vol. 04

Make:

technology on your time

Our Guide to Cool Kits: From Robots to Ukuleles

9 DIY MUSIC PROJECTS

Turn Toys into Musical Instruments

Webcam Music Machine

Build an LP-to-MP3 Converter Cabinet

Espresso Yourself Coffee Hacks

+ Photograph a Balloon Popping

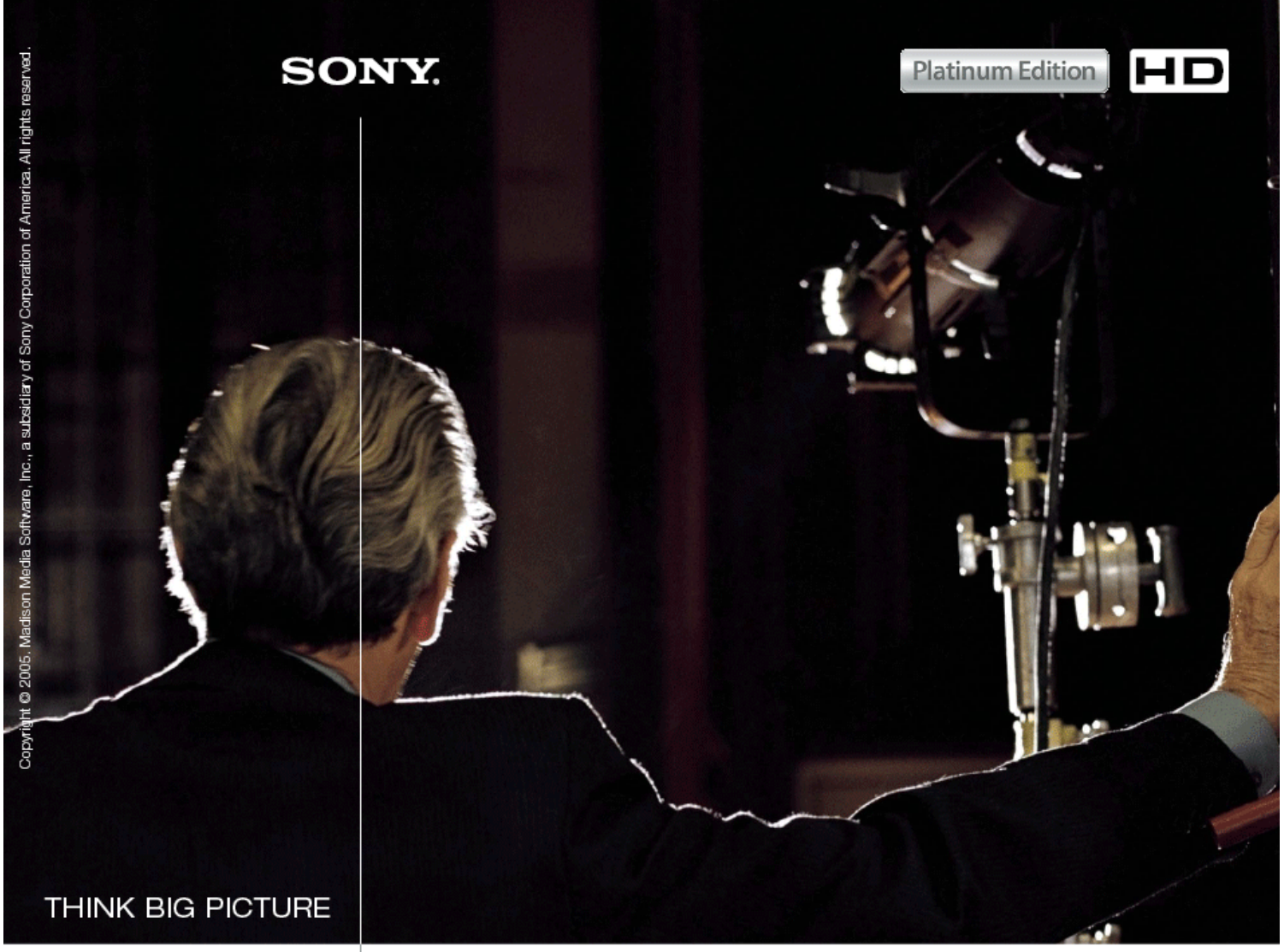
Electric Cigar Box Guitar

MAKE THIS SMOKIN' AXE FOR $13

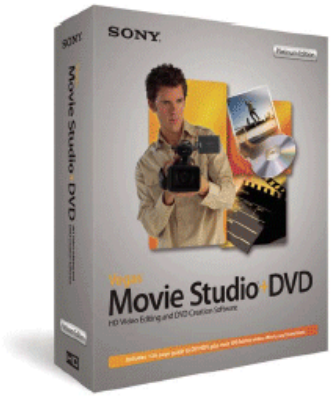
makezine.com

SONY

Platinum Edition HD



THINK BIG PICTURE



You think big. You see widescreen. You require powerful technology to realize your visions. New Vegas® Movie Studio™+DVD Platinum software delivers the features that bring video, digital photos and music to life.

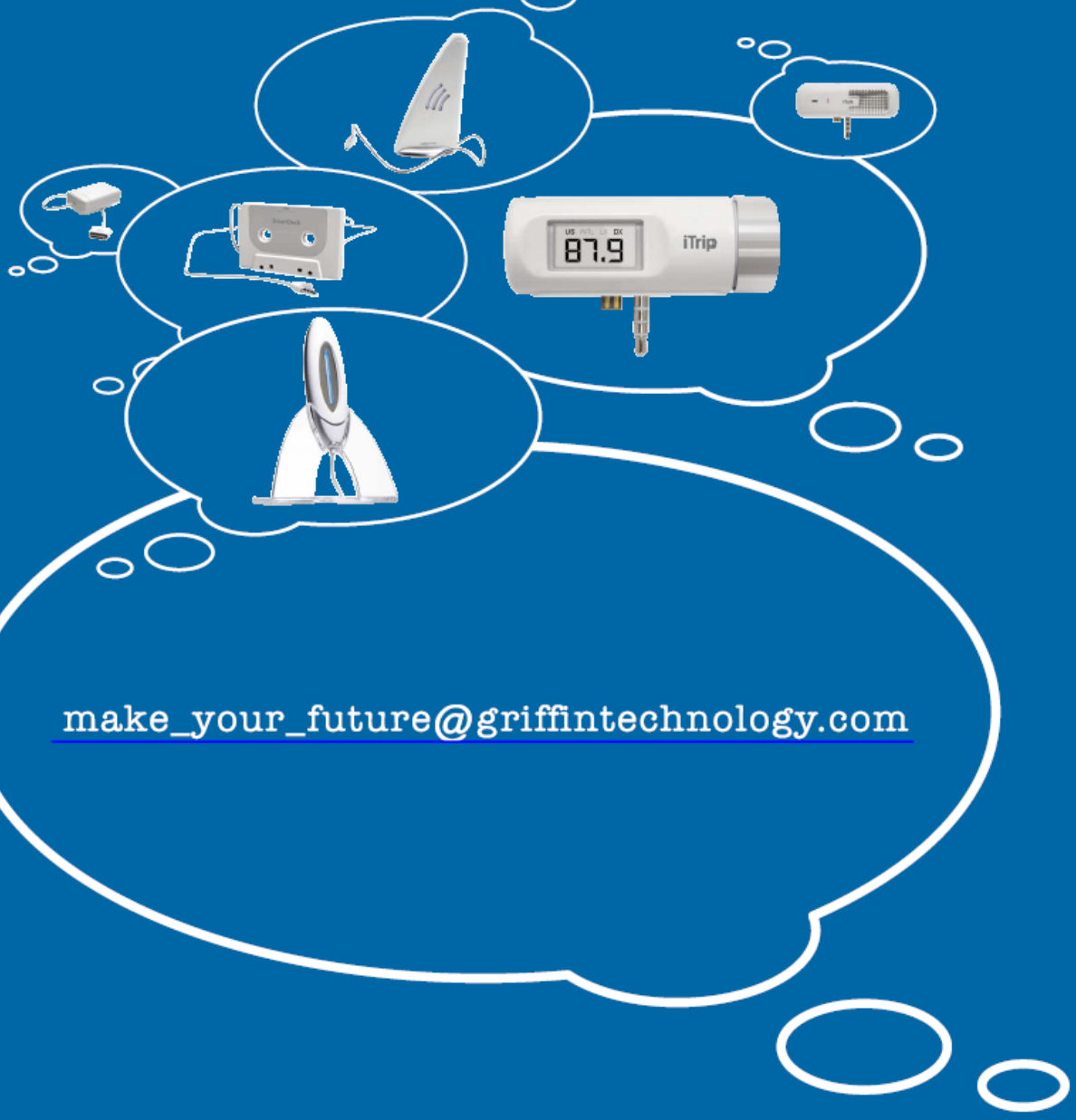
Vegas Movie Studio+DVD Platinum software takes you further than any comparable application, offering support for DV and HDV (High Definition Video) editing as well as many other advanced features. Its comprehensive set of tools, including advanced color correction, lets you create video productions complete with subtitles, soundtracks, special effects, and more. Included DVD authoring lets you easily showcase and distribute your projects. Platinum Edition is perfect for independent filmmakers, videographers and photographers, or anyone who needs professional video production capabilities in an efficient, effective application.

Based on our award-winning Vegas software technology, Vegas Movie Studio Platinum and DVD Architect™ Studio software together offer opportunities to explore your movies and photos from a new perspective. Its HDV capabilities prepare you for tomorrow. The included guide to DV/HDV, 400 bonus special effects and transitions, and ACID® XMC™ software for music creation, provides you with a full production system. Don't settle for a small canvas; think big picture with Vegas Movie Studio+DVD Platinum software. Think big at **sony.com/mediasoftware**.

VEGAS **MOVIE STUDIO+DVD PLATINUM EDITION**

like.no.other™

BEST BUY COMPUSA WHERE AMERICA BUYS TECHNOLOGY. circuit city Office DEPOT Taking Care of Business



make_your_future@griffintechnology.com

MAKE™ readers subscribe to the same philosophy that drives our company: Great products start with great people. So naturally, when we look to expand our team, we know where to begin.

If you're ready for a change and want to develop great products, send us an email with your story. This could be the start of a great future.

MAKE_YOUR_FUTURE@GRIFFINTECHNOLOGY.COM

GRIFFIN

Make:
technology on your time™

Volume 04

Keeping It Reel
Old skool VJ Julie Meitz's sound and moving-image performances utilize multiple 16mm film projectors.

Meet Mister Jalopy
Inside the garage of an unrepentant garage sale fiend.

ON THE COVER
Cigar box guitars have a rich history in American music. Jimi Hendrix, Roy Clark, and Carl Perkins learned their chops on this easy-to-build instrument. Our version, on page 76, incorporates an inexpensive piezoelectric buzzer as an electric pickup. Photograph by Topher Lucas

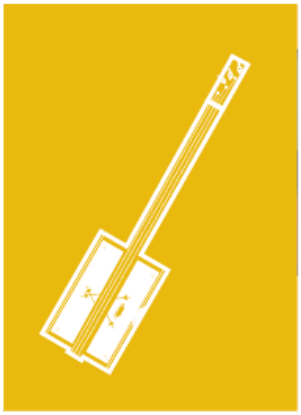
create
innovate
fix.

do-it-yourself Apple notebook parts
thousands of parts and upgrades
free online FixIt Guides

PB FIX IT

pbfixit.com

Make: Projects



CIGAR BOX GUITAR

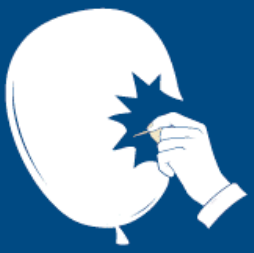
Build this sweet-sounding 3-string instrument in an afternoon.
By Ed Vogel

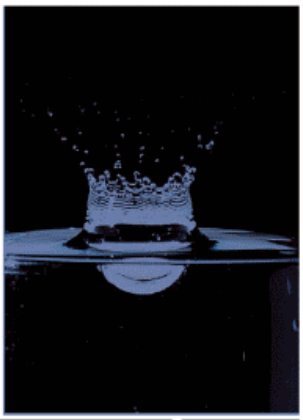
CIRCUIT BENDING

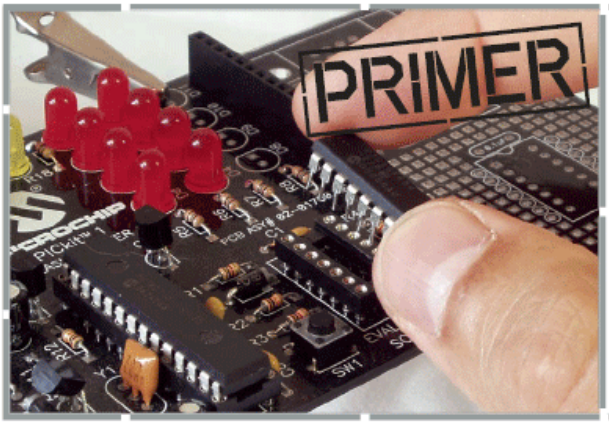
Convert cheap toys into weird-sounding synthesizers.
By Sabastian Boaz and Cristiana Yambo

STROBE PHOTOGRAPHY

Take pictures of popping balloons, breaking glass, and water droplets.
By Tom and Wendell Anderson







Microcontroller Programming

How to program chips.
By Sparkle Labs

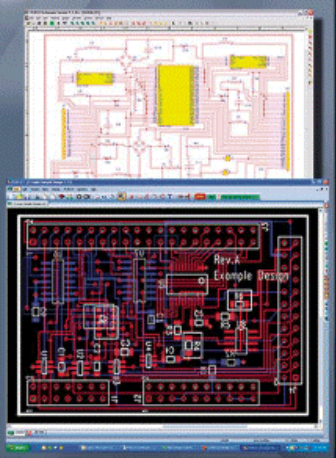
CIRCUIT BOARD solutions for your MAKE technology needs

Need FREE design software?

FREE Download the new version at www.pcb123.com/make

PCB123® VERSION 2.1

PCB123 Provides the Complete Circuit Board Solution, Design Through Order



- DO YOU HACK?
- Are you tired of bread boards & chemicals?
- Get a high quality, rugged Printed Circuit Board in as little as 2 days.
- New libraries contain over a 1000 common devices (PIC MCU, AVR, Flash, OTP, EPROM and much more)

PCB123 13626 S Freeman Rd. Mulino, OR 97042 USA
Phone: (800) 228-8198 x236 / Fax: (503) 829-6657

DOWNLOAD THE NEW VERSION
www.pcb123.com/make

Have design files?

YOUR TARGET FOR CIRCUIT BOARDS

LEADING INTERNET SUPPLIER

pcbexpress

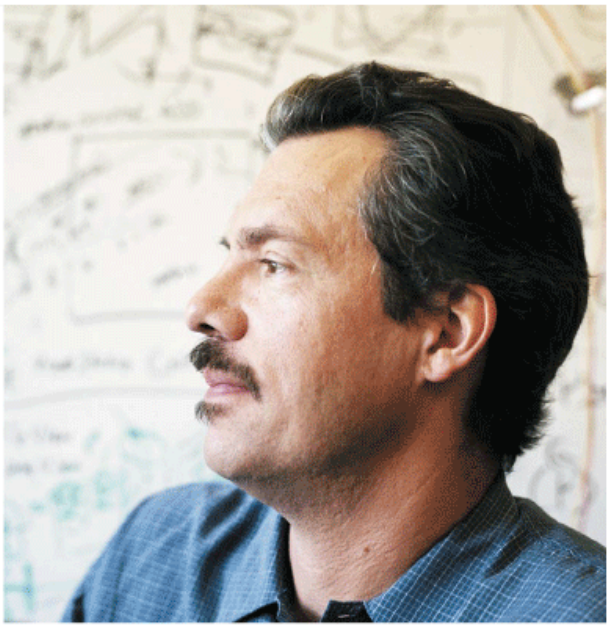
PCBexpress.com

PROTOTYPE CIRCUIT BOARDS

Successfully selling online since 1997.
Experience you can trust! Try us out today at:
www.PCBexpress.com/make

Enter the link for a special MAKE discount!

Volume 04



IBM'S In-House Maker

$0

"I love to put connectors on commercialized technology to leverage all of the engineering and cost reduction that went into a product. It becomes reusable hardware and you just need a little 'glueware' to connect things together and make new devices."
—Thomas Zimmerman of the User Sciences & Experiences Research laboratory at IBM's Almaden Research Center

DIY

Kits for the Holidays

$4

A sneak peek at the best kits of the season: theremins, crystal radios, beer makers, woodcarving, paper rockets, holograms, ukuleles, sumo robots, cheese making, DNA exploration, hybrid lawn mowers, greenhouses, canoes, hot sauces, and more.

CRAFTER

MANIFESTO

Ulla-Maaria Mutanen, a Ph.D. student at the University of Helsinki in Finland, has been thinking about why we enjoy making things. Creator of the HobbyPrincess blog, she developed a Crafter's Manifesto that could just as easily be read as a call for makers to unite. We present it here as our holiday greeting to celebrate the universal urge to do-it-yourself.

- People get satisfaction for being able to create/craft things because they can see themselves in the objects they make. This is not possible in purchased products.
- The things that people have made themselves have magic powers. They have hidden meanings that other people can't see.
- The things people make they usually want to keep and update. Crafting is not against consumption. It is against throwing things away.
- People seek recognition for the things they have made. Primarily it comes from their friends and family. This manifests as an economy of gifts.
- People who believe they are producing genuinely cool things seek broader exposure for their products. This creates opportunities for alternative publishing channels.
- Work inspires work. Seeing what other people have made generates new ideas and designs.
- Essential for crafting are tools that are accessible, portable, and easy to learn.
- Materials become important. Knowledge of what they are made of and where to get them becomes essential.
- Recipes become important. The ability to create and distribute interesting recipes becomes valuable.
- Learning techniques brings people together. This creates online and offline communities of practice.
- Craft-oriented people seek opportunities to discover interesting things and meet their makers. This creates marketplaces.
- At the bottom, crafting is a form of play.

Ulla-Maaria Mutanen is a Finnish crafter who publishes the HobbyPrincess **(ullamaaria.typepad.com/)** blog about fashion, crafting, and technology.

Give the geek on your list a truly unique gift this holiday—their very own subscription to MAKE. (And get a gift for yourself.)

For just $34.95, you can give a full-year of DIY inspiration and ingenious mischief. Plus, while supplies last, you'll also receive your very own MAKE T-shirt!

Simply go to: http://makezine.com/gift

Or call us at 1-866-289-8847 (U.S. + Canada), or 818-487-2037 (all other countries) between the hours of 5 a.m. and 5 p.m. PST.

Your gift recipient's subscription will begin with Volume 04. They will have the opportunity to add digital at no additional cost if they wish to do so. U.S. subs are $34.95, Canadian: $39.95, and all other countries: $44.95 for 4 quarterly issues. Gift orders and gift notifications begin mailing on 12/09/2005. We cannot guarantee arrival prior to the holidays for non-U.S. orders or for any orders received after 12/09/2005.

Make: technology on your time™

EDITOR AND PUBLISHER
Dale Dougherty
dale@oreilly.com

EDITOR-IN-CHIEF
Mark Frauenfelder
markf@oreilly.com

MANAGING EDITOR
Shawn Connally
shawn@oreilly.com

ASSOCIATE EDITOR
Phillip Torrone
pt@makezine.com

PROJECTS EDITOR
Paul Spinrad
pspinrad@makezine.com

ASSISTANT EDITOR
Arwen O'Reilly

COPY CHIEF
Goli Mohammadi

COPY EDITORS/RESEARCH
Terry Bronson
Keith Hammond
Michael Shapiro

WEB EDITOR
Terrie Miller

CREATIVE DIRECTOR
David Albertson
david@albertsondesign.com

ART DIRECTOR
Kirk von Rohr

DESIGNER
Kristy McKoy

DESIGN INTERN
Bess Farah

ASSOCIATE PUBLISHER, MARKETING
Dan Woods

ADVERTISING DIRECTOR
Bill Takacs
707-827-7092, bill@oreilly.com

ADVERTISING COORDINATOR
Jessica Boyd

MARKETING & EVENTS COORDINATOR
Rob Bullington

PUBLISHED BY O'REILLY MEDIA, INC.
Tim O'Reilly, CEO
Laura Baldwin, COO

Visit us online at makezine.com

MAKE TECHNICAL ADVISORY BOARD:
Gareth Branwyn, Joe Grand, Saul Griffith, William Gurstelle, Tom Igoe, Mister Jalopy, Natalie Jeremijenko, Steve Lodefink

MAKE is printed on recycled paper with 10% post-consumer waste and is acid-free. Subscriber copies of MAKE Volume 04 were shipped in recyclable plastic bags.

Please note: Technology, the laws, and limitations imposed by manufacturers and content owners, are constantly changing. Thus, some of the projects described may not work, may be inconsistent with current laws or user agreements, or may damage or adversely affect some equipment.

Your safety is your own responsibility, including proper use of equipment and safety gear, and determining whether you have adequate skill and experience. Power tools, electricity, and other resources used for these projects are dangerous, unless used properly and with adequate precautions, including safety gear. Some illustrative photos do not depict safety precautions or equipment, in order to show the project steps more clearly. These projects are not intended for use by children.

Use of the instructions and suggestions in MAKE is at your own risk. O'Reilly Media, Inc., disclaims all responsibility for any resulting damage, injury, or expense. It is your responsibility to make sure that your activities comply with applicable laws, including copyright.

Contributors

Ten years ago, **Mister Jalopy** (*World's Biggest MP3 Player* and *Own Your Own*) decided to be handy. "People are not born craftsmen; they just have the courage to screw things up," he says. "Embrace your inner amateur and try everything. There will always be an expert to take your money and fix the mistakes." Mister Jalopy is a mediocre welder, a fair shade-tree mechanic, a clumsy designer, and has never touched a piece of wood that he hasn't ruined. However, he still gets a lot done at hooptyrides.com.

A new kind of activist, **Ulla-Maaria Mutanen** (*Crafter's Manifesto*) started her blog, hobbyprincess.com, because she "thought girls should get more active in defining where society and technology are going." The Helsinki native is also building a free product code system and an open database for products, ThingLinks, while working toward a Ph.D. in the social sciences. In her spare time, she likes to "scavenge second-hand shops for wonderful things, sing, and ride a green bicycle." Note to Dean Kamen: She thinks you should invent a flying Segway.

William Lidwell (*MakeShift*) is an artist, author, and entrepreneur. For fun, he can be found practicing martial arts, playing ping-pong, or working on esoteric problems over pizza and beer with friends. For work, he splits his time between writing, consulting, and working on bizarre design projects at the Stuff Creators Design Studio. William is author of the book *Universal Principles of Design*.

Both motivated and broke, **Dustin Amory Hostetler** (*Cigar Box Guitar* and *Retrocomputing* illustrations) loves club soda, the color yellow, cats and dogs equally, and any tree with a tree house. A prolific illustrator, this Toledo, Ohio, native just started a design studio with his wife (studiosansnom.com) and is the publisher of the annual art magazine *Faesthetic*. He also admits to holding grudges, so be careful about criticizing club soda in his presence.

Ed Vogel (*Cigar Box Guitar*) describes himself as "an aging punk who likes musical theater" and makes one-string pizza box guitars with kids at leonardosbasement.org ("fill the belly and then fill the mind!"). He once bet he could make a transistor using late 19th century materials and built a device out of a photoconductive cell, a neon glow bulb, and a resistor. He's now working on a solar-powered adsorption ice machine and can't decide if he likes chocolate cake or broccoli more.

His mom bought him his first 110 camera when he was 6, and **Topher Lucas** (*cover photo*) has been shooting ever since. A photographer who describes his job as being "some sort of license to meet completely random strangers," he's currently working on a project documenting the characters of the Lower Haight, his neighbors in San Francisco, Calif., and is going to Vietnam for a shoot early next year. He also enjoys yoga, the ocean, and riding his motorcycle, but does not like chocolate.

Contributing Writers:
Tim Anderson, Tom Anderson, Wendell Anderson, Thomas Arey N2EI, David Battino, Sabastian Boaz, Joost Bonsen, Gareth Branwyn, Rob Bullington, Cory Doctorow, Daniel East, Jeffrey Goldsmith, Saul Griffith, Jimmy Guterman, Alex Handy, Amy Horton, Andy Ihnatko, Mister Jalopy, Daniel Joliffe, Peter Kirn, William Lidwell, Steve Lodefink, Dave Mabe, Merlin Mann, Bob Miller, John Murphy, Ulla-Maaria Mutanen, Marc H. Nathan, Charles Neveu, Johnathan Nightingale, Danny O'Brien, Will O'Brien, Meara O'Reilly, Ross Orr, Chris O'Shea, Tom Owad, Bob Parks, David Pescovitz, Dave Prochnow, Claude Reith, Matthew Russell, Fred Sandsmark, Bob Scott, Sparkle Labs, Bruce Sterling, Bruce Stewart, Jasmina Tesanovic, Adam Thornton, Cy Tymony, Pacho Velez, Ed Vogel, Patrick Webb, Cristiana Yambo, Warren Young

Contributing Artists:
Oona Albertson, Bit Shifter, Nick Dragotta, Dustin Amory Hostetler, Timmy Kucynda, Andre LaMothe, Gerry Manacsa, Jenny Pfeiffer, Damien Scogin, Derrick Story, Carla Sinclair, Mark Watkinson, Robert Ullman

Shawn Connally

LAZY PROGRESS

I'VE GOTTEN GREEDY, I'VE GOTTEN LAZY, AND I expect too much. I mostly blame TiVo for taking me down this path. If TiVo can figure out what I like to watch and let me rewind a scene to figure out what that mumbling actor is saying, why can't my car stereo let me listen to a song from the beginning if I jump into the car as it's ending? Why can't my special shampoo chemically enhance the roots of my hair and keep my, um, natural blonde highlights looking natural?

The marvels of 21st century technology have made me look at my microwave, toaster, and yard sprinkler with disdain. It's a bagel, stupid, not a frozen waffle. I'm defrosting chicken, not fish. My kids are outside playing — don't you even have a motion sensor, you dumb hydro-dumping apparatus?

Way back in the 20th century, I resisted the mind-rotting capabilities of programming my home phone to remember all my important numbers for me. But now I demand a speakerphone on my cell-

> "So now I'm casting aside my guilt and embracing my laziness."

phone, remote access to the messages on my office phone, and one-button access to my answering machine when I'm sitting on the couch and too lazy to walk into the other room.

I can't believe I used to wait three days before getting to see the photos from my last vacation. And I actually snail-mailed prints of the new house, kid, or car to each family member, instead of doing a mass email pointing to my latest online photo album.

Yet all this leaves me wanting more, more, more. One day, while looking through the galleys of the soon-to-be fourth volume of MAKE, it struck me — I am not alone in my greed and slothfulness. Everyone wants technology to work for them in hipper, better, more logical ways. Laziness is actually a terrific motivator for coming up with creative solutions: "How can I come up with a way to never have to clean my rain gutters again? Why, I could build a little robot that shovels out the debris as it rolls along!"

Makers on every continent, in every walk of life, and in every age bracket are creating — better yet, *making* — the things they crave. A regular alarm clock doesn't get Gauri Nanda out of bed, so she makes one that crawls around the bedroom. Cold fusion trumps retirement; neoprene gets a new life; that thermostat is fooled with just a nightlight and some ingenuity!

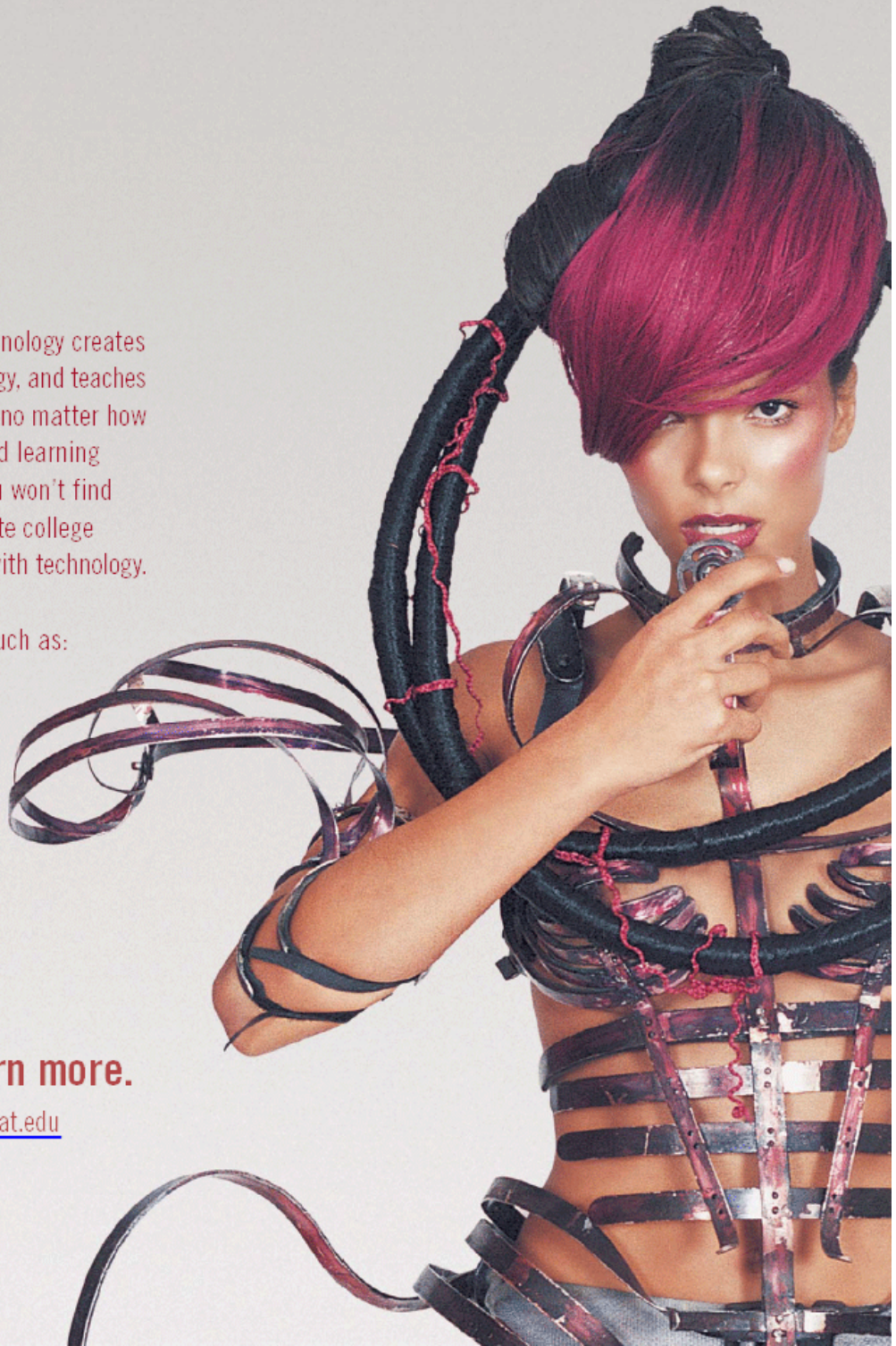
So now I'm casting aside my guilt and embracing my laziness. I'm going to improve the quality of my life by making the technology I paid for work the way I want it to. Our Wi-Fi doesn't work in the guest cabin — it's a little too far away from the house and, as such, cannot be used as the home-office-away-from-home that my husband craves. Recently, I decided to jump into my technology and create a Wi-Fi mesh network (*see Volume 01, page 132*). This is going to be his Christmas present, and my headfirst jump into the maker world. And I'm making a blog for my sister so she can easily document her trip across the country. It's not cold fusion or printed circuit boards, but it's a start.

I challenge you to look around and make your world, or someone else's world, a better, cooler, easier place to be. It's the time for gift-giving, and it's more fulfilling and a lot cheaper to make something, whether it's as simple as a personalized photo album or as complicated as devising a way to make the radar detector in the car talk to the gas pedal so speeding tickets are a thing of the past.

I'd love to hear about the things you make: editor@makezine.com.

Shawn Connally is managing editor of MAKE.

Double-Click
Your Cerebellum



The University of Advancing Technology creates thinkers who understand technology, and teaches them how to apply that thinking no matter how the world evolves. It's accelerated learning in an innovative environment you won't find anywhere else—a select graduate college combining business knowledge with technology.

Choose from specialized areas such as:

>> Information Security
>> Artificial Life Programming
>> Game Development
>> Technology Management
>> Database Development
>> Software Engineering

University of Advancing Technology
UAT
Learn. Experience. Innovate.

Learn more.

www.uat.edu

DEATH TO PAPER! VIVA PAPER!

THE DEAD TREE VERSION IS ALWAYS BETTER THAN THE DIGITAL VERSION. EXCEPT FOR WHEN IT ISN'T.

By Merlin Mann & Danny O'Brien

Illustration by Kristy McKoy

YOU MAY RECALL, SEVERAL YEARS BACK, when the coroner's report on paper came back with findings as grave as they were decisive. Owing to its purported cost, unwieldiness, and utter obviation by widely available clusters of zeroes and ones, the proud and pulpy sheet was reportedly as dead as Trotsky. Four thousand years in the loyal service of pharaohs, lovers, and child-artists just terminated without ceremony or recompense — made redundant, we were told, because simply everyone was using computers nowadays — so, why (God, why?) would any sensible person ever want to write something down again? I mean, really.

Visualize the bafflement among the paperphilic staff of Life Hacks Labs upon hearing from many of these same (albeit slightly rounder and greyer) futuristas that paper is now apparently "back." And apparently paper has really caught on with geeks. Can you believe it? The same scoundrels who were placed in charge of all those computers that supposedly replaced paper back during the Clinton Administration! The very idea. The mind reels.

There is no Lumber Cartel. Friends, we're here today to unveil the august secret that we hope will save potentially dozens of Important Technology Writers from needing to produce another wide-eyed report on how very odd it is that all these geeks seem to love paper so much. The trick is that there is no paradox, no more so than suggesting that people who buy screwdrivers must necessarily hate drills.

Geeks rely on paper for the same reason that the normals do: paper — along with conceptual cousins like whiteboards and magnets — is simply the most efficient tool for completing certain kinds of cognitive work. And no amount of enhanced technology will likely diminish this anytime soon.

Paper's in the room with you. The physicality of paper invites us to stack and tear and tape and fold and occasionally even fashion a missile to hurl at a beloved family pet. Paper is there, and it inarguably represents the purest and most durable instance of the WYSIWYG interface.

A pile of sticky notes and a blank wall brings a brainstorming session to life, while the modest index card lets us capture, pile, analyze, and quickly reorganize our thoughts in cognitively satisfying ways.

Paper likes a day off as much as anybody. This is not to imply that our tasks can't all be accomplished with the help of an appropriate digital device. We've each seen the outsize functional yield of one beardy hacker, a Perl install, and a couple of spare afternoons. It's more to suggest that paper affords presence and immediacy for the tasks that require our minds to be open, ductile, and generative. If you've mastered an electronic tool to the extent that paper seems to impede your flow, then more power to you.

But even in the rarified geek subculture of Extreme Programming, we find paper to be front and center. Index cards are employed in abundance, with clients writing user stories, developers tracking tasks, and the cards themselves serving as physical reminders of progress and next steps.

> "Our real challenge today is not to *use* less paper but to *keep* less paper."

Does this make my FedEx look fat? Unfortunately, the physicality that makes paper so ideal for "thinking" tasks is the very quality that makes it ill-suited for storage, recall, and transmission over physical distance; paper takes up space, weighs something, and can, in time, degrade in quality. Plus, until they finally build out that international network of pneumatic tubes we've been asking for, it's likely that `gzip` and `sftp` will continue to lap faxing and shipping for both cost and efficiency.

Farmer and cowman should be friends. As Malcolm Gladwell noted in his 2002 *New Yorker* review of *The Myth of the Paperless Office*, our real challenge today is not to *use* less paper but to *keep* less paper. Paper still has a role in our lives — just not as the sole information tool we have at our disposal. We don't throw out our wallets when we buy a new suitcase, and no one seems to mind living in a home that contains both a television and a radio. Likewise, there's plenty of room for paper and digital to live alongside each other so long as we remember and respect what each is better at.

For ubiquitous capture, planning, and brainstorming, paper's tough to beat. For storage, searching, and editing, the point goes to digital. As for organizing and outlining? Your call. But whatever you decide to use and for whatever purpose, it's comforting to know that the chance for a fresh start is always waiting at arm's length on a penny's worth of plain old paper.

Learn how to reel in your mind at Danny O'Brien's lifehacks.com and Merlin Mann's 43folders.com.

Maker Faire

Join us for MAKE magazine's first ever Maker Faire

A hands-on event featuring Makers whose science and technology projects will amaze you and ignite your imagination.

Saturday and Sunday
April 22 – 23
2006

makezine.com/faire

- Meet expert Makers and MAKE contributors
- Hear from O'Reilly's Hacks authors
- Attend DIY tutorials
- Explore DIY projects and demonstrations
- See the Ultimate Workshop

Bring your family and friends to the San Mateo Fairgrounds (centrally located in the San Francisco Bay Area) for a weekend of hands-on exploration, recipe-sharing, creative mischief-making, and wholesome play. All-day admission is a paltry $12 adults, $5 teens, and not a cent for kids 12 and under accompanied by an adult. Maker-friendly family tickets and full weekend passes available as well!

Tim O'Reilly

NEWS FROM THE FUTURE

"The future is here. It's just not evenly distributed yet." — William Gibson

In puzzling out the shape of the future, it's not the stories themselves that matter so much as the pattern. Once you've recognized that, the stories jump out at you.

Take this morning's *New York Times*. A story on the increasing competition among the paparazzi for celebrity photographs describes the quality of the information at one leading celebrity photo agency:

"He opens a drawer, pulls out a few stacks of paper. Here, he says, are this week's scheduled movements of every famous passenger of a major limousine company in Los Angeles... Here, too, are ... passenger manifests of every coast-to-coast flight on American Airlines, the biggest carrier at Los Angeles International Airport. 'I get the full printout,' he says. 'If they fly any coastal flight, I know. I can also find anybody in the world within 24 hours. I guarantee it.' He says he has law enforcement officers on his payroll, too, and can have a license plate checked in an hour on weekdays, 20 minutes on weekends."

There's money in tracking celebrities, and the tracks they leave are bigger than those left by you or me, but don't be fooled: information about where you are and what you do is also available, increasingly in real time. Porous access to huge electronic databases containing the tracks we all leave in cyberspace — credit card purchases, travel arrangements, what we read, and who we talk to — ensures that those who have the time for a deeper look can find plenty of information.

Here's where the makers among us come in: rather than just bemoaning the loss of privacy, the fact that big businesses use this data to drive marketing into every aspect of our private lives, or the warning that the police state is coming, makers figure out how to ride the trend and turn it in a positive direction.

So, for example, during last year's presidential election, maker Michael Frumin of New York technology/arts group Eyebeam built an amazing site called fundrace.org, which mined the public databases of the Federal Election Commission and built visualization tools to show the patterns of contribution for each candidate, right down to the local level. Before Fundrace, this data was theoretically available to the public, but because access was difficult, it was largely the province of political organizations, lobbyists, and other industry insiders. Frumin and his colleagues at Eyebeam struck a blow for democracy, leveling the playing field and giving equal access to all.

What's interesting is that even when you can see the direction the trends are taking us, there are many variations in the possible shape of the seemingly inevitable future. Police state, maybe. Intrusive commercialization, almost certainly. But you can also frame this pattern as *the global small town*.

They say that in a small town, there's no privacy. The blogosphere is today's town newspaper and town gossip rolled into one, and digital cameras, cellphones, and SMS from the front lines make sure that breaking news gets picked up quickly. Just when pundits were bemoaning the centralization of radio and television by giant companies like Clear Channel, podcasting and vlogging have flung open the doors of competition once again.

And that's another pattern: this alternation of centralization and decentralization can be seen again and again. A new technology springs up from the edges, breaking the stranglehold of entrenched players and lowering the barriers to innovation. Entrepreneurs capitalize on the new technology; eventually, the winners of the economic competition consolidate their power and shut out newcomers. But then (paraphrasing poet Wallace Stevens), "the story begins again, in the yes of the maker, spoken because he must say yes, because beneath every no lay a yes that had never been broken."

You can get URLs for the referenced stories (and others) at makezine.com/04/nff.

Tim O'Reilly (tim.oreilly.com) is founder and CEO of O'Reilly Media, Inc. See what's on the O'Reilly Radar at radar.oreilly.com.

MADEONEARTH

Report from the world of backyard technology

Photography by Daniel Jolliffe and Jessica Larva

Speak Your Mind

If you're walking through your local park and happen upon a device looking like something out of *Yellow Submarine* with loud random voices blaring from it, you've found **Daniel Jolliffe**'s "One Free Minute."

Designed to promote anonymous public speech, One Free Minute allows calls to the cellphone inside the sculpture to be connected for exactly one minute to a 200-watt amplifier and speaker. The results can be empowering, funny, touching, and downright loud. The speech produced by Jolliffe's sculpture can be heard clearly for more than 150 feet.

The 41-year-old Canadian artist created One Free Minute for his master's thesis project at Ohio State University. It's attached to a bicycle for easy movement, and he's taking it on tour throughout the U.S. and Canada.

There's clearly a political aspect to One Free Minute. By creating a tool that allows anonymous free speech in public places, Jolliffe hopes to let activists speak without fear or recrimination at a time when governments everywhere are increasingly vigilant of who is saying what and where.

The sculpture was designed in Rhino CAD, which offers a wide range of visualization options. Once Jolliffe settled on the look he wanted, he used a process similar to building a wooden boat, creating the shell out of fiberglass and epoxy and then sanding — lots of sanding.

The electronics turned out to be the easy part. Jolliffe assembled the embedded controller by hand, threw in an off-the-shelf car stereo amplifier, a couple of gel cell batteries, a 200-watt compression driver, and a serially controlled MP3 player. The sculpture was ready to make some serious noise.

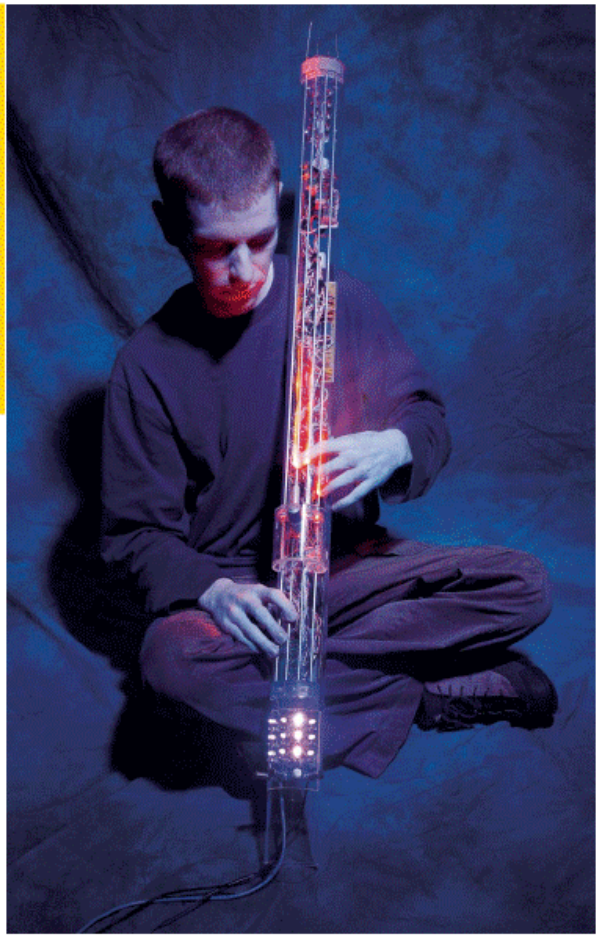
From the woman who called to say she had pancreatic cancer and wanted to tell her children she loved them before she died, to political ranters, to silly singers, Jolliffe credits them all. "The people who call up and lay their guts on the line, saying what they really think — this piece was built for them and they are the real creators of what is good about One Free Minute."

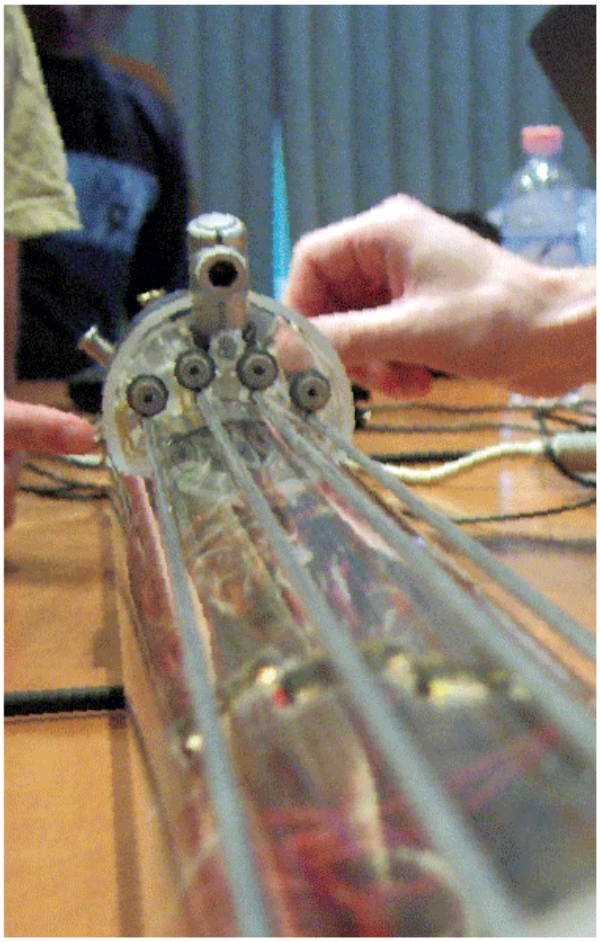
If you want to speak live, send email to info@onefreeminute.net and you'll receive the live number before the next performance. You can also call a number anytime to record your message (see website for numbers) or send MP3 files for public broadcast. *—Bruce Stewart*

To make your own cellular megaphone, see page 129.

» **One Free Minute:** onefreeminute.net

See One Free Minute in action at makezine.com/04/made.





Slap That String

Sitting behind a laptop is boring, but how do you invent a new musical instrument for "playing" the computer? Musician and interactive designer **Ben Dove** needed a new solution, and he didn't want to simply mimic traditional instruments. So he started with the sensing technology first. His "String Thing" uses a combination of laser-powered motion tracking, metal rods for sensing finger pressure, and even a vibration system for physical feedback. Plug it into a computer, and you can expressively play the rods with your fingers: position controls pitch, and pressure controls volume. The result may look like a strange robotic cello, but playing it is a totally new experience.

If this sounds hard to perfect, it was. Dove admits getting the positioning system to work was a nightmare. "I spent so long trying things," he says. "I just could not believe it was such a big deal!" The current model, Dove's thesis project at Italy's Interaction Design Institute Ivrea, is the latest of a long string of prototypes. The first was constructed from a clothes hanger, guitar string, and DV tape. Later, he settled on suspended metal rods for pressure. The motion tracking system uses a webcam connected to the free PC software EyesWeb, which "watches" reflected laser dots on the player's fingers.

The work has paid off: while Dove has more refinements planned, the instrument is already fun to play. Dove's own playing has been "trance inducing, very droney," but others have successfully tried it, too. Some attempted to pluck it, which won't work, but others "seemed to instantly get it — [their playing] sounded better than my efforts!" Move over, Stradivarius, Theremin, and Les Paul: there's a new axe in town. *—Peter Kirn*

»String Thing's construction: people.interaction-ivrea.it/b.dove/string_thing/

Hear String Thing at makezine.com/04/made.

Photography by Ben Dove

Photograph by Steve Lodefink

Testing Your Mettle with Iron Age Skills

The digging stick was a neat invention, and stone tool-making traditions came in handy for a few million years. But metallurgy, specifically humans' discovery of how to turn lumps of red dirt into workable slabs of iron, really opened up the technological floodgates. Blacksmiths had to have skills as designer, engineer, and metalworker in order to make best use of this precious commodity.

With the Industrial Revolution, blacksmiths became nearly extinct. A few skilled artisans prospered by adorning the mansions of the new industrial barons with beautiful hand-forged ironwork. Today, Seattle artist blacksmith **Maria Cristalli** wields her hammer primarily in the service of pounding out incredible hand-forged architectural metalwork for the palaces of today's Silicon Revolution tycoons.

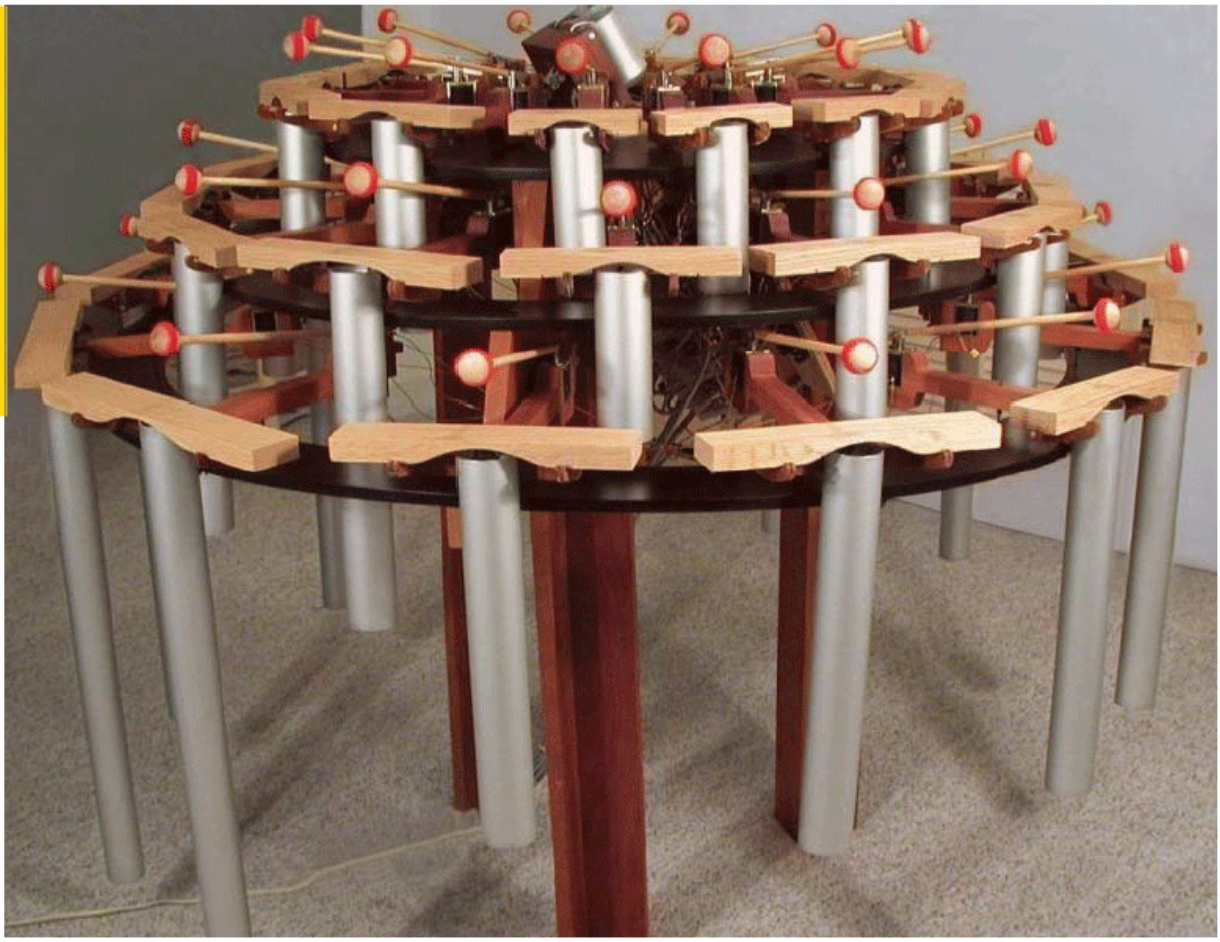
Formally educated in fine arts, Cristalli started a career as a photographer, but when she took a welding class one day, metal got under her skin and there was no looking back. Cristalli's metalworking skills have evolved through a long series of apprenticeships, workshops, and time at the anvil.

The hand forging process is much like it has been for hundreds of years. A bar of metal is heated up in a furnace until it reaches its red-hot working temperature, and the blacksmith then works the piece with hammers, anvil, and huge amounts of skill until the design emerges.

Cristalli's architectural pieces are in high demand, and her commissions include an elaborate iron wishing-well cover with stylized acanthus leaves, an Antonio Gaudi-inspired home interior, numerous fireplace surrounds, gates, and various home and garden accessories. When Cristalli gets burned out on botanical designs and scrollwork, she turns out clean contemporary furnishings and sculpture. Ironing really is women's work.

—*Steve Lodefink*

» **Maria Cristalli's site:** mariacristalli.com



Marimba Madness

Talk about stubborn. **Larry Cotton**, a retired engineer from New Bern, N.C., didn't want PC hardware anywhere near his elegant marimba, even though it would have made things a lot easier. Most makers connect instruments to a computer via MIDI or some other common interface. Cotton had to rig up a low-tech optical reader inside the marimba to play custom piano rolls. "I was just kind of doing my own thing, committed to using nothing that existed already," says Cotton.

He started with photodiodes and 300-pound fishing line. He shined spotlights through the thick monofilament, creating a cheap fiber optic system. He lined up 40 spots across 4 inches of makeshift roll, each one accounting for one of the 37 hand-made oak bars around the circular instrument. An inkjet printer furnished black dots on the transparency, and when the dots blocked light, a voltage change from the photodiodes registered to Schmitt triggers and 555 timers.

Each hand-soldered circuit drove relays and higher-current solenoids (former cassette player mechanisms bought surplus).

Cotton makes custom rolls himself by playing songs on his piano and capturing the audio on his workshop PC. By running it through Cakewalk 6.0 software, Cotton is able to reformat the MIDI computer dots to play in his machine.

The oddly shaped marimba pounds out a mean version of *Flight of the Bumble Bee*, along with the old Carmen Miranda tune "Tico Tico" and other songs. But like nearly all player instruments, you can tell the difference. Asked if there are times you can almost close your eyes and hear a human player, Cotton laughs. "Oh, yeah," he says. "A pretty bad one."

—Bob Parks

Photograph by Larry Cotton

Unroll Your Own

If Cinderella had used duct tape to fashion her gown, she wouldn't have needed those fairy godmothers, and two teens in Oklahoma have proved it. For their winning entry in the 2004 annual Duck Brand Duct Tape "Stuck at Prom" Scholarship Contest, high school students **Casey Isringhouse** and **Krystal Long** constructed royalty-themed prom wear out of duct tape to win the prize, a $2,500 college scholarship. Interested in entering next year? Read the Contest FAQs for tips, such as this: "the entire outfit does not have to be 100% duct tape. However... full duct tape attire [is] a plus."

—Arwen O'Reilly

» **Stuck at Prom Scholarship Contest:** makezine.com/go/ducktape

Art-O-Matic Reflex

Clark Whittington began repurposing vintage cigarette-vending machines in 1997 to vend art instead of smokes. Now Art-o-mats are available in cities all over the United States. At $5 a pop, it can hardly be called a dangerous addiction. And, more importantly, it's a unique transaction: you have an original work of art in your hands. But Whittington is quick to point out "It's the artists who are doing whiz bang work. And many times, it's the first [art] purchase for the buyer."

Artists submit their work, Whittington and friends evaluate it (Is it worth five bucks? Will it fit in a box the size of a cigarette package?), package it, and supply the far-flung machines. The low price tag erases the elitist associations many people have with art, and the machine, by making explicit the relationship between art and money, pokes fun at more pretentious galleries.

Although the Art-o-mat has in fact led to gallery shows for some of its artists, the machines are doing just fine, thank you. In Chicago alone, there are 3,000 sales a year. Not quite enough to retire on, maybe, but then, that's not the point: the art is.

—Arwen O'Reilly

» **Art-o-mat:** artomat.org

Photograph by Duck brand Duct Tape (Unroll Your Own) and photograph by Clark Whittington (Art-O-Matic Reflex)

Think Inside the Box

If you find yourself constantly tapping your desk, you'll love this: Beatbox, created by **Andy Huntington** while studying at the Royal College of Art, London. Beatbox is a series of tapping boxes. You can teach each box a rhythm by tapping it, and it will replay by tapping any surface you attach it to.

"I had been working with tapping toys for the last 18 months, based around solenoids, and became interested in being able to use them to release the acoustic properties of everyday items," he explains.

To teach a box, you press the record button, turning the LED inside red. Tap a sequence, and then press the play button, turning the box green. The box will then accurately tap your rhythm until you record a new one or tell it to stop. By attaching boxes to a variety of surfaces, it is possible to create a wide range of sound textures, so get out your kitchen pots, pans, and pizza boxes!

Beatbox has two modes: the first has each tapper box looping around its own clock, and the other syncs all the tappers to a central loop time. It is also possible to change the overall rhythm speed from the central box.

Developed using PIC chips, solenoids, computer keyboard buttons, LEDs, self-assembled acrylic boxes, and some custom PCBs, the boxes glow white upon each tap, creating a mini light show and a visual indicator for each beat.

Huntington, who is currently looking at turning Beatbox into a commercial product, wanted to get away from a computer-based timeline metaphor by creating a physical interface. The result: an instrument that's easy to pick up and play, yet flexible enough to create more complicated beats. Simple but perfect. *—Chris O'Shea*

» **Beatbox:** extraversion.co.uk/beatbox/

See a video of Beatbox in action at makezine.com/04/made.

Photograph by Andy Huntington

Photograph by Henry Lim

Baroque Bricks

What does someone who is equally serious about LEGO and Bach do in their spare time? Make a fully functional LEGO harpsichord, of course.

Requiring around 100,000 LEGO pieces and two years of theorizing, designing, collecting parts, building, testing, and rebuilding, **Henry Lim**'s harpsichord was definitely a labor of love. Lim is a prolific LEGO artist (see henrylim.org/LEGOSculptures.html), but the harpsichord was the most difficult and ambitious LEGO project he's taken on so far.

The most important design considerations were strength, efficiency, and durability. The instrument had to be strong enough to support the tension of the strings, as well as be able to withstand the repeated movements required of a keyboard instrument. The final design relied heavily on the larger 2x8 and 1x16 bricks and 6x8 and 6x16 plates to achieve the necessary strength. With the exception of the strings, every single part of Lim's harpsichord is made of LEGO.

"LEGO as a medium holds rather well, not to mention it's heavier than hell on a compoundedly large scale," points out the 33-year-old Lim, who currently has the life-sized harpsichord on display in his living room in Redondo Beach, Calif.

Acoustically, the harpsichord needed to be as smooth as possible, so instead of having the standard LEGO studs exposed, Lim covered these up with smooth-topped flat tiles. The end result is a sound as resonant as LEGO will get.

While musically the LEGO harpsichord leaves a little to be desired — "Tuning it is a bitch," explains Lim — that really wasn't the point. Lim's working harpsichord is a majestic LEGO engineering feat.

—Bruce Stewart

LEGO Harpsichord: henrylim.org/Harpsichord.html

Hear Lim's harpsichord at makezine.com/04/made.

Light Makes Right

Most people would consider the Westfield Megabusa, a 1,000-pound sports car with 175 horsepower, a scarily fast car. But when **Dennis Palatov** finished building his Westfield, it just whetted his appetite for an even more extreme car. He started designing his own, the dp1. His goal: a trackday car with an insane power-to-weight ratio and a top speed of 160 MPH. How to do it: increase power or decrease weight. Palatov ruthlessly attacked the latter, setting the target weight for the car at just 700 pounds.

The rest of the dp1's design flowed from the weight target. Two people weigh more than one, so it's a single seater. A smaller frame is lighter, so he located the engine beside the driver, pulled the ends of the car closer together, and used tiny, 13-inch-diameter wheels. Instead of a drive shaft, the dp1 uses a chain drive like a motorcycle and a lightweight, turbo-charged Suzuki Hayabusa motorcycle engine. The body is carbon fiber (what else?) on a steel space frame. The car has no radio, air conditioning, carpet, roof, trunk, windshield, or place to hang your fuzzy dice. Its lightness doesn't get in the way of high performance, though: it has a full undertray to generate aerodynamic downforce, and all-wheel drive to claw its way out of corners.

The dp1's design process has been just as high-tech as the dp1 itself. The parts were fabricated from CAD files designed by Palatov, and the car's aerodynamics were simulated in a software wind tunnel. He's posted progress reports, enginering drawings, and photos on his blog, and has used LazyWeb (online requests for help) to solve design problems and find specialized fabricators.

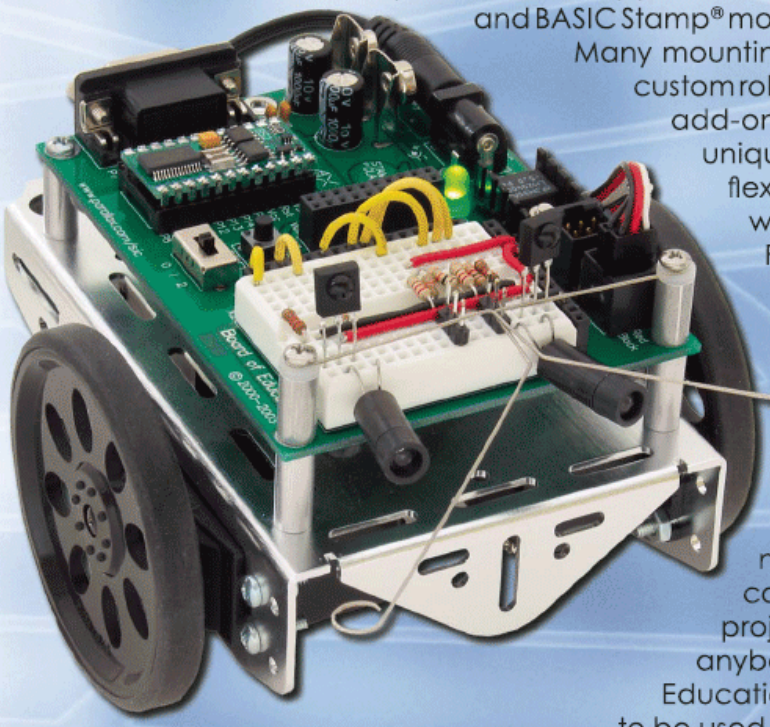
Three years into the project, the dp1 is almost ready to roll. Best of all, Palatov is now a manufacturer. He'll build a dp1 for you, too.

—Bob Miller

» **Dennis Palatov's dp1 build log:** dpcars.net/dp1bld
» **Palatov's design log:** dpcars.randomresearch.com/dp1

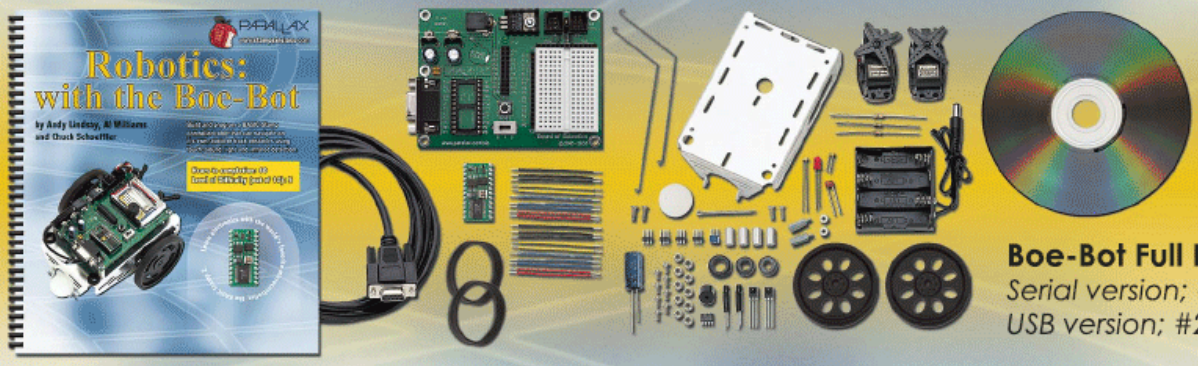
Photograph by Dennis Palatov

Build and Program your own Robot!



The Boe-Bot® robot is built on a high-quality brushed aluminum chassis that provides a sturdy platform for the continuous rotation servo motors and BASIC Stamp® module's Board of Education carrier board. Many mounting holes and slots may be used to add custom robotic equipment or off-the-shelf Parallax add-ons. What really makes the Boe-Bot unique is the BASIC Stamp microcontroller's flexibility of programming when coupled with breadboard circuit construction. Following along in *Robotics with the Boe-Bot*, users quickly learn about embedded projects, from wiring and components to programming and mechanical dependencies.

The Boe-Bot robot takes about 1-2 hours to put together, though each project in the text provides a unique new experience of wiring and source code tuning. Completing the entire set of projects takes 50 hours and is suitable for anybody over 12 years of age. The Board of Education® (and #BS2-IC) may also be removed to be used as your platform for other projects.



Boe-Bot Full Kit - $179
Serial version; #28132
USB version; #28832

To order visit www.parallax.com or call Toll-Free 888-512-1024 (Monday-Friday, 7 a.m. - 5 p.m., PT).

PARALLAX INC

www.parallax.com

Bruce Sterling

EVERYTHING, FOR EVERYBODY, EVERY TIME

Pocket tools. Hand tools. Swiss tools. Multi-pliers. Most tools are designed to fulfill one explicit function, so they have one name and a single efficient form. But multitools are different: they're compact, hingey, clumsy, ungainly, folding, pronged, clickety-clackety.

A multitool haunts the body, in a pocket or purse. Its game plan is to stay with you around the clock, ready for anything. Professionals' tools exist for people who need to get a job done. Multitools are for people who can't define their jobs, and who never stop tinkering.

The original Swiss Army knife of 1891 was built to do four clear things in one package: it opened military canned food, it punched holes in military horse harnesses, it unscrewed Swiss rifles, and it could cut. However, anyone who can do four things with one gizmo naturally wants it to do eight things, or ten, or a thousand. Outside the landlocked Swiss Army, the world market for multitools turned out to be huge, comprehensive, and ever-expanding. Today, there are hundreds of models of Swiss Army knives. They shuffle their features like a Vegas dealer shuffles cards.

Multitools belong, by nature, to ingenious people in conditions of mayhem, where nothing is working right but everything needs doing right away. That means soldiers (of course), but also emergency workers, rescue personnel, explorers, extreme sports freaks, astronauts, survivalists — anybody forced to make do. When everybody's forced to make do, then multitools appear all over the place.

The Leatherman pocket tool was invented by an American engineer wandering through Europe and Iran. Tim Leatherman, harassed by broken rental cars and malodorous foreign plumbing, created a multipronged super-interface for a world of SNAFU. A Leatherman offers a single handful that is pliers, a wire cutter, knives, a saw, a file, scissors, screwdrivers, et multiple cetera — but it's not a mere set of implements. It's a state of mind.

Once a Leatherman is in the user's hand, it's very likely that the so-called "screwdriver" will become a chisel, or the stainless-steel butt of the thing will be used as an impromptu hammer. The specific design of the sub-tools within a multitool is well-nigh irrelevant. Multitools aren't built to solve specific problems; instead, they provoke ingenuity. It's hard to give up and despair with a Leatherman, because the thing offers such a cornucopia of possible actions. Given time and determination, you could escape jail with one. Or perform brain surgery. Or construct an entire castaway geek desert-island utopia, like in Jules Verne's *Mysterious Island*.

> "Multitools are for people who can't define their jobs, and who never stop tinkering."

Multitools are a postmodern technology. They offer chances to reframe the issue, to think outside the box, to redefine contexts, and to do a rapid, crappy job at patching up a makeshift hack. It's not the ultimate truth, but it might last long enough for the user to cash in quick and run away!

Multitools lack purpose. They're all about repurposing other stuff that has lost or misplaced its purpose, or that has the wrong purpose at some critical time, or that has succumbed to a general disaster where all human purpose has been crushed. The original multitools were super tough; they were created for would-be omni-competent guys who were really up against

Illustration by Kirk von Rohr

the wall. A Leatherman has a 25-year warranty. Its plier jaws can soak up 600 pounds of crushing force. The Swiss Army knife (SAK) outfit is a century-old model of socialist lifetime employment. The SAK is not a military weapon, but a force for good in the world, like the Red Cross.

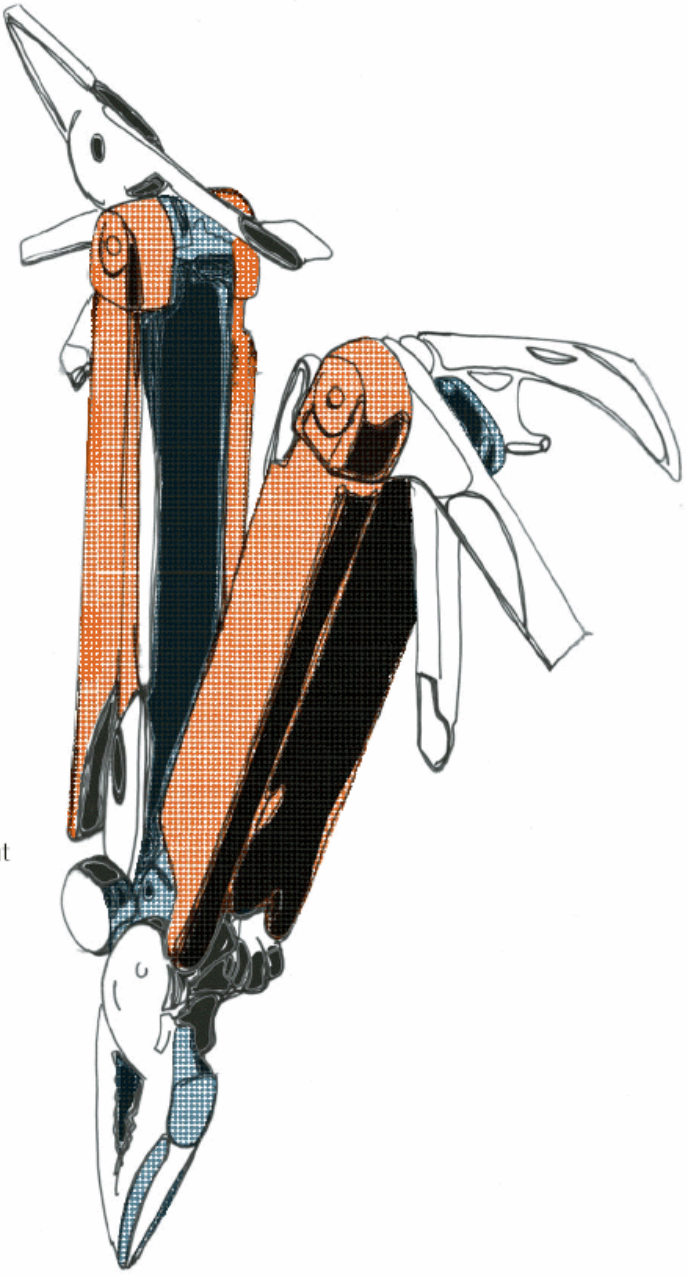
However, as it becomes obvious to people that no real-life technology can ever actually "work," multitools become the people's friend. A certain pop decadence is setting in. Today, there are Harley-Davidson multitools that let bikers pretend to be real mechanics. Caterpillar multitools strut their stuff like bulldozers. The Gerber ProScout has a "camouflage finish." (Hey, what use is a tool you can't see?) The Frost Cutlery Dale Earnhardt #3 Handi-Mechanic couldn't stop the racecar hero from meeting his own high-speed doom. The Gerber Terminator III: Rise of the Machines multitool is a movie tie-in product; it's from a dystopic world where angry hardware kills off the puny humans.

They're getting skinnier — with credit-card slip-cases — and fatter, like the Leatherman Surge, that chromed SUV of multitools, too big to tote handily but packing enough torque to crack a Swiss Army knife like a walnut. They're also adding on a host of extra twiddly bits — not just the removable SAK toothpick, but drill bits, screwdriver tips, chromed sockets, plus the newfangled LED flashlights and flash memory plugs. They're appearing in flashy chrome yellow, and red, and hot pink, and with finger-friendly rubber inlays. The multitool wars are a nail soup of product profusion, from Victorinox, Leatherman, Ka-Bar, Kershaw, SOG, Gerber, Seber, and now the Chinese are getting into the act, with a swarming host of dirt-cheap fakes and downmarket workalikes! Where can it end? Every one of these things is a mobile puddle of improvisation!

> "Tim Leatherman, harassed by broken rental cars and malodorous foreign plumbing, created a multipronged super-interface for a world of SNAFU."

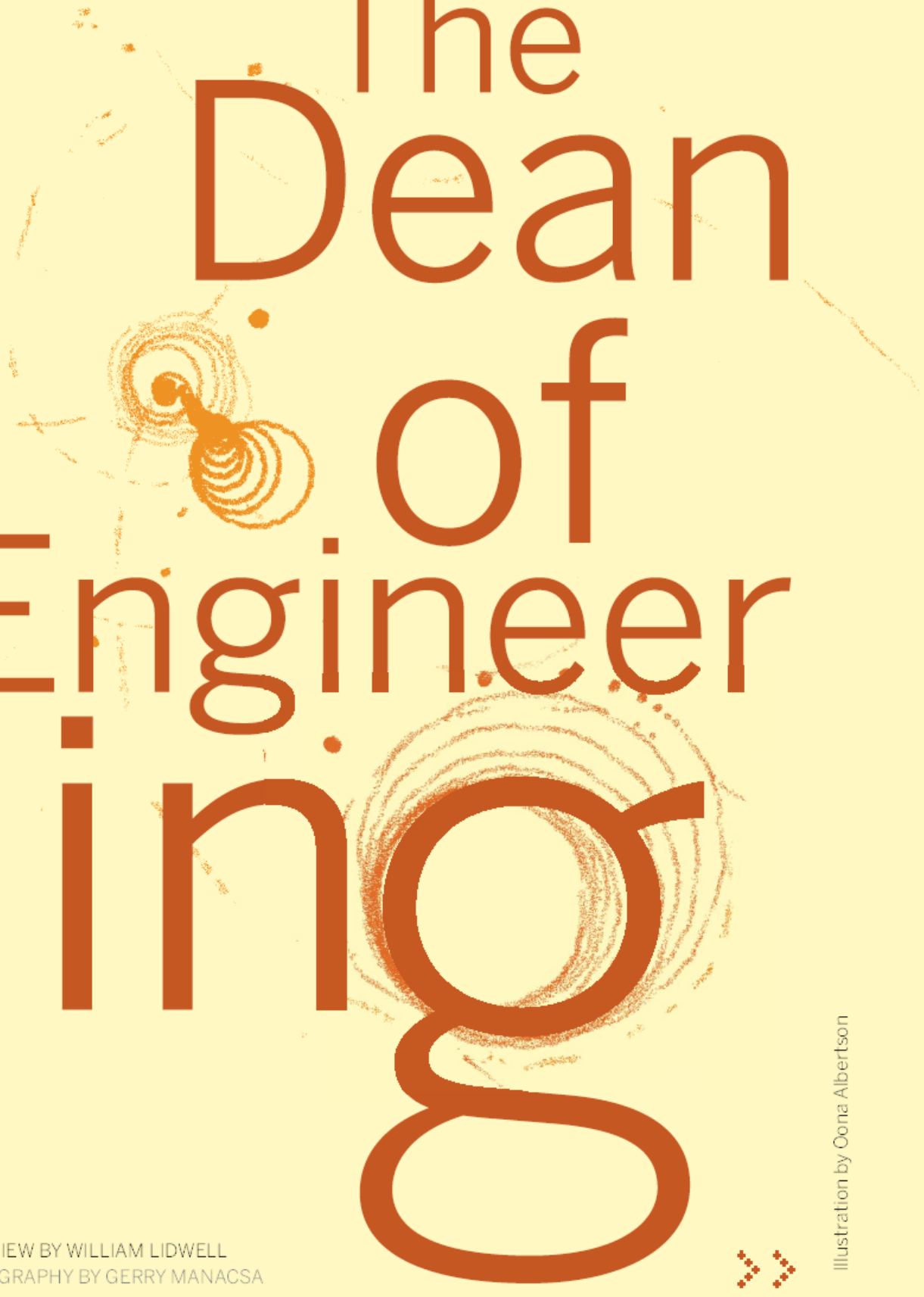
Then there's the dark side: the mischief factor. Since a multitool can do almost anything, it's impossible to design a harmless one. The Transportation Safety Agency has been convinced by grim example that anyone can use small blades to make jets smash skyscrapers. Therefore, they arrest all multitools on sight. You can buy the detainees on eBay now, in heaps, offered for resale by the government; these extremely personal devices, the treasured darlings of pockets, packs, and purses, stripped away from their embarrassed owners and cynically sold off in buckets-full. That's such a shame but ... wow! Six big Swiss Army knives for just six bucks?! Imagine what you could do with that!

The more you fix, the more you get to fix.



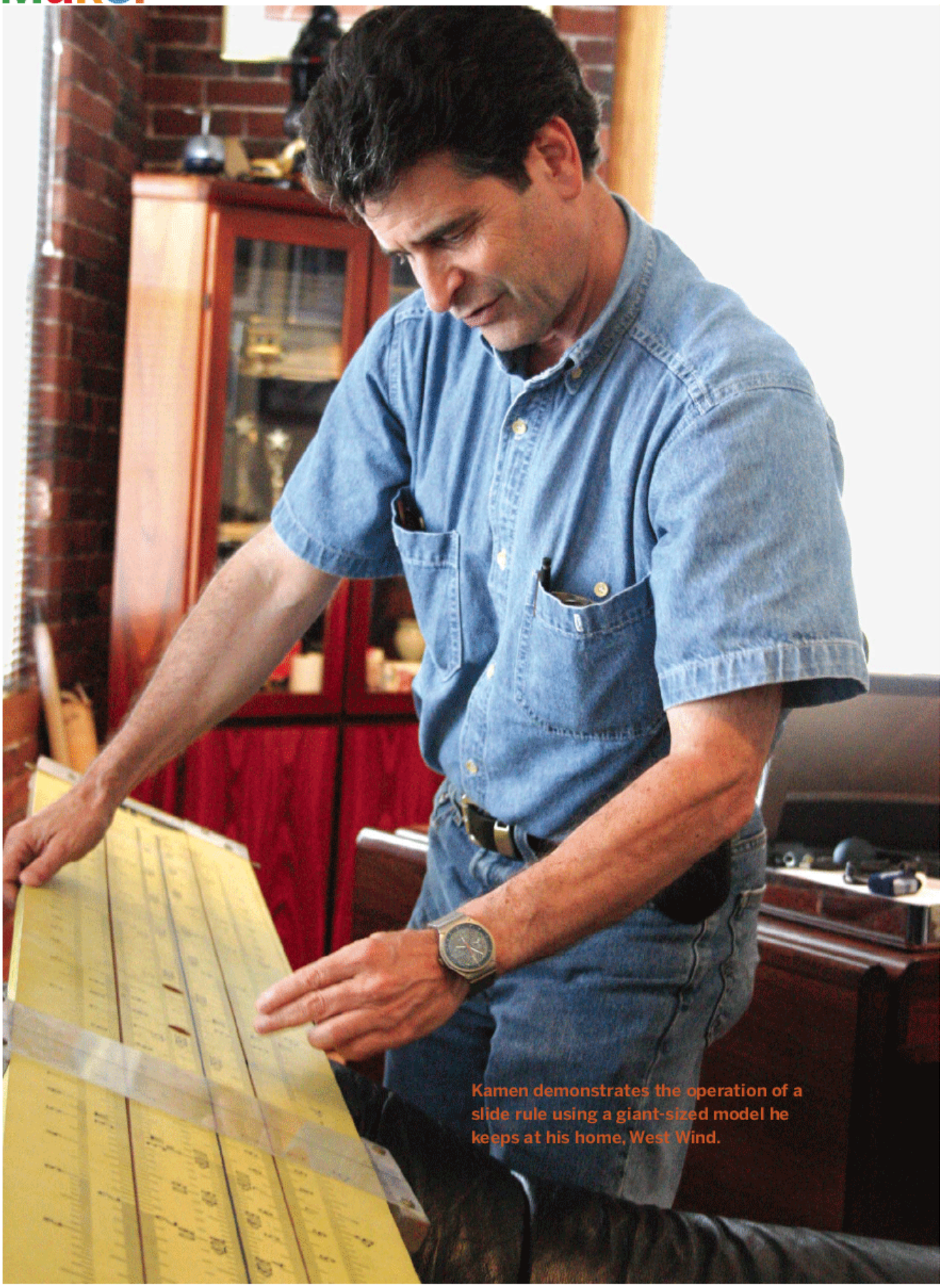
Bruce Sterling (bruce@well.com) is a science fiction writer and part-time design professor.

The Dean of Engineering



INTERVIEW BY WILLIAM LIDWELL
PHOTOGRAPHY BY GERRY MANACSA

Illustration by Oona Albertson



Kamen demonstrates the operation of a slide rule using a giant-sized model he keeps at his home, West Wind.

Dean Kamen holds more than 150 patents on revolutionary inventions

ranging from portable dialysis machines to sophisticated mobility devices to highly efficient and compact Stirling engines. In addition to numerous honorary degrees, Kamen has received such honors as the Lemelson-MIT Prize, Heinz Award, Kilby Award, and the National Medal of Technology. A tireless advocate for science and technology education, Kamen founded FIRST (For Inspiration and Recognition of Science and Technology) to encourage kids to pursue careers as scientists and engineers, as well as to reset societal values so that people aspire to be thinkers and inventors. "Our culture celebrates one thing: sports heroes," he says. "You have teenagers thinking they're going to make millions as NBA stars when that's not realistic for even one percent of them. Becoming a scientist or an engineer is."

Armed with a crack photographer and an iPod recorder running iPodLinux (see *MAKE 02, page 135*), I met with Kamen at his company in Manchester, N.H., and at his home in Bedford, N.H. His company, DEKA Research and Development Corp. (DEKA from DEan KAmen) is located in a series of renovated mill buildings on the shore of the Merrimack River. The buildings are simple and nondescript on the outside, revealing little about the kind of work that goes on inside. The interior, by contrast, is dot-com office meets Monster Garage. It is a casual environment adorned with tools and technology, testaments to past and present inventions, and a wide variety of exceptional artwork created by Kamen's father, one of the legendary EC comic book artists, Jack Kamen. After a few hours at DEKA, we moved to his home, called West Wind. Built around an 87,000-pound steam engine once owned by Henry Ford, West Wind is as much homage to innovation as it is a living-work space. Designed and built by Kamen in 1997, West Wind features multiple workshops, an extensive library, helicopter hangar, and a sufficient number of interesting gadgets and gizmos to qualify it as a sort of technology museum.

Dressed in his customary cotton work shirt and Levi's, Kamen wasted little time in getting things started: "You know how a slide rule works?" he asked without context or warning. I sheepishly confessed that I didn't. "Slide rules were a bit before my time," I said. Clearly dissatisfied with my response, Kamen sprang from his chair and quickly located a six-foot slide rule lying against a wall in his office. He then proceeded to show me how to use this giant slide rule to perform all manner of calculations, simple and complex, and frequently inserted commentary on the design elements that made the slide rule work. Kamen was never condescending or mean-spirited during what turned out to be a 30-minute unsolicited exposition on slide rules. His explanation had the enthusiasm that you have the first time you learn something new and want to share it with others, though this was surely an explanation he had given hundreds of times. Suffice it to say that I now have a deep and unanticipated appreciation of slide rules.

Much of the interview went this way. I came in a skeptic of the Segway. I left exploring financing options for the new cross-country model. Can a Stirling engine really save the world? I came in thinking the notion ridiculous. Now I am tinkering with Stirling engine models. One thing is for certain: Kamen's unique mix of world-saving idealism and inventive genius makes for a very addictive confection.

It is said that Edison embraced enlightened trial and error to achieve the majority of his breakthroughs, whereas his contemporary Nikola Tesla worked through everything in his head before getting his hands dirty in the shop. How would you characterize your approach to innovation relative to Edison and Tesla?

Unfortunately, I would put myself closer to the Edison end of the continuum: the tinkerer, the get-your-hands-dirty and keep-screwing-with-it-

until-you-make-it-work side. I am much more in awe of people like Galileo, Newton, and Einstein than I am of the tinkerers who just kept working with the tools and technology of their day until they got something to work. I am just in awe of those people. I wish I was one of them, but it's not in the cards. So I work hard to succeed at the other end of the scale.

This relates to what you call "frog kissing" in your research and development?

Yes. Engineers are taught to think and work in a risk-averse way: let's avoid making mistakes, let's only do what has been documented to work, let's play it safe. Well that's great, but it will never result in significant innovation. So I try to get my team to try things that aren't likely to be successful — i.e., to kiss a lot of frogs. The princess went out and took a chance. She kissed a frog. Most of the time when you kiss a frog, you end up with warts. But every once in a while, you kiss a frog and you get a prince or princess. It is OK to get warts. It is OK to fail. You laugh at it, learn from it, and move on. And then, every once in a while, you'll kiss a frog and get an iBOT, or a Segway, or a dialysis machine. And that's a big deal.

I understand that some of your engineers built you a replica of a Chinese south-pointing chariot as a gift. What is the story behind that?

Every year the people at DEKA secretly go off and build a spectacular holiday gift for me. And since I have an incredibly talented team of engineers and designers, and an extraordinary machine shop that can literally make anything, they come up with some truly amazing things.

Well, everyone at DEKA has heard me talk more than once about an ancient Chinese invention called the south-pointing chariot. Imagine you have a two-wheeled chariot drawn by horse. Each wheel of the chariot is connected to a differential, both of which turn a central shaft a variable amount as the chariot turns. A pointer is connected to the central shaft. The gears are configured to turn the central shaft so that the pointer always ends up pointing the same way as if you had gone straight. So you could look at the pointer and pull yourself back on course. It is an incredible piece of technology — literally an analog computer, a summing machine. It is a great piece of technology except for one thing: it is well documented in history that the Chinese had knowledge of lodestone [iron] well before they were building these chariots. They knew that if they took a little piece of lodestone and put it on a cork in a bowl of water, it would always float to the same side of the bowl. Today, we call this a compass, but they were building these hugely complicated chariots to tell them which way they were going, rather than using something simple and elegant like a compass. So when we evaluate possible approaches to a technical challenge at DEKA, the engineers each have a passion to use their area of expertise to create a solution. I'll look at these solutions and ask, "It's great, but is it a south-pointing chariot?" Meaning: are we reveling in a particular technology that we love, or did we really apply the best available technology to solve the real problem?

So one year, the gift that they made me was a beautifully crafted, stainless-steel-geared south-pointing chariot. I pulled it around and the pointer always pointed in the same direction. It was a marvel to watch. Then they told me, "Dean, go squeeze that little jack-in-the-box on the pointer." I did, and out popped a doll of Albert Einstein with a compass pinned to his chest. And they said, "Dean, we want you to know that we really do listen to you. And though we love technology, we really do try to separate our love for the technology from the objective of bringing the best solution to the problem." DEKA's goal is not to build monuments to engineering. Our goal is to bring the best available solution to solve important problems. We use the lesson of the south-pointing chariot to help us keep our perspective.

South-pointing chariot built by DEKA engineers and given to Kamen as a Christmas present. It bears a placard that reads, "In Case You Ever Lose Your Sense of Direction. From the Technology Zealots of DEKA. Christmas, 1996."

The Segway is a beautiful piece of design and engineering, no doubt. However, it competes with some pretty simple and efficient alternatives, like scooters, bicycles, and walking. Do you ever wonder if, with the Segway, you created a modern-day south-pointing chariot?

I worry about this with every product we make. To me, a south-pointing chariot is any product that, even when it was first conceived, was not the best solution to the problem. Right now, people use cars for most of their travel for anything beyond a few hundred yards. Most people that we know won't walk one or two miles to get somewhere — they just won't. To walk a couple of miles would take a half-hour to an hour, and we live in an era where time is compressed and so valuable. Over 50% of the car trips in the United States are less than three miles. The average speed within the city limits between any two points within the 20 largest cities of the world is less than 9 mph. Then why does everybody use his or her car to get around? Because walking is less than 2 mph!

So what if you could give people in cities an alternative to walking for distances greater than 100 yards and less than a few miles? People generally don't walk, because even in a congested city, walking is four times slower than taking a cab. But, what if they could get on a Segway and cruise from start to finish at 8 mph? That's the same speed at which a taxi travels. And, it's cost effective, energy efficient, environmentally friendly, and fun. In highly dense urbanized areas where buses and cars do not work well — they have only been used to fill the gap for lack of a good alternative — the Segway shines. I would argue that a car, when used in the city, is in fact a south-pointing chariot. If a better solution comes along in the next 20 years to address the rapidly worsening inner city transportation problem, then the Segway may become a south-pointing chariot. But so far, I have not seen a better solution.

So what about a bicycle? It is cheap, reliable, and inexpensive.

A bicycle cannot mix effectively in a congested pedestrian environment. It can't move at walking speeds with humans, then stop, back up, and spin around. I think bicycles are wonderful. And there are hundreds of millions of them out there. I don't think that they compete with the Segway because while they have many advantages at higher speeds and longer distances, they are poor at low speeds involving lots of stops and tight turns. By contrast, a Segway is designed to use the same infrastructure that pedestrians use, occupy the same footprint as a pedestrian, be highly flexible, mobile, and safe, while increasing the user's transportation efficiency 300-400%. I think that's pretty terrific.

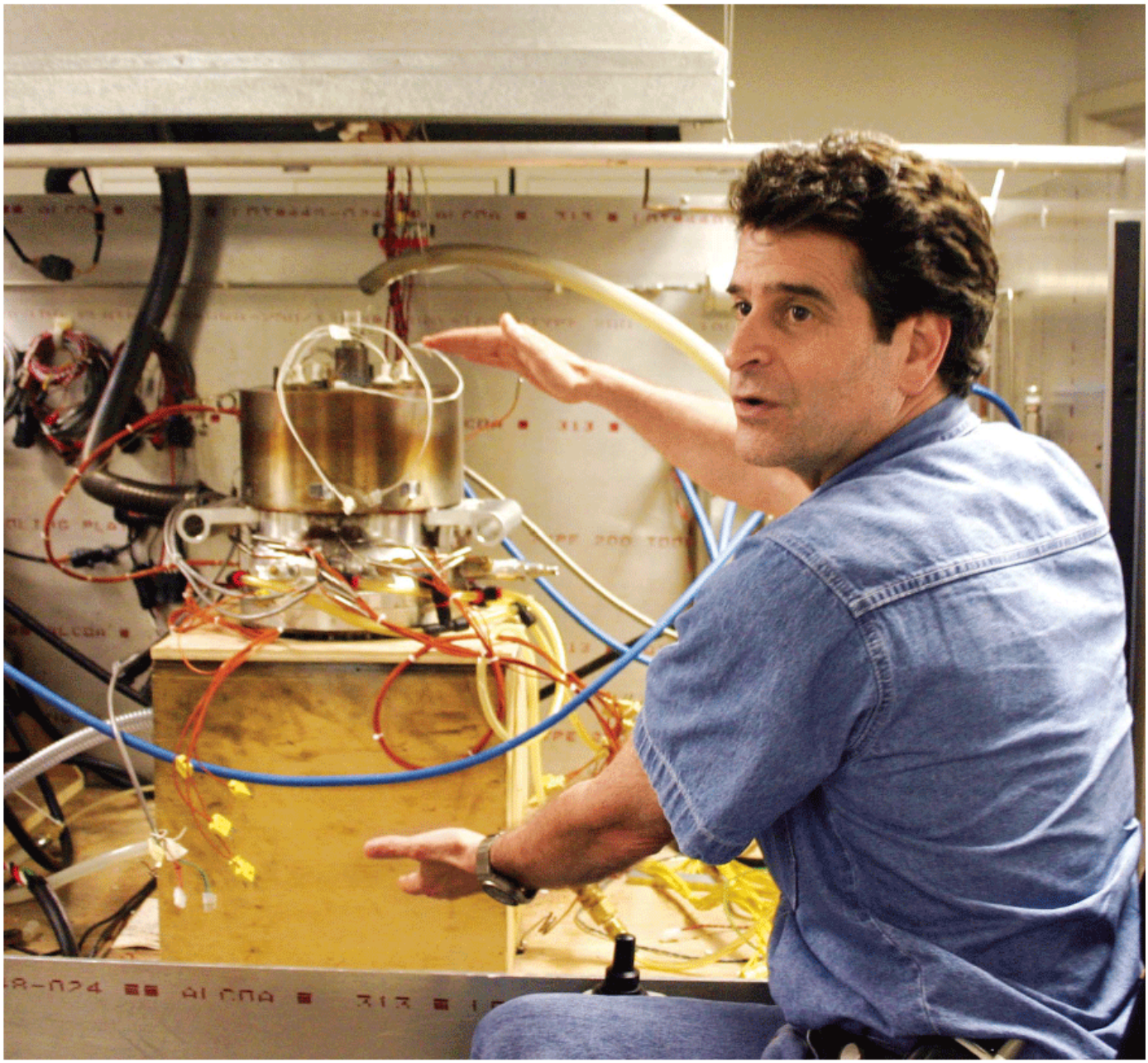
The AutoSyringe, Segway, iBOT, Stirling generator — all of these products addressed nuances of problems that nobody else seemed to recognize. For example, the iBOT enables the wheelchair-bound to interact with people at eye level, traverse stairs and uneven terrain, and be remotely operated so that its owner can navigate it into a vehicle. How do you attain such a deep understanding of the problems you seek to solve?

I try to understand the basic laws of nature. Beyond this, I do very little research as to what the product should be. You would never get the iBOT by doing research on wheelchairs. If you do "product research," the product that you end up with will be similar to what already exists. For example, if you went out to people who make wheelchairs and said, "I want to make the next great improvement," they would typically conduct focus groups with people who use wheelchairs. And these wheelchair users, operating within the context of their existing wheelchairs, might ask for things like a new cup holder. They saw a great cup holder in a minivan, and realized that their wheelchair didn't have one. So they ask for a cup holder, or some other incremental improvement. You have to start with

Kamen twiddles an oscilloscope in his home electronics workshop.

"If I could ask God for one thing, I would ask for assurance that a problem is solvable given existing technology, tools, and resources."

"I try to understand the basic laws of nature. Beyond this, I do very little research as to what a product should be."



basic questions: if this person is now missing this amount of functionality, is there some alternative to a wheelchair that is both dramatically better and not prohibited by the laws of physics and the current state of engineering and technology?

Focusing on the problem in this fundamental way allowed us to understand that wheelchair users need to have the same small footprint on the ground as you and I so they can navigate around areas and obstacles as we do. They need to have their eyes and hands at the same level as a standing person, so they can see over counters and get things down from shelves. They need to be able to get water out of a faucet. And so on. In order to achieve any of these things, we looked at how fully functioning humans do it. They do it by being dynamically stable — by constantly adjusting themselves to maintain balance. Balance is a prerequisite condition to living in a world that is architected by people who walk around balancing themselves. So we decided to forget about wheelchairs and focus on the real problem. The real problem isn't locomotion — wheels solve that problem fine. The real problem is that these people lost their ability to move around while also physically elevating themselves within a small footprint, which requires dynamic stability. Solving this problem would dramatically improve their lives.

Rumor has it that you don't sleep much. What keeps you up at night?

Not knowing if a problem is solvable. If I could ask God for one thing, it wouldn't be for a solution to a particular problem — that would make life boring. I would ask for assurance that a problem is solvable given existing technology, tools, and resources. I don't want answers or clues, just assurance that a problem is solvable. If I go to bed frustrated, it isn't because I didn't solve a problem; it's that I don't know whether we are chasing some windmill over the horizon or whether we are learning and making real progress. I get emotionally stuck between two conflicting lines of thought: [1] I shouldn't give up at this. Giving up is for people with no courage, no vision, and no conviction. You don't give up on an important problem — ever; and, [2] I have failed and failed and failed. Am I just being stubborn? Stupid? People are tired and frustrated. We don't seem to be making progress. Am I just not quitting because I am in denial?

Then I think back on past projects where we were very close to quitting, but we went just a little further and had a breakthrough. It really gives me a chill to think how close we were to quitting and what would have been lost. And then other times, we'd spend a year or two, spend a million dollars, and fail to solve a problem. I'd think to myself, "I should have quit over a year ago. I knew over a year ago that this wouldn't work. Look at the human misery and anxiety and energy we put into this to just shut it down. We could have shut it down over a year ago."

An unexpected success after you are that close to quitting really makes it hard to quit anything else. It's like trying to disprove the existence of aliens. You can't. So how can you prove to yourself that you can't do something? Especially because once in a while, one that you didn't think you could do, you do! It's that "once-in-a-while" event that distorts your judgment and perspective, so then you really start to second-guess yourself. For example, we are working on a system to bring potable water to 20% of the population of this planet. For 60 years, huge international organizations such as the World Bank and the United Nations have tried and failed at this. Yet, I think a few people here at DEKA can solve it. Part of me thinks, "You're nuts!" But another part of me thinks, "You can do this. The world needs this. Be courageous."

DEKA is home to many Stirling engine prototypes. Here, Kamen is discussing the issue of the size-to-energy-density problem common to Stirlings, and how this model makes significant inroads to overcome this problem.

Read more of William Lidwell's interview with Dean Kamen at makezine.com/04/interview.

CHINESE INGENUITY

By Tim Anderson

LOOK FOR THE TECHNOLOGY OF THE FUTURE IN THE OLDEST CIVILIZATION!

I recently took my camera on a trip to the coast of China near Taiwan. Quanzhou was described in glowing terms by Marco Polo. It was the terminus of the "Maritime Silk Road" of trade between Far and Near East.

The fishing junks I saw in the walled harbor of Chongwu were similar to a reconstruction of a 1200 year old ship unearthed near the Maritime museum: sculpted eyes at the bow to see the way, water-tight bulkheads, wings at the stern, kick-up rudder, transom bow and stern. Some have a socket to step the mast for sailing, but small gasoline engines now power most of these boats.

Besides their obvious beauty, these boats impressed me with how smoothly they cut through the waves and the good speed they achieved with their little 6hp "Mao" engines. I saw one sailing into a sharp chop and the sail was very still, which is a sign of a good sailing design.

Many of the boats I came across were at war with worms. Gribble and Teredo, the boring worms, feast on wooden boats in warm water. Walled harbors are built into the mouths of rivers. Fresh water from the river kills the worms, which are saltwater creatures. These boats are careened (left high and dry) with every tide. The drying and oxygen that enters the planking kills the worms, too. The tung oil and lime mixture is impervious to worm larvae.

Paint doesn't appear to adhere well to these boats. Possibly they are soaked with an oily vermi-toxic compound prior to painting, or possibly they are made of tropical hardwoods containing oils naturally toxic to the worms.

Photography by Tim Anderson

Need a boat and all you've got is conduit and styro-foam? Just weld a boat-shaped conduit cage around your foam and head out to sea.

No boat built of temperate species can survive in tropical seas without a coating of antifouling (toxic) paint, hence the custom of every wooden boat being the same green color below the waterline.

Bamboo scaffolding lashings are made with a seemingly weak plastic fibrous material. One strand is easily torn off with a thumbnail, but a few turns of it are apparently plenty strong.

CONSTRUCTION

An unbelievable amount of construction goes on in China *(right)*. The scaffolding is lashed bamboo. Way up in the air on two bamboo ladders tied end-to-end, a man welds with one hand, hanging on with the other *(far right)*.

Construction workers wear bamboo wicker hard hats like this. They cost about 80 cents and are surprisingly sturdy. Probably fine to stop a falling wrench. Motorcyclists also wear them, but they lack padding at the back of the head.

BIKE MODS

Underside of another motorized rickshaw showing frame structure and power transmission *(above)*. This one has an air intake hose going to a larger air filter canister. A layer of shoe foam insulation makes a load of ice blocks last longer.

Bicycle sidecar rickshaws carry materials and people across town *(above)*. There's no limit to what one of these can carry — a load of logs or granite blocks, or a dozen school kids. The cargo capacity of these rickshaws exceeds any I've seen in the world. I saw one bike with a small motorcycle engine under the sidecar. It used an IV bag to drip water on the motor to keep it cool going uphill on a hot day.

Sometimes a motorcyclist will put out his foot to give one a power assist up a hill.

SHOE FOAM FLOATS

Half the world's running shoes are made in this province *(left)*. This dinghy is made from shoe foam. I saw people carrying these bundles of foam blocks on their bicycles and didn't realize they were dinghies. This man paddled to shore from his boat using pieces of plastic flotsam as paddles. He bobbed up and down on the waves as they smashed against the seawall and then climbed up with help from his wife.

Tim Anderson, founder of Z Corp., has a home at stuff.mit.edu/people/robot/home.html. When not ice-kite-butt-boarding in a rooster-crested motorcycle helmet, he can be found all over the world using and documenting heirloom technologies.

HOW TO MAKE A FILM, WITHOUT MONEY, WHILE BEING BOMBED

Being a political idiot has its advantages.

By Jasmina Tesanovic

Back in 1999, while my hometown of Belgrade was being blown up by 19 different countries, I was writing and uploading a diary. One day, a producer from German national TV phoned me. She'd been reading my online journal (*Diary of a Political Idiot*) and thought it might make a good film.

Unfortunately, since her country was so busy bombing mine, she couldn't give me any practical help. However, she thought that if my film somehow got made, she could promote and distribute it, and show it at film festivals.

Immediately, I said yes! What a great occasion to make a meaningful European art film, without those tiresome commercial restrictions, backers, producers, and other artistic brakes that every true cineaste fears!

First, I found a cameraman who had somehow survived Bosnia with his equipment intact. He was a Serbian CNN stringer, which was perfect since everyone in 1999 thought that wars could only be won by and/or through CNN.

Because everything around me was a "military secret" under the Milosevic regime, I had no "right" to shoot a film at all. So I declared my own life to be the intellectual property of the world-famous Belgrade cinema archive. Once the archivists had given me the all-important movie permit, the military authority was even obliged to help me shoot (for example, while the river bridges on the Danube were being blown to pieces).

Soon a new, daily problem emerged: getting electrical power. NATO efficiently bombed the power plants on a regular basis, so we ran from one power-plant coverage area to another. Conveniently, the NATO bombing schedules were regularly published by CNN.

Local volunteer/citizen voltage hackers soon learned how to climb broken power poles and reconnect the wiring, and we learned how to follow them and plug in our equipment. This meant that my film's plot and scenery were strictly associated with available wattage.

Most of the film's extras were hobos, derelicts, and animals, because nobody else wanted to show up every day for a project that might well have no tomorrow.

After 19 days of hectic shooting, our German sponsor impatiently asked for a final edit, concerned that the war might end at any moment and we would lose our target audience on German TV. So we had to make do with the editing, too. A local Andy Warhol fan volunteered for the job. His film studio had been heavily damaged by a famous missile raid on the Serbian national TV building,

Images from the film *Jasmina's Diary*

but he'd managed to turn some semi-functional machinery into a private studio of his own. The film's editing was patchy, but at least the price was right.

With a completed film, we now had the final hurdle: smuggling the product through the military and border customs into an enemy country.

Two blondes in miniskirts, with two underage kids, jumped into a car full of Walt Disney cartoons. They pretended to be heading to Budapest for a "visa arrangement." One of the Disney films was my diary film. The customs officers were too lazy to screen a whole bunch of kids' cartoons.

So my film and I ended up at the Venice film festival, together with Antonio Banderas, Melanie Griffith, Nicole Kidman, and Tom Cruise.

Eventually, my film, dubbed into German and titled *Jasmina's Diary*, was shown to 1.5 million TV-watching Germans. It still airs, every once in a while, in various corners of the world.

In 1999 Granta 67 published an excerpt of Tesanovic's The Diary of a Political Idiot. *You can read it online at* granta.com/extracts/494.

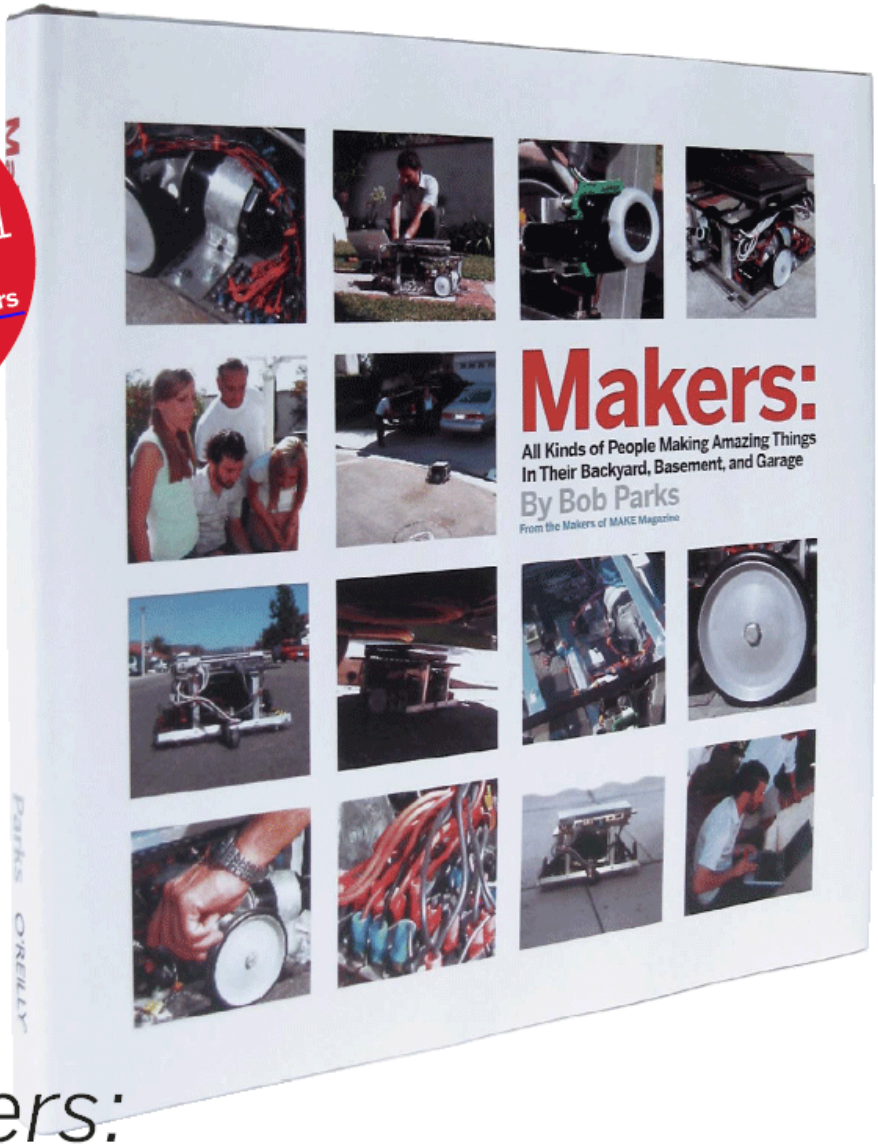
Jasmina Tesanovic's online journal, ***Diary of a Political Idiot*****, became the basis of an autobiographical documentary and a book, published by Cleis Press in 2000.**

Jasmina Tesanovic is a writer and filmmaker from Belgrade, Serbia.

The Perfect Gift for Makers, Aspiring Makers, and Those Who Love Them

Available December 1

Visit makezine.com/makers



Makers:

A beautiful hardbound book celebrating the creativity and resourcefulness of the DIY movement. Author Bob Parks and the editors of MAKE profile 100 people and their homebrew projects—people who make ingenious things in their backyards, basements, and garages.

Technologies old and new, used in service of the serious and the amusing, the practical and the outrageous. *Makers:* explores both the inventions and the characters behind them in living color. Retail price: $24.95.

O'REILLY®

makezine.com/makers

MAXIMOOG

A tribute to the man who gave us so many good vibrations.

By Jimmy Guterman

RIP Bob Moog, 1934-2005. The electronic music pioneer died in August of a brain tumor at age 71.

If you knew Bob Moog, chances are you still associate him with the synthesizers that bear his name (which, by the way, rhymes with "vogue"). He started experimenting with his landmark electronic-music instrument while at a Columbia-Princeton joint program. By 1963, he had developed a machine that could be played in real time, and by the late 60s, he'd developed enough of a following among musicians that his synthesizer was being featured on hit albums by everyone from the Monkees to Wendy Carlos.

Those early analog synthesizers were modular, controlled by an almost infinite variation of patch-cord combinations, but the devices went mainstream in 1971 with the introduction of the Minimoog. The device's leap in ease and functionality made new sounds and possibilities available to non-gearheads. That's when art rockers became Moog's most reliable and popularizing clients, folks like Rick Wakeman of Yes and Keith Emerson of Emerson, Lake & Palmer. It's a period well documented in the delightful short film, *Moog*.

Moog's synthesizers led to an explosion of the imagination and were stuffed with DIY add-on opportunities. Unfortunately, much of the most popular music produced with synthesizers was more interesting technically than musically. As someone who has written books about Jerry Lee Lewis, the Sex Pistols, and Bruce Springsteen, I'm not the sort of guy who adores the flatulent art rock that made the Moog synthesizer famous. But blaming Bob Moog for the not-so-great music made on his great invention is like blaming Jimi Hendrix for Yngwie Malmsteen. You can't control who will be influenced by your genius work. And, to be fair, Beck and others have made stellar records with Moog synthesizers at the center.

In recent years, Moog circled back to his first love, the theremin, the only instrument that makes music out of thin air. I've been a semi-competent theremin player for several years now, so it's been a treat to see the most famous maker of theremins this side of Leon Theremin return to his inventing roots. The theremin's most famous contribution to pop music is in the Beach Boys' "Good Vibrations."

Moog built theremins for fun, going back to the Truman administration. After describing how to build one in *Electronic World*, he returned to manufacturing and selling kits and fully made theremins in the 90s; even the fully constructed models come with notes on how to "hotrod" your theremin, soldering iron in hand, showing that Moog's DIY ethic was still with him. As he met his final challenge, I suspect it served him well.

Jimmy Guterman (guterman.com) is the editor-in-chief of *Forrester* magazine. His most recent book is *Runaway American Dream*.

Moog figurine designed by Archer Prewitt for Press Pop Gallery

The Playful Scientist (And Where to Find One)

Call me crazy, but just don't call me mad. By Saul Griffith

This month, I've been ranting to everyone I know about the term "mad scientist." I don't like it. I feel like it is used to trivialize logical, rational thought and to undermine scientific results and the wonderful pursuits carefully adding to the sum total of human knowledge.

My friends tell me that I might be a little overboard on this one, and that "mad scientist" is a playful satire or fictional stereotype. They then argue that rather than a campaign against the use of "mad scientist," I should encourage its reclamation in the same way the gay community has reclaimed "queer" as a positive term.

"Playful scientist," I say, would be a term well worth reclaiming, but "mad" is a terrible adjective in an era where conservatives seem to be making ground in undermining such things as education on the theory of evolution. I blame comic books. No — wait a second — I blame great literature like Shelley's *Frankenstein* or Marlowe's *Dr. Faustus*.

Perhaps I should blame myself. I kitesurf. It's a fantastic sport, kind of like waterskiing behind a jumbo jet, as I'm wont to say. Pre-2001, it was the domain of cranks and lunatics who experimented with the immature equipment of a new sport. (There, you see! I just used the words "cranks and lunatics" — but really, I meant it affectionately.) Prior to the highly commercialized industry that kitesurfing is today, anyone who did it had to build/modify/repair the equipment. It was wonderful; you were always happy to see another "freak" at the beach trying to jerry-rig something safer or faster or bigger than the last thing they tried. It was great community.

Then the mad scientists of the early days were replaced with adrenaline junkies who consumed the commercial gear and thought that anything noncommercial was tantamount to heresy. The crew of jokesters I surf with were vilified at the beach by people who arrived in shiny SUVs with brand-name stickers on everything they owned. "That won't work." "That's too dangerous." I gave up on giving them my rant on why basic hydrodynamics showed that the fins on their shiny boards they thought were giving them lift were really just giving them drag. I stopped

> "Seek out the weirdoes — the guys and gals who believe that having fun is the goal and hacking stuff is the surefire route to nirvana."

Photograph by Tim Anderson

Kitesurfing: The sport of playful scientists. "It's like waterskiing behind a jumbo jet."

explaining that a rectangle of $10 plywood would be more effective than their $500 carbon fiber, advanced, PCB-impregnated dolphin killer.

So now I go to the less popular beaches and seek out the weirdoes — the guys and gals who believe that having fun is the goal and hacking stuff is the surefire route to nirvana. Failing is fun, after all. Try something new, and even if it doesn't work, it's likely to be hilarious. I was reminded of this just yesterday when I met two new freaks. One had a pair of sunglasses with only one lens. Unperturbed, he just kept going, looking like a one-eyed pirate amidst the East Bay fog.

His friend farms eBay for used sports stuff to modify into wind-powered car-park dragsters, and we had an excited discussion involving the obvious link between jet boats, wind-surfing sails, paragliding lifting winches, and what we should do next weekend. I could tell he was my kind of freak because he'd recently sold his Porsche in favor of a VW transporter with a pop-top roof conversion and retrofitted water cooling. "It's way more fun than the Porsche, and it said. The best thing about meeting the weirdoes is that the conversation works to communicate information first, NDAs later, if ever. It's all about sharing each other's excitement and experience.

There I go again, guilty as charged, characterizing myself and my glorious peers as eccentrics, cranks, weirdoes ... "mad scientists."

So let's go with "playful scientists" instead. Where do you find them? Burning Man is an obvious repository, but there are events every weekend populated by the sort of people you want to know. Oshkosh's yearly AirVenture has all the homebuilt airplane nerds that you could ever want to meet. Keep your eye out for bicycle and car swap meets and carnivals — always a rich source. Try emailing or calling people who built some cool thing that you found on the web. Odds are that they want you to come over and meet them; that's why they put it up on the web. A few weeks ago, I learned an enormous amount by visiting the Alameda workshop of a custom bike frame builder. I've never seen so many handmade jigs and working Bridgeports in such a small space. I guess I'm coming around to the opinion that it's time for everyone to come out of the closet and celebrate being playful scientists. We may be crazy, but we are not mad.

Saul Griffith thinks about open source hardware while working with the power-nerds at Squid Labs (squid-labs.com).

LET THE X GAMES BEGIN

If you've ever wanted to try making a video game, here's your chance. By Alex Handy

For an engineer, designing consumer electronics is a nerve-wracking endeavor. Years of preparation and research are required to create and manufacture new equipment, and nowhere is this more evident than in the video game market. Zero hour for the EE ninjas of the video game world is looming on the horizon, as Microsoft, Sony, and Nintendo prepare to launch next-generation gaming hardware for the 2005 Christmas season.

Independent video game hardware designers are a dying breed, however. The three big game companies have something of a monopoly on the talent in this limited pool, as evidenced by the relatively small market proliferation of fresh video game hardware. This is primarily due to the fact that almost all video game-oriented educational institutions focus exclusively on the software and art side of the industry.

André LaMothe wants to change all that. At 37, LaMothe is fond of griping about the kids today: they can't read binary, they never finish what they start, and they constantly bitch about the quality of games that they could never hope to create themselves.

"What these guys do today," he grumbles, "most of them shouldn't even be calling themselves programmers. They write scripts. The APIs do everything for them so they never need to learn the hardware."

With around 15 books under his belt and hundreds of games published, thanks to his know-how, LaMothe's earned the right to complain. He often receives email from aspiring designers who've read his books and want to make the next Halo. LaMothe replies to every one of these inquiries with the same command: "I tell them to make Pong. If you can make and finish Pong, you can make a real game."

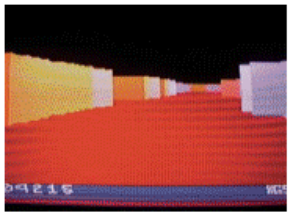
Trouble is, most of them can't.

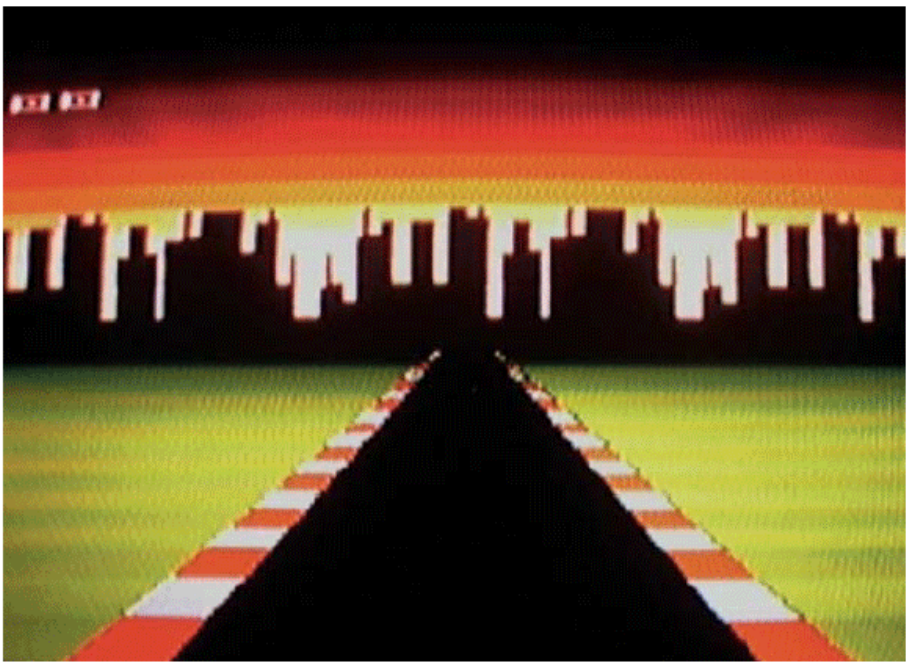
LaMothe has something of a reputation within the games industry as the Yoda of game design. He doesn't work at Electronic Arts or publish million-dollar titles, but he does encourage and teach the next generation of prodigies, and those that prove themselves will be rewarded. Do or do not — there is no try.

Yoda carries a staff; LaMothe wields the XGameStation (XGS), a $200 video game console kit (xgamestation.com). With all those billions of dollars and trillions of yen wrapped up in new console launches, it would seem that anyone else trying to sell gaming hardware would be doomed to failure — especially if your console has only 128KB of RAM and an 80 million instructions-per-second processor. But then, there's a lot about the XGS that doesn't quite fit with traditional console design wisdom.

The XGS is not made for playing games so much as it is for making games. The simple demos included with the console, such as Pac-Man, Tetris, and a basic racing game, are offered up not for entertainment, but for hacking. Indeed, the XGS manual, written by LaMothe's apprentice Alex Varanese, has a section that explains how to easily modify these demos and games. Varanese also wrote a number

Photography by André LaMothe





The XGameStation features a readable circuit board and basic games for hacking purposes.

of XGS programs, including the newly created tile-based graphics engine that allows developers to create platform games in the vein of the old Nintendo Entertainment System. With a light touch, XGS users can change the blocks in Tetris into smiley faces, or modify the background of the Pole Position clone to look like a cityscape. Both of these simple hacks are explained in the XGS manual — LaMothe and Varanese know that the easiest way to get into programming is to modify pre-existing code.

"When I had Alex write the manual, I gave him the old docs for the Apple computers that Steve Wozniak wrote. I handed those to him and said, 'Write it like this,'" says LaMothe.

LaMothe longs for those distant days, when electrical engineering and programming were significantly closer disciplines — the lone programmer creating his or her own vision with perfect clarity and dedication. The XGS software scene is homegrown and almost exclusively staffed by one-man dev teams. New hacks, games, and demos appear every day on www.nurve.net, and all of them are labors of love. Each one is a solution to the problems designers encounter while using the XGS. Each new game created is a triumph over the hardware's limitations.

And this is exactly what LaMothe wants. The XGS was specifically designed with these limitations in mind: what it can't do is more important than what it can. As such, developers must rediscover the tricks of the trade used by their predecessors.

Take interlacing, for example. Many moons ago, if a game designer wanted to draw more than two moving objects on screen at once, interlacing was the only way to get it done.

Every time the screen displays a moving image, it's really putting up many single motionless images, each one swapped out quickly for the next, like a flipbook. The human eye can't really distinguish between each of these still frames. Using interlacing requires drawing Pong paddle one and Pong paddle two in one frame, then drawing the ball and score on the next frame. These two divergent frames are then swapped back and forth, creating the illusion of simultaneous existence. This is why some old games, especially on the Atari and NES consoles, seem to flicker when a lot of action is going on.

Obviously, this sort of workaround isn't used much anymore, but implementing interlacing in a video game is still a terrific way to learn how to interact directly with the video generator on a piece of hardware. This is a trick you'll have to learn while programming the XGS.

> "The XGS is not made for playing games so much as it is for making games."

To the uninitiated, the XGS looks just like any other circuit board. But to the trained eye, there are distinct features that stand out upon first glance. For starters, you can read it. Most modern circuit boards are a snarled mess of mysterious inputs, illegible 2-point font, and unlabeled pin outs. But the XGameStation's various bits are labeled well enough that even a newbie can differentiate between the video processor and the sound filters.

Pop open your Xbox and try to find where the board processes sound — you'll need a magnifying glass and an engineering schematic. As a hackable platform, Microsoft's game console is impenetrable to all but the savviest hackers, but the XGS begs to be rewired, diddled with, and modified.

The XGameStation requires the sort of programming that just about anybody can learn with a little time and effort. Your humble author, for example, has only a rudimentary knowledge of both BASIC and 8086 assembly language — yet within a few minutes, ten years of brain rot vanished as vague memories of if-then loops began to return to the frontal lobes.

LaMothe and Varanese have created compilers for many different programming languages, and even the humble BASIC is usable here. No matter what you remember from your heady and youthful days at computer camp, you'll likely find a way to apply it to design on the XGS.

While there's absolutely no chance of the XGS replacing your Xbox, it could quickly take a beloved position on your workbench, next to the unfinished birdhouse and the old Apple II you've kept since your childhood. If you really want to get into game design, there's no better way to gain a foundation of knowledge for the endeavor than by diving headlong into the XGameStation.

Alex Handy is a purple-haired newlywed who can't put bricks to sleep by looking at them. He lives at www.gism.net.

innovation

New ideas challenge the status quo. That's why people who make cool tools get so much heat from the old guard - and their lawyers. The Electronic Frontier Foundation thinks that innovators who help people speak more freely, share information more easily, and protect privacy more effectively shouldn't fight those battles alone. Learn more about EFF's work to protect your right to innovate in the digital world:

http://www.eff.org/innovate

Member-Supported Since 1990

MISTER JALOPY'S GARAGE

Located on a quiet street flanked by gigantic shade trees in Burbank, Calif., Mister Jalopy's garage is like a portal into the past and the future at the same time. It's fully stuffed from floor to ceiling with vintage tools, car parts, and movie memorabilia he picks up at garage sales.

"I would fill my dream garage with ice cream trucks, carnival rides, Helms Bakery trucks, funeral flower cars, Mercedes-Benz ambulance conversions by Binz, Unimogs, doodlebugs, flathead four-powered log splitters, Cadillac El Caminos, passenger buses from India, Airstreams, Model T fruit trucks, farm equipment, hit-and-miss engines, Spartans, aluminum-bodied mail trucks, dragsters, utility trucks with cherry picker baskets, Aeroflots, diamond-plate F-350s with welders on the back, teardrop trailers, well diggers, and, most favorably, bookmobiles. I would collect houses and skyscrapers, but that would take up too much space," Mister Jalopy notes. A retired music industry executive, Mister Jalopy confesses to owning eight cars, including a 1965 Ford Country Squire Wagon with a whimsical paint job by his friend, a retired Disney sign painter. He's planning to drive it in a local drag race. Read the chronicles of his garage life on his blog, hooptyrides.com.

—Mark Frauenfelder

Photograph by Carla Sinclair

1. Having restored and hot-rod pinstriped an O'Keefe & Merritt stove, Mister Jalopy won't dare start this rare mint green range until the average daily temperature drops below 85. **2.** Good garage policy: WWTBD? (What Would The Bandit Do?) **3.** Automobile water bags and Model A headlights from a time when crossing the desert by automobile was a risky proposition. **4.** The "Outlaw Motorcycle Club" Levi's cutoff jacket from the 1960s was a garage sale find. **5.** The heartbeat of any good garage, the ever-present, never-large-enough, Snap-on rollaway tool chest that has every imaginable tool except the wrench you need at midnight. **6.** Your father's father rode in that kiddie ride. Mister Jalopy is trying to figure out where to mount an engine. **7.** That beautiful art deco Farnsworth radio cabinet hides a complete Macintosh record album digitizing workstation (*see page 54 in this issue*). **8.** The Captain Fantastic pinball machine was rescued from the trash and "almost works!" **9.** Garage sale Oriental rugs really tie the room together, and oil spills just add character. **10.** Purchased for some future race car project, those spindle-mount magnesium racing wheels were from Barney Navarro's 1969 Indy 500 entry.

Photography by Mister Jalopy

THE WORLD'S BIGGEST MP3 PLAYER

Play and digitize your LP collection with this retromodern wonder machine.

By Mister Jalopy

After years of garage sales, I have amassed a treasure trove of scratchy 78 RPM records on obscure regional labels by even more obscure artists. Most will never make it to a commercial CD, as the market is restricted to a few like-minded kooks that don't like to leave the house. And the old-timey stuff that has made it onto CD has been scrubbed and optimized to remove the pops, skips, scratches, and other auditory foibles.

But what if you like those defects? Aren't those pops and scratches part of the fun of listening to an original pressing of Duke Ellington's "Mood Indigo"? And Soft Cell's "Non-Stop Erotic Cabaret" or AC/DC's "For Those About to Rock" sounds exactly as you remembered when you hear it in the correct order with the scratchy pauses between tracks. A whole 99 cents for a single iTunes track? Forget it!

A well-spent garage sale quarter will buy an entire album of Dinah Washington, Three Dog Night, or Devo.

Of course, there are significant downsides to vinyl records. The endless flipping of the album, the steady sound degradation with every play, and the space required for record collections are all legendary. So, with the ever-present bar napkin, I started designing my dream machine. It had to be able to digitize any input — mono or stereo. It should have a radio, preferably with time-shift recording like a TiVo, should sync to my iPod, have a decent turntable, and a big hard drive. And it shouldn't be embarrassingly ugly.

You can rest assured that you won't get mugged carrying this behemoth on a subway — build the world's biggest MP3 player!

Amass the Components Ninja Garage Sale Style

1. Nearly any old Panasonic, Fisher, or Marantz tuner would be great as long as it has a turntable input. My good friend Damon turned me on to the 1970s Sansui tuners. Pretty expensive back in the day, this $10 garage sale Sansui is a reasonably modern, solid-state design with lots of inputs, and it works perfectly. Plus, it's loud as hell.

2. A replacement needle and cartridge will cost more than your excellent garage sale turntable score, so make sure the needle looks decent before you buy!

3. Aesthetically, the $15 Farnsworth is beyond reproach. The turntable was gone, but they were generally monaural so it's better to replace it anyway. The commanding size of the Farnsworth means there is ample interior space for all the stuff to be jammed inside. Can't find a Farnsworth? Find a Philco or a Telefunken! Or an old sewing machine table! Or a round-top refrigerator!

4. I used the KOGI L4AX 14" LCD. It was the cheapest flat screen that CompUSA was selling four years ago. I paid about $200.

5. Nearly a perfect embedded computer, the Mac mini is compact and discreet. A cheaper donor Mac would be just dandy, too.

6. Griffin gadgets are just input/output devices. But they are quite elegant and provide the necessary interface to get the technology to do what you want:
AirClick — Wireless Remote Control
iMic — Line Level Input to USB Converter
RadioShark — Radio Tuner with Time Shift Recording
PowerMate — Programmable Anything Knob

LIBERATE COMPONENTS

It almost always makes sense to break individual components from their original housings. Everything just gets so much smaller.

1 Install the Turntable

Make a cardboard template and use a coping saw to trim the turntable wood top to fit.

2 Install the Tuner

The tuner should be handy, so I decided front and center would be perfect. I removed the wood speaker grill and trimmed the verticals to clear the tuner. Then, I added a new horizontal wood crossbar.

3 Replace the Speaker Grill

The original 12" speaker was long gone, and replacement multirange 12" speakers are no longer available. A $5 Sony bookshelf speaker is sitting on top of the tuner behind that fabric.

4 Use the Chassis

After removing endless capacitors and tubes, the original chassis is the perfect platform for your new modded machine. All the connecting hardware is there, everything lines up, and it is constructed to last until the next ice age. The Mac mini is held in with hardware store Velcro earthquake straps.

5 Liberate the Screen

Like the turntable, the LCD panel is considerably more svelte when you free it from its plastic case. Don't tell anyone, but to reuse the RF shielding, I just smeared some silicone adhesive to secure it.

6 Mount the LCD

The monitor is screwed right to the turntable lid. To find the correct spacer, measure the depth of the monitor and find something just a shade longer at the hardware store.

RETROFIT

7 iMac

The original amplifier/tuner chassis is reinstalled but now with the Mac mini in its place. Those buttons were radio presets, but now they will control the iPod.

8 Study What's There

Momentary switch: a switch that returns to its normal position when force is removed.

A project like this is so much more satisfying if you are able to reuse the existing controls. Under the gold-tone radio preset faceplate, we find the original radio tuner preset button assembly, and to get this switch to work, we need to convert it to a momentary switch. An iPod's remote buttons press and then release. By examining the radio preset assembly, I determined a single spring needed to be removed to convert the old "press and hold" buttons to iPod-compatible momentary switches.

9 Connect Wires to AirClick

The AirClick is the magic bridge to control the iPod. Inside the AirClick, there are gold circuit board switch contacts that are triggered by magnetic pads on the backs of rubber buttons. Very carefully, drill tiny holes through the circuit board switch contacts to connect the new wire. Thread the wires for each contact set through the AirClick case holes, as it will be tidier when we reassemble. For each button function, solder a black wire to one switch contact, a red wire to the other.

Be sure not to drill through a trace on the backside of the circuit board! Despite being careful, I STILL ruined an AirClick!

10 Connect the Old Switch

Solder the other end of each red/black wire pair to the contacts on the old radio preset switch. It should be a one-to-one relationship when connecting the wires from AirClick to the old switch.

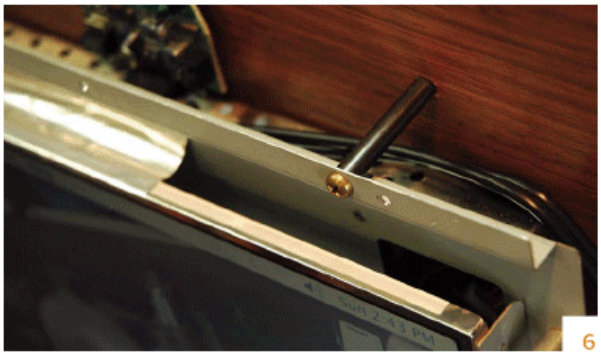
After soldering the wires to the AirClick board, check each wire pair by touching the stripped wire ends and see if it operates the iPod.

11 Connect Griffin Wheel and iPod Dock

To feed through the USB/FireWire connectors, the old knob holes needed to be expanded. Despite the creepy name, the rat-tail file is a fantastic tool to make a round hole oblong. Use the base of the file by the handle for a big, wide cut.

Frequently check the connector in the expanded hole to make sure it does not end up bigger than necessary. And when you are done, touch up the new oblong hole with wood stain on a Q-Tip.


1

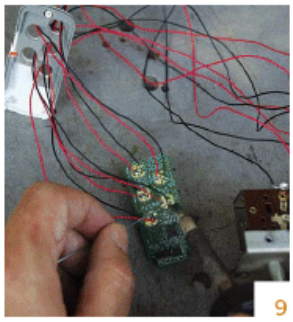

6

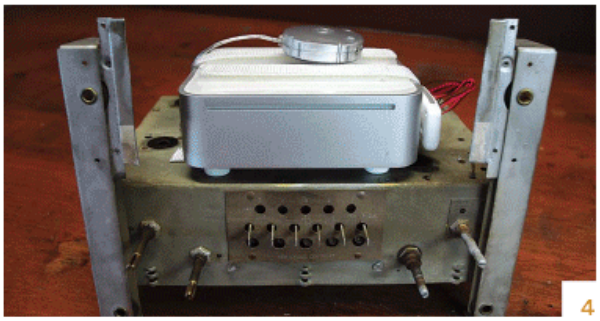

2

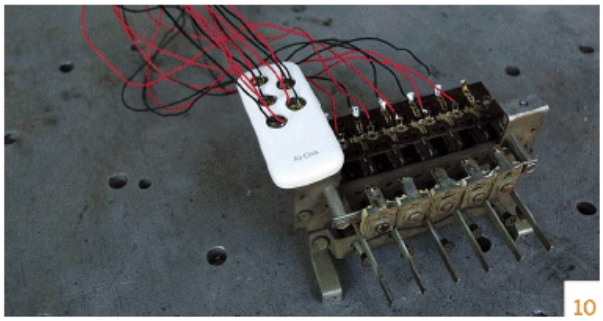

7

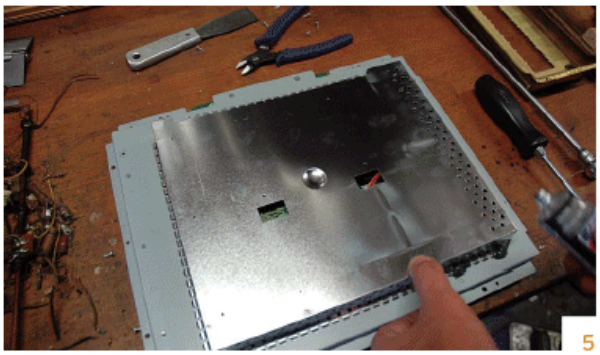

3


8

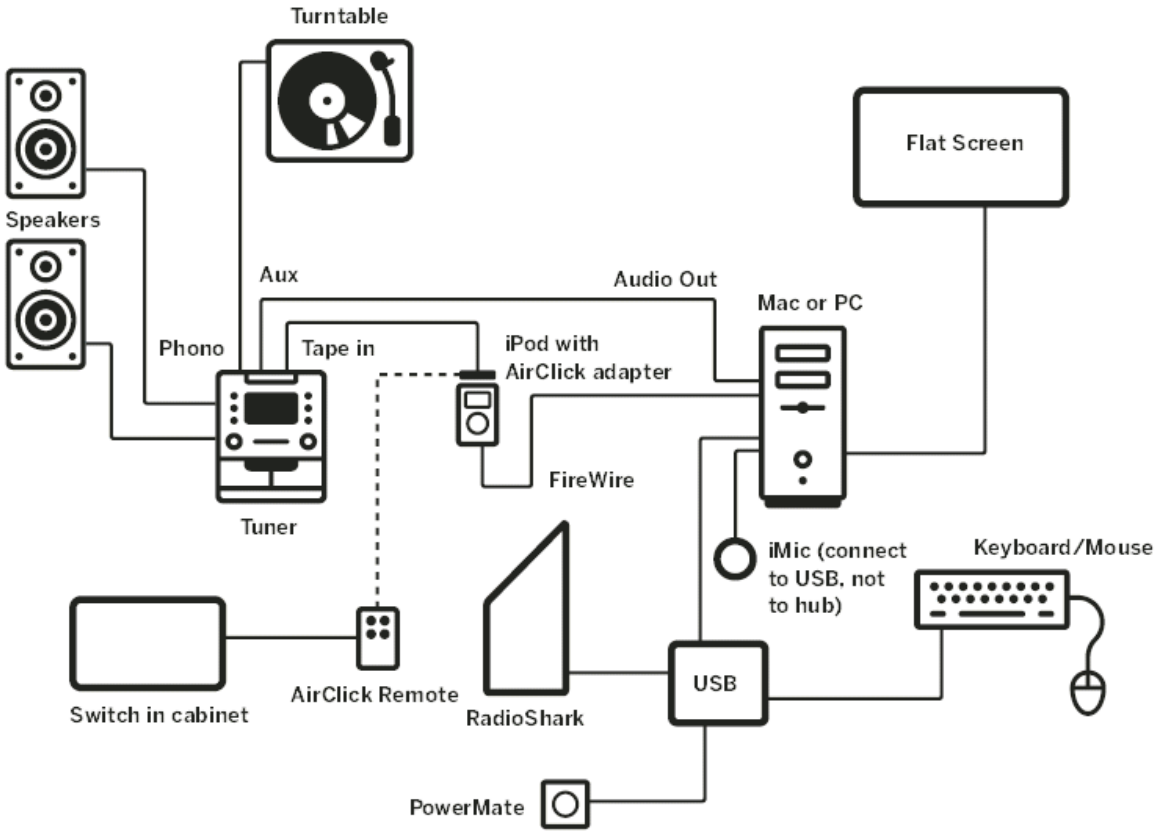

9


4


10


5


11



REASSEMBLE

The new AirClick-empowered switch assembly is back in, and now that row of brown buttons controls the iPod. The PowerMate controls iTunes on the Mac mini. The brown bakelite knob does absolutely nothing. Yet. Since the Mac mini is mounted vertically on the old radio chassis, just lift the old tuner window to put in a CD.

DIGITIZE

Since I used the tuner output, the levels were high enough not to use the turntable 40dB signal boost. Since I don't mind the pops and scratches, the free Final Vinyl software that comes with the iMic was just dandy for my purposes.

LISTEN TO RADIO

Tuning the radio with RadioShark couldn't be easier, and the addition of pause and record buttons is pretty exciting. Mercifully, the RadioShark has a ⅛" mini jack for an external antenna, and plugging in a headphone extension cord helped pull in weaker stations.

The real test will be if I get rid of my records. After holding on to that Haysai Fantayzee 12" for all these years, will I end up selling it for a quarter at my garage sale? Just the idea of people pawing through my records gives me an upset stomach, so I am probably doomed to keep them forever. But I'm sure I'll listen to it more now that it is digitized!

FILM JOCKEY

Combining live performance with old film gets Julie Meitz back to her roots. By Ross Orr

Julie Meitz first picked up a Super 8 camera as a teenager, and has worked with experimental film, video, and multimedia installations ever since. Lately she's been mixing video in live performance, for music shows and other events in the Detroit area.

For VJing, she lugs along a Mini-ITX PC, stuffed with 30 gigs of source clips — her own original footage, found film, or processed feature-film shots. She collages and layers these sequences on the fly.

But every once in a while, Meitz likes to get back to her roots and do some old-skool "FJing," her term for live mixing of multiple 16mm film projectors.

To prepare a film mix to accompany live music, she starts by pulling reels from her five shelves of salvaged educational films and obscure theatrical releases, looking for thematically related clips. The process is not click-and-drag easy: previewing footage and experimenting with combinations can take Meitz a month of preparation for a 45-minute set.

She chooses carefully which of her six balky vintage projectors is up to the strains of performance. One favorite is an old Lafayette Analyzer — originally sold to scientists and sports coaches — designed to jog film forwards and backwards, and instantly change speeds. This lets her "scratch" with film clips much as a DJ can with vinyl.

Meitz preassembles one reel and lets it run continuously (including segments of black leader, to leave gaps for other projections). She overlays more footage alongside or superimposed onto this, swiveling her projectors on lazy Susans as needed.

And effects processing? Completely manual, low-tech, and homemade. Meitz swaps in and out colored gels, or a spinning multicolored filter wheel made from an old film reel. She hand-cranks a fan blade in front of one lens, giving a beautiful strobe effect.

In performance, she is a blur of movement, darting around her clattering setup to change filters, swap reels, and flip levers. The resulting collage can be funny, evocative, quirky, and magical.

Getting the timing of a performance to work can be tense, even using a prepared cue sheet. And there's a constant risk of bulbs burning out, or a show-stopping film jam. Meitz ended a recent performance by giving all her projectors grateful kisses, for making it through the show with only one minor breakdown. She sometimes wonders if the stress is worth it.

But Meitz still delights in the look and feel of projected film. And audiences, jaded with gee-whiz CGI effects, seem to appreciate her efforts to keep it reel.

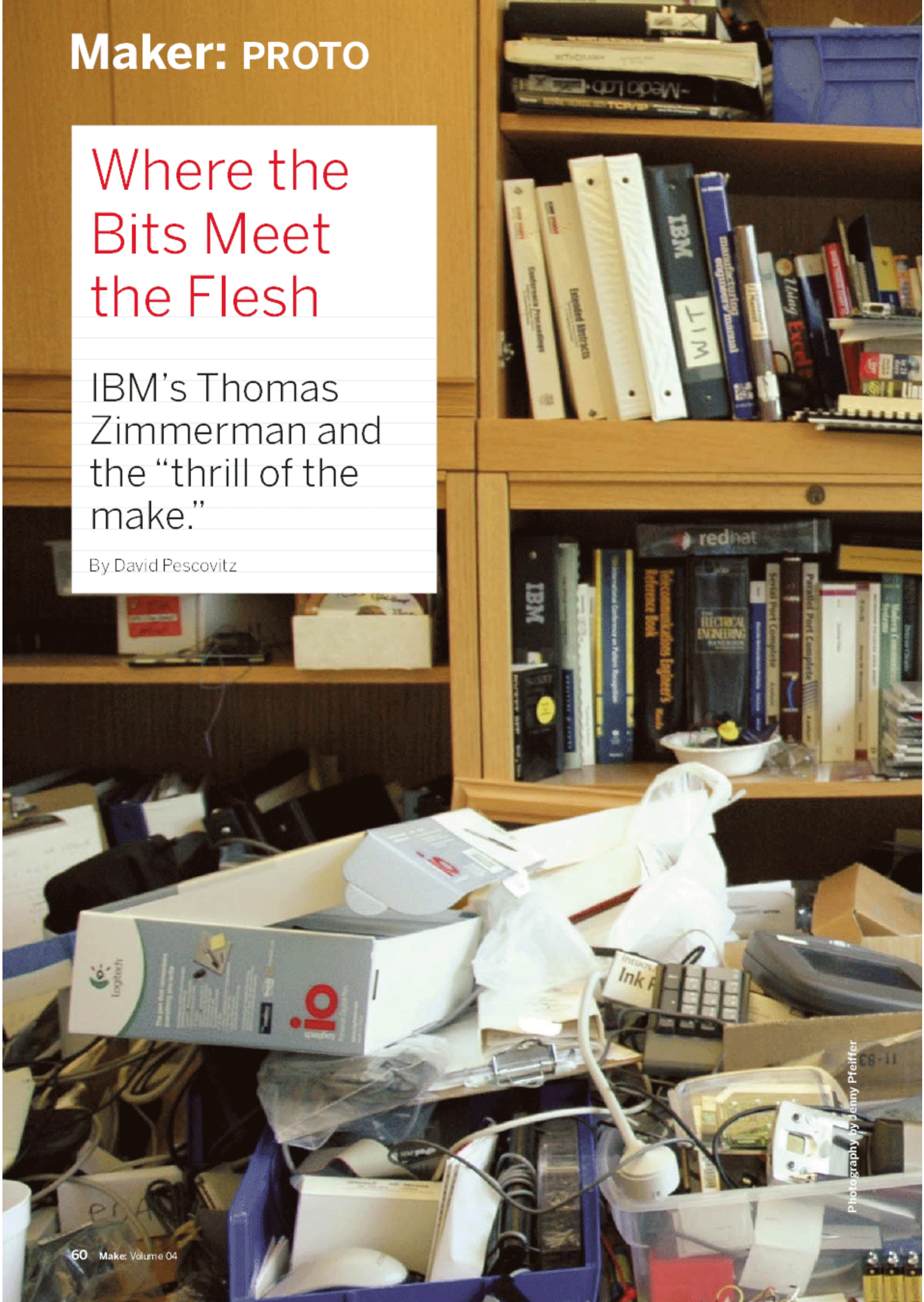
Ross Orr keeps the analog alive in Ann Arbor, Mich.

Photograph by Ross Orr

Where the Bits Meet the Flesh

IBM's Thomas Zimmerman and the "thrill of the make."

By David Pescovitz



Photography by Jenny Pfeiffer

Call the fire marshall: Underneath this stuff, there's a desk belonging to IBM scientist Thomas Zimmerman.

Maker: PROTO

When I extend my hand to greet IBM research scientist Thomas Zimmerman, I half-expect a shock to accompany the shake. Ten years ago, Zimmerman and MIT professor Neil Gershenfeld demonstrated a system where electronic business cards could be swapped just by shaking hands. Dubbed a "personal area network" (PAN), the system was just one in a long line of novel human-computer interfaces Zimmerman has developed since the 1980s. His hit list of inventions includes the famous virtual reality DataGlove, a PAN-based technique that prevents air bags from deploying when a child is in a car seat, and a biometric system that identifies you by the "dance of the pen on the pad" as you sign your name. Zimmerman's technical sandbox, he says, is the realm where "the bits meet the flesh."

> "You just need a little 'glueware' to connect things together and make new devices."

A member of the User Sciences & Experiences Research laboratory at IBM's Almaden Research Center, Zimmerman is the first in a series of corporate makers that I'll be profiling in MAKE. He is a quintessential maker who has managed to parlay a hacker sensibility into a lifelong career.

A graduate of MIT, Zimmerman is an alum of Atari where, during the 1970s, he met many of the scientists who would become pioneers in the field of virtual reality. By then, Zimmerman and a friend had already conceived of a wearable gestural interface, a "data glove," for an "electronic air guitar so we could play just like Jimi," he says. Along with the head-mounted display, the DataGlove became an icon of the promised virtual reality revolution of the cyberdelic late 1980s. Eventually, VPL, the virtual reality company Zimmerman founded with Jaron Lanier, licensed the technology to Nintendo as a video game controller called the PowerGlove.

In Zimmerman's office at IBM Almaden's Silicon Valley headquarters, the Nintendo PowerGlove holds a place of honor high atop a shelf. That is, there's nothing piled on top of it. For the most part, Zimmerman's office is knee-deep in piles of books, papers, cracked-open mice, outdated PDAs, cannibalized disposable cameras, tangles of cables, assorted other bits of high-tech detritus, and rolls of duct tape. Duct tape, Zimmerman says in all seriousness, is one of his essential prototyping materials. To illustrate his point, Zimmerman grabs what appears to be a standard-issue clipboard with a Wacom tablet duct-taped to its surface. A cheap digital camera was once mounted to the clip but he's since yanked it off for another mock-up.

"I love to put connectors on commercialized technology to leverage all of the engineering and cost reduction that went into a product," he says. "It becomes reusable hardware and you just need a little 'glueware' to connect things together and make new devices."

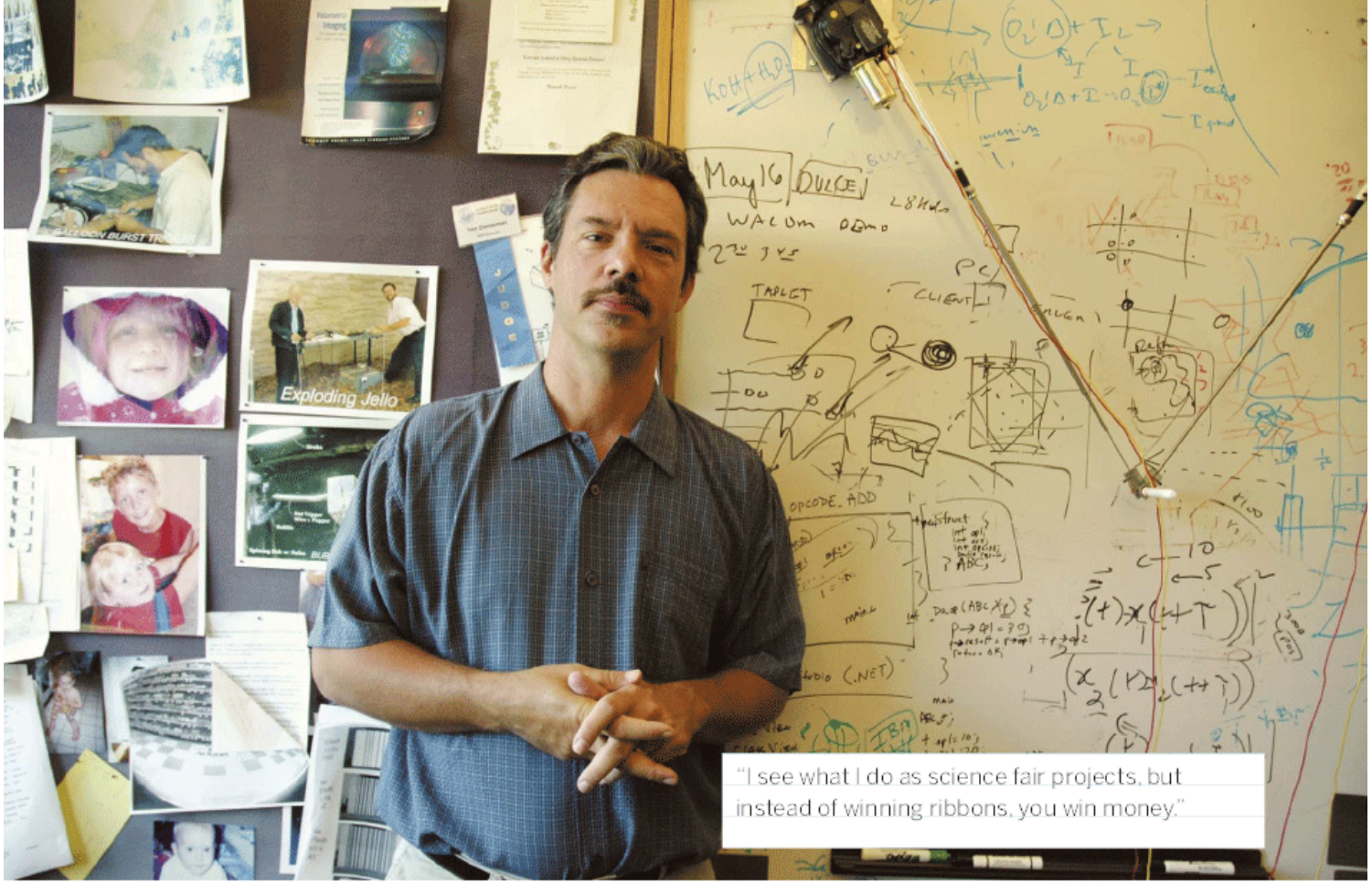
It may not look like much, but the clipboard is a data entry system for healthcare practitioners. Doctors and nurses use forms to populate their patients' medical records, he says, and are reluctant to shift to a typical monitor/keyboard combo.

"Paper is hard to store, retrieve, search, and distribute," he says. "But pen and paper is a wonderful interface to take notes when you're conversing with someone. Pens have a low cognitive load, whereas if I'm using a word processor, a big percentage of my brain is focused on the tools instead of the person I'm talking with."

Zimmerman's idea works like this: the doctor or nurse clips a form onto the clipboard. As he or she writes with a regular pen, the data is captured by the Wacom tablet. The camera on the clip serves two purposes. One, it snaps a photo of the form so the computer can identify it. Two, it measures the angle of the paper on top of the tablet so the digitized text can be correctly entered into the correct fields on the electronic form. This prototype may be a bit, er, raw, but it got the point across. And that's all that matters, Zimmerman says.

"My philosophy is to get your hands dirty quickly," he says. "You can talk about something, but the big step is to hack something and get a demo together. Also, someone told me not to make prototypes too polished because then there's no room for other people to play in, grow it with you, and help shape it."

As with many makers, play is a big part of Zimmerman's M.O. Hanging proudly in his office



is a photo of Zimmerman and his young son with a remote control car they outfitted with a wireless webcam. Beside that are snapshots of exhibits at San Francisco's Exploratorium science museum that Zimmerman designed with a friend: a stop-motion photography rig and a high-voltage contraption rigged to explode a vat of Jell-O. These are the kinds of things that Zimmerman, who lectures frequently at area schools, knows will convey the thrill of the make to the uninitiated.

He felt that thrill last night, he says, at DorkbotSF, an informal gathering of engineers and artists "doing strange things with electricity," as the group's motto goes (*see MAKE, Volume 01, page 47*). An experimental musician, Zimmerman spent the evening jamming on a homebrew theremin. In fact, it takes some doing for Zimmerman to delineate between the gadgeteering he does for IBM and his own pet projects.

Like the modded clipboard, there are other clues about his "professional responsibilities" in the piling cabinet once known as his desk.

For example, a disassembled credit card scanner hints at his latest project. IBM's Retail Store Solutions group in Raleigh, N.C., is designing systems for the grocery store of the future, and Zimmerman has been helping with the "Shopping Buddy," a touch-screen computer that mounts on the handle of a shopping cart. As the shopper grabs items from the shelves, he or she scans the UPC code using a handheld reader. Meanwhile, infrared beacons track the cart's location as it moves through the store for, what else, targeted advertising and coupon delivery. Wireless web access connects the user with online shopping lists. Eventually, Zimmerman says, a credit card magstripe reader could be added to the system for self-checkout right on the cart.

"The Retail group tests this stuff in a 50,000-square-foot building that used to be a manufacturing facility for network boxes but is now a model of a huge store," Zimmerman says. "It reminded me of how NASA used to test lunar landings here on Earth with a simulation of the Moon."

Indeed, IBM, he explains, is a perfect place to fuel his maker's passion. He feels very fortunate, he says, to be immersed in an environment where potential collaborators are around every corner, the basement fab lab hums with high-end CNC machines, "a vacuum chamber is just down the hall, and liquid nitrogen is on tap."

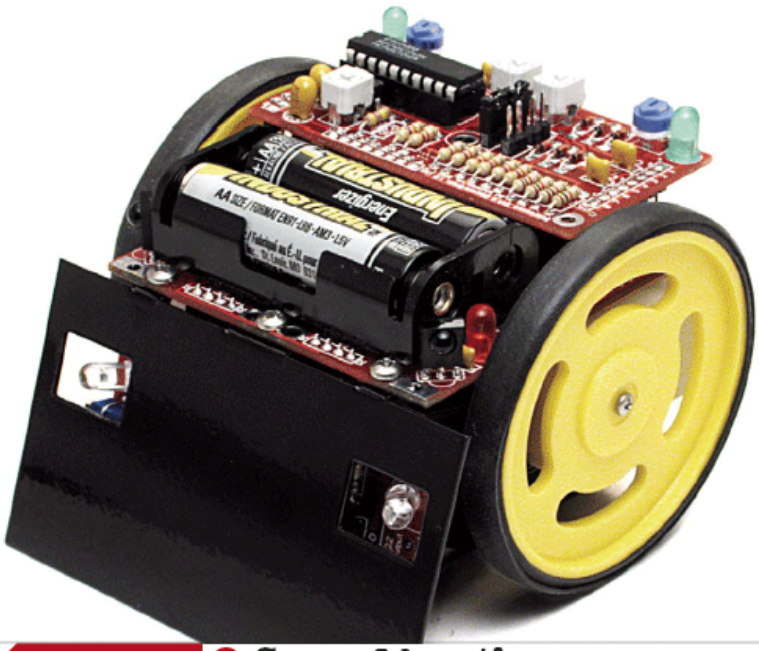
David Pescovitz is co-editor of the popular blog BoingBoing.net and an affiliate of the Institute for the Future.

Kits for the Holidays

There's nothing like the thrill of a kit: open the box and shining new parts gleam up at you, making projects possible that take forever to build from scratch. Sometimes a kit lets you try something you know nothing about; sometimes it speeds up a familiar process. Every kid (no matter how old) wants a kit for the holidays, something to fiddle with before work or school kicks in again. Santa's elves have been very, very busy this year, and they've given us a sneak peek of their best offerings.

Edited by Arwen O'Reilly

Illustrations by Robert Ullman



ROBOTS

Sumo Wrestlers

• The Solarbotics Sumovore: Mini-Sumo Robotics Platform

There are several robotics kits on the market that are billed as "sumo robots," but they're not actually fit for official competition. One kit that is mini-sumo-ready is the Solarbotics Sumovore. Solarbotics, known for their clever kit designs, meticulous attention to detail, and irreverent sense of humor (when's the last time your computer/electronics manual cracked silly jokes?), delivers one of the most satisfying kits I've ever built.

As with most Solarbotics kits, the Sumovore offers a great "out-of-bag" experience, with a handsome construction/operations manual and oodles of high-quality components, all thoughtfully divided into labeled bags for each sub-assembly (main board, sensor board, discrete brainboard). The well-photographed manual takes you step-by-step through the assembly process in a way that makes everything surprisingly clear. There's even a soldering tutorial, although this is not a project for beginners. Anyone with moderate soldering skills and sufficient patience shouldn't have too much trouble. One cool thing about the instructions is the way they tell you what each component does, so as you're building the bot, you get some idea of its circuit logic and overall engineering.

The Sumovore represents over 500 hours of development and has gone through 21 prototypes. It ships with a "discrete brain," using BEAM technology to create sophisticated behaviors from analog circuitry. Add-on programmable "brainboard" kits are available that use popular microcontrollers like the Basic Stamp 2 and the PIC16F877A. With this programmability, and the breadboards built into these add-on boards, the capabilities of the Sumovore are nearly endless.

—Gareth Branwyn

$89, solarbotics.com

TRUE BLUE CHRISTMAS

• MOVIT/OWIKIT WAO Kranius

You don't have to be Elvis Presley to sing "Blue Christmas" this holiday season. Just hide a WAO "Kranius" under your tree, and you'll be singing the praises of this fun-to-build kit.

The Kranius features a potent ATMEL 8-bit microcontroller accessed via an integrated 33-key keyboard. The kit also includes two infrared sensors, four cadmium sulfide photoresistor light sensors, and two motor gearbox pulse sensors, used for guiding the robot.

Accessing sensors is done with a unique 37-command programming language input through the keyboard. This feature is in direct opposition to most other robot kits. If using the matchstick-sized keys is too difficult for you, there is an optional PC Interface Kit (WIN-9762; $34.95). In normal use, however, the keyboard is well-suited for entering lengthy programs into the robot.

In less than three hours of assembly and programming, you'll have a new, blue member of the family scooting about the floor.

—Dave Prochnow

$120, owirobot.com

MORE ROBOT KITS

• Robot Kits Direct

The distribution channel of OWI kits, they have a great grouping of fun-looking robots with special features. robotikitsdirect.com

• Robot Store

See our profile of Maker Natalie Jeremijenko in Volume 02 (*see page 22*) for ideas on what to do with their robot pets. robotstore.com

> **“I’ve done tie-dye kits, aquarium kits, radio-controlled airplane kits. A number of years ago I made a dulcimer from a kit, which is probably the nicest kit experience I’ve had — because the result was something I would not have made otherwise. A great kit has all the parts and idiot-proof instructions and gets you somewhere you would not reach by yourself.”**
>
> **—Kevin Kelly**

HELP ME, OBI-WAN

• Litiholo Hologram Kit

If your heart still flutters at the thought of Princess Leia’s hologram pleading with Obi-Wan Kenobi, you should definitely check this out. While most hologram technology is well out of the realm of you or me, this kit comes with a SafetyLight Laser Diode and “Instant Hologram” film. Litiholo film makes transmission holograms, viewable with the laser or LED light included in the kit. You’ll have your own princess in under an hour. $139, litiholo.com/hologram_kits.htm

DO-ABLE HELIX

• Discovery DNA Explorer Kit

Forensic science is one of the fastest-growing disciplines in science curriculums today, thanks to a host of popular television shows. The Discovery DNA Explorer Kit, “ideal for budding forensic scientists or secret agents,” lets you test it out before you get that degree. Including a centrifuge, magnetic mixer, and electrophoresis chamber, the kit may also unintentionally mimic another common experience in the sciences: when you finish your six experiments, you have to wait for funding before you can get another set of DNA samples. $80, makezine.com/go/discoverydna

FOR FURTHER FORAYS INTO FORENSIC SCIENCE

Kid’s Forensic Facial Reconstruction Kit: makezine.com/go/forensic

+ More Kits

Find more kits online at makezine.com/04/kits

CHEAP FRENCH VACATION

• Cheese-Making Kit

Now that the Concorde is grounded, those weekend cheese-tasting trips are a thing of the past. Never fear! Now you can make your own cheese at home. The Edmund Scientific kit includes a cheese press, rennet tablet, and cheesecloth, along with recipes for a number of cheeses, including hard cheddar, cottage cheese, and cream cheese.
$22, makezine.com/go/cheese

+ Be sure to also check out the Make Your Own Chocolate from Scratch Kit. You may never have to leave the house again.
$10, makezine.com/go/cocoa

RED HOT CHILIS AND PEPPERS

• Hot Sauce Kit

Some like it hot, and if you're one of those, custom-made hot sauce is probably the stuff dreams are made of. Edmund Scientific's Make Your Own Hot Sauce Kit provides you with allspice, black cumin, curry powder, achiote, Jamaican jerk, ginger, bottles, a pepper glossary, and instructions for searing your insides without actually doing real damage.
$20, makezine.com/go/hotsauce

OTHER RECOMMENDED BEER-MAKING KITS:

Munton's Gold Continental Pilsner Beer Kit: makezine.com/go/muntons

Mr. Beer Brew Kit: mrbeer.com

Or, if you don't want to make the hard stuff, try brewing your own root beer: makezine.com/go/rootbeer

Oatmeal Is Good For You

• Brewer's Best Hardware Kit

About a year ago, my friend Noah brought over a copy of DVD Studio Pro and six bottles of his homemade oatmeal stout. I figured the beer would taste like dishwater, but I let him bring it because he was doing me a favor. The beer, however, was amazing. While he tried to teach me the program, I drank my way through most of the six-pack.

It turns out that homebrew like Noah's is surprisingly easy to make. With the basic Brewer's Best Hardware Kit, you can produce good homebrew on the first try. The kit comes with most of the basic equipment you'll need to produce five gallons (about 54 bottles) of beer. And the kit is well suited to first-time users; it includes a booklet with clear instructions on how to assemble the kit's various pieces and a brief overview of the brewing process. All you need to supply is a large stockpot, bottled water, 54 empty brown glass bottles, and the brewing ingredients themselves.

Using this kit over the course of a year, I have brewed four batches of beer. The kit has held up well, though its thermometer doesn't give accurate temperature readings, and the siphon takes some practice. But otherwise, I've found it user-friendly, and no one has complained about its final product. Within the month, you too could introduce your friends to the pleasures of homebrew.

—Pacho Velez

$49, makezine.com/go/beer

FOOD

Photography by Derrick Story

A Fuller Greenhouse

• Geodesic Greenhouse Kit

If you can't face another winter, this is one of the more effective greenhouse kits on the market. The geodesic shape deals well with wind and snow and is remarkably energy efficient. The kit comes with all the materials needed to install it yourself (lumber, hardware, and either 8mm or 16mm triangular polycarbonate sheets), and has a ten-year warranty. That's ten years of vine-ripened tomatoes in March! Start at $3,450, geodesic-greenhouse-kits.com/details.php

CRAFTY

Rocket to Me

• Paper Rocket Kit

This is a downloadable PDF that has the plans for your own paper rocket. It goes sky high (or at least 16 feet high) with the help of a pneumatic launch pad you fold yourself. Folding the bellows can be a little tricky, but once you do this, making an origami spider will just come naturally. Free! groeg.de/puzzles/rocket.html

WHITTLE BITTY KNIFE KIT

• X-ACTO Woodcarving Knife Deluxe Set

Always an advocate of the right tool for the job, the completeness of the X-ACTO knife kit demands my unwavering respect. The wooden box, breadth of blades, and selection of handles means you can take comfort in knowing that you have an absolute X-ACTO solution. It is not for lack of the correct tool that I do not carve my initials in my maple tree, because if I had even modest whittling skills, I would affix the Number 19 Angle Wood Chiseling blade to the Number 8 Heavy Duty Aluminum Handle and leave my name far and wide.

But, my woodcarving experience is limited to when I had a more modest X-ACTO kit when I was 10 and crafted an entire balsa wood Christmas village. While watching *M*A*S*H*, I built everything from Ye Olde Toy Shoppe to the Peppermint Factory from the comfort of a couch and TV table. It is difficult to say if *M*A*S*H*, the TV table, or the X-ACTO knife kit provide the greatest benefit to society, but the fact that the X-ACTO knife kit is in such august company should be reason enough to add one to your arsenal.

—*Mr. Jalopy*

$23.75, makezine.com/go/xacto

PAPER TRAIN

• Pepakura Paper Designer

Not exactly a kit, but this software will allow you to produce any 3D object you can imagine (or at least design using 3DCG software such as 3D Studio, LightWave, or Softimage). The website is full of intricate paper birds, airplanes, spaceships, boxes, and cars made by previous users. The software is open to the public as shareware (and can be used with 3DCG freeware MetasequoiaLE), but more features are available if you shell out some cash.
tamasoft.co.jp/pepakura-en

BE YOUR OWN BOND

• QKits

An eclectic mix: kits for your car (back-up noises, screen wiper robots, and home-built car alarms among others), solar and wind (solar panels and wind turbines of all sizes), and sound kits (someone tying up your phone line? Install the Telephone Interception Kit). You'll also find kits you might not stumble across otherwise, like the Deftness Kit, a basic electronic circuit which is designed to test dexterity. qkits.com

CRYSTAL CLEAR RECEPTION

• XSS Crystal Set Kit

Most middle-aged DIY enthusiasts probably have constructed a crystal radio set; it was a joy to pull radio signals out of the ether using no power source other than the radio signal itself. If you have an interest in "old school" radio technology, or if you're looking for a simple kit to learn how to build more complex electronic projects, the Xtal Set Society has a perfect starter kit, the XSS Little Wonder Crystal Radio Kit.

Designed by Phillip Anderson, WOXI, the XSS tunes the entire AM broadcast band. The kit has large solder pads, great for learning soldering technique. Unlike traditional crystal sets, the XSS uses a molded, high-frequency choke. This eliminates the coil winding process that can frustrate many first-timers.

The XSS is perfect for parents and grandparents to build with kids. It's also priced for school use, and can be used to teach basic radio theory, soldering, and handling of electronic parts and PCBs. The kit also includes a high-impedance crystal earplug that can be used with further crystal set experiments. Crystal radio enthusiasts still thrive in this age of digital communications.

—Thomas Arey N2EI

$15, midnightscience.com

The Grass is Cleaner

• Remote Control Hybrid Lawn Mower Parts and Kit

As these guys put it, "Reality has now taken over lawn mower imagination." You too can have the lawn mower of your dreams: it's not quite as fun as a rideable mower, but it's the next best thing — and cheaper, too. Evatech also points out that the lawn mower can be used as an electric power generator capable of delivering over 60 amps of electric power at 12V DC. The kit includes a frame, deck, alternator mount, elevation plate and lever, ball bearings, and wheels. $400 for parts and instructions, $25 for blueprint to convert your old lawn mower, evatech.net

"I fondly remember two kits from my childhood that had a big impact on me: an electronics breadboard kit (circuits were made by sticking wires in springs; the highlight was a real working transistor), and Things of Science that used to come in the mail each month, bringing a little project to do."

—Neil Gershenfeld

> **"I think playing with well-designed kits is a terrific means to learn about science and engineering and develop creativity and problem-solving skills. I grew up playing with Heathkits. Today, kids have access to more advanced systems like the new VEX kits, available at RadioShack, that enable them to make real robots. Tomorrow? Who knows — perhaps kits to make mobile, self-balancing machines."**
>
> **—Dean Kamen**

Bear Band

• Grizzly Industrial Ukulele Kit

Grizzly Industrial sells milling machines, all sorts of industrial shop equipment and tools, and, of course, ukulele kits. After all, what woodworker hasn't thought about building a musical instrument?

Well, aspiring luthiers will find the Grizzly soprano ukulele kit a really fun and satisfying first project. The kit features a pre-assembled mahogany body, which eliminates the intimidating task of bending the sides. The neck is also pre-shaped and fitted, ready to glue to the body, leaving the builder with the satisfying jobs of final assembly and finish work.

The woods used in the kit are quite nice considering the low price; the only weak part is perhaps the plywood fret board. But one great thing about kit building is the opportunity for improvements and customization. If you build it as instructed, you will end up with a very nice entry-level ukulele, but it can also serve as a great platform to experiment with intermediate techniques like body edge binding or inlay work.

So, whether you aspire to be an exotic island crooner or start the next post-punk, all-toy-instrument band, a ukulele is just a nice thing to have around. In my opinion, no household is complete without one.

—Steve Lodefink

$25, makezine.com/go/uke

CAN YOU CANOE?

• Stillwater Canoe Kit

Stillwater boats are designed to use only four pieces of wood for the hull. Kits include the hull and deck panels cut to shape and the rest of the wood and hardware needed for construction. While the award-winning designer admits other boats have many advantages, these are quick, lightweight, and simple to make. Paddle is not included, though, so be careful which creeks you head up. $59 for single canoe plans, $365 for the kit, stillwaterboats.com

OUT OF THIN AIR

• Etherwave Theremin Kit

Due to its unusual, hands-free interface (pitch and volume are controlled by the body's proximity to and interference with the instrument's electromagnetic field), the theremin is famed both as a novelty instrument and for its importance in 20th-century music. Moog Music, started by legendary synthesizer inventor Bob Moog, now allows you to make your own.

When I began assembling, I had next to no soldering experience, and only a brave desire to learn. However, the instructions are very straightforward, and are actually a great introduction to the world of circuits: accessible as you need them to be, but there's detailed circuitry information for more advanced assemblers. It comes with a nice wooden casing that needs a brief sanding and a varnish or paint of your choice, and a mostly constructed circuit board to which you solder various components that determine the theremin's tone and waveforms.

This kit also comes equipped with a hilarious special performance DVD of Clara Rockmore, one of the earliest theremin players, and a somber instructional demonstration from the 80s with Lydia Kavina, Rockmore's granddaughter. —*Meara O'Reilly*

$349, makezine.com/go/theremin

> **"Of course, between Ikea and online shopping, everyone gets furniture in kit form now. Some Assembly Required is the difference between paying $100 versus $400 for something, not to mention $35 versus $135 for shipping."**
>
> **—Stewart Brand**

The Soul of an Old Heathkit

Howard Nurse built hundreds of Heathkits, starting in the 1950s with a ham radio transmitter kit, the DX-40. As a kid, he loved to go to sleep reading the catalog, which was a window into the world of electronics and a wish list of things he wanted to build.

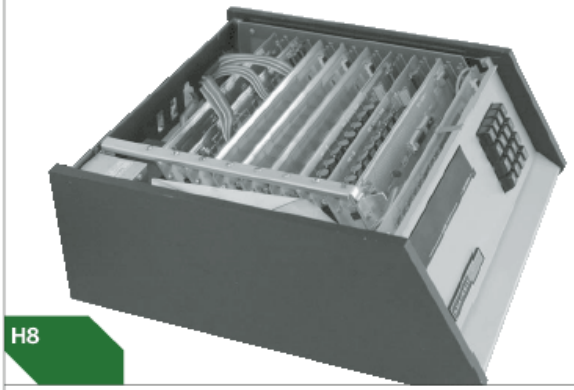
"You have to understand the whole experience of a Heathkit," he said. "It began with the catalog, which became part of my dreams and fantasies." Once he had pored over the catalog and placed an order, he would count the days until his Heathkit box arrived, each day imagining where his letter was en route, who opened it in the Benton Harbor, Mich., headquarters of Heathkit, how the order was processed, and then estimating how many days it would take the post office to deliver it to his home in New Jersey. "Finally you'd get the package in the post box, after all this anticipation," he said.

Electronics were not readily accessible in the 50s. Nurse said the only place he could see electronic components was at a local TV repair shop, which he hung around. The Heathkit catalog opened a door to the new worlds of hi-fi components, electrical test equipment, ham radios, and television sets.

Nurse recalls the joy of opening up the Heathkit box. "First, you'd see the Heathkit manual, which was the heart of the kit." Then he'd find the capacitors and resistors in brown envelopes. A transformer came wrapped in a spongy paper, a predecessor of bubble wrap. "Before you did anything, you had to go through the errata that came with the kit." Then he would do an inventory of the parts — using a muffin tin to sort them. Additionally, he'd use corrugated cardboard to arrange the small capacitors and resistors in rows.

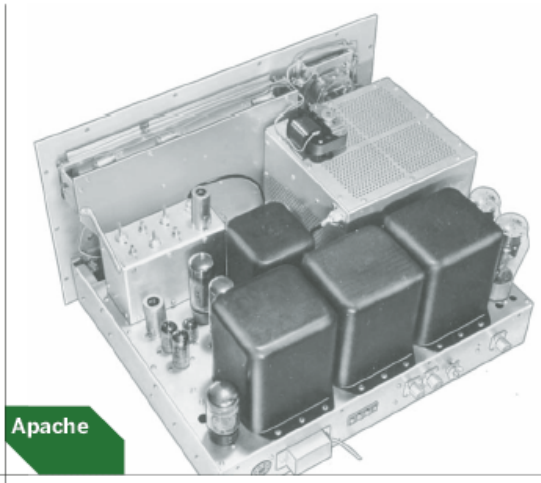
"You have to understand the whole experience of a Heathkit," he said. "It began with the catalog, which became part of my dreams and fantasies."

"After all this waiting and preparation, you'd begin to assemble the parts," he said. "You started by



H8

The H8 Digital Computer rocked 4K of RAM back in 1977 — and was a huge Heathkit success.



Apache

The "Apache" ham radio transmitter was noted for its "many fine features and modern styling."

attaching a few components, and then you got to solder, which was really fun." He added, "Flux was an aphrodisiac." When you finished the assembly and tried it, often it didn't work. This, too, was part of the process of understanding electronics and learning to fix problems.

Nurse eventually got an insider's view of Heathkit. In 1964, his father, David W. Nurse, went to work for the company as vice president, just as Howard was going off to college. His father was promoted to president in 1966 and remained in that position until he retired in 1980.

The Heathkit Company got its start in the 1920s as the Heath Aeroplane Company. Founder Eddie Heath developed do-it-yourself aircraft kits; his company's most famous was the Heath Parasol, a plane with an overhead wing. Unfortunately, Heath was killed in 1931 in an airplane accident. An engineer named Howard Anthony bought the company from Heath's widow in 1935. After World War II, Anthony bought a large stock of surplus wartime electronic parts, among them 5" CRTs (the legend is that he ordered a case but a carload arrived). He designed an oscilloscope kit for $39.50 and began to sell it through mail order. It took 10 years to go through the original CRT shipment. According to an excerpt from the Heathkit Catalog found on heathkit-museum.com, "Mr. Anthony based the success of his idea on the premise that anyone, regardless of technical knowledge or skills, could assemble a kit himself, and save up to 50% over comparable factory built models. All that would be required were a few simple hand tools and some spare time."

In 1951, Anthony also died in an airplane crash. The company changed ownership several times, but continued to produce innovative kits, including a color TV set in 1964. Heathkit did $100 million in annual sales in the 70s on a wide variety of kits, including furniture and satellite television receivers.

"The Heathkit philosophy," said Nurse, "was that they didn't invent new products; they looked for products that were already successful in the market." Then they turned them into kits for the do-it-yourself market.

Nurse believes he may have had a role in persuading Heathkit to undertake its first digital computer. In 1975, the cover of *Popular Electronics* featured the MITS Altair 8800, which originally sold as a kit that required the user to solder and assemble the components. Noticing that it was selling well, he told his father that there should be a Heathkit computer. In 1977, Heathkit launched the H8 Digital Computer, and it proved to be extremely successful. Based on the Intel 8080, the H8 came with 4K of RAM and, a cassette-based operating system. It had a keypad on the front and a nine-digit display. Nurse wrote a radio Teletype software program for the H8 and started his own business selling it.

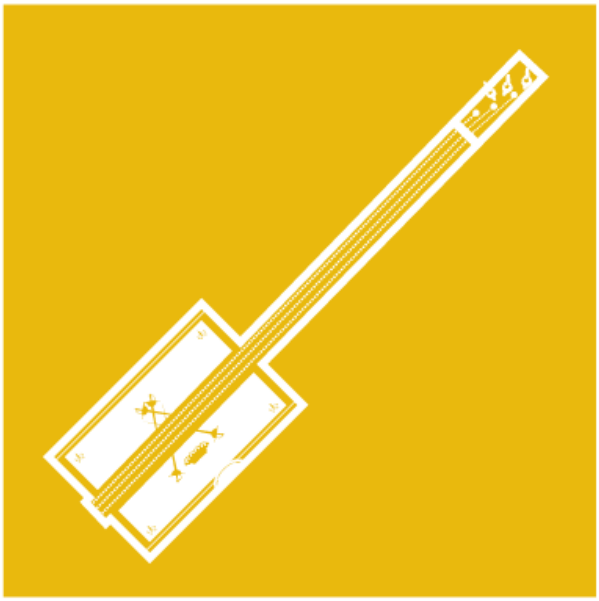
In the 80s, interest in DIY electronics declined significantly, and the Heathkit Company stopped making kits. Today, Heathkits live on as memorabilia exchanged on eBay (about 25 kits a month) and in the enthusiasts who frequent websites and two Yahoo! groups. Heathkits have had a lasting impact on an entire generation. "I'll bet that every engineer in this country over the age of 50 grew up building Heathkits," said Nurse. "Heathkits were special. The best way I can explain it is," and he paused. "A Heathkit had a soul."

Dale Dougherty (dale@oreilly.com) is the editor and publisher of MAKE.

Photography courtesy of Terry A. Perdue

Make: Projects

Use a cigar box and twine to build a sweet-singin' three-string guitar. For something completely different, warp an innocent toy musical keyboard into an irresistibly twisted electronic noise factory. For dessert, savor the hidden intricacies of flash-frozen reality with ultra-fast strobe photography.

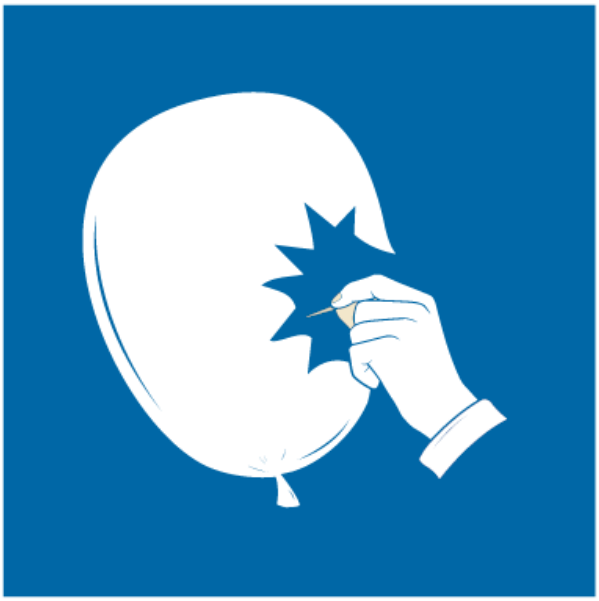


Cigar Box Guitar

76

Circuit Bending

88



High-Speed Photography

102

CIGAR BOX GUITAR

By Ed Vogel

Sweet-sounding, three-stringed mini guitar revives an American musical tradition. >>

Set up: p.79 **Make it:** p.80 **Use it:** p.86

ROCK 'N' ROLL-YOUR-OWN

As a volunteer music teacher, I sometimes meet kids who can't afford instruments. So I decided to design one that they could inexpensively build themselves, based on the traditional cigar box guitar.

Before the 1950s, when factory guitars became less expensive, many folk musicians built their own stringed instruments. Wooden cigar boxes, which were solidly constructed connoisseur objects, became a popular choice for the instruments' bodies. Thus, an American tradition was born, and today, the cigar box guitar is enjoying a folk revival.

My guitar is a simple, three-stringed design that uses only one power tool and common hardware. Despite its low cost, this guitar plays real music and will hold its tuning for a couple of days. A kid can build it (and play it), and so can you.

Photography by Sarah Whiting

Hear the cigar box guitar at makezine.com/04/cigarbox.

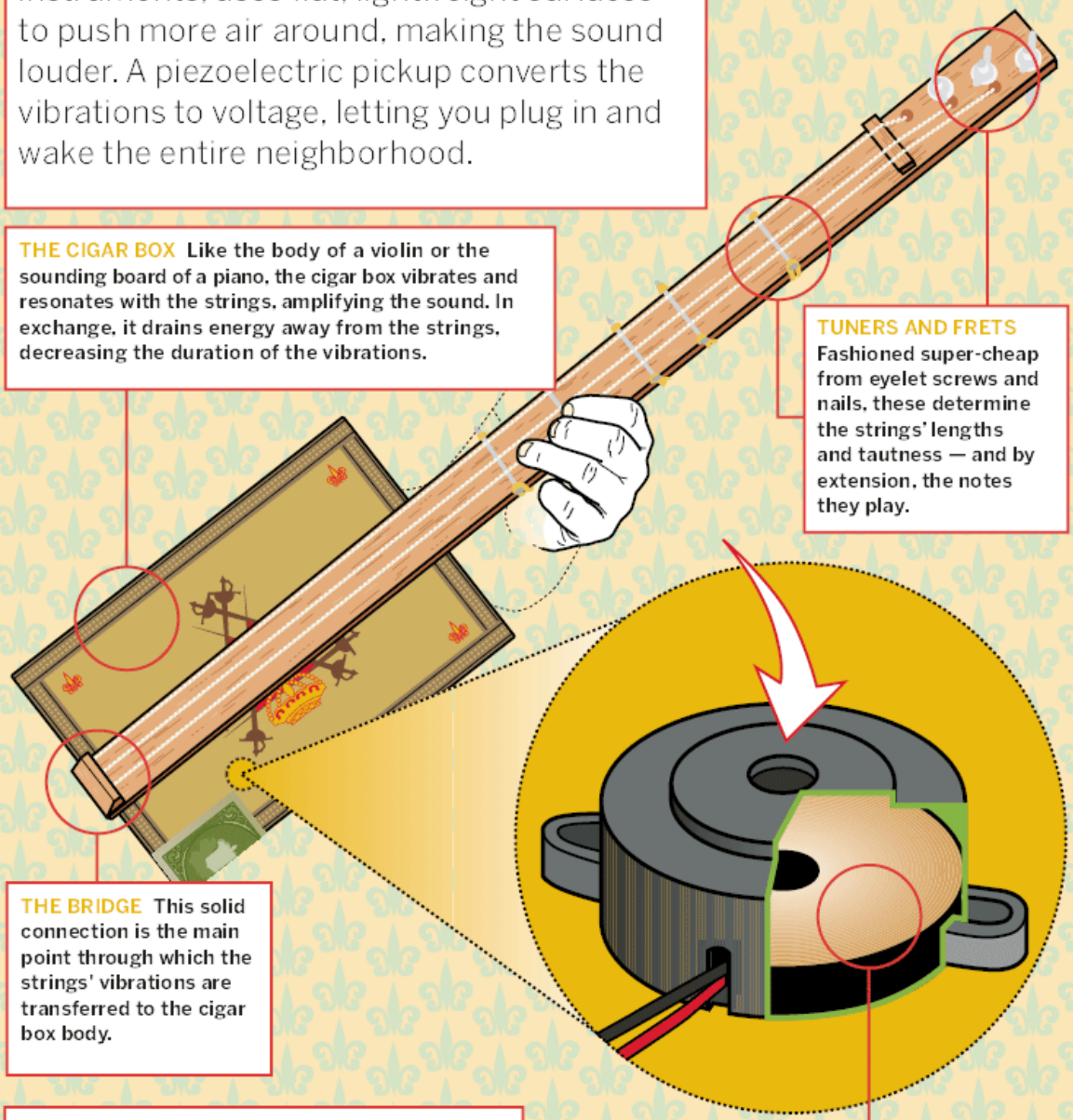
Ed Vogel lives in Minneapolis and believes that nothing may just be the next big thing.

MAKING STRINGS SING

A string vibrating by itself makes very little sound. The cigar box guitar, like other stringed instruments, uses flat, lightweight surfaces to push more air around, making the sound louder. A piezoelectric pickup converts the vibrations to voltage, letting you plug in and wake the entire neighborhood.

THE CIGAR BOX Like the body of a violin or the sounding board of a piano, the cigar box vibrates and resonates with the strings, amplifying the sound. In exchange, it drains energy away from the strings, decreasing the duration of the vibrations.

TUNERS AND FRETS Fashioned super-cheap from eyelet screws and nails, these determine the strings' lengths and tautness — and by extension, the notes they play.



THE BRIDGE This solid connection is the main point through which the strings' vibrations are transferred to the cigar box body.

THE PIEZOELECTRIC EFFECT Certain materials generate voltages in proportion to physical strains applied to them. This was first observed in some crystals, in which electrically polarized molecules all point the same way within a lattice structure. Squeeze the crystal in the right direction, and you alter the relative positions of entire planes of charged particles, changing the potential difference (voltage) from one side to the other. Materials with this property can act as transducers, converting physical vibrations into electrical signal — which lets them work as acoustic pickups.

CERAMIC PIEZO BUZZER The piezo effect works both ways, converting vibration to voltage and voltage to vibration. Inexpensive ceramic buzzers are designed as tiny speakers, but they also work as pickups. The piezoelectric ceramic elements inside these devices are manufactured by mixing metallic crystal powders into a ceramic, and then applying a strong DC voltage to align all of the crystals. The resulting material is cheaper and more durable than piezoelectric crystals.

Illustration by Dustin Amery Hostetler / UPSO.org

SET UP.

MATERIALS

[A] Pen, pencil, or markers (not shown)

[B] Scissors (not shown)

[C] Cigar box
Many tobacconists will give cigar boxes away free. I usually end up paying a dollar for them at a place near my house. If you can't find a cigar box, an intact pizza box will also work.

[D] Mason twine, #15 and #18
Available at hardware stores, this is used by bricklayers and cement workers to mark lines.

[E] ¼"x3" eyebolts and nuts (3)

[F] #12x⅝" wood screws (3)

[G] Drill and drill bits

[H] 3' length of 1x2 red oak
This will be the guitar's neck. The lumber's actual measurements are ¾" by 1½", but 1x2 is how it's named.

[I] ¼" square hardwood stock, at least 1½" long
This will be the nut, at the top of the neck.

[J] ½" square hardwood stock, at least 1½" long
This will be the bridge.

[K] Super glue

[L] 90-second epoxy (or 5-minute epoxy, for a little more positioning time)

[M] ¼" washers (6)

[N] ¼" wing nuts (3)

[O] 2" common nails (at least 3)

[P] Phillips screwdriver

[Q] 3½" x 1" (size 33) rubber bands

[R] Hacksaw blade or hacksaw

OPTIONAL

1500-3000Hz piezoelectric element, a.k.a. piezo buzzer
For amplifier pickup.

¼" phono jack

Soldering iron, solder, and wire

MAKE IT.

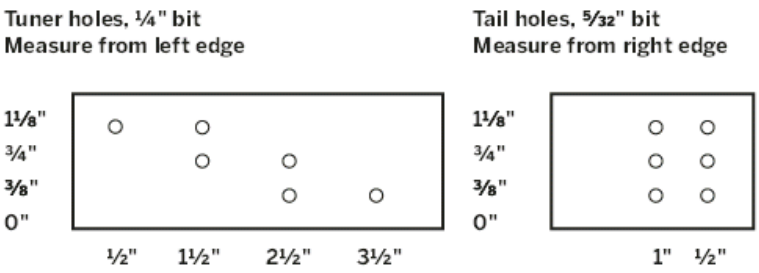
BUILD YOUR CIGAR BOX GUITAR

START

Time: An Afternoon Complexity: Low

1. ASSEMBLE THE NECK AND BODY

1a. Using the diagram at right, drill holes at each end of the 1x2. You'll drill six holes in two rows at the tail, to anchor the strings below the bridge, and six more in two diagonal rows where the tuning pegs will be.

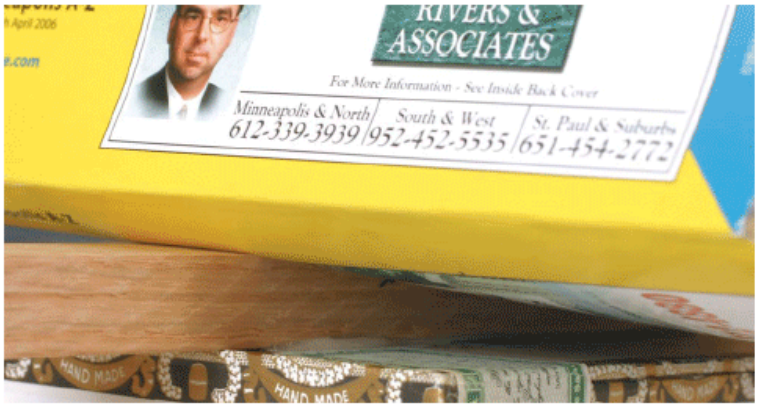


1b. If you want to add an electric pickup to your guitar, skip ahead to **step 4**. Otherwise, super-glue the cigar box shut.

1c. Set the neck squarely on the box so that its six holes are just clear of one of the box's ends. Mark the box along both sides of the neck, so you know where to put the glue.

1d. Mix up some epoxy. I recommend using half a tube, since there may be some gaps to fill.

1e. Apply a generous amount of epoxy to the cigar box, position the neck on top, and weigh it down with a phone book or other weight. With 90-second epoxy, I wait 5 minutes to get a decent cure.



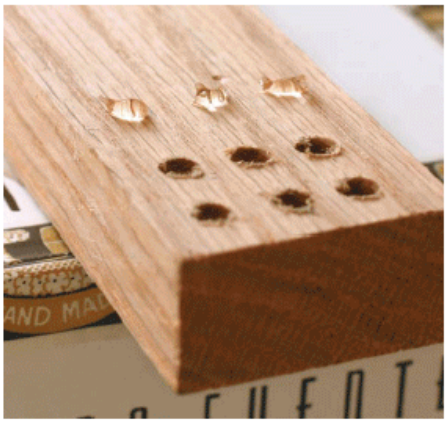
1f. Use the pen to mark the width of the neck (1½") on the ½" square stock. This will be the bridge.

1g. Use the hacksaw blade to cut the bridge.

1h. Put down three dots of super glue for the bridge about ½" up from the six holes at the tail end of the neck.

1i. Set the bridge down on the glue and hold it long enough to sing "Twinkle, Twinkle, Little Star" twice. This song will help you tune later on.

1j. Repeat steps **1f** through **1i**, using the ¼" stock. Glue the nut six inches from the opposite end of the neck.

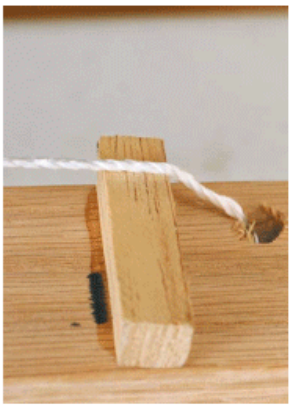


2. STRING THE GUITAR

2a. Take an eyebolt, spin a nut down the threads, add a washer, and then insert it up into a tuner hole at the end of the neck. Put another washer on top and spin on a wing nut.

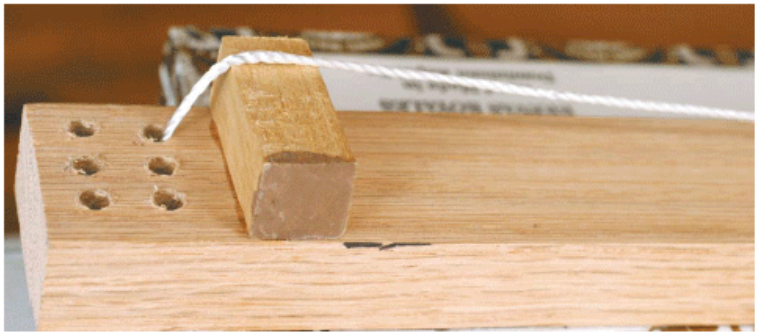
2b. Repeat with the other two bolts, and tighten all three to light-finger tight. Are you still humming "Twinkle, Twinkle"? It can become a real ear-worm. This will work in your favor later, for tuning and playing.

2c. Cut a piece of #18 mason twine about 5 feet long. You won't need all of it, but ends get frayed and we need some slack for pulling on. Thread the string through the empty tuner hole closest to the nut, and tie the end to the adjacent eyebolt in back. Make sure the knot is on the side where the "eye" starts its bend, so that it won't slip out when we tighten the string.

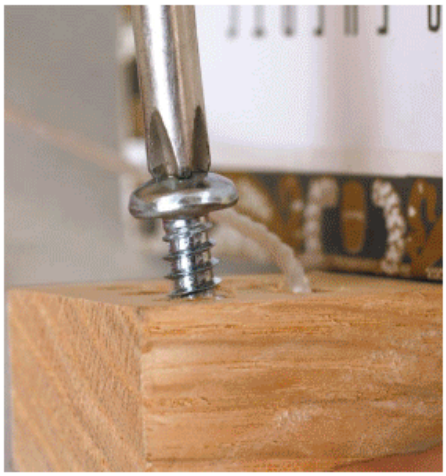


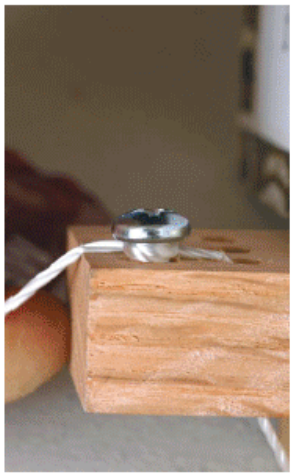
2d. Spin the eyebolt clockwise three times to get some string wrapped on. Tighten the wing nut to firm-finger tightness. Pull the string over the nut.

2e. Pull the string over the bridge and thread the other end down the corresponding hole just below.



2f. Get a screw started in the hole on the other side, but leave some of the threaded part showing so it's easy to wrap the string around it.





2g. Here is where some slack is handy. Make a loose loop of string around the screw, and then wrap the slack around your hand so you can pull the string tight while you tighten the screw to secure the string.

2h. Congratulations! You've just installed your bass string. Repeat steps **2c** through **2g**, using the #15 mason twine, for the tenor and alto strings.

LEGO INSTRUMENTS

People have been building playable musical instruments from LEGO for some time. Henry Lim's LEGO Harpsichord (*see Made on Earth, page 23*) and Brad's LEGO Guitar have been written about many times, but they're only the start.

Telerobotic Glockenspiel Player: XILO is a slightly frightening-looking device that uses the LEGO camera to watch the player and translate his or her movements into real-time Glockenspiel playing. Eight metal tubes lifted from a toy xylophone surround a two-motor whacker in the middle. One motor rotates a mallet into position, and the other brings it down onto one of the tubes to play the corresponding note.

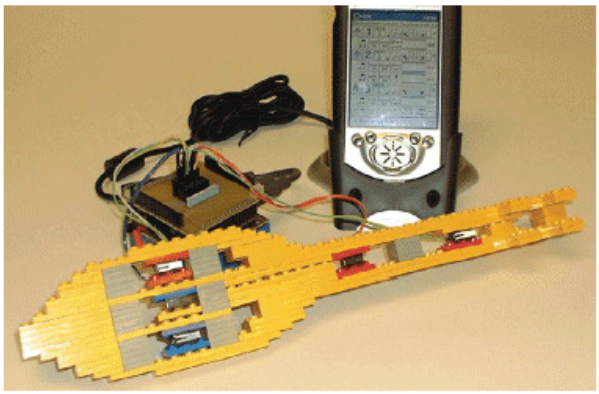
Robotic Ukulele Players: Brown University students Bryant Choung and Amelia Wong built a ukulele-playing robot out of LEGO in 2003, and more recently, Middlebury College students Mike Rimoin and Jarvis Lagmans built a smaller one that plays three-chord, such as "Stir It Up" and "Rivers of Babylon."

Singing LEGO Blocks: The LEGO Mindstorms RCX block (the brain of the system) has a built-in speaker, and Ralph Hempel has written a webpage that explains in eye-watering detail how to make music with it. Remarkably, there doesn't seem to be a MIDI interface for the RCX; at least not yet...

Get links to all these LEGO musical instrument websites at makezine.com/04/lego.

Tom Whitwell is the founder of *www.musicthing.co.uk*. Reprinted with permission from Whitwell's weekly column on *engadget.com*.

LEGO Dulcimer: What is it with medieval instruments and LEGO? Mountain dulcimer enthusiast Peter Always built himself a bright yellow dulcimer, with properly spaced frets made of little grey tiles.

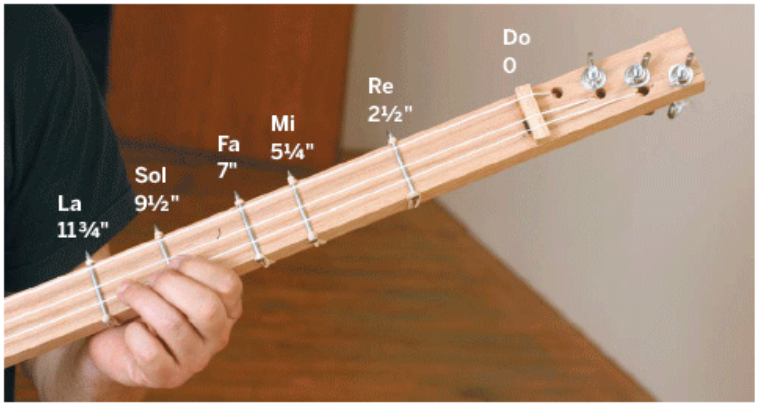


LEGO MIDI Guitar: The "Lifelong Kindergarten" group at MIT developed this LEGO-based system. The idea was that children could use special LEGO components to build their own experimental instruments, which would work as MIDI controllers.

—Tom Whitwell

3. ADD THE FRETS

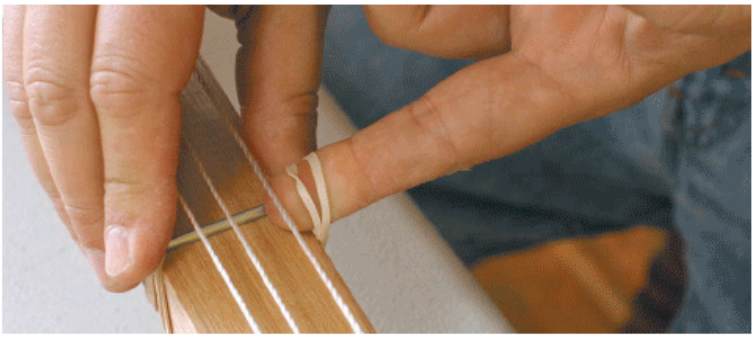
You can usually just find the proper fret locations by singing the major scale. This picture shows approximately where they will go, but it'll take some tweaking to get it right. On my guitar, the five frets went from Re at 2½ inches down from the nut, to La at 11¾ inches down. Try plucking the string and listening for a tone, then marking a dot at the spot with a pencil.



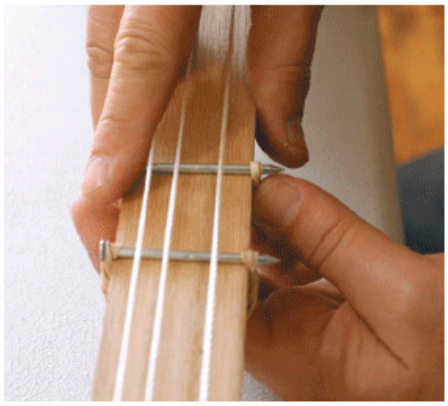
3a. To attach a fret, first take a rubber band and double-loop it.

3b. Fit the looped rubber band to a nail near the head.

3c. Place the nail at a fret position, and pull the rubber band up from underneath the neck. Stretch and loop it around the pointed end of the nail. Notice how the nail point is pointing up. This is a good thing.



3d. Repeat steps **3a** through **3c** above to attach frets for Re, Mi, Fa, Sol, and La. Sing those notes a few times to get that going in your head because it is going to help you tune your guitar. You can add frets farther up, if you want, and the reason my guitar only has frets up to La, instead of up the full scale to Do, is almost maniacal: those are the notes you need to play "Twinkle, Twinkle, Little Star." And nothing else matters.

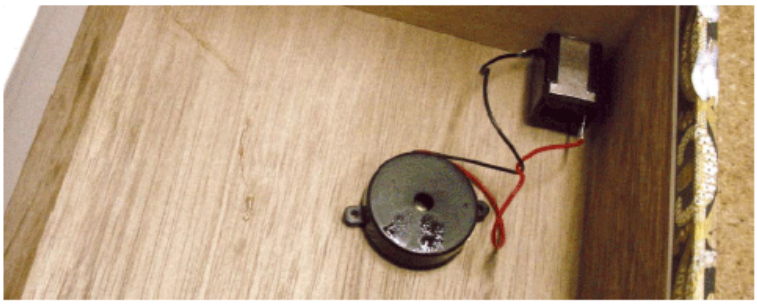


4. ELECTRIFY! (OPTIONAL)

You can testify; now you must electrify! Here's how to add a quick-and-dirty (and I do mean dirty) pickup, so you can play your cigar box guitar through an amp. If you already know you'll want to play electric, it's easier to perform these steps first, before you build the rest of the guitar.

4a. Drill a ⅜" hole in the tail end of the box and mount the ¼" phono jack. (If you've already glued the box shut, you'll have to jimmy it back open with a hobby knife.)

4b. Glue the piezo element inside the box as shown, and solder two wires to connect the piezo pickup to the phono jack terminals. Then glue the box shut. If you haven't already built the rest of your guitar, jump back to step **1c**, and continue from there.



4c. Plug in and rock out! If you find that the pickup is picking up sounds other than the guitar, try covering the sound hole of the piezo element with a couple of pieces of duct tape.

BEYOND THE BOX

Other Easy Materials for Sound Boards and Sound Chambers

The cigar box is admirably suited to the job of radiating string sounds into the surrounding air. You can get the most sound out of one by using a short neck that stops mid-box, attaching the bridge directly to the box (rather than to the neck), and adding a sound hole in front. But that calls for a more complex design than what appears in this article. After you've successfully made one or two of the standard models, maybe you'll find yourself getting more ambitious!

If you can't readily lay your hands on a cigar box, or you just want to explore some other possibilities, here are a few materials and approaches to consider:

An inexpensive styrofoam picnic cooler makes a surprisingly effective sound radiator. Simply glue or screw the cooler to one or both ends of a stick-guitar, for respectable volume and a pleasant tone.

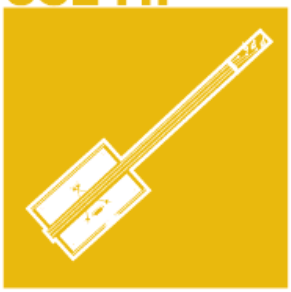
Lightweight metal pots, pans, or bowls are also effective. Attach them concave side out, facing the strings. With aluminum mixing bowls (and especially if you're using steel strings), you can get an exotic sound by placing a little water in the bottom and playing lap-style, tipping the instrument this way and that.

Kinda crazy, but an inflated balloon pressed against the strings where they cross the bridge will greatly increase the volume and add an interesting, percussive tone. With a simple stick guitar, secure a sausage-shaped balloon in place with a long, thin rubber band running around the back of the fretboard. Take a moment to adjust the location for optimal results.

—Bart Hopkin

Bart Hopkin runs Experimental Musical Instruments, an organization that produces books, CDs, and other materials relating to new and unusual musical instruments of all sorts. For information, write emi@windworld.com or visit windworld.com.

USE IT.



TUNE, AND PLAY A TUNE

TUNING

Tuning any musical instrument can be tricky, so I am going to offer two methods: you can tune by ear, using "Twinkle, Twinkle," or you can use a guitar tuner. If both methods still leave you unsatisfied, take your guitar to a music store and have them do it. I have never done this myself, but it might freak them out, which would be well worth the trip.

If trying to tune is making you crazy, put the guitar down for an hour, or even a day. Practice singing the scale and "Twinkle, Twinkle, Little Star." You are not tone deaf. If you were, you would not be able to tell the difference between someone asking you a question and giving you a command. Give in to the earworm and be patient.

After coming back to your guitar, just monkey around with it. You built it; it's yours, and you can do whatever you want! Try over-tightening the strings, and see what the notes sound like until they break. How loose can a string be and still play a recognizable musical sound?

Plan A: To tune by ear

a. Look at the picture you used to position the frets for **step 3**. To tweak in the frets, you'll play the lowest string, the bass string, which is the one nearest the heads of the nails.

b. Turn the bass eyebolt and play the string until you start to hear a relatively clear tone.

c. Tighten the bass wing nut.

d. Use a screwdriver to get some leverage and tighten it a little more. Notice how the tone gets a little higher in pitch as you tighten?

e. Pluck the bass string a few times and sing the first two notes of "Twinkle, Twinkle, Little Star" (which is, of course, the two-syllable word "twinkle").

f. Now tighten the middle string with the screwdriver the same way you tightened the bass string, until it sounds like the third and fourth notes of "Twinkle, Twinkle, Little Star," the second "twinkle." You may find yourself singing "Twinkle, Twinkle" along with the bass and middle strings 10 or 20 times. If you are truly going nuts at this point, proceed to **Plan B: Using a guitar tuner**.

g. The last string is a little trickier, because it requires that the first fret ("Re") is properly set. Additionally, you are going to sing in a different key. Use the middle string to play the first two notes of "Twinkle, Twinkle." Then, while fretting the third string up one fret, tighten it to play the second "twinkle." Your left hand holds the third string down behind the first fret, as your right hand alternates between plucking the string and turning the peg. Again, repetition will make it work.

h. If you feel like you've got it (and even if you don't), strum all three strings. It should sound nice. Another thing that should sound nice is fretting the third string on any fret while strumming all three strings. This little bit of magic lets you play melody and harmony easily, while only fretting one string. This is how the dulcimer works.

Plan B: Using a guitar tuner

a. Get a guitar tuner at a music store, or borrow one.

b. Tighten the bass string until it starts to sound clear.

c. Place the tuner on the cigar box and strum the bass. You should still be below A.

d. Tighten the bass string until you get an A.

e. Repeat **steps b** through **d** for the middle string until you get an E.

f. Repeat **steps b** through **d** for the top string until you get an A again. It will be an octave higher.

Now that the strings are tuned, you can use the tuner to set the frets:

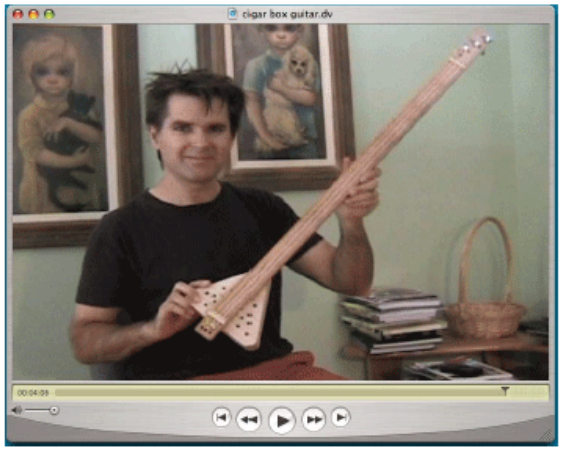
g. Fret the third string to the first fret.

h. Strum and look at the tuner. If it shows a tone lower than B, move the fret down the neck toward the cigar box. If it shows a tone higher than B, move it up the neck toward the tuners.

i. Repeat **steps g** and **h**, moving down the frets, tuning to C#, D, E, F, and so on.

CRAFT BOX GUITAR

Watch MAKE Editor-In-Chief Mark Frauenfelder demonstrate his variant on the cigar box guitar at makezine.com/04/cigarbox.



PLAY A TUNE

Can you guess which one? I'll bet you can! Yes, it is "Twinkle, Twinkle, Little Star." You can do it all on your guitar's bottom string. All you have to do is play the notes that appear above the words notated below:

Do Do Sol Sol La La Sol
Twin - kle twin - kle lit - tle star,

Fa Fa Mi Mi Re Re Do
How I won - der what you are.

La La Fa Fa Mi Mi Re
Up a - bove the world, so high,

La La Fa Fa Mi Mi Re
Like a dia - mond in the sky.

(And so on.)

If you have a hard time remembering which fret is Do, Re, Mi, and so on, then just pencil them in on the neck. It's your guitar, and you can do what you want! To get a more bluegrass sound, you can strum all three strings down and up, double time, for each note.

TAKE IT ON THE ROAD

All-Cigar Box Guitar music festivals have been held recently in Carrolton, Ky.; Huntsville, Ala.; and Red Lion, Penn., and more are being planned for 2006. Check the cigarboxguitars Yahoo! Group for details and updates.

RESOURCES

CBG sites: cigarboxguitars.com, geocities.com/cigarboxguitar

CBG Yahoo! Group: groups.yahoo.com/groups/cigarboxguitars

CBG-building tutorial: cigarboxguitars.com

Musical Instrument Design by Bart Hopkin

Cardboard Folk Instruments to Make and Play by Dennis Waring

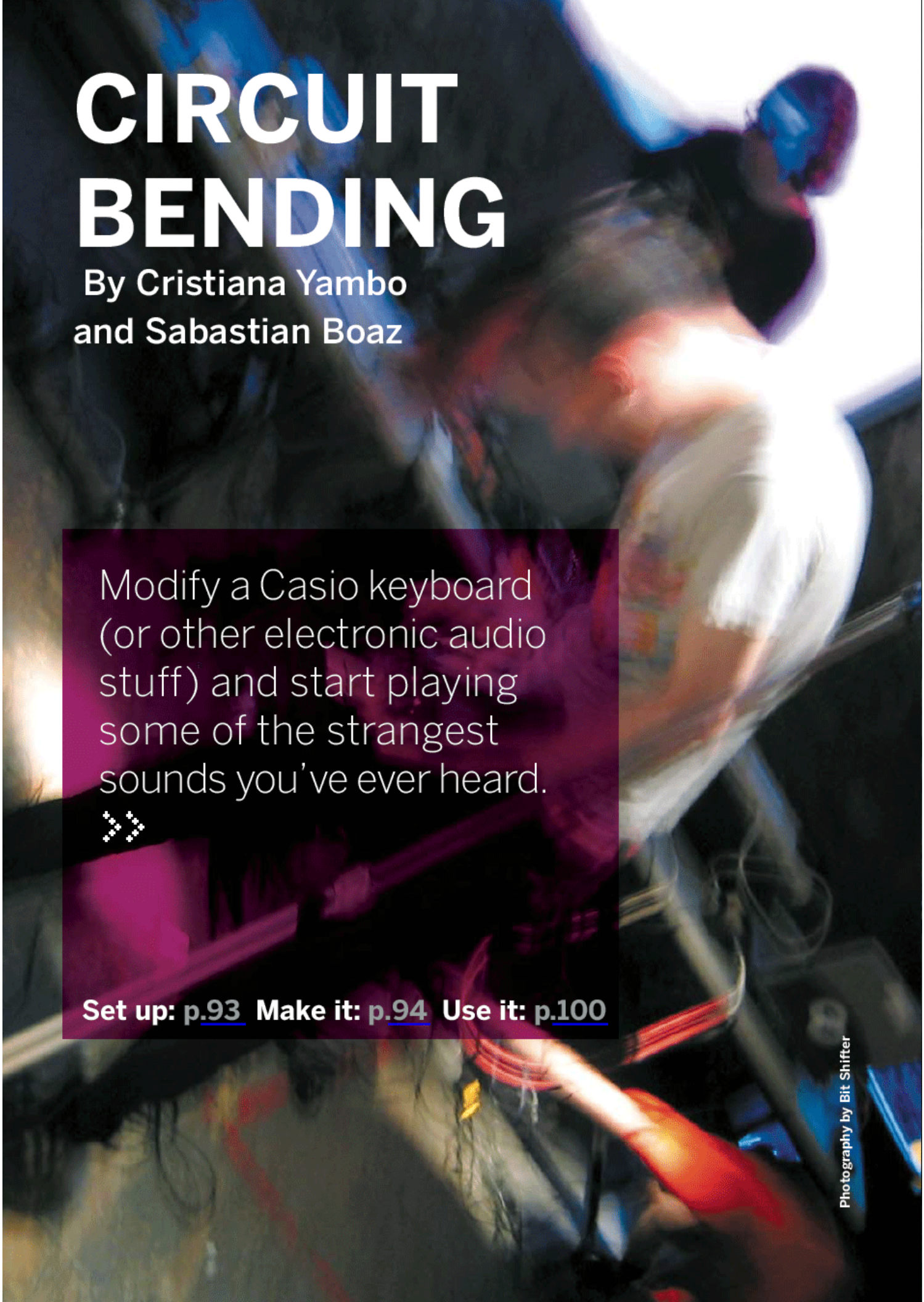
Sound clip of author Ed Vogel playing "Twinkle, Twinkle": www.geocities.com/ed_vogel/cbg1.WMA

CIRCUIT BENDING

By Cristiana Yambo and Sabastian Boaz

Modify a Casio keyboard (or other electronic audio stuff) and start playing some of the strangest sounds you've ever heard.

Set up: p.93 **Make it:** p.94 **Use it:** p.100



Photography by Bit Shifter

SOUNDS OF CIRCUITS

The easiest way to start circuit bending is "playing open circuits." That's where you open up an audio device and use your hands or alligator clips to mess with the board inside and see what it sounds like. But it's almost as easy to permanently "bend" any suitable device by soldering on a few wires and switches. We'll explain how, and then show you how we transformed a Casio SK-5, a common, 80s-era sampling keyboard, into an unstoppably flexible sound organ and sonic effects generator.

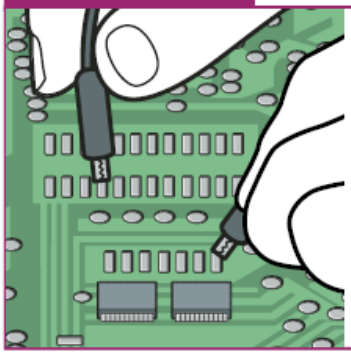
A word of caution: Do not attempt to circuit bend anything that needs to be plugged into a wall, such as a VCR or a television. These devices use high voltages, and playing with the circuitry inside might injure or kill you. Circuit bending is for battery-powered toys and instruments only.

When not sticking her hand in electronic equipment, **Cristiana Yambo** spins industrial beats on the DJ table and hides by day in the guise of a computer programmer. **Sabastian Boaz** doesn't just circuit bend as a hobby but also uses his creations in recording and performing synthpop and industrial music.

BENDING: THE RULES

Any battery-powered audio toy or musical instrument can be bent. Favorites include old Speak & Spells, toy keyboards, and Furbys, available at low prices at garage sales and junk shops nationwide.

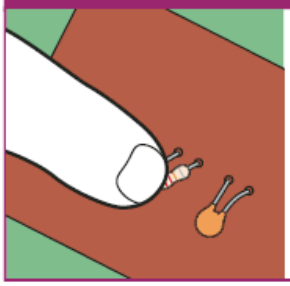
Method 1
SCAN AND MARK



With a pair of alligator clips, probe around the circuit board, connecting solder points and listening for the results.

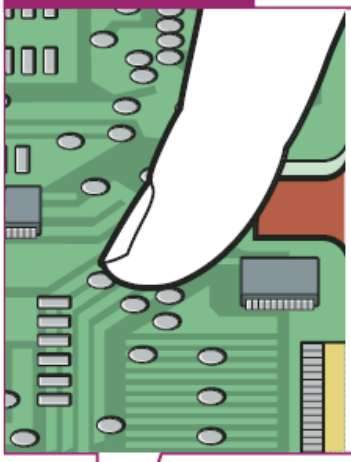
You'll often find good bends by connecting different pins on a chip.

Method 2
COMPONENT JUMPING

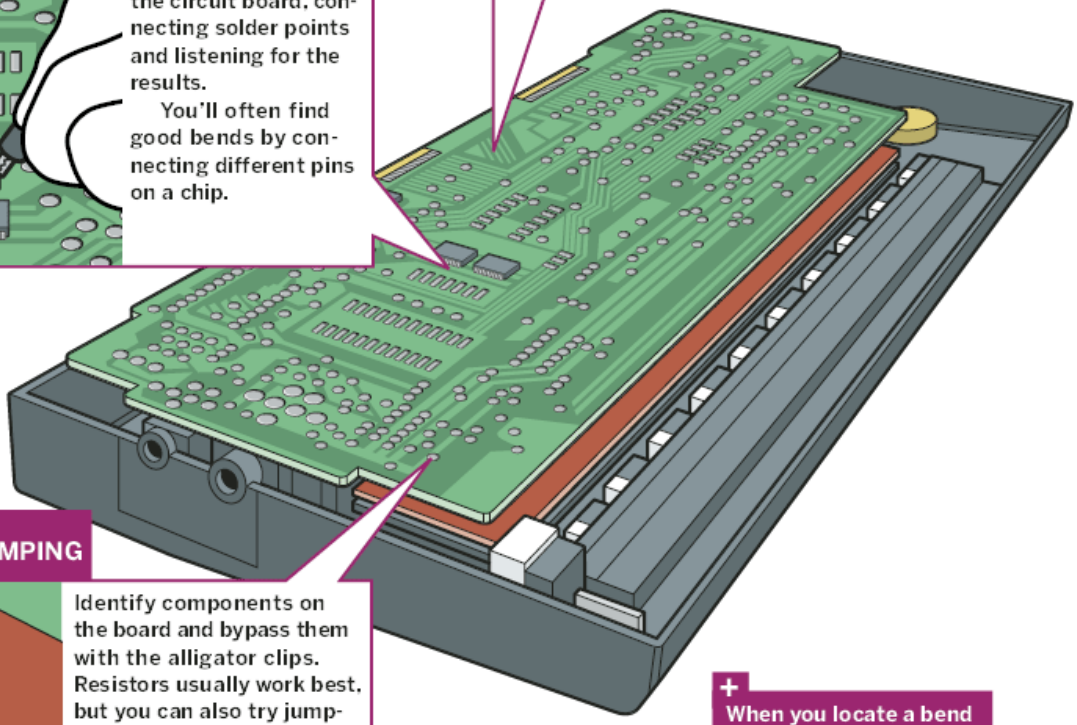


Identify components on the board and bypass them with the alligator clips. Resistors usually work best, but you can also try jumping diodes, capacitors, and other components.

Method 3
LICK AND PRESS



The quickest technique is to lick a finger and press it around resistors and trim pots: neighboring solder points will be bridged by the variable resistor of your skin, producing nice distortions. Avoid getting too much moisture on the board because that can corrode the contacts.



+ When you locate a bend you like, mark the two points with a Sharpie and scan for more bends.

Illustrations by Mark Watkinson

For Your Listening Pleasure

Project co-author Sabastian Boaz has produced several electronic music CDs that feature sounds from his bent instrument collection. His older music relied heavily on circuit bending, and his latest CD, *Head Drone*, builds on these roots by incorporating crazy electronic sounds generated using a variety of techniques.

You can listen to some of Sabastian's music, along with other bent instrument recordings, at makezine.com/04/circuitbending

Permanently Bent

To make bends permanent, solder wires and switches to the connection points. The easiest method is to bridge the points directly. This project brings them out to a patch bay that allows arbitrary connections, for greater flexibility.

ALIEN LIFE FORMS

The father of circuit bending confronts the normals.

It's hard to know who invented electronic music synthesis, but you could say that Reed Ghazala uninvented it. He coined the term "circuit bending" and has been the technique's spiritual father and first major practitioner.

Ghazala stumbled on the idea in 1967. "I was 14 going on 15, in junior high and craving my own synth, but penniless," he recalls. "In my desk drawer was a junked mini amplifier made by RadioShack, battery installed and back off, exposing the circuitry. Closing the drawer after a search for who-knows-what, my room was suddenly filled with weird electronic music: strange 'flanged' oscillator sweeps rising in pitch, repeating over and over again." The amplifier had shorted out against something metal, and that led to a revelation: what if you shorted out circuitry intentionally?

Reed's first instrument took advantage of this idea, but audiences didn't immediately take to the avant-garde sounds. "Rowdy Elvis fans" at an early gig physically attacked Ghazala, hoping to "send me and the band to the emergency room," he says. "But their main target was my instrument. It symbolized a notion of music beyond verbal ballad, telling stories in a language they couldn't understand." The audience succeeded in destroying the instrument.

> "Their main target was my instrument. It symbolized a notion of music beyond verbal ballad, telling stories in a language they couldn't understand."

Despite the lack of early audience support, Ghazala was hooked on creating something new and alien, and his audience-obliterated instrument was followed by decades of prolific instrument building. "When I was first body-contacting bent instruments, I realized neither the circuits nor I stopped at our ends anymore," says Ghazala. "I was extended into the circuit and the circuit was extended into me. We shared the vital electricity that we each depended upon to function, to live. We were no longer two separate entities, like guitar and guitarist. We, literally, were one." He calls the combination a "Bio-Electronic Audiosapian," or BEAsape.

Circuit bending, Ghazala explains, means dropping your intentions. "When I hack a radio receiver, I may clip some diodes in it so that I can tune into a wider frequency range. But that's not circuit bending, because I know where things are going to go. With bending, you cannot presume what you're going to find — just like sending a probe into deep space." And outside presumption lies an alien world filled with alien sounds.

Ghazala's instruments certainly look alien, with flashing lights, eyeballs, laser controls, and hand-inked patterns that resemble psychedelic extra-terrestrial animal prints. Ghazala considers his creations more organism than art object, with body modifications that allow them to "sing things they couldn't sing before."

Perhaps Ghazala's instruments have grown eyeballs and skins because they're evolving. Nearly 40 years after his first experiments, circuit bending has become a worldwide phenomenon. "As the art of circuit bending claims more territory, spreading through the music underground like alien bacteria," Ghazala says, "it's infecting more and more circuitry every day."

—Peter Kirn

Ghazala's tutorial on how to build an Incantor is available at makezine.com/04/circuitbending.

Peter Kirn is a composer, musician, and media artist; his blog (createdigitalmusic.com) regularly covers circuit bending and other far-out music technologies.

SET UP.

MATERIALS

[A] Casio SK-series keyboard We used an SK-5, but they're all great for bending. Check local thrift stores or eBay.

[B] Stranded wire 22-gauge or thereabouts

[C] Small machine screws and nuts At least 77 of each

[D] Flat, non-conducting, easily drillable box For the patch bay, we used a translucent plastic storage box. The patch bay box should be big enough to hold and permit access to 77 screws without crowding.

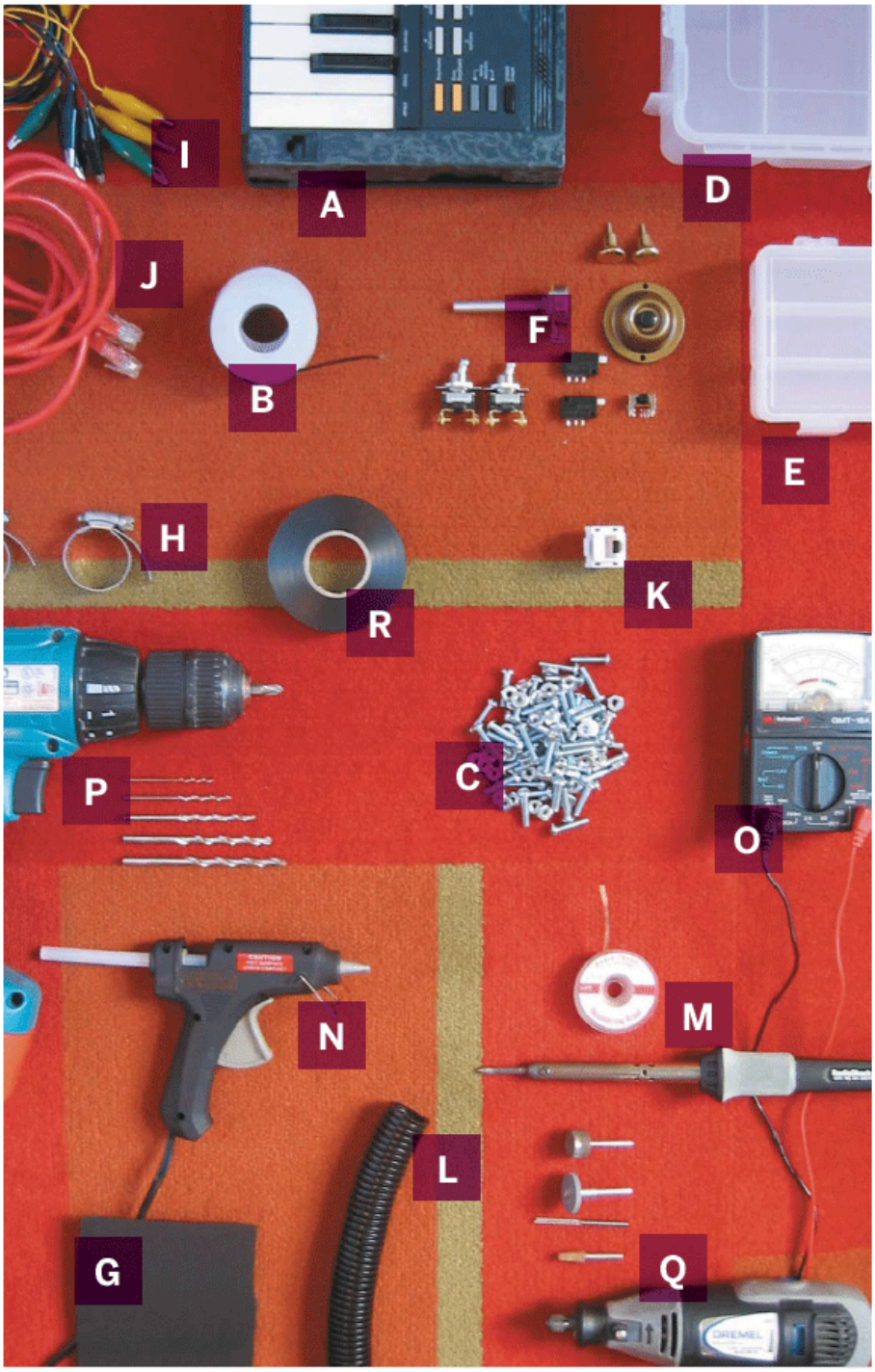
[E] Flat, non-conducting box Like above, but smaller; for external key box controller (optional)

[F] Assorted switches, contacts, and other bend components For the control panel. We used 4 toggle switches, 1 potentiometer, 1 photometer, 2 doorknobs (for body contacts), and a push-button momentary switch to reset the device.

[G] Flat, non-conducting, easily drillable panel, about 5"x5" For the control panel, which fits over the keyboard's speaker area.

[H] Hose clamps (2)

[I] Alligator clips At least a few; the more, the merrier.



Photograph by David Albertson

[J] Ethernet cable For external controllers (optional)

[K] Ethernet jack For external controllers (optional)

[L] Flexible plastic tubing

Momentary switches We used keyboard keys from an old Macintosh. In many older, heavier computer keyboards, each key is its own self-contained momentary switch (not shown).

TOOLS

[M] Soldering equipment
[N] Glue gun and hot glue
[O] Multimeter
[P] Drill and drill bits
[Q] Rotary tool and bits
[R] Electrical tape
Multiple voltage transformer (optional, not shown)

MAKE IT.

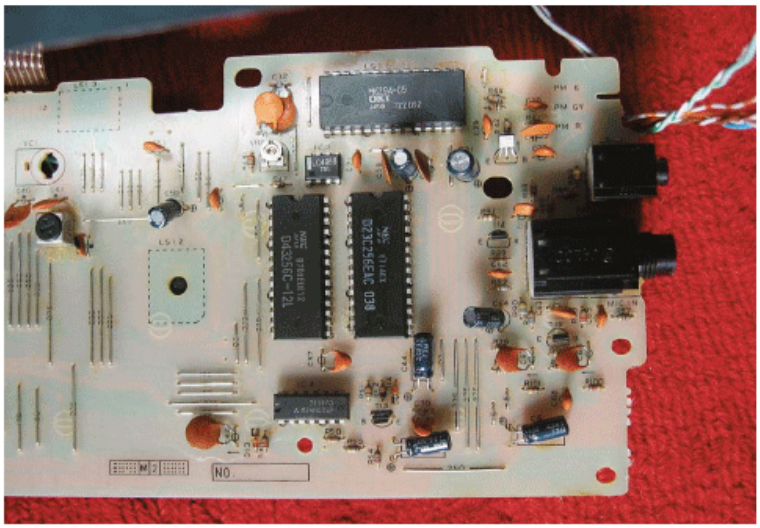
BEND YOUR CASIO SK KEYBOARD

START **Time:** A Weekend **Complexity:** Medium

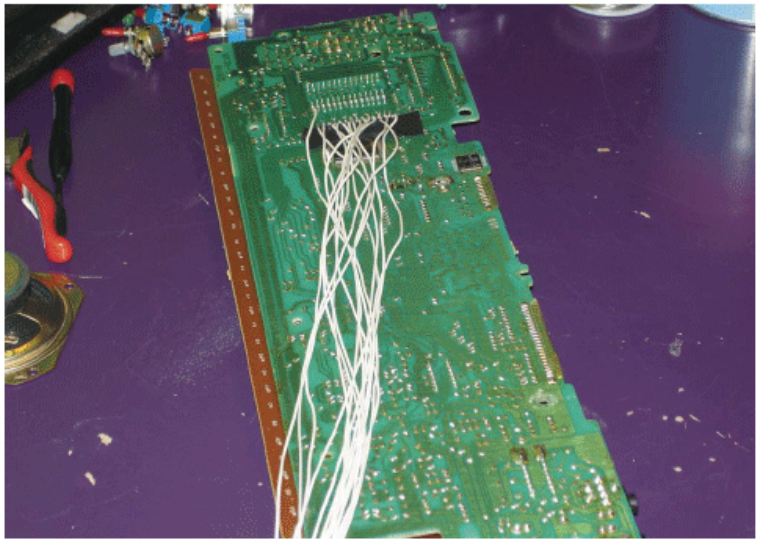
1. CONNECT THE PATCH WIRES

The chips on Casio SK keyboards contain vast potential for unruly sounds, and wiring up a patch bay unlocks all of it by making every possible pin-to-pin connection available.

1a. Find the main chips. Open the case, remove the motherboard, and identify the main sound processing chips; these are two large, rectangular chips next to each other in the middle of the board. Each has 14 pins per side, a total of 56 pins. Turn the board over and find the points of these pins on the underside. You will solder one wire to each of these.

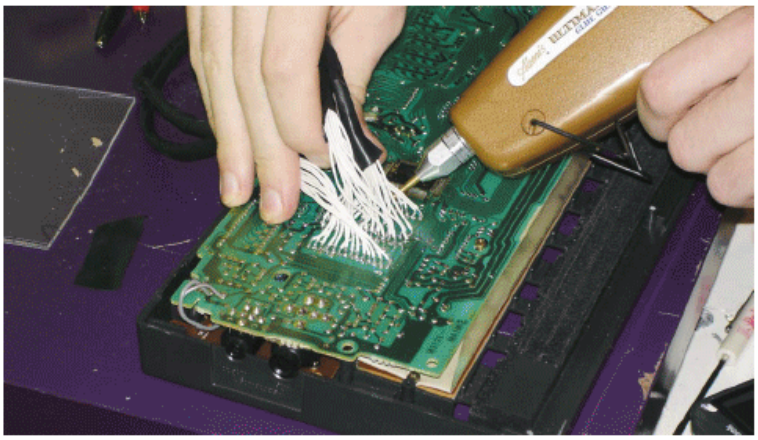


1b. Solder and check wires. For each row of 14 main chip pins, solder 14 lengths of wire, each around 30 inches long, to the contact points underneath. Carefully check each pin for solder bridges. When you finish a row, replace the board and play the keyboard to see if it still works normally. If it makes any weird sounds, you probably bridged two pins together. You can also use your multimeter to test pairs of wires for continuity and resolder wherever you find one.



Photography by Cristiana Yambo

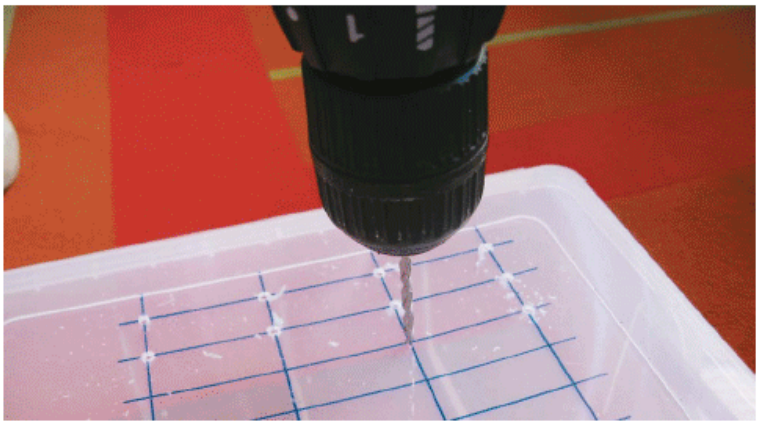
1c. Insulate. Once each row passes its test, cover its pins in electrical tape, and wrap the wires in electrical tape to create a nice cable. After you've soldered and checked all four rows, remove the tape covering the pins and test the unit again. When it passes the test, warm up your glue gun and cover each row in hot glue. This holds the wires in place and insulates the connections to prevent unintended short circuits.



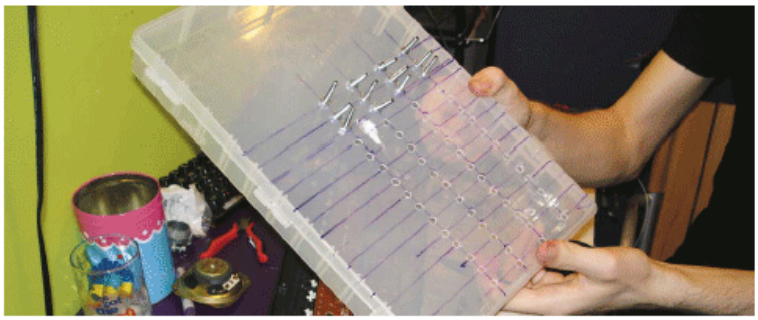
2. BUILD AND CONNECT THE PATCH BAY

Some people construct patch bays using RCA jacks, but screws and alligator clips are cheaper, more compact, and they let you connect multiple clips to the same point, which vastly expands the sonic possibilities.

2a. Drill the holes. Measure, mark, and drill 60 holes in the patch bay box, four rows of 15, one for each of the 56 wires, plus four jumper points on the side to facilitate multiple connections. The holes should fit your screws snugly. Leave room for another, smaller set of holes for the control panel which you'll drill later.



2b. Insert the screws. Bolt screws into the holes, with the heads on the inside and the shafts pointing out.

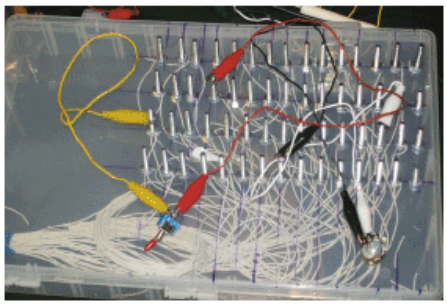


2c. Make the patch cable. Count your control panel components, and then strip and cut enough wires to connect to each of these, plus two more for the tuning circuit; we used 17 total. You'll connect these wires later, so it helps to include some extra ones and label which ends connect to one another. Gather them together with four taped-together sets of patch wires, to make a super-cable that will run between the keyboard and patch bay. Secure each end with hose clamps, and push it through the plastic tube.

2d. Route the patch cable. Cut a large hole in the side of the patch bay box. Insert the patch cable and secure it by hot-gluing the hose clamp to the box.

2e. Connect the patch wires. Now it's time to wire the screws. Wrap the end of each patch wire clockwise underneath the head of each screw and tighten the bolt to secure the wire. Connect each group of 14 patch wires to a different row on the patch bay.

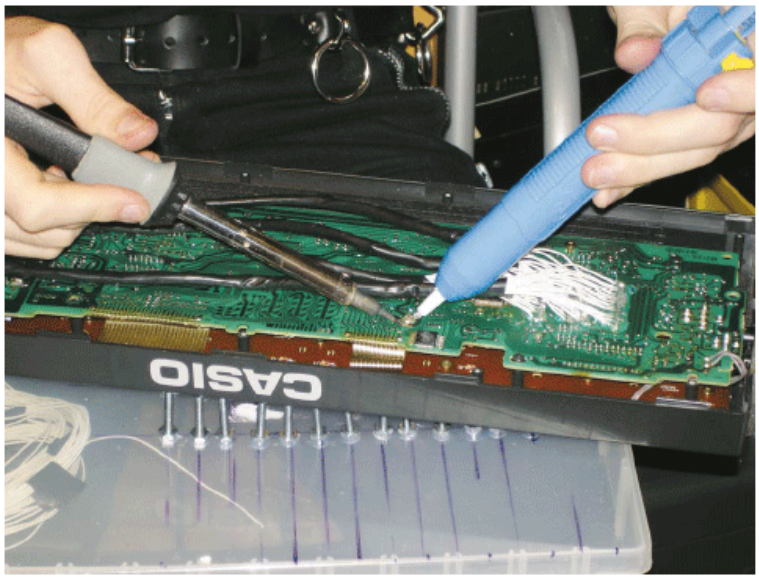
2f. Test the board. Using alligator clips, connect switches and pots between different patch points, play the keyboard, and see how it works. Operating the components and changing their configuration should yield different sounds.



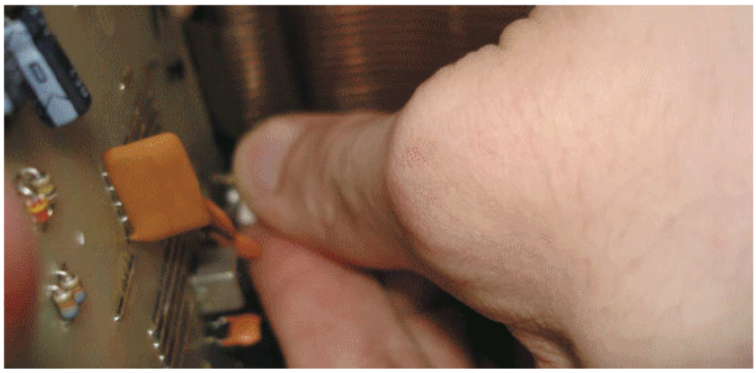
3. REMOVE THE TUNING POT

Many old electronic instruments easily lose their tuning and have a small potentiometer that adjusts them back into tune. We'll bring this component's connections out to our patch bay, so you can create bends that alter the pitch of the entire keyboard.

3a. Unsolder the pot. The SK's tuning pot is normally accessed through a hole in the underside of the keyboard, in the center, and you adjust it with a small screwdriver. Find the component on the board and use a solder sucker or desoldering braid to remove all of the solder.



3b. Pull out the tuning pot. You will probably have to use some force. Then mark where it was located, to help you find it later.



4. BUILD THE CONTROL PANEL

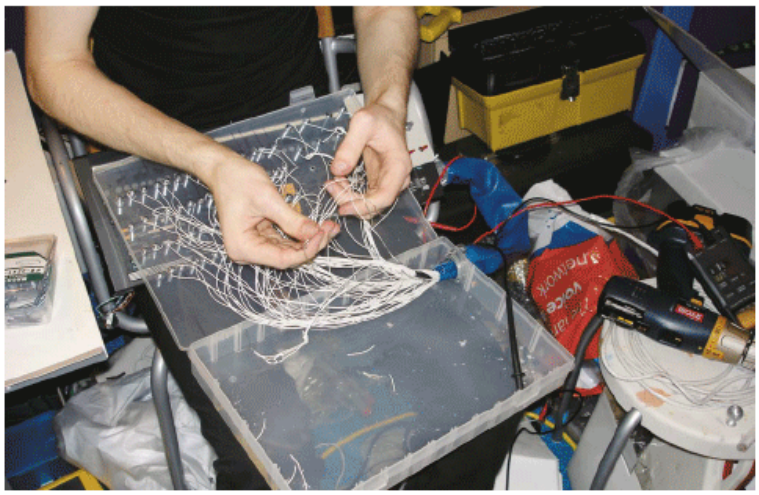
The control panel houses interface components which you can hook into any circuit bends via the patch bay. It also has the reset button, a momentary switch that restarts the instrument after a crash.

4a. Cut out the speaker grill. Using a rotary tool, cut out the speaker grill. This hole is going to be used to house the interface elements.

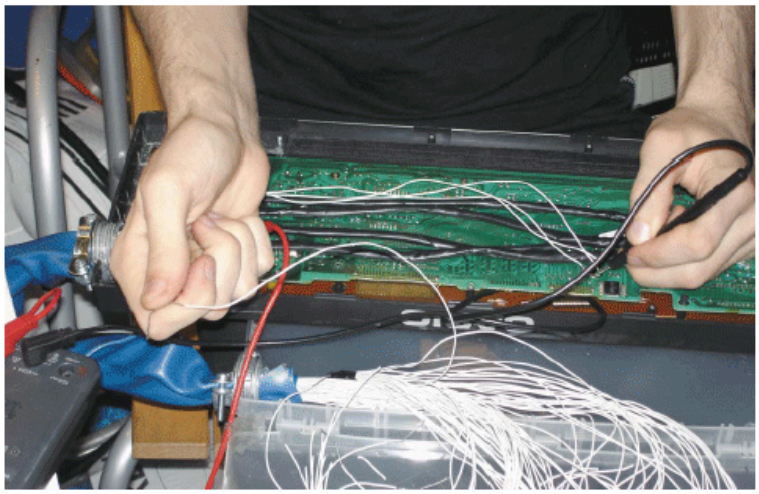
4b. Build the control panel. Attach your components to the panel. For ours, we drilled holes in a piece of hard plastic and then hot-glued in our components: four toggle switches, a pair of doorknobs for body contacts, a potentiometer (separate from the tuning pot), a photometer for light-sensitive distortions, and a momentary switch, which will act as a reset button.

5. CONNECT THE CONTROL PANEL

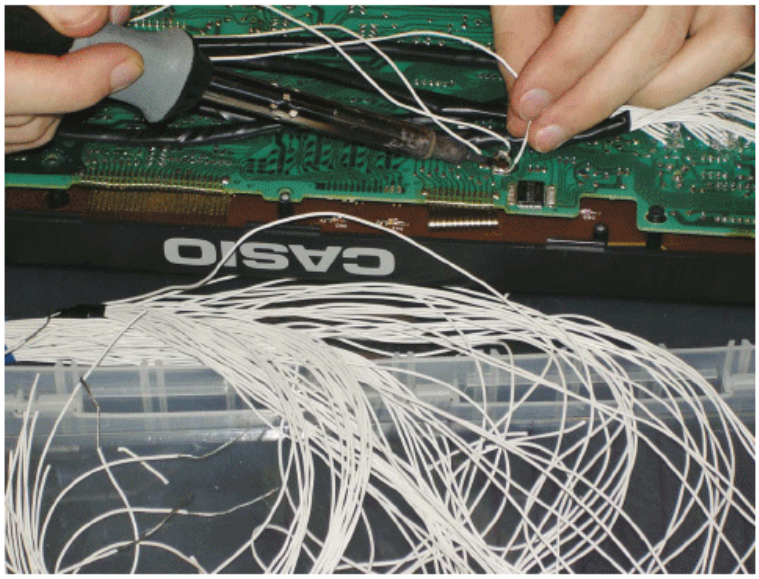
5a. Finish the patch bay. Drill holes and install screws in the patch bay, as in Step 2. You'll need the appropriate number of contact points for each component on the control panel, plus two more to lead to the tuning pot's contacts on the circuit board. Arrange the holes in the same way that your components are arranged on the control panel. This makes it easy to remember which contact point on the bay corresponds to which control.



5b. Wire the control panel. Now you're going to use the extra wires in the cable. If they aren't labeled, use a multimeter to identify matching ends. Then connect the control panel components to the new patch bay array, following your logical mapping. Screw the wires to the patch bay points as before, and solder the other ends to the components.



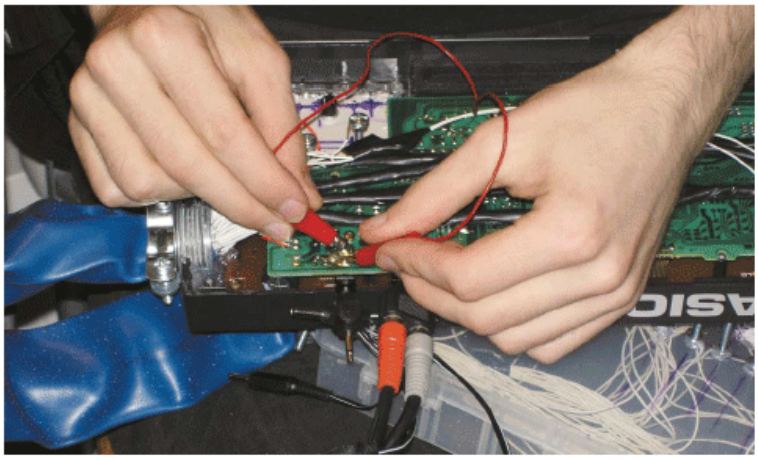
5c. Connect the tuning circuit. Screw two remaining extra wires to the tuning-circuit points on the patch bay and solder the other ends to the tuning pot contacts on the board.



6. CONNECT THE RESET, AND CLOSE IT UP

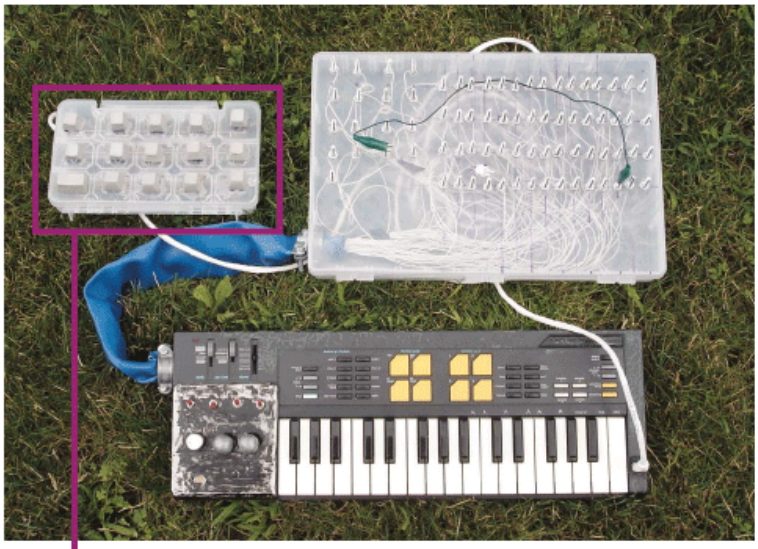
Bent instruments sometimes crash in a way that disables the power switch. One solution is to wire a momentary switch between the positive power line and the circuit board, but with the SK-5 it's easier to install a switch that connects the positive and negative power lines, momentarily shorting them out.

6a. Connect the reset button. Solder the reset button's contacts to the positive and negative terminals that lead from the battery compartment.



6b. Hot-glue the control panel to the case.

6c. Close up the case. Screw it together, switch it on, and then rock out with the ultimate SK!



Extend the capabilities of your new keyboard by adding an external controller port and making two kinds of external controllers. Visit makezine.com/04/circuitbending for complete instructions.

FINISH X

NOW GO USE IT »

USE IT.

JOIN THE CIRCUITS

MAKING TOYS PERFORMANCE-READY

One of the great features of this project is that the patch bay also allows you to connect other devices to the keyboard's circuitry. For example, we alligator-clipped the output of an iPod to our SK-5's tuning-pot contacts. This made the waveform of the music playing on the iPod modulate the pitch of the SK-5's output, an amazing effect.

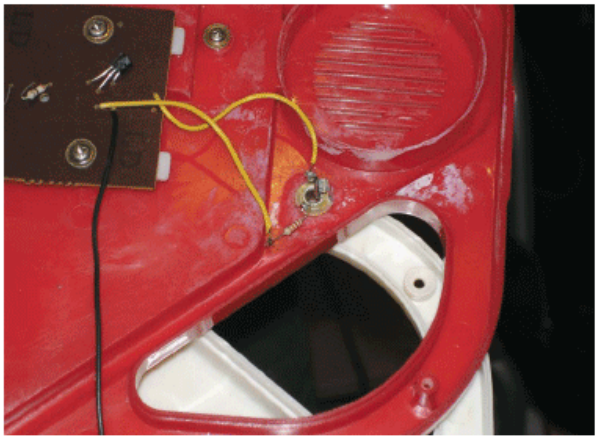
Body contacts can be played with various parts of the body at different pressures for different effects. Touching a body contact with your tongue gives very low resistance, which can translate to an extremely high pitch — and electrocute your tongue a little bit.

SK-series keyboards, like the one used in this project, have wall warts and audio jacks. This means they won't run out of juice, and you can amplify them directly and record them by plugging them in. But many bend-worthy audio toys lack these two essentials. Here's how to remedy the situation.

Adding an Audio Out

With a toy that has only a speaker, you can make an audio out by connecting the two wires that feed the speaker to a standard mono audio jack or a cut audio cable. If the wires are colored, you can follow the convention of connecting red to the tip and black to the ring. But the order shouldn't matter; either way will work fine.

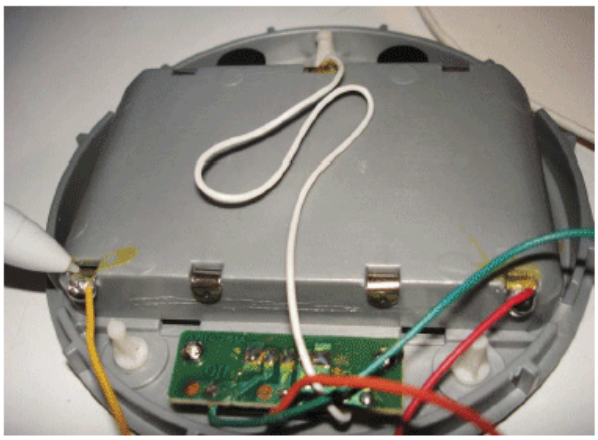
With some toys, output to the speaker might be high enough to cause distortion. To bring it down to regular analog audio signal levels, add a resistor in-line to the wire that connects to the tip. Experiment with different values to find one that works.



Adding a Power Source

Add the battery voltages and find an adapter with the same total voltage — you may already have one from some old appliance. Confirm its voltage with a multimeter (labels can be incorrect) and determine its polarity, which is usually but not always tip positive, ring negative. If it checks out, solder wires from the negative and positive ends of the toy's battery tray to the corresponding contacts of the DC in.

Toys sometimes list an amperage. You can usually ignore this, but if the circuitry is especially sensitive, test the power adapter's amperage along with the voltage. Again, trust the multimeter, not the label.



WELCOME TO THE WARPED WORLD OF CIRCUIT BENDING

If you've grown weary of computer software for look-alike, sound-alike musical instruments, you might have something to learn from Adrian Dimond. His latest project is making modified experimental sound creation devices out of Furby toys.

Dimond, aka Xdugef (xdugef.com), unwinds from his day job as a motion graphics artist by producing raunchy electrical noise. His tools of choice range from modified CD players and ancient reel-to-reel tapes to educational phonics toys and a flanger effects box. That might sound archaic, but Dimond is hardly alone. Fueled by online instructions for device modification, circuit bending has become a phenomenon. Nine Inch Nails uses bent instruments now, and you can hear experimental artist Oval's skipping CD players in a Calvin Klein fragrance ad. Bending's exposure may have gone mainstream, but the sound is far from conventional: bent creations are adored for their noisy, unpredictable nature.

Popular instruments for beginning benders include the plentiful Casio CZ-1 keyboard and the venerable Texas Instruments "Speak &" talking toy series (Speak & Spell, Speak & Read, Speak & Math). Whereas bending once involved countless hours of adjusting circuits with what-if pokes and prods, online treasure maps and tutorials make it easy for newcomers to the field. And once you've cut your teeth with one of the more well-documented devices, plenty of unexplored frontiers remain, particularly the more complex digital devices.

The gamut of bending projects is virtually limitless. Some works are art objects as much as instruments, sculptural creations with elaborate cases and what Dimond describes as "Duchampian collage." Others are more utilitarian, salvaging plastic cases or simply painting absurd illustrations on the bent object. Many are tongue-in-cheek, merciless modifications of toys.

Dr. Age of the U.K. band Cementimental has warped Nintendo games into video art, and built bizarre instruments out of a Ghostbuster voice modifier toy, a Pikachu keychain, and a plastic toilet, which he converted into an optical Theremin. Techdweeb (techdweeb.com) has taken on dancing daisy toys and the infamous talking fish Billy Bass. Carrion Sound (carrionsound.com) has done unspeakable things to Howdy the Talking Pony.

It's a little premature to talk about a circuit bending "scene" yet, particularly since it's hard to know where to draw the lines between "true" circuit bending, device modification, instrumental abuse, and more general noise art. But amidst the countless experimental performances around the world, there's clearly a growing interest in festivals and workshops focused on bending. New York City is a major epicenter, with numerous concerts and classes and the Bent Festival, held in 2004 and 2005 at The Tank (thetanknyc.com). Bending festivals are also in the works for California and Virginia, and Los Angeles' Il Corral (halfnormal.com/ilcorral) has established itself as a West Coast hub for noise and sound art.

In the meantime, benders share hundreds of websites featuring music, schematics, photo galleries of various creations, and (sometimes heated) message boards and mailing lists.

—Peter Kirn

RESOURCES

Circuit-Bending: Build Your Own Alien Instruments, by Reed Ghazala

Reed Ghazala's site:
anti-theory.com/bentsound

Other bending and noise art sites:
cementimental.com/links.html
harshnoise.com

Discussion groups:
groups.yahoo.com/group/benders
groups.yahoo.com/group/bendersanonymous
launch.groups.yahoo.com/group/Roil_Noise
p206.ezboard.com/biheartnoise

Composer, musician, and media artist Peter Kirn profiled Reed Ghazala on page 92.

HOMEMADE STROBE PHOTOGRAPHY

By Tom Anderson and Wendell Anderson

Pictures of high-speed events such as popping balloons, breaking glass, and splashing liquids reveal interesting structures not visible to the naked eye. You can take your own high-speed photos to capture these ephemeral events. >>

Set up: p.108 **Make it:** p.109 **Use it:** p.116

Photography by Tom Anderson and Wendell Anderson

JUMPIN' JACKED FLASH

We built a strobe flash out of a Kodak disposable camera and then designed a circuit that triggers the flash when it detects a sound or other measurable event. The strobe flash will freeze motion!

We use a digital camera set for a long exposure (two seconds or more), and shoot the picture in a dark room. When the balloon pops, the sound-activated trigger circuit fires the flash, and the camera captures the incredible event.

Why not just take the picture of the balloon with a digital camera and its built-in flash? First, getting the timing right is a hard problem: the camera's exposure, its flash, and the event itself need to be synchronized. (Try it yourself and see what luck you have.) The second problem is that a stock camera flash doesn't make a very good strobe because it flashes too long, causing blurry high-speed photos.

Tom Anderson and Wendell Anderson are engineers for an electronics company. As a hobby, they develop audio hardware and software projects.

SOUND TRIGGER

We take long exposures in a darkened room. It doesn't need to be pitch black; we use a garage at night with the lights out. Even though the shutter is open for 2 to 15 seconds, the flash fires just once, triggered by sound. The flash freezes the motion, and we get a picture. When taking a flash picture in a dark room, it doesn't matter how long the shutter is open. All that matters is that the flash fires while the shutter is open.

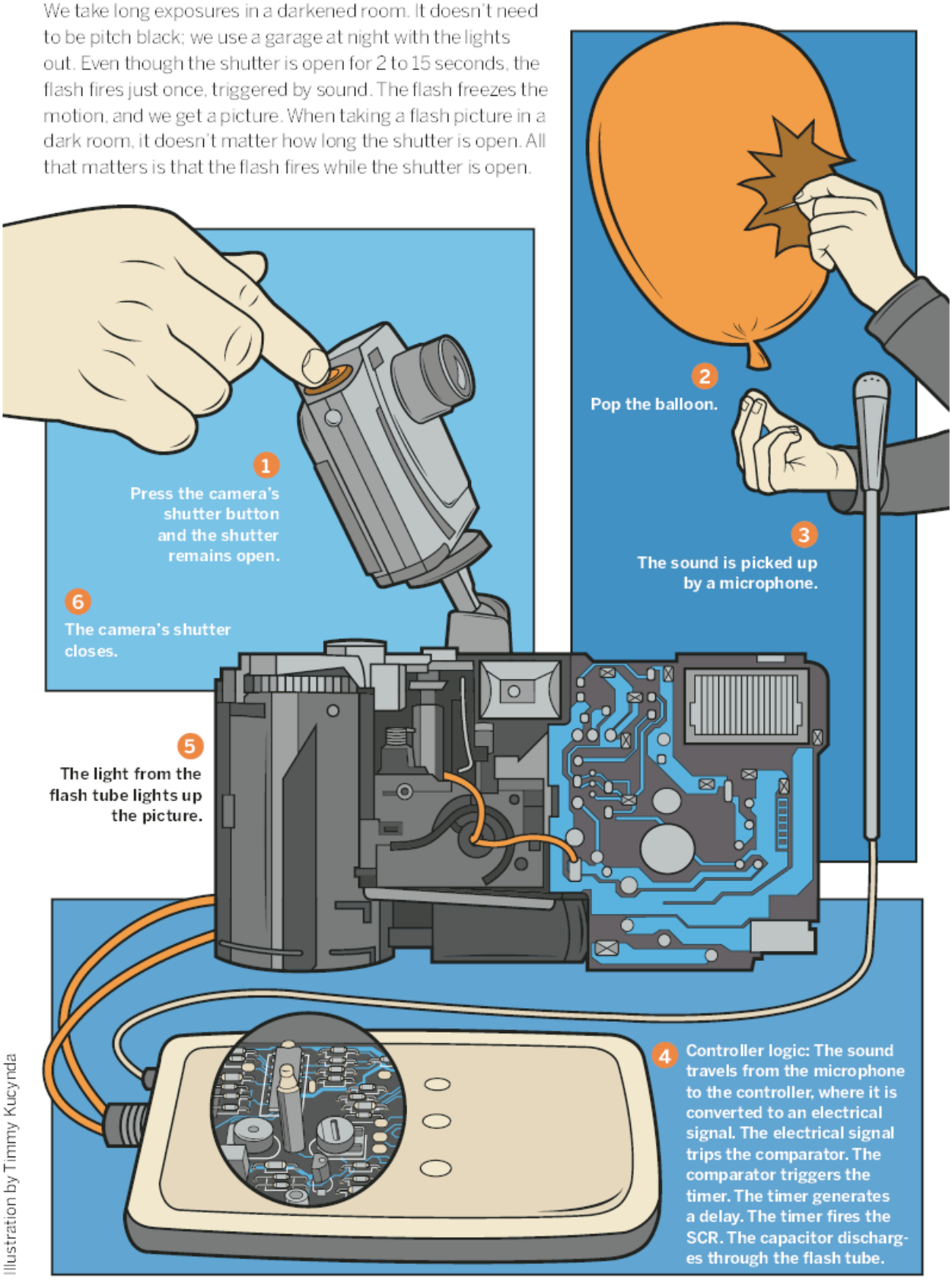
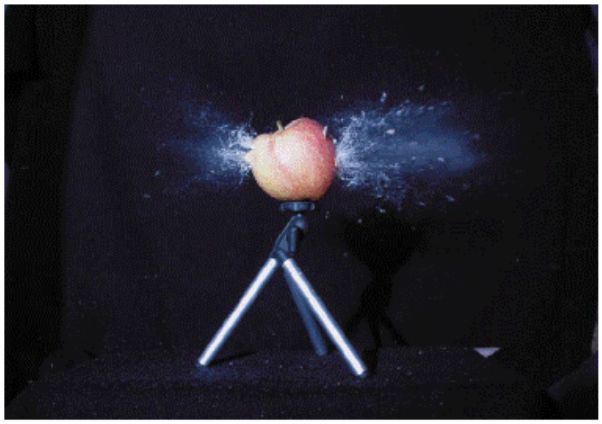


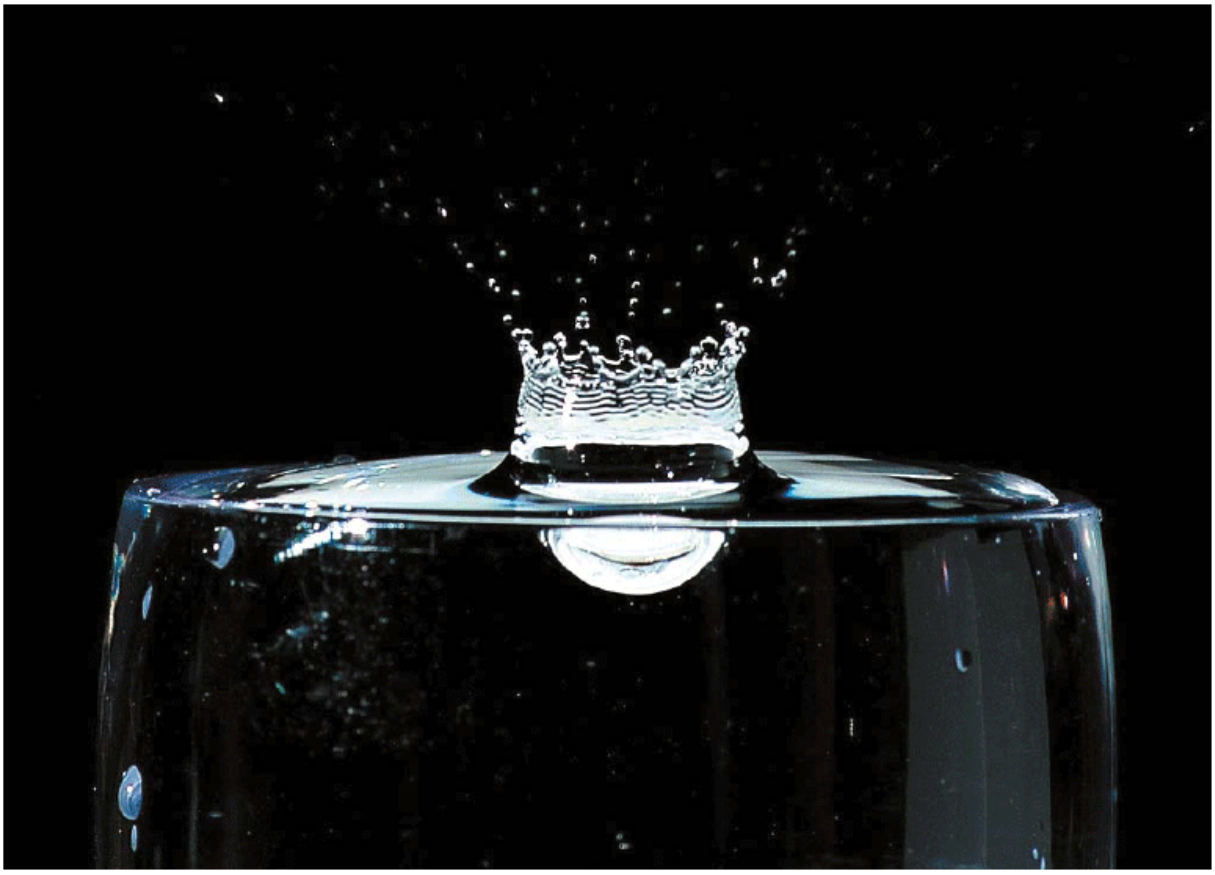
Illustration by Timmy Kucynda



Strobe Photo Gallery
This page, clockwise from top: Bottle blast in Bryn Russell's high-speed studio; .22 bullet meets crayons, by Khuong Nguyen, Ed Bystrom, and Chen-Chei Chuang; Chris Pycior captures Dan Brown making a catch in Lee's Summit, Mo.; drive-by fruiting by Bryn Russell. (Not all of these photos can be taken using the Flash Controller Kit).

Opposite page, clockwise from top: Ken Reppart's glass is more than half full; firecracker explosion by Tom and Wendell Anderson; board breaking by Tom and Wendell Anderson.

See more strobe photography in the Flickr high-speed photography pool, flickr.com/groups/highspeed/pool.

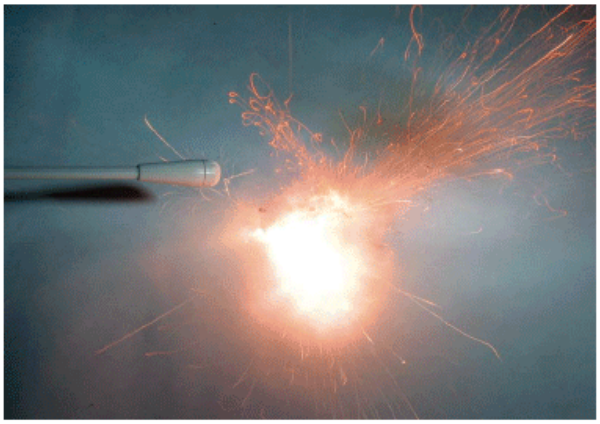


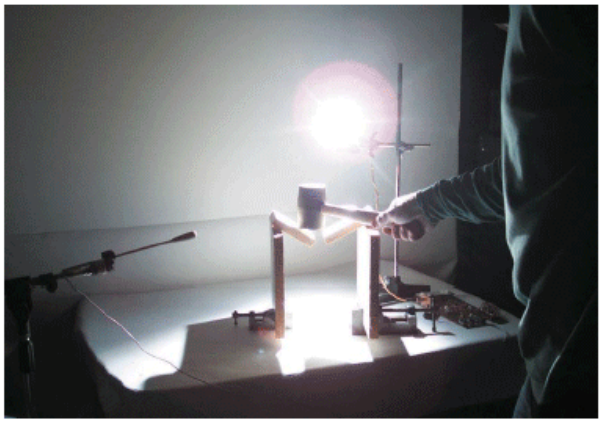
A BRIEF HISTORY OF HIGH-SPEED PHOTOGRAPHY

Ernst Mach published some of the earliest high-speed images in 1887, using the light from a spark gap to freeze a bullet and reveal the shadow of the supersonic shock wave preceding it. But it is MIT professor Harold "Doc" Edgerton (1903-1990) who is largely credited with transforming strobes from an obscure laboratory instrument into a pedestrian device in every camera. In addition to having the scientific and engineering acumen to perfect strobes commercially, Edgerton is equally recognized for his visual aesthetic. Many of the striking images he created of illuminating phenomena adorn art museums worldwide. His photos and strobe equipment can be seen at the MIT Museum.

—Peter Mui

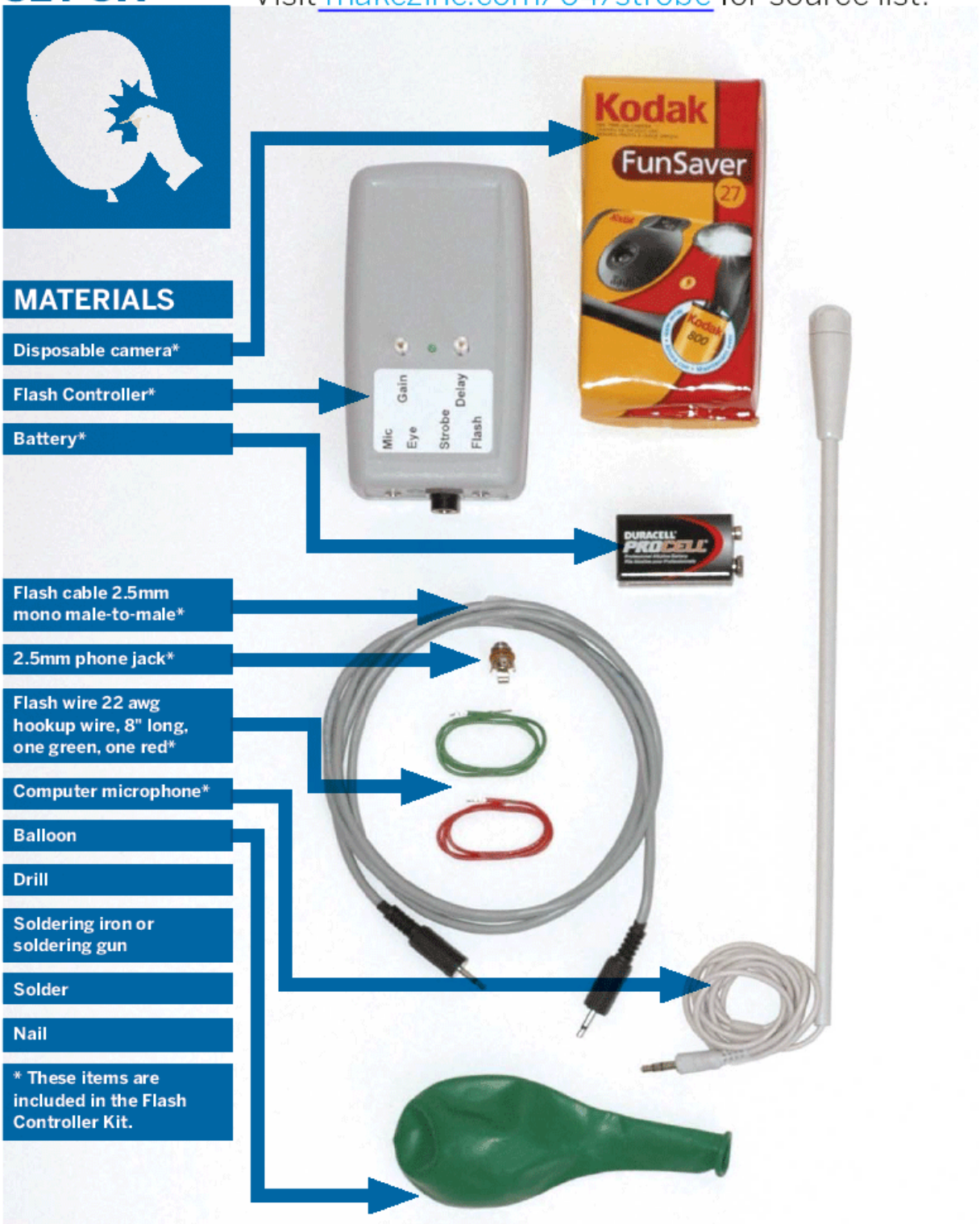
Editor's Note: Peter Mui had Doc Edgerton as his thesis advisor at MIT and after graduation was a research assistant in his lab until 1990.





SET UP.

Visit makezine.com/04/strobe for source list.



MATERIALS

- Disposable camera*
- Flash Controller*
- Battery*
- Flash cable 2.5mm mono male-to-male*
- 2.5mm phone jack*
- Flash wire 22 awg hookup wire, 8" long, one green, one red*
- Computer microphone*
- Balloon
- Drill
- Soldering iron or soldering gun
- Solder
- Nail

* These items are included in the Flash Controller Kit.

The authors of this project have worked with MAKE to develop a limited number of kits for sale. The Flash Controller Kit includes all of the electronic components, the circuit board, an enclosure (the box), a disposable camera, a microphone, and other components described in this project. The Flash Controller included in the kit is assembled and tested, although you can order an unassembled version if you want to solder more than 60 components. (You should at least have soldering equipment and a volt-ohm meter and know how to use them. This is not a "learn to solder" project.) The Flash Controller Kit costs $99, and you can order it at makezine.com/go/flashkit.

Photography by Tom Anderson and Wendell Anderson

MAKE IT.

HOW TO CAPTURE HIGH-SPEED MOTION

START **Time: An Afternoon** **Complexity: Low**

1. DISASSEMBLE THE DISPOSABLE CAMERA

The flash speed of a weaker flash is fast enough to make a pretty good strobe light. So we made one out of the cheapest disposable camera we could find (under $5). We took apart a single-use camera, added a connection for the flash controller circuit to fire the flash, and then put the camera back together.

About Single-Use Cameras

Even if you don't make a strobe photo system, you may find it interesting to take apart a single-use camera, which is surprisingly maker-friendly. These cameras are designed to be taken apart and put back together, but not necessarily by those who buy them. Inside you may find parts that show the wear and tear of multiple re-uses. We got a few used cameras for free just by asking for them at a local camera shop. (Kodak pays about $0.15 each for returning them for recycling, so don't waste your time asking for free ones at the big W. See kodak.com and search for "one-time-use camera recycling" for details on Kodak's recycling program.)

The usual reason for disassembling a disposable camera would be to add new film and a battery, but we want to use the camera as a sound-triggered flash attachment. The actual photos will be taken with a digital (or film) camera.

Camera Disassembly, Step-by-Step

Follow along with the photographs on the next page. First, we remove the stickers and goo from the outside of the camera **[1]**. There are four side latches (left, right, top, and bottom). We found it easiest to start with the left. Using a small, flat-bladed screwdriver, gently pry open the latch, and slightly separate the plastic back from the camera, which keeps the latch open **[2]**. While holding the front and back slightly apart, pry out the top and bottom latch. Finally, pry out the right latch and remove the plastic back **[3]**. Try not to break the latches. (If you do, use duct tape or rubber bands when reassembling.) Remove the film and battery **[4]**.

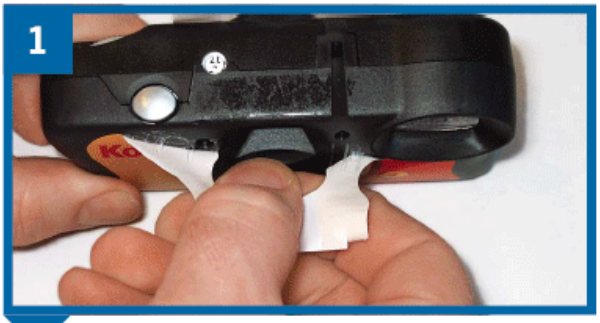
The charged-up capacitor leads should be visible near the bottom center, when looking in through the back of the camera. Using the tip of a small, insulated, plastic-handled screwdriver, short the two capacitor leads together **[5]**. You will probably see a flash and hear a loud pop. After you are sure the capacitor has been discharged, gently pry off the latch that holds the plastic front **[6, 7]**. Behind the plastic front is a lens and shutter. Carefully pry off the lens holder as shown **[8]**. Beneath is the shutter, with a spring connected to it. Remove these as well **[9]**. There should be a hole in the center that is open from the front to the back **[10]**.

WARNING: Nasty Shock Inside

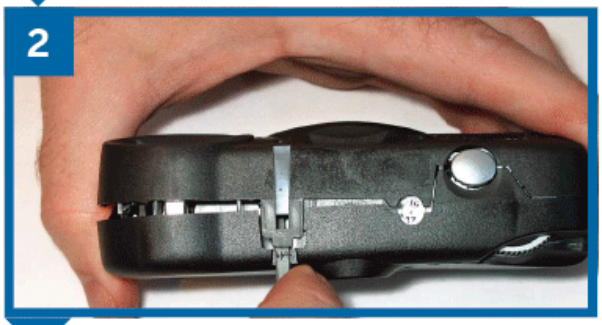
Before you take apart a single-use camera, you need to know that there is a large electrolytic capacitor inside the camera. This capacitor, which stores the charge for the flash bulb, is charged to 330V and can give you a nasty shock if you touch the leads or the circuit board before it is discharged. We tell you how to safely discharge the capacitor, so do not leave out this step.

Watch this video clip of discharging a capacitor: makezine.com/04/flash/caps.mov

1

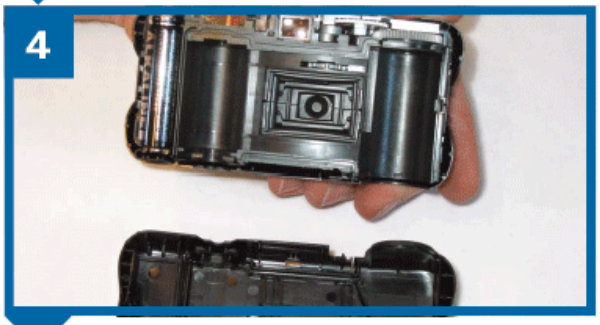


2



3

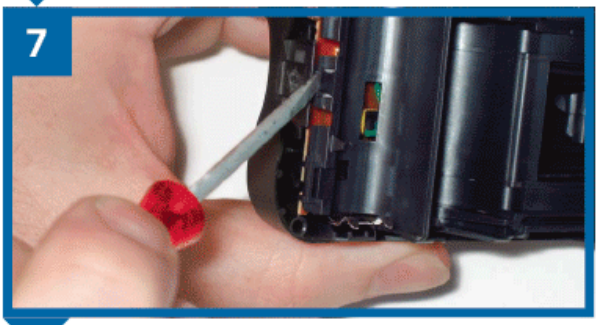
4



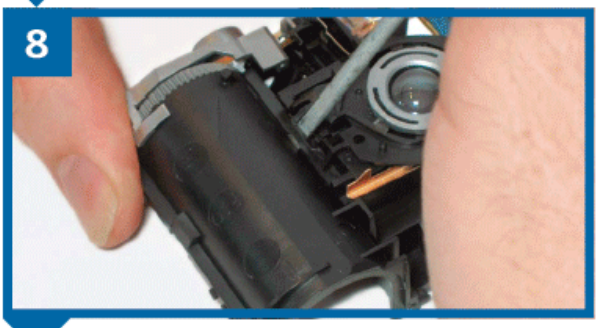
5

6

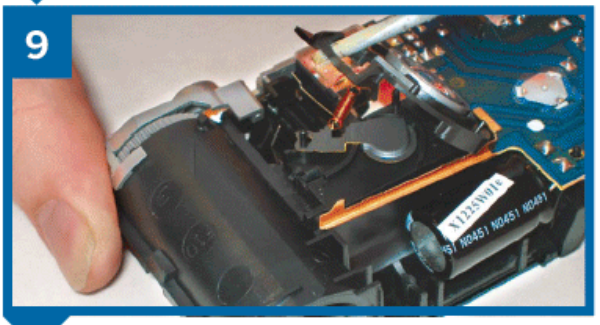
7



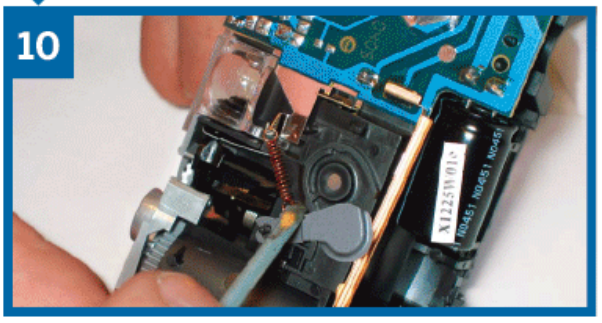
8



9



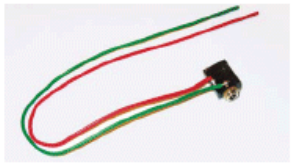
10



2. MOD THE DISPOSABLE CAMERA

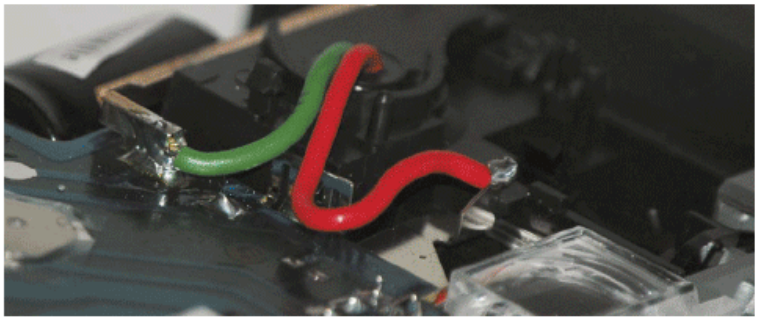
Now we're ready to perform a few operations on the disposable camera so we can control its cheap little flash.

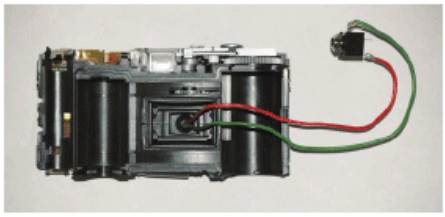
2a. First, we will mount our trigger connector (which comes included with the kit) onto the camera's plastic back, with the connector body taking the place of the film canister. Start by drilling a ¼" hole in the plastic back, as shown.



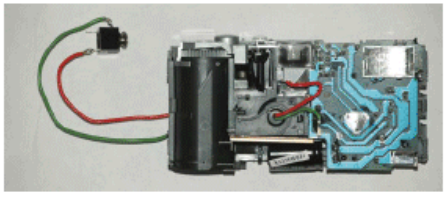
Solder wires to the tip (red) and shield (green) terminals of the 2.5mm connector.

2b. Thread the red and green connector wires through the center hole and solder them as shown, red wire on the top and green on the bottom. Do not reinstall the shutter and lens.



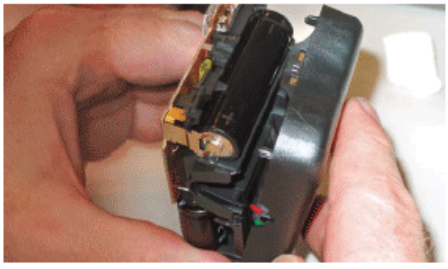


Back of camera, wires threaded through shutter hole.



Front of camera.

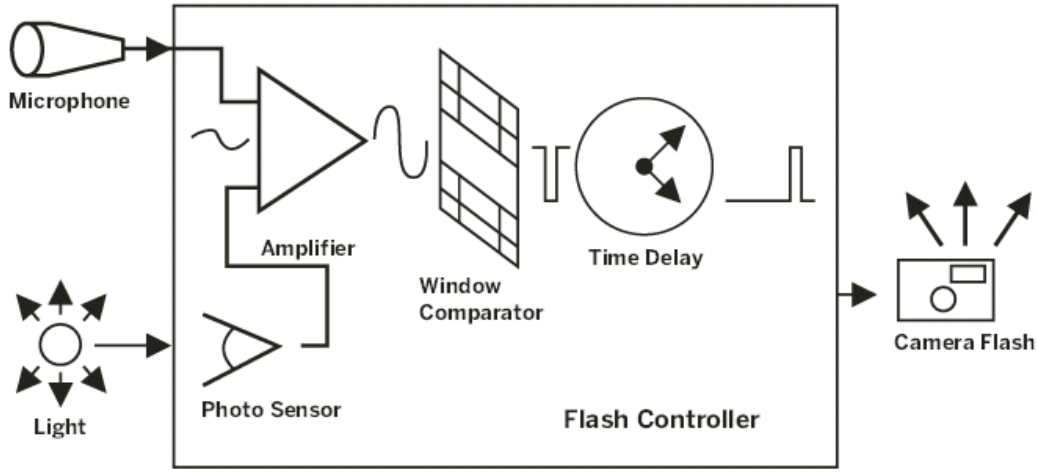
2c. Reassemble. Snap the plastic front onto the camera after reinstalling the battery. Installing the battery will recharge the capacitor, so be careful! Then snap the plastic back onto the camera, and the flash is complete!



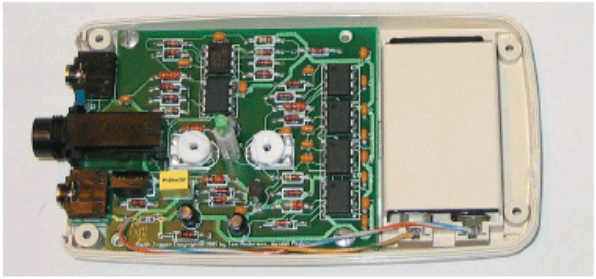
NOTE: Pay attention to the polarity of the battery. If you put it in backwards, it permanently damages the circuit, and you will have to start over with a new camera.

DESIGN OF THE FLASH CONTROLLER

The Flash Controller in our kit responds to a signal and then triggers the flash unit. We needed to add an adjustable delay between the sound and the photo to get the best possible stop-action picture. A good flash trigger should be able to react to loud sounds (like a balloon pop) or quiet sounds (like a drop of water landing in a dish). It should be able to trigger from light as well as sound. It should be able to trigger a flash or a strobe light. This is what we designed and built. If you're interested in making your own controller, see the sidebar on page 115, "Make Versus Buy."



Our Flash Controller circuit consists of six simplified "system blocks." Each block's behavior is programmed by a few components (resistors and capacitors), which are inside the block. Our overall system has two inputs (sound or light) and two outputs (TTL or camera flash). See below for instructions on using and adjusting the settings of the Flash Controller.

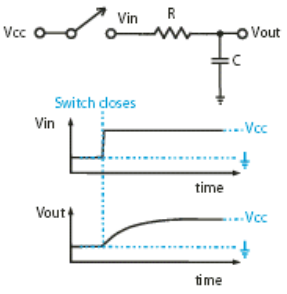


HOW TO MAKE A TIME-DELAY-SUB-CIRCUIT

Do you want your balloon photograph to have a small hole or a big one? A small difference in time delay changes the photo a great deal. You could just move the microphone further away from the sound to add delay (about 1/1000 of a second per foot), but this won't work for light triggering.

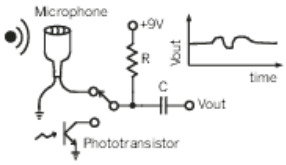
In order to get the best high-speed photographs, it is important to be able to adjust the time between the sound and when the picture is taken.

How does a resistor and capacitor set a time delay?



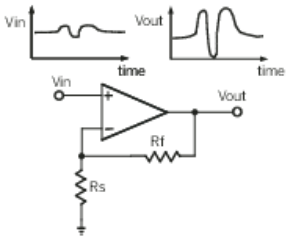
When the switch closes at time t=0, the output voltage Vout follows the formula:

$$Vout = Vin(1 - e^{-t/rc})$$



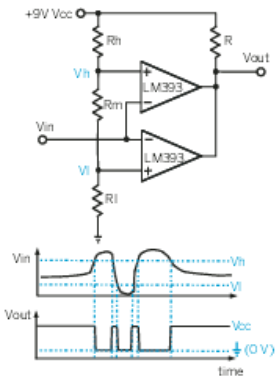
Sensor Block

This sub-unit has two inputs: sound and light. The microphone converts sound into voltage and the photodiode converts light to voltage. Plugging in the microphone automatically makes the microphone active and disables the photodiode. When the microphone is unplugged, the photodiode is automatically active. The Sensor Block output is a low-level voltage (a few thousandths of a volt).



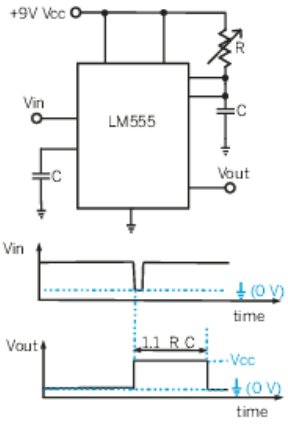
Amplifier Block

This makes the voltage from the Sensor Block proportionately larger. The exact proportion is called "gain," and it is programmed by Rf and Rs, according to the formula Gain = 1 + Rf/Rs. Since the gain is proportional, then Gain = Vout/Vin. The circuit shown here is a simplified version of the Amplifier Block used in our design. Consider what would happen if Rf were a variable resistance: changing Rf would change the gain, which would change how much the signal is amplified. This is one way to make a volume control. This is also why our circuit can trigger on loud or soft noises, depending on the gain setting.



Window Comparator Block

When the voltage from the amplifier is above or below a specified level, the output voltage of the window comparator goes very quickly from Vcc to zero, and delivers pulses of 0V to the Time Machine Block. When you use the photodiode input, the flash will trigger when the light comes on, or when the light goes off. For example, a laser pointer will trigger the flash when the beam is interrupted, or when it is first received.



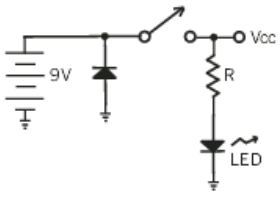
Time Machine Block

This block consists of four 555 timer chips. One sets delay (*see sidebar, "How to Make a Time-Delay Sub-Circuit"*) and one sets output pulse width; the other two are used to prevent multiple flashes, which can be caused by echoes of a loud noise when using the microphone. We added the last two 555s when we noticed "double images" on our original balloon-popping pictures.

When the input voltage of a 555 goes to zero, it outputs a positive pulse whose length is set by R and C. The length of the output pulse (in seconds) = 1.1 * R * C. For example, when R = 560K, and C=10µF, the Length = 1.1 * 560E3 * 10E-6 = 6.2 seconds.

Flash Output Block

There are two different ways our circuit can be used: with a camera flash or a strobe light. The strobe accepts TTL levels and the camera flash accepts the SCR output. The TTL output of the time machine can drive the SnapShot II strobes that we found here (just use a guitar cable to connect to it): www.musiciansfriend.com/srs7/g=home/search/detail/base_id/38402. The SCR (Silicon Controlled Rectifier) is a triggering device for a camera flash, including the one we built for this project. It is also connected to the output of the time machine. The SCR can trigger many types of standard camera flashes, including the one in the modified disposable camera.



Power Supply Block

A 9V battery supplies power to the circuit. The diode prevents damage to the circuit in case the battery is installed backwards. A switch turns the circuit on and off, and the LED is on when the circuit is on.

PROJECT NOTES Choosing a Flash

When we started this project, we investigated building a flash from scratch. It was a big challenge to make it cheap. We figured out how to make a nice one, but it was too expensive. We looked into modifying a cheap flash from Ritz Camera, but it wasn't fast enough, causing the pictures to be blurry.

Cheaper, faster. There are only a few components that can cause the flash to be slow. By substituting faster parts for these components, we found which part was slow — the flash capacitor. Ironically, a smaller, cheaper capacitor would be faster. We tried a disposable camera, figuring it would have a small capacitor to save cost. We were right.

To keep the flash from becoming too dim, a higher voltage can be used on a small capacitor, which increases the stored energy. With this approach, and a few other tricks, a very fast flash (a few microseconds long) can be created. This gets expensive and complicated, though.

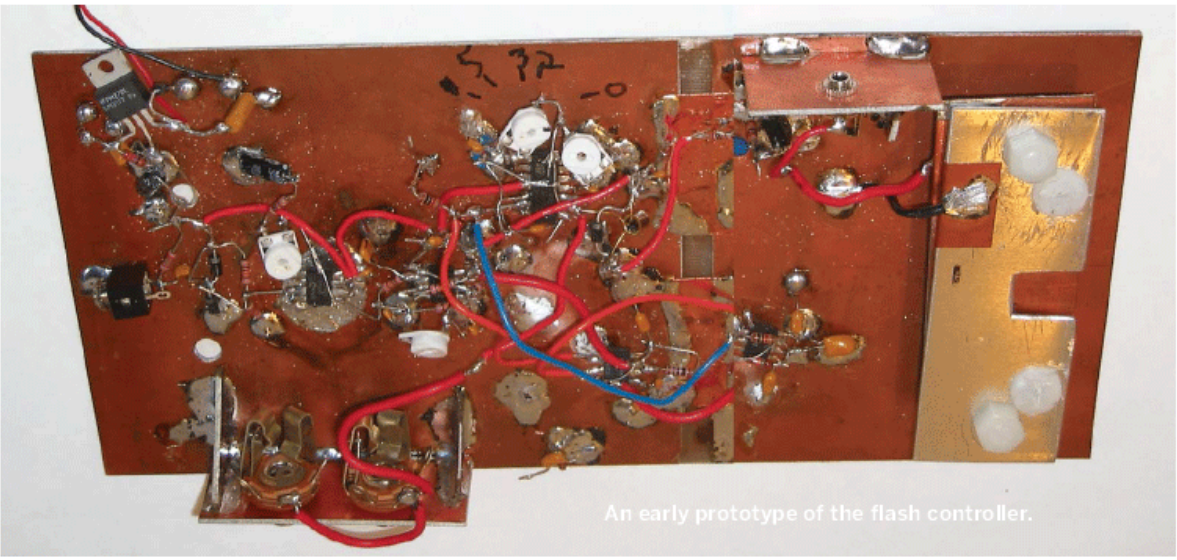
One important enabler for designing this sort of a circuit is to be able to make good measurements of things like flash speed. We built a special circuit that uses a fast photodiode to convert the flashes of light at the input to a voltage output. We measured this voltage output with an oscilloscope.

The sound of speed. Camera flash units use a xenon flash tube, and its flash is accompanied by a distinctive sound. We found that we can hear the difference between a short, strobe-like "tick" and a longer, fill flash, which sounds like "pugghushs."

The xenon flash tube in your camera is probably the most efficient light bulb in your house. It probably also has the shortest operational lifetime. While it may last for about 200,000 pictures, each flash is perhaps about 1/2000 of a second long. So in total, it lasts only 100 seconds!

Industrial strobe lights are used for inspection of machinery because they can freeze moving parts. See a demo at makezine.com/04/strobe/indstrobe.mov.

PROJECT NOTES Designing a Circuit Board



An early prototype of the flash controller.

If you plan to make a flash circuit from scratch, it might interest you to learn how we went from a wish (triggering a flash based on a measurable event) to a finished printed circuit board (PCB) that fulfilled the wish. It required planning, testing, prototyping, and revising.

1. Start with a breadboard. The parts were mostly soldered in mid-air. This allowed us to quickly try out design alternatives, and made it easier to find design problems and fix them.

2. Keep track of the breadboard with a hand-drawn schematic. We entered the schematic into a CAD tool called gschem (geda.seul.org/tools/gschem). Next, we designed the shape of the printed circuit board.

3. Finish the printed circuit board design with another CAD tool called PCB (pcb.sourceforge.net). We sent the output files from PCB to the printed circuit board fabricator PCBexpress (pcbexpress.com).

4. Order parts from Mouser (mouser.com) and Digi-Key (digikey.com). The printed circuit boards and parts arrived in a few days.

MAKE VERSUS BUY

You can build your own flash controller, using the information from this article and the full schematic available at makezine.com/04/strobe, or you can buy the Flash Controller Kit for $99. For more information, see makezine.com/go/flashkit. There are a limited number of kits available.

USE IT.

NOW CAPTURE A BALLOON IN MID-POP

READY...

Blow up a balloon and place it and a subject in a good spot for picture taking.

1. Set camera for a long exposure time, say two seconds, using "Shutter priority." Also, turn off the camera's built-in flash. You may also want to experiment with manual focus vs. autofocus. Use the camera's "Macro" mode for exposure control, if available.

2. Position the camera so it is focused and pointed at the balloon (a tripod is handy for this, if you have one).

3. Position the flash so it is pointed at the balloon and not at the camera (a tripod is handy here, too, if you have another one).

4. Plug the microphone into the Flash Controller.

5. Position the microphone close to the balloon.

6. Plug the cable into the Flash Controller and the flash (or strobe). There are two possible outputs from the Flash Controller. Either or both can be used. One cable (a normal guitar cable, not supplied) connects the Flash Controller to the Snapshot II strobe light (not supplied). The other cable (2.5mm male mono to 2.5mm male mono, supplied) connects the Flash Controller (supplied) to the modified disposable camera flash (unmodified camera supplied).

7. Power on the Flash Controller and the flash (or strobe). Connect the output cable to power up the Controller. Press the button on the front of the camera for a few seconds to power up the flash.

SET...

1. Turn out the lights. The room doesn't have to be completely dark, but darker is better.

2. Press the shutter release. If you don't use manual focus, your camera might need a little light to adjust the focus in the dark, so wait about 1 second for the lens to focus.

GO!

Pop the balloon with a hatpin. The sound triggers the camera flash. Wait for the shutter to close or you will ruin the shot. My camera makes a little click when the shutter closes. Then turn the lights back on and admire the photo.

DO IT AGAIN!

If you're like us, you'll want to make a few adjustments and shoot it again.

Adjust the Flash Controller delay if necessary; more delay means a bigger hole in the balloon. There are two knobs on the top of the Flash Controller. One is for delay, and one is for gain. By twisting the delay knob, more or less delay can be added. The same is true for gain. Increase the Flash Controller gain if the flash didn't go off.

Move the flash closer to the balloon for more light if the photo is too dark.

If you're proud of one of your photos, please post it to your website and send an email about it to editor@makezine.com.

D.I.Y.
COFFEE

THE BOTTOMLESS PORTAFILTER

Mod your espresso maker's filter holder for a tastier cup. By Will O'Brien

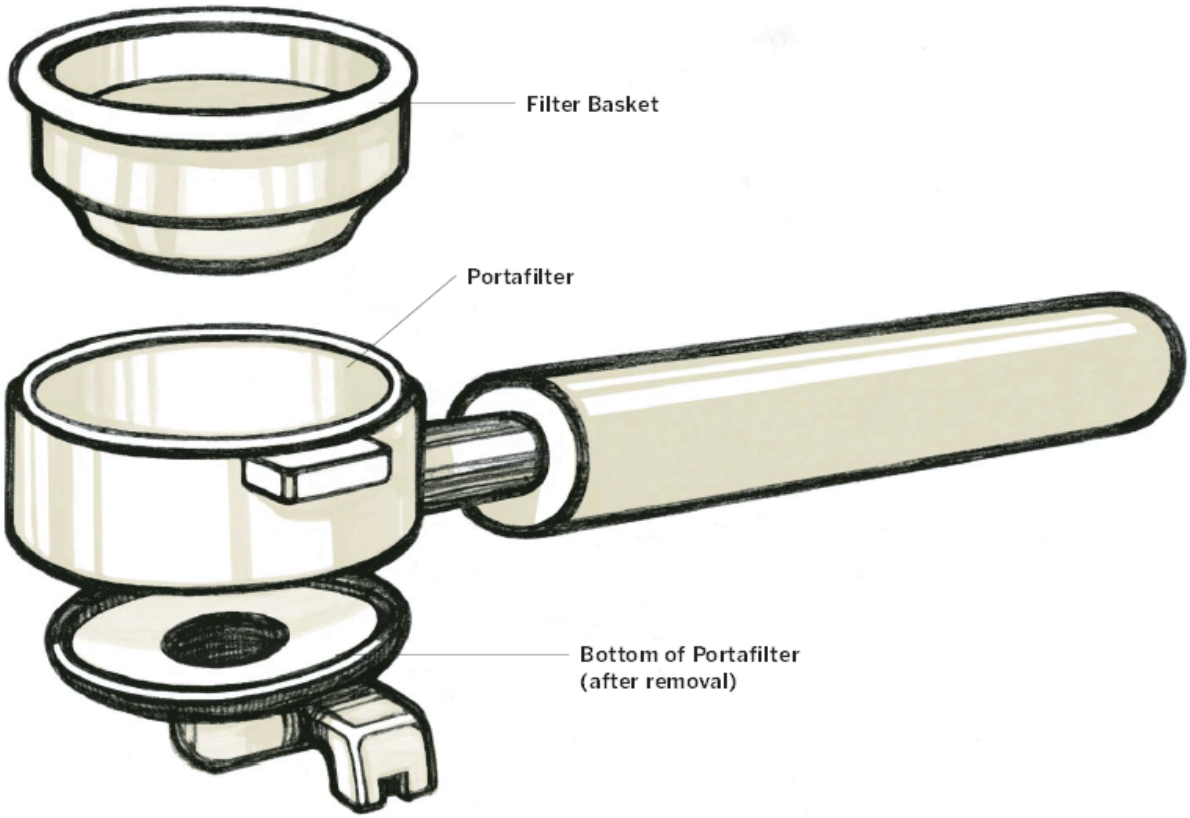
In my office at home, one end of the room is devoted to computers, electronics, and my assorted projects. The other is the home of the holy grail of caffeine: my espresso bar. That's where I measure, grind, and tamp my way to produce some beautiful espresso. I've been tuning and tweaking my setup for the last six months or so, and there's no end in sight. My most recent modification involved some power tools and my portafilter.

The portafilter is the chrome-plated coffee filter holder that most people only notice as the spent grounds are being beaten from its shiny grasp. In this case, I drilled, cut, and ground out the bottom of it to get what's known as a "bottomless" or "naked" portafilter.

No stock machine comes with a bottomless portafilter. The modification can sometimes result in espresso going in strange directions — like the wall on the other side of the room. The only side affect I've observed is a tiny amount of spatter on the top of my espresso cup. So why go bottomless? For some, it's simply so they can fit a triple basket in the stock portafilter. The espresso industry refers to the bottomless portafilter as a "training tool."

By removing the bottom of your espresso maker's filter holder, you get more prized "crema."

Photograph by Will O'Brien



You can even buy your own from espressoparts.com. As a training tool, the bottomless portafilter is excellent for checking your tamping technique. As an espresso machine modification, I've found that my espresso has increased crema, better mouthfeel, and it's just tastier.

Just about every good quality portafilter is made of chromed marine brass. Inside is a tensioning spring collar that grips the basket, which contains the coffee grounds.

The basket should be removed by pulling or gently prying loose. You can probably leave the spring intact while you perform the modification.

Some people have had good success using a hole saw, but due to the uneven design of the portafilter on my Gaggia coffeemaker (probably the worst product name ever), I chose a different route. After removing the basket, I took the portafilter to my drill press and drilled a circle of holes just inside the walls of the portafilter. Once I'd drilled the 25 or so holes, I took up my Dremel tool and cut the remaining material in between the holes. Finally, I knocked out the center of the filter. After that, some time with the Dremel tool or grinder of your choice will flatten out the edges. When you're satisfied with the finish of your mod, wash it thoroughly to remove any remaining brass dust.

Once the modification was complete, I pulled a fresh shot of espresso. The flow of the dark amber liquid was enchanting to watch. You may now partake of the art of Espronography: reading the espresso as it flows from the bottom of your new bottomless portafilter. Several weeks later, I still can't resist watching each shot flow from the filter. As a bonus, I can now easily clean all of the coffee residue from the bottom of the basket.

FREQUENTLY ASKED QUESTIONS ABOUT CREMA

What is crema? It's the delicious reddish-brown colored froth on the top of a well-made shot of espresso.

Why doesn't my espresso have crema in it? Several factors could be at play here. The quality of the coffee, the fineness of the grind, the degree of tamping, the temperature of the water, and the espresso maker itself can effect crema production. Visit sweetmarias.com/espresso-crema.html and then practice. Remember: "No crema, no serva!"

Will O'Brien pulls espresso and modifies innocent kitchen appliances somewhere in middle Missouri.

Illustration by Damien Scogin

After a set amount of time, the toaster tea popper lifts the bag from the cup.

TOASTER TEA POPPER

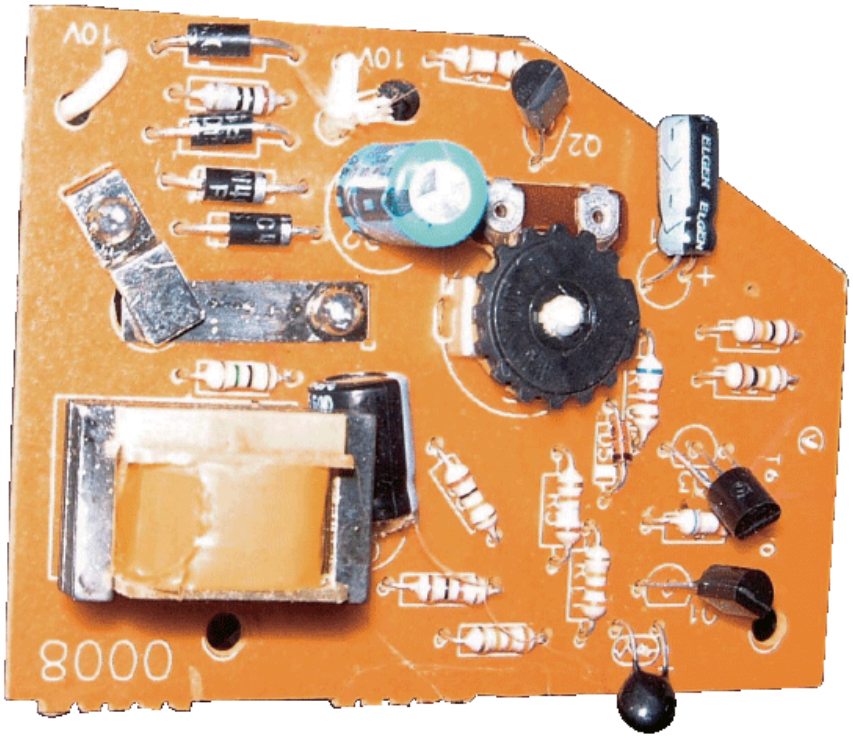
Perfect brew by the clock. By Johnathan Nightingale

I didn't used to care about tea timing. In general, I have found that I can prepare tea of adequate quality by simply leaving the teabag in for "a while." Recently, though, I was persuaded to begin timing and have been convinced that doing so yields a better and more consistent brew. Conventional tea timers have a common failing though, be they hourglass, mechanical, or, in my case, Palm: they require user intervention. At work, I inevitably became distracted by a conversation or got called away to fix something only to return to a patiently beeping timer and some very overdone tea. What I needed was a timer that could remove the teabag on its own.

I found my salvation in a toaster. A toaster is, after all, an easily obtainable and very cheap device that has, at its core, a variable timer controlling a mechanical lifting arm. Most modern toasters use a simple electronic circuit: when the lever is depressed, current flows to the heating elements and to an electromagnet. The electromagnet holds the lever down against the tension of a spring in the handle. While the toast is toasting, a trickle of current flows into a capacitor at a rate controlled by the "darkness" dial, which is nothing more than a variable resistor or "rheostat." When the capacitor is filled, the electromagnet disconnects, the lever pops back up, and current is cut to the heating coils. With all this work already done for us, a basic ability to solder and some simple parts should be all that's needed for this project.

To begin, take the toaster apart. As you remove the front panel, you will see the various components described above: the arm, including a metal tab that the electromagnet grabs; a switch that

Photography by Johnathan Nightingale



Only one style of toaster will work for this project. Here's a simple thrift-store test: push the handle down with the toaster unplugged. If it stays down, you have the wrong kind of toaster — an electromagnetic toaster (the kind you want) will pop back up immediately if no power is flowing to the magnet.

the arm depresses allowing current to flow; and a circuit board with the electromagnet and rheostat (connected to the toaster's darkness dial). The toaster's frame and the heating coils can be discarded, but this is easier said than done: my toaster was built like a tank. A Dremel cutting wheel, tin snips, or some other metal cutting tool will help here.

Of course, we don't want to have to plug this into the wall. The vast majority of a toaster's energy consumption goes into generating heat in the toasting coils. We don't want that and neither does the circuit board; it's counting on having most of the voltage dropped by the heaters. Your circuit board will likely be stamped with something like "10V"; regardless of the appliance voltage, the circuit wants to receive no more than 10V. Since most people like tea to steep a little longer than they like toast to toast, a 9V battery will work well here — the lower voltage will slow the rate at which the capacitor charges, and that's just fine. The problem of how to convert the toaster from alternating current (wall socket) to direct current (battery) is also solved: the toaster circuit contains a bridge rectifier (a simple circuit for converting AC to DC.) Our DC battery will pass straight through, unaltered.

Putting it all together is easier if you can find a suitable container; I used an unfinished wood box from a local craft store. Cut most of the original power cord, attached to the lever switch, and solder the ends to a 9V battery holder. Solder the other lines from the lever switch to the power leads on the circuit board — thanks to the bridge rectifier, polarity doesn't matter. Now arrange the pieces in your box as they were in the toaster. For the arm, I used a wooden dowel with a brass hook. To make a cup of tea, tie the teabag onto the hook, push the lever down to immerse the tea bag, and place your trust in the machine.

As the battery runs down, the timer will slow even more, but not to worry. By the time the battery gets that low, the voltage will have dropped low enough that the electromagnet no longer holds. I estimate that a regular 600mAh battery should be good for at least 8 hours runtime, about 80-100 cups for a 5-minute steeper.

Johnathan Nightingale is an IBM coder by day, reality hacker by night, and habitual over-thinker.

HOT ON THE SPOT

Get consistent shots by adding precise temperature control to your espresso maker.

By John F. Murphy

The art of espresso making is fraught with many variables — coffee bean origin and blend, degree of roast, fineness and consistency of grind, tamping force and technique, and on and on and on. The temperature of the water used to brew the shot is one of the most important variables. In most espresso machines, the brew temperature is controlled by a wildly inaccurate thermostat.

However, control over the brew temperature is key to espresso quality. Different blends of espresso beans and different degrees of roast develop different flavors when brewed at different temperatures. Malabar Gold may taste sweet at a temperature that makes DSB taste sour. Control over the brew temp allows the skilled barista to coax the best flavor from each blend and each roast. In a stock Silvia espresso maker, relative brew temperature is roughly guestimated by "time surfing," or pulling the shot a certain number of seconds after the stock thermostat turns on the heating element. Surfing does work, but it requires careful attention and lacks accuracy.

A better way is to use a PID controller. It's easy to use (just set the desired temp and let the PID do its thing) and highly accurate, meaning the brew temperature of the next shot can be very nearly the same — if not exactly the same — as the last shot. And consistency from one shot of espresso to the next is the holy grail of espresso fanatics.

Photography by John F. Murphy

The Rancilio Silvia outfitted with temperature control.

PID BASICS

In simple terms (which is about all I can understand), a PID controller is a precise, computer-controlled thermostat. PID is an acronym for "Proportional, Derivative, Integral," which has something to do with how the controller holds the boiler (in this application) at a precise temperature.

Here's an analogy that explains how the PID works and why it is a good thing. Imagine you are driving your car down the street at 60mph. Ahead is an intersection controlled by a stop sign. If you continue to travel at 60mph until you reach the intersection and then slam on the brakes, your car is going to shoot past the stop sign before coming to rest. If, on the other hand, you gradually apply the brakes well in advance of the stop sign, you can come to a controlled stop right at the intersection. (This analogy is paraphrased from an explanation in the Fuji PXV3 manual.)

The stock brew thermostat in the Silvia is like the driver who slams on the brakes at the stop sign. The stock thermostat supplies full power to the boiler's heating element until it reaches a certain temperature, and then cuts the power off completely. When the power is cut, the heating element continues to heat the boiler water for some seconds until the heating element cools off; this is like the car skidding through the intersection. On my Silvia, the stock thermostat turns off the heating element at around 220° F, but the water continues to heat up until it reaches about 238° F. This is called "overshoot."

The PID controller is like the driver who gradually applies the brakes and slows down as he approaches the intersection. The PID controller turns the heating element on and off at one-second intervals. As the boiler approaches the desired temperature, the PID turns the heating element on for shorter intervals — like a driver braking harder the closer he gets to the stop sign (this is where the proportional, integral, and derivative calculations come in). Thus, the PID is able to hold the boiler at the desired temperature with very little overshoot. I usually see a 1° F or less overshoot with my PID'd Silvia. Compare that to the 18-degree overshoot with the stock thermostat.

Once the boiler is at the desired temperature, the PID cycles the heating element on and off at intervals calculated to maintain the boiler very close to that temperature. Mine fluctuates by about 1° F. The stock thermostat, by contrast, has a fluctuation of at least 40° F!

THE RANCILIO SILVIA

If you're going to be finicky enough about your coffee that a few degrees variation in brew temperature is a big deal, you'd better start off with a decent espresso machine. The internet is replete with raves about Rancilio's Silvia, so I'll just touch on one key feature: temperature stability. Silvia contains a lot of heavy brass in the boiler, the grouphead, and the portafilter. Once all that brass gets up to operating temperature, it tends to stay there.

When you pull a two-ounce double, the hot brass of the grouphead and portafilter keep the brew water from cooling off before it hits the coffee grounds. Likewise, the brass boiler stays hot even as cool water from the reservoir replaces the water used to make the shot. Without good temperature stability during a shot, accurate temperature control is useless, if not downright impossible.

PID SHOPPING LIST

DESCRIPTION	PART NUMBER	VENDOR	PRICE
Fuji 1/32 DIN PID controller	PXR3-RCY2-4V	TTI Global	$129.00
Solid-state relay (230V/40A out, DC in, zero switching)	RS1A23D40	TTI Global	$26.00
Type J thermocouple, washer probe, at least 30" long	WTJ1-G06-AGN-030AN	TTI Global	$8.25
14-gauge wire (50' spool)	n/a	Home Depot	$3.59
4mm washer and nut	n/a	Home Depot	$0.50
Double-sided foam tape	n/a	Home Depot	$3.00
Lamp extension cord, 6'	144983	Home Depot	$0.97
Crimp-on connectors	64-3038	RadioShack	$1.69
Lighted rocker switch	275-692	RadioShack	$4.00
Project box, 5"x2.5"x2"	270-1803	RadioShack	$3.69

I also used the following tools and supplies that I had on hand: wire stripper/crimper (RadioShack sells them for under $8), soldering iron, solder, heat-shrink tubing, coping saw, and various small screwdrivers. (The last three items were all used solely for installing the optional switch.)

INSTALLATION

Note: I did not actually follow these steps in the order presented. I did a lot of trial fitting, testing, etc., before I arrived at the final assembly. But if I had it to do all over again, this is the way I would do it.

1. Prepare the enclosure. Fitting the PID into the project box was a bit tricky for someone of my limited craftsmanship. The screw towers and circuit board holders in the enclosure interfered with the placement of the PID. I ended up cutting a slot through one end of the enclosure with a hand miter saw and a coping saw. The distance between the circuit board holders molded into the enclosure is very close to the height of the PID, so I simply cut down along the circuit board holders, broke out the piece of plastic between the cuts with a pair of pliers, and reamed out the opening with a power drill until the PID fit.

I also drilled a ¼" hole in the back of the enclosure to run wires to the PID and a ¾" hole in the top towards the back to mount the (entirely superfluous) lighted rocker switch. Actually mounting the PID in the enclosure is simple enough once the opening is prepared: slip the white mounting collar over the PID, slide the PID into the enclosure, then cinch the mounting collar up tight against the inside of the enclosure. This is easier to do than it is to describe.

2. Open Silvia. (Unplug it first!) Silvia is a breeze to open — especially compared to my first machine, a DeLonghi, which was held together by hidden tamperproof screws.

2a. Remove the water reservoir. Shake the excess water out of the two water hoses into a towel or sink.

2b. Remove the four screws that hold on Silvia's top. Set the top aside.

2c. Remove the two screws that hold on the front splash panel. Set the splash panel aside.

3. Install the thermocouple. Now that Silvia's innards are exposed, you can see the bronze-colored boiler with many wires and two blue cylinders attached to it. The blue cylinders are the thermostats. The thermostats are attached to the boiler by three screws. Remove one of the screws, slip the washer end of the thermocouple

under the "ear" of the thermostat, and then replace the screw through the thermostat and the thermocouple washer (see Fig. 1). I test-mounted the thermocouple under the leftmost screw, but later moved it over to the rightmost screw, which is closer to where the cold water enters the boiler. I'm not sure it makes any difference in operation.

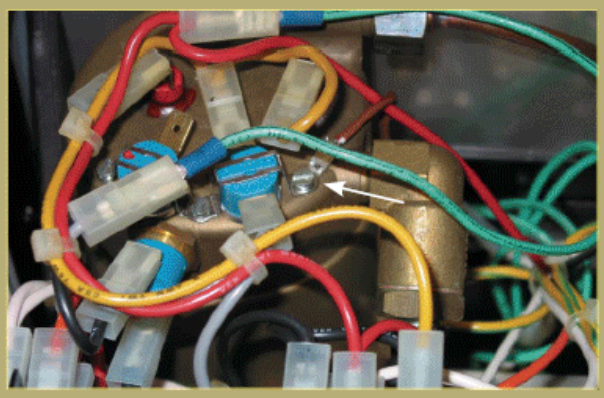


Fig. 1 Thermocouple washer installed under screw of steam thermostat.

4. Remove wires from brew thermostat. The brew thermostat is the blue cylinder on the left. Unplug both connectors from the thermostat (see Fig. 2).

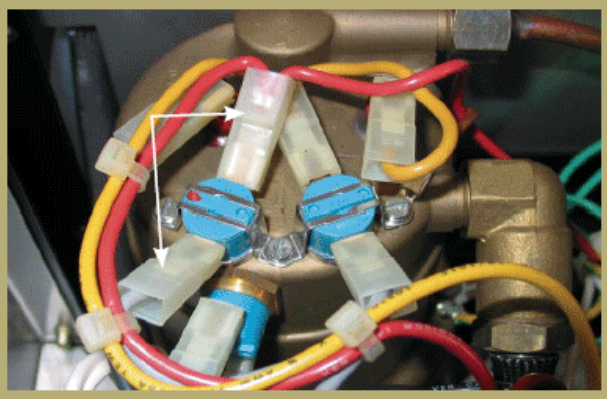


Fig. 2 Removing brew thermostat connectors.

5. Attach heater circuit wires to the solid-state relay (SSR).

5a. Cut two pieces of wire about 12" long. Strip the ends of both wires.

5b. Crimp a connector onto one end of each wire.

5c. Plug the connectors into the wires detached from the thermostat in step 4 (see Fig. 3).

5d. Run the other ends of the wires through Silvia's chassis so that they protrude down behind the splashguard.

5e. Attach the bare wire ends to the SSR. There are four terminals on the SSR; on mine, they were labeled L1, T1, A2(+), and A2(-). Attach the wires to L1 and T1. It does not matter which wire goes to L1 or which to T1. My SSR has screw/clamp terminals; simply slide the wire into the terminal and tighten the screw to hold it in place. If necessary, trim the wires before attaching to the SSR so there is not an excess of wire behind the splashguard (see Fig. 3).

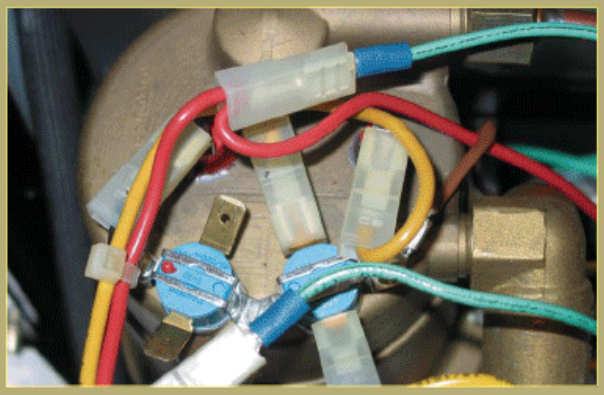


Fig. 3 Boiler detail with thermocouple and SSR wires installed.

6. Attach the PID control wires to the SSR.

6a. Cut two more pieces of wire, about 36" each. They need to be this long because I decided to run the wires out to the PID. Strip the ends.

6b. Since all of the wire I used was the same color, I marked both ends of one piece with tape so I could identify it later.

6c. Run one end of each wire from the boiler compartment down to the SSR.

6d. Attach the wire marked with tape to the '+' terminal on the SSR. Attach the other wire to the '-' terminal (see Fig. 4).

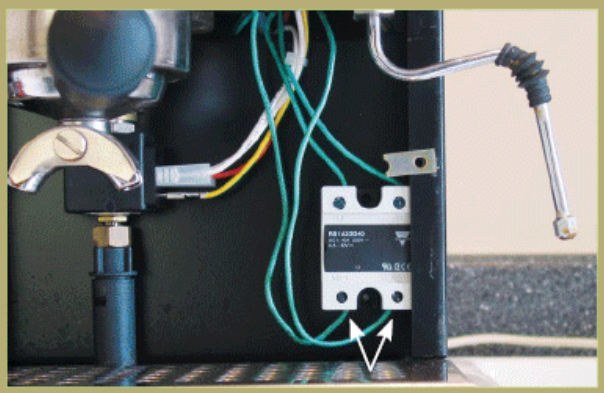


Fig. 4 SSR wiring detail.

7. Run control wires and thermocouple wire out to the PID. I did not want to cut a hole for the wires in Silvia, so I decided to run them out of an existing gap in the bottom left corner at the back of Silvia.

7a. Remove the panel that fits between the water reservoir and the boiler compartment. It is held on with two small machine screws and lock washers on the water reservoir side. The panel is angled and may need a bit of fiddling to get it to slide out (see Fig. 5).

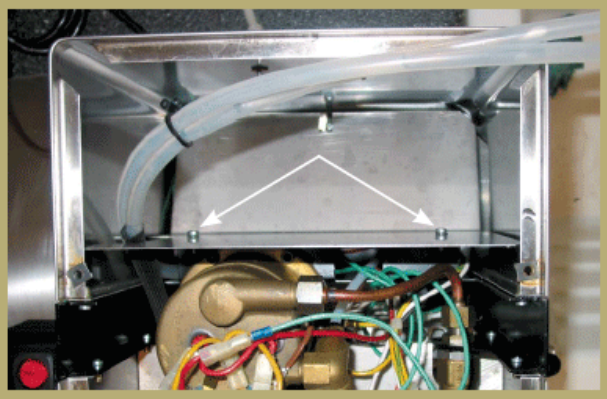


Fig. 5 Reservoir panel.

7b. Run the cycle time (TC) and control wires (the ones attached to the + and - terminals of the SSR) out of the boiler compartment, along the bottom of the water reservoir compartment, and out the opening in the bottom corner of the water reservoir compartment (see Fig. 6).

7c. Reinstall the panel removed in step 7a.

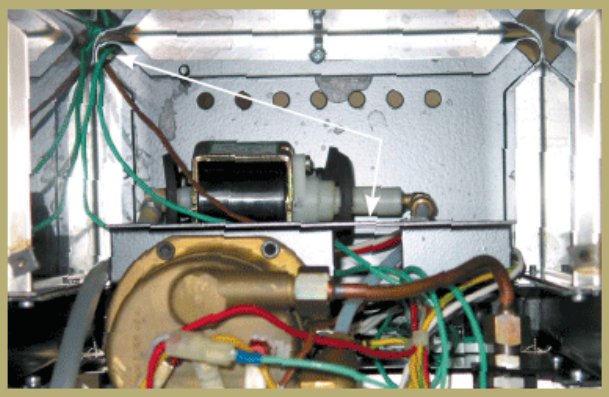


Fig. 6 Wire path out of Silvia.

8. Wire the PID.

8a. Cut the receptacle end (not the end that plugs into the wall) off of the extension cord and strip the ends of the wires about ¼".

8b. Run the extension cord, TC wire, and SSR control wires through the hole drilled in the back of the enclosure.

8c. Slide the white mounting collar over the back of the PID (it must go on before the wires are attached, for obvious reasons).

8d. Attach the wires to the PID as follows (see Fig. 7). The PID has simple screw clamp terminals, so just slide the wire into the appropriate terminal and tighten the screw.

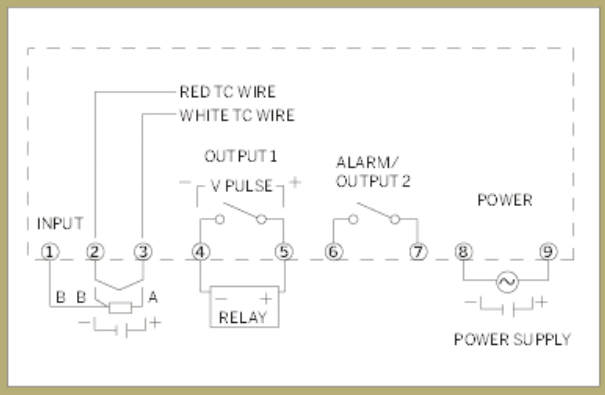


Fig. 7 PID pinout.

8e. The ends of the thermocouple wire go to terminals 2 (red wire) and 3 (white wire). The first time I wired up my PID, I had the leads reversed. When the PID turned on the heating element, the temperature readout started to drop instead of rise.

8f. The ends of the SSR control wires go into terminals 4 and 5. Be sure to match the + wire from the SSR to the + terminal on the PID, and the - wire to the - terminal. That's why I marked the wire with tape in step 6b.

8g. The ends of your power cord go into terminals 8 and 9. (Note: The lighted rocker switch, if used, gets wired between the power source and the PID. I left that step out because the switch is totally superfluous.)

8h. Terminals 1, 6, and 7 are unused.

9. Mount the PID in the enclosure. Slide the PID into the enclosure. Cinch the mounting collar snug against the inside of the enclosure. Screw the cover onto the enclosure. I attached the enclosure to Silvia with double-sided foam tape. Not the most elegant solution, I guess, but it is cheap, fast, simple, and reversible.

10. Secure the SSR, and reinstall the splash panel. Behind Silvia's front splash panel is a bolt that can be used to secure the SSR. I did not have a 4mm washer and nut (available at your local hardware store) to use for this purpose, so I simply hung the SSR on the screw, and then put the splash panel back in place.

11. Reinstall Silvia's top and water reservoir. Put the top back on, tighten up the four screws that hold it down, and reinstall and refill the water reservoir.

12. Fire up! Plug Silvia in, plug the PID in, and turn Silvia on. The PID should display the boiler temperature after a second or two. Press the SEL button on the PID to see the setpoint temperature; use the up and down arrow buttons to adjust the setpoint to 230° F.

TUNING

In order for the PID to work its magic, various parameters must be set on the controller itself. Fortunately, the PID controller takes care of the hard parts through a process called "autotuning"; through trial and error, the PID determines its own optimum settings necessary to hold the boiler at the desired setpoint. There are a few parameters, however, which need to be set by hand.

Manual Settings

Make the following settings by hand. There are about 50 parameters that can be set manually; I only changed 5.

1. Primary Menu: Press and hold SEL key for 3 seconds. The only item of interest on the primary menu is autotune, which is discussed in the autotuning section below.

2. Secondary Menu: Press and hold SEL key for 7 seconds.

TC (cycle time): I have mine set to 1.
P-n2 (input type): Make sure this is set to 2 for type J thermocouple or 3 for type K.
P-dP (decimal point resolution): Set this to 1 to display temps in one-tenth degree increments.

3. Factory Presets Menu: Press and hold SEL for 9 seconds.

P-dF (input filter constant): This setting filters out quick changes in thermocouple readings and slows down PID responses, which is a bad thing for our application. I have mine set to 0.
FUZY (fuzzy logic): Helps eliminate overshoot. Set to On.

Autotuning

Autotuning is the process where the PID controller determines how output to the heating element affects boiler temperature. After autotuning, the PID sets its own proportional, integral, and derivative parameters so you don't have to worry about it.

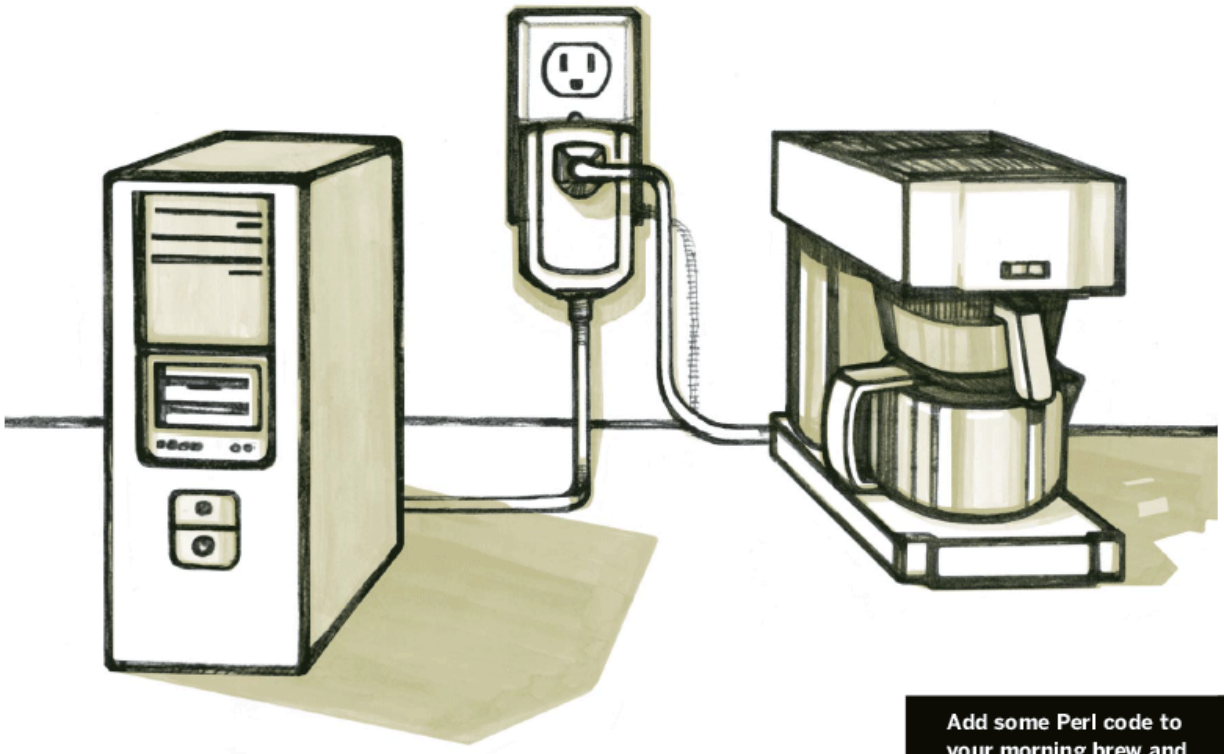
To activate autotuning:

1. Turn on Silvia and the PID and let her warm up for, say, an hour.
2. Run some water through the portafilter or steam wand to lower the boiler temp.
3. Press the SEL key for 3 seconds, and then the down arrow key until AT (looks like A7) appears on the PID display.
4. Press the SEL key once to select autotuning.
5. Press the UP key once. The PID should display 1. The autotune LED on the PID will start to blink.
6. Wait a while (about 7 minutes in my experience). When autotuning is complete, the PID will return to the current temperature display.

That's all there is to it. Silvia is ready to go.

NOTE: *The modifications described on these pages reflect the author's own experience and are not intended to serve as a guide or instructions for others. These modifications involve tampering with high-wattage electrical circuits in a wet environment, which could result in electric shock, burns, other serious personal injury, or death, as well as fire, explosion, and other property damage. The author is not an electrician and the fact that his modifications were successful was purely a matter of luck. The author and/or MAKE is not responsible for injury or damage to or caused by anyone foolish enough to follow his example. Before you tinker with an espresso machine or any home appliance, make sure you know what you are doing or get help from someone who does. Modifying Silvia voids any warranty provided by the manufacturer and/or retailer.*

John F. Murphy is a government lawyer in Fort Worth, Texas, who relies on espresso to fuel him through the work-a-day drudgery.



Add some Perl code to your morning brew and discover the difference it makes.

AUTOMATE YOUR COFFEE POT USING X10

What good is a coffee pot if it can't be controlled from the internet? By Dave Mabe

If you're anything like most geeks I've met, you probably have a coffee pot that gets a lot of use catering to your caffeine addiction. I decided to play around with X10 technology and an open source software program called MisterHouse to automate my coffee pot and make it more user friendly.

I wanted to wake up to freshly brewed coffee, and I'm too lazy to remember to turn off the pot after a period of time to prevent burning. Sure, you could buy a fancy coffee pot that has some of the features I wanted built in, but even the most expensive coffee pot can't touch the flexibilities you can create with a little Perl code.

MisterHouse (misterhouse.net) runs on Windows, Mac, and Linux, and lets you write simple Perl code to control a variety of hardware. To control your coffee pot, you'll need to buy an X10 PC interface and an appliance module (less than $50 new — even less on eBay). You'll plug the appliance module into the electrical outlet and the coffee pot into the appliance module. You'll need a coffee pot with a mechanical switch — it needs to be able to be turned on and off simply by controlling the power supplied to it. The PC interface connects to a computer's serial port and plugs into any electrical outlet.

Once the hardware is connected, configuring

Illustration by Damien Scogin

MisterHouse is a breeze. There are detailed instructions in the misterhouse.ini file included with the software on the website.

Rather than schedule the time to start brewing, I wanted to schedule the time my coffee pot completed the brew so I could know the instant my coffee was ready. First, I timed how long my pot takes to brew our standard amount of coffee (8 minutes until the last drip). I created a file called coffeepot.pl in MisterHouse's code directory on my PC with the following code in it (MisterHouse creates an event loop and executes your code a few times every second):

```
# C2 is the code I set on the appliance module
my $coffee_pot = new X10_Appliance("C2");
my $morning_coffee_time = "5:15 AM";
my $brew_duration = 8;
my $start_brew_at = time_add("$morning_coffee_time
- 00:$brew_duration:00");
my $coffee_timer = new Timer;
my $coffee_brew_timer = new Timer;
my $coffee_pot_on_duration = 40;

if (time_now($start_brew_at)) {
   set $coffee_pot ON;
   set $coffee_timer ($coffee_pot_on_duration * 60);
   set $coffee_brew_timer ($brew_duration * 60);
}

if (expired $coffee_brew_timer) {
# do some optional notification here
}

if (expired $coffee_timer) {
set $coffee_pot OFF;
}
```

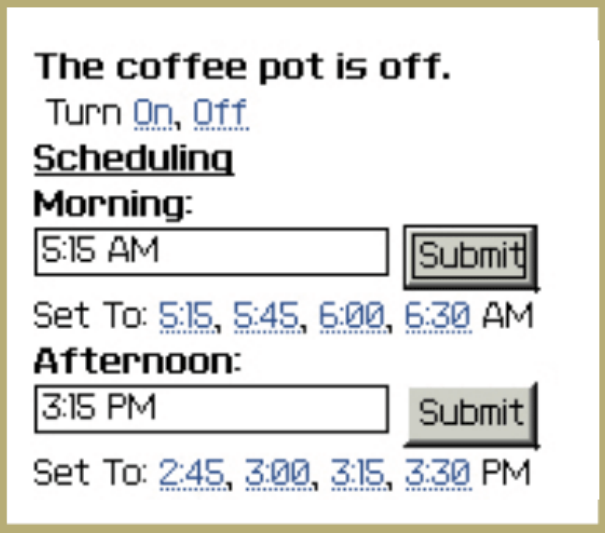
This way, MisterHouse knows to start brewing at 5:07 a.m. if I want to have coffee at 5:15 a.m. A timer is started for the brew time ($coffee_brew_timer) and for the automatic shutoff ($coffee_timer). Once the coffee timer expires, the coffee pot is automatically turned off (Smokey the Bear would be proud).

I drink coffee twice a day — one cup in the morning and one in the afternoon, so I added code for the afternoon brew with some notification features as well. I've placed some motion detectors ($25 each) throughout my home and external home office. Depending on which room there has recently been motion in, MisterHouse turns a light on and off when the coffee's ready. For the early morning brew when there's no motion in the house, I turn on a light near my bedroom that acts as a gentle alarm clock. If the house is motionless at any other time of the day and the brew completes, I send an email to my BlackBerry with a "Turn Off Now" link, in case it's been turned on in error.

MisterHouse comes with its own built-in web server that allows most any object to be accessed and modified using a browser. Along with a fairly comprehensive default web interface, there is full documentation on how to easily roll your own. I wanted to be able to schedule my coffee pot as well as turn it on and off from my BlackBerry, so I created a custom site that looks decent on a mobile browser.

I've also added some vacation logic. My morning brew is automatic — after I schedule it once, it happens daily. However, if there hasn't been motion in the house during the previous evening, MisterHouse knows I'm probably on vacation, so the morning brew doesn't kick off.

Well, there go the lights — it's nectar time!



Learn more about Misterhouse and how it can help you do more than brew a great cup of joe by visiting the wiki at misterhouse.sourceforge.net.

Dave Mabe is the author of the upcoming *BlackBerry Hacks* from O'Reilly and lives in Chapel Hill, N.C.

Your cellphone offers huge possibilities with just a paper cone, battery, and a few wires.

THROW YOUR VOICE!

Build your own anonymous megaphone.

By Daniel Jolliffe

You, too, can bring anonymous voices into public spaces, stage an anonymous protest, or speak to the masses without revealing your identity. I've created a grander version of this anonymous megaphone (see Made on Earth, page 16), but a cellphone, some construction paper, a battery, and a few wires can easily do the trick.

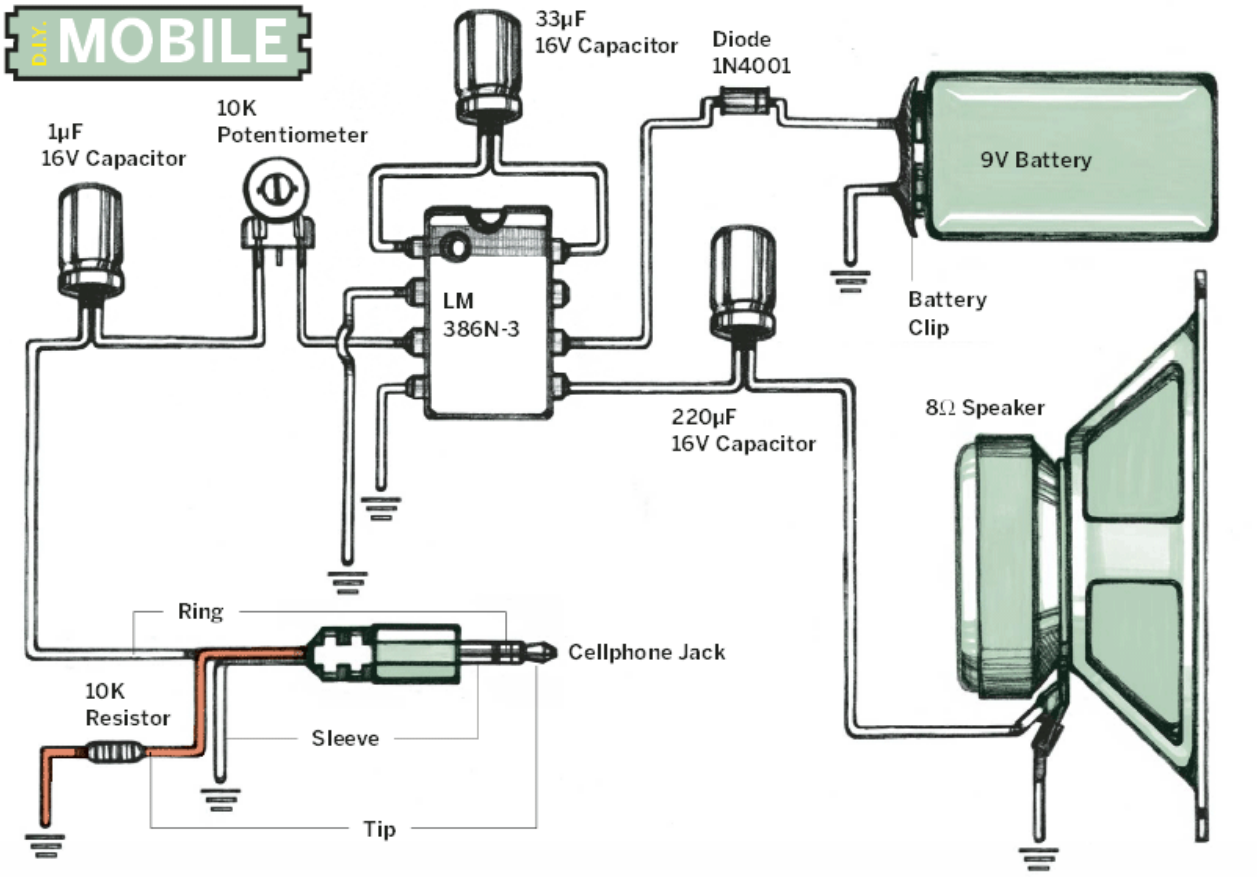
Turning your cellphone into an automatic megaphone is a snap. I'll show you how to build an unattended megaphone that projects a caller's voice up to 30 feet — it all depends on how big a horn you make. It should take about two hours to put together, assuming some familiarity with soldering and basic electronics, and cost you $5 to $10.

Once you get all the parts together (see table on next page), there are basically just two simple steps on the road to anonymous oration.

Solder It

1. Cut the perf board to size and solder the LM386 in the middle.
2. Drill a hole to the end of the board, to tie-wrap the battery and headset cable.
3. Solder in the battery clip and headset wires. With a cable from a cheap headset, you'll have to heat the wire until the enamel covering the wire melts. Tie-wrap them to the board.
4. Identify the headset cable connections. The plug's sleeve goes to ground, the ring is the phone's speaker, and the tip is its microphone.
5. Connect a 1-10KΩ resistor between the tip wire and ground. This fools your cellphone into thinking that a headset is connected. You may have to experiment with different values (I used 2.2KΩ).
6. Solder in the rest of the capacitors and the

Photograph by Daniel Jolliffe



A cellphone checks if a headset is plugged in by testing resistance between the plug's mic and ground. Put a resistor between the two, and you can hijack the cell's audio out and amplify it to drive a speaker. A LM386 takes input from pin 3 and sends an amplified signal to pin 5. A cap bridging pins 1 and 8 increases the chip's gain.

volume control — see the diagram above. Attach the speaker with about six inches of wire.

Don't forget the blocking diode — this protects your circuit when you inevitably connect the battery clip backwards at 1 a.m. If you don't want a volume knob, substitute a resistor for the 10K pot and control the volume from your phone.

Possible Problems

» The headset cable isn't soldered in properly. Use a multimeter to check its three connections.

» Some Nokia phones don't use a standard 3/32" headset jack. If that's the case, get an adapter.

» Most of the component values in this circuit can be approximate, but the one crucial part is the resistor from the tip of the headset plug to ground, which fools the cell into thinking a headset is connected. You may have to swap resistors to tweak this value, depending on your cellphone model.

» If you get feedback and oscillation, you may have to add a suppressor: solder a .05µF capacitor in series with a 10Ω resistor from pin 5 to ground. See the schematic above. Another option is to reduce the pin 1-8 capacitor to 22µF (or even 10µF), which lowers the gain of the amplifier.

MATERIALS:

- 9V battery and clip
- Small perf board
- Headset plug for cellphone (3/32"), with wire attached
- Three capacitors, rated for 16V or more: 100-300µF, 22-33µF, and 1µF
- 1-10KΩ resistor
- Diode, any from 1N4001-1N4004 series
- 10KΩ trim-pot
- 7-16Ω speaker, about 1.5" in diameter *(Use a transistor radio-type speaker, not something out of a pair of headphones)*
- Amplifier chip, prefer LM386N-3 or N-4, but LM386N-1 will work
- Tie-wraps, hot glue, double-sided Velcro
- Card stock for megaphone, about 24"x36"

Assemble It

Roll up the card stock into a cone shape and hot glue the seams to hold it together. Cut the end of the paper horn to fit the speaker, and hot glue it on. (Hot glue is just terrific, isn't it?) Now hot glue or Velcro the battery and amplifier to the horn.

Set your phone to auto-answer after a few rings. Make sure it's also set to route audio through the headphone jack. Velcro your cellphone to the horn. Congratulations — you've created an anonymous public speech device.

Daniel Jolliffe is the creator of One Free Minute (see page 16).

Illustration by Damien Scogin

MINT-TIN AMP

Pocket amplifier punches up headphones.

By Warren Young

Photography by Warren Young

Headphone amps make portable listening good and loud. Commercial audiophile models can cost $200+, or you can build a great-sounding amp inside a mint tin for around $30, following Chu Moy's popular design. Powered by a 9-volt battery, this amp drives high-impedance headphones to thunderous volumes from even weak sources.

To make one, you need an op-amp chip (like the TI/Burr-Brown OPA132), capacitors, resistors, an LED, and a small prototyping board, plus optional knobs, switches, and other bits, all easily obtained. And, of course, you also need a pocket-sized box, like a Penguin or Altoids tin. See the website listed at the end for a full parts list, along with layout diagrams and more detailed instructions.

Prepare the Protoboard

Start with a small prototyping board such as RadioShack's model #276-150 — anything that has at least 12 rows of holes and fits into your case. Larger protoboards can be cut down to size with an X-Acto knife. Then solder nine jumper wires as shown in Fig. 1 on page 133.

The jumpers lower down along the edges are what I call "M-jumpers." They tie three two-hole pads together to form a single pad with three free holes. You can make these by taking a one-inch piece of stiff wire, folding it in half, pinching the kink tight with pliers, and then bowing the two ends over. You may also need pliers to stuff the thick middle bit into the

Your MP3 player's music will sound minty fresh when played through this li'l headphone amp.

hole. Some people make the same connection by threading "S-jumpers" through to the other side, but this makes the jump less visible.

Build the Power Supply

Solder in the capacitors, and use them to orient everything else. Make sure you put the legs in the right holes — the jumpers you placed previously dictate the path of current flow, so there's no room for "creativity" now. All the electrolytic capacitors are polarized, so you must orient them properly. If one leg is shorter than the other, the short one is negative, and there should also be a stripe or other mark on the negative side.

Now solder the LED and the current-limiting resistor. As with the capacitors, the short/negative leg of the LED should lead to the negative side of the power supply, with resistors in series in between. If you're mounting the LED on the lid of the mint tin, solder the resistor close to the board and cover the joint with heat-shrink tubing. That way, its legs won't flex and snap from repeated openings of the case (*see Fig. 1*).

On the underside of the board, solder two 2-inch hookup wires to each side of the third row, in the holes marked V+ and V- (for voltage) in Fig. 1. Leave the other ends dangling loose, but don't let them touch while power is applied.

Now figure out a temporary way to add power to the board. For example, you can solder a 9V battery clip's leads into the holes marked "Batt +" and "Batt -." This only needs to work until you start working on the case.

To test the power, set your meter to DC volts, apply power to the board, and measure from the signal ground ("Ground" in the diagram) to the hookup wires going to the V+ and V- holes. With a fresh 9V battery, you should see about +4.5V DC and -4.5V DC at each capacitor, respectively, and their magnitudes should be nearly identical. If you're off by more than a tenth of a volt, check the wiring and look for solder bridges, wayward drips of solder shorting out to neighboring nodes. Fix any problems and unplug the power supply before continuing.

Add the Amplifier

Solder the IC socket to the board with the notch away from the power supply. Leave one or two rows of holes between it and the power supply caps; use two rows if your caps are exceptionally large. Insert the op-amp into the socket. While placing the other components, refer to the pinout diagram on the op-amp's datasheet.

Next, add all the resistors (*see Fig. 2*). Notice in the photo on page 135 that I used jumpers in place of R5. I almost never install these resistors; they're there to quiet the low-level hiss that you hear with some low-impedance headphones. If you hear a low hiss at normal volume with the audio source disconnected, you can try adding two 47 to 100Ω resistors in the R5 positions. But don't do this otherwise because it will raise the amp's output impedance, inhibiting control over the headphones.

For the remaining resistors, I add them in matched pairs: for each resistor in the left channel, I use my ohmmeter to find another that measures as close to identical as possible for the right channel. I haven't scientifically studied whether this really helps, but it's easy and quick, so why not? It's one less thing to blame if the final product's sound has flaws.

Now add the input capacitors (C2). These aren't polar like the electrolytic power supply caps, so you can orient them any way you like. Axial capacitors are easiest to fit into tight spaces, but most caps can be made to work with a bit of creative lead bending.

Next, take the hookup wires coming from the V+ and V- points in the power supply area and run them to pins 4 and 8 of the op-amp, the chip's V+ and V- points. I recommend you do this on the bottom side of the board, since you'll be adding more wires to the top later. The more wires you can put on the bottom, the cleaner the top side of the finished amp will be, facilitating any repairs and tweaks later.

Finally, add test points at R.out and L.out, and also at R.in and L.in if an alligator clip can't attach to the input capacitor leads directly (*see Fig. 2*). I use half-inch pieces of stiff wire, usually clippings from resistor and capacitor legs, bent in an upside-down "U." These are temporary, used only for the signal test, the next step.

Test the Amp

Now you're ready to see if you have an amplifier yet or not! Apply power to the board, and let it sit a bit. Then, carefully touch the op-amp and

Illustrations by Warren Young

MINI-CMOY POCKET AMP WIRING DIAGRAM

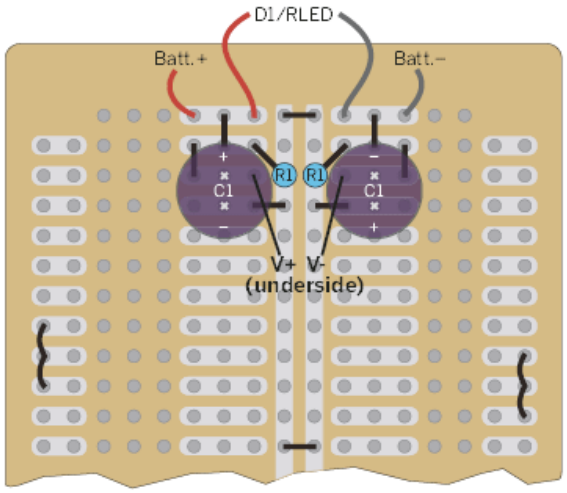


Fig. 1 Add power supply.

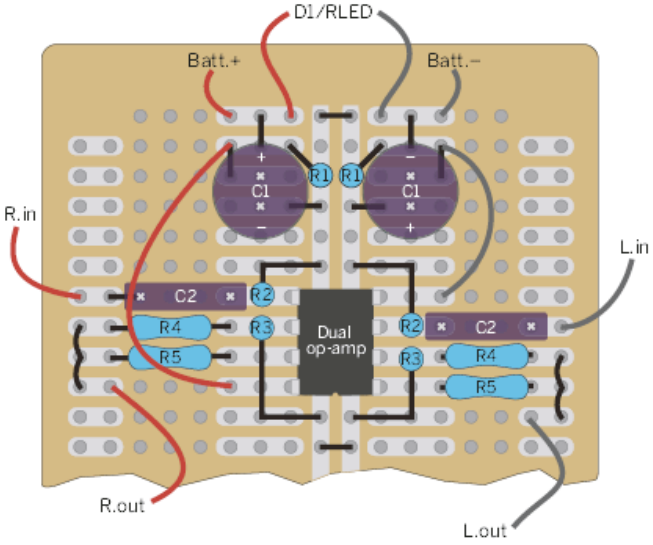
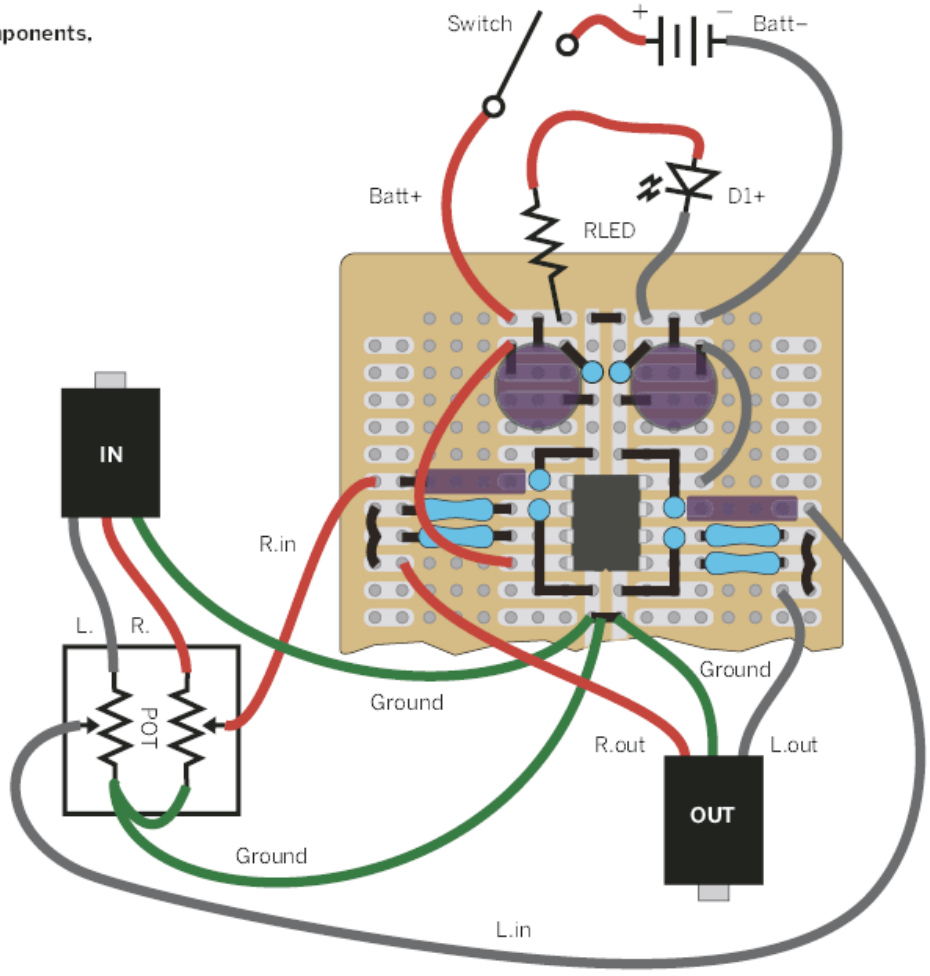
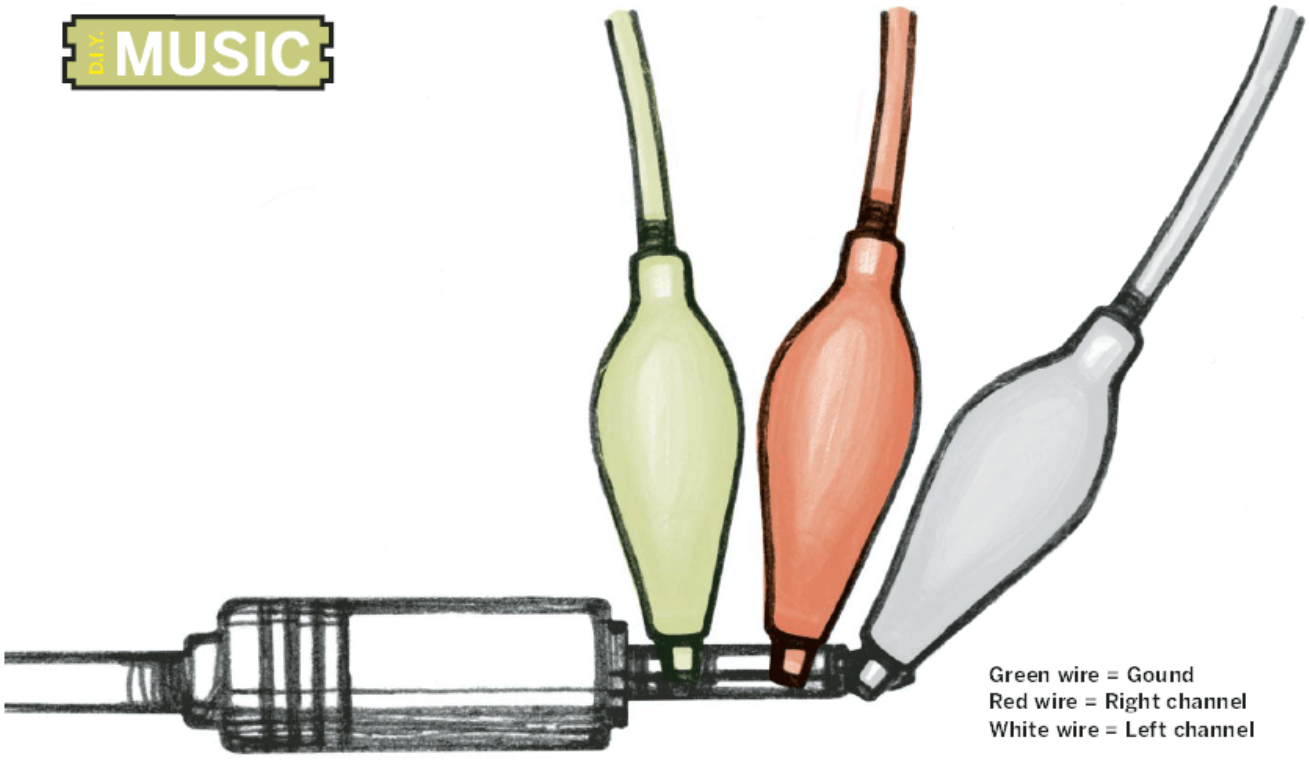


Fig. 2 Add amplifier section.

Fig. 3 Add panel components, enclose, and enjoy!





Testing the circuitry: Plug a stereo mini-to-mini cable into any audio device, and use alligator clips to connect the other end to your circuit board. The plug's tip (left channel) goes to the L.in test point (*see Fig. 2, page 133*), the plug's ring (right channel) goes to R.in, and the sleeve goes to ground. Then take some headphones and alligator-clip three more connections to L.out, R.out, and Ground. Play some music, and see if it all works.

all the resistors' bodies to make sure nothing is overheating. You shouldn't feel any heat at all; if you do, unplug the power and find out what's going wrong.

I use a portable CD player for testing since they have volume controls, useful when you're testing a circuit without a volume control. Turn the player's volume all the way down and start it playing.

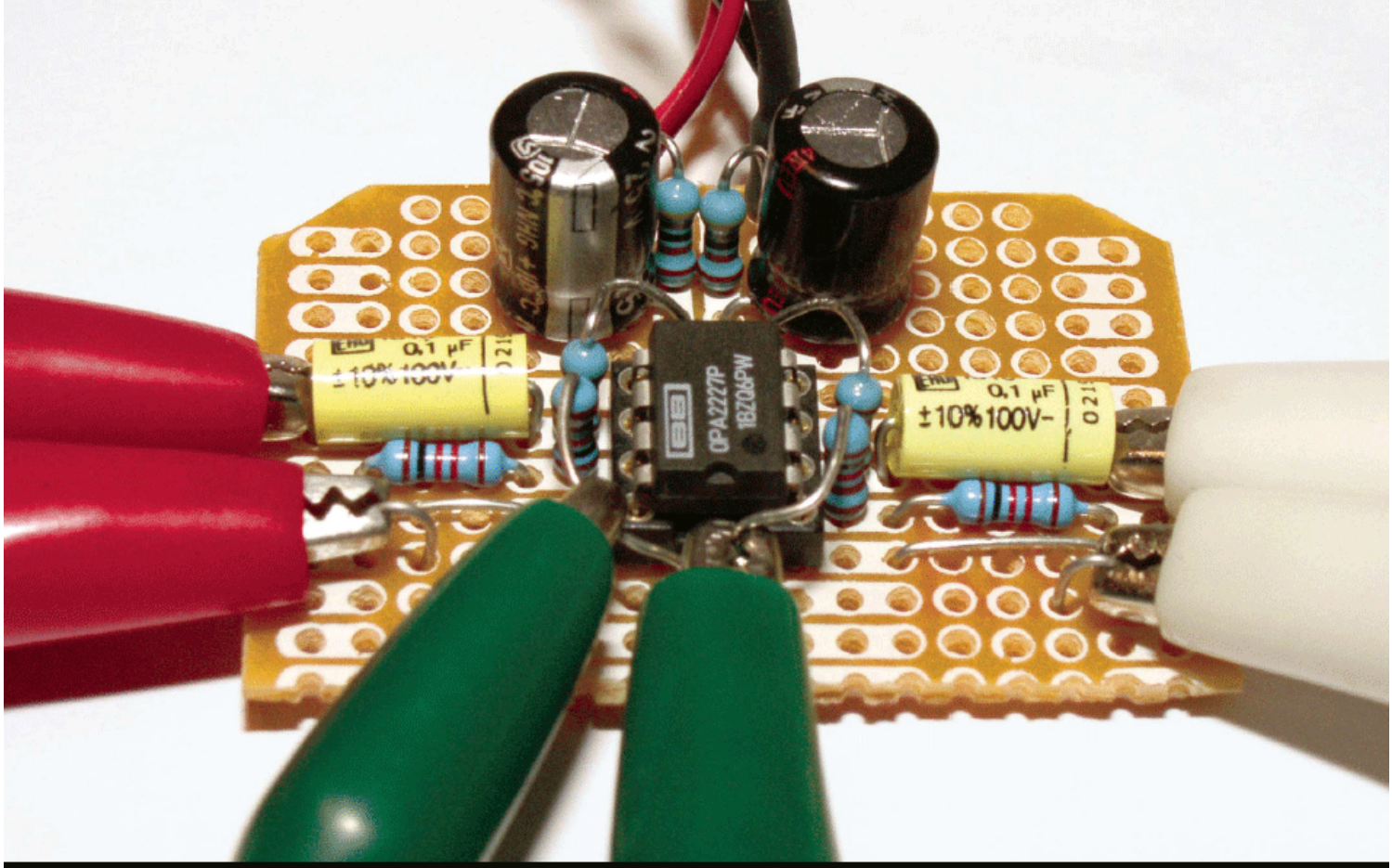
Hook the source into the circuit. There is no one right way to do this, but I use six alligator jumpers and a mini-to-mini audio jack cable. I plug the cable into the player's headphone out and connect three jumpers to the other end. For ⅛" and ¼" stereo mini plugs, the tip carries the left channel, the "ring" further down is the right, and the long remainder, the "sleeve," is the ground. I clip one jumper to each of these, and then clip the other ends to the corresponding test points and across the ground jumper on the board, as shown above.

Then I use the other three alligator jumpers to tie my amp's output points to a pair of cheap headphones. Don't use your $200 cans for first tests — if something's hooked up wrong, you can blow your cans' drivers out.

With the headphones sitting on the table, slowly turn up the volume on the player until you can hear some sound out of the headphones. Put them on now and adjust the volume. If you get good sound, you're done! You might listen for a while longer and try to stress the amp a bit, but basically, you hooked the amp up right the first try. Once you're satisfied that the amp circuit is behaving properly, try your good headphones with the amp. Sometimes efficient, cheapie 'phones will work fine, but the higher load of big, audiophile headphones causes problems.

Amps that don't work right exhibit different symptoms. With some, you'll hear nothing at all, or the sound will be faint or scratchy, even with the player volume turned up. Others sound fine at very low volumes, but distort when louder. And in some cases, the amp plays for a short while, but then stops. This last case comes from the op-amp shutting down; op-amps often have power-protection circuitry, which is triggered by various wiring faults.

Troubleshooting is difficult, and I can't cover it deeply here. But the main things to check are that all the connections to ground are solid, and that



Alligator jumpers all hooked up for testing, from music source (I use a CD player) and headphones. Be sure to use a cheap pair of headphones, because an improperly wired circuit can destroy the headphone's drivers.

you don't have signals or power going to ground when they shouldn't. Check all connections with your meter; sometimes a connection will look right but have high resistance, in which case it needs to be re-soldered.

If your wiring fully checks out, try adding a second battery temporarily, in series with the first. If that cleans the sound up, your circuit or op-amp are marginal. You can either keep on using extra voltage and build for two batteries or try to improve your implementation. See the article, "Basic Troubleshooting for Headphone Amplifiers," at tangentsoft.net/audio/trouble.html for more advice.

Set Up the Enclosure

With the amplifier board built and tested, you can decide where on the case you want to place the panel components — the volume control, power switch, LED, and I/O jacks. To minimize the tangle of hookup wire, the exterior ports for these components should be positioned close to where they hook up on the board. Beyond that, it's your aesthetic judgment. Once you have your layout, drill the necessary holes and set it all up with the board in the case and the panel components fastened into their holes, but not connected to the board. This ensures that everything's going to fit before you start soldering again.

Add the Panel Components

When wiring the panel components into the circuit, add them one at a time, and retest the circuit after each. If you connect all the components at once and then have a problem, troubleshooting becomes very difficult. Also, be sure to test each component on its own, out in the air, and then again once it's fastened in place. This identifies weak wires, bad chassis grounding, and other issues. I've built several amps that worked fine when the panel components were still flopping around on their hookup wires, but failed once the amp was battened down within its case. Fig. 3 on page 133 shows where all the panel components (the switch, LED, in and out jacks, and volume control potentiometer) hook up to the PC board.

First, I hook up the LED and the power switch to the power supply. Once these are working, I add the input and output jacks, remembering the standard stereo plug tip/ring/sleeve ordering

The completed amp. Unless you want to build it in a day, including the time to get the parts, there's little reason to get RadioShack parts; the big mail-order houses have everything RadioShack has and more, with cheaper prices and better quality. I highly suggest you mail order everything you can, if you can stand waiting a week for the parts to arrive.

described above. I connect and test each one at a time, and use extra-long wires for the inputs. That way, it's easy to splice in the potentiometer, which is the next and final step.

The potentiometer has six pins, three in a row for each channel. The middle pin, the "wiper," connects to the circuit board's input capacitor, at L.in or R.in on the diagram. The pins on either side of the wiper connect to the input jack and to ground. If you want volume to increase as you turn the knob clockwise, the ground usually needs to connect to the pin that's on the left, as you face the knob with the pins pointing downward. But it's best to determine the pin arrangement by checking the component's datasheet or testing with an ohmmeter; lowering the resistance between the side pin and the wiper means turning the volume up. If you reverse these connections, the amp will work fine, but the volume knob will operate in the wrong direction.

That's it — now you've got an amp! You can enhance it with various tweaks described on the website, including tuning the gain, adding a DC power jack, using different caps and resistors, and improving the virtual ground circuit.

For the full project tutorial site, including a parts list, background articles and other references, and more detailed instructions, visit makezine.com/04/headphoneamp.

Warren Young is a software developer who used to think the maxim "beware of programmers who carry soldering irons" was funny. He lives in Aztec, NM.

Silly Putty's been around for 50 years, and in that time it's become an international toy classic. Now you can purchase a 5-pound block of the original Silly Putty at crayolastore.com/category.asp?NAV=PUTTY. The block comes in a box; no plastic eggs included. There's also a Bouncing Putty Mailing List at bulkputty.org/mail/, with instructions on how to get 100 pounds of Dow Corning's Coral Putty at bulkputty.org/ordering/dow.html.

VJs' rigs are all different; unlike with DJing, there's no standard "two turntables and a mixer."

VJING 101

Performing live video combines the visual power of filmmaking with the spontaneity of jazz.

By Paul Spinrad

Illustrations by Damien Scogin

It's a great time for live visuals. After a century-long march of color organs, visual music, light shows, and club videos, visualists can finally manipulate and mix original material and samples, both abstract and representational, in real time. You don't have to wait for rendering anymore. Most new laptops with dual-screen support (a VJ must) can now handle live video mixing and effects in resolutions of 320x240 or 640x480, depending on the software — and of course, they're getting better every year. With a super-fast gamer laptop, you can go even higher.

Meanwhile, the home theater boom has brought a flood of dazzling and relatively inexpensive digital projectors. Today's lightweight, $800 DLP projectors have far higher brightness and resolution than the bank- and back-breaking Eidophor projectors that defined the dance club look of the 1980s. Between a laptop and a digital projector, you have all the hardware you need to start VJing.

Software

Recent years have seen an explosion of live video software. Some apps, such as Videodelic, Touch, and Zuma, are mainly synthesizers that use gestural input and settings to generate dazzling abstract patterns. Other software focuses on playing and mixing video clips.

The easiest clip-based applications to learn, including Arkaos, Motion Dive, and Livid Union,

VJ-ABLE GEAR

There's almost no VJ-specific hardware, but you can control live video with many other devices.

Joystick

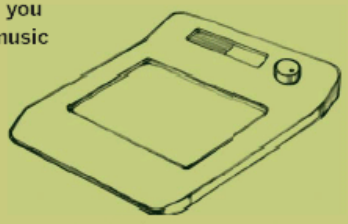
A game controller navigates VJ software fast (and VJing resembles gaming, but with an audience).

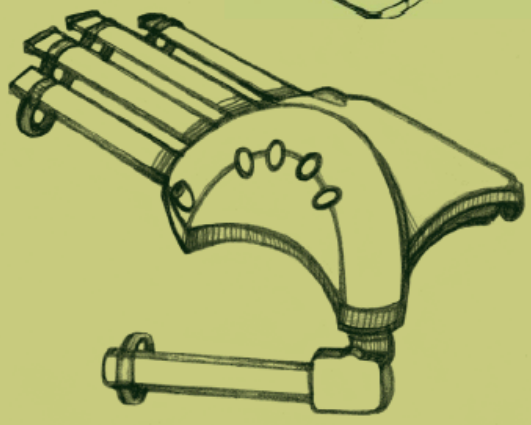
MIDI Keyboard

M-Audio's Oxygen8 keyboard has 25 keys that you can assign to trigger different video clips. Meanwhile, 8 knobs up at the top will tweak effects parameters and other continuous values. A USB port in back of this portable keyboard lets it talk to your laptop directly, without requiring a MIDI-USB adapter.

Touch Controller

The STC-1000's abstract interface won't make you think you're playing music or a game.





Data Glove

Center-stage VJs need to move. The P5 Data Glove works in mouse mode with any app, and reaches its full gesture-recognition potential with MIDI and Max/MSP interfaces. Refer to the p5glove Yahoo! group.

Ms. Pinky

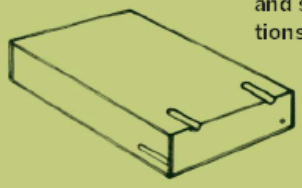
Special vinyl LP lets you turn any turntable into a precise controller for playing and scratching video.

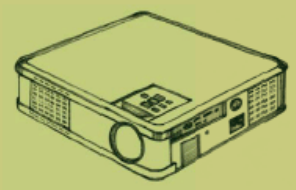
Turntable

Following their DJ heritage, many VJs use turntables like the Technics 1200 series, outfitted with Ms. Pinky or the EJ MIDI system.

External Hard Drive

Hard drives let you store and swap different collections of video clips.





Digital Projector

Lightweight LCD or DLP beamers throw your visuals onto the wall (or anything else) for all to see.

Laptop

Live video eats up processing power, so VJs favor RAM-enhancedPowerBooks and gamer PC laptops with fast graphics.

use the interface metaphor of DJing: you see two preview screens (instead of turntables) on either side of a slide control, or "fader." You trigger video clips by clicking on their thumbnails, paging through your collection as desired, and you can apply effects and mixing algorithms to both.

Other apps, such as Flowmotion and Resolume, present a channel-switching metaphor, letting you draw from and layer multiple concurrent video sources. As with the DJ-style apps, you can also apply filters and effects. The most versatile of all VJ applications, such as Isadora, VDMX, and Max/MSP with Jitter, are complete visual programming environments that let you string together clip libraries, live streams, functions, inputs, and outputs to create your own virtual video instruments. Most VJ software runs on Mac OS, but some also run on Linux or Windows.

Accessories

A lot of VJ software takes MIDI input from your laptop's USB port (translated via a MIDI-USB interface dongle such as the M-Audio Uno or Edirol UM-1X). The VJ applications use this input to synchronize cuts and effects to music coming from the DJ or other source. More importantly, MIDI-in also lets you attach outboard MIDI controllers, which make it easier to perform. Mousing around on a screen can be difficult in a high-energy environment, but with a MIDI keyboard connected to your laptop, you can trigger clips with the piano keys and twiddle settings with physical knobs.

You can also use a variety of other devices to generate non-MIDI inputs as well as MIDI, such as substituting for the mouse and hotkeys on the keyboard. Joysticks, graphics tablets or touch controllers, and data gloves are all tools that can assist your performance — and, to varying degrees, show the audience that you're not just checking your email while running a DVD of canned visuals.

One special case is scratching video back and forth, DJ style. To perform this move, you can retrofit any turntable with either the Ms. Pinky system, which relies on a special pink vinyl disc and compatible VJ software, or the EJ MIDI Turntable, which uses a barcode-like disc, an optical tonearm cartridge, and a small box that translates your turntablism to MIDI. Alternatively, you can forget the tables altogether, and scratch with a jog shuttle controller such as the ShuttlePRO.

As flexible as laptops are, mixing video and running computationally intensive effects can make a laptop sluggish, or even make it crash. That's why many dedicated VJs invest in a hardware mixer, such as the Edirol V-4, and put this at the center of their rig. Hardware mixers run their processing algorithms on a chip, which means that they don't offer the endless array of effects that you can get in software. But they're faster, immediately responsive, and crash-proof. If you're hardware-mixer based, you can still use a laptop as one of your mixer's inputs. VJ applications like Grid2 are designed for this purpose, turning a laptop into a dedicated, fast-triggering clip server.

Content and Culture

The VJ's palette encompasses all imagery, abstract or representational, recognizable or obscure, iconic or ambiguous. Anything you've ever shot, ripped, recorded, generated, or downloaded is fair game, and you can also capture material live from camera or video feeds. Unlike with DJing, you can mix freely, without worrying about key or tempo. The dissonances that a VJ creates are cognitive, not musical, and juxtapositions that give people pause are part of the fun. With a visual vocabulary, ranging from old icons to today's news, you can construct puns, arguments, and even narratives.

VJing is for the moment, for the people you're with, growing out of a unique time and place. What you throw onscreen is an expression of the now, not a dead document for posterity. If you want to impose an unchanging visual message on remote, passive audiences, you're probably better off as a filmmaker. But if you prefer interaction, flow, and living experiences, then VJing may be for you.

Resources

VJ Central reference and forums: vjcentral.com
Eyecandy Yahoo! group: groups.yahoo.com/group/eyecandy
Eyewash (NYC): forwardmotiontheater.org/Events
La-Va (Los Angeles): la-va.org
Video Salon (SF): dimension7.com/videosalon.html

Paul Spinrad is projects editor for MAKE and the author of *The VJ Book*.

AIR SCRATCH

Use a webcam to turn motion into music.

By Peter Kirn

Leon Theremin introduced the world to music made from the ether in 1919 with the Theremin-invox: wave your hand through the air, and the tube-based instrument produced sound. Now it's possible to realize new possibilities for controlling sound in the air, all with a cheap webcam and off-the-shelf DIY software.

You'll need several elements to pull this trick off:

1. A webcam.
2. Motion analysis or "computer vision" software.
3. A means of translating the motion analysis into control (usually MIDI).
4. Something to control, like software synthesizer settings or effects parameters.

The easiest part of the equation is the webcam. I've used both an Apple iSight (apple.com/isight) and a Logitech QuickCam Pro for Notebooks (logitech.com/quickcam); I prefer the Logitech camera because it's cheaper and works well on both Windows and Mac.

There are many forms of video motion analysis, including motion detection and motion tracking. Motion detection responds to any change in the color of specified pixels anywhere in a video source. It can tell if something is moving, but it can't track the direction of a pixel or object through space. Since you can divide the image into a grid, motion detection works well for camera-controlled

It may look like a camera, but this Logitech QuickCam really wants to be a musical input device.

drum machines; each grid section triggers to a different percussion sound.

Motion tracking is more sophisticated, tracking a pixel (or object) through space. For continuous control of parameters, like a video theremin, controlling an effect, or scratching in air, you'll need some form of motion tracking.

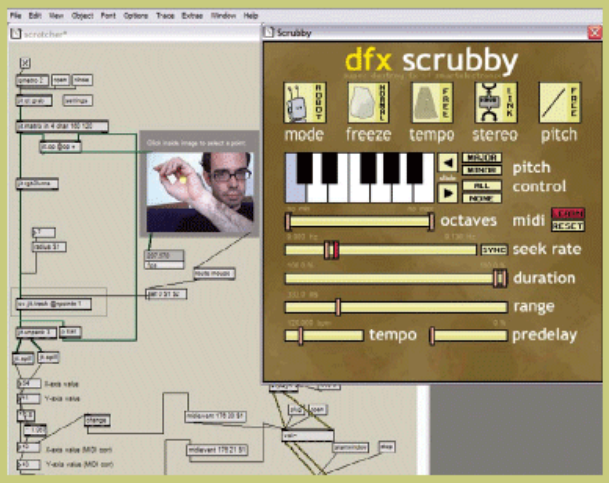
Implementing motion tracking from scratch is thorny stuff, but there are many off-the-shelf solutions, a number of them free. Interactive toolkits let you create your own custom software by "patching" visually instead of coding, ideal for handling the motion data flexibly. By transmitting MIDI, they can also be used to control instruments and effects software. On Windows, the free software EyesWeb (eyesweb.org) is perfect; it's designed specifically for experimenting with computer vision and has plenty of tweakable parameters. Mac and Linux users can combine the interactive toolkit PD (Pure Data, puredata.org) with PiDiP (recursive acronym for Definitely in Pieces, ydegoyon.free.fr/pidip.html). Both PD and PiDiP are open source, though they're a little less robust when it comes to motion tracking.

The best cross-platform solution is Max/MSP and Jitter from Cycling '74 (Mac/Windows, cycling74.com); it lacks the ingredients for computer vision but has extensive modular MIDI, audio, video, and number-crunching capabilities. Two cross-platform add-on libraries for Jitter include a full toolkit of computer vision capabilities: the commercial Tap.Tools ($65-$119, electrotap.com) and cv.jit (free, www.iamas.ac.jp/~jovan02/cv). I regularly use both.

Max/MSP/Jitter is an expensive solution, costing hundreds of dollars, but to get you started, I've created a simple standalone application developed in Jitter that does the work for you, converting motion tracking to MIDI data. The download, instructions, and details on how it was made are available on the MAKE site (+ makezine.com/04/diy_airscratch).

You may still want to build your own tool using one of the aforementioned options, but trying out this tool with your favorite instruments and effects will give you a sense of what does and doesn't work. Some quick fixes to tracking problems include using a brightly colored object for tracking, or shining a small flashlight at the camera (perfect for darkened onstage performances.)

Photography by Peter Kirn



A custom Cycling '74 Max/MSP and Jitter patch does the work, with the help of the free cv.jit add-on. That yellow dot on top of my hand is tracking movement, which can be routed to an instrument or effect in the form of MIDI data. Here, I'm using the free Windows/Mac VST effect plug-in DFX Scrubby to mangle a looped groove.

You can construct your own audio functionality using these applications' modular capabilities, or you can route MIDI data to your audio software of choice. Mac users can route MIDI between applications, easily using the Inter Application Communication (IAC) driver; select IAC in the sending and receiving application, or another virtual in/out, and you're done. Windows users need to install the MIDI-routing tool MIDI Yoke (midiox.com).

Lastly, you need something to control. I wanted "virtual scratching" ability, so I could wave my hands to shuffle and distort beats. The free audio instrument Musolomo (Mac, plasq.com/downloads) fit the bill perfectly. Destroy FX's donationware Scrubby and Buffer Override (Windows/Mac, destroyfx.smartelectronix.com) also work well, though for these you'll need a host that supports sending MIDI to effects, like the free modular host Buzz (Windows, buzzmachines.com).

Put it all together, and you've got video control of audio. You'll need to experiment with lighting, positioning, and your technique, but as with the original theremin, the effort is part of the fun. Especially when the reward is magically pulling music from the ether.

Peter Kirn is a composer/media artist and editor of createdigitalmusic.com.

The essential tools of a Game Boy musician: a classic Game Boy and a homebrew cartridge.

MUSIC BOX

Turn your Game Boy into a musical instrument.

By Peter Kirn

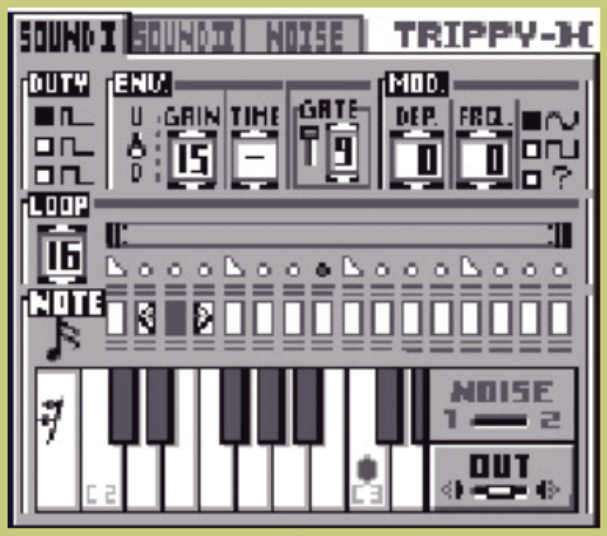
To its fans, the low-fi, 8-bit sound of a Game Boy might as well be a Stradivarius violin. So how can you make your original, gray 1989 Game Boy, or even your new DS, into a retro music-making machine?

Cartridges for Music

The easiest way to start out is via the Game Boy Camera, an accessory for the original Game Boy. The camera's onboard software includes a fairly limited but usable music creation tool. Used cameras usually go on eBay for $10-$20 (about the same price as an old Game Boy, if you're lucky). The music software is simplistic, but the camera's photos are appealingly low-res.

For more serious music making, you'll want a homebrew option; by far, the best are Oliver Wittchow's Nanoloop (nanoloop.com) and Johan Kotlinski's LSDJ (littlesounddj.com). These are not Nintendo-licensed, but while Nintendo has made some moves against backup hardware, they've generally left homebrew developers alone. Nanoloop 2.0 is available for sale as a Game Boy Advance (GBA) cartridge (€80, US$100). Nanoloop 1.x for the original Game Boy is currently out of production, but an upcoming 1.3 update will make it available again for older systems.

The situation with LSDJ is more complicated: $29 buys you a ROM image, but you're on your own beyond that. You can load the ROM in an emulator; my favorite is KiGB (Mac/Windows/Linux, kigb.emuunlim.com). An emulator makes screenshots and audio capture easy, but you'll still want a real Game Boy for portability and authentic sound.



The Game Boy Camera's DJ game is basic but friendly: the keyboard at bottom chooses pitch, while the rectangles at center are steps in the step sequencer. The tabs at top represent different instruments, the sounds of which can be edited using various parameters in the top third of the screen.

LSDJ uses a character-based interface, constructing songs out of sequences called "chains." The cross in the lower right corner functions as a map of the software's editing structure. The (P)hrase editor shown here is where the real magic happens. Here, I've sequenced a drum pattern using LSDJ's built-in sampled drum kits.

You'll need linker or "backup" hardware for creating your own flash cartridge, and unfortunately, the classic-style cartridges needed are harder to find than the GBA cartridges. See LSDJ's website for caveats and up-to-date advice, but the UK-import Game Boy Transferer is probably your best bet (Windows only, www.robwebb.clara.co.uk/shop/copiers/copiers.htm).

Assuming you've got a cartridge compatible with your Game Boy, sound quality is your next consideration. Aside from their "oldskool cred," vintage Game Boys also sound far better than the GBA and Color models, so for Nanoloop 1.x or LSDJ, older is better. With Nanoloop 2.0, you'll need a GBA model or later; the SP and DS have worked best for me.

Start a Song

Don't expect to pick up any of these options without a manual or tutorial handy. Here's some basic advice, but for links to additional tutorials, resources, and some quickie "survival guides," see + makezine.com/04/diy_gameboy.

Game Boy Camera

From the camera's main menu, select Play. At the beginning of the Space Fever II game that appears, shoot the shape labeled with the letter "D" for the "DJ" game. Select New from the following screen to create a song. Hit Select for the sequencer/editor; hit Select again to toggle between one of three sound types. Since left and right choose beats (or "steps" as they're called in a step sequencer like this), you'll need to hold down A+left or right to add a pitch on the keyboard.

Nanoloop 2.0

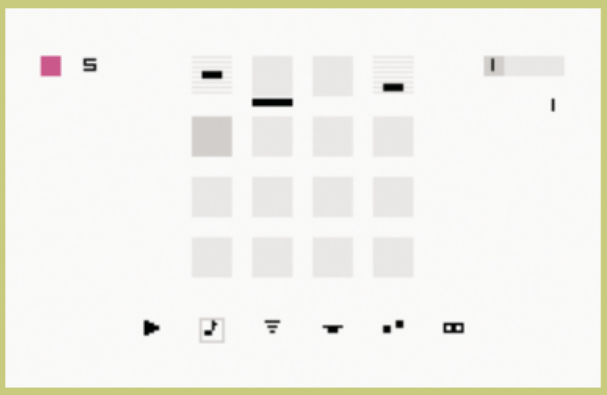
Nanoloop is the most graphical of the Game Boy music "power tools." The grid you see on startup is a step sequencer for an individual channel. First, you'll want to add some notes, so select the note icon on the bottom (with A+left/right to select the edit parameter). Next, navigate to the step you want to edit (with left/right), and then change the pitch (using B+up/down to edit the step parameter). You can then layer channels (use up/down to select a channel), edit sounds with the instrument editor (hit Start to toggle views), or see an overview of your whole song (hit Select). See Wittchow's documentation at nanoloop.com/manual_201.html for more information.

LSDJ

LSDJ has the deepest sound and song editing, but it also has the steepest learning curve. It uses hex codes in place of graphics, and is conceptually challenging to beginners because it works much like vintage "tracker" music software (see

Photography by Peter Kirn

en.wikipedia.org/wiki/Tracker). The payoff is complex sequencing and nifty features like built-in Roland TR-808 samples; see wiki.littlesounddi.com/ for tutorials and frequently asked questions.



Nanoloop 2.0 uses a minimalist graphical interface that hides some powerful features. Each large gray box is a step in the step sequencer (for constructing loops). By choosing a parameter at the bottom (the note icon represents pitch), you can edit that parameter on each step. A separate instrument editing screen with a similar interface gives you other controls over sound.

The VJ Book

A couple of years ago, while I was watching a friend set up his light show equipment for a party, I was struck by the expressive potential of live visuals, and I also knew that laptops and digital projectors made the field much more accessible. Now, you really can show anything! I decided to write a book on the topic, a combination how-to guide and cultural manifesto, including interviews with people working in and around VJing and other forms of live visuals performance. This became *The VJ Book*.

Researching this book was a blast, and I learned that a lot of nice, smart, and interesting people have been doing incredible stuff with visual culture and video technology for years. But meanwhile, most folks don't pay much attention. That's largely because dance clubs, where most VJing has been happening, emphasize music first — as they should. This trains us to view live video as mere wallpaper, not worthy of attention or analysis, even if the VJ is working hard to communicate interesting ideas.

But at increasingly popular gatherings such as Eyewash and Video Salon, VJs now perform front-and-center, for attentive audiences. Today, a subculture; tomorrow, the world! —*Paul Spinrad*

The VJ Book (Feral House, 2005), *thevjbook.com*

Better Vibrate than Never

1980s pop sensation Thomas Dolby is still pushing musical frontiers at his new company, Retro Ringtones. For my book, *The Art of Digital Music*, he discussed the art and science of composing for mobile phones.

DAVID BATTINO: Do you find that composing for extremely limited devices makes you more creative?

THOMAS DOLBY: Yeah. The attraction for me is sort of puzzle-like. That's coupled to the knowledge that one day this is going to go off when you're in line at Starbucks and everybody's going to turn around and go, "Whoa! Cool ringtone."

It's also challenging to see how small you can make the ringtones, because file sizes are really important. And obviously, the more audio you use, the lower the sample rate has to be. So there's this constant battle to determine the minimum amount of audio you need to actually make a statement. Sometimes that means you need to get quite creative with the song. And then there's the philosophical dilemma of "Would I be pissing off the artist if I made a different arrangement" versus "Well, he might be more pissed off if I used twice the length of audio and had to downsample it to 4kHz."

Recently, I've been adding vibration tracks and LED tracks to our ringtones, which is a lot of fun because you get a little extra boost. I either enhance the kick drum with a short vibration or have the vibrations play a regular phone-ringing pattern — vvvvt, vvvvvt — in counterpoint or opposition to what's going on with the music.

I just did a "Sex Machine" one. [Plays a James Brown ringtone with sampled vocals; the phone's vibrating alarm hits on the downbeats.] It's obviously restructured from the original. The horn stabs are just one horn stab being retriggered, and all the answer phrases of "Get on up!" are always the same. And then, to justify having the horn stab in at all, I wanted to come back to it more quickly.

So I'm taking quite a lot of artistic liberty with the song. And I don't know whether Mr. Brown would prefer to hear that, or a linear section of his song, but downsampled so it's just unbelievably crunchy.
—*David Battino*

Excerpted from *The Art of Digital Music* **by David Battino and Kelli Richards:** *backbeatbooks.com*, *artofdigitalmusic.com*.

You haven't lived, not really, until you've experienced the thrill of tandem dog-carting.

MUSH!

Building a tandem dog cart.

By Adam Thornton and Amy Horton

We are owned by three Greater Swiss Mountain Dogs. The Greater Swiss Mountain Dog was bred as a general-purpose farm dog, but one of their traditional tasks has been hauling carts full of milk jugs. They're relatives of the St. Bernard, the Rottweiler, and particularly the Bernese Mountain Dog. They can be thought of as "the poor man's horse," although they make for peculiarly snuggly horses.

Drafting with Dogs

Canine drafting has a fairly large following in the Newfoundland, Rottweiler, Swissy, and Bernese Mountain Dog worlds. If you are interested, canadasguidetodogs.com/clubs/draftdog.htm is a pretty good place to start looking. There's also a Yahoo Groups list: CARTING-L.

You'll need a strong, reasonably large dog that likes to work. If you want to build a cart like the one in this article, you'll need a pair of them, although you could, if you really wanted to, build a scaled-down tandem cart for your Chinese Cresteds. If you live in a colder climate, you might want to investigate sledding. Conversely, your local sled dog club may also put on carting events when the weather is warmer, and it's quite likely to have members who know about drafting.

Two of our Swissies — Golem and Ursa — already know how to draft, and, although we have two carts (technically, a cart and a wagon; wagons have four wheels, while carts have two), both of them are designed to be pulled by a single dog. Since we've got two carting dogs, we wanted to build a cart that both of them could pull at once.

Photography by Adam Thornton

MATERIALS

1 sheet 5/8" MDF
3 96" 2x4 studs
2 96" select 1x8 hardwood boards
2 26" bicycle wheels, tubes, tube liners, and tires
2 10' 1/2" conduits
1 10' 3/4" conduit
Lots of 1 1/2" #8 wood screws
Some 4" framing nails
2 cans of primer
6 cans of spray paint (we used black metal flake)
4 5/16" washers
4 1/2" chair leg tips (rubber)
4 1/2" hose clamps
4 cotter pins
2 screw hooks, 3"x1/4"
2 2' lengths of 3/4" chain
2 spring-loaded carabiners

TOOLS

Electric drill and variety of bits
Electric screwdriver
Circular saw
Hammer
Conduit cutter
Flat file
Pipe bender
Socket set
Pliers

OPTIONAL

Compound mitre saw (don't try mitred corners without it!)
24"x48" sheet of hardboard
A couple dozen 5/8" wire nails
A couple dozen 5/8" wood screws
Masking tape
2 dryer vents
EL wire, battery, and driver
32"x49" industrial carpeting
Type-R decal
Vanity license plate

Tandem Cart Design

The basic design of the cart calls for two wheels on independent axles (thus no need for a differential), two hooks in the front (one for each dog to pull), and four shafts that guide the dogs, with brakes affixed to them so the dogs can slow the cart simply by slowing down and letting the brakes press on harness loops near their shoulders.

Capacity was much more important than speed to us, so it didn't matter how much the cart weighed; we were unlikely to build an empty cart too heavy for the Swissies to pull. Since our existing two-wheeled cart was about 16 inches wide, we decided to make this one 32 inches wide. We decided that 4 feet would be about the right length. After having built a MAME cabinet last year, we had become fans of MDF — medium-density fiberboard — and we decided to make the deck out of 5/8" MDF.

MDF comes in 49"x97" sheets, so we bought one and cut a 32"x49" deck, and used the rest, balanced on a spare dog crate, as our work table for the rest of the project.

Framing the Deck

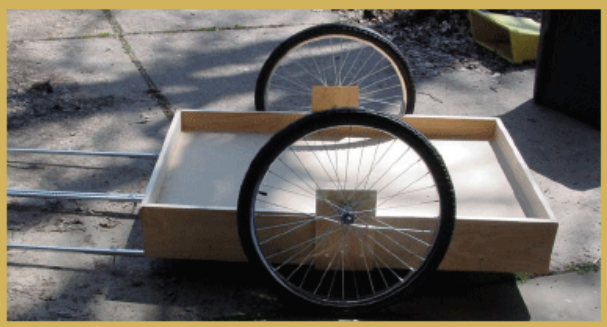
First we built a frame of 2x4 studs underneath the deck (since these will not be visible on the finished cart, construction-grade is fine), with two front-to-back stringers and a crossbar to anchor the back of the larger conduit holding the shafts. The 2x4s were nailed to each other and screwed to the MDF. All screws in this design are countersunk (*see Countersinking, page 148*).

Having built the deck, we then faced it with select-grade 1x8 lumber (we chose a higher grade lumber so it would look nice when painted). We decided to make the bottom of the lumber even with the bottom of the 2x4s, so 3 3/8" of the lumber would extend above the deck. We made the dubious choice to mitre the corners: this is a lot of work for not much result, and we recommend against it, unless you have a big mitre saw.

Fortunately for us, our neighbor Michael lent us his compound mitre saw, which made cutting the mitres very easy. We screwed the facing boards to the deck assembly, and then screwed the hooks (for the dogs to pull) into the front end, through the facing board, and into the 2x4s.

Placing the Wheels

Additionally, we used sections of 2x8s to create raised axle mounts. These are not present in the final cart, because it turned out that they dropped the ground clearance of the cart so low that it was impossible to traverse even the slightest bumps. Don't bother with these, even though they are visible in the pictures. It turns out with this design that putting the axle about 2 inches forward of the center would balance it when both the shafts and spoiler are in place. Our cart is just slightly front-heavy, but not enough to make a difference, since you can easily adjust the load to compensate. The height of the axle above the deck ended



The cart uses standard 26" bicycle wheels.

Making the deck: It's OK to use less-expensive construction-grade lumber for framing, because the studs are on the underside of the deck and can't be seen.

up being as low as we could lay the electric drill down inside the cart to drill the axle holes out through the sides. This gave us about 7 inches of ground clearance; that's enough for carting on the street, but you wouldn't want to use this cart in rough terrain.

A better design would actually have been to put the axles through the framing 2x4s as well, but this would have required longer axles than came with the wheels. Most likely, 5/16" threaded rod would work fine; we may eventually move to this design, as it would increase both stability and ground clearance.

The wheels are standard 26" bicycle wheels. Because we didn't care about the weight, we went with steel wheels at $20 each; with tires and tubes and tube liners, it ended up costing about $70 for the set, and was therefore the most expensive single component. You could cut this cost substantially by buying a used bike and throwing away everything but the wheels.

Fastening the Shafts

The next phase was to attach the shafts that the dogs would pull between. The shafts actually function as brakes; the motive force is provided by the rings at the back of the dog harness pulling on the two hooks screwed into the front of the cart. We used ¾" conduit for the parts of the shafts attached to the carts. We simply used long screws to attach them to the framing 2x4s and used ½" conduit for the detachable part of the shafts. We cut these with a conduit cutter and filed the burrs off the ends. Then we carefully drilled 17/64" holes through the assembled shafts and held them together with ½" cotter pins.

The shafts were then bent into shape with a pipe bender. This was a lot trickier than it sounds, and we never did find a good way to get them all

The shafts serve as brakes — the dogs pull the hooks.

completely straight. Thankfully, our dogs aren't particularly precision-crafted either, and good enough was, indeed, good enough. Chair leg tips cushion the ends of the shafts. We bent our shafts so that they'd be about 16 inches off the ground when the cart was level (you should adjust this to fit your own dogs' heights, of course).

You will want brakes on the shafts; we used plain old hose clamps. These go behind the loops on the dogs' harnesses; when they slow down, the shafts stop at the loops, so the dogs don't get run over by the cart as they slow.

Pimping the Ride

At this point, you certainly could drill holes for the axles in the sides of the cart, mount the wheels, and begin carting. We decided, in honor of MAKE's automotive issue (*Volume 03*), to pimp our ride a bit. Thus, we constructed a spoiler out of scrap MDF and fashioned two oversized exhaust pipes from dryer vents tacked to a hardboard base.

The finished cart. Installing a carpet is optional.

Then we sprayed the contraption with endless coats of metallic-flake black (all projects seem to take five times as much paint as they should), and mounted the wheels (5⁄16" holes for the axles and large washers to spread out the pressure).

Final detailing included a vanity license plate reading "DOG CART" (designed and purchased online at signsbyyou.com), which we outlined in purple EL wire to make it look hip. Finally we added a Type-R decal, which makes the cart 25% faster. We plan to carpet the deck, but we haven't done that yet.

Countersinking

Countersinking is easy: After drilling the pilot hole for your screw, put a 5⁄16" bit in and drill just enough for the bit to bite, leaving you with a 1⁄4"-3⁄8" hole at the top of your pilot hole, big enough for the screw head to sink into so that it's level with or recessed into the surface of the piece you're screwing on. Practice on some scrap first, and practice with all your different materials: 2x4s, high-grade lumber, and MDF all drill very differently when you're countersinking.

You could also just buy a countersinking bit; they cost $10-$15.

The Completed Cart

In order to get the brakes on the level part of the shafts, we added 2 feet of chain with carabiners to clip to the dogs' harnesses. This gives us some flexibility in how far forward the dogs are when they're pulling.

Here's the finished product (*at left*), with the dogs saddled up and ready to go. Golem is the big dog and Ursa is the small one. Vinnie, our third Swissy, does not yet know how to cart.

Conclusion

The cart works fine, but the dogs need some more training; in particular, Golem freaks out when Ursa starts pulling and the cart rides up on him. His response is to dig in his feet. This means that Ursa does a huge amount of work, and that Golem needs a lot of cajoling to actually start pulling. Although they both pull well individually, Golem is confused about how to do it as part of a team. Ursa has no such issues, although she does get annoyed that Golem is slowing her down.

Nevertheless, we did return Michael's saw to him today in the cart, which involved several hundred yards of hilly drafting, carrying a pretty heavy load, and some distance (although Michael and Dee are neighbors of ours, their backyard backs onto our side yard, and they are a fair distance away by road). The dogs are easily able to pull the cart loaded with a heavy saw. We now have high hopes of someday taking turns and riding our canine chariot through the neighborhood.

Amy Horton studies molecular evolution, while Adam Thornton is a bewhiskered curmudgeon.

Take me apart: The Robosapien is a robot with a purpose — to be hacked.

HACK A ROBOSAPIEN

This maker-friendly bot begs to be opened up.

By Dave Prochnow

One-and-a-half million Robosapiens were sold last year. Appealing to both adults and kids, Robosapien has probably gone further toward inspiring future roboticists than the most ambitious educational product.

But that's only half the story. Robosapien is one of those few toys that you absolutely must take apart, for three reasons. First, as you disassemble Robosapien, you will be truly amazed at the simple beauty of its design. Counterbalancing springs, integrated plastic strain reliefs, and intricately geared servo motors will delight even the most jaded toy buyer. This robot ain't no bucket of bolts.

The second reason for opening up Robosapien is learning the basics of robot and toy design. Yes, the insides of this robot are well documented, ensuring a good, competent education in robotics — that is, if you're willing to pick up a screwdriver and open it up.

Finally, you've got to open up Robosapien if you want to become one with this robot's greatest inner strength — it wants to be hacked. I should know: with the blessings of WowWee Ltd. and Robosapien's inventor, Mark W. Tilden, I wrote *The Official Robosapien Hacker's Guide* (TAB Electronics, 2005), which details over a dozen

WARNING: Before you begin either of these hacks, beware that, if you don't know exactly what you're doing, you could damage your Robosapien. While these instructions make every effort at holding your hand through the process, one errant soldering mistake could render your robot a gigantic paperweight.

Photography by Dave Prochnow

modifications, construction projects, and hacks that can be performed on this remarkable robot. Regrettably, there were two hacks I couldn't thoroughly discuss in this book. Here they are.

What's the Frequency, Robosapien?

By far, the easier of these two Robosapien hacks is the replacement of the main processor crystal. Labeled "Y1" on the Robosapien main circuit board, this crystal is actually a monolithic capacitor. As such, it doesn't require a big leap of imagination to think that switching this capacitor crystal's value could result in a different Robosapien "personality."

And that's exactly what will happen: the frequency of the robot's operation can be slowed down or sped up by almost 50% just by using different-sized capacitors. Plus, the Robosapien IR remote control will still work. This hack allows you to vary the speed of motor actions for either fast and lightweight or slow and powerful designs.

Open, Sesame

The first step (and one of the hardest in this hack) is to get inside Robosapien to the main circuit board. All you will need for this portion of the hack is a No. 0 Phillips screwdriver.

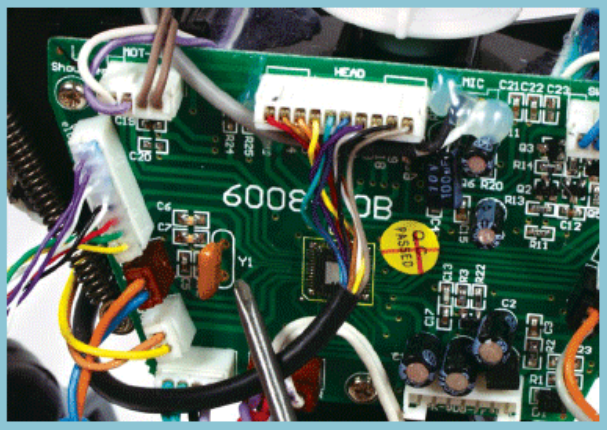
Before you begin any hacking surgery, make sure you remove the four D-cell batteries from the Robosapien's feet. With your patient now suitably anesthetized, there are four screws that hold the back plate to the Robosapien body — one in each shoulder and two in the waist.

Once you remove these screws, the back plate will lift off. Be careful, however; the power switch wiring harness (this also holds the speaker wiring) is attached to the main circuit board. Just pull the main circuit board plug for the power switch harness, and the back plate can be removed. Set both the front and back plates aside.

Gain Some Capacitance

The main circuit board is located on the back of the Robosapien. Take a moment to study all of the lovingly applied labeling that WowWee Ltd. added to the main circuit board — all of this done to help you, the hacker.

Locate the crystal capacitor. It is to the left of the IC U3 and labeled "Y1." Although this crystal looks like a capacitor, it is actually a ceramic resonator. Take a pair of diagonal cutters, snip the Y1 capacitor off, and remove it from the circuit board. You will now solder either a new ceramic resonator or a capacitor in its place. I began with a .22µF monolithic capacitor. Alternatively, you can add an inexpensive ceramic resonator (digikey.com). Your beginning frequency for the resonator would be around 4MHz. Just solder this replacement capacitor or resonator crystal to the decapitated leads from the old crystal.



The Robosapien main circuit board is located on the robot's back. The crystal capacitor is labeled Y1.

Plug-n-Go

If you really want to experiment with a wide variety of capacitor crystals, you might wish to solder two header pins to the Y1 crystal passthrough pads. Then you can just temporarily attach your capacitors or resonators to these header pins, until you find the perfect hack.

Typically, resonators with higher frequencies (6MHz to 12MHz, for example) will result in a "faster" Robosapien. (NOTE: The IR remote control might not function properly at frequencies higher than 6MHz.) Lower frequency resonators (2MHz to 3.58MHz) will make the robot behave more slowly.

This same principle holds true for the replacement capacitors, as well. For example, try a 2.2µF capacitor to increase the speed of Robosapien. Just remember to hold onto the original Y1 crystal, so that you can return your robot to its factory state of mind.

The Soccersapien

How about hacking Robosapien into a powerful, fast-moving, soccer-playing robot? Yes, it can be done and it's easier than you think. Be forewarned, however, that this is a much more elaborate hack. If the complexity of the previous hack left your head reeling, then you might want to hold off on this one until you get some more circuit-building experience.

This hack will make it possible to triple the walking speed of Robosapien by using NiCad rechargeable batteries, two H-bridge post buffers, and two Radio-Control (RC) grade, high-torque, high-RPM motors in the hip gearboxes. One of the most common places to find these motors is inside an RC car. With motors in hand, you will need to build two H-bridge circuits and attach these directly to the motors.

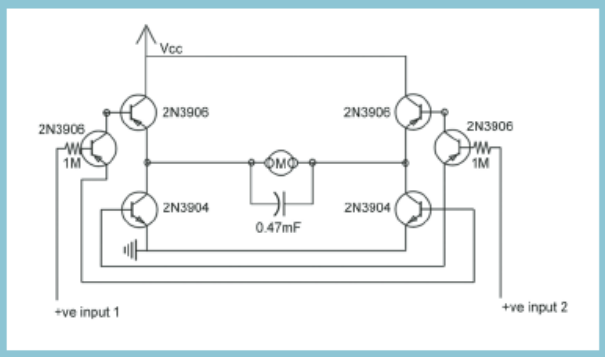
In order to gain access to those hip gearbox motors inside Robosapien, you will have to remove the front and back plates as described earlier, as well as dropping the robot's trousers. Removing these "trousers" can be a tricky proposition because two screws are hidden under black plastic plugs on the backside bottom plate.

After disassembling countless Robosapiens, I have seen these plugs both slipped in and glued in place. While the slipped-in plugs can be easily pulled out with a small knife blade, the glued-in plugs must be drilled out. I use a hand drill equipped with a small bit. Don't opt for a power drill for this step — too much speed will melt the plastic. Just a simple hand twist or two and you'll have an easy-access hole through each plug. Now increase the diameter of your drill bit to accommodate the size of your screwdriver shaft, and slowly ream out the hole to its final dimension.

If you happen to scratch or mar the black plastic, don't fret. This plastic is actually painted black and can be quickly re-covered with some gentle sanding and a little dab of black gloss paint.

I've included a sample H-bridge schematic diagram to help you build this circuit. Wiring each H-bridge to the Robosapien main circuit board is deceptively easy. Each drive input for the H-bridge circuit is connected to the motor lines that are currently in Robosapien (i.e., "LEG-L" and "LEG-R"). Therefore, just snip the leads from the two motors in each Robosapien hip gearbox. Remove the old motors and insert your new high-torque motors.

Just make sure that these motors have a static resistance greater than 4 ohms, are approximately ¾-⅞ inch in diameter, no greater than 2 inches in length, and have a pinion gear attached to the shaft (e.g., ideally any Mabuchi FA-130 series motor). Alternatively, you can use the existing motors and couple the H-bridge circuits to them, but the performance improvement isn't nearly as dramatic as with the higher-torque motors.



Schematic diagram of an H-bridge circuit. (Schematic redrawn from original design by Mark W. Tilden ©1997)

Greasy Bot Stuff

Now that your new motors are ready to go, you must find some power to drive the H-bridge circuits. Both Vcc and ground can be found on the two outside connectors located along the lower edge of the Robosapien main circuit board ("L-SW-GND-C" and "SPK-VDD-Fr-VCC"). Just remember that a big bypass capacitor (e.g., 330µF 16V electrolytic capacitor) must be attached to Vcc to avoid frying the Robosapien brain.

Now Fire 'em Up

It's off to the races. Before you send Robosapien forth fleet footed, make sure you test this new high-speed "mover" on a slick surface. Alternatively, you can coat the footpads on the bottom of each battery compartment with something slippery. Insert your NiCad batteries and get ready to be impressed — all over again. The second "running" forward mode will now give the robot more than enough speed for robot soccer applications.

Dave Prochnow is author of *The Official Robosapien Hacker's Guide* (TAB Electronics, 2005). You can learn more about this book and other projects at pco2go.com.

1+2+3 Sneaky Uses for Everyday Things

By Cy Tymony

Turn a cup into a speaker and a microphone. People seldom think about the common devices they use everyday and even less about adapting them for other purposes. Anyone can learn real-life MacGyverisms using everyday items — you just have to be a little sneaky.

Turn a Cup into a Speaker: A typical speaker consists of a coil of wire attached to a paper cone with a magnet mounted close by. When an audio signal travels through the wire, it creates a magnetic field. Since magnets attract and repel each other, the speaker's magnet causes the coil to push and pull the paper cone. This rapid motion vibrates the air to create sound.

This project illustrates how to use an ordinary paper or styrofoam cup, wire, and a magnet to create a Sneaky Speaker.

You will need: Cup, magnet, thin insulated wire, tape, ⅛-inch plug cable, radio or music player (with earphone jack)

Make It: You can use any thin wire available (e.g., from an old telephone cord) and a ⅛-inch plug cable from an old headphone cable. Use a strong magnet for this project (not the weak, ceramic type used for refrigerator magnets). A rare earth magnet, if available, works nicely.

First, wrap ten or more turns of thin wire around a thick pen and use tape to keep it into a coil shape. Mount the coil on the back of the cup and affix it with tape.

Next, connect the coil wires to the ⅛-inch plug cable. Insert the plug into the radio's earphone jack, and turn the volume to maximum.

Hold the magnet near the end of the coil. You should be able to hear sounds emanating from the cup. If not, reposition the magnet on the back of the wire coil. Once you've located the area that provides maximum volume, tape the magnet to the back of the cup.

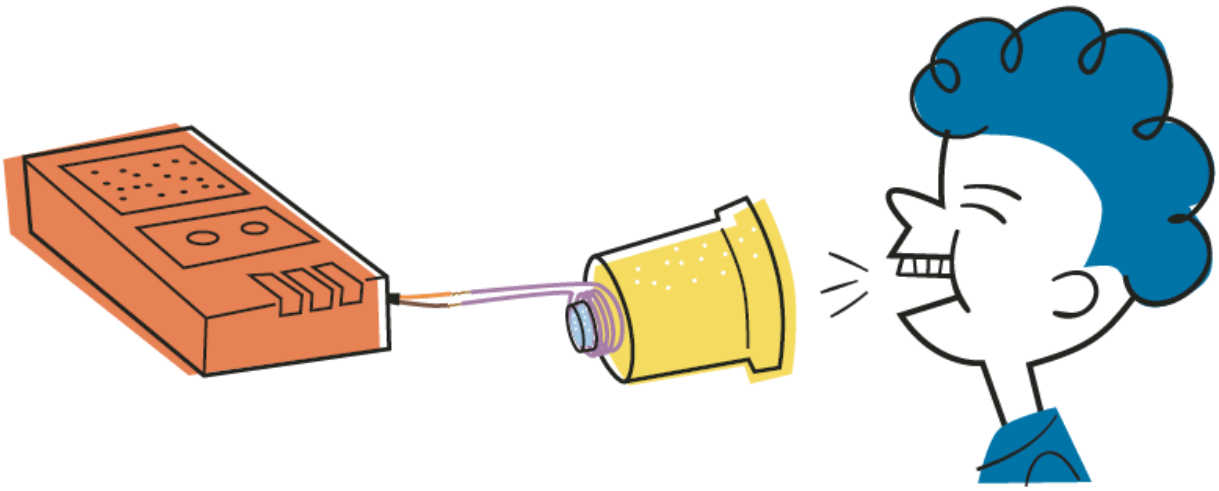
Turn a Cup into a Microphone:

Just as the audio signal in the coil near the magnet can vibrate the cup to produce sound, you can reverse the effect and create a Sneaky Microphone.

This project uses the same parts and setup as the Sneaky Speaker but substitutes a tape recorder for the radio.

Simply insert the ⅛-inch plug cable into the tape recorder's microphone jack. With a blank tape in the recorder, press the RECORD button. Speak loudly into the cup to record a message. Rewind and play back the tape, and you'll hear your message recorded with your Sneaky Microphone.

How it works: By speaking loudly into the cup, you vibrate the coil near the magnet. An electrical audio signal is produced in the wire that corresponds to your voice. The signal is detected and amplified by the tape recorder, which records it on tape.



Going Further

Take apart an old speaker and study its design closely. Experiment with longer coil lengths. Test the project with larger magnets to increase the sound level. Place the speaker in the wire coil and see what occurs. Suspend the cup with a clothes hanger frame and adhesive tape. For added volume, set up a speaker array connected in parallel to the ⅛-inch plug cable. Place the wire coil against the back of your ear and bring the magnet near the coil.

Cy Tymony (cy@sneakyuses.com) is the author of four books, including *Sneaky Uses for Everyday Things*. He has been creating useful high- and low-tech inventions all his life. Find out more at *sneakyuses.com*.

Illustrations by Mark Frauenfelder

OWN YOUR OWN

IF YOU CAN'T OPEN IT, YOU DON'T OWN IT

A Maker's Bill of Rights to accessible, extensible, and repairable hardware.

By Mister Jalopy

Recently, the gas gauge on my 2000 Chevrolet pickup started acting perquacky and, as I'm a lazy person by nature, I asked the Chevrolet dealership what it would cost to repair. At a staggering $800, I briefly considered living without a gas gauge. Picturing certain roadside disaster, I buckled down and decided to fix the problem myself.

Hopeful that I would be able to buy just the fuel sender, Chevrolet broke the news that I would have to buy the combined $500+ Delco fuel pump and sender assembly. Now, only the fuel sender unit was faulty. The fuel pump still worked like a champion but I had to buy the whole pump/sender assembly. Mercifully, my local auto parts store sold the same exact unit for $259.

After draining and dropping the gas tank, I removed the old assembly; it's clearly designed to have a removable, replaceable fuel sender unit. It's held in place by two plastic tabs and a single wire connector. And to prove my point, I did remove it. It took longer to get the pliers from the toolbox than it did to disassemble.

Sometimes components fail and you have no idea why, but in this case, the cause of failure was obvious. There are two little spring-metal tangs that glide over the PCB resistor contacts, and one tang had broken off. The metal tangs are fragile, under pressure, and move whenever gas sloshes in the tank, so failure was only a matter of time. After seeing how fine the tangs were, I was surprised that they hadn't broken earlier. A quick Google search proved I was lucky that it had lasted as long as it had — it's a very common problem.

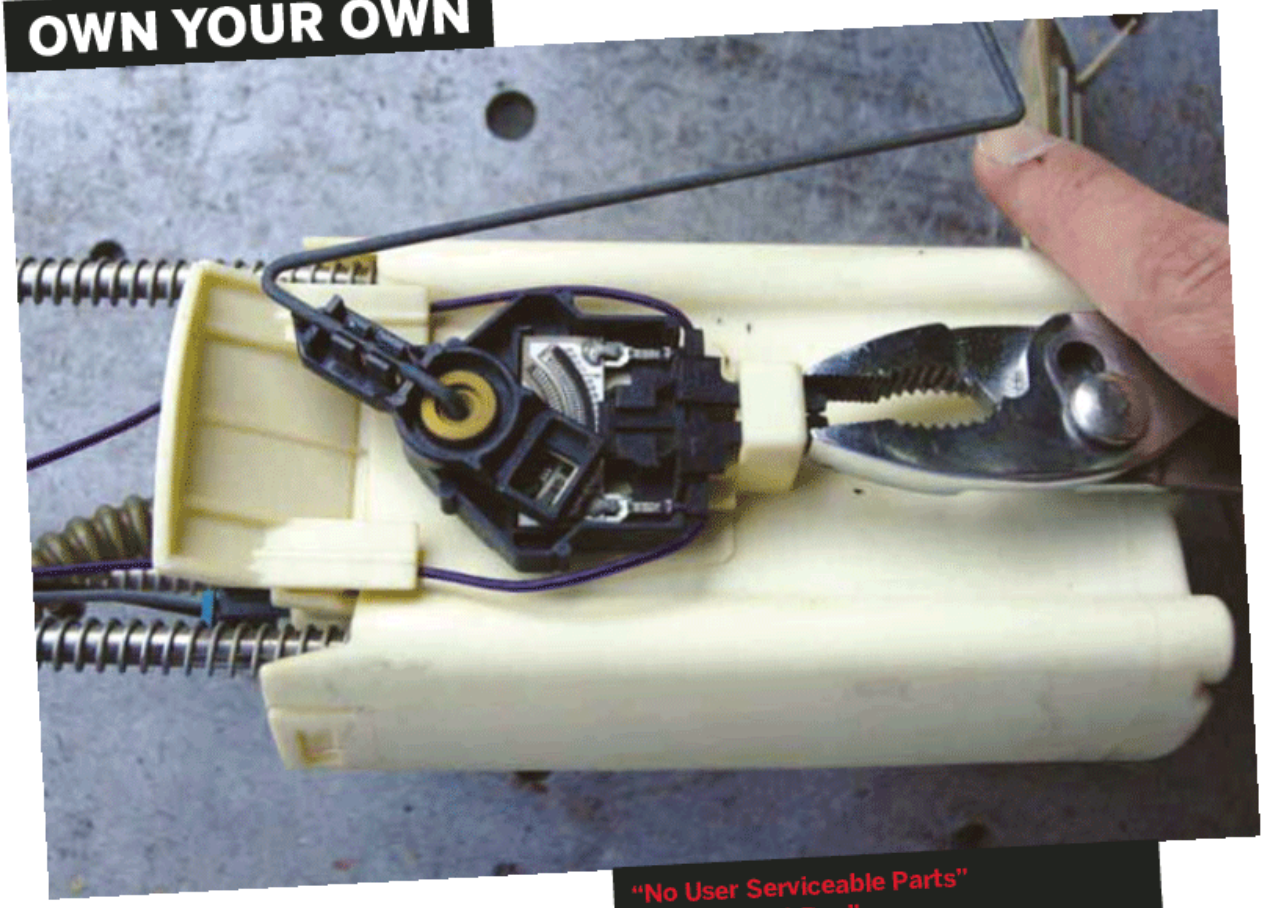
> "When your covered wagon broke a wood spoke, did you throw away the whole wheel? The whole wagon?"

I bet Chevrolet specified to their subcontractor that the fuel sender unit would be removable. Perhaps they were planning to offer it as a separate SKU. Is it a purely financial decision by Chevrolet to not sell the fuel sender independent of the fuel pump? Or how about just selling the tangs for a dollar? When your covered wagon broke a wood spoke, did you throw away the whole wheel? The whole wagon?

In MAKE Volume 03 (*see page 7*), Dale Dougherty wrote an essay on what makes a product maker friendly. And it was an idea that stuck in my head as I was building the retromodern remote-control

Photography by Mister Jalopy

"Buying a piece of equipment that you can't open, repair, or refer to a schematic for means you're setting yourself up to throw it away tomorrow."



"No User Serviceable Parts" means "Don't Buy"

Inside the gas tank of an older car, there's a fuel sender with a float that "sends" a resistance value to the gas gauge to record the tank level. Then, outside the tank, the fuel pump pumps gas from the tank to the engine. Newer cars have combined the fuel pump and sender in a single mechanism (as shown) that is inside the gas tank and can only be replaced as a complete assembly. In 30 seconds, the sender assembly can be removed from the assembly but Chevrolet won't sell you a replacement.

LP-to-MP3 converter cabinet (*see page 54*) and was extremely frustrated that the Mac mini is a sealed box. Apple techs open it with some sort of putty-knife-like special tool. Sometimes, smart engineering and new solutions require new tools. The Model T required special tools, but they were included with the car. It's hard to imagine the case for requiring a special tool to open a Mac mini. For all the props that Apple gets for industrial design, would it kill them to put four screws on the bottom? Would that greatly harm the aesthetics?

In the same way digital rights management (DRM) locks up data, buying a piece of equipment that you can't open, repair, or refer to a schematic for means you're setting yourself up to throw it away tomorrow.

You don't own the iTunes songs you buy. Apple does. Granted, I can't get inside to look at the digital rights software and fully understand what I have agreed to, but I know that it has a limited life. I listen to my grandfather's 78 RPM records and will always be able to play an unlocked CD, but will my grandkids get to listen to my iTunes library?

If you can't open it, you don't own it. You bought the hardware but, like DRM, the manufacturer restricts your use by controlling access, replacement parts, and information. It's yours and usable only as long as the manufacturer chooses to support and repair it.

So, what does all this have to do with Chevrolet and the fuel sender unit? Clearly, components should be available at a granular enough level to be able to make repairs at reasonable prices. Ideally, you would be able to buy the little metal tangs, but I would be satisfied to buy the sender unit. Chevrolet's decision to sell assemblies rather than components is unfortunate but understandable. There is a rationale, as they are in business to make money and selling bigger pieces means more money.

After thinking about this, I've come up with a Maker's Bill of Rights. I expect and hope that other makers will add and make changes to this list. Post your suggestions at makezine.com/04/ownyourown.

Mister Jalopy breaks the unbroken, repairs the irreparable, and explores the mechanical world at hooptyrides.com.

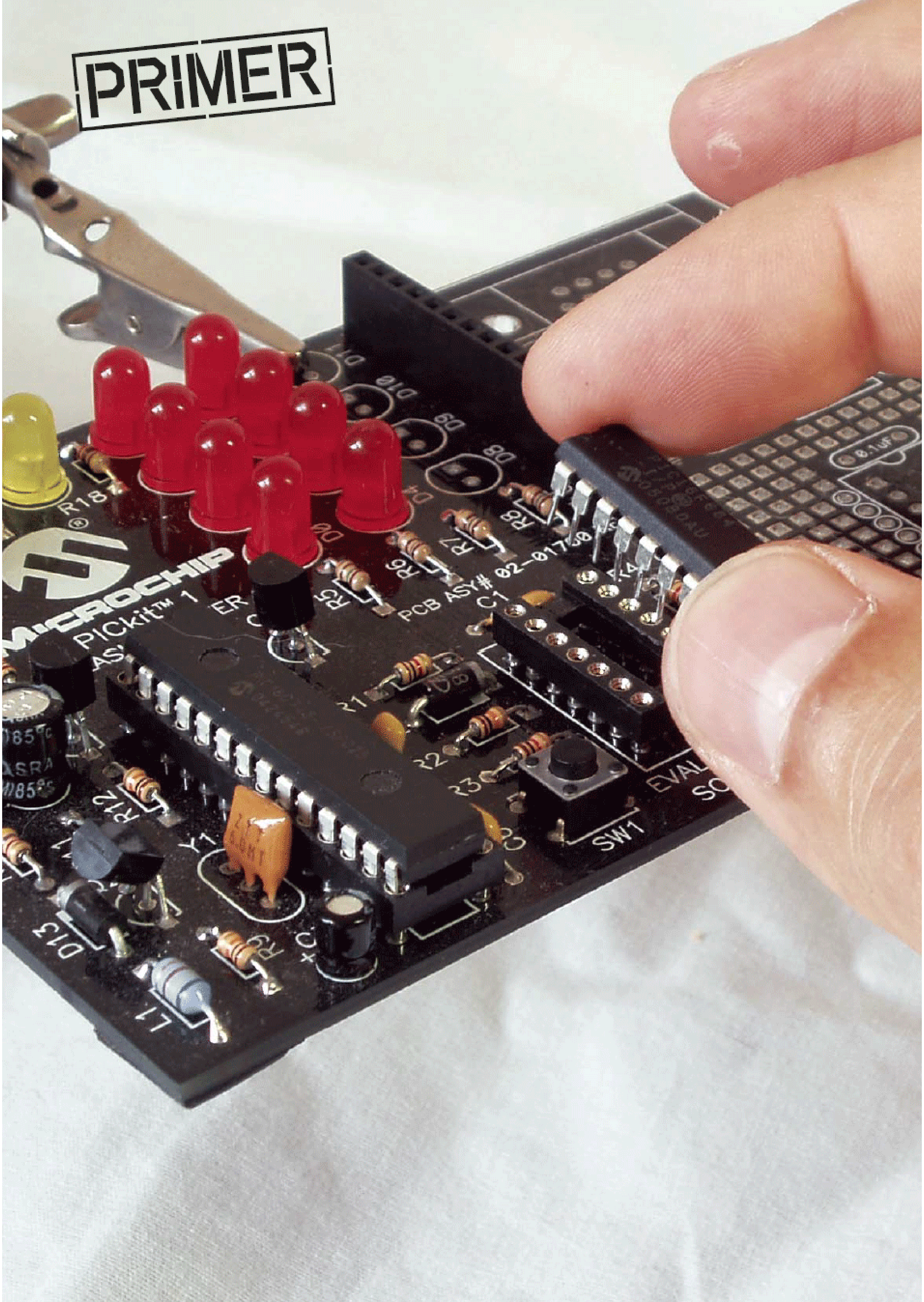
www.makezine.com/04/ownyourown

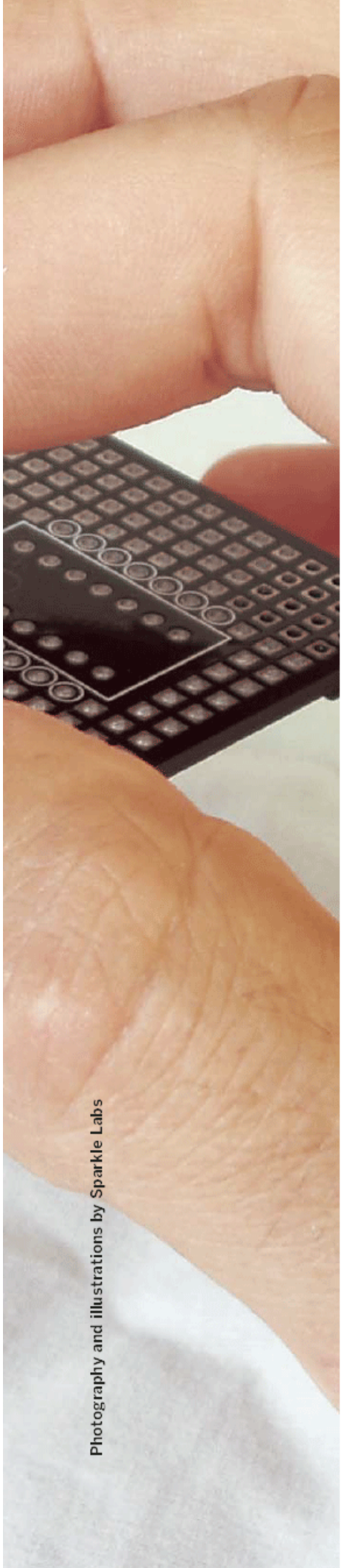
THE MAKER'S BILL OF RIGHTS

■ Meaningful and specific parts lists shall be included. ■ Cases shall be easy to open. ■ Batteries shall be replaceable. ■ Special tools are allowed only for darn good reasons. ■ Profiting by selling expensive special tools is wrong and not making special tools available is even worse. ■ Torx is OK; tamperproof is rarely OK. ■ Components, not entire sub-assemblies, shall be replaceable. ■ Consumables, like fuses and filters, shall be easy to access. ■ Circuit boards shall be commented. ■ Power from USB is good; power from proprietary power adapters is bad. ■ Standard connecters shall have pinouts defined. ■ If it snaps shut, it shall snap open. ■ Screws better than glues. ■ Docs and drivers shall have permalinks and shall reside for all perpetuity at archive.org. ■ Ease of repair shall be a design ideal, not an afterthought. ■ Metric or standard, not both. ■ Schematics shall be included.

Big ups to Phillip Torrone and Simon Hill for their Maker's Bill of Rights ideas.

PRIMER





Photography and illustrations by Sparkle Labs

Microcontroller Programming

By Sparkle Labs

Easy-to-program chips tell circuitry to do what you want.

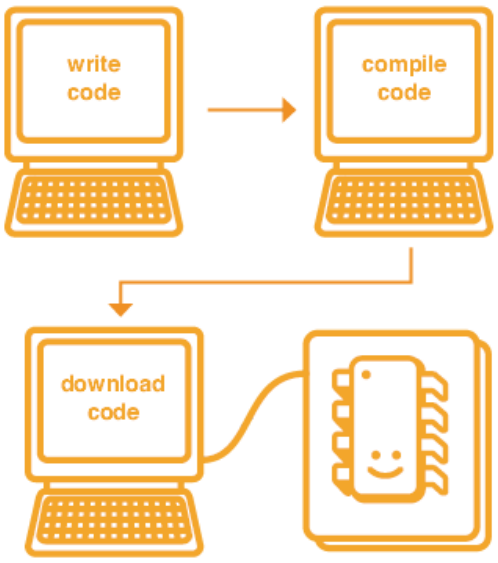
Press a button and a light flashes a pattern. What makes it flash? It seems like there's a tiny monkey in there flipping the switch. If so, many household items contain these tiny monkeys. They're what send the infrared (IR) codes out of our remote controls and then decode them in our televisions. They run our washing machines and toasters. These tiny monkeys are microcontrollers, and you can train them to help you with your own projects.

Microcontrollers are small computers, all on one chip. The chip carries a central processing unit (CPU), program memory, data memory, and input/output (I/O) pins that can connect to various devices. The chip works by the CPU following the instructions in the program memory, which tell it what to read and write to data memory, and what to input and output to the pins.

Programming the microcontroller means writing and storing these instructions in the chip's program memory. The microcontroller speaks assembly language, which consists of binary instructions (ones and zeros). You can program directly in assembly language, but most people prefer to use a higher-level language like C or BASIC because they're easier to understand. When you do it this way, programming a microcontroller is a four-step process.

This article explains the process. In our example, the chip will simply make an LED flash. This may not seem like much, but the hard part is setting up your programming environment and making all the pieces work together. After you get the light blinking, you can take over the world!

PROGRAMMING A MICROCONTROLLER



1. **Write the code.**
2. **Compile the code.**
3. **Download the assembler code onto the chip.**
4. **Build and test your target circuit.**

Low-Level Microcontroller vs. BASIC Stamp Module

First, decide whether you want to use a low-level microcontroller or a BASIC Stamp module. Inexpensive low-level chips (a.k.a. PICs), from Microchip or Atmel, require additional hardware, software, and effort. BASIC Stamp modules, from Parallax and NetMedia, are easier for beginners but pricier.

BASIC Stamps combine their microcontroller with oscillators and other components into one, pluggable package, simplifying circuit design. They also include all development hardware and software.

For our example circuit, we're using the low-level, two-dollar Microchip PIC 12F675.

Low-level microcontroller chip

PROS
- » Really cheap ($1-$6)
- » Wide variety available

CONS
- » Requires hardware programmer ($200)
- » Requires development environment
- » Circuits require more components

BASIC Stamp module

PROS
- » Generally easier
- » No hardware programmer required
- » Development environment included
- » Simpler circuitry

CONS
- » Expensive ($50)

Microcontroller Programming Hardware and Software

To program a low-level chip, you need three pieces of hardware: a PC, a hardware programmer with compatible cable, and the target circuit that you'll plug the micro into. You'll also need some software.

1. PC: The vast majority of software tools for programming microcontrollers run on Windows machines (*but see sidebar, page 162*). You don't need a fast machine; any PC with the proper port for your hardware programmer cable (serial, USB, etc.) will do.

2. Hardware Programmer: This is what you plug your chip into in order to transfer your program from the PC. Traditionally, you then remove the chip and place it in your circuit, but some hardware programmers support in-circuit programming, which lets you burn the chip in place, within the circuit, making it easier to debug and re-run the software.

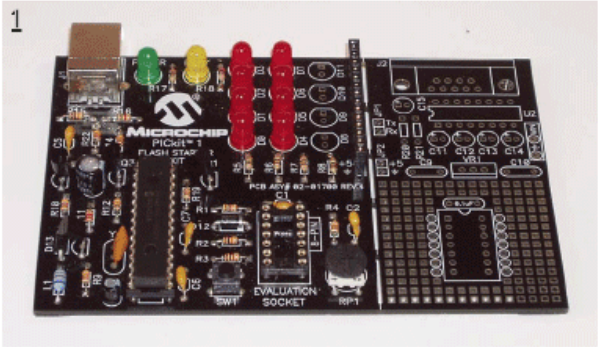
For our example here, we used Microchip's PICkit 1 Flash Starter Kit, a $35 USB programmer that contains a small demo board and can program some but not all of Microchip's 8- and 14-pin micros.

3. Target Circuit: If you're just starting out with microcontroller programming, you can experiment with a demo board, like the one included with the PICkit 1. These are printed circuit boards with a space to plug in your chip and various input and output devices such as buttons, LEDs, and potentiometers. Using one of these boards, you can explore the features of your chip and run different programs without worrying about wiring.

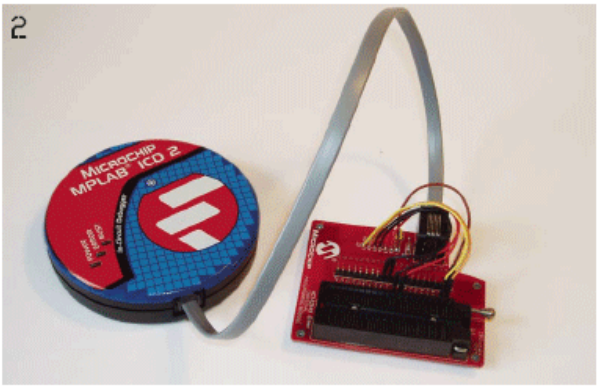
If you have a standalone circuit idea in mind, the next step is to build your own. There are plenty of circuits published online, and you may be able to find one that's close to what you need. But schematics often contain errors, so you need to be careful. If you're up to it, you can also design your own circuit from scratch, as discussed below.

Software: In addition to the hardware, you need to put together your software development environment.

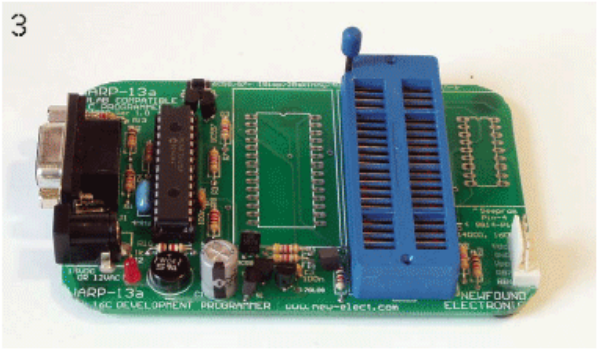
1



2



3



This will include the text editor where you write your code, a compiler, the software that drives your hardware programmer (which probably came included with the hardware), and microprocessor simulation and debugging tools.

You can buy most of this software grouped together into an integrated development environment (IDE) from companies like Microchip and Micro-Engineering Labs. We used Proton Lite, a free trial-version IDE that restricts you to 50 lines of BASIC code — which is plenty for our simple blink program.

Designing a Circuit

First, think of what inputs and outputs your circuit will have: switches, sensors, lights, motors, etc. Then you can determine the power requirements. For simplicity, our circuit uses batteries, but a wall-wart with a voltage regulator is more reliable.

Next, determine how your inputs will interface with the microcontroller. Some pins take only digital inputs, a.k.a. logic inputs, where 5V means 1 and 0V means 0. The general rule for these is that power brings the voltage up and ground draws it down. To make a button that changes an input pin from 0 to 1, for example, connect the pin to ground, through a resistor, and also connect it to a button that, when pressed, completes a connection to power.

Some micro pins take analog as well as digital inputs; you can feed these from analog sensors that produce a range of electrical values. For example, a potentiometer's knob changes its resistance, which changes a voltage fed through it. Connect a pot to a pin that works as an analog-digital (ADC) converter, and the micro will convert the current position of the knob into a number you can program with.

An LED will light up directly from a micro's output pins, but things like motors require more current. You can supply this by connecting an output pin to the base of a transistor that has higher current running through it. Motors may generate voltage spikes that can damage your chip, but a diode running in reverse across the transistor will protect the circuit.

Once you know which sensors connect to which types of pins, you need to study your microcontroller's datasheet. As with most micros, pins on the PIC12F675 perform multiple tasks, and you set registers in your software to tell the pins how to behave. In the registers table from the PIC12F675 datasheet on Microchip's website, we see that the TRISIO register tells a pin to be input or output, and the ANSEL register determines which pins connect to the ADC. These registers have eight bits, one for each pin. So, to connect a simple binary button to a pin, set its corresponding bit in the TRISIO register to 1 (input) and in the ANSEL register to 0 (disconnect). To connect an LED, set the TRISIO to 0 (output). To read a potentiometer value, set the pin's TRISIO to input (1) and set the ANSEL to connect the ADC (0).

WRITING THE CODE

There are many general refererences for programming in BASIC, but here are two handy sample code segments for microcontrollers.

Button on pin GPIO.0 lights an LED on pin GPIO.1:

```
if GPIO.0 = 1 then
  GPIO.1 = 1
else
  GPIO.1 = 0
endif
```

Turn an LED on for 1,000 program cycles:

The main program runs the **startlight** subroutine when a button is pressed, turning the LED on, and calls the **endlight** subroutine inside a loop, to turn it back off.

```
startlight:
GPIO.1 = 1
counterVar = 1000
return

endlight:
counterVar = counterVar -1
if counterVar = 0 then
  GPIO.1 = 0
endif
return
```

Open Source PIC Programming

Contrary to Microchip documentation, PIC development does not require a Windows PC. I use free Unix tools on Mac OS X, plus a USB-to-serial adapter to connect my Mac to my hardware programmer. Here's all the software you'll need.

gputils: Package includes gpasm assembler, which translates compiled source code into the hexified format suitable for burning onto a PIC.

gpsim: PIC simulator steps through code and indicates pin status, for wiring-free debugging.

picp: Utility for PICSTART Plus and Warp-13 hardware programmers, writes hex code to the PIC.

Fink: Unix package manager for Mac OS X lets you install the utilities above, and other software.

X11 for Mac OS X, and Xcode Developer Tools (with X11 SDK): Available from Apple, these let you install Fink.

—Mikey Sklar

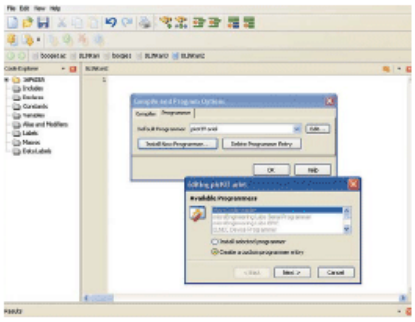
Make an LED Blinky

Here's how we built and programmed our microcontroller-based LED blinky circuit.

START »

1. SET UP YOUR DEVELOPMENT ENVIRONMENT.

Install the IDE and the PICkit 1 software and hardware. Adjust the IDE settings to make sure it knows where to find the programmer and that it's set up for our controller, the Microchip PIC 12F675.



Adjusting IDE settings.

2. ASSEMBLE THE CIRCUIT.

Before getting down to building and coding specifics, take a look at the PIC 12F675's pinouts, from its datasheet on the Microchip website. You can see here how our circuitry's wiring diagram follows the chip's pinouts.

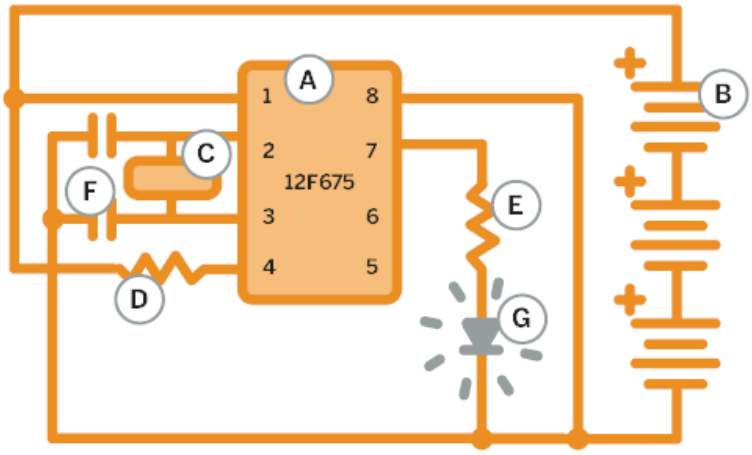
PIC 12F675 Pinout

1. VDD
2. GP5/T1CKI/OSC1/CLKIN
3. GP4/AN3/T1G/OSC2/CLKOUT
4. GP3/MCLR/VPP
5. GP2/AN2/T0CKI/INT/COUT
6. GP1/AN1/CIN-/VREF/ICSPCLK
7. GP0/AN0/CIN+/ICSPDAT
8. VSS

Our circuit includes the microcontroller, a power source, a timing crystal, support components for the microcontroller, and the output LED.

Power comes from three AA cells that provide 4.5V, which is close enough to digital logic's 5V "high" voltage. A 10K-ohm pull-up resistor maintains a high voltage level to the chip's master clear pin, Pin 4; sending low voltage (logical 0) to this pin would make the PIC reset. A 4KHz oscillator supplies the source blink pulse, which is slowed down by two capacitors. Voltage to the LED comes from the microcontroller's output Pin 7, connected to ground in series with a 220-ohm resistor.

Follow the wiring diagram at right. We soldered our circuit together using a small piece of perfboard.



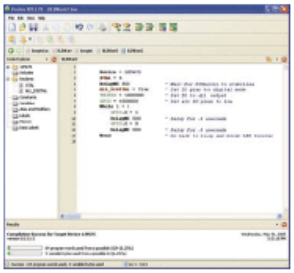
A. PIC 12F675
B. Three AA cells
C. 4KHz crystal oscillator
D. 10KΩ resistor
E. 220Ω resistor
F. 22pF capacitor
G. LED

»

3. WRITE THE BASIC CODE.

We wrote ours in the text editor window of Proton Lite. Here it is in full, with comments included to explain what's going on:

Device = 12F675	Tell the compiler what kind of chip we are using.
DelayMS 500	Wait 500 milliseconds for things to settle down.
XTAL = 4	What speed of crystal or oscillator.
ALL_DIGITAL = True	Turn off all analog-to-digital converters (ADC); some of the chip's pins can be used to detect analog voltage levels, which we don't want to do.
TRISIO = %00000000	Write the byte "%000000000" to the register.
"TRISIO"	TRISIO decides which pins are input and which are output.
GPIO = %00000000	This line sets all of the I/O pins to be output. The GPIO register tells the status of our output pins; all output pins are now set to low (0V).
While 1 = 1	1 is always equal to 1, so this creates a loop forever.
GPIO.0 = 1	Here we make the "0" bit of GPIO equal to 1. GPIO is now %00000001, with Pin 7 high (+5V). This makes Pin 7 output light up the LED.
DelayMS 500	Wait .5 seconds.
GPIO.0 = 0	Set Pin 7 to low again, switching LED off.
DelayMS 500	Wait .5 seconds.
Wend	Go back to the beginning of the While loop.
End	This marks the end of the code.

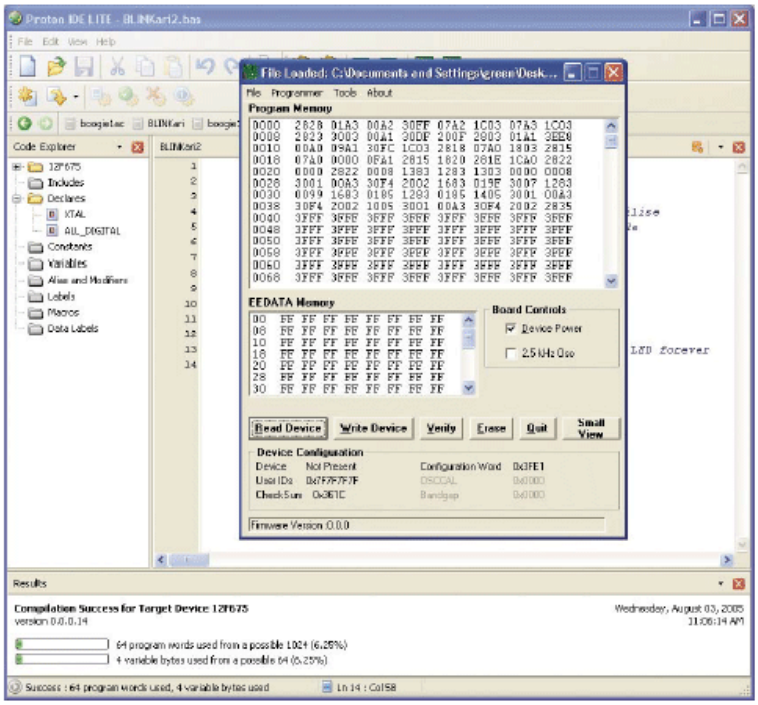


Proton Lite code window.

4. COMPILE THE CODE.

Save your code (which is a plain text file) to your hard drive, and then click Proton Lite's "Compile and Download" button. This creates a hex version of the file and launches the PICkit 1 software.

Within the PICkit 1 software interface, click "Import HEX" to open your newly created hex file, which was written to the same directory as your original code file. This hex file contains the microcontroller assembly code.



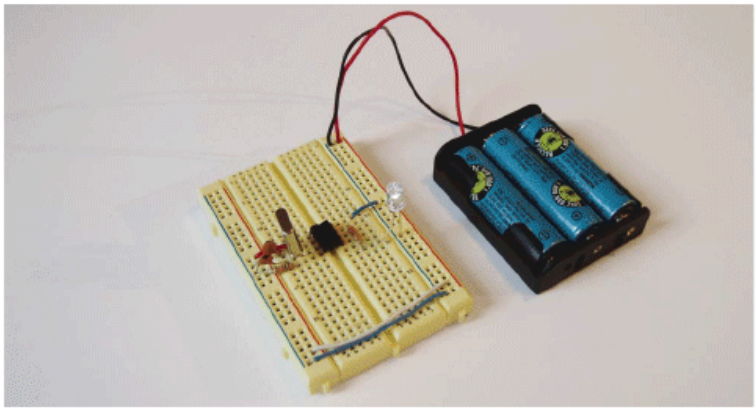
5. BURN THE ASSEMBLER CODE ONTO THE CHIP.

Insert the microcontroller chip into the PICkit hardware programmer and click "Write Device." It's that simple; your microcontroller is now programmed!

6. BUILD AND TEST YOUR TARGET CIRCUIT.

One common method is to prototype it on a breadboard. This is what we did for our example.

Plug it into your target circuit, connect up the power, and bask in the blinking glory!

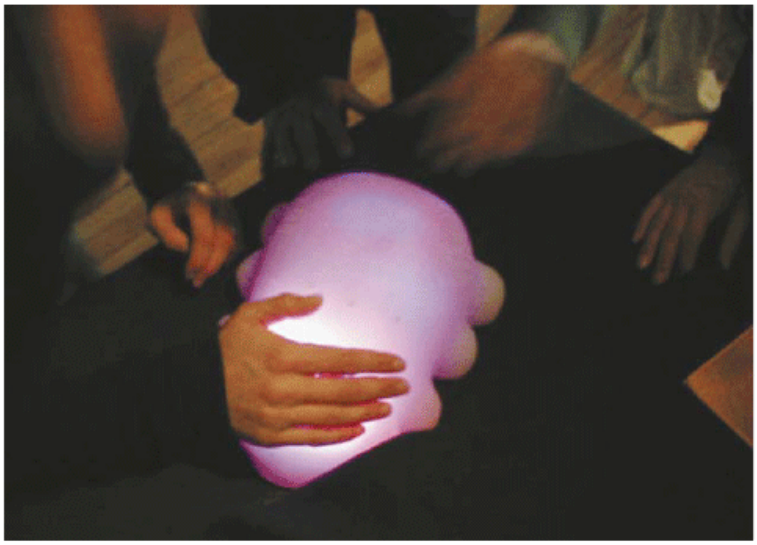


NEXT STEPS

Now you can experiment with other input and output devices. Resistive sensors are fun; these change their resistance in response to things like light, flex, and temperature. You can also use gravity sensors, compasses, accelerometers, and rangefinders.

For outputs, buzzers and small speakers make sounds, and motors give your project legs or wheels. LCD panels show information, and LED matrices make colorful displays.

Mount a rangefinder on a servomotor, and your micro can point it around and read its physical surroundings. Have your micro output serial data to a PC, and you can make a sensor control a game character. We've created a lot of fun projects with our little micro monkeys, and we invite you to do the same.



The Platypus Amoeba has touch sensors on its back, and responds to petting with lights and sounds.

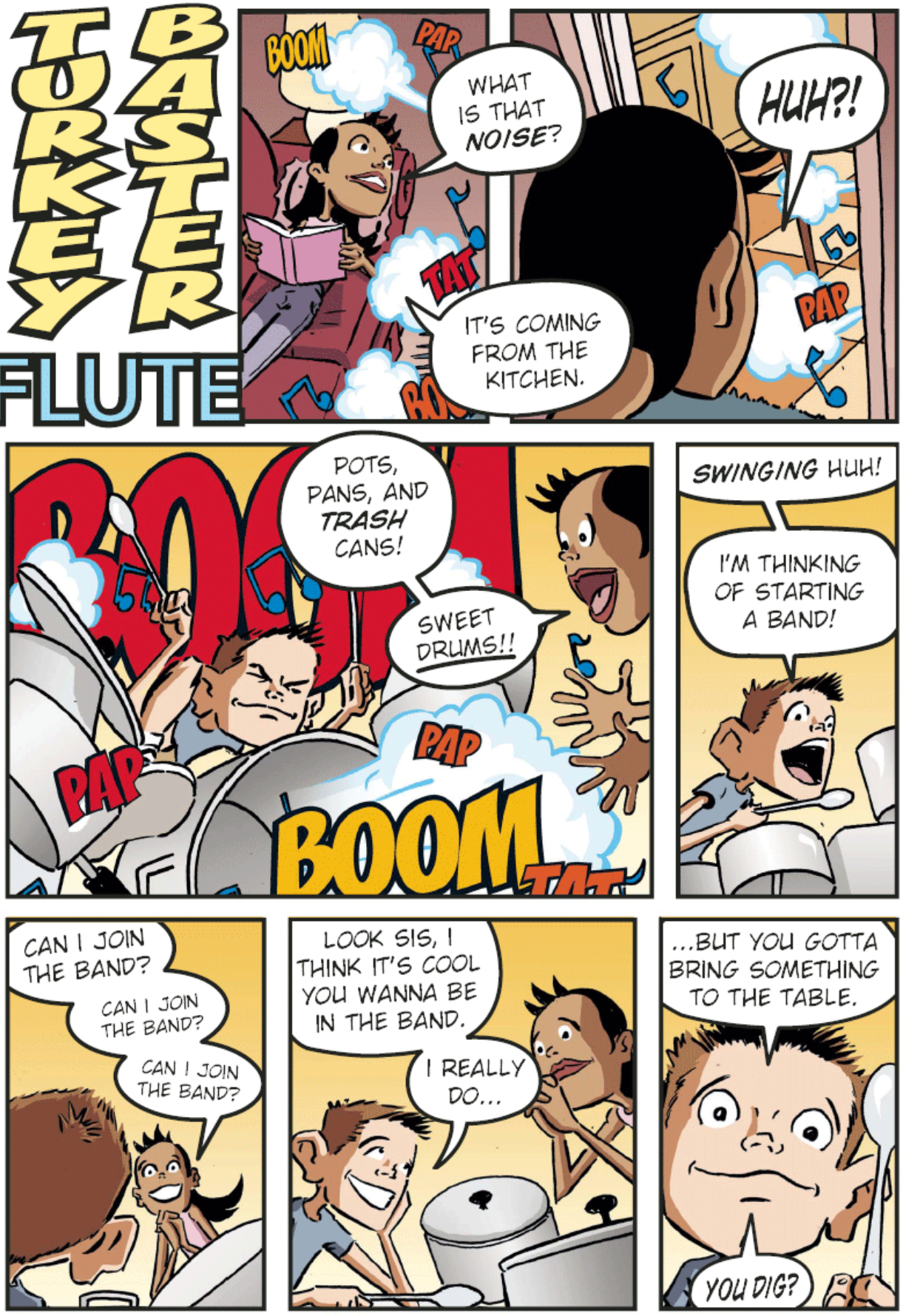
FINISH

Sparkle Labs (sparklelabs.com) is a product development firm in NYC. They build "hi-tech, hi-touch" environments and products, using new technologies to create soft and playful interactions.

HowToons.com

BY SAUL GRIFFITH, NICK DRAGOTTA & JOOST BONSEN '05

TURKEY BASTER FLUTE



The best tools, software, gadgets, books, magazines, and websites.

TOOLBOX

Rock God PC

Fretlight Guitar

$600, optekmusic.com

Wouldn't it be great if you could pick up a guitar, plug it in to your computer, and have it teach you to become a rock god? That's the premise behind the Fretlight guitar.

The guitar itself is pretty sweet. It sports a Fender Stratocaster body style, with a unique fretboard that hides the true nature of this piece of technology. Underneath the fretboard lie 126 LEDs, and until you plug it into your computer, you'll never even know they're there, which means that you can not only use this guitar at home to perfect your playing but can take it on the road as well, with no one the wiser.

The Fretlight plugs directly into your computer via USB, the other end into a special 8-pin DIN jack in the body. (It also has the standard amp jack.) Its software shows you the basics of scales, chord location, and all the stuff I slept through in high school music class. Picking a chord on the computer sends a signal back to the guitar that light up the fretboard corresponding to finger placement.

Optional software is available (for more moolah) to teach music theory and download tablature files from the internet.

With a price equaling 20 or so guitar lessons, you not only get to skip out on the smug guitar teacher in the faded Styx T-shirt, but get a quality guitar as well. And while it helps if you know your way around the guitar, with a little patience you too will be jamming in no time. For a full tour, check it out online. It rocks!

—Rob Bullington

Chemical Camera

35mm Voigtländer Bessa R
$560, photovillage.com

Lately everyone from Pulitzer Prize winners to grandmas is switching to digital. But my favorite new camera is this 35mm Voigtländer Bessa R, an all-manual throwback to the workhorse Leicas of 50s and 60s photojournalists.

Japan's Cosina Company has created a complete new rangefinder-focusing camera system. They offer crisp lenses, brilliant viewfinders, and retro-chic good looks — in short, 90% of the oomph of the legendary Leica M series, but at about one-fifth the price. Cosina even revived the venerable Voigtländer brand name, many years after its last German incarnation went kaput.

> Voigtländer Bessa R: 90% of the oomph of the legendary Leica M series, but at about one-fifth the price.

But aren't serious photographers all buying digital SLRs? Well, interchangeable lenses for rangefinders can be much simpler and smaller, for unobtrusive stealth. And the crop factor of most DSLR sensors means they have trouble matching Voigtländer's outstanding selection of wide-angle optics. To equal the 91° coverage of the tiny Color-Skopar 21mm shown here, a typical DSLR would need a 14mm lens — quite an exotic and bulky monster, if you can even find one. And other Voigtländer lenses go even wider!

The Bessa R was Cosina's original rangefinder model. The new Bessa R2A and R3A add auto-exposure, and replace the R's plastic plates with stout metal castings. But the R is a cult classic, and a couple hundred dollars cheaper; and its mechanical shutter keeps shooting even if your batteries die. Officially discontinued, it's still in stock at CameraQuest, Photo Village, and B&H Photo Video.

—Ross Orr

All Juiced Up

NewerTech iPod Replacement Batteries
$20-$35, newertech.com

After several years of heavy-duty use, the batteries on my old iPods were losing steam. I ordered replacement battery kits from NewerTech, which claims its batteries last longer than fresh-out-of-the-box iPods.

The kits arrived with instructions and a tool to crack open the case. I still marred the case while prying it open. (If this had happened on a pristine iPod, I'd have been hopping mad.) It was a trivial matter to swap out the old battery and replace it with a new one. The new batteries last a couple of hours longer than Apple's batteries.

—Mark Frauenfelder

Knit Wits

Knitting For Dummies
$21.99, ISBN: 076455395X

I hate television, but if my wife, Jacqui, and kids were going to watch it, I wanted to put the passive consumption of media to good use — by getting them knitting. And with *Knitting For Dummies*, a set of needles, and some yarn, Jacqui and my daughter, Ariane, were off to the races.

Sure, they both made some mistakes on their first pieces. There was a gaping hole knit in error where that kitty face resides, but Jacqui turned adversity into opportunity with style. By using a pair of scissors, some felt, and thick thread, voilà, she created a scarf with a kitty face. Such stylin' costs $100 or so in shops on Haight Street here in San Francisco.

Creating this scarf took probably 10 hours of television watching — not counting the learning curve. So now our TV is earning us $10 an hour. And hey, we've got unique fashions on our heads and around our warm necks.

—Jeffrey Goldsmith

Ultravision

INOVA X5 Ultraviolet Flashlight
$60, inovalight.com/site.html?X5-ov

Got a *CSI* fantasy? Then just drop one of these in your bag of tricks and start shining it around in spare moments. Featuring five high-power LEDs backed by two 123-sized lithium batteries, the X5 puts out a surprisingly strong UV flood, capable of fluorescing most common hidden inks, watermarks, and other hidden aspects of your daily crime scenes. Bored at lunch? Dump out everybody's wallets and check out the hidden markings on currency or your video club card. Need a good scare? Turn off the lights in your bathroom or kitchen and start looking around with the X5. I'm still reeling.

—Bob Scott

website

In Control

arcadecontrols.com

When I decided to build my "Taxicab" jukebox/MAME machine (*see MAKE, Volume 02, page 21*), I found that all internet roads pointed to one definitive how-to source: the "Build Your Own Arcade Controls" website.

The site was started back in 1997 by John St. Clair as a way to collect information for interfacing actual arcade controls with PC emulators. Today the site has over 50,000 visitors a month and is a must-visit for anyone looking to build a home arcade or jukebox machine.

BYOAC has an extensive step-by-step "newbie guide" on building these incredibly fun machines, plus as much detail as you'd ever want to know. Its real power, however, is in the community it has created, primarily through its message boards. That's where I learned the most, and if I can build one, anyone can.

The only thing the site asks in return for connecting you with this helpful community is that you share your project. Hey, someone could learn from you! That way, the gift keeps on giving.

If you would rather work from a book, St. Clair has also written *Project Arcade: Build Your Own Arcade Machine*, which has received great reviews.

—Patrick Webb

Key to Happiness

Utili-Key 6-in-1
$13, swisstechtools.com

A well-crafted tool in an elegant package is one of the true great joys in life. This little key-shaped piece of metal is usually my first and, frequently, last tool I need for minor cutting or screwdriving jobs. It also doesn't hurt that its design feels a bit like "Q" made it for James Bond. It is officially on the FBI's "no-fly" list but that hasn't stopped my SwissTech Utili-Key from coming along with me through many airports, smuggled in plain sight between my house and office keys on my keychain. I've used the Utili-Key for everything from opening up my new iPod, to extracting a dollar from a clogged vending machine (helping to defray the $13 cost in the process), to lending it to MAKE columnist Cory Doctorow to adjust his glasses at a conference.

—Marc H. Nathan

Two Tiny Tools

Versadriver:
$10, countycomm.com/versadriver.htm

Palm Pal:
$12, coolstuffcheap.com/palm-pal-hand-wrench-pocket-tool.html

I finally found a pocket-sized driver set that isn't afraid of major appliances. The Versadriver's carabiner-shaped handle folds flat, and the strategically placed detents let you change your grip, trading speed for torque when necessary. The perfect complement is the equally handy Palm Pal Hand Wrench, which fits right in the Versadriver's tiny pouch.

—Bob Scott

Badass Office Blade

Al Mar SLB Knife
$70, agrussell.com/knives/

If your inner geek is trapped in a suit at work, you've probably longed for a good, compact knife. Trendy tactical folders are generally too big, too heavy, or just plain too scary looking for parceling out Gouda in the CEO's office. Wobbly penknives, on the other hand, are a ticket to the ER when facing anything more challenging than staple removal. Enter the Al Mar SLB. Featuring a stout-but-stubby 1⅞-inch locking blade and an attractive, lightweight black Micarta handle, the SLB is easy to carry, particularly if you ditch the pocket clip. The AUS-8 alloy steel takes and holds an edge after multiple FedEx box openings, too.

—Bob Scott

The Palm Pal Wrench lets you tackle bolts from ⅜ inch down to 8mm — just flip over to change from SAE to metric. The Versadriver (at left) works with a variety of custom bits.

SHARE YOUR STUFF

USB Devices for Two (or More)

Keyspan USB Server
$130, keyspan.com/products/usb/server/

I'm in a mixed marriage — my wife has a PC and I have a Mac. We don't have a lot of desk space, so we use a Keyspan USB Server to share USB devices. This tiny, silent device plugs into our network with an RJ45 connector at 100 megabits per second and accepts up to four USB devices. It works flawlessly with an Epson flatbed scanner, a card reader, jump drives, and a USB-powered Zip drive. We could also use it for printers and larger disk drives, but because the USB Server only lets one computer use a peripheral at a time — and at the slower USB 1.1 standard — we stick with a dedicated print server and a network storage device for those circumstances. Still, the USB Server keeps us from buying two of everything and saves us the hassle of unplugging and plugging when we want to move a device from one machine to another.

—Fred Sandsmark

Measuring just 5"x3"x 1", the Keyspan USB Server lets more than one computer share different USB devices.

+ Straight Shooter

Porter Cable 6 Gal. Compressor Combo with Finish & Brad Nailers & Crown Stapler
$329, homedepot.com (catalog #100349449)

Whenever I told anyone that I was planning to install a chair rail in my dining area, the most common response was, "You do have a nail gun, right?" I complained that nail guns were too expensive and that I was going to do it with a good old-fashioned nail set. The following Saturday morning, I wasted half of the day with my $6 nail set — bending nails, dropping expletives, and gouging up the expensive trim I was trying to mount on the wall.

For my next home project, I went to Home Depot and took the plunge for a nail gun combo set from Porter Cable. It almost paid for itself on that first job, and every job since then, I've thanked myself for buying it. For less than what I thought a single top-of-the-line nailer would have cost, I got a pancake compressor with a 25-foot hose, a crown stapler, a brad nailer, and a finishing nailer.

Each nailer came in an individual hard plastic case for easy storage and with a full box of ammo. Unless you're framing a wall, you're pretty much covered with this setup.

—Matthew Russell

If you have more than a chair rail on your list of projects, get yourself a Porter Cable combo set. On second thought, get one anyway — your friends will love you for it.

Get a Grip

Safety-Walk Tape
$1/foot, hardware stores

Hardware stores and home centers sell some wonderful stuff made by 3M called Safety-Walk. This self-adhesive roll of gray, nubby rubber comes in 1-inch and 3-inch widths. It's intended to add skid protection to stair steps, but I always have some of it on hand because it's terrific for making personal electronics easier to handle.

I've got a strip on the slick silvery back of my iPod. It prevents the thing from sliding off the passenger seat of my car when I apply the brakes. I've got it on the back of my Sony 616 phone; now, it doesn't escape from my fingers when I dig through my pocket to answer it, it doesn't fly out of my hands as I'm fumbling for a pen, and it won't slip out of my pants pocket when I sit down.

It's only about a buck a foot, too. Have this stuff in the house somewhere and it'll get used.

—Andy Ihnatko

Fry that Fly

Charcoal Companion Amazing Bug Zapper
$10, check Froogle.com for an even lower price

I like it when flies come into my house. The drone of a dumb horsefly bumping against lampshades is my signal to run to the broom closet and pull out the Bug Zapper, a red and yellow $10 flying insect killer that looks like a toy tennis racket.

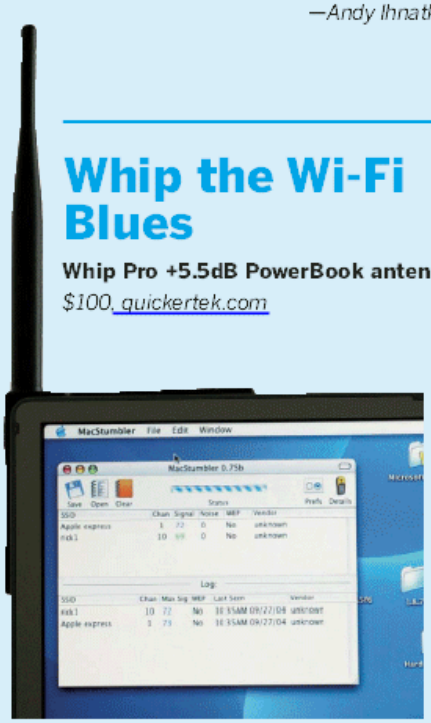
By simultaneously pressing two buttons on the handle, the rows of wires strung across the head become electrified, and a red LED in the handle illuminates to confirm that the Zapper is ready to kill.

My hunting method is primitive but effective: I swing wildly in the general direction of the tiny winged vermin. The heavy, stupid flies are almost too easy to zap; I prefer the smaller, quieter flies that tease me by alighting on an armchair or counter, only to flit away in the nick of time. But no matter what kind of fly I'm after, the end game never changes — the wires touch the fly, there's a tiny spark and a crackle, and the fly drops to the ground, inert. *Haematopota pluvialis*: prepare to meet thy doom.

—Mark Frauenfelder

Whip the Wi-Fi Blues

Whip Pro +5.5dB PowerBook antenna
$100, quickertek.com



Frustrated by the Wi-Fi reception problems on your large-screen PowerBook? Use QuickerTek's high gain Whip Pro antenna. My 15-inch aluminum PowerBook was showing two wireless networks near my office; my new Whip Pro shows eight. I don't know where they might be or to whom they belong, but I see them and most of them show signal strength of over 20 using MacStumbler. In other words, it sees more networks and sees them with better reception. I found that one network was even on the same channel as my AirPort base station and changing that proved to be very helpful with reception on my own network. Interesting to see just how many people surrounding my own office never checked competitive networks on their frequency.

On the down side, installation is not for the timid, though it is not quite as tough as one might think. In fact, this model was designed to make the form meet the function, and the aesthetics actually make installation easier in terms of mounting and assembly.

—Daniel East

Micro GPS Shoot Out

I don't ask for directions. There, I said it. And my girlfriend has a better sense of direction than I do. There, I said that too. I need GPS. That's where these babies come in — each represents a different approach to an always-on-you GPS solution. *—Bob Scott*

Suunto X9

$700, suunto.com

A technological tour-de-force (and priced accordingly), this huge but comfy GPS watch also includes the usual Suunto complement of outdoor gizmos: barometer/altimeter, compass, and thermometer. Well-integrated GPS receiver can automatically set and correct the time, set compass declination, and reduce altitude/barometer ambiguities. A necessarily terse user interface demands practice before you head out. Power and antenna constraints translate to a relatively long GPS acquisition time, but that's a good excuse for a quick drink on the trail. A serial interface cradle lets you type in waypoints and routes on a PC, but doesn't support data import from other programs.

DeLorme Blue Logger

$180, delorme.com/bluelogger

Not much bigger than a fun-size candy bar, this receiver doesn't have a display, so you'll need a Bluetooth-ready laptop or PDA with mapping software to make a complete navigation setup. But the eight-hour rechargeable battery and wireless connection lets you throw it on the dash without dangling wires. Uniquely, it can also operate as a standalone track logger, automatically storing thousands of position and speed data points for later wireless download. Use it to track the roving of everything from balloons to your cat. Supports the NMEA data exchange standard for easy interfacing.

Garmin Geko 201

$150, garmin.com/products/geko201

Simple, tiny, and runs 12 hours on two AAA batteries. No maps, but it supports upload/download of waypoints and routes with an optional serial cable. Supports NMEA and the faster Garmin interface standards. Cheap, fast, and reliable. Loaded with lithium batteries, it's my choice for the gadget bag.

+ Billboard Bags

Relan Bags Made from Billboard Material
$55-$90, relanbag.com

Joni Johnson, an entrepreneurial artist, figured out billboards were made out of a really durable material, designed to withstand eight years in the great outdoors. When working for eco-conscious Aveda, Johnson began using the vinyl-laminated nylon fabric of Aveda's own signs to create cosmetic bags. Today Relan continues to make items for other companies out of their own billboards and banners.

The line includes messenger bags, shaving kits, yoga mat totes, and wine bags. The material is both water- and tear-resistant, it looks cool, and the trim on many of the bags is made from recycled tire rubber.

—Shawn Connally

+ Light Touch

FingerWorks TouchStream LP
$320, fingerworks.com

Note: FingerWorks has ceased operations, but you can still buy the keyboard from online retailers and eBay.

Three weeks of 12-hour days in front of my laptop, and the mere amount of force it took to press a key was causing pain in my wrist. Keyboards are cheaper than wrists, so I bought a FingerWorks TouchStream LP, which has a perfectly smooth surface like a trackpad, but with a keyboard overlay. The lightest touch will activate a key. The TouchStream is far more than just a pad for typing, however. Place together two fingers on the right-hand surface and it becomes a trackpad. Two fingers on the left-hand surface mimic the arrow keys. Add a third finger for shift-arrow, to quickly highlight text. The TouchStream supports a dizzying array of gestures. Special modes exist for everything from Emacs to Photoshop.

—Tom Owad

A Bag for All Gadgets

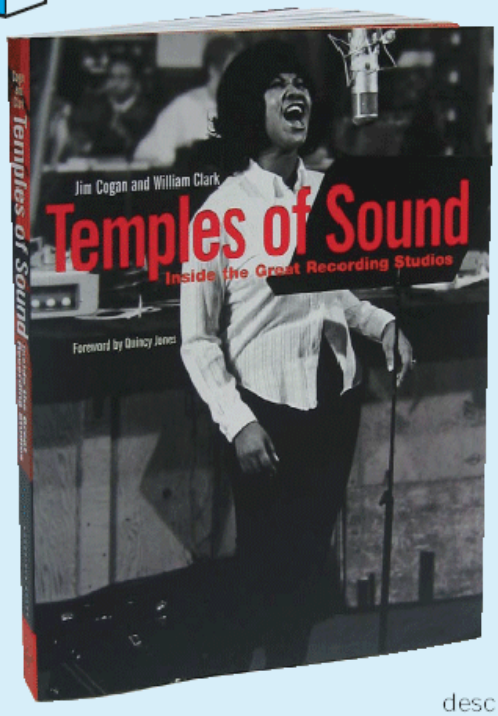
CountyComm Bail Out Bag
$40, countycomm.com/BAILOUTBAGGEN5.htm

I'm a guy that thinks he might actually need a voltmeter at lunch. Backpacks are the old standby, but they tend to get disorganized and are storage overkill for my daily use. The Bail Out Bag's scads of ammo pockets, dividers, and compartments handily corral the less exotic civilian gadgets. Wrap-around handles and all-black nylon construction (or olive drab) provide no-fail support and hacker chic at the same time.

—Bob Scott

Bail Out Bag is a cheap, tidy solution that's a lot less clunky than a backpack on mass transit.

MAKE LOOKS AT BOOKS



Sound Advice

Temples of Sound: Inside the Great Recording Studios, by Jim Cogan and William Clark
$25, ISBN: 0811833941, Chronicle Books (2003)

"Those studios were built with some incredible technology. For instance, the studios were built on four or five inches of cork. A cement slab was then floated (suspended) inside the building that did not touch the walls of the building, and then the wall of the studio was supported by that slab. There was no physical contact between the outer walls and the inner walls."

That's how sound engineer Bruce Swedien describes the design of Universal Studios in Chicago, built in 1957 by Bill Putnam. Putnam was, by many accounts, the grandfather of modern recording studio engineers, a technological innovator with golden ears and a will to build whatever he needed to capture what he heard. Along with other greats, he ushered in an era of American popular music that had "the sound" — a rich presence that many digital engineers are still trying to replicate.

Temples of Sound is a fascinating insider tour of the legendary recording studios of the past — the rooms that recorded the most revered American pop music of the twentieth century: the sounds of Frank Sinatra, Ray Charles, Brian Wilson, Aretha Franklin, Barbara Streisand, Simon and Garfunkel, the Mamas and the Papas, the Rolling Stones, and Marvin Gaye. They all had preferences for certain studios and certain engineers. Jim Cogan and William Clark's lovingly narrated travelogue brings you back to an era when the materials and physics really mattered.

—David Albertson

Further exploration: see Jim Cogan's story on Bill Putnam in the Oct/Nov 2003 issue of *Mix Magazine*, mixonline.com, search under "Bill Putnam." Also, *Tape Op Magazine* is a regular source for audio engineering buffs: tapeop.com.

+ The Father of Invention

Jack Kamen Comic Book Reprints on Book and CD-ROM
BudPlant.com, comicsoncdrom.com

Dean Kamen's penchant for the fantastic, it turns out, runs in the family. When the millionaire inventor wants a drawing of one of his medical or personal transportation concepts, he turns to his father, Jack Kamen.

In the 1950s, Jack Kamen worked for EC Comics, the publisher of *Weird Science*, *Tales From the Crypt*, and *Mad*, drawing supernatural creatures, flawlessly beautiful (but oh-so-WASPy) women, and *Leave It to Beaver*-style families gone berserk.

Much of Kamen's early comic book work is available in reprint form, both in book and CD-ROM format. Recommended titles: *Jo-Jo, Congo King* (volumes one and two, CD-ROM, $19.95 each, comicsoncdrom.com/titles/jojo.htm), loaded with late 1940s "good girl" art, and the EC Comics reprints available from art dealer Bud Plant .

—Mark Frauenfelder

Rocket Man

Strange Angel: The Otherworldly Life of Rocket Scientist John Whiteside Parsons, by George Pendle
$25, ISBN: 015100997X, Harcourt (2005)

I already knew a bit about Jack Parsons before I read *Strange Angel*. I knew he was an avid DIY experimenter, a pioneering rocket scientist from Pasadena who co-founded Jet Propulsion Laboratories in the 1930s, and an avid follower of occultist Aleister Crowley.

I also knew he accidentally blew himself up with explosives while working in his home laboratory. Parsons seemed like an interesting but doomed and mentally ill man.

I hoped authour George Pendle's account of Parsons would go beyond the brief accounts of his life I'd read about, and I wasn't disappointed. In fact, *Strange Angel* is the best book I've read this year. Pendle's story presents the dizzy roller coaster ride of Parsons' life within the well-researched context of the era in which Parsons lived.

I loved Pendle's multi-page forays into the history of Pasadena as a paradisiacal Eden for old-money families from the Midwest and New England, and the crooked Los Angeles political machine of the 1930s.

Pendle also provides the best short biography of English occultist Aleister Crowley I've ever read. L. Ron Hubbard figures prominently in the book, too: he lived in Parsons' house in the 1940s before he founded Scientology. Pendle paints an unflattering portrait of Hubbard, claiming he swindled Parsons out of around $20,000 and swiped Parsons' girlfriend, to boot.

Pendle conducted interviews with people who knew Parsons, and scoured the archives of JPL, CalTech, and Thelema Media (which publishes Crowley's books) to collect enough bits of factual history to construct a dimensional portrait of a man who heretofore has been presented as a cardboard cutout.

Parsons' life was far more interesting and sadder than I could have guessed. This would make a great movie.

—Mark Frauenfelder

How-To Library

The Prelinger Library
301 8th Street, Room 215, San Francisco
To make an appointment to visit, go to prelingerlibrary.org

You might have heard of the Prelinger Archives (archive.org/details/prelinger), a stupendous collection of industrial films from decades past. But you might not know that there's also a Prelinger Library, a library every maker should know about. Even if you can't go, the fact that it exists should inspire: it's a collection of roughly 40,000 books, periodicals, maps, textbooks, government documents, and printed ephemera on subjects ranging from engineering, cooking, and astronomy to landscape and environment. The subject list sounds like a what's what of modern living: cultural, rural, and urban geography, travel and tourism, highways and car culture, natural history, city planning, media, and technology, just to start.

There is no Dewey decimal system: this library is what Rick and Megan Prelinger call "access-oriented." Shelves tower above browsers, titles glimmering faintly down the aisles, a taste of what's to come. Everything is grouped together by subject: the shelves start out with books about San Francisco and wend their way through the things of this world until they end with outer space. The beauty of the organizational system lies in its seeming randomness; in an age where internet searches and closed stacks are common, serendipity doesn't get much of a foothold. Best of all, in true maker style, the library is "appropriation-friendly," where users are encouraged to scan, photograph, and copy away to their hearts' content.

—Arwen O'Reilly

Monster Possibilities

The Big Box of Monster Garage
$40, motorbooks.com

It's hard to find a set of books that appeals to geeks, car junkies, TV cable fans, and connoisseurs of good design, but this is exactly what Motorbooks has achieved with its *How to Customize Damn Near Anything*, *How to Weld Damn Near Anything*, and *How to Custom Paint Damn Near Anything*. These are how-tobooks with attitude, as illustrated by the "damn near anything" references and the hot graphics sprinkled throughout.

This boxed set based on the popular Discovery Channel show is touted as being "a must-have holiday gift for all the DIYers in your life." And they're pretty much right on the mark. Everyone from 10-year-olds to 80-year-olds — and especially if they're male — will get into checking these out.

In *How to Custom Paint Damn Near Anything*, pinstriping and flames play major roles. Lots of photos and step-by-step instructions make it look easy (as long as you have a steady hand). Everyone wants a helmet with flames flying off it — now you can be doubly cool by painting it yourself. How to create diamond plating and tribal designs are also outlined in detail, and the results are quite stunning.

And once you've mastered custom painting, you can move on to *How to Customize Damn Near Anything*, and tackle engine building, chassis construction, and more intense painting effects (think skulls). Suspension, shocks and springs, plus recipes for speed (and ways to make sure your brakes then stop you) are all included.

How to Weld Damn Near Anything attempts to clearly explain MIG welding and plasma cutting, as well as covering the basics and the all-important Welding Shop Safety. And this one includes perhaps the funniest photo and caption in the set: "Every shop should have one or more of these" (*see page 34, bottom photo*).

A big box of monster tips and tricks to customize damn near anything.

Indeed, every shop should have *The Big Box* on its shelves.

—Shawn Connally

Have you used something worth keeping in your toolbox? Let us know at toolbox@makezine.com.

David Albertson is creative director of MAKE.
Rob Bullington is the marketing and events coordinator for MAKE.
Shawn Connally is managing editor of MAKE.
Daniel East is a writer for several Mac publications and the founder of the Mid-Atlantic Apple & Macintosh User Groups Team.
Mark Frauenfelder is editor-in-chief of MAKE.
Jeffrey Goldsmith is publishing cool books through his nascent CaffeineSociety.com.
Andy Ihnatko (www.andyi.com) is *The Chicago Sun-Times*' technology columnist and the author of best-selling Mac books for Wiley Publishing.
Marc H. Nathan is an angel investor and technology enthusiast who lives with his wife and bulldogs in Houston.
Tom Owad is a Macintosh consultant in York, Pa., and editor of Applefritter (applefritter.com). He is the author of *Apple I Replica Creation*.
Arwen O'Reilly is an assistant editor for MAKE.
Ross Orr hacks low-tech gadgets and invasive plants in Ann Arbor, Mich.
Matthew Russell tries to live life as a renaissance man, but hasn't made much progress since becoming enthralled by the cult of Mac.
Fred Sandsmark is a freelance writer and musician living in Castro Valley, Calif.
Bob Scott is a statistical construct of various consumer electronics marketing departments.
Patrick Webb manages computer projects at his day job and is a writer, private pilot, and technology aficionado the rest of the time.

1+2+3 Wizard Christmas Crackers

By Charles Neveu

Make trick crackers that go off like a gunshot and burst into a blinding, sparkling ball of flame.

MATERIALS

Flash paper

Flash cotton

Non-flammable confetti (optional)

Strong cotton (not nylon or polyester) thread

Clear nail polish

Small toy: *Strange coins, medallions, rings, and carved animals work well.*

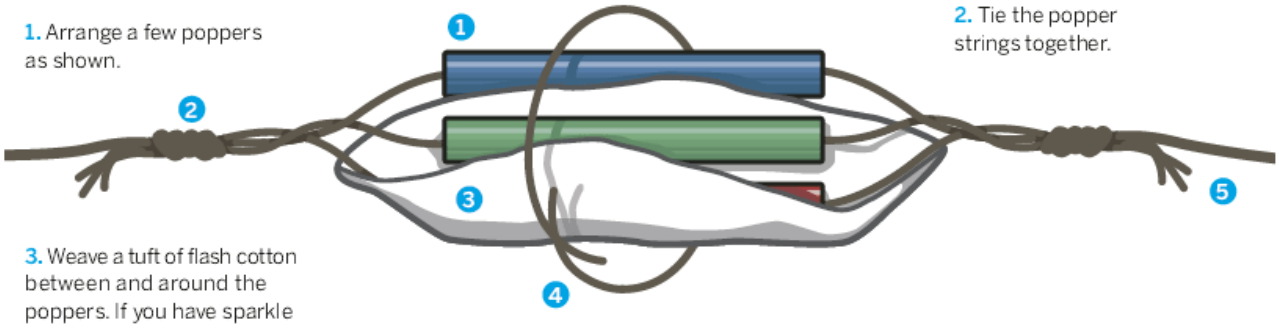
String poppers: *The kind with strings coming out both ends, not the champagne bottles. I buy these in Chinatown.*

Flash cord (optional)

Electric flash powder, also called sparkle powder (optional): *Available at skylighter.com or theatrefx.com.*

1. Make the igniter.

1. Arrange a few poppers as shown.



2. Tie the popper strings together.

3. Weave a tuft of flash cotton between and around the poppers. If you have sparkle powder, coat the igniter with nail polish and roll it around in the powder.

4. Tie the flash cotton around the poppers with a small bit of thread or flash cord.

5. Tie two strong 18" strings securely to the string bundles on each end.

2. Build the tube.

6. Find an appropriately sized cylinder (I use a AA battery) and wrap flash paper around it, gluing the tube closed with nail polish. After the polish is dry, remove the cylinder.

7. Insert the igniter assembly so that one string handle comes out each end of the tube. Insert the toy in the tube. Optionally, stuff in some non-flammable confetti — but not so much that it will interfere with the ignition of the tube. For a better grip, you can tie a small ring to each handle.

3. Twist the ends.

8. Twist the ends of the tube closed. Make sure the handle strings are not mechanically attached to the tube. You don't want the tube to pull apart like a normal cracker; it should remain intact and be ignited along with everything else.

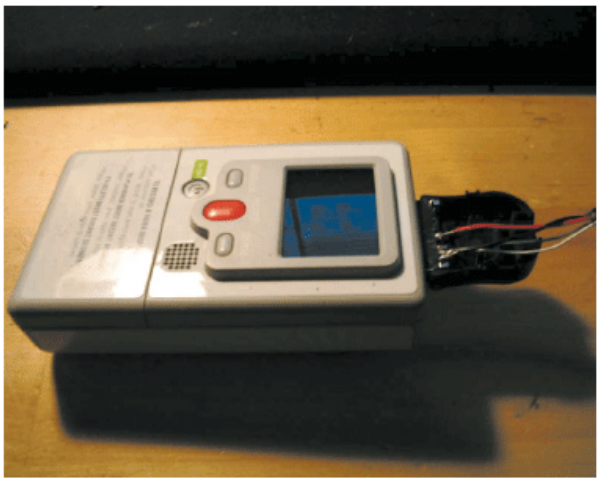
9. Stand away from anything flammable and keep the cracker away from people and pets. With one person holding each string, stand apart, and on a count of three, yank the strings sharply to pop it. Don't be timid: if one person gives, it might just pull the handle strings off.

Illustration by Damien Scogin

CVS Hackathon

By Phillip Torrone

Gadgeteer and hacker Phillip Torrone blogs daily, pointing out DIY projects as well as showcasing his own how-to solutions. You can find blogs, podcasts, and images at makezine.com.



Highly connected communities are getting smarter and more nimble, especially when there are mutually shared warranty-voiding goals. The MAKE: Blog tends to become a clearinghouse of information during intense weeks of ravenous device modding. A favorite of mine is the digital CVS One-Time-Use Video Camcorder.

Introduced in June of 2005, the CVS disposable digital video camera was meant to be purchased for under or around $30 (less with rebate), and eventually returned to the store for processing. After their "processing," which costs another $12, you get a DVD back with your videos, a meager maximum of 20 minutes. It's a one-time-use camera, so you don't get to keep it, but the idea of a low-cost digital video camera to use for a variety of projects is extremely appealing to any maker out there.

CVS has released disposable digital still cameras with much success (and those too were hacked for photography projects). When I heard about the CVS video version, I expected it to be used in interesting ways. But what I didn't expect was how quickly and efficiently the makers, hackers, and modders worked, both independently and collaboratively. If blog posts were fossil records, you could see the evolution of this lowly camera to the maker-friendly, super-duper, all-purpose video camera it is today.

CVS Disposable Video Camera Hack Timeline (on the makezine.com/blog)

Day 1 CVS disposable video camera is introduced.

Day 3 Camera disassembly is documented.

Day 7 USB pinouts posted.

Day 10 Videos posted, file formats explored.

Day 20 Hacked! Maker John Maushammer hacks the camera in less than 18 hours.

Day 22 MAKE: Audio interview with Maushammer.

Day 59 Videos can be downloaded over USB with no need to desolder the flash memory.

Day 64 Hack using a Palm III sync cradle posted.

Day 65 How to build a helmet cam, with video, posted.

Day 78 Camera manufacturer Peer Digital says, "Do-it-yourselfers are not our target audience. It's sort of a non-issue."

Day 82 CVS camera auctions are removed from eBay, no reasons given.

Day 83 Using the CVS camera in a rocket posted.

Not too shabby. In less than two months, a crippled camera went from sitting on the shelf to becoming part of a rocket. We've posted dozens of how-tos, each project building on the past ones, from cameras on RC planes to night-vision mods. The CVS disposable digital has become more than it was initially intended to be, and that's truly the most interesting thing about this device — what you make with it.

Check out our latest posts on makezine.com/blog and mod yourself an excellent (and cheap) digital video camera this weekend.

Photograph by Bill Bradford

MAKER'S CORNER

Check out the cool gift ideas for the maker on your list:

Makers: — Celebrate the creativity and resourcefulness of the DIY movement with this beautiful hardbound book worthy of any maker's coffee table. Bob Parks and the editors of MAKE profile 100 makers and their homebrew projects, backyard inventions, and basement creations. Available December 1. Preorder yours today at makezine.com/makers.

Gift Subscriptions to MAKE — It's great you've been so sharing with your issues of MAKE. Your friends appreciate it. We appreciate it. But now is the perfect time to reclaim your own subscription. Give the geek on your list a truly unique gift this holiday — their very own subscription to MAKE. While supplies last, you'll also receive your very own MAKE T-shirt!

Early Volumes of MAKE — We've been hearing from newcomers to MAKE who'd love to get their hands on the often hard-to-find early volumes of MAKE to complete their collection. Now available is a special collector's edition gift box of the entire first year of MAKE, as well as individual copies of all four volumes.

Find these and many other cool gifts sure to bring a smile to the face of a maker this holiday season at makezine.com/coolgifts.

MAKE T-Shirts — OK, we heard you. MAKE T-shirts are now available at makezine.com/coolgifts.

Bay Area Maker Faire

Note: New dates now slated for April 22 and 23 to allow for more outdoor projects.

Join the MAKE team and thousands of other makers at MAKE magazine's first ever Maker Faire. Meet expert makers and MAKE contributors. Hear from O'Reilly's Hacks Series authors. Attend DIY tutorials. Explore DIY projects and see demonstrations. See the Ultimate Workshop.

Bring your family and friends to the San Mateo Fairgrounds (centrally located in the San Francisco Bay Area) for a weekend of hands-on exploration, recipe sharing, creative mischief making, and wholesome play.

All-day admission is a paltry $12 for adults, $5 for teens, and not a cent for kids 12 and under accompanied by an adult. Maker-friendly family tickets and full weekend passes available as well! Join us on Saturday, April 22, and Sunday, April 23, 2006.

Tired of waiting for your MAKE?

Add MAKE Digital Edition to your subscription (free to print subscribers). MAKE subscribers can now read, search, and share their MAKE magazine online. Get access to special audio and video extras.

And best of all, you'll be reading your MAKE up to three weeks prior to receiving your print edition. Available to MAKE subscribers only. Get more information at makezine.com/digital.

MAKE AMENDS

In our profile of Ed Storms (*Volume 03, page 25*), we failed to mention his employment with Lattice Energy, LLC in Chicago. Dr. Storms' current work with a scanning tunneling electron microscope has been made possible by Lattice. You can read Lattice Energy CEO Lewis Larsen's letter to MAKE, in which he clarifies several points about Dr. Storms' employment status, at makezine.com/03/interview.

In the Welding Primer (*Volume 03, page 163*), Mister Jalopy warns readers to "Make sure your welding area is clean and inflammable as the sparks are going to fly!" We meant to say that your welding area should be non-flammable.

And One Mouse to Rule Them All

By Tom Owad

How Tom tames his computers.
1. HP Scanjet with automatic document feeder
2. PowerBook G4 Titanium (display broken off in mishap)
3. PowerBook G4 12" Aluminum
4. Dell UltraSharp 2001FP 20.1-inch LCD
5. Color Classic (running System 7)
6. FingerWorks TouchStream LP keyboard
7. Acer Wireless ADB keyboard
8. RackMac TZ (running Mac OS 9)
9. GatorBox LocalTalk-to-Ethernet adapter (hidden from view)
10. Replica I (a replica of the Apple I, hidden from view)
11. Apple IIGS (with all the extras)

The computers are stacking up. They're on my desk, behind my desk, in the attic, in the basement, in the garage. Ideally, I'd like to have one monitor, one keyboard, and one mouse on my desk, with all my computers hooked up through them.

What's the most efficient setup for a workspace with a range of equipment spanning 30 years of technology? I began with a 1970s DEC desk with a built-in, three-foot rack. Desks like these are hard to find nowadays. It's much easier to find self-standing, three-foot racks, which can then be crafted into a custom desk.

This desk's rack contains my Apple IIGS, Replica I (an Apple I replica), RackMac TZ, and GatorBox LocalTalk-to-Ethernet adapter. Sitting atop the desk is a SCSI-based HP Scanjet with Automatic Document Feeder, which I use to scan documentation on the RackMac. The two PowerBooks and the Color Classic are on the desk.

In trying to find a monitor that would work with all these, I came up with the Dell UltraSharp 2001FP 20.1-inch LCD. This display supports DVI, VGA, S-Video, and composite video. Switching modes occurs at the push of a button, so it's easy to rotate through multiple systems. The 12" PowerBook connects via DVI, the RackMac via VGA, and the Apple IIGS via composite. I access the PowerBook through the Mac OS X server tools and have a serial interface, via USB adapter, for the Replica I, which allows me to control it through a terminal window on my 12" PowerBook. The Color Classic, of course, has its own internal display.

This approach eliminates the need for a desk full of monitors, but it leaves the keyboard and mouse problem. I use a FingerWorks TouchStream LP keyboard/gesture pad with my PowerBook. Since I connect to the Replica I via a terminal session, this also works with the Replica I, but leaves me with three ADB systems needing keyboards and mice. ADB switches are extremely difficult to find. In lieu of this, I decided to use infrared keyboards. I chose an Acer Wireless ADB keyboard.

I connected an infrared receiver to each of the ADB Macs and positioned these on my desk. I stow the keyboard in an open slot in the rack. When I want to work with any of the ADB Macs, I slide the TouchStream aside and pull out the Acer Wireless. Communication from the keyboard to the receiver is one way, so if I have all three machines on at once, all three will receive the same keyboard and mouse input. I keep a piece of tinfoil handy to cover the other receivers, if more than one is active.

With one display, a handful of video switches, and infrared keyboards, there are very few computers that cannot be incorporated into this setup.

Tom Owad (owad@applefritter.com) is a Macintosh consultant in York, Pa., and editor of Applefritter (applefritter.com). He is the author of *Apple I Replica Creation* (Syngress, 2005).

Illustration by Dustin Amery Hostetler / Upso.org

Cory Doctorow

R.I.P.:

RIP, MIX, BURN

On June 27, the Supreme Court issued its decision in Grokster vs. MGM, a lawsuit over the legality of peer-to-peer networking. The decision creates a new form of copyright liability that goes to the heart of what MAKE is all about: making cool stuff out of other stuff and sharing it with the world.

The Grokster case was about "secondary" liability. If you make a tool that allows your users to infringe on copyrights — like a camera, pencil, VCR, or the internet — should you be held liable for their actions? The granddaddy of secondary liability cases was the Betamax decision, which was handed down in 1984, when the studios argued that the VCR should be made illegal because it would Napsterize the movies that were aired on broadcast TV (yes, they claimed this!).

The court then found that the VCR was not illegal, nor was any technology "capable of sustaining a substantial non-infringing use." That is, if your technology could be used for non-infringing purposes (say, recording the copyright-free congressional wrangles on C-SPAN), then it was legal to build it. Your customers might still be on the hook if they got caught making infringing copies, but it wasn't your responsibility.

Betamax stood us in good stead for more than 20 years. The knowledge that any technology that could be used for good was legal to build gave makers the certainty to develop, capitalize, and sell or distribute all kinds of tools from printers and scanners to Microsoft Outlook to the Google Toolbar.

But as the majority of internet users seek an end-run around the entertainment industry's price fixing, limited back catalogs, and antiquated delivery mechanisms by means of P2P systems, the entertainment companies have tried to create a new kind of secondary liability — for inducing your users to infringe copyright.

This is thoughtcrime. If Alice and Bob both build identical VCRs, but Alice advertises that you can use her VCR to duplicate copyrighted movies while Bob merely winks knowingly and lays his finger alongside his nose, Alice faces liability and Bob doesn't. Grokster and its codefendants were accused of this kind of thoughtcrime. Napster was sued into oblivion, found guilty on the grounds that they'd had the ability to control their users, so they couldn't find refuge in the Betamax defense. Grokster and the other post-Napster P2P companies set out to deploy P2P systems that lacked this control: systems built on technology like Gnutella, where the people who deploy the software have no way of knowing what users are downloading or searching for.

But the Supremes found that since the architects of these systems had hoped that their users would download infringing songs — because they targeted ex-Napster users — they were guilty of inducing infringement.

The court saw their intention to attract 70,000,000 Napster users as evidence that they had intended to induce the infringement — even though Napster itself has since been bought out by record labels who are marketing a new service (also called Napster) to those same users.

If you're a maker, this is scary news. With every word you utter, every email you write, every IM you send, you've got to make sure you never breathe a hint of any expectation that your users might infringe copyright. Apple couldn't get away with "Rip, Mix, Burn" under this standard.

In 1984, the Supremes' Betamax decision gave every tinkerer and garage startup a gift: an easy-to-understand standard for which all kinds of products are lawful in the marketplace. That gift paid a dividend: 20 years of innovation, encompassing everything from the PC revolution to the internet. This year, they took that gift away with the Grokster decision: an impossible-to-gauge standard that makes your technologies' uses secondary to your state of mind when you sat down at your workbench.

Cory Doctorow (craphound.com) works for the Electronic Frontier Foundation (eff.org), co-edits boingboing.net, and has written several novels.

Wabi-Sabi

By Dale Dougherty

The Japanese have a deep appreciation for things humble and handmade.

Do you have a favorite cup or pen or T-shirt? Why do you like it so much? I have a favorite coffee mug that's at least 30 years old. It's a ceramic mug with a few nicks in the handle and it bears the call letters of a public radio station, which sent it to me as part of a membership drive. I cannot explain why I like to use that particular mug first thing in the morning. To be honest, I never really thought about it until I returned from a trip to Japan earlier this year.

On my trip, I picked up a small book called *Wabi-Sabi for Artists, Designers, Poets and Philosophers*, written and published by a San Franciscan, Leonard Koren. He defines Wabi-Sabi as "the Zen of things." Koren writes that Wabi-Sabi "is a beauty of things imperfect, impermanent, and incomplete. It is a beauty of things modest and humble. It is a beauty of things unconventional." Originally, Wabi referred to "the misery of living alone in nature" and Sabi meant "lean" or "withered." Over time, Wabi-Sabi came to mean an appreciation of the simple things in life. It seems akin to the way the word "organic" is now used.

In Japanese culture, Wabi-Sabi is wrapped in the mystery and ritual of the tea ceremony. The ceremony traditionally takes place in an outbuilding that is by no means elaborate; it's more of a shed or a shack. The ceramic bowls used to serve tea have been uniquely created for this use and they are often passed down from one generation to the next. They are rough-hewn, not polished. The tea ceremony, like a lot of what you see in Japan, is about taking something that we do regularly and making it into an art form, a deeply considered experience. It's the difference between eating fast food on the run and enjoying a satisfying meal in the company of friends or family.

Wabi-Sabi defines an aesthetic sense of an object, apart from its function. It's a way of understanding why we are attracted to some things, what they mean to us, and how they make us feel. One insight of Wabi-Sabi is that objects gain value by being used. "They record the sun, wind, rain, heat, cold in a language of discoloration, rust, tarnish, stain, warping, shrinking, shriveling, and cracking. Their nicks, chips, bruises, scars, dents, peeling, and other forms of attrition are a testament to histories of use and misuse ... They still possess an undiminished poise and strength of character." In Volume 02 of MAKE (*see page 50*), Joe Grand showed us how to put a new computer inside the well-worn case of an Atari console. I must admit that I wondered why someone would really want to go to all that trouble. Now, Wabi-Sabi helps me understand why Joe treasures his old Atari system.

Bob Dylan, in his book *Chronicles, Volume One*, says that when he was asked early in his career what kind of music he played, he answered, "folk music." When he was then asked to describe folk music, he answered that "it was handed-down songs." He started out learning this music and only later did he decide to make his own kind of music.

> "One insight of Wabi-Sabi is that objects gain value by being used."

Wabi-Sabi challenges conventional notions of beauty — that what is new is better, that mass-produced products are perfect. In fact, our experience is exactly opposite. Nothing is perfect. Nor are we. Large billboards in American cities this past summer featured large American women instead of excessively slender supermodels, showing that beauty comes in all shapes and sizes. Koren writes, "Wabi-Sabi appeared the perfect antidote to the pervasively slick, saccharine corporate style of beauty that I felt was desensitizing American society."

Wabi-Sabi helps us identify something that is truly authentic, based on valuing our own experience. When something becomes your favorite, you don't want to replace it with something new. The things we make are more authentic than the things we buy. Our own knowledge and experience are reflected in what we have made. As Finnish crafter Ulla-Maaria Mutanen writes in the Manifesto that appears in this issue (*see page 7*): "If you make something yourself, you see part of yourself in that object. This is not possible in purchased products." Making something is a creative ritual, like the tea ceremony. We follow a set of steps that have been handed down to us, but what we end up with is all our own.

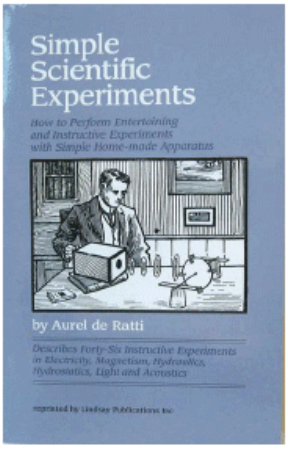
Dale Dougherty is editor and publisher of MAKE.

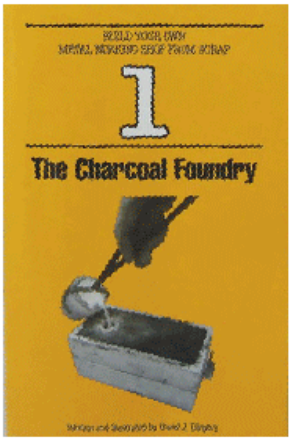
Treasure Trove

By Dale Dougherty

Makers past and present populate a unique catalog of hard-to-find lore.

Vince Gingery pulls the crucible from a gas-fired furnace (left).
Dave Gingery's *Charcoal Foundry* shows you how to build a very basic furnace (right).





This 96-page reprint, of a booklet published a century ago, has 46 experiments including a device that makes smoke rings, and one that detonates flour.

"I have been an incurable experimenter and gadgeteer since childhood. I love old science and technology books, and have a special fascination for people, past and present, who can build something out of nothing. In fact, I have something of a reputation myself." Sound like anyone you know? That is how H. Peter Friedrichs introduces himself in *The Voice of the Crystal*, his 185-page book about making crystal radios from household materials. This 1999 gem is one of many in the extensive catalog of Lindsay Publications, Inc.

Not into crystals? Try red-hot metal. *The Charcoal Foundry* by the late David Gingery is the first of a series featured in the catalog. Gingery writes: "As is usually the case with the hobbyist, experimenter, or inventor, I didn't need a machine shop, I just wanted one." He sets out to build a lathe by casting the parts himself, and then to "use it to produce the rest of the equipment to make up a full and practical machine shop." Even if you're not that ambitious, the book will convince you that you can learn to build your own foundry and make items from scrap metal. "If you have ever built sand castles or made mud pies, you have some experience in green sand molding," writes Gingery. "It really is that easy. The sand ... will take an impression of the pattern and provide a cavity into which we pour the molten metal."

Lindsay, who only uses one name, is the man who puts out the eponymous catalog. He says, "Sand-casting goes back 3,000 years. Dave Gingery used to say 'When you shake out the sand and see the casting, it's like Christmas morning.'" Lindsay, an engineer, has been publishing for 25 years. Metalworking is a big category for him.

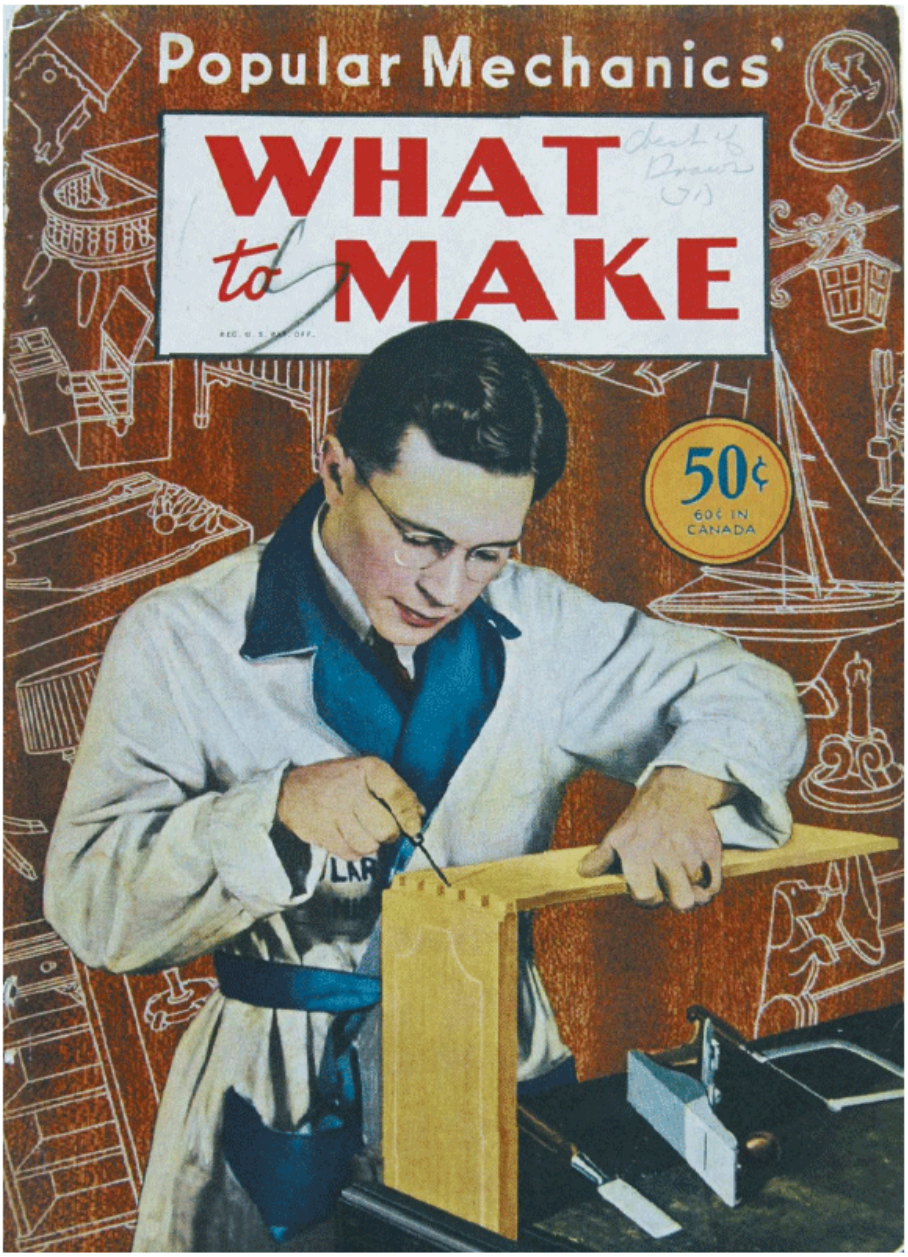
"I don't offer everything. Just the very best I can find," he tells me. "There's a lot of good old stuff." Many of the Lindsay offerings are reprints of out-of-copyright works, such as the 1885 *Distillation and Rectification of Alcohol*, a so-called treatise that explains the making of wine, whiskey, and liqueurs. If that leads you to building a distillery, you can learn to make a boiler or a kettle from *Coppersmithing*, published in 1893. If you're a fan of *Six Feet Under*, you may want to undertake reading the 1900 *Preserving the Dead: The Art and Science of Embalming*.

Lindsay also carries self-published books, such as those by Gingery and Friedrichs, that don't end up in bookstore chains. "I rarely offer beginner's books, which are more easily found. My books are more complicated," says Lindsay, "but not nearly as

Photography courtesy of Lindsay Publications

What to Make of This?

We found this 1944 issue of *Popular Mechanics* at a flea market. Yes, you'd think they knew we were coming, some 61 years later. Projects include all kinds of thankless work including making household furniture, Christmas cards, dollhouses, and the like, all with the classic diagrams that seem to make anything possible. And all for 50 cents. Yet the unusual pops out amidst the commonplace, for instance, the "Swank Martin Apartments," which are elegant, three-story hexagon-shaped birdhouses. There's an article on designing skate sails, which is news to me, a Californian, but the concept is similar to windsurfing. Now, via Google, I find a Museum of Skate Sailing in Sweden, and learn that current designs achieve 75mph.



Photograph by Kirk von Rohr

complex, mathematical, nor as expensive as top-end engineering texts."

The catalog is a treasure trove of lost knowledge and, more importantly, the books themselves are guides by and for the resourceful. The title *Impoverished Radio Experimenter* says it all. In *How to Use Tin Can Metal in Science Projects*, author Edward J. Skibness says that the book's subtitle should be "How to Do Much Without Much."

And Friedrichs writes, "Crystal radio is old news, and may be of limited value as an educational experience. However, it excels as an exercise in creative and logical thought." Indeed, these are books that teach the timeless lesson of learning by trial-and-error.

WayBack Website

"The Museum of Retro Technology grew out of an early page on odd steam locomotives," explains Douglas Self, a designer of hi-fi equipment whose website hosts the Museum. Self decided he needed a broader name when he began to add "odd technologies" that had nothing to do with steam engines. "Electromechanical amplifiers were one of the first new topics — the technology is so odd and so obscure I could not resist adding it," he says. Now the museum covers four categories of technology: Communications, Computing, Transport, and Power.

Museum of Retro Technology: www.dself.dsl.pipex.com/

MakeShift

By William Lidwell

This MakeShift challenge is brought to you by Dean Kamen and the creative team at DEKA. Dean and his team will also be participating in the analysis and winner selection. And remember: Don't be afraid to kiss frogs!

The Scenario: You're driving through a remote region of Mexico currently experiencing drought conditions. From the road, you see a family working desperately to keep their crops irrigated by carrying buckets of water. A quick scan of the farm leads you to believe that you can help. You pull over and introduce yourself (en español, por supuesto). You learn that the pond level has dropped due to the unusually dry summer, and the stream that it normally feeds has stopped flowing. This family of five has been doing its best, but it is clear that they are doomed to fail given the severe heat, distances, and carrying capacities involved. These crops represent food for the winter, annual income, and seed for next year's crop. Una solución elegante a este problema difícil es necesaria.

Supply List:

- **Metal barn with industrial farm equipment (wagon, tiller, mower, etc.)**
- **1 dilapidated greenhouse, with most of its glass and equipment intact**
- **1 broken-down farm tractor**
- **3 donkeys**
- **1 old oil tank, approximately 1,500-liter capacity**
- **3 oak barrels, about 200-liter capacity (not watertight)**
- **Numerous rolls of black and clear 4 mil plastic, about 1mx50m each**

Send a detailed description of your MakeShift solution with sketches and/or photos to *makeshift@makezine.com* by Dec. 31, 2005. If duplicate solutions are submitted, the winner will be determined by the quality of the explanation and presentation. The most plausible and most creative solutions will each win MAKE T-shirts and a SWISSMEMORY™ USB Victorinox 512MB. Think positive and include your shirt size and contact information with your description. Good luck! For readers' solutions to previous MakeShift challenges, visit *makezine.com/makeshift*.

William Lidwell is a consultant with Stuff Creators Design Studio and co-author of the book *Universal Principles of Design*.

Photograph by Jill Butler and Jason Holden

READER INPUT

Where makers tell their tales and offer praise, brickbats, and swell ideas.

Alan sent us this email after we saw his pictures on Flickr of a waterlogged MAKE, Volume 03 that barely survived a river rafting trip, and we offered to replace it.

Hey, glad you like the pics. I actually ended up bringing both MAKE and *Consumer Reports* down the river. Despite how weathered MAKE was by the end, *Consumer Reports* didn't have a chance — it was practically torn to pieces.

Thanks for making such an interesting (and robust) magazine; it's always a must-read for me, and yes, I would love a replacement copy. Thanks for the offer.

Keep on makin' MAKE.

—Alan Joyce

I just had a brief email discussion with Eric Wilhelm, the author of the Halloween article in Vol. 03 of MAKE. He was extremely helpful in ironing out a few wrinkles in my understanding of the project (not the fault of the article, just my own knowledge gaps), and in the course or our discussion, he suggested I contact the MAKE team to let them know that this was the type of article that is right down my proverbial alley ... so that's what I'm doing!

I subscribed to MAKE sight-unseen after reading a blurb about it on SFGate a number of months ago, and I haven't been disappointed in the least. The Halloween article especially appealed to me because I've always had a nagging interest in how to interface with objects external to a computer, and now I know. I have no idea how I'll actually use the project, but that makes little difference — I just want to build it. I suppose this suggests a desire for more projects where the obvious "cool" factor is appreciated by geeks and non-geeks alike. More Halloween fun and less how-to-turn-your-PSP-into-a-web-server ... maybe.

Keep up the outstanding work.

—Steve Borgstrom

OK, MAKE is the best damn magazine I've ever gotten. Period. Let's just get that out of the way. I'm going to keep getting it. In fact, when I got the email saying that if I upgrade to a premiere membership, I'd get FULL ACCESS TO THE DIGITAL EDITIONS, I thought, "Now THAT'S what a maker would want!" Right?

Aw, jeez. Actually, it is what a maker would want, but what this actually is isn't that. What a maker would want is a real, honest-to-gosh PDF file. Searchable text and all that. Come on, folks, I've got a dual 2.0GHz G5 with Spotlight and space on my portable drive for eBooks out the wazoo, and here I can only get a bunch of rendered images that will print to enormous, awkwardly laid-out, non-searchable PDF. Bleah.

Anyhoo, it just seemed odd since this is a magazine that's had brilliant criticism of bonehead DRM, and this implementation feels like just that. Then, it's probably just a tech issue, but I thought you should know how it reads.

AWESOME MAGAZINE and well done!

—Simon Tarr

My son made the potato gun and was totally successful in so doing. Thanks for putting out a great magazine that looks beautiful but more importantly, got my video-obsessed kid reading. Much appreciated! The trees in our backyard are taking a pounding, however...

—Rick Kleffel

Vol. 04, November 2005. MAKE (ISSN 1556-2336) is published quarterly by O'Reilly Media, Inc. in the months of February, May, August, and November. O'Reilly Media is located at 1005 Gravenstein Hwy North, Sebastopol, CA 95472, (707) 827-7000. SUBSCRIPTIONS: Send all subscription requests to MAKE, P.O. Box 17046, North Hollywood, CA 91615-9588 or subscribe online at makezine.com/offer or via phone at 866-289-8847 (U.S. and Canada), all other countries call (818) 487-2037. Subscriptions are available for $34.95 for 1 year (4 quarterly issues) in the U.S. Canada: $39.95 USD; all other countries: $49.95 USD. Application to Mail at Periodicals Postage Rates is Pending at Sebastopol, CA and at additional mailing offices. POSTMASTER: Send address changes to MAKE, P.O. Box 17046, North Hollywood, CA 91615-9588.

I'm sure Mister Jalopy is 100 times the welder I am, so the point I'm about to raise was probably in the original article and got dropped somehow, but ...

The nice, clean "tube of toothpaste" welds he demonstrates require one extra step that wasn't explicitly discussed: as you squeeze the trigger and move the weld gun away from you, make very small circular motions with the tip of your weld gun (some folks make a zigzag, and others make a running series of half-moon shapes, but the little circles work for me).

By the way, my second welding project was a welding cart made from several discarded steel shelving units, some casters from Enco, and a dumpster-dived bank of drawers that look like they came from the Soviet Ministry of Card Catalogs.

The magazine keeps getting better. Keep it up!

—Travis J.I. Corcoran

I was browsing my local Barnes and Noble looking for something interesting when I noticed MAKE magazine. Curious, I picked it up and began to read. I was amazed. There were so many wonderful ideas and projects that I purchased it immediately.

After reading it cover to cover twice, I bought a subscription. Please keep up the good work. It's very few mags nowadays that see hacks for their inventive and exploratory nature, rather the media image of the malicious hack junkie, hopped up on caffeine and trying to break into the admin accounts of anyone that passes them a furtive glance.

Kudos to you for portraying the real story! Wowed,

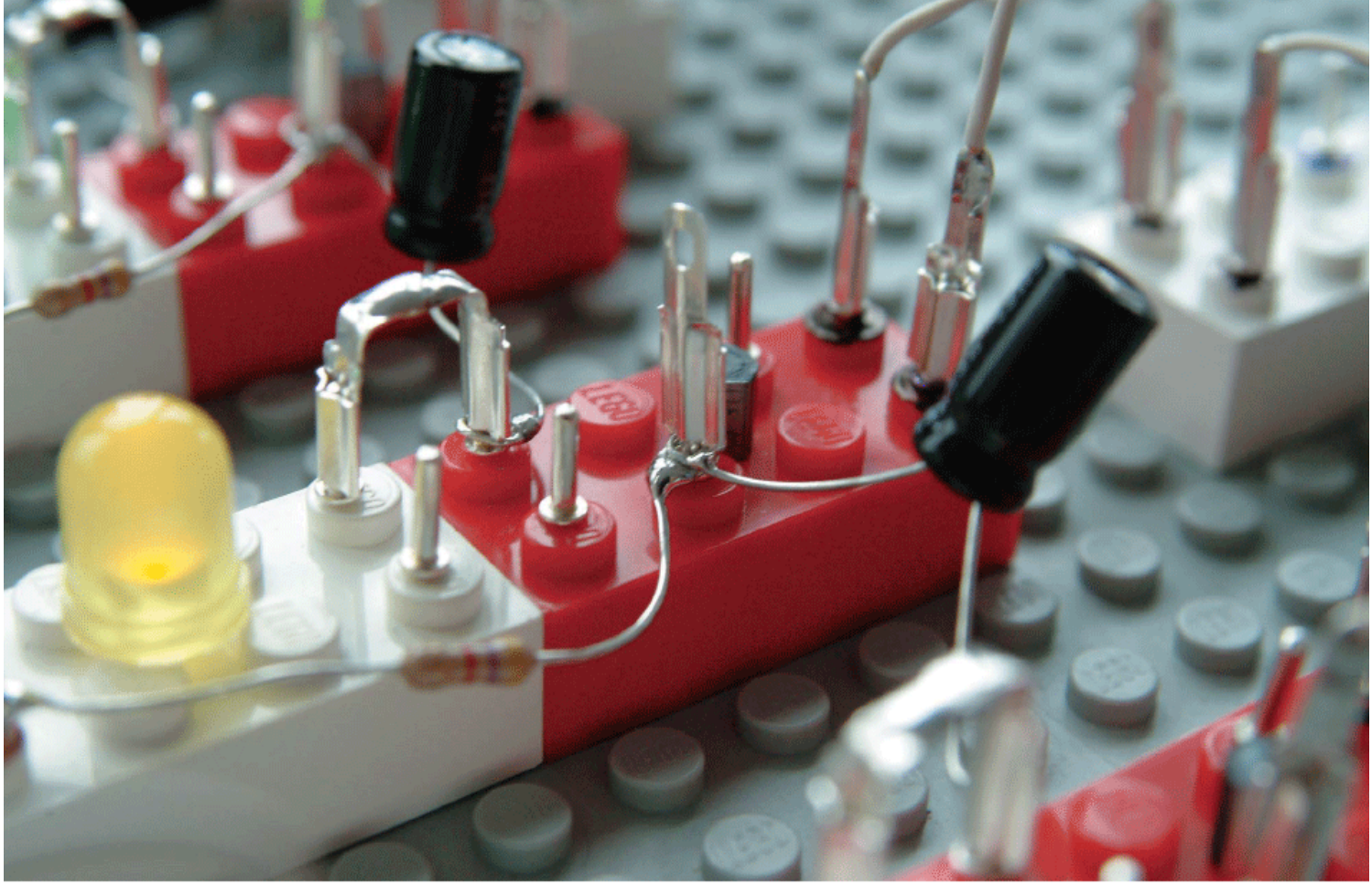
—D. Griffin

I made PVC marshmallow guns for my two boys this weekend. At first, they had no idea what I was doing. After my 8-year-old saw the first mini-marshmallow fly out of the tube and smack the wall, he was hooked and so was his 5-year-old brother.

Thanks for helping me be a hero for $5.71 (cost for 2 guns).

My oldest slept with his gun last night and was amazed that when he woke up it smelled like marshmallows. "Yup," I said, "I love the smell of marshmallows in the morning." The male bonding has begun.

—John Bobo



HOMEBREW

My Lego Electronic Lab Kit Bricks

By Claude Rieth

I still own a Philips Electronic Lab Kit. My parents gave it to me in 1975. It's been stuffed away in a box for more than 25 years.

About a year ago, I felt the urge to tell my kids (who were 5 and 7 at the time) about electricity, switches, lamps, batteries, and basic circuitry. Digging out the old Philips Kit, I found that lots of parts were missing. Unfortunately, Philips had discontinued it, and there was no way to get replacement parts.

With my desire to avoid "vendor lock-in" schemes wherever possible, and my strong belief in open standards, I was looking for a kind of OSS lab kit, easily expandable, cheap, fast to make, solid, and based on standard pieces available almost everywhere.

Naturally, LEGO came to mind for the basic building blocks. They are very solid and you can buy the colorful plastic bricks almost anywhere (I had three boxes full). The colors allow for good categorization of components. I bought some LEDs, prototyping board, soldering nails, and shoes, the initial idea being that the soldering nails would be stuck to the prototyping board, which somehow would be connected to the LEGO brick. I tried, but it was too much work to manufacture a brick.

Then I tried to stick a soldering nail through one of the studs in a brick. It was easy and fast, giving me the "eureka" effect.

The first brick was composed of a LED soldered to two nails. The solder forms a little bullet on the bottom of the nail. Holes for the LED's pins were made by sticking and removing a nail. For other bricks (transistor), a Dremel tool was used. Bricks glue easily with super glue.

For simple daisychaining, every pin of a component needs to be connected to two nails.

Being too lazy to build bricks for all kinds of resistors and capacitors, I found that looping their wires and blocking them with a nail/shoe provided a nice connection and avoided redundancy.

My next steps: standards for bricks (e.g., color usage for transistors, like NPN: yellow and PNP: red), creating LEGO CAD piece definitions, and writing instructions for a set of circuits to build.

Do you have your own Homebrew story to share? Send it to us at homebrew@makezine.com.

Photograph by Claude Rieth

was **so impressed.**

- John

I just **LOVE !!!!!!!!!! this service.** Thank you!

- Victoria

The service is, in a nutshell, outstanding, and the choice of DVDs **improves every month.**

- Steve Koschmann, Make: vol. 03

AWESOME! **I love the operation** you guys run over there. Thanks.

- Evelyn

I'm starting a little business making some custom car interiors and the videos help tremendously. **Thanks from me and a lot of other people who just can't afford to buy them!!!!!!!!!!**

- Jimmy

Thanks for your prompt reply, you've got yourself some **repeat customers** over here, I can assure you.

- Gabe

This is service **above and beyond!** I will be renting again.

- Roy

Many thanks; **AWESOME service!**

- Ely

I wish my local Blockbuster was so responsive! **I will be renting many other titles** since you have such a great selection.

- Koji

Please don't add any more movies. Its already too hard to decide what to get next. I guess **I'll start with blacksmithing and work my way down the alphabet!**

- Tim

Your service and communication has always

WinBook recommends Windows® XP Professional.

Mobile Freedom.

Brought to you by Intel® Centrino™ Mobile Technology.

intel inside
centrino™
MOBILE TECHNOLOGY

32" LCD-TV

$999

Complete your digital home with this brilliant 32" LCD-TV.

DISCOVER WINBOOK

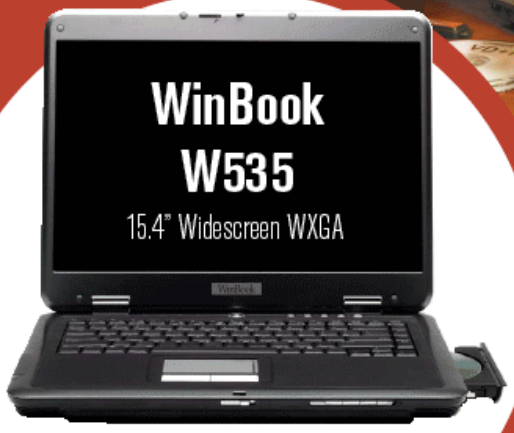
Set yourself free from cables and cards. Enjoy the freedom and flexibility of the WinBook X610 or W535 featuring Intel® Centrino™ Mobile Technology with integrated wireless LAN capability. Edit your digital photos in the den, then view them in the living room on your brilliant 32" LCD-TV! Enjoy great mobile performance and the freedom to work and play without wires and cords.

WinBook X610

Thin & Light – only 3.3lbs.

Featuring the Intel® Centrino™ Mobile Technology and Windows XP Professional.

$1,399.99



WinBook W535

15.4" Widescreen WXGA

Featuring the Intel® Centrino™ Mobile Technology and Windows XP Professional.

$1,299.99

WinBook®

For a great wireless experience, select Intel® Centrino™ Mobile Technology in the WinBook W535 and X610.

WinBook is a direct seller of high-quality, value-priced notebook computers. WinBook products have been honored with almost 600 industry awards for performance, innovation and most of all - value. Since we were established in 1993, every product we have sold has won multiple awards. That's why we say that WinBook products are "Critically Proven."

Order Yours Today.

Call **888.621.3419**

www.winbook.com/mag/makenov05

100% U.S. Based Service and Support!