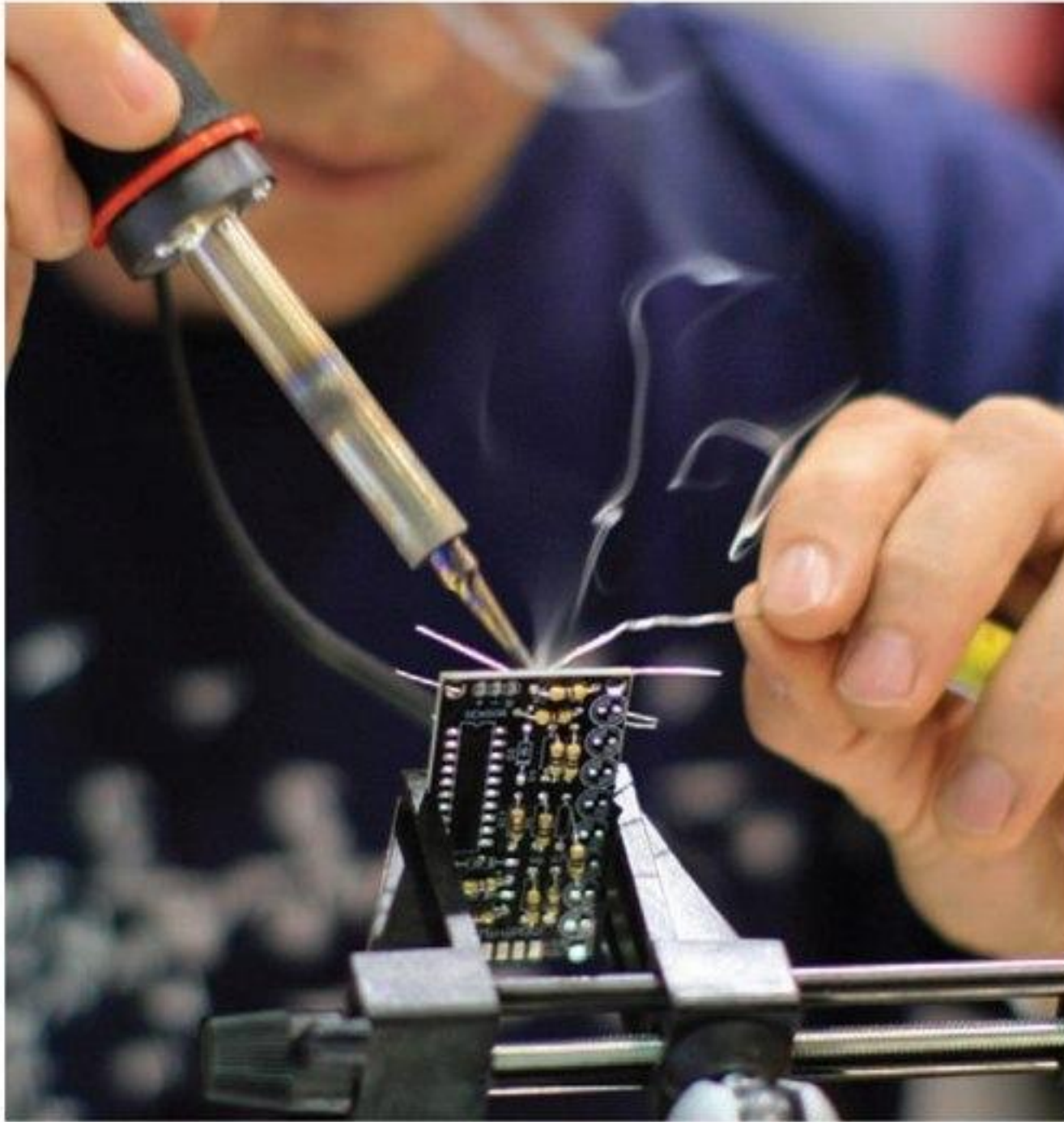


## IN THE MAKER SHED

By Dan Woods



# Getting Started: 3,100 New Electronics Makers



### OUR 6TH ANNUAL BAY AREA MAKER FAIRE

drew to a close just 72 hours ago, and I'm working through the post-Maker Faire blues — transitioning from the adrenaline rush of being surrounded by 100,000 passionate DIY enthusiasts one day to the relative serenity of the office the next. It's enormously satisfying, however, to reflect on the profound impact that Maker Faire has on attendees.

The heart of the Maker Shed's mission is to help people get started making. Through project-based kits like Getting Started with Arduino and Getting Started with Compressed Air Rockets, we help newcomers start making for the first time and help experienced makers learn new skills.

Nowhere is this more true than in the Maker Shed pop-up stores we operate during Maker Faire: 14,000 square feet and hundreds of kits and components combined with dozens of makers, authors, and volunteers helping people explore everything from Arduinos to cheese making.

And nowhere is our mission more visible



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than in the Maker Shed's "Learn to Solder" tent where, with the helpful coaching of Mitch Altman, Jimmie Rodgers, and a dozen local hackerspace volunteers, some 3,100 attendees mastered soldering for the first time. Participants left the Maker Shed with smiles on their faces, new skills, increased confidence, and a cool flashing LED merit badge to show for it. The perfect gateway project kit.

If you'd like your own Learn to Solder merit badge kit — or you're looking for a cool gateway project or for a group or after-school class — they're available for purchase in the Maker Shed ([makershed.com/pin11](http://makershed.com/pin11)). We'll also include one with every Maker Shed order of at least \$10 through August 31. It's on me. ✓

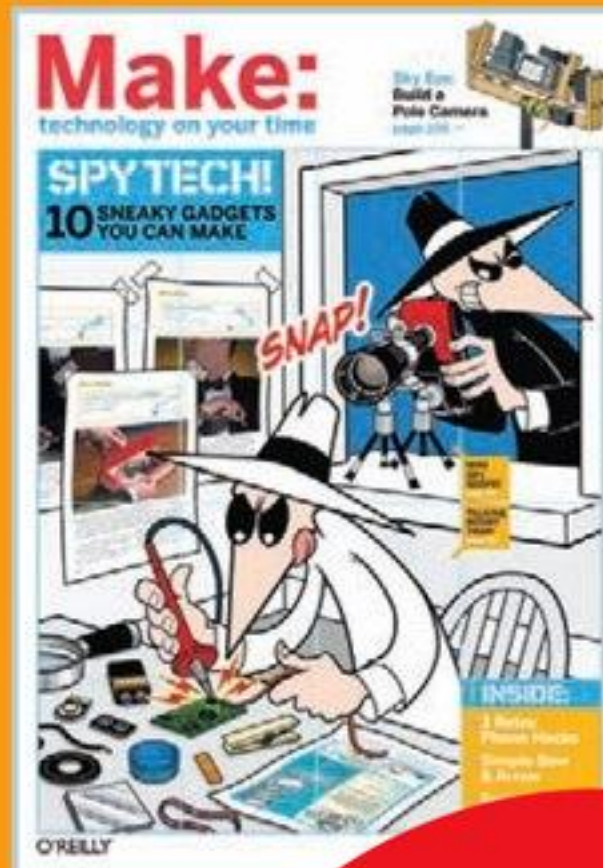
Dan Woods is MAKE's associate publisher and general manager of e-commerce.

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# Made On Earth

Reports from the world of backyard technology



## Face to Face

**Tom Banwell** is a self-taught man of many talents. He's a leatherworker, a caster/sculptor, and a tireless inventor of a vast selection of imaginative facemasks, many of which have been featured in films, television, and major magazines.

His most complex and extraordinary works are his "steampunk" gas masks, but he's also known for his delicate, laser-cut leather party masks and other uniquely shaped costume masks. Just to keep things interesting, he also makes rayguns.

His fantastic blog is a must-read for any costume designer or lover of steampunk. It's filled with well-written, step-by-step explanations and interesting tips and tricks. (Be sure to search for "A Steamier Raygun Holster," "Elevated Shoes," and "Modifying a Straw Hat.")

When asked why he gravitated to gas masks, Banwell says, "A gas mask, though functional,

dramatically alters the appearance of the wearer. This can be perceived by the viewer as terrifying — as one resembles a monster — or humorous — as one becomes a silly clown."

Banwell manages to combine these two feelings to create unforgettable masks that embody both fear and curiosity. The formal, antiqued leatherwork feels classic and foreboding, but he says the form of the masks — which can resemble a rhinoceros or an elephant — is "pure fantasy."

Banwell is constantly looking at the world around him and re-creating it in the most mad and pleasing manner possible. Looking through his fan photos, it's clear that when seemingly ordinary people don his masks, they unleash the more fantastic selves that lay dormant.

—Stacey Ransom

» Steamy Leather: [tombanwell.blogspot.com](http://tombanwell.blogspot.com)

Tom Banwell





## Analog Wranglers

**Brian Dewan** may be a jack-of-all-trades, but he's clearly a master of many. An inventor and builder, this Catskill, N.Y., resident is also a performance artist, cartoonist, and multi-talented musician.

Dewan plays and sings along with semi-traditional instruments like autoharps, zithers, and accordions, making them seem appropriate for everything from heavy metal to folk songs. He also performs with the cheerfully lunatic Raymond Scott Orchestrette. (Raymond Scott composed the music for numerous Warner Brothers cartoons.)

In collaboration with cousin **Leon Dewan**, Brian has created a series of instruments called Dewanatrons that vary in complexity from simple, elegant, wall-mounted interactive sound sculptures such as their *Melody Gins* and *Courtesy Modules* to the extraordinary *Dual Primate Console Mark II*, shown here.

It's impossible to precisely control, so the "primates-in-charge" must guide the machine to produce melodies, percussion, and innumerable unpredictable sound effects. Brian explains, "It is the responsibility of each primate to encourage or restrain the instrument."

Some simpler pieces are best experienced in unison: a dozen *Wall Gins*, for instance, were displayed in Brooklyn's Pierogi Gallery, configured to play simultaneously, creating an eerie and enthralling ambient soundscape.

All the musical instruments are "analog, solid-state" works covered in knobs and dials, full of oscillators and other physical sound manipulation controllers, with beautifully finished cases that bespeak Brian's fine-furniture-building background. They are artifacts and heirlooms of a Dewan-ized version of the past.

—Rose White

» Dewan's Instruments: [dewanatron.com](http://dewanatron.com)



## Turn Signals and Turntables

Combine two unrelated things inside the brain of Dutch artist **Olaf Mooij** — the electronica song “God is a DJ” by Faithless, and the Popemobile — and the result is the DJ Mobile.

With 14 woofers, tweeters, and other loudspeakers boldly splaying in various directions out the back of a dark blue 1983 Ford Sierra, the DJ Mobile has a surreal, cartoonish look.

Not only does the car have a professional-quality Beyma sound system, but it’s also got a DJ setup, with a place to set up turntables and a mixer on the roof of the car. There’s a hole in the roof as well, where the DJ can stand and mix.

The idea came to Mooij, 53, when he heard the song and then thought of the infamous vehicle that the Pope makes public appearances in — a normal-looking car in front with a bulletproof glass, pope-sized display case in the back.

Mooij bought the used car from a local gas

station. “I always liked the Ford Sierra,” he says. He worked up the quirky design using buckets, cardboard, and duct tape. Later, he swapped the prototype materials out for wood and polyester.

As you might imagine, the DJ Mobile commands a good deal of attention when it gets driven around. Though it’s street legal, Mooij notes that driving around can be dangerous because of how distracting it is to other drivers. The people most noticeably affected when in the presence of the DJ Mobile are “the guys with big car hi-fi sound systems,” says Mooij, who get “pale with jealousy.”

Next up: Mooij is currently building a temple out of three old Volkswagen Beetles.

—Laura Cochrane

» DJ Mobile: [olafmooij.com](http://olafmooij.com)



## Hutt's Cantina

When **Jason Hutt** was just 2 years old, his mother took him to see *Star Wars* at the movie theater. He sat in rapt silence throughout the entire film, and a lifelong obsession was born.

"There's really never been a time in my life when I didn't love *Star Wars*," he says. "My mom loved space and science fiction; she cultivated that interest in me throughout my childhood, and *Star Wars* was really the center of it."

As Hutt's collection of *Star Wars* action figures (1,600 and counting) and memorabilia grew, he realized he needed a fun way to display it. His penchant for DIY projects led him to creating a massive and intricate diorama of the Mos Eisley cantina scene.

"The cantina scene has to be one of the most iconic in all of science fiction," he says. "It's where the adventure truly begins as the heroes meet for the first time and begin their epic journey."

By day, Hutt works in NASA's International

Space Station Mission Control at Johnson Space Center, and is father to three young girls. It was by night, after his daughters went to bed, that his project took shape. Working for about an hour each evening, it took nearly four months to complete.

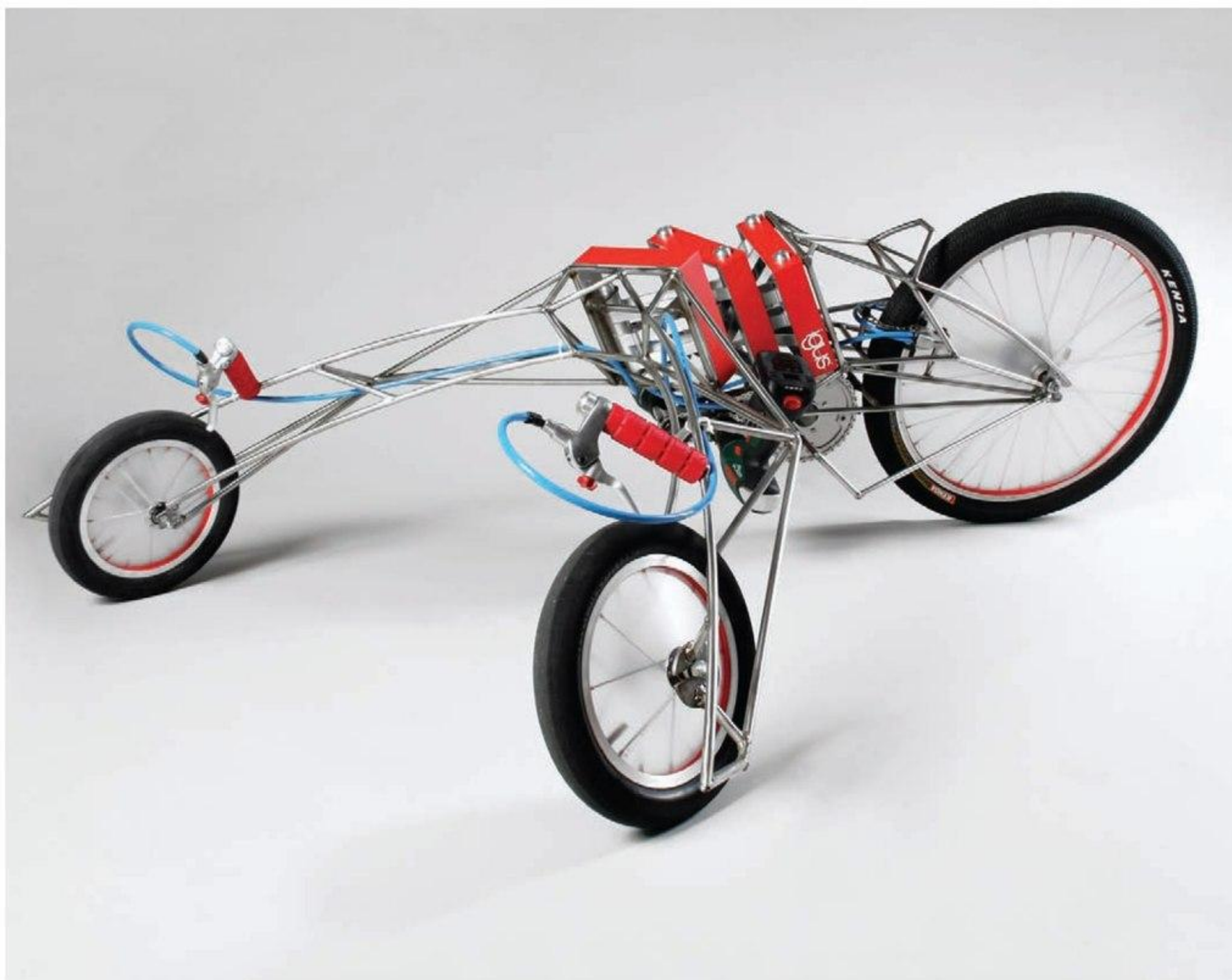
He started with sketches and lots of research and chose MDF to create the base and walls of the structure. From there, he had to get creative to find ways to replicate some of the details of the iconic scene. The bar posed the greatest design challenge.

"The bar was a mini-project in itself, as I used a combination of wood spheres, doll-house pipes and accessories, some empty jars, and a half dozen other things," Hutt recalls.

Now that his cantina diorama is complete, Hutt is beginning work on Jabba the Hutt's Throne Room and also has plans to create an Endor bunker-fight diorama.

—Rachel Hobson

Rachel Hobson



## Drill-Powered Future Trike

In MAKE Volume 26, we featured a drill-powered go-kart you can build at home. As cool as that vehicle is, it looks positively retro compared to the EX, a futuristic drill-powered vehicle designed by promising young German designer **Nils Ferber**.

Ferber's work explores outside-the-box thinking and the potential of design to "alter reality," he writes. The EX (a play on *eccentric*, as in "deviation from what is ordinary or customary") sure meets these criteria, with its sleek, *Tron*-worthy shape and its complete rethinking of a steering mechanism.

Working with fellow designer/builders **Sebastian Auray**, **Ruben Faber**, and **Ludolf von Oldershausen**, Ferber and team started out by prototyping designs in Lego blocks, wood scraps, and finally steel. The final trike is fashioned in stainless with many CNC and specially fabricated parts.

Through their design process, they developed

a unique way of driving and steering the vehicle. The driver lies down on the EX, forward-facing. This creates "an exciting driving experience" and allows the driver to operate the strange "spine-shaped joint" steering.

To steer the EX, the driver has to employ body weight to flex the six axles of the basically groin-mounted spine-joint, a sort of short spinal column that's used to flex and bend the vehicle in the desired direction of travel.

Propelled by two Bosch 18-volt cordless drill/drivers, the EX achieves speeds of 30 kilometers per hour (almost 19mph). And given the position of the driver and proximity to the ground, we can only image the thrill ride offered by this ingenious crotch-rocket. Let's just hope that EX doesn't take on any unintended additional meanings.

—Gareth Branwyn

» EX Riders: [nilsferber.de/ex.html](http://nilsferber.de/ex.html)



## Pedal Power

As gas prices soar, **Ian Fardoe** of Staffordshire, England, is faring better than most — at least better than those of us who drive cars. The 40-year-old is car-free and always has been.

"I've been cycling all my life. I did learn to drive a car but realized that I hated it a long time before I took my driving test, so didn't even bother," he explains. And with the price of petrol above 130 pence a liter (about \$8 a gallon) this year, he's much better off.

Fardoe commutes 4,000 miles a year by bike, so building a wacky, plastic-wrapped tricycle is no surprise. Called a *velomobile*, the trike's outer shell is made from repurposed corrugated plastic that was harvested from a recumbent bike's fairing, and fashioned after vehicles found in Australia's Pedal Prix.

The first build took about six weeks, but Fardoe spent 18 more months tweaking the design to make it more practical and efficient. The initial frame weighed in at only 11lbs and

didn't stand up to his 6-mile commute to work.

"I bought some hot glue and zip ties, etc., to make it look remotely pretty. The making it pretty bit didn't work very well," he jokes.

Overall, the vehicle cost about £2,600 (\$4,000) to build — far less than commercial velomobiles, which can cost twice that price.

Fardoe admits his way of building is very learn-by-doing, which is how his vehicle earned the name *OTP (On the Piss)*.

But hot glue and zip ties aside, it's a pretty serious ride. He's done 125 miles in a single trip and reached a top speed of 73mph going downhill, 53mph on flat ground.

In the process, Fardoe has become a pretty serious velo pilot; at press time he was planning to race a commercial velo in the Cycle Vision races in the Netherlands in June.

—Jerry James Stone

» Fardoe's Velos: [picasaweb.google.com/ian.fardoe](https://picasaweb.google.com/ian.fardoe)

Ian Fardoe



# Pendulum Perfector

If you've visited enough science museums, you've seen a Foucault pendulum. Named after its inventor, French physicist Léon Foucault, the pendulum demonstrates the Earth's rotation by knocking down pins arrayed around the pit over which it swings. Although the pendulum appears to swing around the pit, it's the pit, and Earth it stands on, that rotate beneath the pendulum. And there's a good chance the pendulum you know is one of more than 100 made so far by **Cary Ponchione**.

For 34 years, Ponchione worked in the basement shop of the California Academy of Sciences museum in San Francisco. Shortly before moving from its home of 87 years in Golden Gate Park, the Academy downsized its in-house exhibit-building shop and offered early retirement to Ponchione.

But calls for the pendulums that the Academy could no longer make kept coming

in. "They asked me to take [them]," Ponchione says of the pendulum orders, and a small business, Academy Pendulum Sales, was born.

A friendly, outgoing machinist and fabricator, Ponchione keeps a spare, tidy shop by the tracks in Richmond, Calif., where he assembles pendulum kits for customers to install. "As you can imagine," the semi-retired maker deadpans, "it's not a full-time job."

Though he has others join, turn, finish, and polish the cast brass hemispheres that make the 235-pound, 16-inch bob, Ponchione makes and assembles most of the small parts, and still hand-winds the ring electromagnet, which adds the perfectly timed kick that keeps each pendulum swinging.

—William Abernathy

» Foucault Pendulums: [calacademy.org/products/pendulum](https://calacademy.org/products/pendulum)

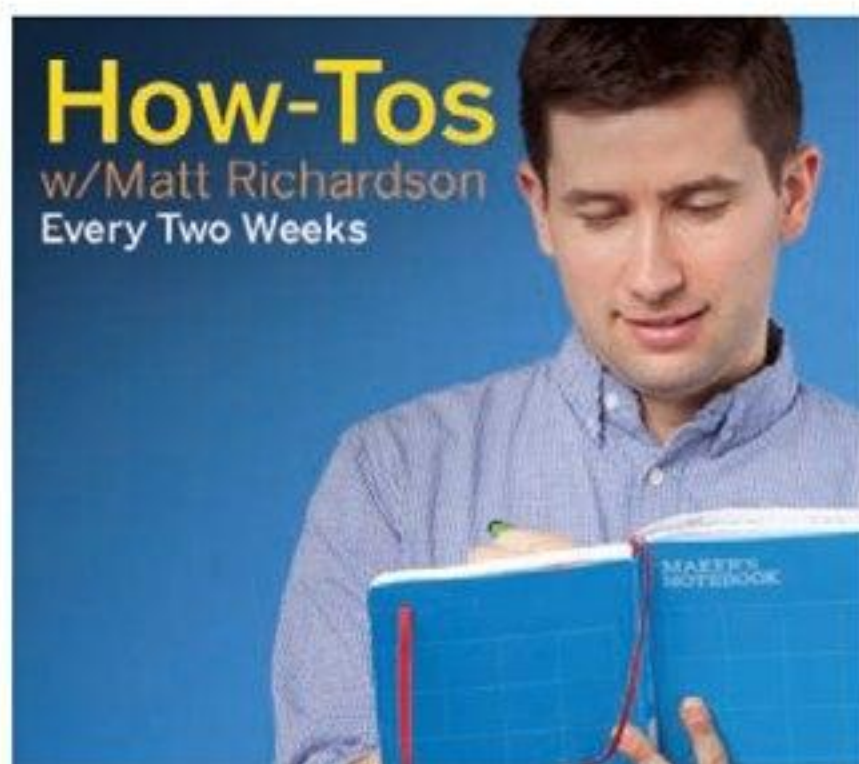


## TALES FROM THE WEB

By Gareth Branwyn

# Building a MAKE Video Network

**WE'VE GREATLY EXPANDED MAKE'S VIDEO** offerings with a regular roster of excellent project and tutorial series, all conveniently accessed from [blog.makezine.com/video](http://blog.makezine.com/video) and [youtube.com/makemagazine](http://youtube.com/makemagazine) and iTunes. We've come a long way since our original Weekend Projects series! Tune in to see what we've got going on.



⚙ **How-Tos with Matt Richardson** In this biweekly series, Matt shows how to make a cool project, from a physical mailbox that tweets your mail's arrival to fun photography hacks to an Arduino-powered music box. [blog.makezine.com/tag/howtoswithmatt](http://blog.makezine.com/tag/howtoswithmatt)

⚙ **Becky's Workshop** Every month, our CRAFT/MAKE crossover star, Becky Stern, presents an innovative project to add some high-tech high-touch to your life, from pocket reflectors for cycling to T-shirt hacks to working with electroluminescent wire. [blog.craftzine.com/archive/video\\_beckys\\_workshop](http://blog.craftzine.com/archive/video_beckys_workshop)

⚙ **Collin's Lab** Every two weeks, Collin Cunningham presents a new project or explains an electronics concept in entertaining and easy-to-understand language. [blog.makezine.com/tag/collinslab](http://blog.makezine.com/tag/collinslab)

⚙ **The Latest in Hobby Robotics** Tune in weekly as Frits Lyneborg and friends from the Let's Make Robots community discuss the week in DIY robots. [blog.makezine.com/tag/latestinrobots](http://blog.makezine.com/tag/latestinrobots)

⚙ **Make: Live** Our increasingly popular streaming show and tell, hosted by Becky Stern and Matt Richardson, airs every second and fourth Wednesday of the month. Watch as they bring MAKE magazine to life, with in-studio and on-cam makers showing off their projects. [makezine.com/live](http://makezine.com/live)

⚙ **Tiny Yellow House** This show from prolific backyard builder Derek "Deek" Diedricksen has been described as "*This Old House* meets *Wayne's World*." Each month Deek builds forts, cabins, and "microhomes," and teaches woodworking, construction, reuse, and recycling in the process. [blog.makezine.com/tag/tinyyellowhouse](http://blog.makezine.com/tag/tinyyellowhouse)

And that's not all. We've also got a weekly **Meet the Makers** series, **Super Awesome Sylvia's Mini Maker Show**, **Home Décor with Meg Allan Cole**, **Corinne's Craft Closet**, **The Latest in Arduino**, and more. Check the MAKE video page ([blog.makezine.com/video](http://blog.makezine.com/video)) and watch them all. 📺

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Gareth Branwyn is editor-in-chief of [makezine.com](http://makezine.com).



## MAKING TROUBLE

By Saul Griffith, Omnivorous Inventor

# Pneubotics: Walking Bouncy Castles

**SOMETIMES I FEEL LIKE A FALSE NERD,** or a geek with two important genes missing: I'm not particularly interested in space exploration, except as fiction, and I've never cared for robots. So I find it strange that I'm now working on a Defense Advanced Research Project Agency (DARPA) robotics program.

I think what I never liked about robots is that they're complex machines that really don't do much. They're fragile and very expensive. I like simple, robust things; things that don't cost more than they should.

What I've found myself working on (with Jack Bachrach, Geoffrey Irving, Pete Lynn, and the good guys from Meka Robotics) is completely soft, completely compliant, very lightweight, and very cheap. No joints. No servos. Just skins — inflated skins.

For a long while I've been fascinated by inflatable objects for their extreme strength-to-weight ratios (they can carry a lot of load for very little mass). I also love the challenge of designing something "human safe," in the robotics lexicon. Biology doesn't use metal, and it doesn't use servos. Nature points to some very interesting alternatives.

To make it work, we had to invent a new kind of actuator. Think of it as a vascular system for robots. It's fluidic — works equally well with air or water — and by pumping either of those around, you can change the dimensions of the skin and effect motion. Our first actuator was quite literally a bicycle inner tube in a sewn pair of membranes. It worked really well for a \$5 prototype!

For the next trial, I asked my sister to return an inflatable 4-foot-high elephant I'd designed and given to my niece. When it arrived, Pete burned the midnight oil and sewed up some vascular "muscles," and in a day or two we had four moving legs. It actually walked. About one

mile every 24 hours, but hey — baby's first steps! It moves like no machine you've ever seen; more like the way biology moves. A walking inflatable elephant might sound ridiculous, but it works, and the numbers on paper told us it should have incredible strength, good speed, extremely low weight, and cost very, very little to manufacture.

**Biology doesn't use metal,  
and it doesn't use servos.  
Nature points to some very  
interesting alternatives.**

The next prototype was designed to walk with a human rider on it and to look less like an elephant. We built it in under a week for less than \$1,000 in parts. A 15-foot-long, 5-foot-high robot with 28 muscle actuators (four in each of six legs, another four in the trunk). It worked too (after a few exploded actuators).

I like the idea of a robot you can sew together. I like that it has no heavy, sharp, or costly parts. Most of all, I like the intellectual challenges of it. There aren't any CAD packages for designing highly elastic kinetic membrane structures. We had to write our own. There aren't any analysis simulations. We had to write our own. There aren't any walking bouncy castles out there. We built our own! We call our weird new style of robotics "pneubotics," as in *pneu* for air (like pneumatic).

Who knows if the robotics community will like it or even care. Either way, that's not why I built it. I built it because perhaps my niece will forgive me if she gets a walking elephant next Christmas that she can ride to school. 🦋

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Saul Griffith is chief troublemaker at [otherlab.com](http://otherlab.com).



## COUNTRY SCIENTIST

By Forrest M. Mims, Amateur Scientist

# Startups: Origins of the PC Revolution

**TODAY'S SMARTPHONES AND TABLETS,** laptop and desktop computers all trace their ancestry to the arrival of the hobby computer era of the 1970s.

After Intel introduced its 8008 microprocessor in 1972, several individuals and teams began using the new chip to build DIY computers. But these computers made little progress due to the 8008's limited capabilities.

The computer revolution was jump-started in 1975 when MITS, Inc., a small electronics company that I co-founded in Albuquerque, N.M., announced the Altair 8800, a kit computer designed around Intel's new and powerful 8080 microprocessor.

Many books have been written about what happened next, and *Idea Man* (Portfolio/Penguin), a new memoir by Microsoft co-founder Paul Allen, shines a spotlight on many details that were previously known only to insiders. Whatever your favorite kind of computing device or operating system, *Idea Man* is a book well worth reading, especially if you have entrepreneurial aspirations.

The story begins at Out of Town News in Cambridge's Harvard Square on a snowy December afternoon in 1974. Allen visited the newsstand each month to check out the latest issues of *Radio-Electronics*, *Popular Science*, and similar magazines.

When he saw the January 1975 issue of *Popular Electronics*, it stopped him in his tracks. Emblazoned on the cover was a photograph of the Altair 8800 microcomputer. The blurb over the photo read:

PROJECT BREAKTHROUGH!  
World's First Minicomputer Kit  
to Rival Commercial Models ...  
"ALTAIR 8800" SAVE OVER \$1,000

Allen opened the magazine and found complete construction plans for the Altair 8800, which was available as a kit (\$439) or fully assembled (\$621). He noticed that the core of the Altair was Intel's powerful new 8080 microprocessor, the successor to the 8008. He paid 75 cents for the magazine and hurriedly strode almost a mile to Harvard's Currier House, where sophomore Bill Gates resided.

Gates shared Allen's enthusiasm for the Altair. Both had become expert assembly language programmers in high school, and they decided to contact Altair developer Ed Roberts, who headed MITS, Inc. Their plan was simple: offer Roberts a version of the BASIC language that would run on the Altair.

After eight grueling weeks of programming, Allen flew to Albuquerque with a paper tape, punched with their new BASIC. The code ran fine when simulated on a PDP-10 minicomputer at Harvard, but would it work with an Altair? While Roberts watched, Allen carefully entered into the Altair's front panel toggle switches the code he'd written on the airplane to enable the Altair to load the BASIC from the Teletype terminal connected to the computer. The paper tape reader then loaded the BASIC into the Altair's memory. When Allen typed **PRINT 2+2**, the Teletype immediately printed 4.

Roberts was amazed. So was Allen, though he didn't let on. Soon Roberts hired Allen, and later that year Gates joined him in Albuquerque. There, Allen and Gates formed a partnership that they initially called Micro-Soft.

### Idea Man

Allen tells what happened next in *Idea Man*, a detailed and appropriately technical account of the origin and early history of Microsoft. It's much more than a book about microcomputer history and Allen's life as a billionaire,



for it's packed between the lines with tips for aspiring entrepreneurs, designers, programmers, and makers with revolutionary ideas.

*Idea Man* has attracted considerable attention in the media world because of its candid revelations about friction between Allen and Gates and what Allen describes as Gates' efforts to reduce Allen's stake in Microsoft.

The shouting matches he describes closely parallel what Roberts and others told me over the years. Some believe that dredging up these old stories is sour grapes, especially since Allen played much less of a role at Microsoft after his 1982 bout with cancer and his growing disillusionment with Gates' confrontational leadership style.

Having just spent four years writing an exhaustive history of the world's leading atmospheric monitoring station, Hawaii's Mauna Loa Observatory, I disagree. Debates, arguments, and leadership flaws, whether in the low-pressure environment of a remote station at 11,200 feet or in the high-pressure environment of a startup company, are the sparks that illuminate the organization's

history. Allen would have short-changed his readers had he failed to describe the disputes.

Allen even describes an expletive-laden temper salvo directed by Steve Jobs against a hapless Apple employee while he and Gates watched with surprise. Leadership antics like these will provide business analysts, academics and, yes, psychologists much to ponder when they study the astonishing success of Microsoft and Apple.

Whether these disclosures have burnt the bridge in the four-decade relationship between Allen and Gates remains to be seen. In January 2011, four months before the release of *Idea Man*, Allen was in Albuquerque to dedicate Startup, a personal computer museum gallery, to the memory of Ed Roberts, who died in April 2010. When I asked Allen about his book, he said he was concerned how Gates would react.

Gates seems to have mellowed over the years. After he joined Allen in Albuquerque in the mid-70s, the teenage-looking Gates sometimes had major battles with the burly Roberts, a former Air Force officer who expected respect. Last year when Gates

learned that Roberts was near death, he flew across the country to spend several hours with him days before Roberts died.

Allen writes in *Idea Man* that Gates regularly visited him in 2009 when he was hospitalized with his second battle with cancer: “He was everything you’d want from a friend, caring and concerned.” Based on their past history, it seems likely the two billionaires will eventually make their peace, perhaps while agreeing to disagree on some points. After all, many Microsoft customers who have a love-hate relationship with the company’s software (including me) keep going back for more.

## After Microsoft

Microsoft made its founders two of the world’s richest men, and *Idea Man* follows Allen’s account of the MITS-Microsoft years with highlights about his life, business, and philanthropy. He enthusiastically discusses his billionaire lifestyle, including his sports teams, his love affair with the guitar, and his far-flung travel adventures aboard his mega-yachts.

Much more important to us makers than the celebrity name dropping and travel stories are the details of Allen’s business successes and failures, his founding of the Allen Institute for Brain Science, and his carefully restored World War II-era aircraft collection.

Then there’s Allen’s partnership with Burt Rutan that culminated in *SpaceShipOne*, the first privately developed and launched reusable, manned spacecraft. The historic *SpaceShipOne*, which earned the \$10 million Ansari X Prize, is now suspended between Lindbergh’s *Spirit of St. Louis* and Chuck Yeager’s Bell X-1 at the Smithsonian Air and Space Museum in Washington, DC.

## Lessons for Makers

*Idea Man* provides important tips and lessons for today’s generation of makers, some of whom might even now be developing what might become the next billion-dollar technology or product. Here are some lessons I’ve gleaned from its pages and between the lines.

» Does your idea pass the balloon test? Good

ideas and futuristic visions don’t guarantee successful products and ventures. As Allen wrote about his pre-Altair days with Gates, “Each time I brought an idea to Bill, he would pop my balloon.”

» Texas-style handshake agreements with partners, supporters, and customers are great. I sold millions of books to RadioShack over handshakes and purchase orders. But Allen’s experience suggests it’s best to follow handshakes with carefully drafted agreements that all concerned are willing to sign.

» Use care and prudence when working and dealing with partners and financial backers.

» Get to know your partners and their idiosyncrasies before signing on with them.

» Carefully read any agreement or contract before you sign it!

» Partnerships are a two-way arrangement. So get to know yourself. Are you living up to your agreements? Is your management style reasonable or do you create chaos?

» A partnership agreement should provide contingencies for all eventualities. For example, the partners should agree to pursue arbitration in the event of a serious disagreement. The agreement should cover what happens should a partner be incapacitated or die.

» Never, never, never release imperfect products! Delaying a promised new product is always better than releasing a defective one.

» Treat your customers with the respect they deserve.

» As Roberts learned so well, if your first products don’t succeed, try again. 🚀

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Forrest M. Mims III ([forrestmims.org](http://forrestmims.org)), an amateur scientist and Rolex Award winner, was named by *Discover* magazine as one of the “50 Best Brains in Science.” He was a co-founder of MITS, Inc. and wrote the first Altair 8800 user’s guide.



## MAKE FREE

By Cory Doctorow, Digital Rights Defender

# Four Horsemen of the 3D Printing Apocalypse

### CHARLES STROSS' EXCELLENT NEW

novel, *Rule 34* (Ace Books), is a futuristic police procedural set in a near-future Edinburgh, in which 3D printing has become boringly ubiquitous.

You can buy safe, prepackaged 3D printers at the local housewares shop, and they're handy for whipping up generic replacement parts for broken appliances (at one point a character drops and cracks his wife's cherished German onion slicer and realizes he'll have to google for a 3D file to match the broken piece) or paid-for 3D files licensed from big media companies.

These printers are controlled by DRM that checks jobs against a blacklist of forbidden shapes and prevents them from being output if they match (presumably there's some loose matching algorithm in use that can get past ruses like simple changes to the shape).

Of course, this doesn't work. The bad guys handily outmaneuver the prohibitionists, and a black market springs up, producing such wicked marvels as solid-state meth labs, brass knuckles made from super-hard polymers, and X-ray-invisible, nonferrous stick-up knives.

I think Stross' speculation on the future of 3D printing gets the shape right, even if the details might not match exactly. Since the early days of computer regulation, hysterics have made recourse to the "Four Horsemen of the Infocalypse": child pornographers, organized crime, terrorists, and pirates. Invoking one or more of these terrible fellows is often sufficient to stifle further debate and end critical thought ("Won't someone think of the children?!").

It's not that bad guys don't use our beloved machines to do bad things. But a prohibition against running certain programs is a non-starter. In practice, a computer's owner can,

with sufficient technical knowledge (or access to a large, searchable database of general knowledge, such as the internet), trivially unlock her device so that it can execute any valid program.

But when all you have is a hammer, everything starts to look like a nail. In Stross' world, as in our own, the regulatory response is to build devices that have internal snitches that check to see if their owners are running naughty unlocking programs. And in Stross' world, as in our own, the need to prevent the dissemination of snitchware countermeasures leads to widespread surveillance and censorship of the internet.

Pro-regulation hysterics make recourse to the Four Horsemen of the Infocalypse: child porn, organized crime, terrorists, and pirates.

And in Stross' world, as in ours, none of this actually works worth a damn at stopping bad guys. Instead, it creates a vicious cycle of more surveillance and more control to overcome the failings of the current round of censorship and surveillance.

*Rule 34* abounds with imaginative horrors about the potential for technology to do bad, and as imaginative as Stross is, I'm guessing that the real thing will be even ickier.

We need real solutions to the bad stuff that people come up with when they get technology. The first step to finding a real solution is to stop doing things that don't work. ✓

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Cory Doctorow's latest novel is *Makers* (Tor Books U.S., HarperVoyager U.K.). He lives in London and co-edits the website Boing Boing.

# Maker

## GLENN DERRY: MOVIE MAKER

*Avatar's* special effects innovator hacks together blockbuster filmmaking tools — and shares his recipe for an indie-budget virtual camera.

*By Bob Parks*

When the credits finally scroll up after a great special effects movie, don't you wonder at the alphabet soup of job titles on the screen? (What's the difference between a previs supervisor and a virtual production supervisor?) Well, regardless of title, there are always a few key engineers who work at a director's side, solving near-impossible problems without complaint. When the director asks for a 2-ton *Tyrannosaurus* that moves like a ballerina, these guys are on it. When the director asks for a new way to film giant blue people flying through the air, they say, "No problem."

Glenn Derry is one of those guys. The 36-year-old owner of a small Hollywood engineering company called Technoprops spends his days solving specialized challenges on the set. When he was 16, he worked for director Steven Spielberg on *Jurassic Park*, making a dinosaur move gracefully. At 30, he worked on *Avatar*, taking orders from James Cameron to create

a "virtual camera" device that lets directors climb inside computer-generated films as they shoot real-life actors (see page 37 for an indie film version you can build).

The virtual camera is so effective that it's becoming de rigueur on effects films, necessitating Derry's travel to movie sets — including those of *Real Steel*, in which Hugh Jackman coaches robots in arena boxing, and *The Adventures of Tintin*, Spielberg's motion-capture animated version of the classic comic (both due in theaters later this year).

By now, Derry's almost used to the frantic pace of technology development in the movie business. "Nothing is ever carefully planned out," he says. "Your job is to solve problems fast and hope to God you don't hurt anyone with a dinosaur tail bigger than a Kubota backhoe."

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Bob Parks is a frequent contributor to *MAKE*, *Runner's World*, and *Wired*. He lives in Vermont with his wife and two children. He can be reached at [xbobparksx.com](http://xbobparksx.com).

Noah Webb



**⚡ VIRTUAL VIRTUOSO:**  
Hollywood F/X innovator  
Glenn Derry perches on  
racks of equipment to  
be used in future CG  
film endeavors.

**THE DAY I SPOKE WITH DERRY, HE WAS**

chatty and in good spirits, though physically exhausted. Three days earlier he'd had neck surgery to remedy a pinched nerve, but he denied any connection between the neck brace he was wearing and his demanding schedule of maintaining his cameras and using them on film sets around the country.

All he could talk about were the fun side projects he has on deck. In one corner of his 18,000-square-foot prop fabrication shop stands a hydraulic lift that once moved the robotic armor "AMP suit" in *Avatar* but now might be modified into a promising Formula 1 simulator. In his home workshop are remnants of giant hydraulic chimes and gongs he constructed to make a colossal musical instrument.

Elsewhere, Derry's staff of ten mechanical and electrical engineers and programmers tinkered with an open source CNC mill as it churned out metal parts for an upcoming film production. By hacking around like this, Derry and crew have cultivated the uncanny ability to chew up random consumer products, bits of castoff metal, and fiber-optic cables, then spit it all out in the form of tools that have become essential to modern spectacle filmmaking.

Derry's father worked in the film industry as a welder, machinist, and physical effects guy ("From the time I was a teenager, my dad blew up cars," he says), and this connection and some lucky timing landed him an internship on *Jurassic Park*. The need for good engineers became clear to Derry his first time on the set, where the teenager worked on giant robotic dinosaurs (the film used physical puppets as well as computer-generated dinos). "I was soldering op-amp circuits by hand, one at a time," he says.

But the production soon ran into major problems. When you move a robot bigger than a carnival ride, the great mass of steel shakes and sways awkwardly. Already a budding electronics whiz, Derry helped

come up with the solution: mount accelerometers on the dinosaurs' limbs and feed the signals back into the controller. Making the dinosaurs move more gracefully turned out to be a formative experience, recalls Derry. "I was 16, surrounded by electronics card cages and getting screamed at by Spielberg and Stan Winston."

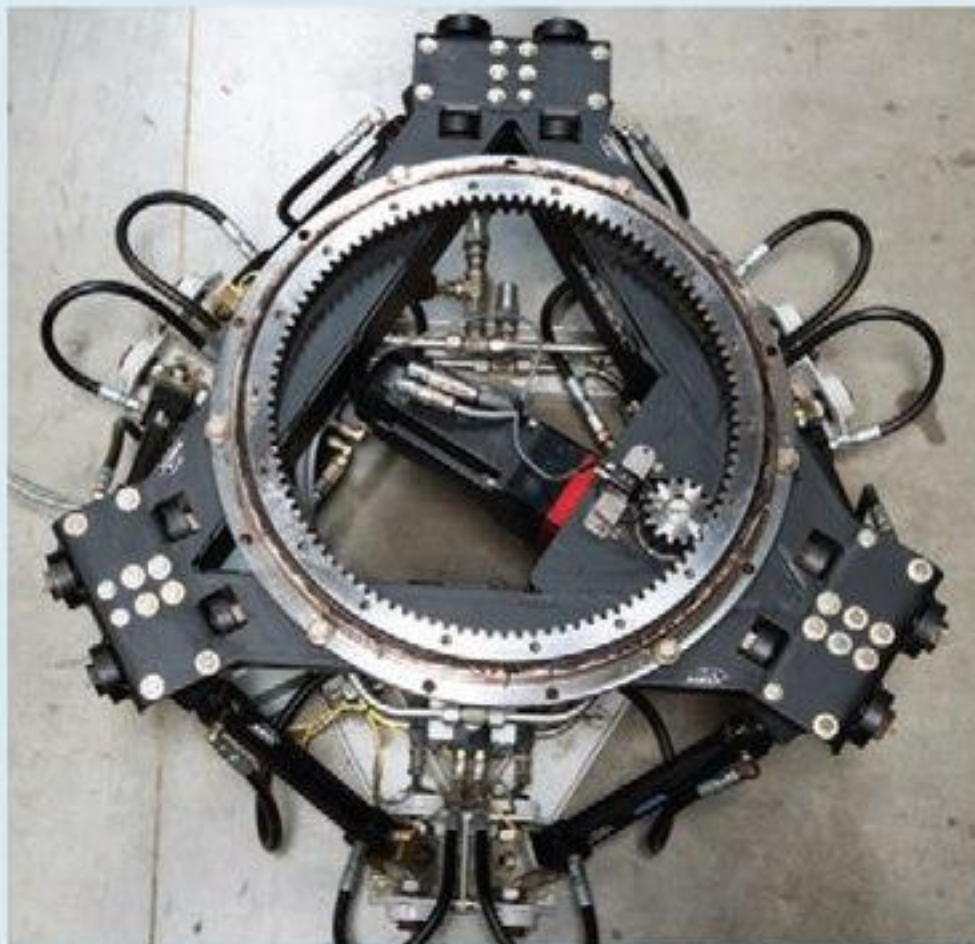
He started college, studying to be a musician, but the lure of movie work was too much. (Years later he returned to study mechanical and electrical engineering at UCLA.) Derry worked full time as a puppeteer on the second *Jurassic Park* film in 1997, where they started out using the same animatronic technology they'd used to control the shark head in *Jaws*.

But Derry, who'd spent years in his bedroom sequencing keyboard music with MIDI controls, put two and two together: he rigged up a MIDI interface that would let any desktop music package control a dino's facial gestures and fine movements, resulting in more credible movie monsters.

All this prepared him for the toughest challenge yet of his career: *Avatar*. To make that film, Cameron became fixated on a motion capture system that would track the actors' faces as well as their bodies, a feat never before achieved in film production. Derry, the virtual production supervisor, found a sensor that was simple and reliable enough to attach to a little boom in front of the actors' faces.

Cameron also wanted to direct scenes that mixed live actors and animated characters. But motion capture systems couldn't be used near live-action filming because the little reflective dots on motion capture suits don't show up under white-hot studio lights. Derry told Cameron it was an easy fix, but he labored two years to solve it. He and his team built special LED trackers that blinked at the exact frame rate of the motion capture cameras, which enabled the cameras to see them.

“ I was 16, surrounded by electronics card cages and getting screamed at by Spielberg and Stan Winston.”



**MECHA MOTION:** Derry's 7-axis motion controller (top left) is at ¼ scale to the full-sized hydraulic 7-axis motion base (bottom left) used on *Avatar* to move the massive, robotic AMP suit torso. His sprawling prop fabrication shop (top right) is overseen by plaster casts of actors' faces from various projects (see if you can spot Daniel Craig, Simon Pegg, Nick Frost, Andy Serkis, Cary Elwes, and Timothy Dalton), digitally scanned and 3D-printed.

Cameron wanted to live and breathe inside Pandora, the jungle moon setting for *Avatar*, and it was Derry's job to make it work. It started when visual effects expert Rob Legato suggested the director use a system that would let him look inside the artificial world of the movie, frame shots, pick lenses, and choreograph camera

movements. Derry built a device that resembled a 16mm movie camera with an LCD eyepiece. The idea was that the director could carry it around the set, checking out different angles, but the camera shape was cumbersome. It was then that Derry developed the virtual camera, a 7-pound package that automatically swings toward



✚ **PANDORA BOX:** (Left) Director James Cameron used Derry's virtual camera on the set of *Avatar* to live, breathe, and compose shots inside the world of Pandora. (Right) Derry's facial capture head rig from *Avatar* transformed Zoe Saldana's performance into an incredibly credible 9-foot-tall blue warrior princess.

the user no matter how it's held.

Directors have delighted in the way the technology connects them artistically with moviemaking again. Spielberg told Derry that using the virtual camera felt like shooting Super 8 film in the backyard as a kid: "He said *Tintin* felt handmade, even though there was this giant juggernaut of a special effects company behind him."

A product so valuable to the movie industry would seem to be easy to commercialize. Instead, Derry has been hiring himself out, before rival effects experts figure out how to make their own virtual



cameras. And Cameron insists that the concept be shared with other directors. "If Jim wants to share it, I'm not going to tell him he can't," Derry shrugs. "Besides, I was able to prototype stuff on the most expensive movie ever made, so now I can bring the technology to smaller-budget films."

But with *Avatar 2* in production, Derry's busy schedule precludes indie filmmaking or other hobbies. Derry looks wistfully at his old electric bass and piano in his Santa Clarita, Calif., home, which he shares with his wife and two kids. "As many would-be rock stars learn," he says, "you eventually get a real job." Although making 9-foot blue people fly around isn't exactly a day at the office for most of us. ✚

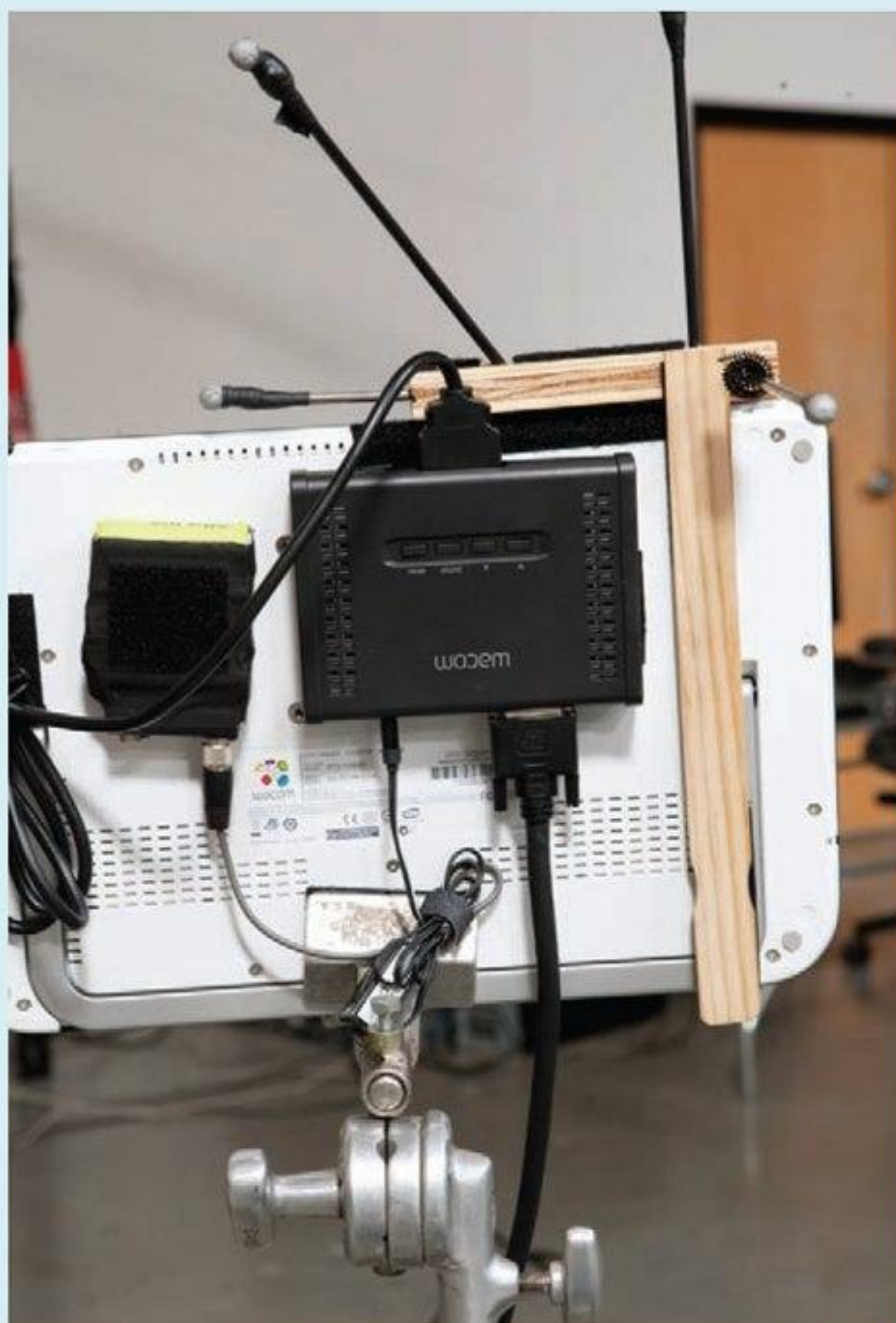
✚ See [makeprojects.com/v/27](https://makeprojects.com/v/27) for a video profile, slideshow, and virtual camera how-to.

Courtesy of Glenn Derry (left); Noah Webb (right)



# Make Your Own Virtual Camera

Learn how at [makeprojects.com/v/27](http://makeprojects.com/v/27).



## “THERE DOESN'T HAVE TO BE A CRAFT

services truck out front to make a high-quality computer-generated movie,” says special effects expert Glenn Derry. Planning great camera shots is the key.

To make your indie shine, Derry advises using a device he hacked together with James Cameron called a “virtual camera.” It helps you compose shots in effects movies, and even plan complex shots in traditional live-action films.

The gadget, essentially an LCD screen festooned with motion capture markers, is something you hold while walking around a motion capture studio. It lets you see the animated world of a digital movie or a mockup of a live set.

Derry has created a plugin especially for MAKE readers to make a low-cost virtual camera (note that “low cost” in Hollywood

## KEY COMPONENTS

**Cintiq 12WX LCD touchpad** Wacom ([wacom.com](http://wacom.com)), \$999

**Xbox 360 Wireless Controller** Microsoft, \$50 list price; available online for \$30–\$40

**V120:Duo motion tracking camera system** OptiTrack ([optitrack.com](http://optitrack.com)), \$1,499

**MotionBuilder** Autodesk ([autodesk.com](http://autodesk.com)), \$3,995

**Custom plugin for MotionBuilder** download from [makeprojects.com/v/27](http://makeprojects.com/v/27)

terms means software and hardware that add up to \$7,000; but student discounts and borrowed equipment would bring the price down considerably).

“The indie filmmaker will take longer to finish a film, and will need to bribe his or her buddies in the CG class with beer,” says Derry. “But this setup uses the same concept as the stuff we use on *Avatar*.” 📺



# PEASANT DA VINCIS

Incredible inventions from Chinese villagers.

By Tom Vanderbilt

In 2004, the Chinese artist and collector Cai Guo-Qiang began to hear stories about fantastic “peasant inventions” trickling out of the Chinese countryside: submarines, airplanes, robots, and even “UFOs,” fashioned in tiny backyard workshops by people without easy access to technical information, tools, and proper materials.

The following year, Cai would acquire his first invention, a fish-shaped submarine — replete with eyes, fins, and painted depth markings on the side — named *Twilight No. 1*.

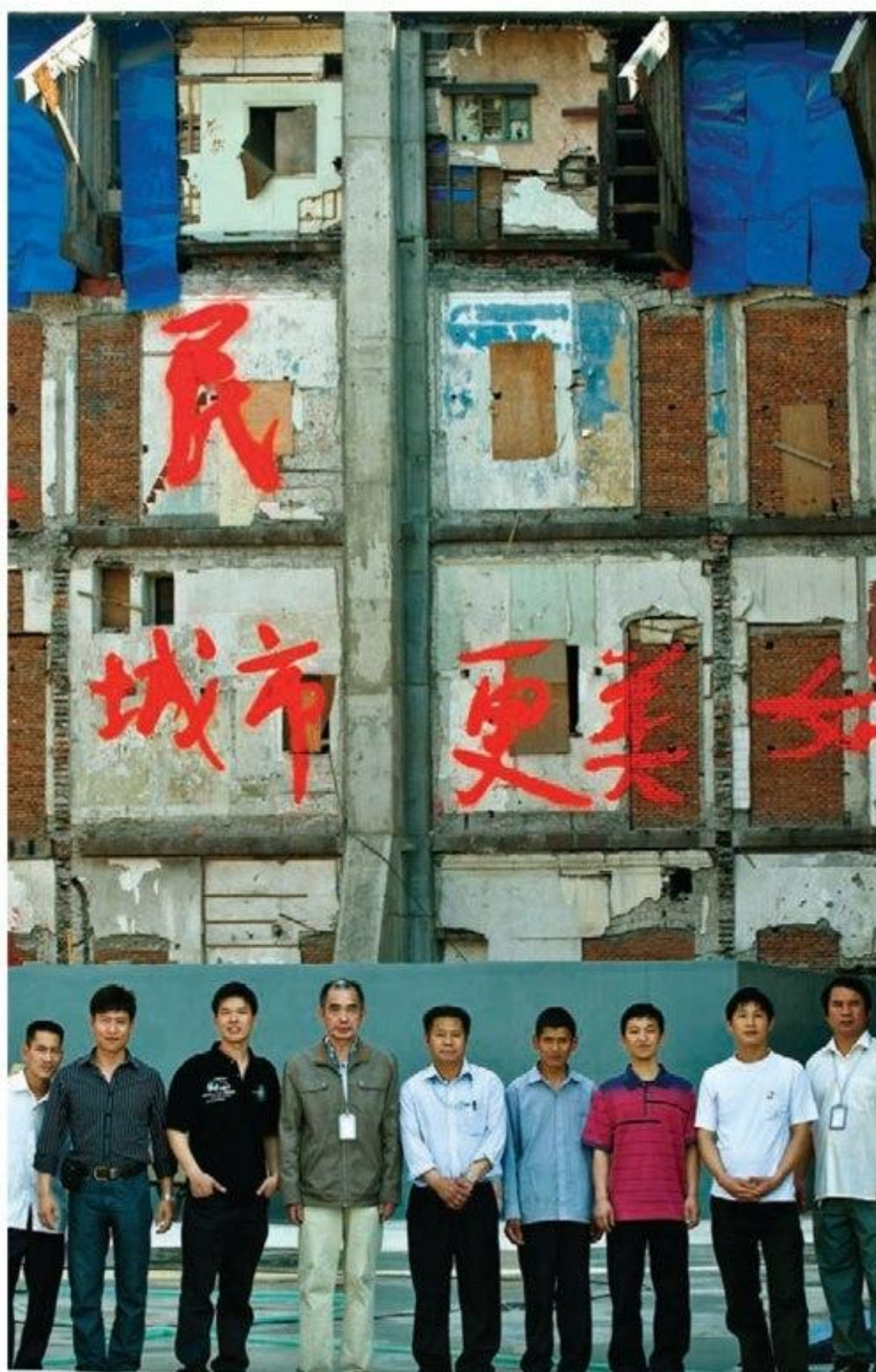
The sub, which is pedal-power-propelled by its pilot, is one of a number of submersibles built by Li Yuming, a 70-year-old with a grade-school education who lives in Wuhan. Having mortgaged his house to fund his work, Li rises each day to tinker with his submarines,

working just outside the door from his wife, who, as Cai recounts, “watches his shadow at work.”

The life of a would-be peasant inventor is not an easy one, Cai tells me over breakfast at The Peninsula hotel in Shanghai one morning. When Li built a second, larger submarine — named, naturally, *Twilight No. 2* — and set out to sail it down the river, “the government was worried that he would have a liability issue if it sunk,” Cai says. Authorities were also concerned it would clog the traffic of local waterways. “So the government river authorities towed the boat to a subsidiary river where there’s less traffic, and just let it sink.”

As an artist, Cai has become known primarily for his work with the traditional Chinese media of gunpowder and fireworks (I first met

Lin Yi, courtesy Cai Studio



## GIZMOS FROM THE PROVINCES

✚ (Opposite) Du Wenda's *Flying Saucer D*, fashioned from aluminum, propeller blades, and LEDs, on the rooftop of the Rockbund Art Museum in Shanghai.

✚ (Left) Nine inventors with the painted slogan *Peasants — Making a Better City, a Better Life*, by Cai Guo-Qiang.

✚ (Below) Li Yuming's *Twilight No. 6* is suspended as part of the installation *Fairytale* at the Rockbund Art Museum.



him a number of years ago at the Fireworks by Grucci test compound on Long Island, N.Y.); his largest audience came as organizer of the fireworks program at the Beijing Olympics.

But he also has something of a curatorial and collecting bent (among other things, the Socialist Realist work of Konstantin Maksimov, a Russian artist who toured China in a moment of Sino-Soviet outreach).

After Li's submarines, Cai went on to purchase any number of Chinese mechanical readymades, ranging across the countryside to distant villages, buying functioning airplanes in Sichuan province (the inventor, Wang Qiang, used plastic bathroom drainage tubes for the fuel tank), rickshaw-pulling robots in Tongxian, flying saucers in Xiaoxian, and even a working submarine made from fused oil drums in Fuyang.

The bulk of these devices were displayed this past summer in the show *Peasant Da Vincis*, at the Rockbund Art Museum in Shanghai, set amidst propagandistic banners that proclaimed aphorisms inspired by the

creators themselves, e.g., "Never learned how to land."

Atop the building spun a (non-)flying saucer by Du Wenda, while on the second floor, Wu Yulu conducted a "robot workshop" demonstrating a delightful range of automata, from a chess-playing contraption to a robotic interpretation of artist Yves Klein's famous *Leap into the Void*. A somber note was struck by the placement of a shattered motor, the remnants of a plane built by Tan Chengnian, who died in 2007 after he crashed his third airplane.

"There's something common shared between all these inventors," Cai says. "They want to fight their gravity, and the restraint of the circumstances that they find themselves in." The act of creation is more important than the result. ("What's important isn't whether you can fly," announced one banner.)

While five of the inventors who came to the show's opening had created airplanes or other flying machines, Cai notes that for three of them, the trip to Shanghai was their first



commercial flight. When Cai asked Wu Shuzai, the creator of a rough-hewn wooden helicopter (which some compared to a chicken coop) with rotor blades repurposed from a threshing machine, where he wanted to go if he could get his craft aloft, his answer was the capital of Jiangxi province — basically a few towns over. “That’s where he wants to go,” Cai says. “The nearest idea of a city he has is a country town.”

The notion of DIY home industry in China invariably recalls Mao Zedong’s doomed drive, during the Great Leap Forward, to ramp up steel production through a 600,000-strong network of “backyard furnaces.” What the program had in revolutionary fervor it lacked in logistical organization and smelting know-how — the resulting iron output was substandard and essentially had to be scrapped.

Where *Peasant Da Vincis* diverges from this precedent — and from the enormous Chinese manufacturing power also on display in Shanghai last summer at the World Expo — is that with these inventions, “peasants are

#### DREAMS TAKE FLIGHT

✚ (Top, left) Wu Yulu’s 13"-high *Walking Robot*, made of repurposed electronics and materials, stands at attention.

✚ (Right) Wu Shuzai built his *Wooden Helicopter* with salvaged lumber, polyester tarp, and a gas engine. His wife dismantled his first copter for firewood.

✚ (Bottom) *What’s Important Isn’t Whether You Can Fly*, proclaims this painted calligraphy by Cai Guo-Qiang.

trying to find their own voices and their own creativity, courageously in a very controlled environment.”

China, says Cai, “is desperately trying to transition from a society where everything’s ‘made in China’ to where things are ‘created in China.’” Among these backyard boffins may be some future Nobel Prize winner.

But in the end, Cai’s desire is more immediately personal. “What I’m really collecting is my childhood dreams.”

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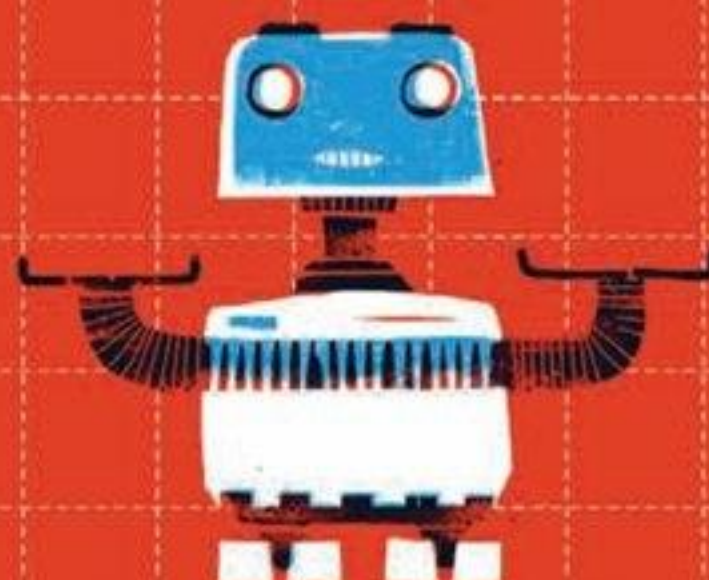
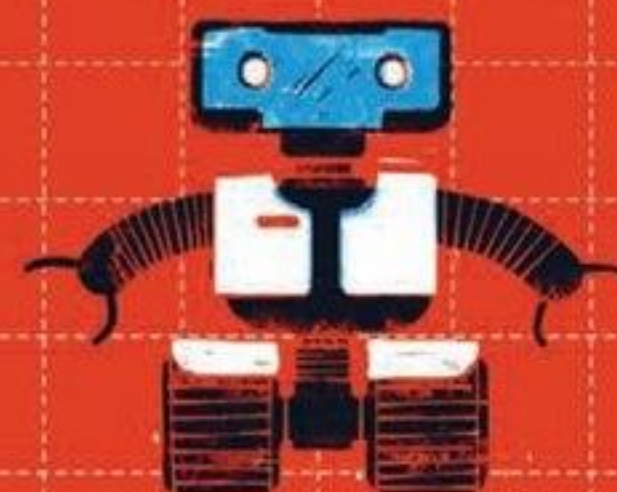
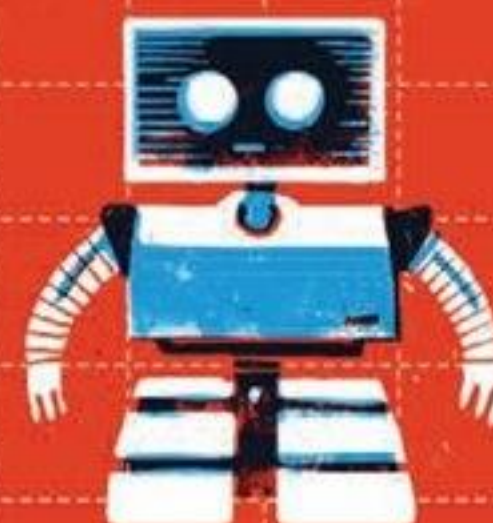
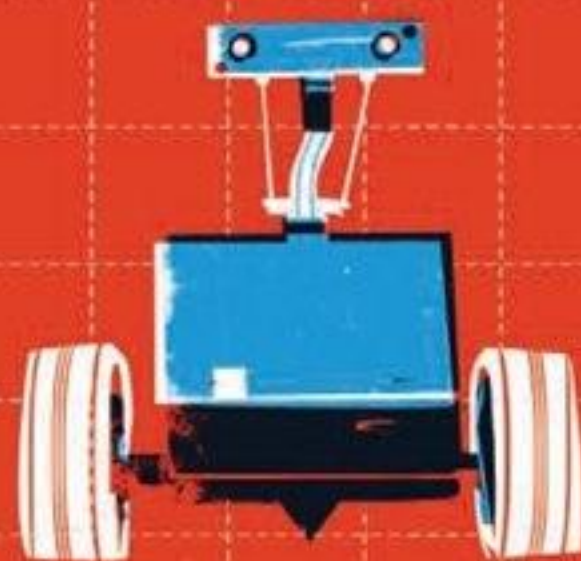
Tom Vanderbilt is the author of *Traffic: Why We Drive the Way We Do* and *Survival City: Adventures Among Ruins of Atomic America*. He contributes to many publications, ranging from the *New York Times Magazine* to *Wired* to *Artforum*.

**Make:**

# ROBOTS!

One roams around drumming rhythms and loops, another bops to the beat. A Roomba spy keeps an eye on your house, as a Teleclaw hands you a treat. Hack any toy to behave like a bot, and meet new friends at Maker Faire. Welcome, Robot Overlords! Please forgive us if we stare.

» Go to [makezine.com/27](http://makezine.com/27) to download your free Make: Robots desktop wallpaper.



Brian McLaughlin

**Make:** ROBOTS!

# YELLOW DRUM MACHINE

COLLABORATE ON  
**Make:Projects**  
makeprojects.com

BY FRITS LYNEBORG

A couple of years ago I started getting into Picaxe microcontrollers, and I ordered a bunch of random components to experiment with. Turning these funny little spring-mounted motors on and off, I thought, Hmm — I could put a stick on that and let the microcontroller drum! This mini sound-recorder board? Hey, if the robot is drumming, it could record itself and play a new beat with the first one in a loop. Oh, nice yellow tracks, a rangefinder — cool, it could move around and look for things to drum on.

After that, the Yellow Drum Machine (YDM) practically made itself. Using hot glue and wooden sticks, it didn't take me long to make a simple chassis, and after a weekend, the finished robot was driving around my house, making wicked beats on stuff it found.

## ▼ START

### 1. Build the chassis.

Assemble the Gear Motor and Tread set into 2 tracks with 20 links each. Put a wheel on each motor and solder a 4" (10cm) lead to each motor contact (4 total, Figure A, page 44).

Make a flat wood chassis about 5½"×2¼" (14cm×5.5cm); it should be a bit longer than the tracks. I cut flat sticks into 4 pieces and

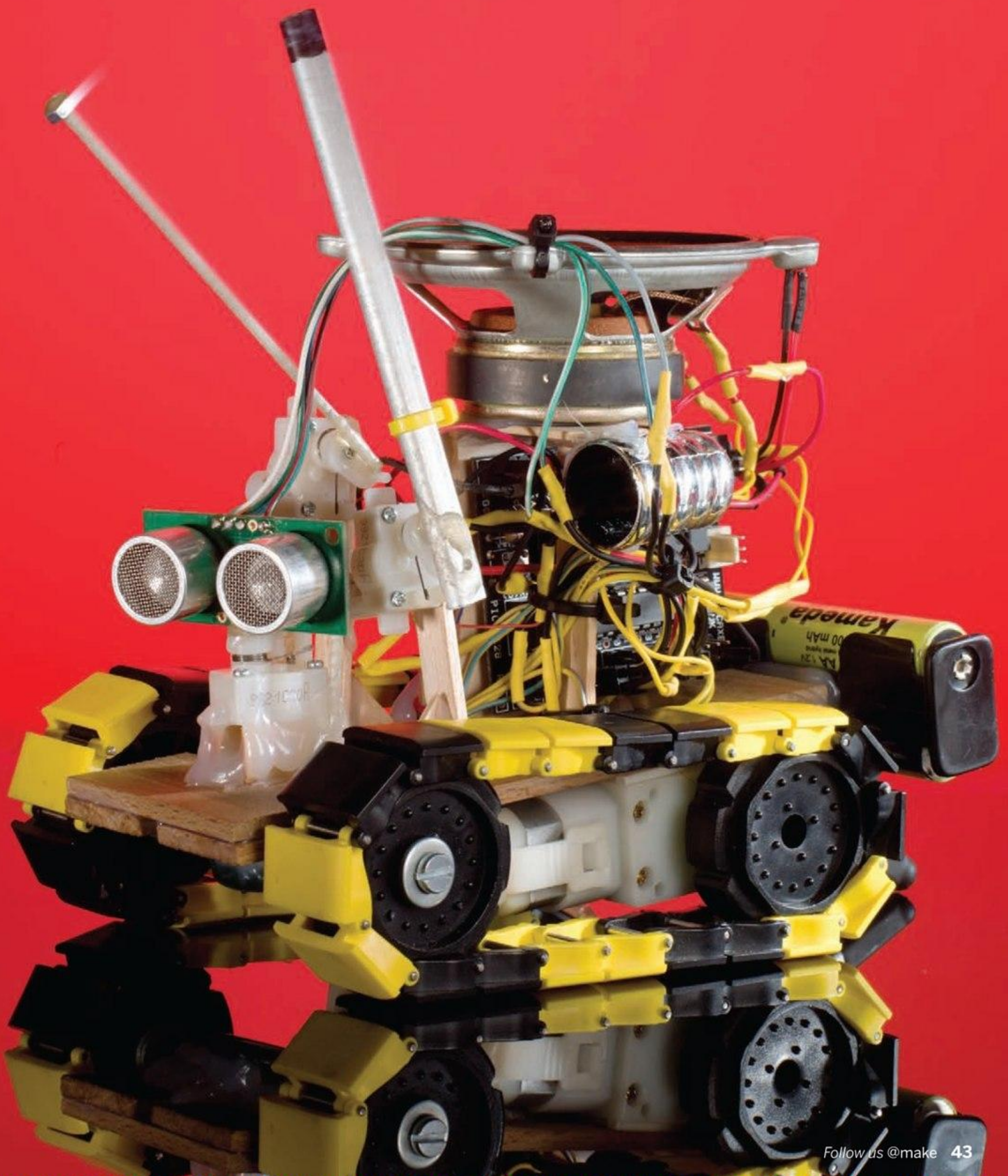
glued them together (Figure B). You can also use more sticks, or a single piece of wood with a hole drilled in it for wires to pass through.

Flip the chassis upside down and affix the motors flat to its rear underside with double-sided tape (Figure C). Orient the motors so that the tracks will run parallel along the chassis without touching it or sticking past its rear or front edges. The motors themselves should sit at least ½" away from the rear edge, to leave room for the GM10 "tail" motor (Step 3). Reinforce the join with 2 applications of hot glue, letting it cool in between.

Prepare your front axle so its wheels will turn freely without touching the chassis. I used 2 washers on each side to space the wheels away from the chassis, and a metal screw hot-glued into each end of the axle to

Garry McLeod

BUILD A FUNKY LITTLE  
FREE-RANGE DRUMBOT  
THAT ROAMS, MAKES  
BEATS, AND SAMPLES.













# ROOMBA RECON

BY RAYMOND CARUSO WITH EVIN PAPOWITZ

TURN AN OLD ROOMBA  
INTO A WEB-CONTROLLED  
WIRELESS REMOTE  
SURVEILLANCE VEHICLE.















**Make:** ROBOTS!

# SPAZZI: A SOLENOID- POWERED DANCEBOT

BY MAREK MICHALOWSKI

At BeatBots, we believe that dancing is one of the most worthwhile occupations a robot can have. We like making cute characters move in interesting ways, and as you'll see, this doesn't require expensive components or complicated programming. For Spazzi here, we decided to forego the rotational motors (servos and steppers) that many robots use. Instead, we went with solenoids, for movement that is fast, linear, and percussive.

We designed our popular teleoperated robot Keepon (pictured in Figure A, page 58) for research and the rigors of a child-filled playroom, so he's made from high-end components and custom-machined metal parts. (A toy version, My Keepon, comes out later this year, and a portion of sales will subsidize the distribution of research robots to autism therapy practitioners.)

We designed Spazzi as a bouncy and easy to build robotic character that achieves the same adorable bounciness as Keepon through a simpler mechanism: solenoids and springs controlled by an Arduino microcontroller connected to a computer.

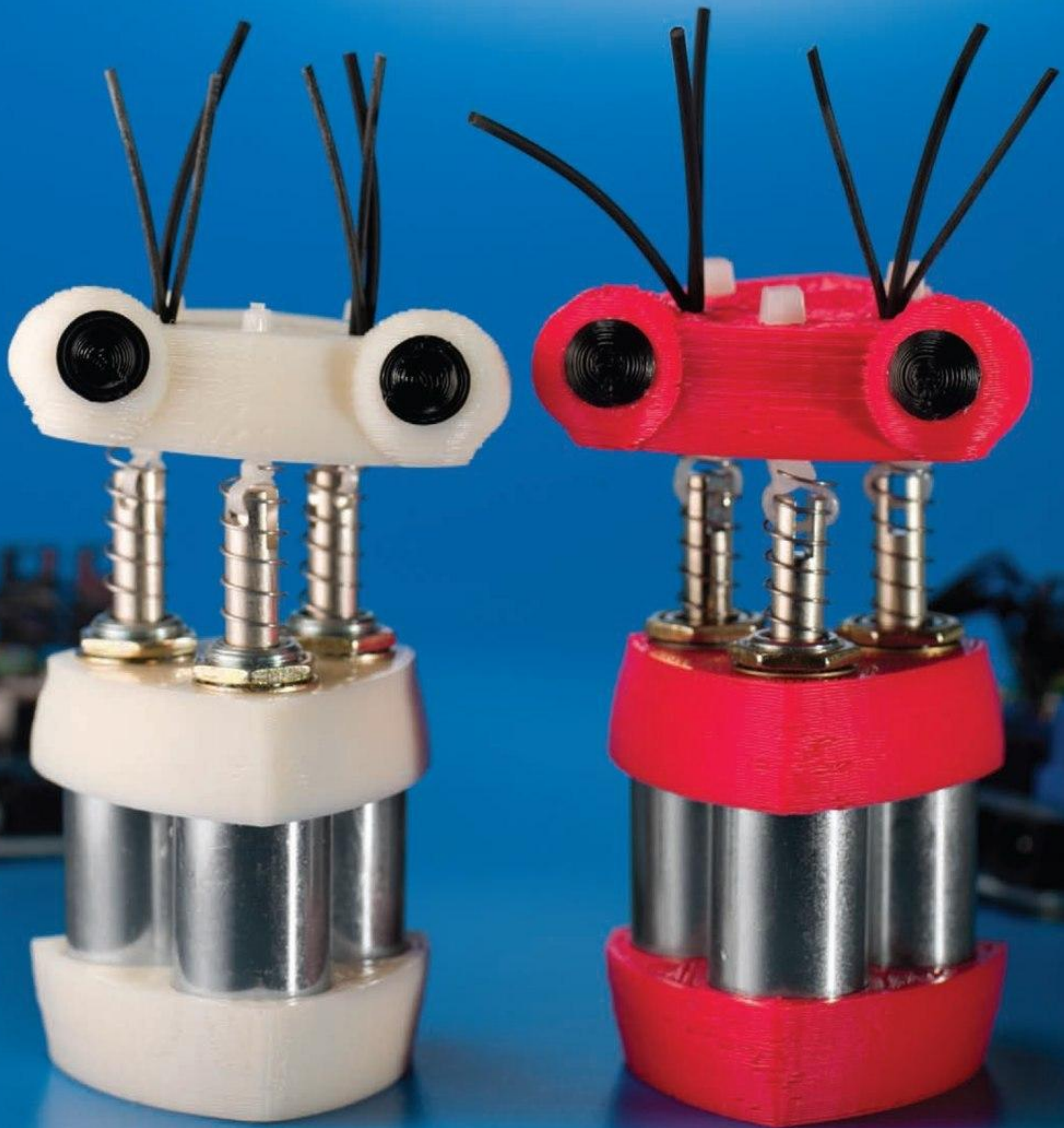
A solenoid is an electromagnet that

pulls a rod (or "plunger") inside its coil when current is passed through. Spazzi's physical form is extremely simple; for his lower half, 3 solenoids stand parallel to form a triangle sandwiched between 2 plastic parts — a base and a waist. The plungers run up through the top of the waist and hold up the robot's plastic head, extended by compression springs.

The 3 plastic body parts are based on the Reuleaux triangle — a shape with various interesting properties and uses (search online for more info). I made these parts on a 3D printer, but you could improvise your own body and head parts from any material, including cardboard. The core of the robot is just its assembly of solenoids and springs.

Garry McLeod

BUILD A CUTE ROBOTIC  
BOBBLE-HEAD THAT DANCES  
TO YOUR MUSIC, AND EVEN  
MAKES SOME OF HIS OWN.



















# TEACHING OLD TOYS NEW TRICKS

BY DJ SURES

Watching an animated robot is certainly amusing, but interacting with a robot is an experience! You can make interactive robots with unique personalities out of many common toys, and I designed the EZ-B Robot Controller ([ez-robot.com](http://ez-robot.com)) to make the process as easy as possible. This tutorial will introduce how the EZ-B works, and then explain how you can use it to teach an old Digger the Dog pull-toy some new tricks: autonomously chasing a red ball and obeying voice commands.

The EZ-B is a microcontroller circuit board that connects to numerous inputs and outputs. Put one inside a toy, and it will control servomotors, sensors, speakers, LEDs, and other devices that enable your bot's behavior.

Meanwhile, the EZ-B also connects wirelessly to a nearby computer using the Bluetooth protocol. Unlike with other microcontroller boards, all the programming and computational "heavy lifting" with the EZ-B happens on the PC side, and the onboard microcontroller just acts as a slave interface to your robot's motors, sensors, and other peripheral devices. This lets your robot perform voice recognition, speech synthesis, visual feature detection, and other functions far beyond the capability of standard microcontrollers, and it also means you never have to compile or upload new firmware.

## Plug-In Peripherals

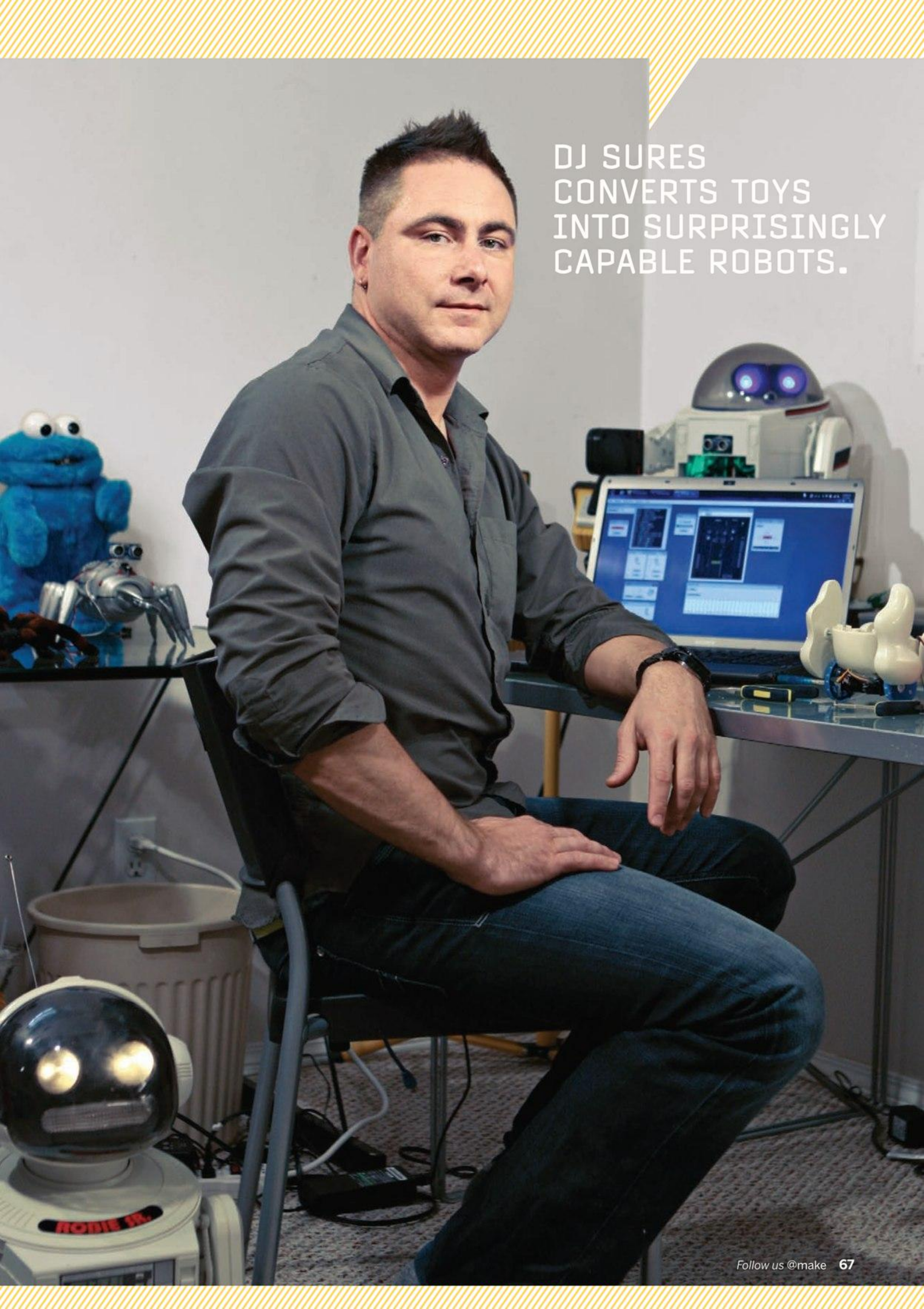
The EZ-B circuit board has the same general pin arrangement as an ordinary Arduino microcontroller, but instead of connecting the microprocessor chip's I/O pins to single female headers for plugging wires or shield pins into, it breaks them out into 3-pin rows, each with their own voltage and ground.

This lets you solderlessly plug in hobby servomotors with their standard 3-wire female plugs (red = power, black = ground, and white or yellow = signal/data).

Many Arduino-compatible sensors and peripherals also use this type of connector. On the sensor (inputs) side, these include distance sensors, tilt sensors, compasses, thermometers, button pads, and joysticks.

Popular effector components (outputs) with 3-wire plugs include servomotors,

Colin Way

A man with short dark hair, wearing a grey button-down shirt and blue jeans, is sitting on a black office chair at a desk. He is looking towards the camera. On the desk, there is a laptop displaying a website with various charts and graphs. To the left of the laptop, there is a blue Cookie Monster plush toy and a small robot with a silver body and a blue head. To the right of the laptop, there is a white robot with a dome-shaped head and glowing purple eyes. In the foreground, there is a white robot with a dome-shaped head and glowing yellow eyes. The background is a plain white wall. The top and bottom of the image have a yellow and white striped border.

DJ SURES  
CONVERTS TOYS  
INTO SURPRISINGLY  
CAPABLE ROBOTS.



























# Make: Projects

Build an aquarium whose gentle curtain of recirculating water sets the stage for an ever-changing jellyfish ballet. Then wire up a lightweight, portable sign that instantly displays anything you type in big, bright LED letters. Finally, turn back the clock and make the limestone-based spotlight that was state-of-the-art pre-Edison incandescent lighting.

Jellyfish Tank

82



PS/2/You

92



Limelight

104





# JELLYFISH TANK

## Convert a regular aquarium into a jellyfish habitat.

*By Alex Andon*

I was always terrified of jellyfish as a kid. The thought of a slimy translucent blob just below the water's surface that could deliver a painful sting kept me out of the ocean most of the summer. It wasn't until years later when I collected a small jellyfish at the beach and observed it in an aquarium that I realized how stunningly beautiful they are. As it pulsed steadily and allowed its tentacles to flutter behind it, I was completely hypnotized. Soon, I decided to design and build an aquarium that could keep jellyfish alive and well.

Jellyfish can't live in a regular aquarium because they get sucked into the filtration pumps and liquefied. Using my extensive experience in building aquariums as part of my research projects at Duke and the University of Delaware, I developed a tank with a special water flow to keep jellies suspended in the middle of the tank.

The jellyfish aquarium design described

in this article has no dead spots for water flow, eliminates strong points of suction, and creates a laminar water flow pattern that sweeps the delicate jellyfish away from the edges of the tank.

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Alex Andon is the founder and president of Jellyfish Art ([jellyfishart.com](http://jellyfishart.com)). He has a B.S. from Duke University in biology and environmental science.

**SET UP: p.85**

**MAKE IT: p.86**

**USE IT: p.90**

Garry McLeod























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