vol. 03

Make:

technology on your time

Build a Geeked-Out Haunted House!

Mr. Jalopy Teaches Welding

SPECIAL SECTION

MOD YOUR RIDE

TURN YOUR CAR INTO A TECH-ENHANCED, GREASE-EATING MONSTER MACHINE

Basement Cold Fusion

Stunning Spud Gun

O'REILLY® makezine.com

Make your own RFID Reader

The Parallax **Radio Frequency Identification (RFID) Reader Module (#28140; $39.00)** is the first low-cost solution to read passive RFID transponder tags. All it takes is a microcontroller like the BASIC Stamp® and you can retrieve each tag's 10-byte code. This is suitable for a wide variety of hobby and commercial applications, including access control, automatic identification, robotics, inventory tracking, and car immobilization.

Features:

- 1-Wire®, 2400 baud serial TTL interface to PC, BASIC Stamp and other processors
- Bi-color LED for visual indication of activity
- 0.100 pin spacing for easy prototyping and integration

RFID tags are available from Parallax:

- **54x85mm rectangle tag (#28141; $2.25)**
- **50mm round tag (#28142; $2.25)**

To order online visit www.parallax.com or call our Sales Department **toll-free at 888-512-1024** (Mon-Fri, 7am to 5pm, PT).

PARALLAX

www.parallax.com

No Assembly Required

$39.99

AirClick

Remote Control for iPod

- Control your iPod, iPod mini, or computer from up to 60 feet away
- Uses RF signals that travel through walls for remote control use anywhere in the house
- Tiny remote attaches to backpack, bike, steering wheel – anywhere, for on-the-go control

$39.99

iTalk

iPod Voice Recorder

- Internal microphone and laptop quality speaker
- Connect external microphone or headphones
- Passthrough jack for headphones or additional speaker
- Automatic level control for perfect recordings

$14.99

LapelMic

Multi-use Stereo Microphone

- Self-powered microphone with stereo-quality sound
- Swivel clip for easy attachment
- Connects directly to iTalk, iMic, or PowerWave

$35

iTrip

FM Transmitter for iPod

- The only FM Transmitter designed exclusively for the iPod & iPod mini
- Powered from the iPod – no batteries necessary
- Choose any empty station from 87.7 to 107.9, and change your iTrip stations directly from the iPod

$19.99

TuneJuice

Battery Backup for iPod and iPod mini

- Provides up to 8 hours of additional power to iPod
- Uses any disposable or rechargeable 9-volt battery
- Carry emergency iPod power wherever you go
- Works with any dockable iPod or iPod mini

Made for iPod

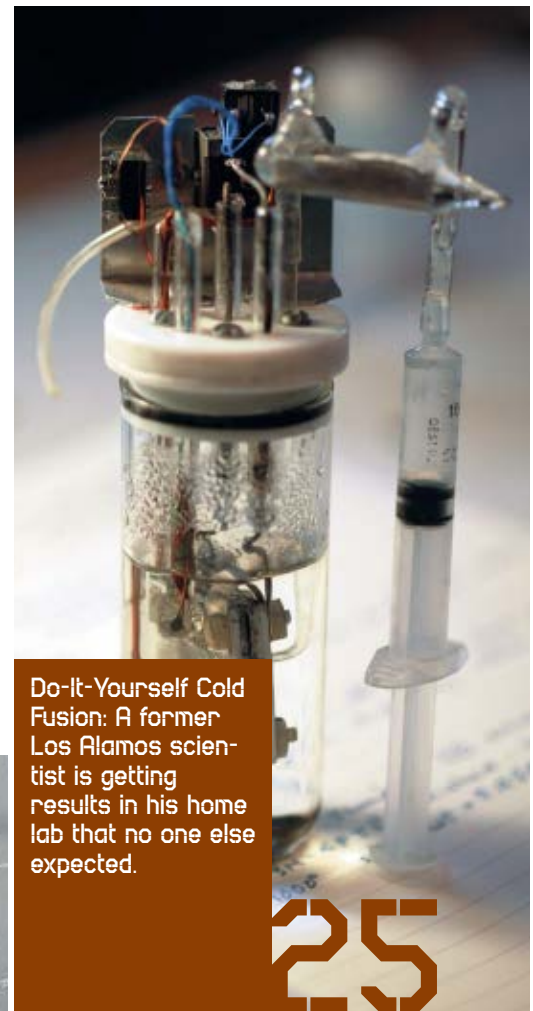
- Made for iPod mini
- Made for iPod Photo
- Made for 4th Generation iPod with Click Wheel
- Made for 3rd Generation iPod with touch wheel and buttons

Buy now at **www.griffintechnology.com**

Another great idea from GRIFFIN

Make:
technology on your time™

Volume 03



Do-It-Yourself Cold Fusion: A former Los Alamos scientist is getting results in his home lab that no one else expected.

25

16

Go, Cart: Putting a gasoline engine in a shopping cart.

ON THE COVER

Saul Griffith restored a 1960s-era Dune Buggy, outfitting it with a jack for an iPod. When he parks his buggy, he simply unplugs the iPod, leaving nothing to steal. Photograph by Thayer Gowdy.

Project BlackDog™ is offering bounties, including a **$50,000 1st prize**, for the best applications ported to run on BlackDog. You can port your applications or create new ones, and **TAKE YOUR BLACKDOG FOR A WALK!**

Project BlackDog offers open source developers an exciting new platform for mobilizing your software applications. BlackDog is fully equipped with:

- 400Mhz processor
- 64MB of RAM
- 256MB of Flash memory
- USB 2.0
- Serial Peripheral Interface
- biometric scanner

It also includes a software development kit, complete with sample applications, and everything you'll need to create any application you can imagine.

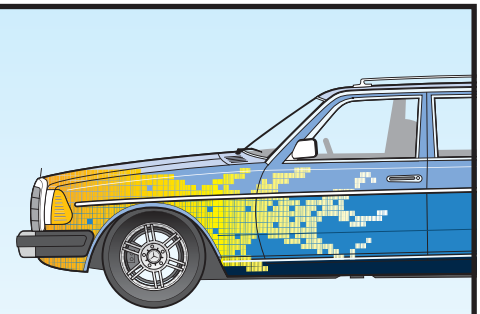
For more information, please visit:

www.projectblackdog.com

Make: Projects

MOD YOUR ROD

Control your car by computer, integrate an iPod into your stereo, become a Wi-Fi hotspot on wheels, make a liter of biodiesel, and more. A MAKE special section.



Halloween Haunted House Controller

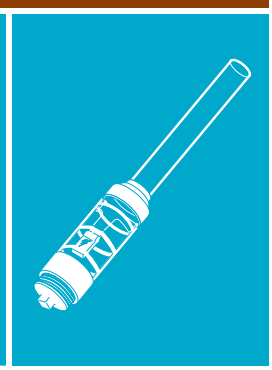
By Eric J. Wilhelm

VCR Cat Feeder

Convert an old VCR into a programmable pet food dispenser.
By James Larsson

Night Lighter 36

Make a see-thru potato cannon for late-night fun.
By William Gurstelle



Unlock the Secrets of Your Car's Engine

Repair your own car and save - guaranteed!

Use your PC or PDA to access
hundreds of dealer codes . . .
Ford • GM • Chrysler • Toyota • Honda

Customize your own "Virtual Dashboard"

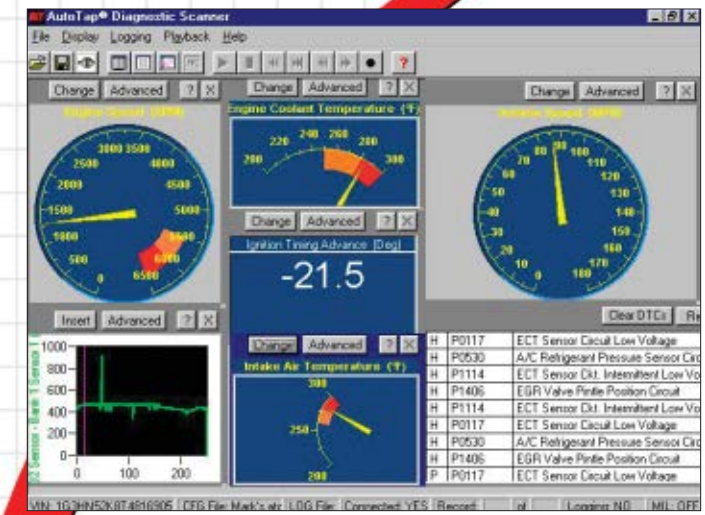
Quick troubleshooting...Hundreds of trouble codes with simple descriptions.

Hi-performance.....Monitor knock retard and add higher octane fuel as required.

Check engine light.....Monitor/Reset the "Check Engine Light".

Emissions readiness.....Determine what is necessary to pass emissions tests.

Towing a trailer.....Monitor transmission temperature to prevent premature failure.



Visit our website today!

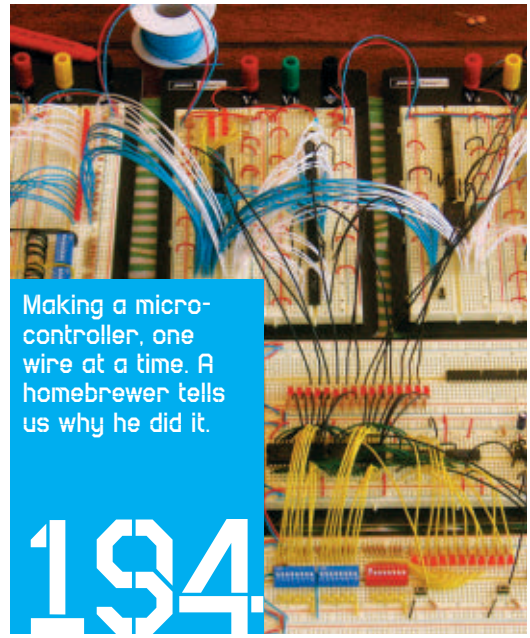
www.autotap.com/MAKE

Register now for our FREE information:
- How today's OBDII cars and trucks work
- Most common failures and how to fix them

Purchase Now and Save
- FREE 30 Day Trial
- 5 Year warranty
- Reduced price on access to web support
- Best offer on real-time, phone, repair assistance

AutoTap®
OBD II Diagnostic Scanner
707 Dayton Road Ottawa, IL 61350 • T: 815-433-5100

Volume 03



DIY

Dale Dougherty

MAKER FRIENDLY

WHAT WOULD IT MEAN FOR PRODUCTS TO BE more maker friendly, not just user friendly? When I see a product described as user friendly, I wonder if it's designed to be too easy, like a book that's written for newbies, and if it will actually prevent me from doing some interesting things. I suspect that makers want to know as much information about a product as possible and that they enjoy learning — if not from manuals then from their own hands-on experience.

We've seen the microwave oven with the sticker: No User Serviceable Parts Inside. When it comes to consumer electronics, software, and websites, a lot of them are designed to lock out users and keep them from getting behind the user interface. Shouldn't more of these products be maker-serviceable? Shouldn't the manufacturers make it easier to take a product apart to tune or tweak it, or simply to repair it myself?

So let me tell you about trying to repair my daughter's damaged iPod mini. The year-old unit had fallen off a table while the audio jack was attached; the plug that held the jack broke off,

> "Makers really want the details, and more importantly, want access to the product itself."

leaving the stem inside the iPod mini port. I first grabbed a set of tweezers to see if I could pull out the jack, but I couldn't get a grip on it. I tried pliers but I didn't have a pair small enough. I considered sending the unit in for repair, but it was out of warranty. The Apple support site indicated they'd charge for a replacement unit rather than actually repair it. I stopped by an Apple store where the resident geek admitted he couldn't do anything. "You should try opening it up," he said. "It's out of warranty so...." Knowing that I was faced with buying a new one, I decided I had nothing to lose opening it.

Now the iPod mini is in no way maker friendly (nor are any of the user-friendly iPods). The person at the Apple store told me I needed to use a blow dryer to heat the glue that held the plastic top on. So after doing that – about a minute on high — I used a butter knife to pry off the plastic top. Then I bent and removed a metal bracket, which was soldered to the body. Only then was I able to get at the piece that held the jack. I pulled it out and ejected the stem by pushing it out from the back. After I put all the pieces back together (without the requisite soldering and gluing), I was thoroughly amazed that the restored iPod mini actually worked. Still, I shouldn't need to blow dry an iPod mini to open it, no matter how cute it is.

Manufacturers should encourage makers, not thwart their efforts. To be maker friendly means to provide access to good information about the product. Makers really want the details, and more importantly, want access to the product itself. Makers want to look inside and see the moving parts. They want to do the unexpected, such as make repairs and improvements, and even harvest components once the product ceases to be useful.

Look at the lessons of open source, which provides open access to the underlying source code. When a system is open and easily modified, it anticipates adaptation to a variety of uses that were never considered in the project's original design.

The personal computer had a design that was maker friendly. I recently replaced a video board on a two-year-old PC without even needing tools, not even a butter knife. Try doing that on your TV.

If you know of products that you'd recommend as maker friendly, or ones that fail miserably on that account, drop me an email and let me know.

Dale Dougherty is the editor and publisher of MAKE. He can be reached at dale@oreilly.com.

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

CREATIVE DIRECTOR
David Albertson
david@albertsondesign.com

ART DIRECTOR
Kirk von Rohr

ASSOCIATE EDITOR
Phillip Torrone
pt@makezine.com

PROJECTS EDITOR
Paul Spinrad
pspinrad@makezine.com

DESIGNER
Kristy McKoy

DESIGN INTERN
Bess Farah

EDITORIAL ASSISTANT
Arwen O'Reilly

ASSOCIATE PUBLISHER, MARKETING
Dan Woods

COPY CHIEF
Goli Mohammadi

COPY EDITORS/RESEARCH
Terry Bronson
Sarah Saulsbury
Michael Shapiro

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

ADVERTISING COORDINATOR
Jessica Boyd

MARKETING & EVENTS COORDINATOR
Rob Bullington

WEB EDITOR
Terrie Miller

PUBLISHER AT LARGE
John Battelle

Visit us online at:
makezine.com

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

MAKE TECHNICAL ADVISORY BOARD:
Gareth Branwyn, Joe Grand, Saul Griffith, William Gurstelle, Natalie Jeremijenko

MAKE is printed on recycled paper with 10% post-consumer waste and is acid-free. Subscriber copies of MAKE Volume 03 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.

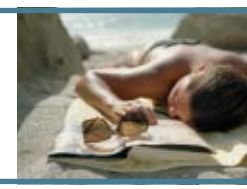
Contributors

Charles Platt (*Maker Profile*) is a former science-fiction writer (his best known book is probably *The Silicon Man*) who switched to journalism and became a senior writer for *Wired* magazine. Currently running a small R&D business in Florida, Platt pursues portrait photography as a spare-time interest, and is a longtime fan of Hong Kong martial arts movies. His favorite show is Viva La Bam on MTV. His interest in MAKE-ing gadgets began when he built a tic-tac-toe computer from telephone relays in 1966.

Sparkle Labs (*DIY Nightlight*) was founded by **Amy Parness** and **Ariel Churi** as a collective of designers and engineers after years of collaborating in NYU's Interactive Telecommunications Program. Their vision for Sparkle Labs is to explore new technologies and sustainable materials in order to create more thoughtful designs. It designs, programs, prototypes, tests and brands its own designs as well as those of its clients. Amy and Ariel work in the East Village in NYC with other Sparkle Labs designers, engineers, and two Siamese cats.

Timmy Kucynda (*VCR Cat Feeder* illustration) lives and works in the upper Haight with his dog Munky. Outside of illustration, he spends his time playing the conga drums and skateboarding (just trying to keep the dream alive), and helping Munky to spread the love around the neighborhood. Green clothing gets the thumbs up. High heels or any shoes that make too much noise are a thumbs down.

Thayer Gowdy (Cover and *VCR Cat Feeder* photos) is a self-described workaholic, whose two other favorite occupations are to travel to "dusty little Latin towns to take photos and drink cheladas" and "watch my husband surf cold northern California waves while I daydream about traveling to dusty little Latin towns." She is also working on a knitting book based on biological patterns found in nature, and lives in San Francisco with her husband and two cats. Her favorite foods are chicken mole enchiladas and homemade marshmallows.



Eric Wilhelm (*Halloween Haunted House Controller*) is an engineer who enjoys finishing projects almost as much as he likes starting them. He has a PhD from MIT in mechanical engineering and works at Squid Labs, where he designs, models, builds, and tests new technologies when he's not kitesurfing, tandem bicycling, or cooking highly elaborate breakfasts. He and his wife live high up in the hills of Oakland, Calif., with an amazing view of the San Francisco Bay.

Bill Gurstelle (*Spud Gun*) is an author (and former engineer) living in Minneapolis, Minn. His first book, *Backyard Ballistics*, is about "making interesting things that go whoosh, boom, or splat," and his fourth book, tentatively entitled *Adventures in the Technology Underground*, will be published in February. He appeared on the television show "Win Ben Stein's Money," and with Ben Stein's money, built a full-size wooden catapult. He is currently laying siege to the people next door, and says, "If all goes well, soon the whole neighborhood will be mine."

Contributing Writers:
Tor Amundson, Tim Anderson, Fernando Botelho, Gareth Branwyn, Jill Butler, Nick Carter, Kevin Conod, Cory Doctorow, Rob Elam, Joe Fung, Joe Grand, Saul Griffith, Dan Gonsiorowski, William Gurstelle, Jason Griffey, Nigel Hall, Charles Hoffmeyer, Joe Holt, Mister Jalopy, Xeni Jardin, Brian Jepson, Steve Koschman, James Larsson, William Lidwell, Steve Lodefink, Carlo Longino, Jake Ludington, Cameron Mallory, Merlin Mann, Matt Maranian, Dave Mathews, Dan Mikesell, Johnathan Nightingale, Quinn Norton, Danny O'Brien, Tom Owad, Bob Parks, John Perez, Charles Platt, Polly Powledge, Mike Riley, Bob Scott, Chris Smith, Sparkle Labs, Ewan Spence, Bruce Sterling, Damien Stolarz, Howard Wen, Eric Wilhelm

Contributing Artists:
Michelle Denham, Nick Dragotta, Thayer Gowdy, Sara Huston, Erik Johnson, Timmy Kucynda, Tim Lillis, John Perez, Damien Scogin, Nik Schulz, Stacy Stelnicki, Casimir Sienkiewicz

REAL SECURITY VS. JUNK SCIENCE

Why copy-restriction technology succeeds only in hurting the user.

DRM (DIGITAL RIGHTS MANAGEMENT) — basically, copy-restriction technology — is built on junk science. But it has a more popular, less visible cousin that actually works: conditional access. The two get mixed up a lot — deliberately, as DRM vendors often point to conditional access systems to prove their wares' viability. Conditional access may not always be used in a way that's good for the public interest, but at least it actually works.

Here's the problem with DRM: a single leak, however obscure, is all it takes to render the system useless. It doesn't matter if you're not leet enough to crack the DRM on a DVD; you can always download it after searching Google. Making the first copy is hard, but every subsequent copy is as easy as can be.

> "No iTunes customer ever bought a song for the DRM it contained, but lots ponied up their $0.99 because they wanted the access it got them."

Leaks happen. Always. The DRM systems place the proprietary file and the tools necessary to open it in the hands of infinitely skilled, infinitely resourced attackers (bored Norwegian teenagers, rabid Ukrainian gangsters, Princeton engineering grad students) who go through this crap like Superman shredding wet Kleenex. They have all the advantages, and if DRM requires that they never break the systems, the DRM systems are doomed.

Conditional access (CA) is a lot like DRM. It often relies on cryptography; it secures or restricts access to files and resources and is often included alongside of DRM. Apple's iTunes Music Store (iTMS) has a conditional access system that doesn't give you access to a song until you go through the one-click purchase process that moves $0.99 from your bank account into Apple's hands.

But CA has an important difference. CA doesn't worry that you'll get unlawful access to a work that they're protecting today, nor with the disposition of the stuff you got access to yesterday. CA systems are all about what you do tomorrow.

If the iTMS was compromised so that you could download ten tracks without paying for them today, it wouldn't matter: tomorrow, they could patch the system and go back to charging you for access again.

Looked at that way, it's clear that iTunes DRM is just a cost-sink, while the CA is a vigorous, multi-hundred-million-dollar profit center. No iTMS customer ever bought a song for the DRM it contained, but lots ponied up their $0.99 because they wanted the access it got them.

What's more, the DRM hypothesis of keeping honest users honest is herein revealed for a sham: every song for sale on the iTunes Music Store is likewise available as a totally free, unencumbered MP3 on P2P networks like Grokster and Kazaa. Honest users choose to get the iTunes version not because of the DRM, but in spite of it.

Lots of us have had an intuition that the right goods at the right price is all that it takes to sell stuff on the internet, even when the same stuff can be downloaded gratis. iTunes music sells because Apple's interface and service/support are better than the P2P networks.

If you want to compete with free, start by making a better product.

Cory Doctorow (craphound.com) works for the Electronic Frontier Foundation (eff.org), and co-edits Boing Boing (boingboing.net). His new novel is *Someone Comes to Town, Someone Leaves Town* from Tor Books.

A fool and his money are soon parted.
Don't be a fool. Go electric.





ZAP®

501 Fourth Street, Santa Rosa, CA 95401 USA tel (707) 525-8658 • web: www.zapworld.com e-mail: zap@zapworld.com • Stock Symbol: ZP

AND MILES TO CODE BEFORE I SLEEP

HOW TO HACK YOUR CIRCADIAN RHYTHM

By Merlin Mann & Danny O'Brien

Illustration by Sara Huston

EVERYONE LOVES SLEEP. IT'S LIKE VIRTUAL reality without the dumb helmet. But if you're the sort of person who hyper-focuses on challenging tasks, you probably like the idea of sleep more than the actual practice. Sleep good: just not sleep *right now*.

Not right now, when I've almost completely debugged my application. Not right now, when I've almost checked all these solder joints. Not right now, when I'm only three-sixteen hundredths of the way through ripping my entire DVD collection. These progress bars don't stare at themselves, people!

The problem comes when "right now" consistently turns out to be 5:30 a.m., and the nagging voice you're waving off is your own body's need to collapse.

Congratulations. Your sleep pattern is now a neat inverse of the rest of your timezone's inhabitants. You've hacked your sleep schedule, and now it's in pieces on your workshop floor.

The traditional nerd folk remedy for a shattered sleeping schedule is that life hack known as "wrapping around," or "phase shifting." Sleep experts call it "chronotherapy," and prescribe it for those who have advanced night owl tendencies. In anyone's terms, it's called "staying up even later than you normally do and seeing what exactly happens."

Here's what exactly happens: you stay up two or three hours later than usual every night, until you are so out of phase that you click back into the next cycle, and resynchronize with the rest of the world.

It takes about ten days. At first, it's a great release to not force yourself to go to bed, like trying to get yourself on a diet by eating so many pies you'll never eat food again.

But then — according to Life Hacks own experimental subject, who we'll call Exhibit DO'B — wrapping around has all the painful aspects of a bad holiday: jetlag, unpaid time off work, and having to deal with strange cultural oddities like breakfast and morning people. It's a hormonal rollercoaster ride, and not covered by any warranty.

You will eventually reach the point where you're going to sleep at around 3 p.m. and waking up at 11 p.m. At that point, fun empties from the universe. However your diurnal rhythm is programmed, God did not mean you to look up from your lunch and see the sun rising. When I — er, our subjects — have done this, I found my body temperature plunged so quickly it felt like it was trying to slide out of my toes. My goosebumps had goosebumps.

But perhaps the worst part of wrapping around is that it's a hack, but it's not a *complete* hack. It's a temporary fix, a kludge. You may sync yourself back with the real world, but that next all-nighter is going to throw you just as far out of whack as before.

If you want to permanently sort out your sleeping patterns, you need good sleep hygiene. For that, we heartily recommend William Dement's *The Promise of Sleep* (Dell), which does a good job of romping through the accepted wisdom of handling your sleeping patterns. For those of you who like your info provided raw and cut-and-pasteable, there's

> "If you want to permanently sort out your sleeping patterns, you need good sleep hygiene."

nothing better than Bora Zivkovic's sleep science blog, Circadiana, circadiana.blogspot.com/.

The sleep hygiene hack is this: lots of sun in the morning. Sun is the vertical sync signal in life's erratic hormonal TV transmission. Get a big shot in the AM, and your body will latch onto the correct rhythm. Hide from the "evil day star," as many hackers do, and you'll lose vertical hold, and be flipping over and over the days and nights.

If you can't stand the sun, you can build your own artificial one. While thermonuclear explosions are too short to really resync your sleeping patterns, and magnet confinement fusion can disturb the neighbors, for sleep rebooting purposes, as Zivkovic says, solar activity can be simulated with "a piece of board, 3-4 strong neon lightbulbs, balasts, a switch, a plug, and some wires." Shine it in your face at dawn if you tend to sleep late, dusk if you tend to arise early.

Don't forget the flipside: hide from light when about to sleep. For computer geeks, that means dim your screen! For extra hack points, write a script that dims your screen gradually over time.

For those who crave that late-night creativity: go to sleep *really* early, like 9 p.m. You'll get up at maybe 4 a.m., but for night owls, that's when you're at your best.

It's important to move to a sleeping pattern that looks like a sine wave from one that looks like a seismograph. Don't mess your sleep cycle around; if you hack life that much, one day it will hack you right back.

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

"All the Speakers That's Fit to Hear"

Madisound Speakers

Midwest: A cold front brings thunderstorms, raining caps and coils over much of the nation.

Vol. XXVI | *EVERYDAY, SEPTEMBER, 2005* | FREE

BK-16 Folded Horn Kit Wows them at CES 2005

LAS VEGAS, 2005 - Attendees at the CES show in Las Vegas were delighted with the sound they heard from the Fostex BK-16 folded horn they heard in the Madisound room.

We have chosen the **Fostex FF165K** 6.5" full range for use in the BK-16 cabinet. The **FF165K** has a **Kenaf fiber cone**, inverted foam surround and aluminum dust cap.

The **FF165K** is run full range with a frequency response out to 15kHz. The **T90A** super tweeter has been added to cover the upper frequencies. The **T90A** is a top-mount horn tweeter with an **Alnico magnet**. The tweeter is rolled off on the low end with a **Fostex Tin & Copper foil capacitor.** The system frequency response is 55Hz to 35kHz at 95dB.

The **BK-16** cabinet is made from **Baltic Birch** plywood and is sold flat, unassembled, unsanded and unfinished. Cabinet dimensions are 9.75" W x 14.75" D x 29" T.

The kit includes:

- Pair of Cabinets - Flat
- Pair of FF165K
- Pair of T90A
- Pair of DB-Cup
- Pair of Crossovers
- Nordost 2-Flat wire
- Instructions

Kit Price: $635 /pair
No Cabinets: $439 /pair

Loudspeakers and advice for over 25 Years.

Madisound Offers:

- Capacitors
- Inductors
- Resistors
- Loudspeakers
- Kits & cabinets
- Grill Cloth
- Binding Posts
- Banana Plugs
- Cable
- Crossover design
- Advice
- Books

Speaker Enthusiasts Get Assist

From Dr. Joseph D'Appolito

MOSS, NORWAY - Seas Fabbriker AS announces a joint project with Dr. Joseph D'Appolito, speaker guru. The result is ***The Thor,*** a handsome 1/4 wave transmission line speaker. The Thor delivers accurate bass and articulate treble frequencies in a T-line design that has been used by many skilled and ambitious hobbyists.

This kit uses two Seas **Excel W18E001** magnesium woofers and **T25CF002 Millennium** Sonotex dome tweeter, mounted in a **D'Appolito** configuration. Usable in-room bass response extends to 30Hz.

Thor is an audiophile product sure to impress discriminating listeners. The **highs** are transparent. The **midrange** has exceptional clarity and openness. The **bass** is deep and solid, not boomy.

The cabinets are assembled Oak veneer in Clear or Black finish, or Cherry veneer. The grills are black and are recessed flush with the speaker front. Cabinet dimensions are 45½" H x 9" W x 14¼" D. Assembly requires some skill at soldering.

Price per pair: $1615.00

Premium crossover upgrade, add $200.00

The Thor is also available without cabinets, subtract $590 from the cost.

MADISOUND SPEAKER COMPONENTS, INC.
8608 UNIVERSITY GREEN
P.O. BOX 44283
MADISON, WI 53744-4283 U.S.A.
TEL: 608-831-3433 FAX: 608-831-3771
e-mail: info@madisound.com
Web Page: http:/www.madisound.com

Tim O'Reilly

NEWS FROM THE FUTURE

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

In his book, We the Media, Dan Gillmor refers to "the former audience" to describe the shift in power represented by blogging and citizen journalism. But the former audience isn't just taking control of news. A fan group recently completed a full-length feature film of Terry Pratchett's Discworld novel *Lords and Ladies*. Cost: 300 euros. Over at untamedcinema.com, fans create high-quality trailers for movies they wish the studios would make. And much of the buzz in the months leading up to the release of the latest Star Wars flick centered around the 40-minute fan film, *Star Wars Revelations*, which many think is better than the last two efforts from the man himself. The producers of *Serenity*, a science fiction movie due out in September, who have been doing an aggressive online push for fan participation, decided to show an unfinished copy of the movie in ten cities, five months in advance of the official release.

On the radio front, Infinity Broadcasting, a unit of Viacom, has announced that its KYCY-AM station in San Francisco will be switching to an all-podcast format. Meanwhile, Evan Williams, of blogger.com fame, is launching Odeo, a company that aims to bring podcasting to the masses. And, hot on the heels of the new buzz, we see several startups focused on bringing advertising to the new medium.

The principles of "former audience" participation don't apply only to the media world. Neil Gershenfeld's *FAB: The Coming Revolution on Your Desktop — From Personal Computers to Personal Fabrication* hit the Amazon bestseller lists immediately upon publication. A researcher at the University of Bath aims to release, under the GPL (a free software license), designs that would allow rapid prototyping machines to make copies of themselves. A USC researcher has prototyped a "contour crafting" robot that can extrude concrete walls; his next project is to extrude an entire house.

It's not personal fabrication that will most change the way we create physical goods, though (at least not at first). Never mind "the network is the computer" — the network is the factory. "Build to suit" (as when you configure and order your next computer online) may mean internet coordination of a network of suppliers, and the computer you order may never be touched by an employee of the company that sells it to you. It may not even have been designed by an employee of that company, as new product design is increasingly being outsourced.

In a manufacturing realm that is both larger and smaller than consumer goods, the Liftport Group, a consortium focused on building a space elevator, will be opening a carbon nanotube manufacturing plant in New Jersey. Meanwhile, scientists at the University of Washington and the Fred Hutchinson Cancer Research Center have successfully induced a state of hibernation in mice. It's time to crack out the science fiction of the 50s for ideas about promising applications for human hibernation, from space travel to trauma care.

Did I say trauma care? The U.S. Army is researching mobile robot surgery units for battlefield use. And as for life extension, Ray Kurzweil likes to point out that average life expectancy in developing nations is going up by a quarter of a year per year. When that number goes above a year per year, we live forever, right? On the other hand, largely driven by the spread of AIDS, life expectancies in many African countries have fallen every year since 1988, a phenomenon some are referring to as "the African cliff." But, in a true sign of the discontinuities of the modern world, a startup in Kenya recruits villagers for city jobs by texting job offers to (and accepting applications from) their mobile phones, leapfrogging services in the developed world.

You can get URLs for the referenced stories at makezine.com/03/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.

Shopper Chopper

So you want to polish up your metalworking skills, you've just bought a welder, and you're interested in mechanical engineering. If you're like **Michael Dowling** and **Noam Davidson**, you acquire a shopping cart and build a go-kart out of it.

"Noam has wanted to build a go-kart for awhile," explains Dowling. "With a Safeway shopping cart we found, and an old lawnmower motor, the idea just presented itself."

"We thought that it would be hilarious if we could speed down the aisles of a grocery store, doing some high-speed shopping and then race out the door," Davidson, 21, says.

Davidson's father apparently bought into the idea, buying him a welder, then securing a plasma cutter, a beam bender, a horizontal/vertical band saw, and a shear press for cutting sheet metal.

The University of British Columbia students gathered other supplies, including wheels off of a wheelchair, damper shocks from a hydraulic hospital bed, gears from an old belt sander, and a plastic steering wheel, once again acquired from a shopping cart, this time a kiddie version. They spent most of last summer creating their masterpiece.

The final model has an upgraded motor (from a paltry 2hp to a flip-inducing 10hp). "When we took it out for a test drive, in a semi-choked position, the torque the motor generated was too much and it would flip the cart over. So instead of depowering our cart to a smaller engine, we installed a wheelie bar on it," Dowling says.

Speeds of up to 60 kilometers per hour were attained without even letting the throttle out. Dowling and Davidson have yet to find a long straightaway in their Vancouver, Canada, neighborhood to test the cart with even a touch of the throttle, which they estimate could get them up to 110 km/hr.

"The 10hp motor had way too much power for the

Photography by Michael Dowling

cart and was actually pretty frightening at first to drive," Davidson says.

The shopping cart go-kart may not get the chance to test its ultimate speed, however. The guys have moved on to grander projects and a grander shop.

The new and improved workshop includes an industrial lathe, two mini mills, a 4'x4' CNC router table, a bigger band saw, different types of mills, and a milling machine.

"We kind of have moved on to bigger and better things," Dowling says. "We would like to build a real go-kart or dune buggy."

—Shawn Connally

» **Go-Kart:** *batman.mech.ubc.ca/~mdowling/Go-kart.html*

At right, top: Plastic steering wheel from a child's shopping cart. From the gear box next to the steering wheel, a makeshift series of welded shafts follow the steering wheel's movements and move the cart accordingly.

At right, middle: Detail of drive train, including slip clutch and the sprocket gear that drives the rear axle.

Below: Damper shock recycled from a hydraulic hospital bed and wheels from an old wheelchair.

Gods of Thunder

Innovative engineering is often an iterative process of refinement and testing. For **Nelson Pass**, this means constructing ever-huger sound systems, and then field-testing them by throwing ever-louder parties.

For his latest creation, Pass built speakers that deliver bone-shaking volumes down beyond the low threshold of human hearing. The lowest registers are handled by a pair of sub-subwoofers known as El Pipe-O, named after their resemblance to an old college roommate's beloved water pipe.

El Pipe-O's acoustical properties derive from twin, 10-foot-tall cylinders cut from 24-inch-diameter cardboard tubing, normally used to cast concrete pillars. Mounted over 21-inch (read: immense) woofers, these tubes act like organ pipes. At one party, Pass and his collaborators decided to test whether the manufacturer's peak power rating for these woofers, 800 watts, was accurate. After blowing the speakers out, they concluded that it was.

At frequencies above 50Hz, the system routes its output to another set of speakers — the Klein Horns, so-named because they look like Klein bottles ("klein" also means "small" in German). The Klein Horns' massive wooden cabinets take sound pressure and raise its volume acoustically by routing it through chambers that follow the same "exponential horn" principle as a trumpet, only for sub-tuba frequencies. As with El Pipe-O, the Horns' dimensions are dictated by the lowest frequencies, the magic number being one quarter of the bottom note's wavelength, or 9½ feet for a 30Hz tone.

Rounding out the system are a pair of ribbon tweeters and a crossover network that directs the sound to the six speaker channels. All together, they produce sound that's flat over the entire audible spectrum (and even a bit below), even at mad volumes. *—Paul Spinrad*

Pass DIY: *passdiy.com*

Photograph by Nelson Pass

Go, Jet Kart, Go

In the small town of Lebanon, Oregon, you might see **Richard Flanagan** cruising down an empty farm road in his homemade, jet-powered go-cart. But you'll definitely hear him.

The 57-year-old machinist reaches speeds of 60 mph in the 7x3½-foot vehicle, and more importantly, he can generate a lot of fire and noise. "People come out of their houses to look," says Flanagan. "At night, it lights up the neighborhood."

To hear him talk, jets are easier to build than you'd think. He starts with a turbo charger from an old car — made to compress air for the intake of a traditional engine, it also works well for pushing the fuel and air mixture into the jet's combustion chamber.

Flanagan buys turbos from junked cars and 18-wheeler diesel trucks, then adds his own shafts, ball bearings, and custom-welded chambers. (He's holed up 75 used turbos for future projects.)

To keep everything running smoothly, he created an electronic throttle control that captures sensor readings on exhaust temperature, RPM, and volume of fuel. A car battery and power converter deliver the necessary voltage, while bicycle tires help it glide over rough terrain.

After recently selling three on eBay, Flanagan hopes to create more for like-minded drivers. Who doesn't want a ride with a calculated max speed of 200 mph, and the option of using gas, diesel, or paint thinner as fuel? All for $1,500.

"The demand is incredible," he says. "Every kind of nut out there wants a jet engine."

—Bob Parks

Tankful of Tunes

In the late 90s, bass player **Ezra Daly** couldn't find a decent stand-up bass for under $1,000. So he decided to make his own. At the time, he was working in a hardware store, and began experimenting with plastic buckets and broomsticks. He tried other containers as resonators, and eventually settled on using motorcycle tanks.

They were "the coolest thing I could think of, and they come in all sorts of shapes and sizes," he says.

For the next three months, Daly took woodworking classes, apprenticed with welders, and studied milling and electronics. He dubbed his first instrument — made from a Guzzi Ambassador gas tank and scrap wood — the "Frankenbass."

Getting more adventurous, his next design used two tanks. This unlikely marriage of Triumph and Harley parts was called the "Venus de Moto."

He sold his third, the "Cycle Pole Slap Bass," to Alex Kirt of the Wood Box Gang. It took over a year to make, and came with a custom case made from a fiberglass kayak. Since then, Daly has begun to outfit his creations with fancy details, such as Harley fork covers, silver dollars, and side lamps that flash to the beat. The basses he makes are hybrids — they can be played acoustically or with electric pick-ups. They're also smaller and lighter than traditional stand-ups.

When bikers harass him about killing classic bikes to make his instruments, Daly points out that "no motorcycles were harmed. The tanks are still intact and, if need be, can be used again."

—Phillip Torrone

Wreck and Roll: *wrecknroll.com*

Photography by Richard Flanagan (Jet Cart) and Ezra Daly (Tankful of Tunes)

Solar Death Ray

Twinkies turn into fiery black husks in a few minutes. A *Clue* board game bursts into flames. A Richard Simmons video melts into a sticky plastic glob. As a concept, it's funnier than a Letterman stunt — and based on real science. Readers of Solar Death Ray can suggest any object at all, and **Louis Giersch**, a 26-year-old grad student, will obligingly expose it to 1,000-degree temperatures in a homegrown, 112-mirror solar concentrator.

The site's highlight may be its hilarious post-ray writeups, which read like mock lab notes, but it was Giersch's attention to detail that made the Death Ray work at all. (The hosts of a recent *Myth Busters* episode tried to build a concentrator, but couldn't properly focus the mirrors.)

Giersch, who studied plasma spacecraft propulsion at the University of Washington, started by writing an application in the Matlab visualization language. Mirrors on the 4'x6' backboard have a tolerance of 0.5 degrees either way to properly focus light, and the software supplies the exact angles Giersch needs. He built small wooden bases for each mirror, with the correct corresponding angle, and used a compound miter saw with an onboard protractor to cut the blocks quickly. The blocks screw into the frame along eight concentric circles from the plywood's center. Mastic adhesive glued on 3½-inch mirrors.

An improved Death Ray is currently in planning, boasting a suntracker and motors to automatically position it for the greatest solar blast. It sounds like the ultimate weapon of mass destruction, but not for use in Portland maybe. "I've stored up a whole bunch of stuff that I really want to burn," says Giersch, "but clouds keep coming up out of nowhere. I got halfway through a Rubik's cube, and it just sort of petered out."

—Bob Parks

Solar Death Ray: *solardeathray.com*

Photograph by Louis Giersch

Photograph by Gauri Nanda

Time That Waits for No One

Covered in brown shag carpet and propelled by gray, rubberized wheels, Clocky, a mobile alarm clock invented by **Gauri Nanda** of MIT's Media Lab, may be the next pet rock. But this adorable inanimate object has a purpose: to get you out of bed in the morning.

Here's how it works: after Clocky's alarm goes off, you hit the snooze bar. Clocky rolls off the bedside table and finds a new hiding place. A few minutes later, it goes off again and you have to hunt for the damn thing to turn it off. Presto: you're out of bed and probably won't go back to sleep.

Clocky's movements are entirely random. An internal computer is programmed to make it move in varying directions, says Nanda, 25. "The idea is that he will find new places to rest every day, which creates a sort of hide-and-seek game. The over-sleeper has to employ more of her senses before disabling the device."

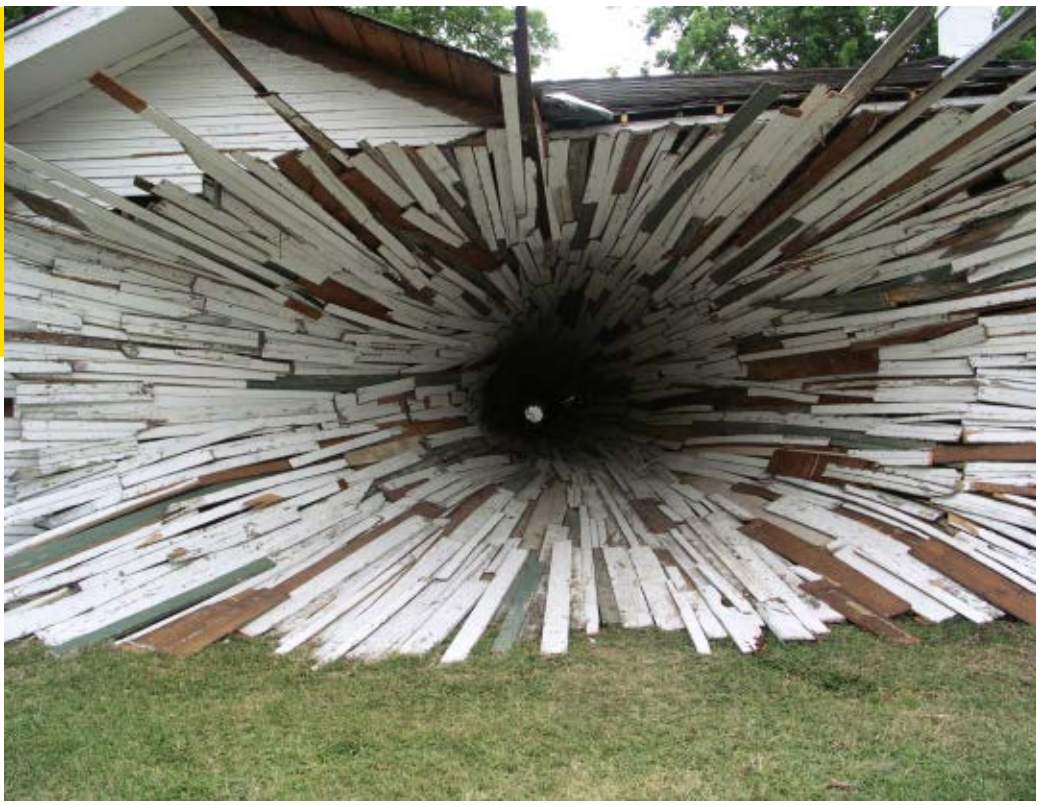
Clocky, whose first wheels came from an old Lego set lying around the Media Lab, is covered in shag, a nod to the carpet her parents had used to cover stereo speakers back in the 70s. "As I started to develop the clock, I realized that the look worked really well with the concept that Clocky is like a troublesome pet that you love, and less like an annoying, stressful device that you've learned to defeat," she says.

This union of "troublesome pet" and useful gizmo has generated a splash of publicity for Clocky. Nanda was recently interviewed on *The Today Show* and demoed Clocky on a bedroom set for *Good Morning America*.

Was Nanda worried about getting up in time for those early-morning shows? Not with Clocky by her side ... or rolling across the room.

—Michael Shapiro

Clocky: *www.clocky.net*



Household

All good things must come to an end — but not all ends are lucky enough to be good, much less artistic. So when the Art League of Houston gave two local artists the freedom to transform soon-to-be-demolished houses into one giant sculpture, the artists jumped at the opportunity.

The result? Inversion, a wormhole-like fissure in the side of a house that looks like a time travel experiment gone awry. While no unusual gravitational fields are detectable in the area, this anomaly still has the power to suck in passersby.

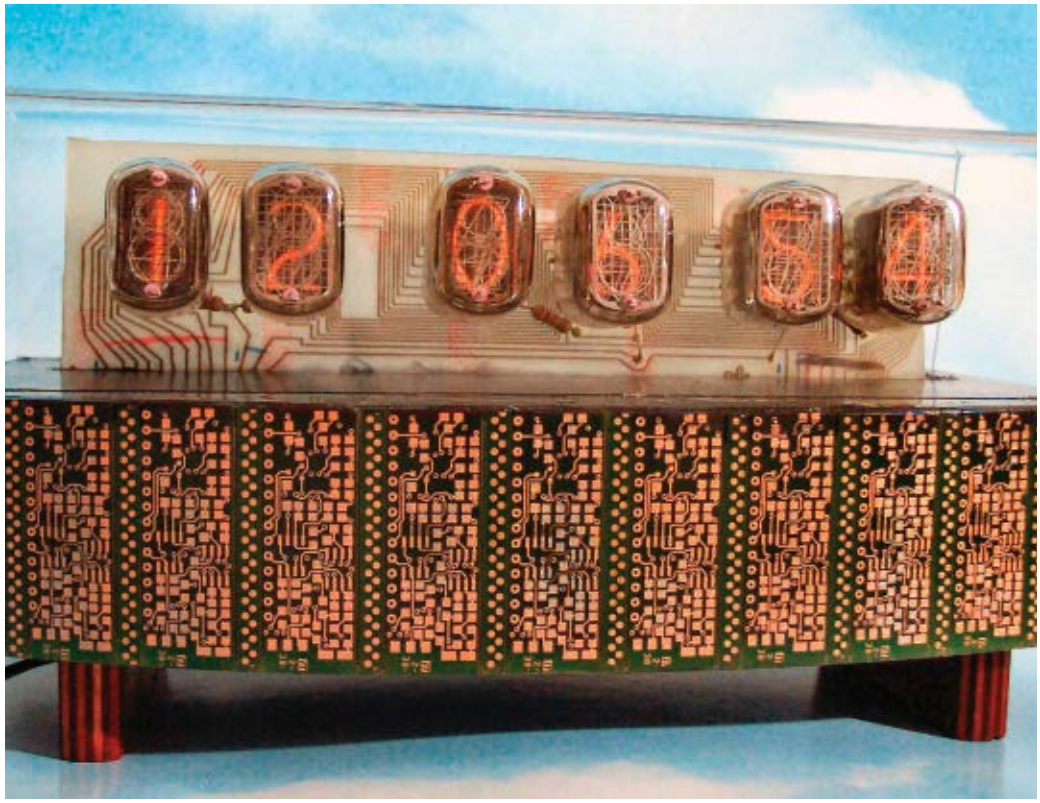
Houston sculptors **Dan Havel** and **Dean Ruck** created the giant sculpture by peeling off the exterior skin of the old houses and connecting the wooden planks in spiral fashion inward. The resulting funnel is about 8 feet in diameter at its opening and converges to about 2 feet as it exits into a courtyard behind both buildings.

What drives two artists to spend 300 hours stripping planks and wielding nail guns to create a temporary structure? "A lot of art has to do with the language of architecture. Being aware of space and how it relates is a big focus of the project. We approached the houses as one big object — not as something small in a container — but something we could carve," says Havel. "We also were interested in manipulating a solid geometric architectural form to create a more fluid, organic characteristic."

Inversion came to its end in June 2005. "A key component of the project was the structure's demolition," said the artists. "The temporary, ephemeral aspect of the project forces the viewer to experience the project differently, retaining a stronger memory of the houses instead of it becoming an everyday background on Montrose Boulevard. Inversion celebrates both the past and future of the Art League as it nears groundbreaking of a new studio/classroom building."

—Jill Butler

Photograph by Jill Butler



Photograph by Andrew Argyle

Nixie à la Mode

A furniture maker by day, **Andrew Argyle** had been making clocks for years when he discovered that eBay had made previously obscure nixie tubes easy to obtain. These old neon indicator tubes were all but abandoned in the 70s with the advent of LEDs, but along with nostalgia for vinyl and typewriters, nixies have experienced a revival.

Like other electronics enthusiasts, Argyle began turning the tubes into glowing reminders of the past, present, and future. "I like to try and recycle components from old computers," he says. "The complexity and beauty of old technology is often lost. This way, at least something is preserved from a disposable past."

The motherboards for his clocks come from the scrap piles of friends and family, the interface cards from various high-tech salvage places, and the wood for the cases from the local lumberyard — unless, that is, he's mounting the nixies in a chunk of 400-million-year-old coral he collected on the shores of Hudson Bay. Constantly innovating, he's currently working on making the clocks wireless so he can send anything in text form to the display: stock prices, temperature, dates.

When asked about other, possible variations, he admits to trying to adapt a "bizarre Russian alphanumeric display to show the time and have a playable version of Pong on it." He also wants to add a Geiger counter, which he sees as the nixie's "spiritual cousin."

The rage for nixies has spawned numerous web pages with schematics, as well as those selling everything from miniature to jumbo tubes in bulk, custom-made clocks, and even nixie wristwatches. After all, says Argyle, "there's nothing like seeing the warm orange glow of the neon from your own creation."

—Arwen O'Reilly

Nixie: *glowingtech.com*

GET A LIFE

The virtual makers inside Second Life.

Wheel of Virtual Fortune: Second Lifer Chandra Page makes and sells imaginary vehicles, such as this unibike, which she sells for cash-convertible Linden dollars.

EVER SINCE ONLINE GAMES WERE INVENTED, people have chafed to break the limits of the gaming experience. But the rule-breakers have generally come across as hecklers — cheats, player-killers, "griefers," tossers of rotten tomatoes — instead of creators. Since it was all for play, there was no good way to take the audience behind the curtains of game design and turn them into game designers themselves.

Enter Second Life (secondlife.com), which is massive, online, and multiplayer, but not a traditional "massive online multiplayer game." Second Life, which has 20,000 participants and the goal of a million users by 2007, is probably best understood as a platform for development. Development of what? Well, pretty much anything people can think up for the platform, really.

Second Life has a graphic design engine on board. Any player can use that — you can practice in a "sandbox." If you build something permanent that you want to show off to players — a nice church, let's say, or a mall store or casino or strip-joint — then you pay rent or buy virtual property. That's where the owners of Second Life make their own money — they use real estate taxes, like a town does.

Most of the people "playing" Second Life simply swan around goggling at the stuff done by the local creatives, maybe buying virtual clothes, toys, or tickets to public events. But the movers and shakers in Second Life are the people who make stuff.

You might call them franchise game developers. Prosumers. Creative-class hackers. Otaku hobbyists. Role-playing game athletic stars. Salonistas. Minor celebrities. Culture-industry entrepreneurs.

They're also a bit like bloggers who can work in 3D. I'm running out of synonyms here, so let's cut to the chase: Second Life is more centered on user creativity than any "game" has ever been before.

Now come some weird implications, which are mostly economic. The virtual things one makes in Second Life are the maker's intellectual property. The game doesn't claim to own them — the maker does. This means the maker can sell them — for fake money within the game, and, uh, for real money, too. The "Linden dollars" that circulate within Second Life are swiftly convertible into actual U.S. dollars, on, say, eBay or the "Gaming Open Market" (gamingopenmarket.com), where 1,000 Linden dollars can be exchanged for about US$4.

Trading game money for real money isn't new — it happens in EverQuest, Ultima, Anarchy Online, Lineage, Camelot, and many other games, but in Second Life, makers are, in some sense, in the design and manufacturing business. The skills they learn on the Second Life website are remarkably akin to those in genuine 3D product design, the programs the big boys use: CATIA, formZ, SolidWorks. Those are the digital CAD-CAM specs behind actual objects.

So it would seem pretty likely, maybe even inevitable, that the making of virtual assets has to cross over into plans for genuine products that can also function outside the context of a game. We're not talking about the licensed ancillary rights to a toy Darth Vader lightsaber here — no, I mean the spontaneous creation of real stuff from a highly unreal world with, let's just say, a million people living in it.

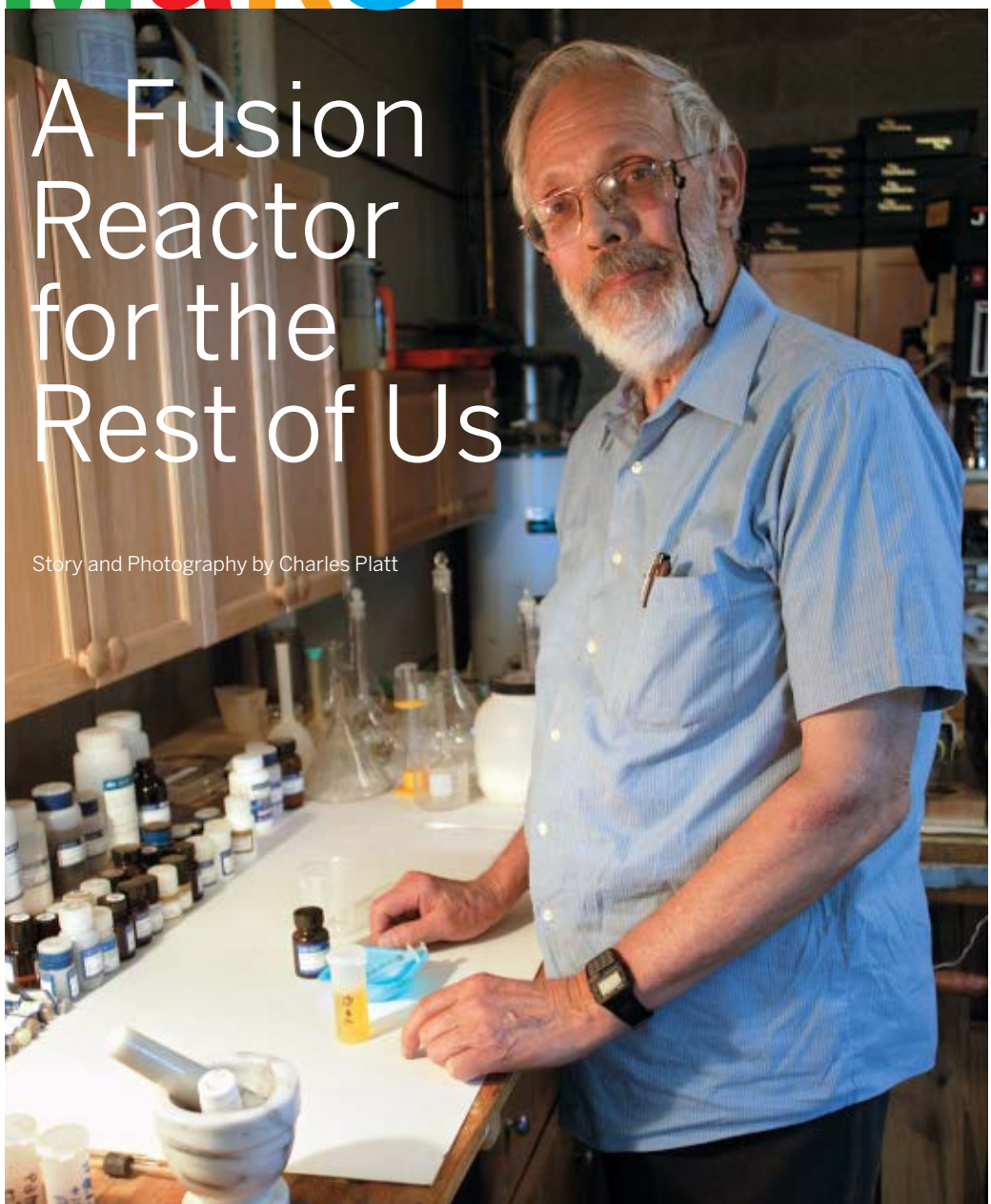
Then what? Do we play? Or do we just watch?

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

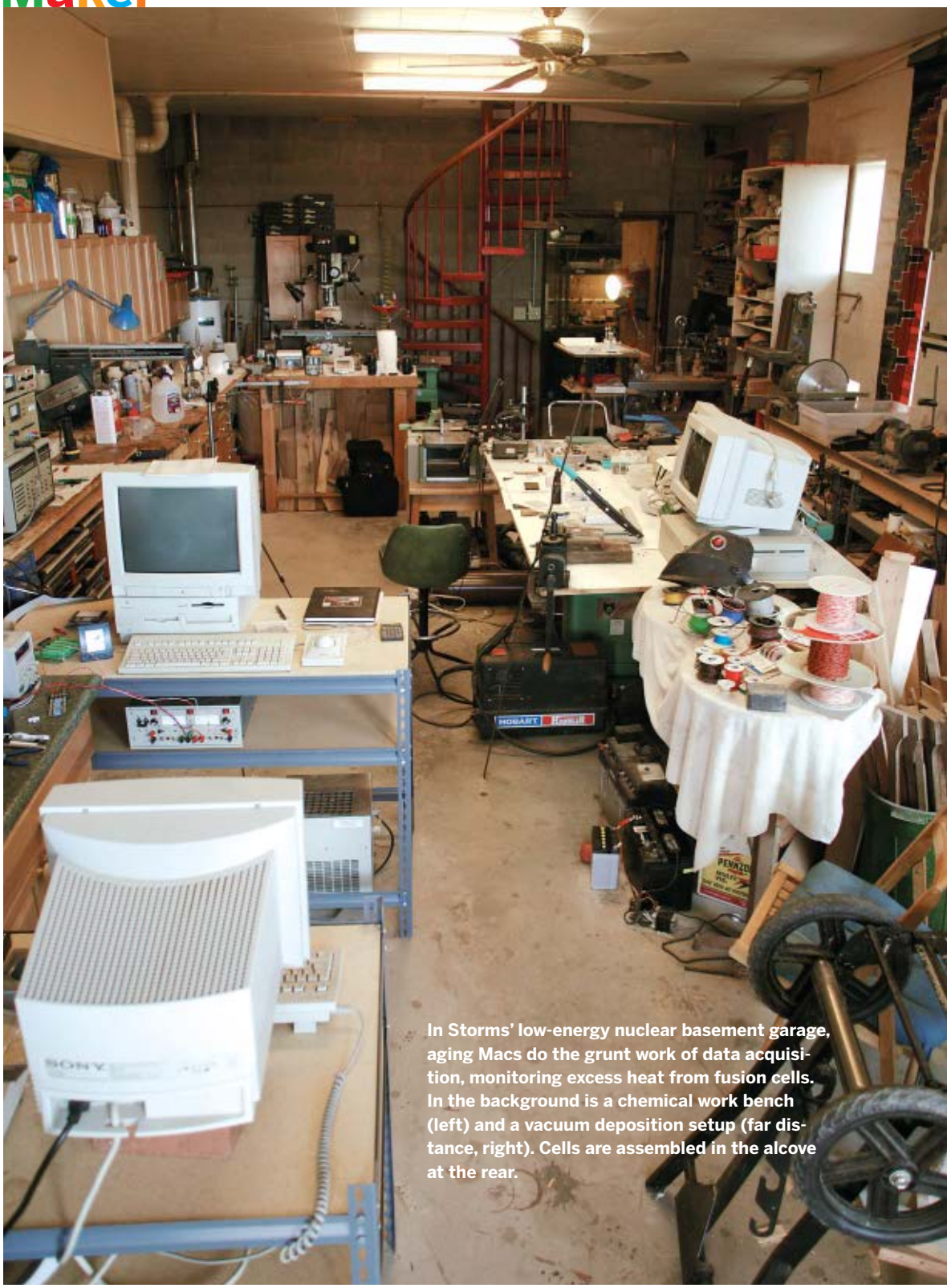
Photograph by Chandra Page

A Fusion Reactor for the Rest of Us

Story and Photography by Charles Platt



"Watch out for any dog poop," Ed Storms warns me as I step behind his scanning tunneling electron microscope (STM). Imported from Czechoslovakia, this sleek, state-of-the-art laboratory hardware dominates a recreation room that used to contain a ping-pong table. I don't see



In Storms' low-energy nuclear basement garage, aging Macs do the grunt work of data acquisition, monitoring excess heat from fusion cells. In the background is a chemical work bench (left) and a vacuum deposition setup (far distance, right). Cells are assembled in the alcove at the rear.

any dog poop, but I have to pick my way around some furniture and across rubber exercise mats that Ed's wife, Carol, placed beneath the equipment to prevent it from damaging the parquet floor.

Storms has a laconic sense of humor, but his relaxed style is deceptive. During more than a decade of supposed retirement, he has worked from his home with relentless ambition and infinite patience to understand and control an obscure phenomenon known as low-energy nuclear reactions (LENR). His latest acquisition, the electron microscope, is on loan from a small Chicago company of speculative investors who hope that Storms may make a crucial breakthrough in his one-man research initiative.

The stakes are immense.

If LENRs exist and can be harnessed, they could eliminate our dependence on carbon-based fuels. Oil would become obsolete for most applications, and electric power lines would largely disappear as cars, homes, and airplanes would acquire their own individual nuclear power cells, capable of generating electricity for decades while costing virtually nothing to maintain. Moreover, LENRs would not be hazardous, quite unlike the dramatically dangerous fission and hot-fusion reactions that occur in bombs and nuclear power plants. Since they don't emit chemical pollutants such as carbon dioxide, they could even alleviate global warming.

Hard to believe? Certainly, this kind of lyrical speculation seems uncomfortably reminiscent of "futuristic" visions from 1950s *Popular Mechanics* magazine covers, or classified ads offering mysterious additives that guarantee 100 miles from a gallon of gas. Since LENRs have been notoriously difficult to replicate on a reliable basis, many skeptics dismiss the entire field as "pathological science."

Still, Ed Storms does not remotely fit the profile of a crackpot inventor. He spent most of his working life in Los Alamos National Laboratory, one of the most prestigious research environments in the world. Arriving with a degree in radiochemistry, his first task was to design and build a mass spectrometer — a device used to measure the presence of elements in vapor with extreme precision. He became involved in the SP100 program, an effort to build a power reactor for use in space, and he played a significant role in the Rover program, which developed a nuclear-powered rocket motor. This project reached the point where it was tested in Nevada. "We had a reactor with liquid hydrogen flowing in at one end and hydrogen gas coming out at the other end, around 2,500 degrees Kelvin," Storms recalls. "The specific impulse and the thrust were just enormous. It could have taken 100 tons to the Moon without any problem. But Nixon killed the program when he needed the money to bomb Vietnam."

The final and fateful phase of Storms' tenure at Los Alamos began when Stanley Pons and Martin Fleischmann announced their discovery of "cold fusion" in 1989. The laboratory sponsored a major effort to replicate the effect. Of about 100 scientists who were involved, Storms was one of only three who succeeded. During a year-long series of 250 separate experiments, he measured excess heat on numerous occasions and detected tritium, a radioactive byproduct, 13 times, causing him to become convinced beyond any doubt that although the phenomenon was elusive, it was real.

"There's a lot of room for the solitary experimenter."

Other researchers lacked his persistence or were simply unlucky in their selection of metal electrodes, which turned out to be a crucial factor. Pons and Fleischmann were widely discredited, and Los Alamos almost forgot about cold fusion, along with most other conventional research institutions.

In 1991, Storms took early

retirement. He retreated into an unspoiled, mountainous area of New Mexico, worked for

two years with his wife to build a beautiful home among the pines and junipers, and then resumed his research on his own. Today, he is a central figure in a loose-knit international network of LENR researchers who work mostly outside of mainstream science and publish their results on a website (lenr-canr.org) for which Storms is the science editor. Piece by piece, they have accumulated a formidable body of evidence suggesting that nuclear fusion can and does occur at moderate temperatures, and can be demonstrated using equipment that is small enough, cheap enough, and safe enough to assemble on a kitchen table.

Storms picks up a wafer of palladium less than an inch long and places it in the chamber of his electron microscope. As a pump evacuates air from the chamber, a picture of the palladium appears on a video monitor. It looks like a lunar landscape, pitted and scarred.

"We know now that the nuclear reactions occur in micro domains," he says, pointing to little blips in the image. "The amount of heat that we measure has to do with how many of those micro domains you create on the surface. The energy density is one million watts per cubic centimeter. Most of the sample is completely dead, but if you concentrate on the part that you know to be alive, a couple of microns below the surface, you're up to 100,000 watts per cubic centimeter."

He speaks in his habitually dry, academic style, but allows himself a wry smile. "This is a higher energy density than anything outside of nuclear weapons." If he's right, the only thing that makes LENRs safe to play with is that they occur on a microscopic scale, without creating any neutron radiation to trigger a chain reaction.

He shuts down the $175,000 electron microscope and we walk outside, across a decked area where hummingbirds drink from feeders overlooking a spectacular view of Santa Fe. In the far distance, beyond the town, Storms points to a thin white line which he identifies as tents that have been erected to cover a temporary stash of nuclear waste on a hillside near Los Alamos. While activists and politicians squabble over disposal plans, the "temporary" stash keeps getting bigger. Since LENRs create virtually no radioactive byproducts, Storms sees them not only solving the energy problem but the nuclear waste disposal problem, too.

We enter the other half of his house and walk down a red steel spiral staircase into a garage recessed into the hillside. Carpentry tools such as a radial-arm saw and a band saw remain here since he used this space for his home construction work, but most of the garage has been remade as a laboratory. A chemical workbench stands against one of the cinderblock walls, while an impressive array of vacuum equipment is mounted on an improvised bench opposite. Computers are hooked up to calorimeters, doing data acquisition.

Storms shows me a hand-fabricated electrolytic cell, which would look familiar to any high school student who has seen oxygen and hydrogen liberated by an electric current passing between two electrodes immersed in water. Martin Fleischmann's idea was to substitute an electrode made from the precious metal palladium, which he immersed in deuterium oxide, commonly known as "heavy water." Although it sounds exotic, heavy water is all around us as a trace isotope in everyday water. It yields deuterium,

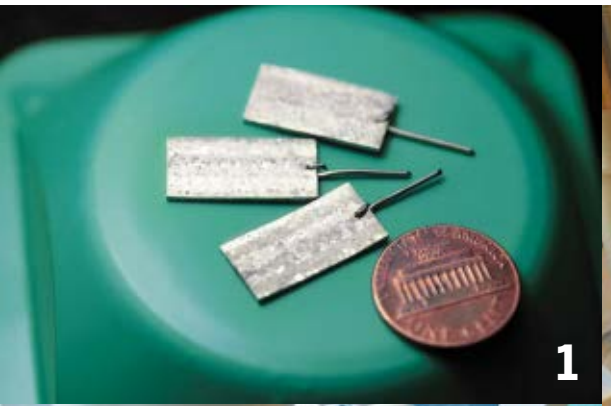
AN ELECTRON MICROSCOPE AT HOME: Edmund Storms, a former Los Alamos scientist, is spearheading the effort to develop a reliable way to enable cold fusion reactions.

1. Wafers of palladium, used as cathodes in Storms' experiments, ready for analysis.

2. A palladium wafer is placed in the vacuum chamber of Ed Storms' scanning tunneling electron microscope.

3. The microscope resolves an image of micro-domains on the palladium surface.

4. Storms sits with his STM where the ping-pong table used to be in his mountain retreat.


1


2


3

4

At 74, Storms shows no signs of slowing down — because he feels he has no choice: "Once you realize that this is real, you can't go back, because your integrity and your conscience won't allow you to go back."

a fancy name for hydrogen that has one extra neutron in each of its atoms. The deuterium penetrates the lattice structure of the palladium, where Fleischmann theorized that nuclear fusion could occur after the deuterium has reached sufficient density. The fusion would liberate heat, which could be harnessed to create electricity.

According to conventional nuclear physics, this was impossible. Atomic nuclei repel each other so strongly, you should need huge amounts of energy to overcome that repulsion and make them fuse. LENR advocates responded by suggesting that unique conditions in a Pons-Fleischmann cell could change the rules regarding nuclear fission; but hot-fusion proponents insisted that positive results were "experimental errors," even after one observer counted 92 separate groups who had validated the phenomenon.

The elusiveness of the phenomenon was blamed initially on impurities in palladium. "People analyzed the surface of the palladium," Storms recalls, "and found platinum from the anode, silicon from the glass, boron from the Pyrex, lithium, and other elements — zinc, copper, and silver." But subsequent studies indicated that impurities were actually necessary. "If the palladium is super pure, it doesn't work," Storms says. "We now believe that when the impurities reach a certain mix, they enable the phenomenon. I've seen this myself. On the occasions when I hit it right the first time, it turns on instantly. It takes no time at all."

He claims the "micro domains" that foster LENR are most common where a thin film of one metal is deposited on another, and he uses an expensive vacuum deposition system to enable this. "I vaporize a palladium wire by passing a high current and low voltage through it," he explains. "If you get it hot enough, it will vaporize without melting, and in a vacuum, you can deposit the vapor on other metals. Other people have done this with electrodeposition, but vapor deposition is cleaner. You can adjust the plating conditions to produce various geometrical characteristics, all kinds of morphologies, widely varying in size. My effort is to sort through that and find what it is about an active material that makes it unique."

Since Storms is an experimentalist, not a theorist, he isn't trying to explain why the phenomenon occurs. He is simply changing variables one at a time in the hope of hitting a combination that will make it occur more reliably.

This is the same kind of trial-and-error approach that Edison used when struggling to develop a working filament for a light bulb. It's comparable, also, to the efforts of scientists who developed high-temperature superconductors — ceramic compounds that ought to behave as insulators yet somehow conduct electricity with zero resistance. Even now, no one knows exactly why these materials behave the way they do. In fact, according to orthodox theory, they shouldn't work at all.

The problem with LENRs is that they are not only difficult to replicate but difficult to detect. Japanese researcher Tadahiko Mizuno claimed he once had a cell that generated 100 watts of heat throughout a period of several days, but such reports are rare, and a more typical result would be 50 milliwatts. Since you must put some

TEST CELL: Inside this typical electrolytic cell, the metal-mesh screen is an anode made from palladium. A glass-covered heater applies a known amount of energy, while a glass-covered thermistor measures temperature.

electric power into a cell before it generates output, you have to be able to measure the difference between input and output power accurately while eliminating environmental factors and other sources of error, such as ordinary chemical reactions that produce heat of their own.

The first step in this direction is to place your LENR cell inside an insulated container known as a calorimeter. This protects the cell from outside temperature fluctuations while enabling accurate measurement of internally generated heat. "Anybody can build a calorimeter," Storms says with a shrug. "A man named John Dash, at Portland State, actually teachers high school students how to do it, for cold-fusion experiments."

On the LENR website, Storms has provided his own step-by-step guide for calorimeter construction — which seems appropriate, since he has been fabricating his own scientific equipment on and off throughout his life. When he was still a high school student, he constructed a Geiger counter, not only soldering electronic components onto circuit boards but learning to do glass blowing so that he could make his own detector tube. Even that wasn't the end of the story: to create a good enough vacuum inside the tube, he had to build his own mercury diffusion pump.

The same spirit still

motivates him now as he machines his own metal parts and does his own computer programming. He insists that others can make their own contributions to the field if they are willing to make this kind of effort. "There's a lot of room for the solitary experimenter. I can name half a dozen people in the United States right now doing what I'm doing and having mixed success, and I get email from students who see that this work is real and valuable, and they want to get in on the ground floor."

He feels that individuals will continue to play an important role in LENR research so long as the phenomenon remains elusive and poorly understood. "Anything truly creative in science is usually done on a small scale by a people outside of the mainstream of academia or the government. Entrepreneurs, little companies. And then, if it works, it grows. It becomes Microsoft."

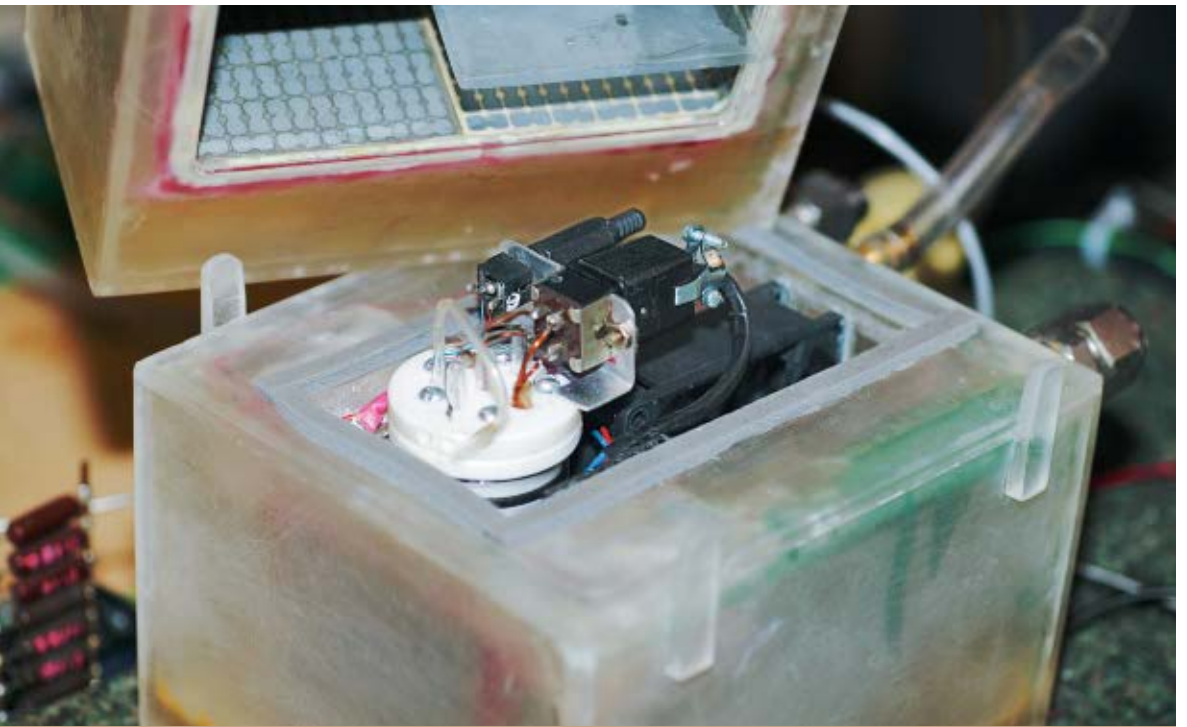
Storms isn't trying to explain why cold fusion occurs. He is simply changing variables one at a time in the hope of hitting a combination that will make it occur more reliably.

Indeed, the history of science is peppered with instances where chance events enabled individuals to make radical discoveries. In the 1700s, Galvani learned accidentally that muscles can be triggered by electricity. French physicist Henri Becquerel discovered the radioactivity of uranium entirely by chance, in 1896. Penicillin, smokeless guncotton, organometallic compounds, and the industrial synthesis of polyethylene and Teflon all entailed an element of chance, often because equipment was poorly maintained or accidentally contaminated.

If Storms does manage to hit upon the ideal conditions to trigger LENRs, he believes the phenomenon will be harnessed for commercial purposes almost immediately. "Nanotechnology is coming along," he points out, "and the computer industry knows how to put down any morphology on a microscopic scale." As soon as the ideal configuration of microdomains is established, semiconductor labs should have no trouble mass-producing nuclear batteries.

Currently, however, the stigma associated with cold fusion continues to discourage well-funded research and development. A recent review by the Department of Energy refused to advocate the allocation of public money, and the academic community remains hostile. "In the United States, they simply are not willing to explore new ideas readily," Storms comments. "That's why a lot of the work now is being done in Italy, Russia, and Japan."

Almost all peer-reviewed journals still refuse to publish LENR papers, while open communication



Above: A Seebeck calorimeter opened to expose an electrolytic cell in which heat may be generated by low-energy nuclear reactions. **Below:** Inside this cell, metals can be plated onto the surface of palladium wafers.

is difficult even within the community. "People who are successful now are not broadcasting the results until they get their patents," Storms says. "Whenever someone has information of any substance, they make you sign a nondisclosure agreement, and after that, you can't talk about it."

Has he been in that position himself?

"Oh, sure. I've signed half a dozen NDAs."

Still, he remains fundamentally optimistic, and at the age of 74 he shows no signs of slowing down — because he feels he has no choice. "Once you realize that this is real," he says, "you can't go back, because your integrity and your conscience won't allow you to go back. You know, Carol wants me to work on the house, and I kid her, I don't have time, because I'm too busy saving the world. That's how big this is."

He pauses, perhaps wondering if he sounds a little over-dramatic. "When you retire, you have to do something to keep yourself occupied," he says, retreating to his more usual laconic style. "And since I don't play golf," he gestures at the cluttered garage workshop, "I might as well be here."

Cold Fusion 101

Learn how to make your own calorimeter and/or LENR cell. Find PDF files about the following at: lenr-canr.org/acrobat/

StormsEhowtomakea.pdf

StormsEcalorimetr

LonchamptGreproducti.pdf

Washington Post on LENR:

Weinbergerwarmingupt.pdf

Charles Platt has been a senior writer for *Wired* magazine and has written science fiction novels such as *The Silicon Man*.

WHAT IS COLD FUSION?

Nuclear fission splits atomic nuclei to produce energy, while nuclear fusion joins nuclei together to produce energy.

Nuclear power plants cause fission reactions by adding neutrons to plutonium or uranium atoms to make them unstable enough to split. When the atoms split, they release additional neutrons, which bombard additional radioactive atoms, causing them to split. Nuclear power reactors use control rods to absorb some of the neutrons to prevent a chain reaction that would lead to a meltdown.

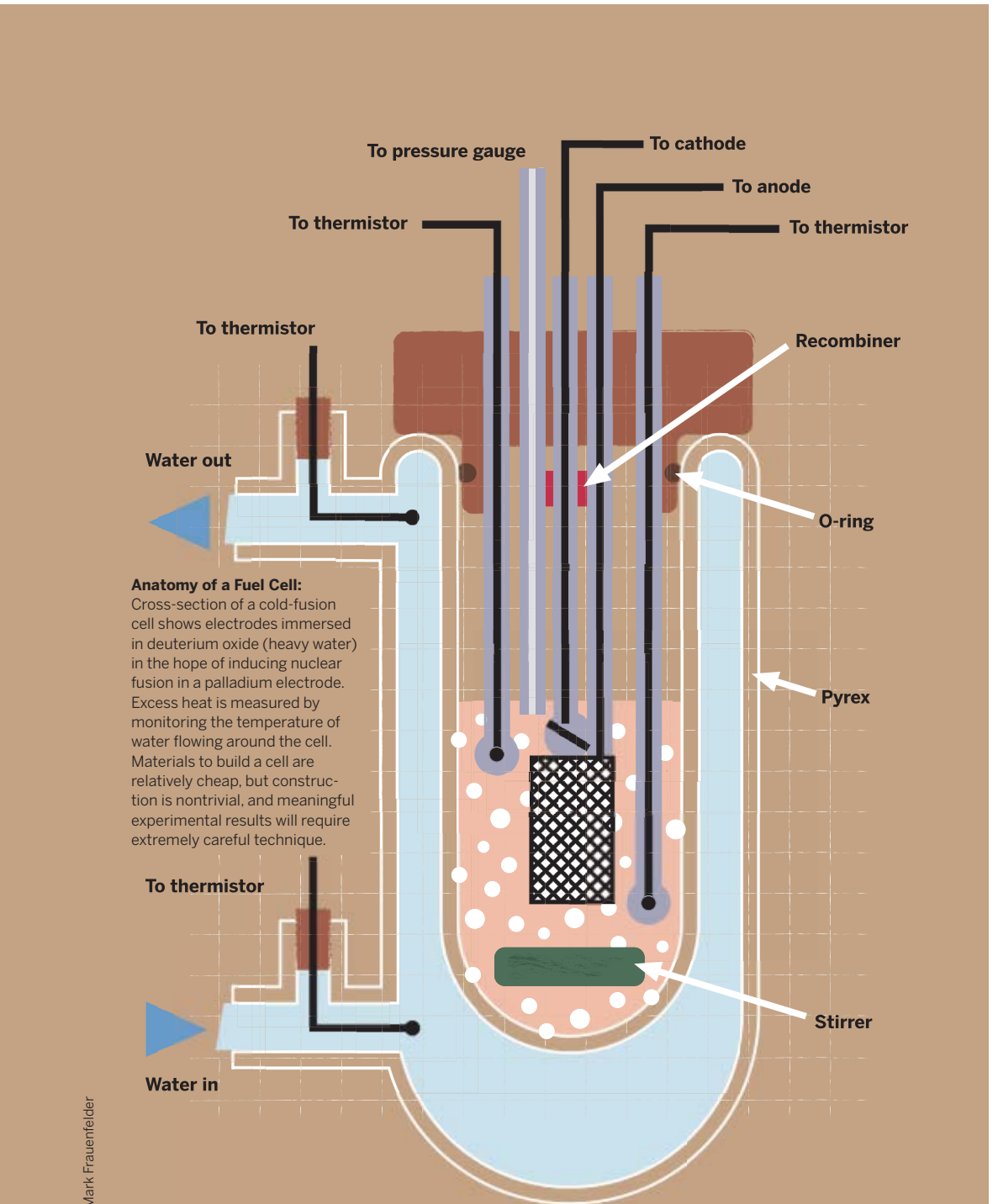
Fusion is harder to achieve, at least by people. The sun and stars are giant fusion machines, but here on Earth, getting deuterium or tritium nuclei to collide with enough force to fuse them together requires very high temperatures. Researchers try to contain the reaction in powerful magnetic fields (solid containers would be vaporized) but progress in this field has been slow.

When Professor Martin Fleischmann of Southampton University and Professor Stanley Pons of the University of Utah announced the discovery of "cold fusion" in March 1989, the news tore through the scientific community like a nuclear explosion. Most scientists could not repeat Pons and Fleischmann's results, and the consensus was that the scientists were careless and foolish at best and scam artists at worst.

But a small number of scientists said they were able to reapeat the results, and research has continued on a small scale. in 2004, the U.S. Department of Energy reviewed the current cold fusion research and concluded, "The experimental evidence for anomalies in metal deuterides, including excess heat and nuclear emissions, suggests the existence of new physical effects." According to Storms, the Pons-Fleischmann experiment has been successfully repeated hundreds of times in the last 16 years.

Today's experimental cold fusion setups are more elaborate than the original Pons-Fleischmann cell, but the general idea is the same. The theory is that the deuterium dissolves in the palladium in such a way that the deuterium nuclei (which normally repel one another with great force) come close enough to fuse.

— Mark Frauenfelder



Anatomy of a Fuel Cell: Cross-section of a cold-fusion cell shows electrodes immersed in deuterium oxide (heavy water) in the hope of inducing nuclear fusion in a palladium electrode. Excess heat is measured by monitoring the temperature of water flowing around the cell. Materials to build a cell are relatively cheap, but construction is nontrivial, and meaningful experimental results will require extremely careful technique.

Illustration by Mark Frauenfelder

SWAMP TECH

By Tim Anderson

LIVING FREE IN THE FLORIDA EVERGLADES

I've been living outdoors for the past few months, mostly in the swamps and rivers of Florida. Fisheating Creek, southwest of Lake Okeechobee, is particularly stunning: white sand, cypress knees, cabbage palms, perfect cool sunny weather, and very few mosquitoes when I was there in March.

Living outdoors is great. I wake up just before sunrise, have lots of energy all day, and sleep well at night, unlike the caffeine-vampire seasonal-affective jetlag meltdown that afflicts most of the people I know back in the land of progress.

I brought plenty of work with me. My laptop is full of more PDFs than I can read and the digital remains of my last five computers. I've got a few thousand trip photos and Xeroxed notebooks of projects I need to finish drawing.

Too bad swamps are so damn interesting. My laptop resides in a urethane rubber envelope inside a gasketed, hard backpack. When I get paranoid, I put that inside a dry bag. I have desiccant but don't usually use it. I bag my toys up when they're warm, and condensation hasn't been a problem.

Photography by Tim Anderson

Ruben Cano in Ft. Pierce gave me some old-growth lumber from his flattened house and a dead corn snake for dinner. My mom says these gentle snakes are the best ones for toddlers to pet, but alas, it was killed for resembling a Copperhead.

Canoe set up for a good night's sleep.

CANOE AS HOME

I outfitted my canoe like a Chinese sampan. That consisted of taking out the center thwart and putting bent willow hoops for a little covered-wagon roof over it. With so many alligators around, I was glad to have something more solid than a tent to sleep in. I have different little roof tarps to choose from depending on the weather.

For a cool, dark den to use my laptop computer, I use the aluminized tarp. If I don't want to distract people from the scenery, I toss a camouflage tarp over that.

Here's the sampan canoe with a bug net (at right), which the locals call a "skeeter bar" because that's where the bugs go for a drink and a good time. I sleep in the middle in a chaise lounge folding chair.

Solar panels and fishing rod are at the bow. I have two Solarex 20-watt (peak) solar panels from the MIT flea market and a few 6- and 12-volt gel cell batteries retired from emergency room lighting systems. These batteries can run my lights, computer, sewing machine, and inverter full of radio and telephone wall warts for longer than I can stand it.

FOOD ISSUES

American hobos developed this fine cooking stove (near right). This one is made from a 3-liter olive oil can. There are air intake doors at the bottom on three sides. I kept cutting and folding down the intake door flaps until there was no charcoal in the ashes. The top is cut with an X and the flaps folded up with a vertical crease to support the pot. The pressure cooker uses very little fuel. It makes it hard to burn food because the bottom doesn't dry out. I'd boil a dozen eggs and steam-bake bread in a bowl atop them at the same time. Seawater has the perfect salt content for making bread dough. I carry an aluminum license plate to put under the stove when I'm worried about killing the grass. I looked forward to distilling drinking water like the old-time gladesmen did, but I never got thirsty enough to get around to it.

A simple method made possible by plastic is to run the steam into a plastic bag for a condenser. (above, bottom right). I tried it with a rice cooker and it worked great. All the salt stayed in the cooker and the fresh water collected in the bag in the tub. The bag was such an effective condenser that the steam hardly puffed it up at all.

I caught a Brown Hoplo armored catfish with my cast net. Delicious flaky yellow meat, simple bone structure, but it's got plenty of bones on the outside. These are South American "sucker fish" kept in aquariums to clean the glass. When they escape, they thrive in the wild, breed, and get quite large. They can't be caught on bait because they feed so low on the food chain. They're not a mercury hazard for the same reason. I removed its tiny entrails full of algae and cooked it over the hobo stove in a pressure cooker.

For vegetables, I sprouted lentils or mung beans (above right) in a quart yogurt tub with vent flaps cut in the lid. Soak two cups of dry beans for a day, discard the water, and rinse the sprouts every day. Eat as many as you want, and the next morning the tub will be overflowing again. Sprouts are very important to yachties, Mormons, and anyone who wants to live well on stored food. The book *Sailing the Farm* (out of print, Google for a used copy) is full of sprouting tips and other ingenious methods for living well on a boat with very limited resources.

The book *Gladesmen: Gator Hunters, Moonshiners, and Skiffers* (upf.com/Spring1998/simmons.html) explains how Everglade frontiersmen distilled swamp water. They used a 5-gallon can for a boiler and a coil of ⅜" copper tubing for a condenser. The condenser coil was cooled in a second 5-gallon lard can full of water.

(ISBN: 0813015731) Glen Simmons and Laura Ogden. $24.95 Cloth. 5¾x8½. 224p. index illus.

LET THERE BE SPEECH

How do you make a $200 computer for blind kids?

By Fernando Botelho

The Challenge

The lack of accessible media material in developing countries can place someone blind, such as myself, in a de facto Stone Age when it comes to productivity. In this context, an inexpensive PDA-type computing device can be nothing less than revolutionary for a blind student. A single device with the functionality of a talking notebook, calculator, textbook, calendar, and dictionary is particularly exciting when the alternative is having none of these.

Your mission, should you accept it, is to make a computing device accessible to millions of blind kids around the world. To do this, you need to find the cheapest device capable of handling Linux, a keyboard, a speech synthesizer, and speakers or earphones. Then, your GPL-licensed creativity will make people like me fundraise in order to mass-produce it.

Traditional solutions such as brailled or recorded books are expensive and often inadequate substitutes for eyesight when it comes to studying or working competitively. Conventional computers using proprietary software are also not a realistic solution given an estimated blind population of more than 180 million. A PC can easily cost in excess of $1,300 when hardware and commercial screen-reading software are included. Finally, the gift of a proprietary solution is the gift that keeps on costing, given the constant need to purchase expensive upgrades to have the latest screen-reading applications and other software.

Here is where you come in. The realities of a population that is 70% to 90% unemployed require a solution that is creative, bold, and uncompromising. While this is a tough challenge, having somebody such as yourself hacking away at it gives us a realistic chance at bringing education and employment to millions of blind folk.

Specs

The magnitude of the challenge requires much more than an incremental improvement on what's now available. The solution we need must cost about $200 and meet the following requirements.

The device must be made entirely of mass-produced parts. This is essential because the idea is to benefit from manufacturing economies of scale and have easy availability of hardware and software. Your solution will be used as a proof of concept. You need not worry if you plugged a PDA board and a keyboard together without these being protected by a sturdy box. The real challenge is getting inexpensive hardware and open source software to talk. Other requirements such as case, assembly, packaging, and language localization, are things someone like myself can fundraise for.

The hack must be entirely based on open source software. This allows your work and that of others

Photograph by Joe McNally/Getty Images

to add up into solutions that cannot be taken away by misguided corporate policies. It also ensures that the end user will remain in charge of the device.

The device must have a "real" keyboard. In other words, it does not have to be a full-size keyboard, but it cannot be a thumb keyboard either. End users will be blind, and a thumb keyboard will prevent them from achieving significant speed at best, and will be completely unusable at worst.

The device may or may not have removable storage media such as a CompactFlash card (even though this would be desirable), but it must have a way of connecting to other devices. This could be via wireless means such as Bluetooth or Wi-Fi, or something as simple as a USB or IR port. The idea is that even if surfing the internet is not possible, the student can, for example, download books or other files from the teacher's desktop machine.

The device must have sufficient computing power to run a version of Linux, a screen reader, and a software speech synthesizer. Hardware speech synthesizers are expensive, reduce portability, increase power consumption, and are not as easily changed to the local language.

Fernando Botelho is an international consultant who manages projects related to trade development, technology, and disability issues.

State of the Art: The Perkins Brailler, a device for embossing Braille was invented in 1951 and costs $700. It has over 500 parts and requires frequent repairs, each of which can cost $100 or more.

"A Perkins Brailler is the classic typewriter for embossing Braille when you have some money, as opposed to a slate and stylus, the classic way of producing Braille when you have no money," says Fernando Botelho.

Shoulders to Stand On

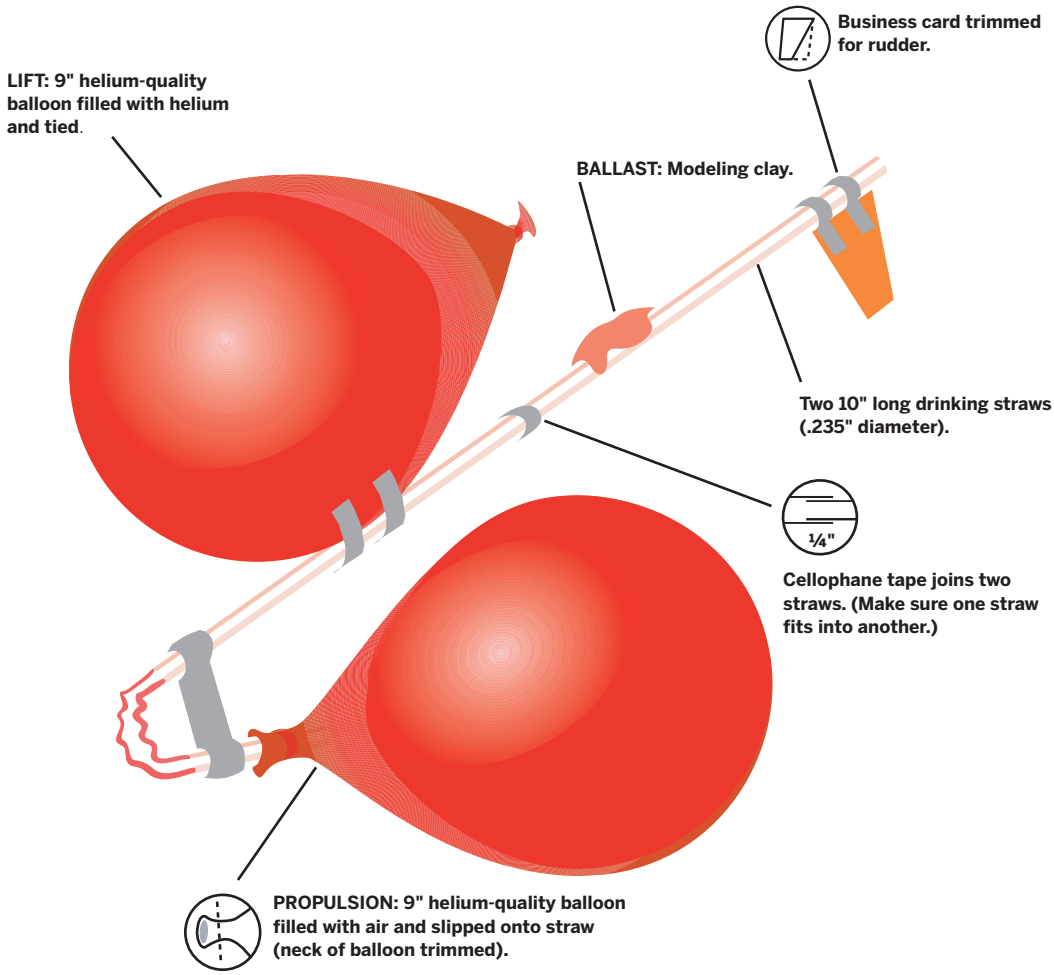
Let us not reinvent the wheel. Here are some leads that might help. I am not a hacker, but I can also try to help at talking.solution@f123.org. Thanks!

1. Talking Linux kernel: linux-speakup.org/
2. Lightweight screen reader for Linux: yasr.sourceforge.net/
3. Waysmall computers: gumstix.org/
4. OS speech synthesis: www.speech.cs.cmu.edu/festival/
5. Desktop for the blind: sourceforge.net/projects/emacspeak/
6. More speech synthesis: tcts.fpms.ac.be/synthesis/mbrola.html
7. Free speech synthesis: freetts.sourceforge.net/docs/index.php
8. Generic Linux for the blind page: leb.net/blinux/
9. Rollable portable keyboard: man-machine.com/FX100.htm
10. Low-cost PDA: amidasimputer.com/specs/

1+2+3

BLIMP By John Perez

Fun for about a dollar.



UP, UP, AND AWAY!

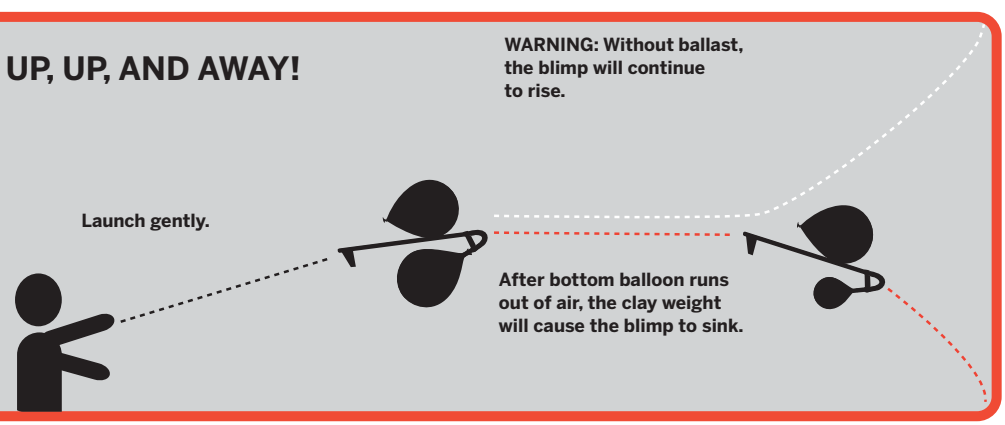


Illustration by John Perez

BOTS BREWED HERE

Silicon Valley's HomeBrew Robotics Club is leading the development of an open source robot hardware system.

By Quinn Norton

Started in 1985, the HomeBrew Robotics Club (HBRC) is a spin off of Silicon Valley's HomeBrew Computer Club, which launched Apple and a host of other personal computer companies.

Chuck McManis has headed the club since 1987, and for 15 years has seen everything a determined group of amateur hackers can build, from octopods to robot blimps. The HBRC has spawned a number of companies, and while none have become the Apple Computers of robotics, from where Chuck is sitting, it's only a matter of time.

Twelve-year-old Tony Pratkanis prepares his robotic blimp for takeoff at a HomeBrew Robotics Club meeting in Silicon Valley.

Make: The HomeBrew Computer Club (HBCC) showed us the microcomputer revolution — what does a robotics revolution look like?

Chuck McManis: In the 19th century, cars could look like anything. Before 1986, a computer didn't look like a computer — no one knew what a computer looked like. Now everyone knows a car or a computer. Robots right now can look like anything — probably the most successful robot out there is the bread machine. No one thinks of it as a robot, but it acts autonomously and reacts to its environment; it does the things that robots do.

How do you encourage people to build in HRBC?

Chuck: By setting small measurable goals. In our Tabletop Challenge, the robots move from one end of the table to the other without falling off. It looks simple, but that's a lot to consider. Building any robot gives you a sense of whole systems design, and tremendous satisfaction seeing your creation do the things you built it to do.

You've said Lego Mindstorms are a good place to start. What about for a more ambitious builder?

Chuck: The benefits of Mindstorms are that everything works together: batteries, motors, controls. Mindstorms, though, leave off at about 5 lbs. Advanced builders build robots that work outdoors and indoors, in adverse conditions, and on non-smooth surfaces. They're looking for new motors, higher payloads, longer run-times, teleoperation, and more extensive mapping.

Can you explain the idea behind RoboBRiX, the robotics platform born at HBRC? How is it unique in a world of robot kits?

Chuck: Mindstorms gave us standard sensors and actuators; however, there was never enough technical information about how they really worked.

RoboBRiX was longtime HBRCer Wayne Gramlich's answer to creating an affordable DIY modular robotics subsystem. He recognized the challenge of wiring up systems that delegate the things robots need to do. Wayne has recaptured the spirit of the original HBCC in that his work is completely documented on the web, the software is released as open source, and he tried to get the price down. They were picked up for sale by robotstore.com, and should be for sale by Jameco soon.

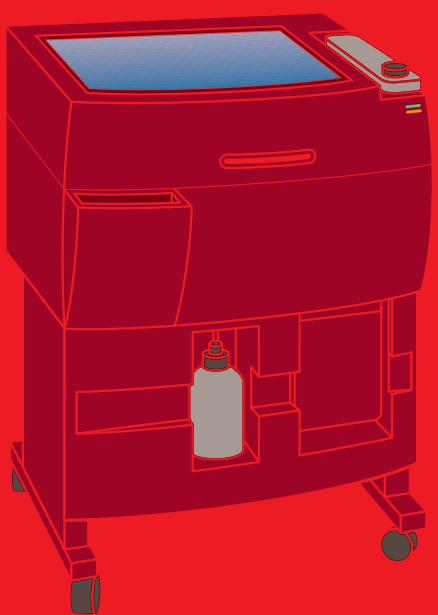
Quinn Norton is a freelance writer and co-blogger at ambiguous.org.

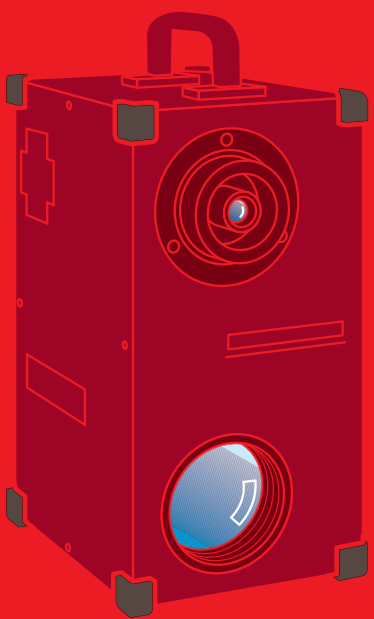
Photograph by Quinn Norton

THE MAKER'S ULTIMATE TOOLS

The tools we use — or wish we could get our hands on. By Saul Griffith

Here's what would go into an extremely expensive ideal toolbox for someone who wants to be able to make pretty much anything, from ultimate fighting robots to hybrid go-karts, and even play around with microelectromechanical systems. You can and will make do without these, but in a perfect world, where the streets are paved with socket wrenches, these five tools would be in your basement. For the complete list, turn to page 46. For an ultimate tools narrative, go to *makezine.com/03/ultimate*.





3D Printer, $25,000

zcorp.com/products/printers.asp

This makes surprisingly beautiful parts; just don't expect them to be robust. It's the fastest way to go from computer model to physical part. My pick of the bunch is Z Corp's printer — it's the cheapest and fastest. Neat fact: They're used to print replacement body parts.

3D Scanner, $30,000

kmpi.konicaminolta.us/vivid/default.asp

These machines are still quite expensive, and accuracy depends on how much you spend and the size of the object you are scanning. They're used a lot these days for restoration of antiquities and sculptures as well as assisting in surgery.

Illustrations by Nik Schulz

Plasma Cutter, $10,000

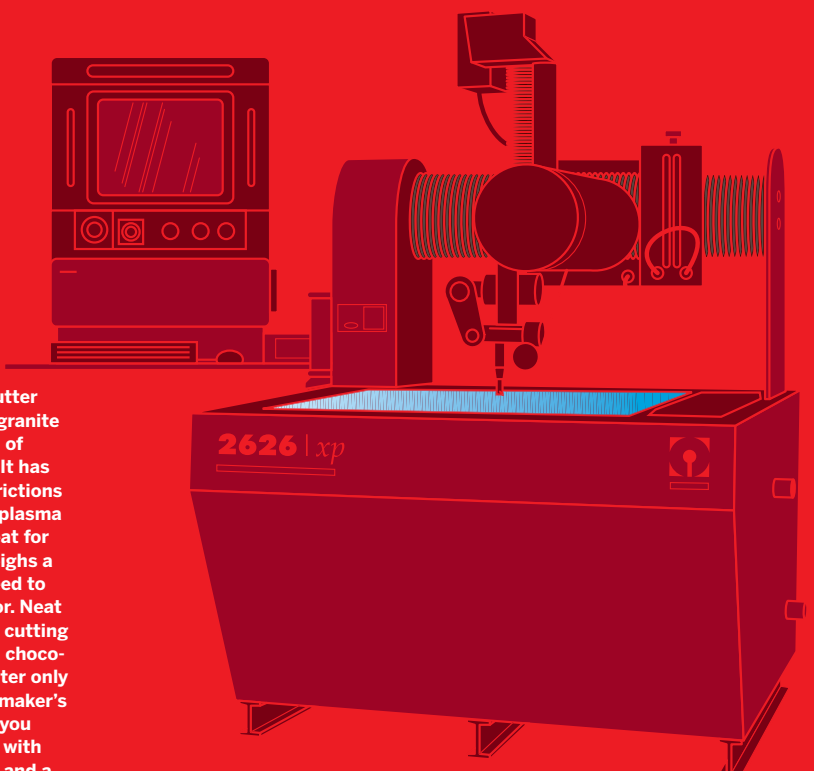
toolking.com/hobart/view.asp?id=4276

It's more difficult to use than a laser cutter, but there's a big advantage: it cuts metal or anything that conducts electricity. Think of it as a robotic oxy torch. You can be up and running for about 10K. Make your own parts for that car restoration project or build custom aluminum chandeliers. Poor maker's alternative: An oxy torch and a very steady hand or a high-quality bandsaw and lots of patience.

Laser Cutter, $19,900

epiloglaser.com/mini2412.htm

CAD-driven high-powered lasers cut plastic, paper, and wood in thicknesses up to about ⅜ inch with very high precision. For kicks, you can write your name on toast or etch your face on an eggplant. They're also good for cutting rubber stamps. Poor maker's alternative: Print the patterns with your inkjet printer and cut them out with a scroll saw. Not as accurate or as fast, but a workable workaround.



Water Jet, $100,000

omax.com

This rich man's plasma cutter cuts through 8 inches of granite with a barely subsonic jet of abrasive grit-filled water. It has none of the material restrictions of the laser cutter or the plasma cutter (though it isn't great for wood). The water tank weighs a ton (literally), so you'll need to reinforce your garage floor. Neat fact: Used extensively for cutting up chicken carcasses and chocolate bars (though with water only — no abrasive grit). Poor maker's alternative: Rumor has it you can do something similar with a washing machine pump and a hypodermic needle.

THE ULTIMATE TOOL BUYING GUIDE

A complete list of tools you need to make almost anything.

If a genie were to grant me my wish for a shed full of tools, this is what I'd ask for. Think of it as an extremely biased guide to outfitting yourself with the ultimate shop for launching your own space program.

- Necessity
- Priority
- Extremely useful
- Surprisingly useful
- Infrequent but handy
- Can do without, better with
- You didn't know it was so lovely

Hand Tools

Tool Name	McMaster #	$ Budget	$ Deluxe
Box Knife	3814a11	1	10
Precision Blade	35435a11 38995a71 35515a12	1	10
Claw Hammer	6484a21	10	50
Ball Peen Hammer	6481a31	10	50
Blacksmith's Hammer (Heavy Weight)	6462a24	10	80
Rubber Mallet	5917a8	10	40
Miter Box	4201a11	15	45
Hacksaw	4086a34	5	25
Tight Spot Hacksaw	4060a16	2	5
Hole Punch Tool	3461a22	40	150
Center Punches and Chisel Set	3506a76	25	120
Metric and Imperial Socket Sets	7290a24 5757a35 5582a11	30	1200
Torque Wrench	85555a221	50	300
Hex Key Sets, Imperial and Metric	5541a31 5215a24 7162a13 5215a12	2	80
Torx Key Set	6959a85	2	40
Mini-Hex Drivers	52975a21 7270a59	2	40
Combination Wrenches, Metric and Inch	5314a62 5304a73 5314a25 5772a53	25	800
Vise Grip Long Nose Locking Pliers	7136a19	2	50
Needlenose Pliers, Small and Large	5451a12	2	35
Bull Nose Pliers, Small and Large		2	35
Vise Grip, Large	7136a15	5	60
Vise Grip, Med Curved	5172a17	5	45
Adjustable Wrenches	5385a12 5385a15	3	40
Crow Bar / Ripping Bar	5990a2	2	30
Tube Cutter	2706a1	15	80
Glass Cutter	3867a16	2	25
Bolt / Chain Cutter	3771a15	50	150
Sheet Metal Snips	3585a13 3908a11 3902a9	10	40
Finishing Saw	4012a1	10	30
Coping Saw	4099a1 6917a11	4	10
Hole Saw Kit	4008a71	25	120
Pull Saw	4058a52	10	20
Metric / Inch Tap and Die	2726a66	40	1200
Drill Sets	28115a77 31555a55 31555a56 31555a57 8802a11 8802a12 8802a13	5	1200
Deburring Taper	3018a4	5	80
Deburring Tools	4253a16 4289a36	2	25
Drill Stops	8959a16	2	10
Vise	5344a31	10	1500
Clamps	5165a25	2	45
Quick-Grips	51755a7	15	50
Jaw Puller	6293k12	50	180
Files	8176a12 8194a12	2	100
Hydraulic Floor Jack		25	200
Block And Tackle / Lifting Winch		50	500
Screwdrivers, Flat and Phillips	8551a31	1	90

Tool Name	McMaster #	$ Budget	$ Deluxe
Jeweller's Screwdrivers	52985a21 52985a23	10	40
Propane Burner		10	50
Heat Gun		50	250

Power Tools

18V Electric Drill	29835a16	25	300
Band Saw	4164a12	250	5000
Reciprocating Saw (Sawzall)	4011a25	120	250
Sliding Compound Miter Saw	3001a21	200	600
Tilting Table Saw	27925a12	300	2000
Drill Press	28865a31	100	2500
Plunge Router	36485a11	100	300
Manual Lathe	8941a12	500	5000
Mig Welder	7899a28	200	1500
Stroboscope	1177t92	25	250
Adjustable Hot Plate	33255k61	50	800
Dremel	4344a42 4370a5	50	150
Angle Grinder	4395a16	50	250
Bench Grinder	20535A654	75	300
Belt Sander	4892a21	100	200
Disc / Belt Sander	46245a49	250	1500
Bridgeport Mill		500	15000
Heisseschneider Hot Knife		50	200
Sewing Machine		25	2500
Air Compressor	4364k3	200	2500
Spot Blaster	31195k11 3210k11	50	500
Vacuum Pump		100	1000+
Oxy / Acetylene Torch	7754a12	250	1500
Plasma Torch		600	3000

Computer Controlled Tools

Inkjet Printer		25	250
Large-Format Printer		900	25000
Nc Mill		2500	120000
Nc Lathe		5000	150000
Laser Cutter (Co2)		12000	50000
Plasma Cutter		3000	20000
Wire / Sink EDM		100000	250000
Water Jet		80000	150000
3D Printer (Z Corp, FDM, STL)		25000	250000
Plotter / Cutter (Roland)		1000	25000

Electronics Tools

Wire Stripper		2	80
Pliers Set	5323a49	10	120
Work Holder And Magnifier	5007a14	5	100
Multimeter		75	250
Temp-Control Solder Station		150	1000

Tool Name	McMaster #	$ Budget	$ Deluxe
Hot Air Tool for Point Reflow / Desoldering		30	500
Bench Power Supply, Multi-Output		150	500
Toaster Oven, Adjustable Time / Temp		40	60
Microscope (See Safety / Measurement / Visualization)			
Oscilloscope		500	5000
Micro-tweezer Sets		2	100
Pick-n-Place		3000	25000

Fetish Tools

Optics Bench		1000	400000
Mask Writer		50000	1000000
Mini-jector		4000	50000
Thermoformer		1000	20000
ESEM		25000	500000
3D Scanner		5000	100000
Excimer Laser Cutter		100000	1000000
PCR			100000
Micropippettes		20	2000
Spin Coater		500	25000
High Temp / Vacuum Oven		2000	30000
Chemistry Hoods and Glass Equipment		2000	1000000
Ultrasonic Welder		5000	25000
Tube Bender		1000	40000
Tanks for Anodizing, Etching		25	2500
Kiln		500	5000
Anvil		250	1000
Crucible		20	2500
Thin Film Evaporator / Sputterer		5000	100000

Safety, Measurement, and Visualization

Safety Goggles	2404t21	1	10
Ear Muffs	9205T6	2	30
Micrometer	2054a75	5	300
Caliper	8647a44	5	500
Head-Mounted Magnifier	1490t3 1509t14	5	120
Feeler Gauges	2070a7	1	25
Spirit Level	2169a4 2169a1	5	50
Tape Measure	19805a74	1	25
Adjustable Stereomicroscope	10705t64	500	25000
Hot Gloves		5	100
Work Gloves		1	40
Welding Mask		15	100

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.

- 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.

Make:

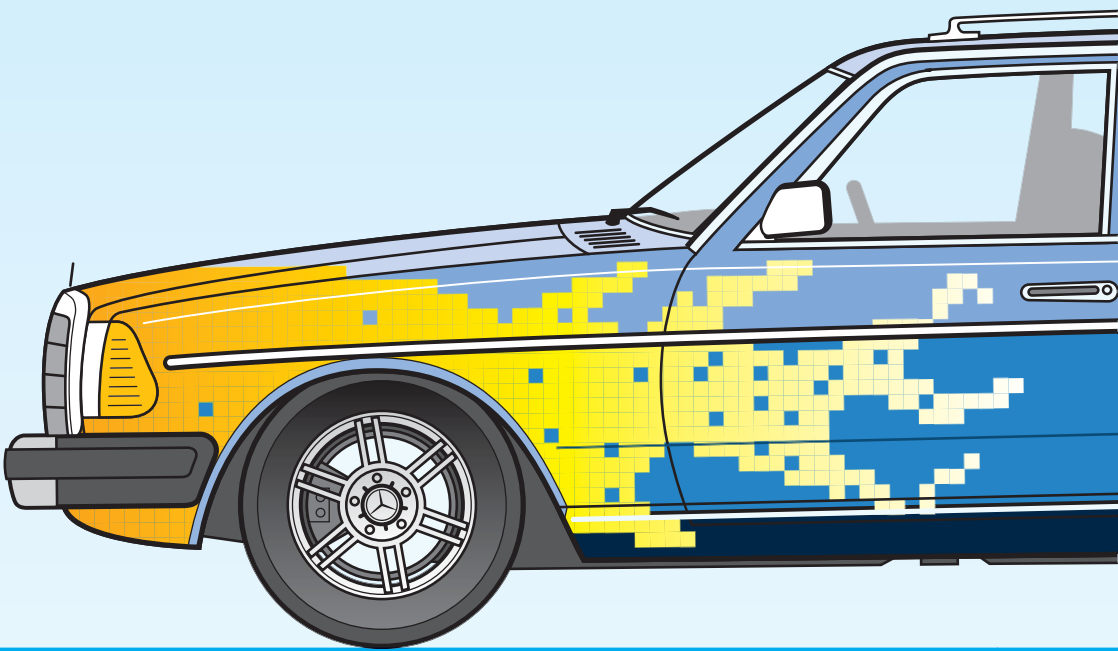
Bay Area Maker Faire
November 12 & 13, 2005
San Mateo Fairgrounds

Visit makezine.com/faire for all the details.

50252

MOD YOUR ROD

CARS ARE HACKABLE PLATFORMS ON WHEELS

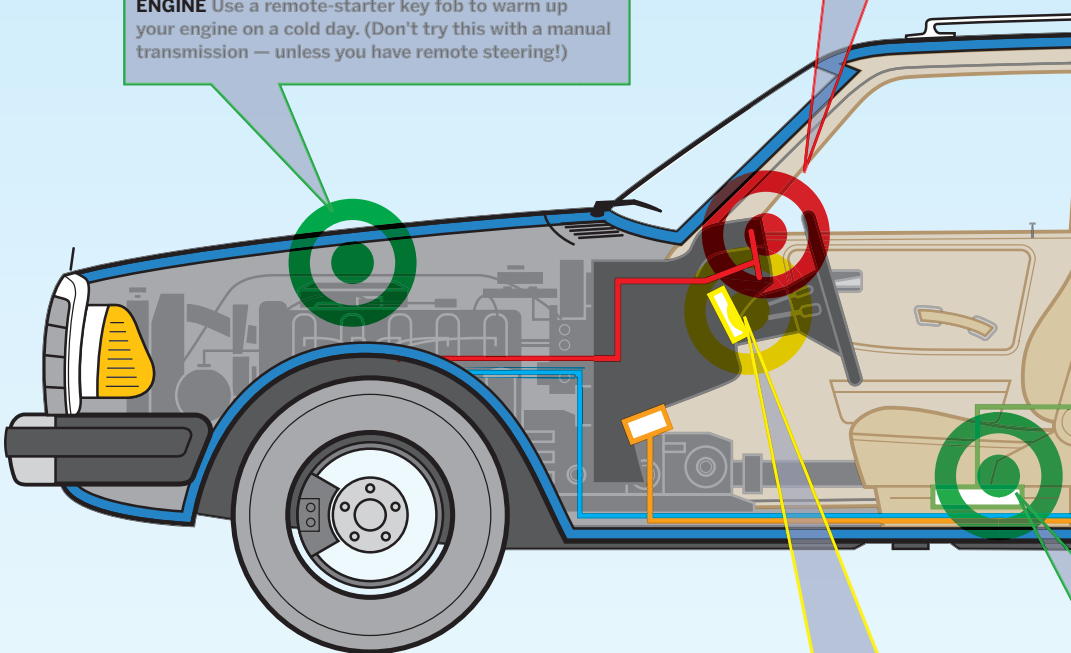


JAMES BOND DEPENDED ON Q TO TRICK OUT HIS CARS. BUT WITH MAKE'S GUIDE TO CAR HACKING, YOU'LL LEARN HOW TO TURN YOUR RIDE INTO A FULLY LOADED, GREASE-EATING, MP3-BLASTING, WI-FI-TRANSMITTING MONSTER MACHINE.

Illustrations by Nik Schulz

DIAGNOSTICS Determine continui
voltage presence of your car's 12V
Uses a light and buzzer to indicate

ENGINE Use a remote-starter key fob to warm up your engine on a cold day. (Don't try this with a manual transmission — unless you have remote steering!)



ENTERTAINMENT SYSTEM An in-car PC lets you play DVDs and MP3s that you download from your home PC while your car is parked in the garage.

PORTABLE MP3 PLAYER ADAPTER An aftermarket adapter device lets you play and control your iPod through your car's stereo system.

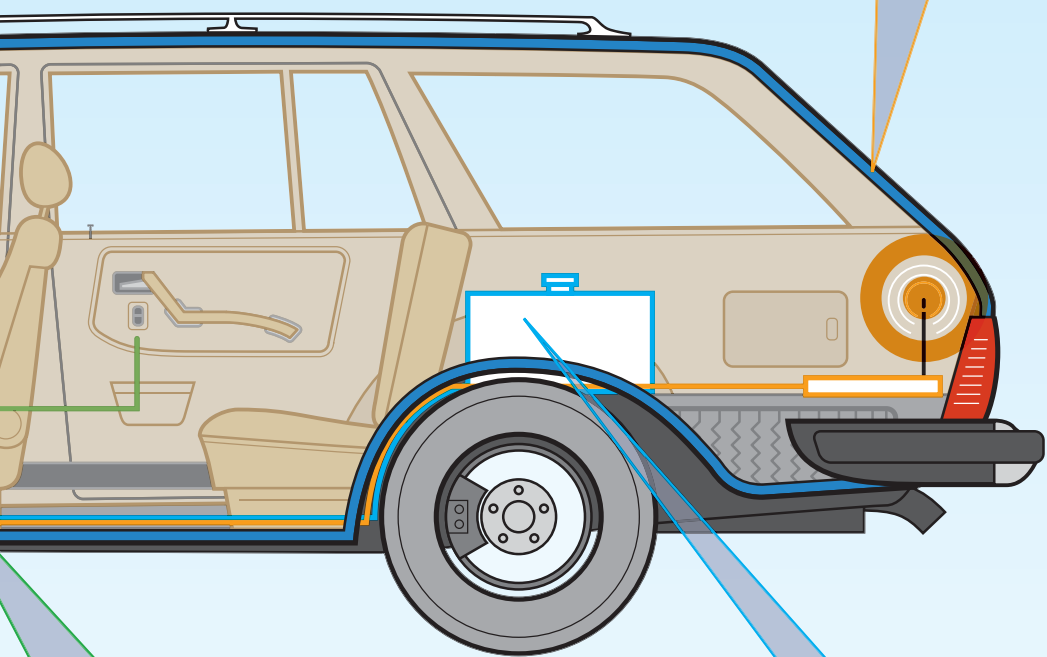
PAGE 56
A SNAP WITH
ONIC TOOL.

ty, polarity, and
wiring system.
conditions.

3 STOMPBOX MOBILE HOTSPOT PAGE 60

TURN YOUR CAR INTO A WI-FI HOTSPOT, THEN USE GPS AND WEBCAM INPUT TO GENERATE A PHOTO TRAVELOG.

NAVIGATION AND COMMUNICATION High speed EVDO turns your car into a Wi-Fi hotspot. And by wiring a pager to the PC, you can power up the PC remotely.



POWER WINDOWS Cool your car on a hot day. A relay circuit controlled by an in-car computer's parallel port will let you roll down the windows remotely.

POWER LOCKS Locked out? A reed relay connected to parallel port pins gives you the ability to unlock your car with a handheld Wi-Fi device, or even a remote PC.

GREASECAR CONVERSION KIT Install a Greasecar system into a diesel vehicle, and the engine becomes capable of running on filtered vegetable oil.

4 BIODIESEL AND ALTERNATIVE FUELS PAGE 68

HOMEBREW A LITER OF ROAD-READY BIODIESEL OUT OF USED (OR NEW) VEGETABLE OIL, AND DISCOVER THE OTHER WAYS PEOPLE ARE LEAVING DINOSAUR FUELS IN THE DUST.

MOD YOUR RIDE

1

HACKABLE PLATFORM ON WHEELS

YOUR CAR'S 12-VOLT WIRING IS LOADED WITH OPPORTUNITIES FOR ENHANCING YOUR VEHICLE IN WAYS CARMAKERS ONLY DREAM OF.

BY DAMIEN STOLARZ

I've installed computers in all my cars. I've also designed and installed circuits to control different parts of my cars. Here are some of the most obvious hackable access points on a car:

Engine Install a remote starter (such as the Commando EZ-2500 Remote Starter available from commandoalarms.com), and you can press a button on a key fob to make the car start up automatically. (Don't try it on a car with manual transmission!)

Door locks We've all locked ourselves out of our car at one time. Wouldn't it be nice to be able to unlock the car from any computer using a password?

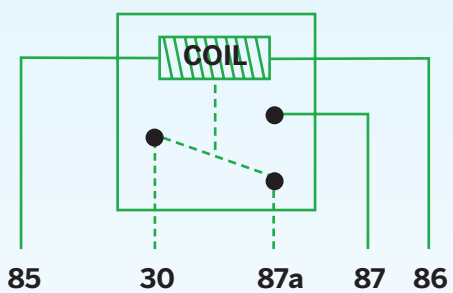
Windows, lights, horns You can make a relay system to remotely unroll your car's windows a couple of minutes before leaving the office to flush out the hot air. Or use it to blast your horn and flash your lights when you're lost in the megamall parking lot.

Before we get into the specifics of my car hacks, here's an introduction to relays, diodes, and parallel ports — all of which figure into most electric car hacks.

RELAYS AND HOW TO USE THEM

Many components in a car, such as car windows and door locks, use relays. Relays are electrically controlled switches. When you press the button on your key fob to lock your car's doors, the fob activates a small current to the relay, which in turn flips a switch that allows a much stronger current to flow through the solenoids that activate the locks.

Relays with one switch are called single pole (SP). Relays with two switches are called double pole (DP). If the switch has only one



position, i.e., two terminals, on or off, it's a single throw (ST). If the switch has two positions, i.e., three terminals, it's a double throw (DT).

The relay shown here is a SPDT (one switch, two positions). You can see that there are five numbered terminals. Two of them are used to activate the switch, and the other three make up the two-pole (double pole) switch. When you power up the relay (putting 12V across 85 and 86), it activates a magnet that pulls a switch inside the relay, and this switch then connects 30 and 87. If you disconnect the voltage between 85 and 86, the magnet stops, and the spring-loaded switch clicks back to its normal position between 30 and 87a.

You can connect relays to make complex conditional switches ("If the car is on and the window is down and the trunk is open, then honk the horn"). For some examples of interesting car relay applications, visit the12volt.com/relays/relays.asp.

DIODES: A ONE-WAY STREET FOR ELECTRONS

Diodes are electronic components that ensure current only runs one way. They have a stripe indicating the negative terminal. The current can only flow from plus to minus, so you should put the stripe toward the direction you want the current to flow.

Let's say you wanted to add a switch that keeps your radio on, even if your car's keys are removed. You could just run a 12V line from your battery, through a switch, and to the "ignition" input on your radio. If you flipped that switch, your radio would turn right on. The problem is that current would flow back through the ignition wire and back into all the other devices it powered. The solution is to use two diodes: one between your new switch and the radio (stripe toward the radio) and another between the ignition and the radio (stripe toward the radio) to ensure current goes to the radio only.

IN CONTROL: PARALLEL PORTS

Parallel ports are an easy way to control switches from an in-car computer (see MAKE's *Halloween Project,* this volume, page 86). A parallel port has eight pins that can be set at 5V or 0V. Using a resistor and a small 5V "reed" relay (such as a RadioShack 275-232 or 275-310), you can programmatically activate or deactivate a switch by setting 0 or 1 on a parallel port line.

If you're triggering a light load, such as a small light, you can just connect the 12V through the relay. If you're trying to switch a larger load, such as headlights or the door locks and windows, you'll want to chain the relays together. The tiny 5V relay will pass 12V to the big 12V 30A automotive relay, which will control your heavy load.

You don't have to hack a parallel port. There are many USB, serial, and parallel port-based relay controllers you can purchase and plug into your PC. These are already safety-fused and easy to program, and include example code. For instance, ontrak.net makes the ADR2010 that I used to control my Nash's windows via an onboard computer.

PAGER POWER

I wanted to be able to activate and access my cars' PCs from my house, so that I could connect via Wi-Fi to download music and grab email (via my company's CarBot software) to be read to me as I drive. Instead of keeping the in-car computer on continuously (which would kill the car battery), I bought a pager (service is about $4/month) to connect to the "ignition" switch of the in-car PC. The power supply for the PC (an M1-ATX from mini-box.com) has a mode where it will turn on and then stay on for two hours, giving me time to do what I need to do.

By rigging the pager buzzer up to the ACC/ignition pin on the PC's power supply (isolated by a diode, so that ACC doesn't fry the pager), I can turn on the PC in my car from anywhere in the city.

The PC, running Windows XP Pro, is configured to automatically connect to the internet (via Wi-Fi or EVDO) and run Trillian, a popular instant-messaging client. I can now dial a pager number to make my car computer wake up, go online, and start up IM — at which point I can log in and start controlling the machine.

POWER WINDOWS HACK

I decided to upgrade my old Nash with power windows. The kit I purchased online took the good part of a day to install but was very simple electrically. It's just a motor with two wires. If you apply 12V to one wire and ground to the other, the window goes up. Reverse the connection, and the window goes down. The rocker switches that came with the kit perform this reversal when you manually activate them, but to trigger this up-down with a computer required a more complicated arrangement of relays. You can see from the diagram (next page)

that two of the relays apply 12V and ground to make the window go up, and the other two relays apply ground and 12V to make the window go down.

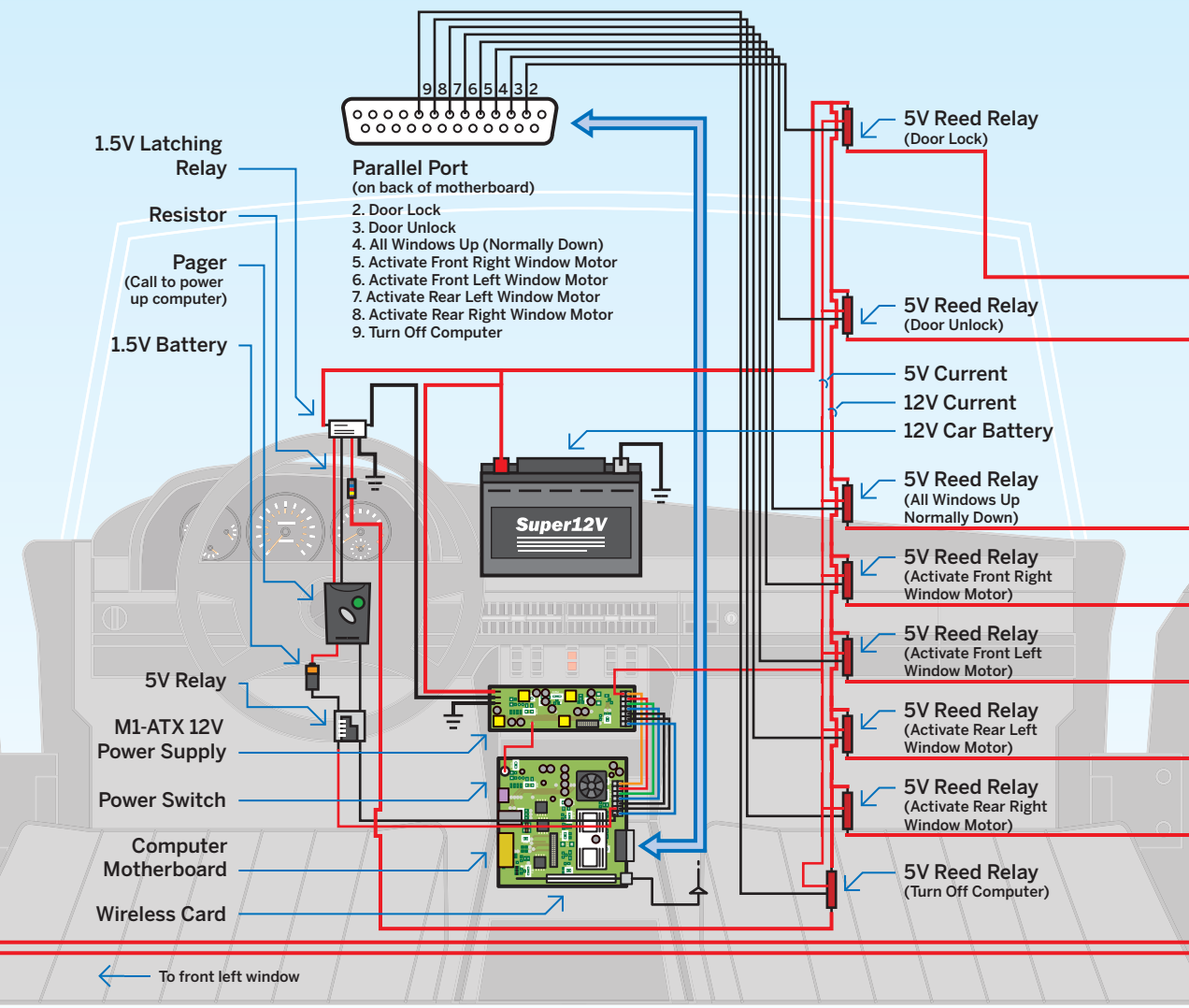
My friend developed an onscreen interface for controlling my windows, and I bought an ADR2010 controller board from ontrak.net. It has simple command language for turning ports on and off and was ideal for this application.

Using my in-dash touch screen, I can control the ADR2010, which activates the relays I've connected to the parallel port, which in turn can switch the bigger relays that control the windows.

DOOR LOCKS HACK

To unlock the doors via computer, I had to figure out how the switches work in my Caravan. After pulling the right door panel off, I disconnected the lock switch and used an ohmmeter to test all three positions: off, up, and down. I found that it usually has a 20Kohm reading, but that it drops to 2Kohm when I "unlock" the switch and 4Kohm when I "lock" the switch.

I used the voltmeter to measure the voltage of both lines that went to the switch, with respect to ground. One terminal was on the ground of the car,



the other on each wire. (The leads on my ohmmeter have sharp ends, so I just poked a tiny hole into the wire to test the voltage.)

The voltages were both around 0V. I then followed the wires out through the door into the body of the car. One wire, a purple and green one, continued into the passenger footwell area. Using alligator clips and the sharp terminal probe, I connected that purple and green wire through the 2Kohm resistor to ground. Lo and behold, the pleasant "unlock" sound reverberated throughout the minivan.

Since the switches to unlock the doors are merely applying a resistance temporarily, I felt comfortable using a simple reed relay connected to parallel port pins.

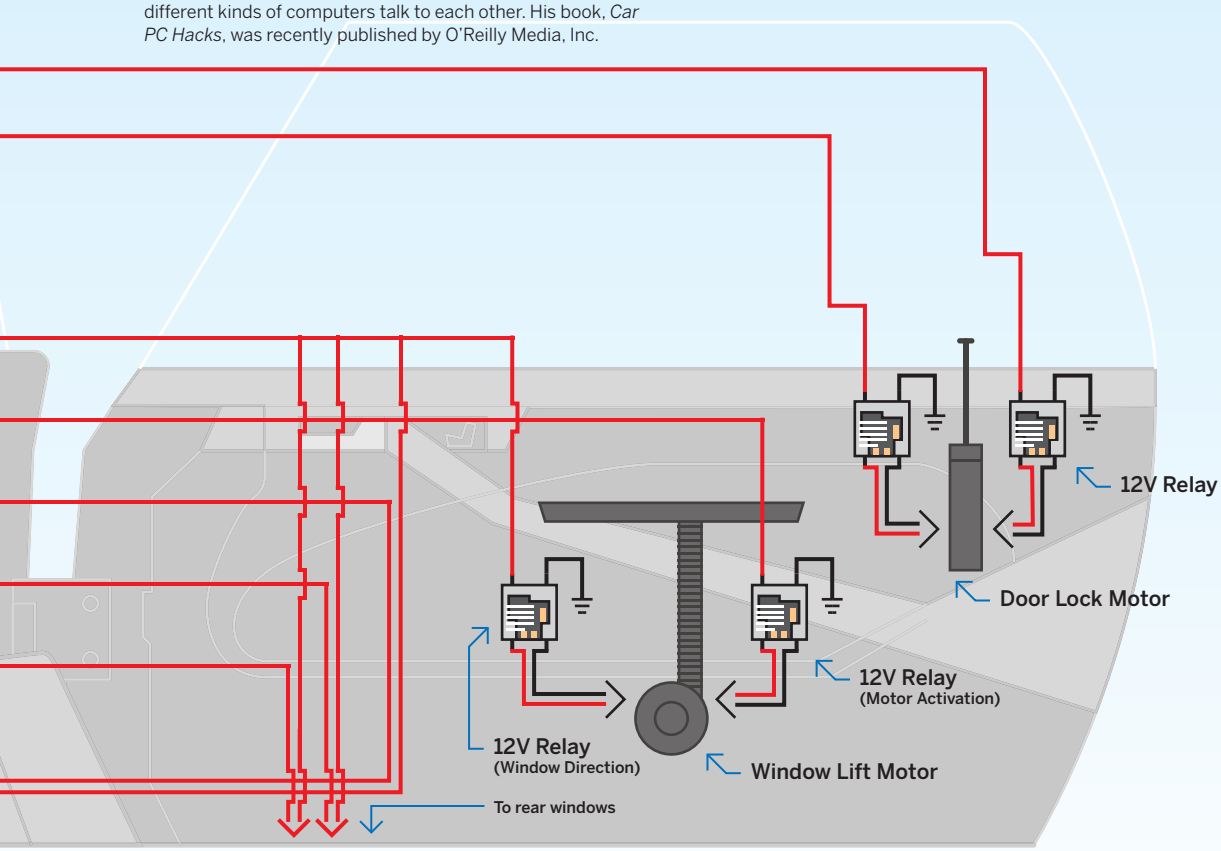
Now, if I lock myself out of my car, I can call a friend or relative who can log into my car, and ask them to "unlock" my car.

Further exploration:
the12volt.com, crutchfield.com, ontrak.net.

Inventor Damien Stolarz has spent over half his life making different kinds of computers talk to each other. His book, *Car PC Hacks*, was recently published by O'Reilly Media, Inc.

HACKING YOUR CAR'S NERVOUS SYSTEM

Every one of author Damien Stolarz's cars are outfitted with a computer and a Wi-Fi card. In addition, he's added a pager to the computer — a CarBot PC, made by his company (carbotpc.com) — so he can call in from any phone and power up the system for two hours (to keep the car's battery from running down). By adding a relay system controlled through the PC's parallel port as shown here, Stolarz can control his windows and locks remotely, as well as fill his in-car PC with MP3s, videos, and email from his home computer.



HACKABLE

MAKING A MACSWAGEN

ADDING A MAC MINI TO A VW: A PRO TELLS US HOW HE DID IT.

BY PHILLIP TORRONE

Matt Turner is a professional fabricator and installer of mobile electronics. He's been working in the industry for 12 years and has built numerous award-winning show vehicles. His latest project, outfitting a 2001 VW GTi with Apple's Mac mini, brings hope to all car owners looking to Macify their ride.

When the Mac mini was announced, along with its form-factor dimension, Turner spent two weeks planning how he would install the mini into his car. Through careful planning and examination of his VW GTi, he selected over a dozen off-the-shelf parts that would provide a driver/user with the best in-car computer experience from a variety of standpoints.

MINI POWER

In car computer systems, the first challenge is power. The Mac mini presented a new puzzle. The power button is located on the back of the enclosure — great for homes, but not so great when it's inside a car. You can't let the mini stay in sleep mode all the time (it'll take it's toll on the car's battery), so Turner first contemplated a secondary battery bank with a relay, but "that didn't really seem to me to fall in line with the inherent simplicity of Apple's computers," he says. After taking apart the mini, he discovered a simple, two-conductor momentary pushbutton switch that tells the hardware to fire up, and this actually made the process of relocating it (electrically, at least) pretty simple. "The wiring for the button actually terminates in a connector that plugs into the main board, so I simply unplugged it and cut the original wires, extended them with a Monster Cable 2-channel 3-meter RCA cable and soldered this cable to both ends of the cut switch wires," says Turner. A drilled hole and button relocation solved the problem. Turner proclaims, "There's really nothing quite like hopping in the car, starting it up, and pushing that button to be greeted with the signature Apple startup sound."

Turner's initial power setup took the electrical system's output (which varies between 12V and 14V DC), converted it to 110V AC, and then stepped it back down to 18V DC through the Mac mini's power supply brick. But the Monster Cable inverter he used would sometimes go into a protection mode

Photograph by Matt Turner

MACSWAGEN SHOPPING LIST

> 1.42GHz Mac mini with 512MB RAM, SuperDrive
> Bluetooth and AirPort Extreme
> Xenarc 700TSV 7" USB touch screen monitor with VGA and dual composite video inputs
> Cirque Easy Cat USB Trackpad
> Griffin PowerMate assignable USB control knob
> LaCie 8-in-1 USB Flash Card reader
> Belkin USB 7-port hub
> Belkin USB 4-port bus-powered hub
> Belkin FireWire 6-port mini hub
> Alpine PXA-H701 Multimedia Manager with RUX-C701 Controller
> Monster Cable MCPI300 300-watt power inverter
> Female USB
> Ethernet and FireWire ports
> 40G iPod dock and a Griffin RadioShark USB AM/FM tuner

and not allow the Mac to power up normally. The lack of ignition-controlled wake and sleep functions and the quirky workarounds to power the computer and inverter to stay on while pumping gas or running into a store for a quick pickup were solved with new hardware specifically designed for the Mac mini: the CarNetix CNX-P1900 ($90, carnetix.com).

This dual-output, 140-watt intelligent DC to DC power regulator simply replaces the Mac mini's standalone power brick. It accepts 7.5V to 18V of constant input, has an ignition sense and pulse trigger input, and outputs a stable and consistent 18.5V, a secondary 5V or 12V output for powering USB hubs or screens, a delayed 12V amplifier for accessory turn-on lead, and a pulsed ground output for triggering the Mac mini's power button for automated operation of sleep, wake, and startup functions. The wide range of voltage input capability allows the P1900 to never sacrifice its output based on low voltages encountered during engine cranking, when battery voltage can often drop to as low as 7.5V.

When Turner was Slashdotted, the manufacturer leapt at the opportunity to fill the void for in-car power solutions for Macs. Turner says, "The unit I installed in my VW is a pre-production model using the GTi as a test environment." Production models have been available since the end of April, and a Mac mini-specific plug-and-play wiring harness should be available in August 2005.

IT'S IN THE BOX

Turner first wanted to have the mini mount in-dash, but with all the connectors sticking out of it, the mini stretched out from 6.5 inches deep to over 10.5. The choice was to either rework all the airflow controls and ductwork in the car or find a new home, such as the glove box. Turner says, "I still wanted the Mac mini to look as if it were a factory-installed option, so simply mounting the computer in the glove box itself or in the glove box door wasn't really what I wanted to do. That's not the way that I felt Volkswagen would do it. Instead, I chose to modify the internal storage dividers in the glove box to make an actual compartment that would house the Mac."

The full complement of connections was then routed through the sub-dash of the car, wire-tied along factory harness runs, and plugged into the computer. The Mac mini itself slides into the housing from the front to allow access to the back of the computer if removal of the computer is ever necessary.

DASH FABRICATION

The most striking feature of the mini installation is the in-dash LCD screen that controls the whole shebang. Turner adds, "The first thing to do when trying to make a large component fit in a small area (like a 7-inch monitor in a double DIN-sized opening) is to take it apart and remove as much stuff as you can that is extraneous or unnecessary for the project at hand. In the case of the Xenarc monitor, this meant opening the case of the monitor, removing the built-in speaker, reversing the orientation of the power lead, removing and relocating the infrared receiver for the remote control, and doing away with the front of the case entirely, including the buttons on the front bezel (all these functions are now performed via remote control). This gave me a flat surface to build trim on top of, as well as reduced the overall size of the monitor significantly."

To make the aluminum panel, Turner made an acrylic version first. This was used as a cutting template for the aluminum. Turner notes, "All of the other aluminum parts in my vehicle (the iPod and

trackpad plate, the port and flash reader plate, and the ring around the boost gauge) were all made with the same technique of using separate jigs to make a complete, one-piece, acrylic jig that was used to cut the aluminum parts. They were all then hand-sanded, polished, and brushed in the same manner."

Turner then hand-sanded the inside of the beveled aluminum starting with 80-grit sandpaper and working through 120, 180, 220, 280, 320, 400, 600, and 1000-grit sandpaper to reach a polishable surface. He used a pneumatic die grinder with a polishing head and a block of blue jeweler's rouge to polish the aluminum bevel to a mirror finish.

> "THERE'S REALLY NOTHING QUITE LIKE HOPPING IN THE CAR AND PUSHING A BUTTON TO BE GREETED WITH THE SIGNATURE APPLE START-UP SOUND."

CONTROL: RUB, ROLL, AND PUSH

The touchscreen isn't the primary method of user interface; in fact, there are three ways the driver or passenger can operate the mini. The first is, of course, the touchscreen, but Turner comments, "The touchscreen doesn't have the resolution to control the OS, nor should it." The Griffin PowerMate USB control knob and the Cirque Easy Cat USB Trackpad control most of the functions.

What's next for Turner? He's interested in a turn-by-turn GPS and would like to see a Mac-based OBDII interface to show engine speed, timing, and vehicle speed. When that happens, Turner proclaims, "The dream will be complete."

For more on Turner's creations, along with extensive details on the Mac mini install, visit: tunertricks.com.

Phillip Torrone is associate editor of MAKE.

2 ÜBER TESTER

MAKE YOUR OWN 4-IN-1 CAR WIRING DIAGNOSTIC TOOL.

BY DAVE MATHEWS

When you're working on your car's 12V wiring system, it helps to have a few special tools to get the job done. The Uber Tester is a 4-in-1 gadget that won't remove door panel clips but does test for most wiring conundrums you might encounter. Plus, with its dual notification (buzzer and light), you'll be able to use the tool when your stereo is blasting or when you're contorted under the dash.

Photography by Dave Mathews

This 9V-powered handheld device will test the following scenarios with just three wires:

1. DC polarity — positive or negative voltage
2. Speaker polarity — "pop test"
3. Connectivity — wire loop back
4. Presence of voltage — fuse tester, constant or ignition switched power

Installing a 12V accessory or stereo properly — that is, with the correct speaker polarity, switched power source, and constant voltage for the clock and preset memory — requires a tester such as this. Tracing wires in today's vehicles is next to impossible with their nearly identical colors and tight wire looms. This gadget will help you find that needle in a haystack.

SET UP.

MATERIALS:

[A] Enclosure (gadget box) 3"x2"x1"
(RadioShack #270-1801)

[B] 12V, snap-in, high-brightness lamp – blue
(RS #272-335)

[C] Mini 12V DC electric buzzer
(RS #273-055)

[D] 1" alligator insulated test/jumper cable set
(RS #278-001)

[E] Wire crimps, shrink tubing, or electrical tape

[F] Cotton balls
(to keep the innards from moving around)

[G] 9V battery snap connector
(RS #270-325)

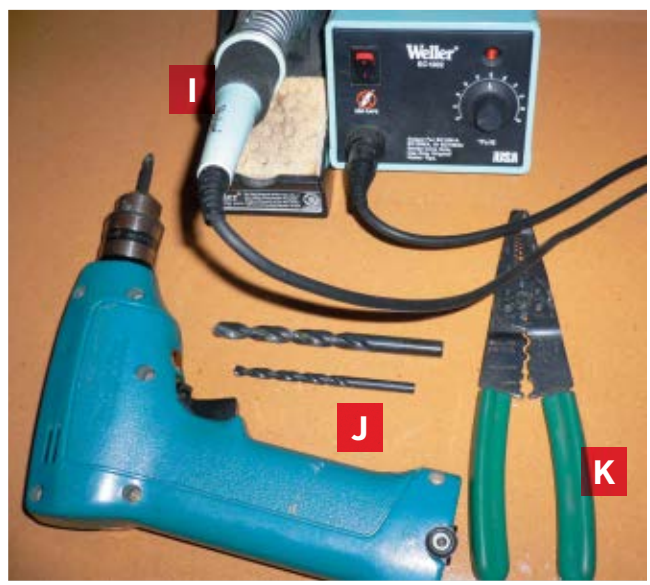
[H] 9V battery

TOOLS:

[I] Soldering iron and solder

[J] Drill with large and small bits

[K] Wire cutters



www.makezine.com/03/weblink

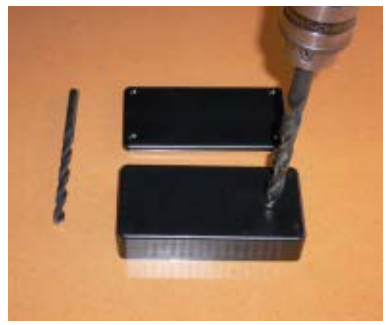
ÜBER TESTER

START

Time: A Couple of Hours **Complexity:** Easy

1. DRILL HOLES AND INSERT LAMP

Start by drilling a hole for the lamp in the bottom of the gadget box (not on the removable lid) about a quarter of an inch down. Then drill a hole just large enough to let the three jumper wires pass through it. Strip ¾" of insulation off the lamp wires and insert the lamp into the hole you drilled for it.



2. INSERT WIRES

Cut one alligator clip off the end of each of the red, green, and black wires and poke the wires into the gadget box, leaving the alligator clips outside of the box. Tie the three wires into a knot to prevent them from pulling through the hole, leaving about 2" of wire to work with inside the box. Strip the wires back ¾" to prepare for the connections.

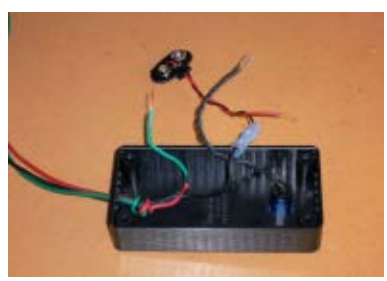
3. CONNECT WIRES

Connect the black wire from the 9V harness to the black alligator clip wire.

Connect the red wire from the 9V harness to the red alligator clip wire, the red buzzer wire, and to one of the lamp wires.

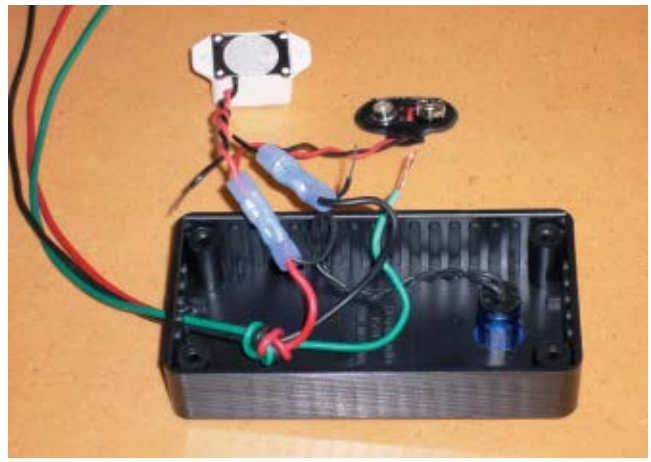
Connect the black wire from the buzzer to the green alligator clip wire and to the second wire on the lamp.

Check wiring. Note that coming from the alligator clip jumpers, the red wire makes three connections, the green wire makes two, and the black one only connects to one. That's it!



4. TEST YOUR UBER TOOL

Connect the 9V battery to the connector and touch the black and green alligator clips together — you should hear a tone and the light should illuminate. Connect the red wire to a positive 12V (or lower) source and the black to ground, and you should hear a tone and see the light illuminate. If so, your wiring is properly connected.



5. REINFORCE THE ALLIGATOR CLIPS

Now would be a good time to put some extra solder on the jumper wires inside the alligator clips. Usually they are merely crimped on, which will not provide a strong enough connection to allow you to let your tester dangle. Just pull back the protective covers on the jumpers, clip the jumpers to a piece of cardboard to keep them from moving around, and load up the solder under where the wires are crimped.

6. FINISHING UP

Now it's time to stuff the buzzer, battery, and wires into the gadget box. Put the cotton balls in the leftover space to keep the tester from sounding like a baby's rattle.

12V UBER TESTER WIRE GUIDE

Red/Black
9V output and speaker polarity pop test
Black/Green
Continuity test
Green/Red
Voltage presence — constant or switched

Memorize this guide, or copy it and paste it onto your gadget box.

To prevent your battery from dying, keep the red wire from shorting on the black or green wires by pulling the insulation hood over the metal. You should see years of service from your battery since it is rarely used.

END

Dave Mathews has been installing car stereos since his first go-kart in the 1980s and has never stopped tinkering with aftermarket audio. While this creation came to fruition in 1993, more stories and video clips on technology he is currently peering into can be found at davemathews.com.

3

STOMPBOX MOBILE HOTSPOT

TURN YOUR CAR INTO A WI-FI HOTSPOT, THEN USE GPS AND WEBCAM INPUT TO MAP YOUR CURRENT LOCATION ONLINE AND AUTO-GENERATE A PHOTO TRAVELOG. BY TOR AMUNDSON

When Verizon released its new BroadbandAccess service, I had to give it a try. $80 a month for DSL-like speeds in many cities? Yes, please!

I subscribed, bought the 5220 PCMCIA card, and it worked. But the card's antenna was so weak that I often had to rotate my laptop. Also, it only served one computer. What if I wanted to run multiple machines or share connectivity with friends? Then it hit me: I could build the card into an access point and install it in my car with some beefy antennas. I called the project StompBox because this little box would bring my own network "stomping grounds" with me wherever I went.

OVERVIEW

In technical terms, the StompBox is a cellular router. Like all routers, its job is to push data back and forth between multiple interfaces. Ours has two interfaces: Verizon's BroadbandAccess and Wi-Fi.

I decided to base StompBox on embedded hardware rather than on a laptop or full-blown PC. This makes it cheaper, smaller, more reliable, and better for "just plug and unplug" vehicular use. For the platform, I chose Pebble Linux, a Debian distribution from NYC Wireless. For hardware, I used the Soekris 4521, a compact embedded computer that runs on 12VDC and has a great user community. All the software needed — Pebble Linux plus drivers plus code — fits onto a 128MB Compact Flash card that functions like a computer hard drive but is tougher and more vibration-resistant.

The Wi-Fi interface is simple. The Linux driver HostAP can run an access point from any 802.11 card with a Prism2 chipset. You simply configure your choice of SSID and WEP key and turn it on.

As for the Verizon interface, wireless networking pioneer Phil Karn wrote a how-to on getting the 5220 card to work under Linux. His solution is to make the system treat the 5220 card as a USB modem, and then send it the proper Hayes AT commands to dialup Verizon's network.

With this foundation in place, you can expand your access point's capabilities by adding a USB card, a GPS unit, a webcam, and other devices. I hooked up a GPS and did some Google Maps hacking to create an auto-updated web page (hosted on my home network to avoid wireless traffic jams) that tracked my car's route and showed its current location against a satellite photo. Unfortunately, this and many other bleeding-edge Google Maps hacks were rendered inoperative last May when Google changed the unsupported beta API that hackers' code had been relying on. Then in late June, a Google Maps API beta was officially released, so now old map hacks can be repaired and new hacks written in a more stable environment. Meanwhile, the StompBox's web page also shows photos captured by a webcam pointing out of the car window.

SET UP.

HARDWARE

Soekris net4521 (with case)
From soekris.com

» Verizon 5220 EVDO/1xRTT card
» Pigtail adapter (Orinoco to N-Female, panel mount)
» N-Male to FME-Female antenna adapter cable
» CDMA antenna (800/1900MHz dual-band)
For cellular network

» Senao 2511 Mini-PCI 802.11 card (or any Prism2-chip-set equivalent)
» Pigtail adapter (Hirose U.FL to N-Female, panel mount)
Wi-Fi antenna (2400MHz band)
For Wi-Fi

128MB Compact Flash card

An old mousepad, or other piece of foam less than ¼-inch thick
For vibration-proofing the cards

Serial cable (null modem, DB9-F to DB9-F)

12VDC car power to M-type (5.5mm) plug cable

» Any GPS unit with standard NMEA output via USB or serial port. If serial, add a USB-to-serial adapter, preferably one that uses the Prolific PL-2303 chip.
» 2-port USB PCMCIA card, low profile so that it fits inside the router
For GPS enhancement

D-Link DCS-900W wireless internet camera
12VDC to 6VDC power transformer
For webcam enhancement

12V battery power supply (optional)
(I used a Xantrex P400)

12V car power two-outlet splitter (optional)
To offload car battery while engine isn't running (power enhancement)

SOFTWARE

StompBox .IMG file
Ready-to-go "disk image" for the CF card; downloadable at makezine.com/03/stompbox

Debian 2.4.26 distribution (optional)
Necessary if you want to compile extra code

TOOLS

Phillips screwdriver

Small and large pliers

Drill press (preferred) or drill

Stepper bit
For drilling antenna holes in the case

Dremel tool
For cutting an opening to the USB card

A host computer with a terminal emulator installed and a 9-pin serial port (or a USB-to-serial adapter, listed in previous column for GPS)
For setup. I cover Linux and Macintosh in this article. You could probably also use a Windows machine, but I haven't tested this yet.

Compact Flash reader/writer
For setup

12VDC power supply (deep-cycle battery, lab-bench supply, wall wart, or even your car battery) 1.5 amps or higher, with a 5.5mm "M" plug
For testing

STEPPER BIT

The stepper bit, with its Christmas-tree shape, lets you bore wide, round holes in sheet metal without having to swap in successively larger bits. Hole diameters are marked on the inside of the bit's hollow, making it easy to set a drill press to stop at the right point. They're great for drilling out metal cases and panels, for installing new ports. They're also safer than regular drill bits and not very expensive.

STOMPBOX

MAKE IT.

START **Time: Two Weekends Complexity: Linux-Geek Easy**

1. CONFIGURE THE CF CARD

StompBox's software resides on the Compact Flash card, and I've wrapped it all up in a ready-to-go image downloadable at makezine.com/03/stompbox. While all the software components on this card are open source and easily available, the specifics of configuring it are beyond the scope of this article. If you want to make your own setup from scratch so you can control exactly what's in your system, see moro.fbrtech.com/~tora/EVDO/cfimg.html.

1a. Download the StompBox .IMG file to your host computer, then insert the CF card into the reader. It doesn't matter what's on the card for now; we're going to overwrite it with the image.
LINUX: If the card was not blank, the system may try to auto-mount it. If so, please unmount the drive before continuing, using the `umount` command.
Mac OS X: If the card was blank, you'll get a "not readable" pop up; click "Ignore." Otherwise, it will auto-mount on the desktop. Run the Disk Utility and repartition the drive into "free space," and then reinsert. Once OS X "ignores" the drive, you can continue.

1b. Find out your system's physical address for the CF card. On my PowerBook, it's usually `/dev/disk2`, but it differs for every system. Warning: Be sure you have the correct address before proceeding, or you can damage your other drives!

1c. Open a terminal window (Applications/Utilities/Terminal on a Mac) and copy the image to the card using the standard Linux command:

```
dd if=/files/stompbox.img of=/dev/disk2 bs=8192
```

Change the input file (IF) and output file (OF) parameters above to match your system. Copying can take up to six minutes, during which you should see the light on the CF reader blink. Once it's done, remove the drive.

2. ASSEMBLE THE HARDWARE

2a. Remove the four screws on the bottom of the Soekris net4521 case, and then slide the top off.

2b. Remove all six screws in the motherboard and the two serial-port socket screws to detach the motherboard from the bottom case. Lift it out, and put it someplace safe.

Photography by Tor Amundson

2c. Hold the pigtail adapters' N-Female plugs against the existing antenna holes in the Soekris case. Trace around them with a pencil, and then use the drill and stepper bit to make holes just large enough to accommodate the plugs. Brush away any burrs.

Antenna holes drilled to fit pigtail adapters.

2d. Mount the Wi-Fi pigtail on the right-hand side of the case (the side closest to the power jack). This is the one with the tiny U.FL connector on the end of the cable. Insert the N-Female connector through the case hole and put the lockwasher on the outside. Then screw on the nut and tighten down, using two sets of pliers: one to hold the N-Female jack in place, and the other to turn the nut. Don't over-tighten!

2e. Repeat step 2d above, this time on the left-hand side for the 5220 pigtail. When you are done, both N-Female jacks should be mounted to the case, the 802.11b on the right and the 5220 on the left.

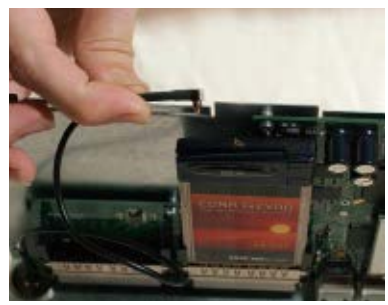
2f. Insert the Mini-PCI card (Senao 2511) into the Soekris motherboard. It angles into the connector and then snaps downwards into place.

2g. Connect the Wi-Fi antenna pigtail's U.FL connector to the antenna port closest to the mini-PCI socket. These connectors are tricky; you may have to use a tiny screwdriver or metal stick to gently snap it down into the socket. Be careful; these connectors are fragile.

2h. Insert the 5220 card into PCMCIA Slot 0 on the Soekris (the one on the right, closest to the mini-PCI socket). It should slide in smoothly, parallel to the motherboard.

2i. Look at the 5220 card end-on; you should see the connector socket. If it's covered by a small plastic cap, remove the cap.

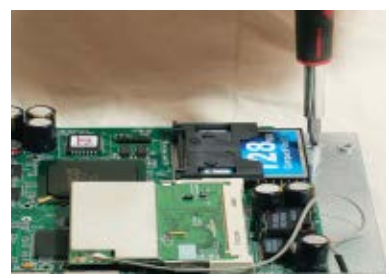
2j. Connect the CDMA antenna pigtail's Orinoco connector to the tip of the card, just below the fold-out antenna. It should snap securely into place with just fingertip pressure.



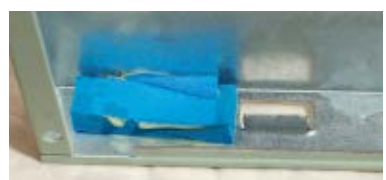
2k. For GPS, insert the USB PCMCIA card into PCMCIA slot 1 (the remaining slot, away from the mini-PCI socket).

2l. Insert the Compact Flash card into the Soekris' CF slot and secure with the bumper screw included in the case.

2m. Use the Dremel to cut two holes in the top of the case, just above each of the USB card's ports and big enough to connect USB cables through.



2n. Cut a small strip of foam and put it inside the upper case where the PCMCIA cards will touch. Once the case is closed, this will snug the cards into place and keep them from vibrating loose.



2o. Reassemble the case, sliding it together carefully. Secure it with the four screws on the bottom.

3. CONFIGURE THE PLATFORM

On the Soekris, the default speed of the BIOS (which does things like count memory, self-test, and handles machine-level communication) is 19,200 bps, while the higher-level Linux OS normally talks at 9,600 bps. For the very first boot up, we'll need to change the speed of the Soekris BIOS to 9,600 bps. That way, we can run our host computer's terminal emulator at one speed and be able to configure both the BIOS and OS.

3a. Plug the Soekris into your 12VDC power source, using an M-type (5.5mm) plug.

3b. Hook your host computer up to the Soekris using the serial cable and an USB-to-serial adapter, if necessary.

3c. Run the terminal program on your host, and set the baud rate to 19,200 8-N-1 (19,200bps, 8 data bits, no parity, 1 stop bit). I used ZTerm.

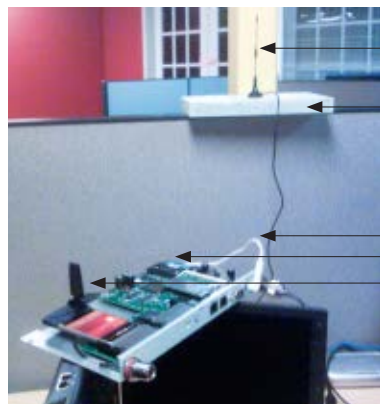
3d. Plug in the Soekris and watch for the BIOS screen. As it counts through memory, quickly press CTRL-P to access the BIOS set-up. You should see:

```
comBIOS Monitor. Press ? for help.
```

Now, reset the speed by typing:

```
set conspeed = 9600
```

3e. Enter `Reboot` to restart the system. You should see the BIOS boot up, followed by the operating system. This will take one to two minutes. If your system does not boot, the CF card might not have been written correctly or isn't compatible with the Soekris (rare, but it happens). Other possibilities are that you have weak power supply or faulty hardware.



3f. You should now see the prompt:

```
Debian GNU/Linux 3.0 pebble ttyS0
pebble login:
```

Log in as root, with a null password (just hit Return). Your access point is now ready to configure; you can start by changing to a better password.

4. CONFIGURE THE ROUTER

4a. If you don't have one already, create a dynamic DNS account. Browse to dyndns.org from your host (or any other) computer and follow the instructions for setting up an account for the DynDNS service.

4b. From your terminal, run the router configuration script on the Soekris by entering:

```
/usr/local/bin/initial-configuration
```

Answer all the questions, and the script will set up the system. You'll need to know your DynDNS account info and the Verizon phone number for your 5220 card. Also, be ready to set some names, passwords, and private network IP addresses for wireless and wired clients (example: 192.168.1.0 and 192.168.2.0). Its last step is to generate new SSH keys, which takes several minutes. When the script completes, it prompts you to reboot; go ahead, and then unplug the Soekris. The router is now ready to go online!

5. GET ONLINE

Plug the router back in, and it should now attempt to log on to the 3G network automatically, a few moments after it boots. You can see if it worked by logging in via terminal and checking the "pppd" messages (from Linux's point-to-point protocol daemon) in the "messages" logfile at `/var/log/messages`. Use the commands `tail` or `grep` to see the most recent messages or to search the entire file.

If it worked, you'll see pppd messages that list your network's IP addresses. Otherwise, check for an incorrect phone number, an inactive account with the provider, or poor reception. When you're too far from coverage, or have bad antenna connections, you'll see a "pppd: LCP timeout" message. You can check your coverage by swapping the 5220 card back into your host computer.

Any Wi-Fi client devices should now be able to join your new network, or you can physically plug Ethernet-enabled devices into the router's ETH1 port.

6. INSTALL IT IN YOUR VEHICLE

Now that your device is online and powered, it's time to put it in the car!

6a. Decide where you want to put your antennas. With regular, ground-plane antennas, reception will be best when they are centered on the largest available expanse of metal, such as your car's roof. But they should not be positioned close to each other; keep the antennas at least 20cm apart, preferably farther. If you get terrible reception (or don't have a metal roof), you may want to select a ground-plane-less antenna, like the kind that mount on truck mirrors. Visit a good ham radio store or local amateur radio club for advice.

6b. Using the N-Male to FME-Female adapter, connect the 3G antenna to the N-Female jack on the left of the router, away from the power jack. Hook the Wi-Fi antenna to the other jack, on the right. Then position and mount both antennas.

6c. Secure the router inside the vehicle where it won't get knocked around, then hook it up to the cigarette lighter via the car power cable.

You now have the heart of the StompBox — a Wi-Fi access point that you can drive anywhere! The next page describes some fun ways to expand on it.

3G COVERAGE

3G is a general term for several types of wireless broadband service, including EVDO, 1xRTT, EDGE, UTMS, and others. Verizon's BroadbandAccess is EVDO/1xRTT. In a 1xRTT area, you'll get ISDN-like speeds, and in an EVDO-capable area, you'll get DSL-like speeds. In both cases, your upload will be slower than your download.

If you drive out of range, your link slows as more packets are lost, until you finally drop offline. Your range depends on the type of antenna and how well it's positioned on your car.

You can greatly improve that range with an auto-gain two-way amplifier. I use Wilson Antennas model #811201. Make sure you can scale down the auto gain as you get closer, or your signal can get too noisy in a good coverage area!

For more advice, ask an amateur radio buff about working at 800/1900 dual band (for 3G) and 2400 MHz (for Wi-Fi).

END

GOING FURTHER

EXPANSION: ADDING GPS

Since this is a standard x86 platform running Linux, it's open for expansion. Add a GPS unit, and you get vehicular tracking. The router runs Linux's gpsd in the background to poll data from an attached GPS unit and publish it as a network service. I connected my GPS serial port to the router using a USB-to-serial adapter with a Prolific PL-2303 chip. The software on the CF card finds the PL-2303 and attaches the gpsd program, but if you use a USB-connected GPS or a different adapter, you'll need to manually softlink the device to `/dev/gps`.

Since I wanted something flashy and fun for the vehicle-tracking page, I used Google Maps as the interface. When I first did this last spring, the Google Maps API hadn't been officially published yet, so this was still pretty new and shaky territory. And my scripts broke later, along with many other Google Maps hacks, when Google changed their API out from under us map hackers. But now that the Google Maps API beta has been released officially, it is a much more stable way of using Google's mapping systems, and it gives beautiful results.

I didn't want internet visitors curious about StompBox to flood and bog down my mobile network, so I used gpsd in combination with the dynamic DNS system to offload traffic onto my home network. I set up a PHP script on one of my servers at home to periodically telnet into StompBox's GPSd port (2947), then query it for position and speed. It then plugged those numbers into an XML document and fed them into the Google Maps Hacking tool set, generating a map. You can see the scripts that did the work on the StompBox website, makezine.com/03/stompbox.

Note that this setup is designed for internet users to track the StompBox remotely, not for in-car, real-time GPS navigation! For that, you're far better off using a dedicated navigation device or software.

GPS how-to:
moro.fbrtech.com/~tora/howto/gps.html

EXPANSION PART II: ADDING A WEBCAM

Another fun trick is to add an onboard camera. I chose the easy route: a wireless web camera, the D-Link DCS-900W, which has its own onboard server and a wireless link. Plug one in, configure it, and you can pull still or moving images from it using any browser. It also points out of any window, sticking in place with a suction cup.

Our CF card software is configured to use a DCS-900W camera that's set up on the IP address ending in ".8" on your network. So, for example, if you set 192.168.1.0 as your network, the camera should get the address 192.168.1.8. Set the camera's SSID and WEP keys as you defined for your network.

You can view the camera input from within your StompBox network by going to that IP address. With the firewall rules I added, you can also view it from the public internet by visiting the dynamic DNS name of your system, at port 81 (i.e., http://192.168.1.8:81). Assign a password to limit demand on the camera, if word gets out!

To further avoid network traffic jams, use the `getcam.sh` script, also on the CF card. This offloads image serving onto a home server. Edit the script to point to your server, and an automatic process (known as a cron job) will upload the latest images every five minutes. Change the interval by editing the file `/etc/cron.d/getcam` and add cameras by duplicating the

Tor Amundson is a nomadic mad scientist based in Silicon Valley who's studying our side of the temporary dimensional rift he discovered.

4

MAKING BIODIESEL

THE BEST WAY TO LEARN HOW TO MAKE YOUR OWN BACKYARD BIODIESEL IS TO START WITH A ONE-LITER BATCH. BY ROB ELAM

It's easy to make a small batch of biodiesel that will work in any diesel engine. You don't need any special equipment — an old juice bottle will serve as the "reactor" vessel — and on such a small scale you can quickly refine your technique and perform further experiments. After a few liters' worth of experience, you'll know if you've been bitten by the biodiesel bug.

The principle behind biodieseling is to take vegetable oil (either new or used), and process it into a fuel that's thin enough to spray from a regular diesel engine's fuel-injection system. This is done chemically, by converting the oil into two types of compounds: biodiesel, which shares the original oil's combustibility, and glycerin, which retains the oil's thick, viscous properties. Drain away the glycerin, and you're left with a fuel that you can pour into any diesel vehicle with no further modification.

Once you get to the far side of the learning curve, making biodiesel is very much like cooking. In fact, a commercial biodiesel production plant shares more in common with a large-scale bakery than a petroleum refinery. There's organic chemistry involved in baking a cake, but most bakers wouldn't consider themselves organic chemists.

BIODIESEL CHEMISTRY

Vegetable oil is a triglyceride, which means that its molecule consists of a glycerin "backbone" with three fatty acids attached, forming a shape like a capital letter E. To make biodiesel, we add lye and methanol. The highly caustic lye breaks the three fatty acid branches off of the glycerin backbone. These free fatty acids then bond with the methanol, which turns them into fatty acid methyl esters — otherwise known as biodiesel. The freed glycerin, which is heavier, sinks to the bottom, leaving the fuel (and lye) on top. Wash the lye out of the upper layer, and you have pure biodiesel.

But it's not that simple. With some triglyceride molecules, only one or two fatty-acid branches break off, which leaves mono- or di-glyceride molecules (shaped like capital Ts or Fs), rather than free glycerin. At the same time, mixing methanol and lye produces some water — and oil, water, and lye mixed together make soap.

With all of these incomplete and competing chemical reactions, your batch will inevitably contain soap, water, leftover lye, methanol, and mono- and di-glycerides, along with the nice biodiesel and glycerin. Mono- and di-glycerides are emulsifiers, so they prevent mixed liquids from separating, making it harder to extract biodiesel. The picture gets even muddier when you use waste vegetable oil rather than pure oil, since it contains free fatty acids, water, and countless random contaminants from all those French fries.

These by-products are bad for an engine, potentially causing micro-abrasions that damage fuel injectors or clog fuel filters. But you can remove them by washing or cooking the biodiesel in various ways, or by processing the incompletely converted biodiesel again, as if it were vegetable oil. In extreme cases, you'll end up with a thick, soapy mass that never separates. All biodieselers wind up with a batch of this glop sooner or later. Fortunately, you can use it to make a good, grease-cutting soap — which is something that all biodiesel homebrewers need to have on hand.

Photography by Sara Huston

MATERIALS

[A] At least one liter of vegetable oil (you can double this recipe if desired, using a larger bottle).
Either new or waste vegetable oil is fine. If you are using waste oil, try making batches with samples from different restaurants' grease barrels.

[B] One bottle methanol gasoline treatment, such as Heet (in the yellow bottle) or Pyroil brand.
Sold at auto parts stores. You can buy larger quantities in bulk from local auto-racing suppliers, petroleum distributors, and chemical suppliers.

[C] One bottle isopropyl alcohol gasoline treatment, such as Iso-HEET (in the red bottle) or Pyroil brand.
Carried by the same retailers as methanol. You won't need much of this, even if you start making larger batches.

[D] Between 5 and 10 grams of lye, quantity explained below. You can use regular lye (sodium hydroxide, NaOH) or potash lye (potassium hydroxide, KOH). NaOH is easier to find, but KOH is easier to work with.
NaOH is widely available as Red Devil Lye drain cleaner. You can buy KOH from local soapmaking and tanning craft suppliers, or from braintan.com.

[E] Phenolphthalein solution.
Available from beer and winemaking and lab chemical suppliers. Also contained in many educational chemistry sets. Should be fresh.

[F] One or two gallons of distilled water.
Used for washing the fuel.

[G] Vinegar.
To neutralize discarded lye.

TOOLS

[H] Metric gram scale, sensitive to at least ½ gram.
Available at some tobacco and "head" shops, or look for a triple-beam scale at pawn shops and flea markets.

[I] Two syringes, eyedroppers, or pipettes, calibrated in milliliters. They should each hold up to 10ml, and be marked in increments no larger than .2ml.
Graduated eyedroppers and oral syringes are available in drugstores, sometimes with the baby supplies. You'll use these for different chemicals that you shouldn't mix up, so it helps to get one syringe and one eyedropper.

[J] Candy thermometer.

[K] Measuring cup, beaker, or other way of measuring 220ml and one liter of liquid.

[L] Two 1-pint glass Mason jars with tight lids, and three or more small Mason or babyfood-size glass jars.

[M] Two 2-liter bottles or larger, glass or PET/PETE (#1) plastic. Favor juice, water, or milk bottles over soda, since their wider mouths are easier to funnel into.

Two-liter pot, and a hot plate or electric burner (not gas).

Cheesecloth, clean rags, and a bucket.

Funnel and plastic spoon.

Masking tape or labels, and a marker for labeling.

[N] Safety goggles and gloves.

Litmus strips or electronic pH meter (optional) .

BIODIESEL

MAKE IT.

START **Time: Six Hours over Three Days** **Complexity: Low**

1. FILTER AND DE-WATER YOUR OIL

If you're using new oil, you can skip to Step #2. But if you're starting with waste oil from a restaurant fryer, it will contain food particles, water, and free fatty acids (FFAs) — contaminants that you need to remove or adjust for. The FFAs make the oil more acidic, (a.k.a. rancid), which counters the effect of the lye. You can compensate for this by adding more lye into the main reaction later, but you need to perform a titration test beforehand in order to determine how much extra lye you'll need.

BIODIESEL HOMEBREWING SAFETY

While biodiesel is safe to handle and store, the homebrewing process involves flammable, poisonous, and caustic chemicals, alcohols, and lye. Keep all chemicals clearly labeled, sealed, and out of reach of children and pets. When handling methanol and lye, wear long sleeves, safety glasses, and gloves made out of nitrile — or, even better, PVC. Wash the gloves after each use, and be careful not to touch your skin or eyes. Keep a water hose nearby in case of skin contact. Methanol can be absorbed through the skin, so wash immediately with water if contact occurs. Immediately flush lye off skin with water or vinegar. Methanol fumes are poisonous, so wear a mask, or hold your breath while pouring, and work outside or with good ventilation.

1a. Start with more than one liter of oil, since the following steps will slightly reduce your oil's volume. Warm the oil to about 95°F in a pot on an electric hot plate (don't use a gas burner, here or anywhere else in this project), then filter it through a few layers of cheesecloth in a funnel (or use a coffee filter).

1b. Heat the oil to 140°F and maintain the temperature for 15 minutes. The water will fall to the bottom, so you'll risk steam explosions if the temperature gets too high. Pour the oil into a bottle or other vessel and let it settle for at least 24 hours. This removes water, which would produce soap in your batch. If you see water at the bottom (it will be dirty, not clear), don't pour it back out with the oil.

2. TEST YOUR OIL

Determining the acidity of the vegetable oil.

2a. Dissolve one gram of lye in one liter of distilled water (0.1% lye solution), or use an equivalent ratio to make a smaller amount. This is your reference test solution, which you can store sealed and re-use for later batches.

2b. In a small jar, dissolve 1ml of slightly warm oil in 10ml of isopropyl alcohol. Stir until clear, then add two drops of phenolphthalein solution.

2c. Using a graduated syringe or dropper, add your reference test solution drop-by-drop into the oil-alcohol solution, keeping track of how much you're using. The more acidic the oil, the more you'll need to add. Stir constantly, and continue adding solution until the mixture stays pink for ten seconds. Note the number of milliliters of lye solution you used; this is the number of extra grams of lye you'll need to add per liter of oil.

This process is called "titration," and it's a standard method of determining a solution's acidity.

BIODIESEL

3. PROCESS THE OIL

This is the main chemical reaction that produces the biodiesel.

3a. Determine how much lye you need. If you're using new oil, use 5 grams of NaOH or 7 grams of KOH per liter. With used oil, use these amounts plus one gram for every milliliter of solution you used in the titration step 2c. For example, if it took 1.5ml of lye solution to turn the mixture pink, use 6.5g of NaOH or 8.5g of KOH.

3b. Measure your lye into a clean Mason jar. Add 220ml of methanol, cover securely, and tip the jar to make sure the lid doesn't leak. Then swirl or shake the jar gently until the lye dissolves fully. This will take a few minutes, and the jar will become slightly warm in the process. This mixture is the methoxide solution, and it's dangerous stuff; you'll need to wash the Mason jar lid after you're done with your batch, or its seal will dissolve. (Some regular homebrewers prepare methoxide ahead of time and store it in #2 HDPE plastic.)

3c. Warm a liter of your oil up to 130°F. Let it cool down if the temperature gets too high.

3d. Pour the oil into a large bottle, add the methoxide solution, cap tightly, and shake like crazy for about five minutes. The contents might change color a couple of times.

3e. Set this mixture aside, and admire. In half an hour or so, you should see a darker, dirty, glycerin layer start to sink toward the bottom, and a larger, lighter, biodiesel layer rise to the top. This is a good time to clean up. If you're sure your bottle won't leak, you may want to let it settle upside-down, so you can drain the glycerin out by cracking the bottlecap. Or you can lay it sideways to make it easier to pour off the biodiesel.

3f. Let the liquids continue to settle overnight.

4. SEPARATE, WASH, AND DRY THE BIODIESEL

Your bottle now contains biodiesel, glycerin, mono- and di-glycerides, soap, methanol, lye, and possibly a little leftover oil (triglycerides). The glycerides are all oil-soluble, so they'll reside predominantly in the upper, biodiesel layer. The thin layer of glycerin, which is water-soluble, will sink. Depending on the oil and catalyst you used, it might be either liquid or solid. Soap, methanol, and lye, which are also water-soluble, will be mixed throughout both layers — although some of the soap can sometimes form its own thin layer between the biodiesel and glycerin.

If you see more than two layers, or only one, then something's wrong — possibly excessive soap or mono-glyceride formation. These are both emulsifiers, and in sufficient quantities they will prevent separation. In this case, check your scales, measurements, and temperatures. You can reprocess the biodiesel with more methoxide, or try again with fresher oil (or new oil). If you can, shake the bottle even harder next time.
In an engine, glycerin droplets in biodiesel will clog fuel filters, soap can form ash that will damage injectors, and lye can also abrade fuel injectors. Meanwhile, methanol has toxic and combustible fumes that make biodiesel dangerous to store. You don't want any of these contaminants in your biodiesel. If you left your biodiesel to settle undisturbed for several weeks, these water-soluble impurities would slowly fall out of the biodiesel (except for the methanol). Washing your biodiesel with water removes the harmful impurities, including the methanol, much faster.

Unfortunately, washing will not remove the invisible, oil-soluble mono- and di-glycerides. These are a problem in rare instances when large amounts of certain types of monoglycerides crystallize. This can clog fuel filters and injectors, and cause hard starts, especially in cold weather. High-quality, commercial biodiesel has very low levels of mono- and di-glycerides, which is the ideal for biodiesel homebrewing. You can roughly test for the presence of mono- and di-glycerides in your own batch by processing it a second time, as if it were vegetable oil. If more glycerin drops out, then your first reaction left some unfinished business behind.

4a. Pour the biodiesel layer off the top, into another bottle. Don't pour off any of the glycerin, as it makes washing difficult; better to leave a little biodiesel behind. If you let the bottle settle upside-down, drain the glycerin from the bottom.

4b. Gently add some warm distilled water to the biodiesel.

4c. Rotate the bottle end over end, until the water starts to take on a little bit of white soapiness, which may take a few minutes. Do not shake the bottle. You want to bring water and biodiesel into contact, without mixing it too vigorously. The biodiesel contains soap, and if you overdo the agitation, the soap, biodiesel, and water will make a stable emulsion that won't separate.

4d. Turn the bottle upside-down, crack the cap, and drain away the soapy water. If you're using a soft drink bottle with a narrow neck, you can plug the opening with your thumb instead of using the cap.

4e. Add more warm water and keep repeating the sloshing and draining process. Each time there will be less soap, and you can mix a little more vigorously. If you go too far and get a pale-colored emulsion layer between the biodiesel and white, soapy water, don't drain it away; it's mostly biodiesel. Just keep washing and diluting until the water becomes clear and separates out quickly. It takes a lot of water. But if the emulsification layer persists, try applying heat, adding salt, and adding vinegar, in that order.

4f. After draining the last wash water away, let the biodiesel sit to dry in open air until it's perfectly clear, which may take up to a couple of days. In general, the better your washing, the faster the fuel will clear. If you're in a hurry, you can dry the fuel faster by heating it at a low temperature. As with the evaporation method, the fuel is done when it clears. If you can read a newspaper through the biodiesel, it's dry and ready to pour into a vehicle. Congratulations — you're done!

END

USE IT.

You can put your liter of biodiesel into a jar to pass around to your admiring friends, or use it in a diesel engine. We generally filter fuel before adding it to the vehicle to remove micro-abrasives, but a liter or two probably won't do any damage. To be safe, you can filter your liter through several coffee filters. Since it's a small quantity, don't worry about whether it's OK to add your homebrew to your tank, so long as it's clear. Even if your liter contains a lot of mono- and di-glycerides, they'll be safely diluted by the rest of the fuel in the car.

Litmus strips or a pH meter will test the fuel's acidity — one indication of how clean it is. Biodiesel should measure a neutral 7, with a higher number indicating soap or leftover lye. To test for the presence of glycerin, you can use the Gly-Tek test kit (gly-tek.com), which detects leaked antifreeze in motor oil.

If you start using biodiesel regularly, however, you should have the fuel tested, and change your fuel filter often. Biodiesel can free petroleum residue stuck in the fuel system, which can cause clogs. Also, watch for old fuel lines, which may get sticky and need replacement. Biodiesel can degrade the natural rubber used in older cars' hoses, but it's fine with now-standard synthetic rubber.

Biodiesel will normally store for months, but, like petrodiesel, it can be attacked by certain bacteria. To prevent this, you can mix in the same biocide chemicals that are widely used for petrodiesel storage. Also note that biodiesel made from animal fats can gel in cold weather; if this might be a problem, test a sample in the freezer before filling your tank. Biodiesel made from canola oil has the lowest solidification point.

GOING FURTHER

There are numerous recipes for biodiesel, generally characterized by number and type of main reactions. The method described here is a single-stage process, which uses an alkali to catalyze the main reaction, and relies on titration to determine the proper amount. Two-stage methods dispense with titration and run reactions twice to achieve complete conversion. The two-stage, base-base method repeats the lye reaction, while the two-stage, acid-base method uses sulfuric acid for the first stage. These methods, while more complicated, are also more foolproof and better suited for large batches.

Homebrewers make and wash larger batches of biodiesel in a variety of tanks; one clever design uses a 55-gallon drum that's tipped on its edge to make a drainage point at the bottom, which is fitted with a valve. This makes it easy to drain glycerin or water. Various recipes can turn the dirty leftover glycerin into soap, 40-weight oil, paintbrush cleaner, and other useful products. High-volume operations can buy a $31,000 glycerin-purification distiller from Recycling Sciences (rescience.com), which will convert dirty biodiesel glycerin into nice, clear, commercially valuable glycerin.

Popular, high-volume washing methods include mist washing, in which water droplets sprayed on the surface of biodiesel settle down through the liquid; bubble washing, which uses an aquarium air pump and air stone to gently agitate water and biodiesel; and bulk washing, in which water and biodiesel are agitated manually. For final filtration, down to 5 microns, biodiesel can be pumped through standard, under-cabinet, household water filters.

RESOURCES

This article is partly based on a series of articles by Maria "Mark" Alovert that first appeared in the Energy Self-Sufficiency Newsletter: rebelwolf.com

Mark Alovert's site: localb100.com

Homebrewing forums: biodiesel.infopop.cc, veggieavenger.com/media

Biodiesel policy and activism forum: biodieselnow.com

Biodiesel processor designs and other info: journeytoforever.org/biodiesel.html

Biodiesel stations and industry info: nbb.org

VW Diesel forum: tdiclub.com

Setting up a commercial biodiesel pump in your town: propelfuels.com

---

Rob Elam is a founder of Propel Fuels, a Seattle-based biodiesel services and fuel distribution company.

BIOFUELS TODAY

THE NATION'S #1 MOCK-NEWSPAPER FOR MAKE READERS INTERESTED IN ALTERNATIVE FUELS.

Grassroots Network Offers Alternative to Big Oil

By Dan Gonsiorowski

SEATTLE — Spotting an old, diesel Volvo with a bumper sticker promoting a cause is not unusual on the streets of Seattle. Spotting two or three of them parked on the same block is a little strange, however — especially when all of them advertise the same cause. But that's the scene on the street outside of Dr. Dan's Alternative Fuel Werks in Seattle, and the stickers all broadcast some variation of "Biodiesel-Powered." The Fuel Werks promotes and sells biodiesel to a segment of the population that Dan Freeman (a.k.a. Dr. Dan) affectionately calls "affluent crackpots." They are people willing to pay $3.67 a gallon to power their cars with a renewable energy source and decrease the amount of pollution released into the atmosphere from the burning of fossil fuels.

Oil and automobile companies have been slow to offer alternatives to the petroleum-fueled car, but conscientious drivers left out in the cold by those industries are addressing the issue themselves. Grassroots distributors like the Fuel Werks are popping into existence nationwide, to serve both private consumers and neighborhood biodiesel cooperatives who pitch in on large, shared storage tanks. Co-ops form via word-of-mouth, flyers posted at local garages, or online queries. One biodieseler, Eric Forrer, has been trolling craigslist for interested individuals in Seattle's North End area. After he finds enough members, Dr. Dan will install a 270-gallon tank in a highly visible location near Forrer's home, and keep it filled.

The biodiesel distribution chain favors local, independent businesses. Consumers buy fuel from co-ops or small distributors like Dr. Dan's, while the distributors buy it from anyone who can make high-quality stuff, from backyard homebrewers to local startups like Seattle Biodiesel, which, in turn, gets the raw vegetable oil they use to produce biodeisel (mostly soybean) from, well, Iowa, for now.

We can seemingly leave lefty political stereotypes aside while viewing the National Biodiesel Board's map of biodiesel distributors, at nbb.org/buyingbiodiesel/distributors. The vast majority are in the Midwest, where vegetable oil is grown and processed, rather than in coastal Sierra Club strongholds such as Seattle, San Francisco, and Berkeley. But it isn't simply a matter of economics, as evidenced by the involvement of musician and farm advocate Willie Nelson. His company, Willie Nelson's Biodiesel, markets biofuel as a way to empower independent farmers to plant crops that will let them participate in the energy market.

Back in Seattle, Dan Freeman hopes that the Fuel Werks will, one day, sell biodiesel that is not only processed, but also grown in-state — and all without the backing, consent or assistance of automobile manufacturers or oil companies.

Deep-Fried Ride: Veggie Oil Inside

By Xeni Jardin

FLORENCE, MA — Do-it-yourselfers are turning to an offbeat solution to rising fuel prices: they're modding cars and trucks to run on discarded cooking oil. With a Greasecar system installed, any diesel vehicle can run on vegetable oil.

Instead of fueling at gas stations, Greasecar devotees tank up at restaurants, where deep-fryer oil is tossed out daily. Since many establishments pay disposal fees, they're happy to give the stuff away.

Greasecar Vegetable Fuel Systems (greasecar.com) sells conversion kits for about $800, around the same price as its Missouri-based competitor Greasel Conversions (greasel.com).

Converted vehicles are actually dual-fuel hybrids, capable of running on both diesel and vegetable oil. The engine can draw fuel from either the regular tank, or a heated oil tank in the trunk. The vehicle starts up in diesel, then switches over to pure veggie power once the grease is warm enough to flow through the fuel injection. This approach allows the grease-burners to work just fine in cold climates.

Bonus benefits: The air coming out of the tailpipe will smell faintly of French fries, and you can slap on a "Drive Vegan" bumper sticker. Greasecar representatives say converted vehicles experience no change in fuel economy, either — though they admit you may need to change your unit of measurement to "fries per gallon."

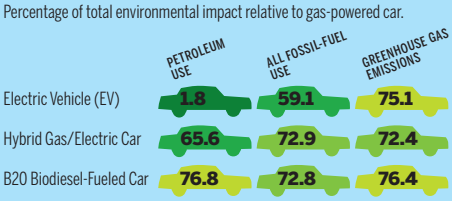
Slippery Characters Steal Fryer Oil, Leave Mess

By Paul Spinrad

SPRINGFIELD, MO — The multibillion-dollar, used cooking oil recycling business is taking a beating from a new kind of criminal: the grease bandit, as reported in the *Springfield News-Leader*. In some regions, the growth of the biodiesel industry has given new value to old grease. As a result, bandits now cruise the backs of restaurants, sucking the substance out of discard bins with homemade pumper trucks. Many restaurant workers don't realize that they're the wrong trucks, but Keith Wendorf, spokesman for oil recycler Griffin Industries, says that his company's shiny 18-wheelers steam-clean the pickup areas, while the thieves leave pools of grease.

How Eco Is Bio?

Percentage of total environmental impact relative to gas-powered car.



Source: Argonne National Laboratory Transportation Technology R&D Center's GREET model, www.transportation.anl.gov/software/GREET

By Polly Powledge

CHICAGO — Hybrids, EVs, or biodiesel — which is best for the environment? Figuring out the answer can be tricky. Diesel gets better mileage than gas, but it takes more petroleum to produce. Electric vehicles (EVs) don't use gasoline at all, but if you plug them into the grid, you're using energy from coal-burning power plants, which pollute. B20 biodiesel (a common blend containing 20% pure biodiesel and 80% petrodiesel) reduces fossil-fuel use, but a rigorous analysis must account for the diesel that's used to truck the vegetable oil to the biodiesel processing plant.

Fortunately, scientists at Argonne National Laboratory have constructed a computer model that lets you do apples-to-apples comparisons of a variety of fuel technologies, and see how they rate ecologically. The results of these "well-to-wheel" calculations can be surprising. For example, while an EV consumes very little petroleum over its lifetime, hybrids are actually slightly better at reducing greenhouse gases.

Photograph by Phillip Torrone

MODYOURROD

5

HARDWIRED IPOD

WANT A BETTER WAY TO PLAY MP3s THROUGH YOUR CAR STEREO THAN USING AN FM TRANSMITTER OR A CASSETTE ADAPTER? CUT THE STATIC BY CONNECTING YOUR iPOD TO YOUR STEREO'S AUX JACK.

BY DAMIEN STOLARZ

If you have an iPod (or any portable music device, for that matter), and you drive, it's a no-brainer that you want to bring that audio experience into your car.

Here are my four goals for making a car-based portable music system:
1. I want to play the music through my car's speakers.
2. I want to control the functions safely while I'm driving.
3. I want to mount it securely so it doesn't fly around.
4. I want to power and charge it so it doesn't run out of juice while I'm driving.

Each of these problems has a number of solutions depending on how much money and effort you are willing to spend. But clearly, the main problem to solve is: how do you get that audio signal into your car speakers?

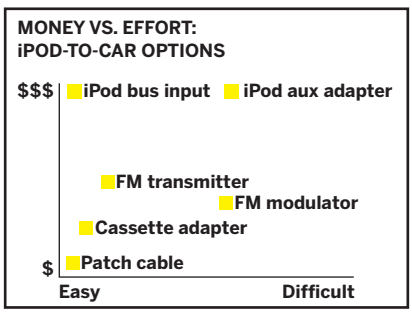
To help you decide the best way to get your iPod into your vehicle (and there are probably a million possible permutations of device + car), we're going to look at the different ways you can (or should be able to) integrate a portable MP3 player into a car.

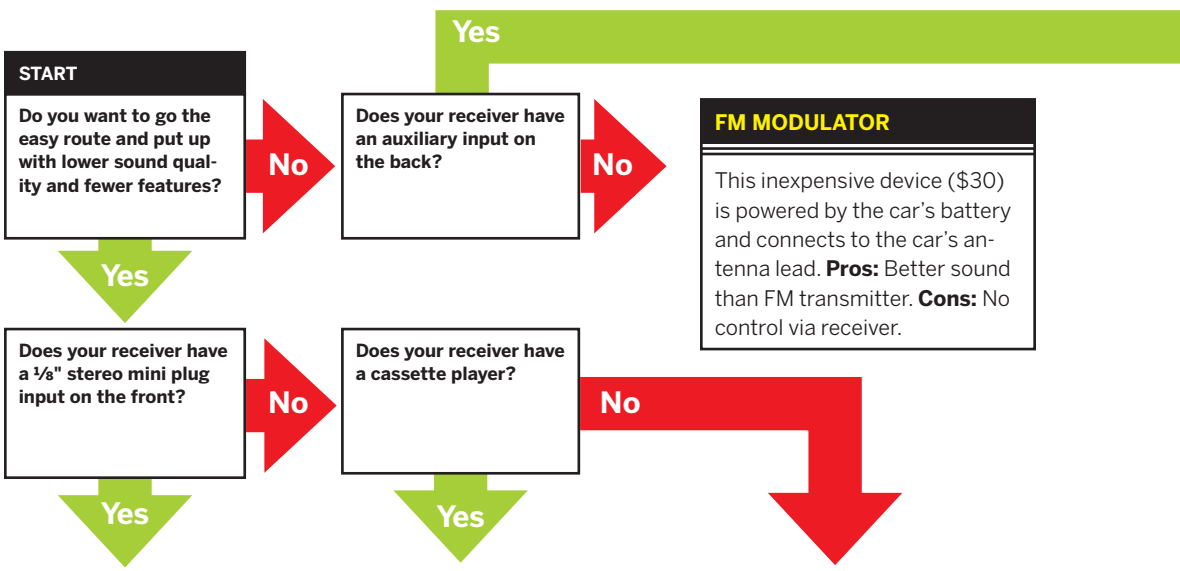
The focus of all these approaches is to put the audio into the head unit. The head unit is the more technical term for the "radio" or "tuner" or "stereo" or "cassette deck" in your car; that is, the head unit is the thing in the dashboard with the dials and buttons that acts as the "analog hub" for your car's audio media experience.

IPOD

GOAL: PLAY YOUR IPOD THROUGH YOUR CAR SPEAKERS

You can get audio into your car's receiver in one of four ways: FM transmitters, FM modulators, tape adapters, or directly into the head unit via an AUX in, CD, or satellite radio interface. This decision tree will help you find which method is right for you.





FM MODULATOR

This inexpensive device ($30) is powered by the car's battery and connects to the car's antenna lead. **Pros:** Better sound than FM transmitter. **Cons:** No control via receiver.

PATCH CABLE

A male-male mini plug cable costs $2 and connects your iPod's headphone output to the stereo's input jack. **Pros:** Dirt cheap, sounds good. **Cons:** No charging, no control via receiver.

CASSETTE ADAPTER

Translates audio signals from your iPod to the magnetic pulses that your tape deck expects to read off a cassette tape. **Best choice:** Griffin's SmartDeck ($29), which plugs into the top of the iPod and can translate the fast forward/rewind buttons on your tape deck into next track/last track controls on your head unit. **Pros:** Cheap. **Cons:** SmartDeck doesn't charge your iPod.

FM TRANSMITTTER

A $20 to $70 mini-radio station that beams your iPod output to your car's antenna. **Best choice:** Monster iCarPlay Wireless Plus FM transmitter. **Pros:** Charges batteries, tunable across FM spectrum, on-cable controls. **Cons:** Sound quality is not as good as any other solution offered here.

IPOD AUX ADAPTER

Several companies make adapters that interface between your iPod and the CD changer jack on your car's receiver. These companies either reverse-engineer stereo systems or go under non-disclosure agreements with receiver manufacturers to create sub-$100 black boxes with the proprietary CD changer interface on one side and RCA jacks on the other. These boxes trick the receiver into thinking that a CD changer is plugged in, allowing the iPod's signal to play through the speakers.

Some companies make a single, omnibus adapter and let you choose your car via dual-inline package (DIP) switches on the bottom of the unit. You also have to buy a $5 adapter cable that fits your car's jack. Other vendors sell a separate adapter box for each brand of OEM vehicle.

Most adapters give you limited control of your iPod via the receiver. Some brand name car stereo companies have iPod adapters that will show artist/song information on the receiver's display. Monster Cable's iCruze system has an optional dash mount LCD that displays artist/song information. They range in price from $100–$500. Sources: mp3yourcar.com, theistore.com, crutchfield.com, installer.com/aux, logjamelectronics.com/auxinpconv.html, monstercable.com/icruze.

Pros: Charges batteries, best sound quality. **Cons:** Expensive, installation can be difficult for certain cars, receivers, and adapters.

Getting Audio Out of the iPod

It's worth noting that there are two ways to get audio out of the iPod: top or bottom. The top connector on the iPod is a variable output, amplified signal. It's designed to power your headphones. The amplification is controlled with the volume function of the scroll wheel. When using the variable output with any of the adapters listed here, you wind up with two ways to increase volume: the iPod or the head unit. This may seem like a good idea, but it can cause distortion.

The best way to get audio out of the iPod is from the bottom, where there is a line level output. This provides a nice, fixed level designed for amplification by another device (i.e. your head unit). Keep this in mind when buying any adapter equipment.

The $50,000 Solution

If you're about to buy a new BMW, you can skip this decision tree entirely and simply plug your iPod into the manufacturer-supplied cable. In 2004, iPod made a deal with BMW and created the first iPod integration adapters. These first adapters were really a hack that made the iPod emulate a CD changer, but they've since added steering wheel and head unit control of the iPod.

Since that time, Apple has started making more deals with auto manufacturers, which are implementing different levels of iPod display and integration depending on the model of the car. In the coming years, the iPod's proprietary bottom-connector may become a de facto standard for in-car integration. So when you buy a new car, you may be able to simply ask for the "iPod integration" option. **Pros:** Excellent sound and control. **Cons:** You have to buy a BMW for it to work.

IPOD

MOUNTING, CONTROL, AND CHARGING SOLUTIONS

MOUNTING IT

After deciding how to connect your iPod to your receiver, you need to figure out how to mount it. If you are using a system that lets you control your iPod through your stereo's buttons and dials, then you should stow it in your glove compartment or other out-of-the-way place. If you want to use the iPod's controls, then you should mount it on the dash or other accessible location.

The cheapest and most space-age mounting solution is good old Velcro. If it's good enough for securing objects in the zero-G environment of the space shuttle, it's good enough to affix your iPod securely to your dashboard. You'll want some sort of iPod case or plastic belt clip, just to make sure you don't gum up the back of your iPod. You can get sticky Velcro at craft and hardware stores.

The Apple iPod dock that comes with some models of iPod provides audio output and recharging. Since you already have it, you can also Velcro or tape this to the center console of your vehicle, if you can find a level surface.

Because iPods are about the size of some mobile phones, you can also use a mobile phone holder. Mobile phone holders come in a variety of forms — some clip to AC vents, while others stick to the dash. Check your local car wash for a deal.

MacMice PodBuddy offers FM transmitting, power, and mounting (dvforge.com/podbuddy.shtml).

There are dozens of mounting systems designed specifically for the iPod. Initially, these were all cast in white plastic to match the iPod, but recent versions from Belkin are being made in black to better match the interior of most cars. The iPod holders made by ProClip blend in almost seamlessly with the finish of most cars.

CONTROL IT

While the iPod has a great interface, it's certainly not designed with automobile drivers — who must keep their eyes on the road — in mind.

The wired remote control that comes with the various generations of iPod can serve as an effective hands-free remote. You could even affix it on the steering wheel (given enough wire length) so that you have a "hands-free" remote.

Learn about the Apple iPod remote control protocol at maushammer.com/systems/ipod-remote/ipod-remote.html.

If you're interested in wiring up your own remote wired controller for the iPod, perhaps to connect it to your steering wheel controls or your own dash-mounted interface, the protocol and pinouts are available at Maushammer (see above for URL).

POWER AND CHARGE IT

You can buy a FireWire-to-cigarette lighter adapter for less than $10. But if you must, you can build one. First, put 12 volts through a 1-amp fuse to the power pins on a six-pin FireWire cable. You simply put the +12V on pin 1 and the ground on pin 2. A FireWire has a flexible voltage range from 8V to 30V, so you can put the 12V from the car straight into it.

Since the FireWire end connector is fairly hard to solder, it's probably easier to just cut a FireWire cable in half and put the voltage on the two relevant pins.

A great place to learn more about mounting and charging your iPod in the car is iPodlounge (ipodlounge.com).

The $30 SiK imp iPod charger (sik.com) has line level audio output.

GAME SYSTEMS TO GO

Portabilizers take apart video game systems and turn them into portable gaming units. By Howard Wen

Benjamin J. Heckendorn hacks video games, in the most literal sense. The 29-year-old from Verona, Wisc., disassembles video game systems, cuts apart their circuit boards within, rewires them, and stuffs them into smaller, custom-made casings. Adding battery power systems and an LCD display, he transforms them into portable gaming units.

Four years ago, while employed at a company that had computer-controlled machining equipment, work turned to inspiration as he fashioned out a handheld casing to contain the circuitry of an Atari 2600 (also known as the Atari Video Computer System; see MAKE Volume 02, page 192). "I thought it would be a cool project in the memory of the old Atari 2600," he recalls.

Heckendorn's portable 2600 was somewhat clunky, with a tiny LCD screen (cribbed from a handheld TV) and woodgrain exterior that evoked the original design styling of the 2600. But it had an antiquated, retro-cool charm about it. When Heckendorn debuted his creation in 2001 on the internet, it caused a buzz in the classic video games community. Over time, he produced several refined versions of the device, and sold a number of them.

Other people, inspired by his work, made their own game portables — many out of systems besides the Atari 2600. An online community centered on the "portabilizing" of video game consoles emerged. Heckendorn himself turned other game consoles into handhelds. (Most recently, he constructed a portable PlayStation 2.)

His hobby has evolved into a book that was released in early 2005, *Hacking Video Games: A Complete Guide for Turning Your Old Game Consoles Into Awesome New Portables*. A do-it-yourself guide, the book features eight pre-designed projects the reader can build. Systems covered include the Atari 2600, Nintendo Entertainment System, Super Nintendo, and PlayStation 1.

Don't try to convince Heckendorn and his fellow "portabilizers" that nowadays one can simply emulate many of the classic video game consoles on a PDA or handheld computer. To them, the guts of the old systems are what make their hand-built gaming portables unique. "The best thing about using original hardware is that it makes for a more interesting story," says Heckendorn. "The fact that original parts are still used is intriguing to people."

Portabilizing Your Video Game System: A Primer

Thinking about giving your old video game system a second life as a portable? Here are five important points to keep in mind for portabilizing it:

Wiring

In order to pack the original circuit boards of a video game system into a smaller case, the beginning

Tighe Lory's Portable Nintendo Entertainment System

Tighe Lory says once he figured out how to make his 2½ lb. portable version of the Nintendo Entertainment System (NES), the actual construction of the gaming device was simple. More than a hundred people have asked him if they could buy his portable NES, but he isn't selling. He wants people to make one on their own.

Anatomy of a Homebrew Portable Gaming Device: The NES Portable

A. Joypad

B. Control buttons

C. Reset button

D. Speaker

E. External power jack, designed for the standard 10V GameGear adapter

F. 8 AA battery pack

G. Player 2 controller port

H. Volume control

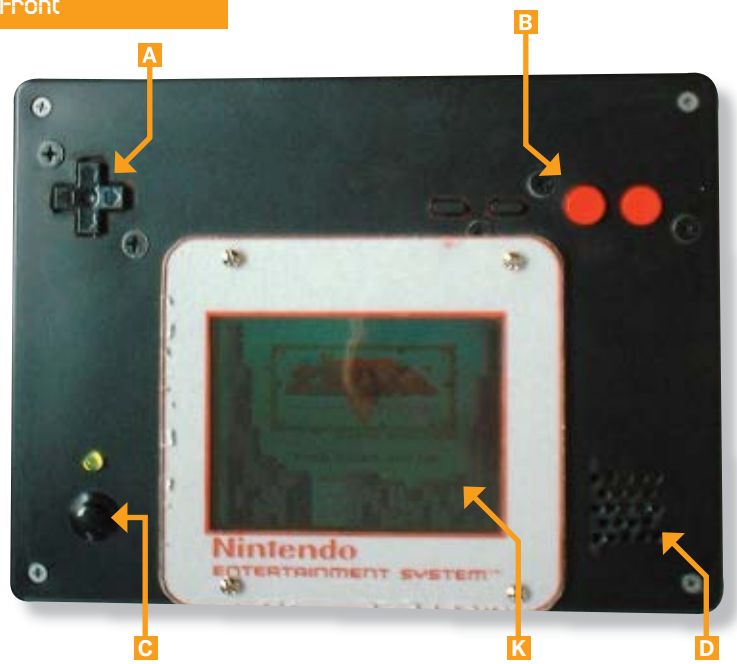
I. AV out, for playing on a TV. Uses a stereo ⅛" jack to male RCA plugs.

J. Cartridge slot

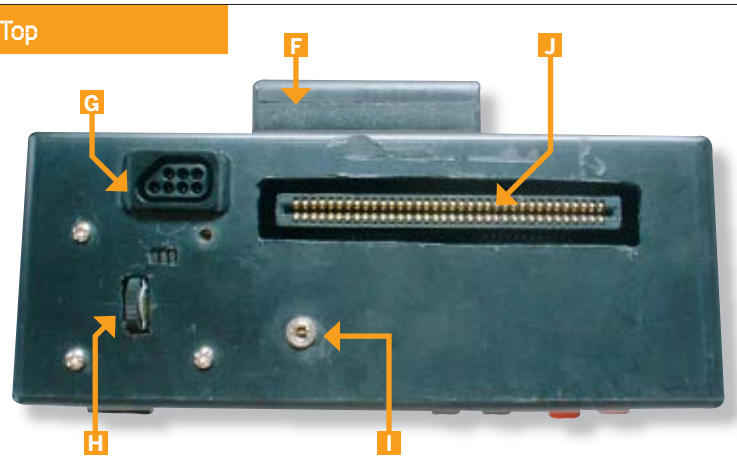
K. Screen

L. Power on/off

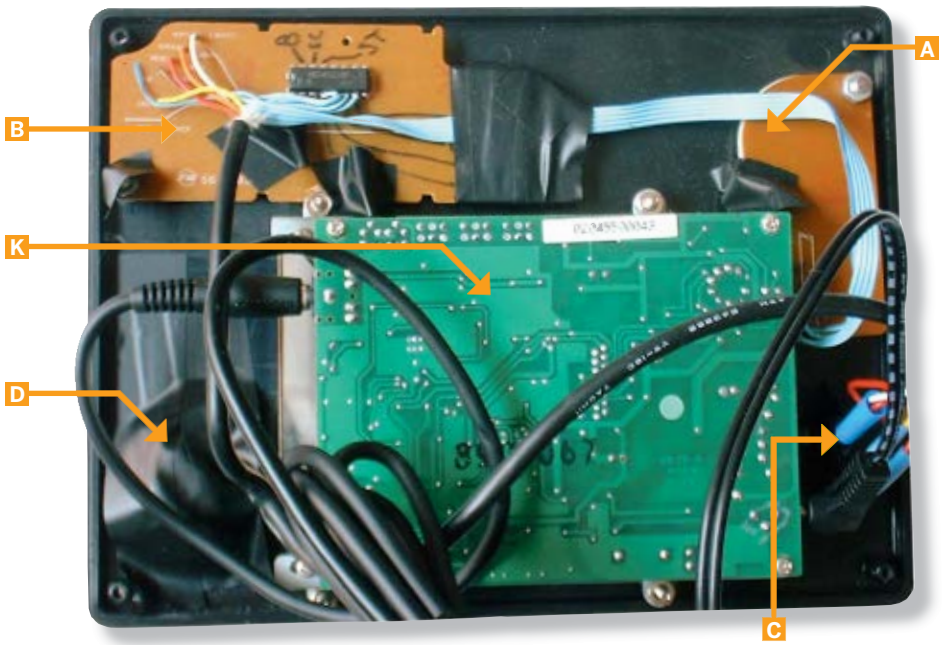
Front



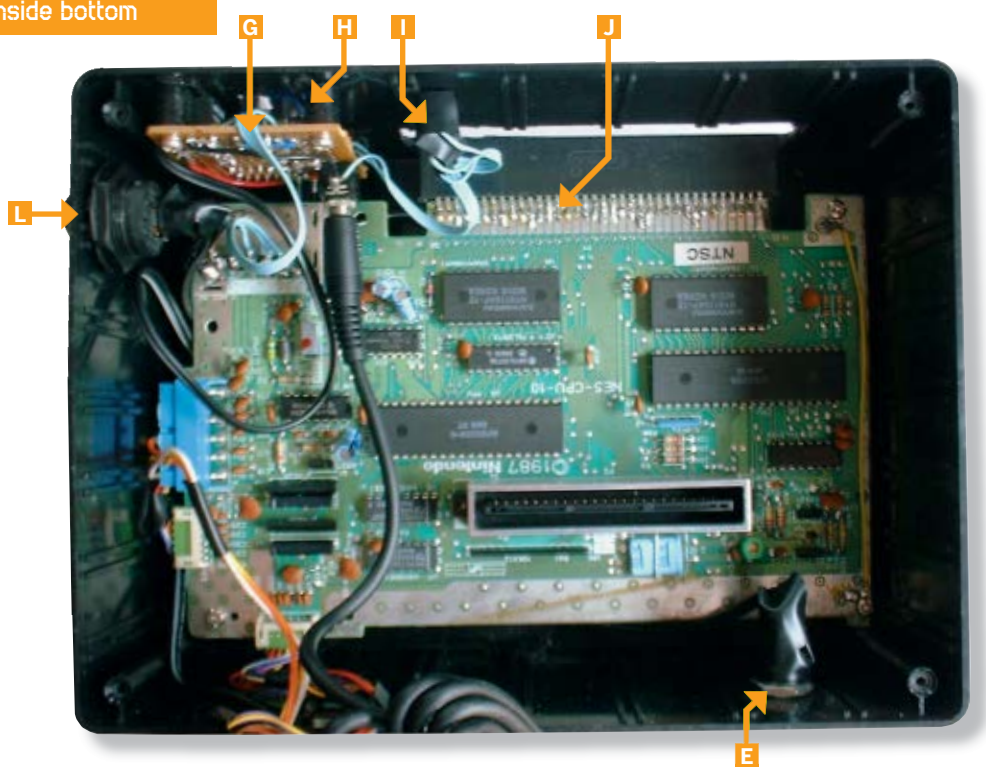
Top



Inside top lid



Inside bottom



Photography by Tighe Lory

work typically involves sawing apart the boards and reconnecting the circuit pathways with wires. "It helps to be good at soldering, since a lot of the connections a person needs to make can be quite small and close together," notes Heckendorn.

Erik Zuroski, a 21-year-old computer engineering student from Milwaukee, Wisc., recalls wrangling with wiring as the biggest problem he faced when turning a PlayStation 1 into a portable. A single wire may not seem to take up a lot of precious volume inside a case, but they add up, and can become a frustrating, springy mess. He recommends, "Make sure to leave yourself enough room for wiring. It might make the final product a little bit bigger, but it will save you hours of frustration."

Video Output and Display Screen

Pulling a video signal off of an old video game system and connecting it to a modern-day LCD screen may require the construction of additional circuits.

Says Tighe Lory, a 29-year-old programmer from Richmondville, N.Y., who made a portable Nintendo Entertainment System: "I had to create a new circuit board that amplifies the weak composite video signal after I removed the RF modulator from the NES."

Heckendorn warns that taking apart a miniature television, from which to cannibalize the LCD screen, can pose another challenge.

"Some of the pocket TVs have strange internals, like multiple interconnected circuit boards instead of just one and weird [screen] lighting schemes," he explains.

Portable Game Websites

Benjamin J. Heckendorn's personal website:
benheck.com

The Portables of Doom! — a web community for the portabilizing scene:
doomportables.org

Erik Zuroski's portable PlayStation 1:
people.msoe.edu/~zuroskie/hhps

Tighe Lory's portable Nintendo Entertainment System:
classicgaming.com/nestable

Brian Gardiner's portable PS One:
palmpsone.com

Power

The power requirements for a video game system, especially that of modern consoles, can be daunting. Lory's portable NES runs for four hours on eight AA batteries — and that is considered impressive in this hobby scene.

Because a video game system's power regulator is often situated on the periphery of its circuit board, it's usually the first component to be removed and discarded. Still, Heckendorn says, "Don't over-power the unit. Most systems need the power to be regulated before using it."

Case Design

While most people don't have access to machining equipment like Heckendorn did, it is possible to work with plastic. Design your portable's casing with a CAD program and upload the file to a rapid prototyping firm, a company that will manufacture your case. (Expect to spend about $300 per case when using such a service.)

"Stereolithography is a very expensive technology, but it is the only way to give yourself the freedom of creating your vision," says Brian Gardiner, a 27-year-old tech help analyst from Rocklin, Calif. He created a portable PS One with an especially slick-looking case that looks like something Sony itself might have designed. "To me, the appearance of my device was just as important as the functionality."

Don't rule out the possibility of using electronics cases from unwanted equipment either.

Cost

Expect to spend $200 or more for all the necessary parts. (The bulk of this goes to the display screen and battery.) If you choose to custom-design a handheld case for a more professional final product, the cost can go up to $600 and quite possibly more. For that price, you can buy a Nintendo DS and a library of games.

To the portabilizers, the price is worth it. "You don't do a project like this to save money," says Lory. "I really love the NES, and it was fun to take one apart and make it better than it was before, and breathe new life into it."

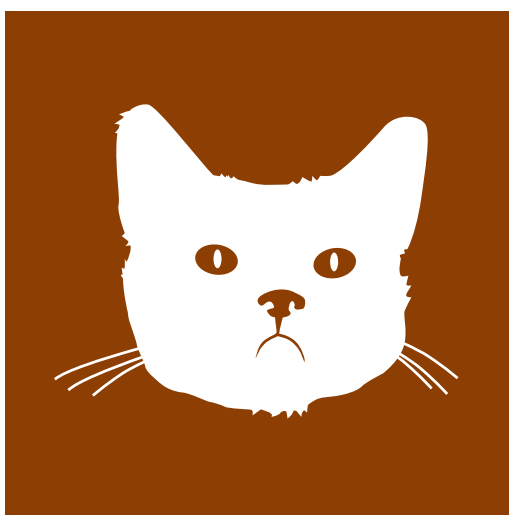
Howard Wen is a freelance writer who has written for *salon.com, oreillynet.com, playboy.com,* and *Wired*, among others.

Make: Projects

Scare the kids in your neighborhood. Use that extra VCR to feed your pets and give you a weekend away (now that the neighborhood is out to get you). Then build a glowing potato cannon; maybe you can use it to impress the neighbors and get back on their good side.

Haunted House Controller

86



VCR Cat Feeder

98

Night Lighter 36

108

Illustration by Erik T. Johnson

HALLOWEEN HAUNTED HOUSE CONTROLLER

By Eric J. Wilhelm

Build a relay board that synchronizes lights, motors, and other electrical devices to a scary soundtrack playing on a computer, and create spooky haunted house special effects! >>

Set up: p.89 **Make it: p.90** **Use it: p.96**

GEEK MEETS GHOUL

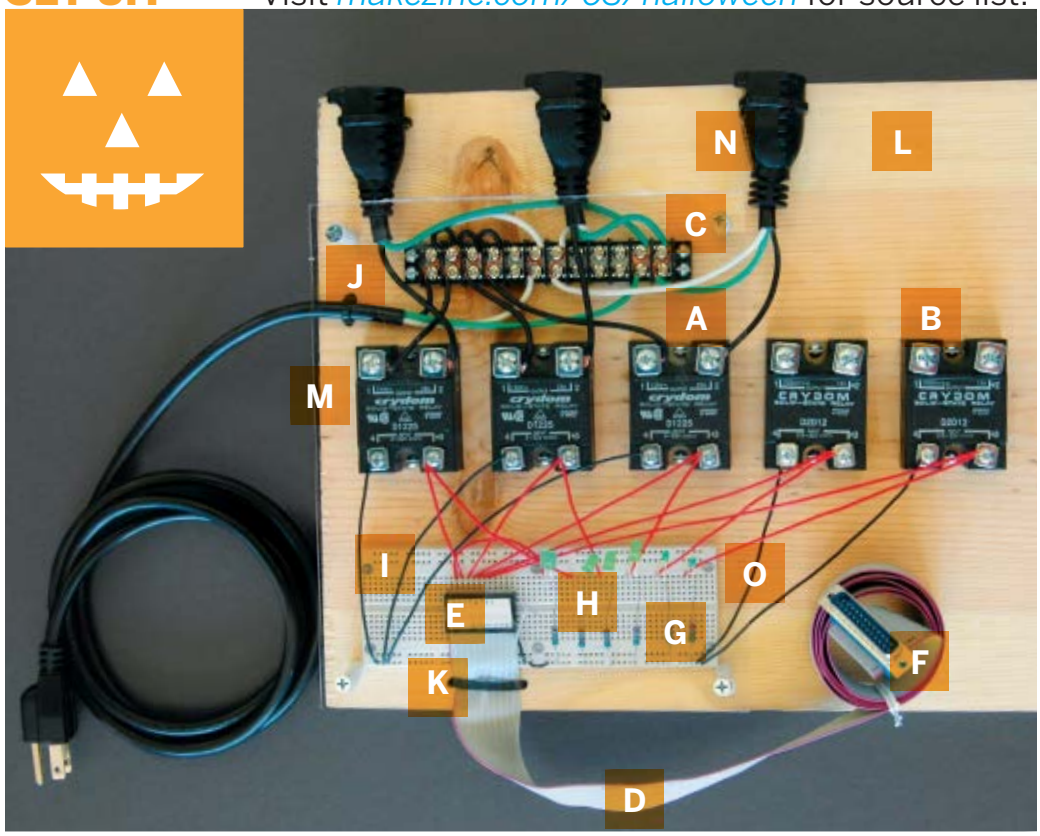
I loved neighborhood haunted houses as a kid. Trick-or-treating was more of a search for haunted houses than for candy and mischief. I was ever-hopeful that around the next corner, I would find another garage converted into a cardboard-and-bed-sheet maze filled with low-budget frights. But I often thought, "I could do better than that."

For the last ten years, I've been perfecting my technique of scaring kids. This project shows you how to build a tool I frequently use in my haunted creations: a relay board that switches on electrical devices in time to an audio file that's playing on a laptop. The laptop connects to the controller board via its parallel port. Using this setup, you can then write code that synchronizes lights, motors, fog machines, pumps, laser pointers, and other devices to sound cues in a spooky soundtrack.

Eric Wilhelm is a partner at Squid Labs (squid-labs.com), where he finds solutions to unique engineering problems.

SET UP.

Visit *makezine.com/03/halloween* for source list.



MATERIALS

[A] 120 VAC solid state relays logic-compatible input voltage (range should include 3.3-5 VDC), screw mount, with load voltage and load current ranges sufficient for any AC devices you expect to control. Get one for each device; I used three Crydom D1225 relays.

[B] DC solid state relays single-pull single-throw, logic-compatible input voltage (range should include 3.3-5 VDC), screw mount, with load voltage and load current ranges sufficient for any DC devices you expect to use. I used two Crydom D2D12 relays.

[C] Terminal block for 16- to 22-gauge wire I used a 12-position barrier screw terminal strip.

[D] 25-wire flat ribbon cable

[E] 25-contact male D-subminiature connector with "displacement connection" that crimps onto ribbon cable

[F] 24-pin DIP (dual inline package) plug with displacement connection, for connecting ribbon cable to breadboard. These may be called either "IDC DIP plugs" or "DIP plugs," but don't confuse them with plain DIP plugs that don't bite into ribbon cable.

[G] 470-ohm resistors one for each relay, plus one extra.

[H] LEDs (standard 2V is fine)

[I] Small plugboard (solderless prototyping breadboard)

[J] Four stand-offs or some hard plastic or metal tubing that's wide enough to accommodate your screws. These need to be long enough or cut to sufficient length to clear height of relays plus some extra headroom for wiring; I used 1.25-inch for relays 0.9 inches tall.

[K] Cable ties

[L] Non-conductive base I used plywood.

[M] Non-conductive transparent cover I used a small sheet of hard acrylic.

[N] Grounded extension cords Get one for each AC relay. One should be at least 6 feet long; the rest can be any length because you'll be cutting them and only using the ends.

[O] Wire 16-gauge stranded for AC devices, 22-gauge solid core for DC and signals.

TOOLS

Windows-based laptop (or a desktop computer, but those are less convenient and harder to conceal)

Wood screws

MAKE IT.

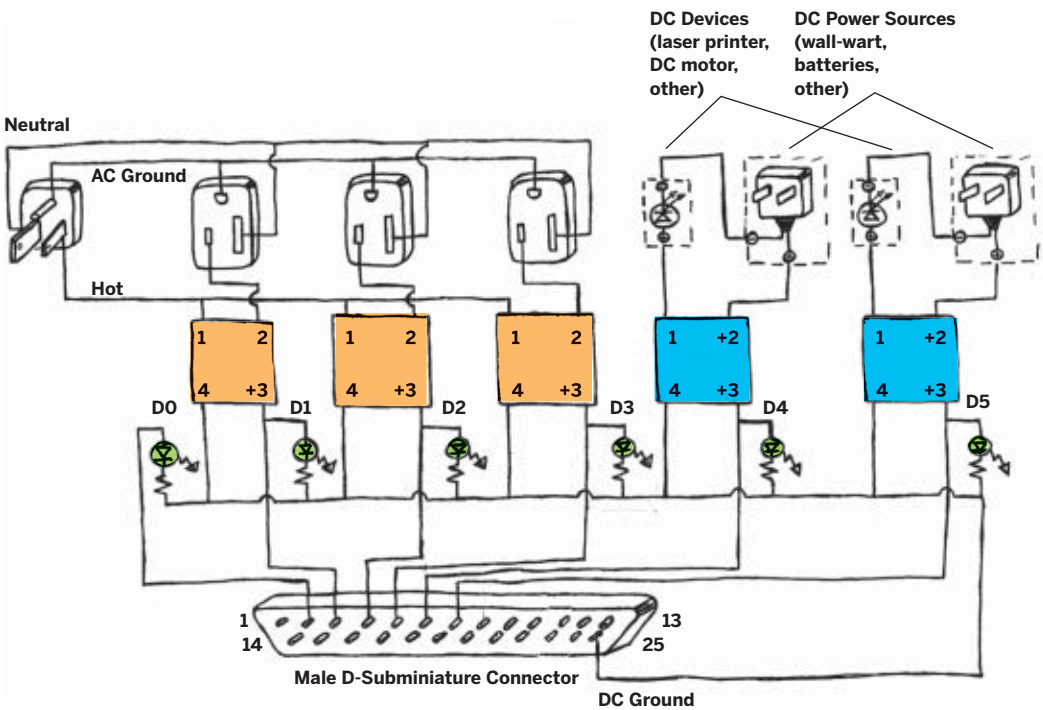
BUILDING THE CONTROLLER BOARD OF DOOM

START

Time: A Weekend Complexity: High

1. ASSEMBLE THE CONTROLLER BOARD'S AC SIDE.

My controller board consists of three AC relays (to power 120 VAC props) and two DC relays (to power things like laser pointers and battery-powered props), but you can add another relay. The relays are switched on and off by signals sent from a personal computer through its parallel port. The schematic below shows how the various components are connected. If you can't read a schematic, don't worry; you can still build the controller by following along with the photos. (Also, see page 151, *Reading and Drawing Schematics*.) But to program it later, you'll need to get into some simple C++ code and do some light tweaking, compiling, and debugging.



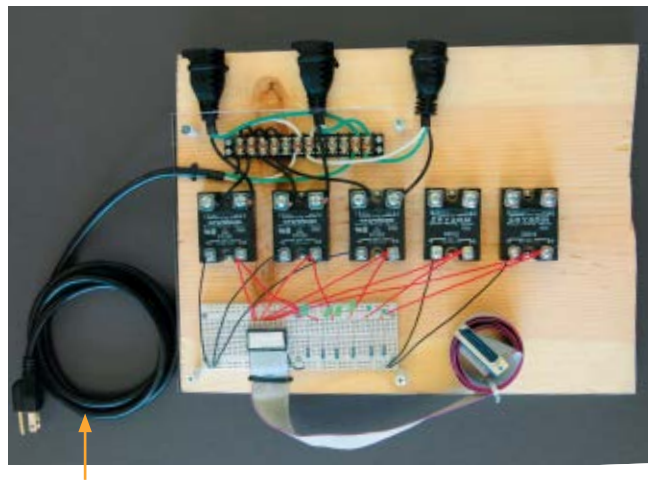
AC Relay - Crydom D1225
DC Relay - Crydom D2D12
General Status Indicator (always on)

Photography by Dale Dougherty

1a. Attach main components to wooden base. Using the photograph as a guide, lay the solid state relays, terminal block, and breadboard onto the base. Mark places for holes, and drill holes appropriately sized for the screws. Using wood screws, attach the components to the base.

1b. Attach receptacles. Cut all of the extension cords approximately 12 inches from their receptacles, and strip ¾ of an inch of insulation at the cut. Mount three receptacles to the edges of the base by drilling through holes and securing with cable ties.

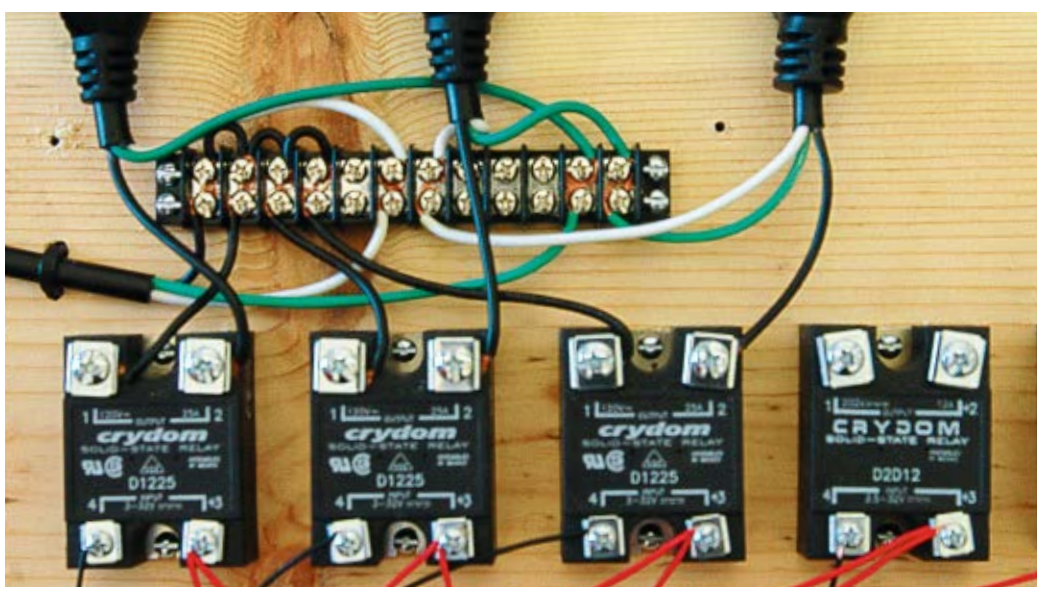
1c. Attach AC power cord. Attach the cut end of the fourth extension cord to the base, and strip ¾ of an inch of insulation.



This is the cord that supplies AC power to your props.

1d. Attach wires to terminal block. Wire up the AC side of the controller, as shown, using the screw connections on the terminal block. Use short pieces of the #16 wire to connect the hot side of each receptacle to the hot output (Terminal 2) contacts of the solid state relays. It's always best to switch the hot side, not the neutral.

The wires in extension cords are often color coded: black is hot (live), white is neutral, and green is ground. If yours aren't color coded, look at the plugs with the blades pointing towards you and the round, ground plug at the top. Hot is the smaller blade, on the right, and neutral is the wider blade. Use a multimeter to test conductivity between the blades and wires to identify which is which.

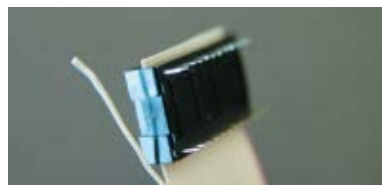


2. MAKE THE DATA CABLE.

2a. Snap D-sub connector to cable. Position one end of the ribbon cable squarely between the D-subminiature connector's two rows of forked contacts, and then press down with the strain relief. The connector should snap into a locked position.

Each of the forks ("insulation displacement connectors") should pierce through the ribbon cable's insulation and make a connection with a wire inside.

2b. Snap DIP plug connector to cable. Peel one wire away from either edge of the other end of the ribbon cable, and connect the remaining 24-wire ribbon to the DIP plug, using the same method as above.

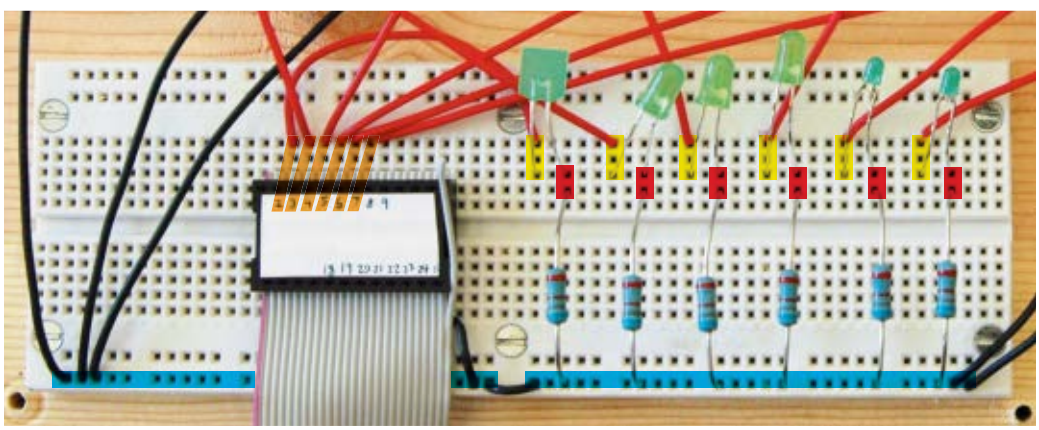


It doesn't matter which edge of the ribbon cable you peel the wire away from.

2c. Determine pin-to-pin relationship. Use the multimeter to see which pins on the D-subminiature, parallel port connector correspond to which pins on the DIP plug. The pins we're interested in are the ones that connect to the parallel port's Pins 2-9, which are the output data lines, and the port's Pins 18-25, which are all grounds.

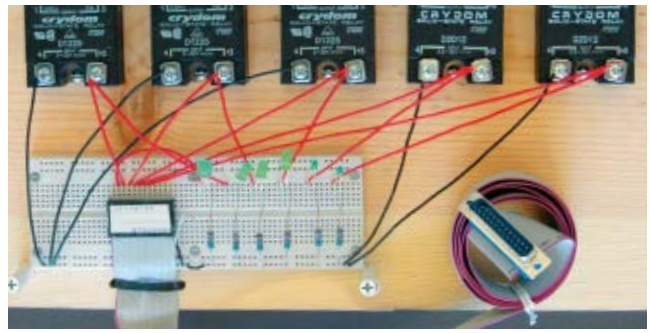
You might sketch a map of the DIP plug's layout or attach a label to help you remember.

3. WIRE UP THE BOARD'S SIGNAL SIDE.



Ground (from parallel Pin 25)
LED to Resistor
+ input to LED
+ input to relay (Terminal 3)

3a. Wire up the breadboard. Plug the DIP into the breadboard. Using the schematic or photos as a guide, wire up the controller's signal side, using #22 wire. This will connect the relays' input terminals to the parallel port via the ribbon cable, while LED/resistor pairs show the state of the parallel port. The first output pin, Pin 2 on the parallel port, will always be on as a general status indicator. Then, starting with Pin 3 and going down the line, each input pin connects to both the positive-side input (Terminal 3) of each relay and the relay's LED indicator. The other sides of the relay inputs and indicator pairs connect to ground.

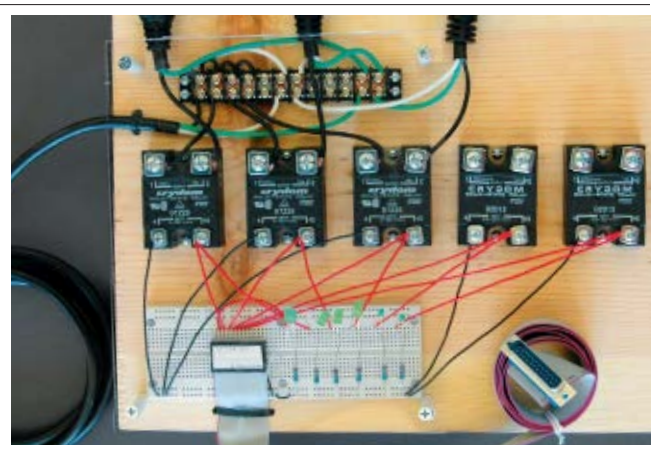


4. CONNECT THE COMPUTER.

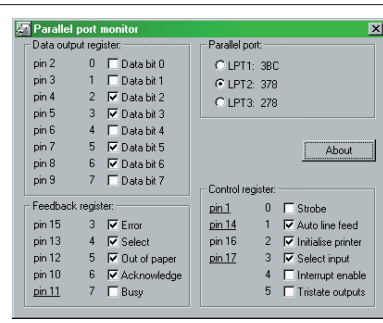
4a. Secure the DIP connector to the board with a cable tie, so that it won't get yanked out of the breadboard.

4b. Cover the AC portion of the controller. Mark and drill holes in the base and cover and connect them with the stand-offs. I used clear acrylic so I could still see the LEDs.

4c. Ensure your wiring is correct before attaching to a computer. A parallel port can only source a few milliamps of current, and can be damaged if the data lines are shorted to ground.



4d. Plug the controller into your computer's parallel port (leave the AC unplugged for now) and see if you can illuminate the LEDs. Use a parallel port monitor such as "lpt.exe" from neil.fraser.name/software/lpt. The port number of the parallel port varies between machines, so be sure to check all options. You may have to change your parallel port's setting in the BIOS to something other than bidirectional, such as ECP or output only.



Note that a parallel port's eight output pins are addressed in binary fashion: writing a 0 to the port turns them all off; writing 1 turns on only the first data pin (Pin 2); writing 2 turns on only the second data pin (Pin 3); 3 turns on the first and second, and so on up to 256, which turns on all eight.

4e. Test the controller board by plugging it into 120 VAC and then plugging a lamp into one of its AC plugs. The power to the lamp should now be under computer control.

4f. Attach your devices. AC devices can be attached by simply plugging them in. For DC devices, splice a DC relay's output terminals between the positive wire that comes from its power supply (for example, the device's wall wart) and the device's positive power input. For battery-powered devices, you can use an external battery pack and run the wires through the controller, or use an equivalent wall wart AC to DC transformer and plug that into the AC on the board.

5. CREATE YOUR ACTION SEQUENCES.

The devices you use with the controller complete the display. Lights, strobes, fans, and fog machines are easy; just plug them in. I created one vivid effect by directing laser pointers into the eyes of a stuffed rubber mask, and when the controller switched them on, the eyes seemed to come alive. Projectors shouldn't be repeatedly power-cycled with a controller, but you can set motors up to block or deflect their beams.

Motors outfitted with rotating cams will pull strings that make skeletons dance and bats flutter, and reels will raise and lower hanging spiders. To drop a guillotine blade, I used a 12 VDC automobile seat motor to rotate a cardboard hook that released the rope. I reinforced this effect with an aquarium pump that gave a quick squirt of warm water just after the blade dropped, treating onlookers to the feeling of fresh-sprayed blood.

5a. Think of some simple but scary scenarios that can be conveyed by sounds and darkness and enhanced by your devices. One approach: weave a story that's just plausible enough that kids will wonder if it's true, and while they're pondering, startle them with something dramatic, like an abrupt lighting change or the hiss of a fog machine.

5b. Create the soundtrack. Using a wave file editor, I sampled, cut, and pasted sounds from Halloween CDs. The sequence of sounds should suggest a series of events, but it needs to be short and concise; trick-or-treaters aren't known for long attention spans, and you don't want the next group arriving in the middle and missing the fun. You can hear my guillotine sequence soundtrack at oreilly.com/go/soundtrack .

5c. Download Borland's free C++ Compiler, then download inpout.dll and add it to your compile libraries. This is what makes calls to your parallel port from Windows NT and XP. For details and links, see hytherion.com/beattidp/comput/pport.htm.

5d. Write the controlling code that syncs your devices to your soundtrack. You can model your code on my sample at oreilly.com/go/syncode. Include inpout32.dll and define all of your devices as variables at the top of the file. Then play your soundtrack file and run through a precisely timed sequence that pushes values to the parallel port (often at machine address 0x0378) and calls to the Sleep function. Compile, run, debug, and repeat as needed.

Or, instead of writing a fixed script, you can also use the controller board to switch lights and other devices in time to the beat of music you're playing on Winamp. Check out discolitez.com for a Winamp plug-in, or try mine at 8-legs.org/ewilhelm/projects/2.165. My plug-in works by calculating the difference in the Fast Fourier Transform of a song between one time step and the next. When the value of this difference in a narrow frequency range exceeds a threshold, one of the relays is triggered. This lets you set a string of Christmas lights along the floor to flash with the kick drum, sync another at eye level with mid-range beats, and use a third along the roof to complement cymbal crashes.

5e. Dress up your haunted house with other tricks. I discovered that baby Furbys behave very strangely when given half of their normal 6 VDC. Instead of batting its eyelashes and making baby sounds, mine moaned and screamed like it was just skinned alive. So, I completed the effect by actually skinning it and wiring it up to the controller and a 3 VDC source. Remember that in the dark, you often need only to suggest something rather than fully recreate it. For example, two bright white lights and a rush of air from a fan along with the soundtrack were enough to evoke the feeling of a truck stopping just short of trick-or-treaters at the door.

You'll know you have it right when kids come to the door holding their bags open for treats, watch wide-eyed for a few terror-filled moments, clamp their bags shut and sprint back to their parents before the piece of candy you tried to drop in their bag hits the ground. Happy Halloween!

FINISH X

NOW GO USE IT »

USE IT.

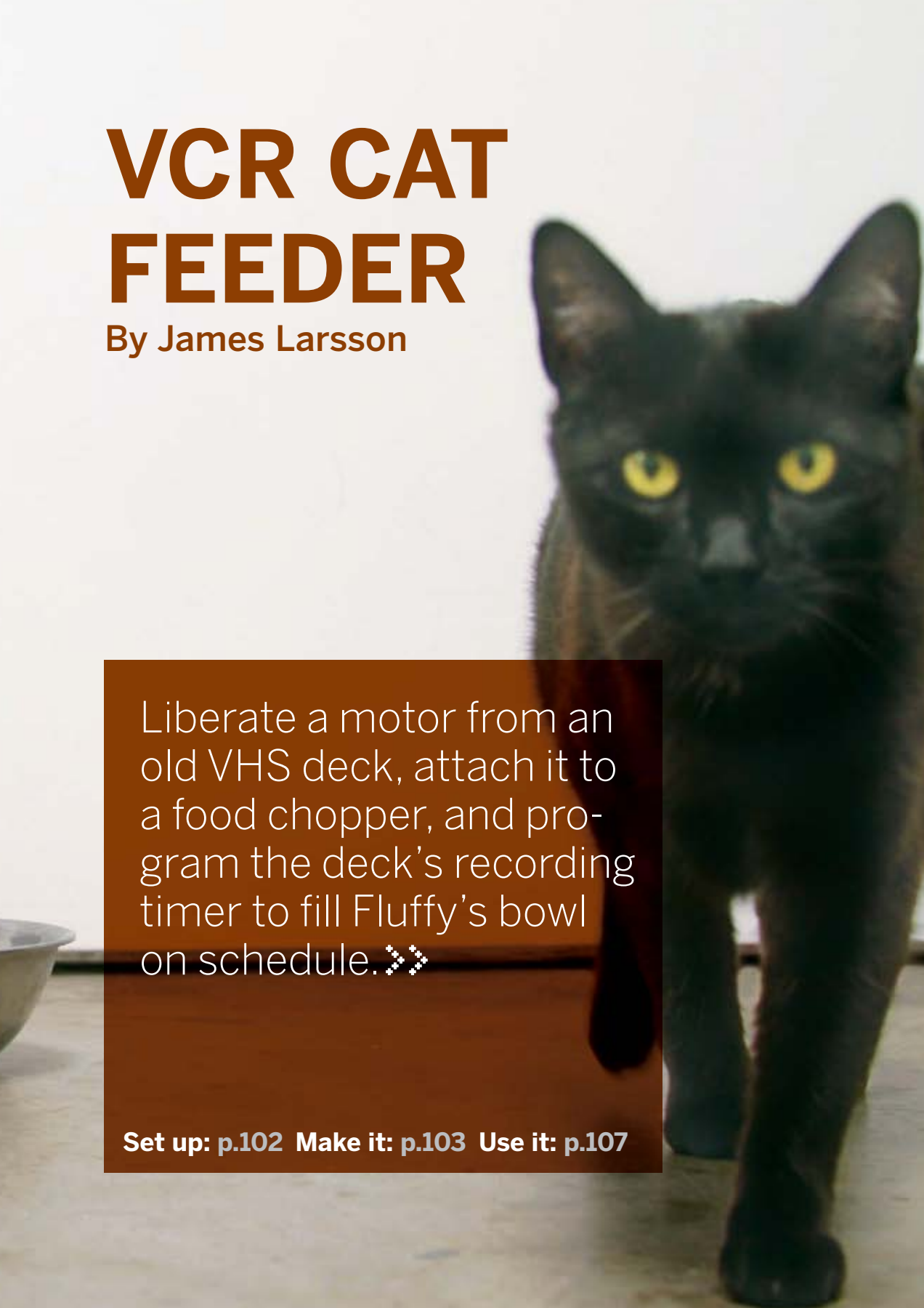
Illustration by Eric T. Johnson


DOWNLOADING ILLEGAL MP3s? LOOKS LIKE THE RIAA CAUGHT YOU RED-HANDED!
OR SHOULD I SAY HAND-LESS! hee-hee-hee.'
CHOP!
MUSIC FROM COMPUTER TRIGGERS BLADE.
DOWN THE STAIRCASE TO THE BALLROOM, MY NERDIES! YOU'VE BEEN INVITED TO ATTEND A VERY SPECIAL PARTY--THE
NIGHTMARE WEB LAUNCH EXTRAVAGANZA!
.ZOMBIEPETS.COM
♫ IT'S AFTER-MIDNIGHT ♫
THRILLER MASH-UP SOUNDTRACK.
AN I.P.O. IS WONDERFUL, BUT NOT SOMETHING TO LOSE YOUR HEAD OVER! WATCH OUT FOR THE VULTURE CAPITALISTS OVERHEAD-- THEY'RE SWOOPING DOWN!
POP!
IS THRILLER=THRILLER NIGHT
POP!
NOW THAT'S A WEBSITE FOR GORED EYES! AND TO THINK THAT EVERYTHING WAS CONTROLLED WITH MAKE'S HALLOWEEN RELAY PROJECT! IT'S ENOUGH TO MAKE THIS OLD CRYPTO KEEPER SHED A FEW TEARS, AND A FEW BODY PARTS.'
PUMPS SQUIRT AT 'THIS IS THE END OF YOUR LIFE.'
NOW YOU'LL HAVE TO EXCUSE ME - I HAVE A LITTLE HACKING TO DO! I DON'T WANT THOSE PESKY VULTURE CAPITALISTS TO GET ALL THE GOOD GOBBETS TO THEMSELVES! UNTIL NEXT ISSUE, PLEASANT SCREAMS! hee-hee-hee.'
MOTORS REBEL VULTURES DOWN DURING VINCENT PRICE MONOLOGUE.
fin

Photograph by Thayer Gowdy

VCR CAT FEEDER

By James Larsson



Liberate a motor from an old VHS deck, attach it to a food chopper, and program the deck's recording timer to fill Fluffy's bowl on schedule.

Set up: p.102 **Make it:** p.103 **Use it:** p.107

A VCR TO FEED YOUR PET

Any old VCR has a programmable timer that connects to motors for recording TV shows. This is analogous to feeding a cat, and following this principle, you can convert a VCR into a weekend pet feeder. You set the VCR's timer, and when feeding time comes, the motor that would ordinarily spin the video head operates a food delivery mechanism instead. You can even program different size portions for different days, for times when you plan on returning midday.

Pet feeders are sold commercially, but few match the versatility of a modified VCR (no matter how silly this project might sound). My feeder is based on an auger mechanism, like some vending machines. A helical shaft propels food from a hopper into the pet's bowl. You can use the same basic mechanism to drop food into a fish tank.

James Larsson is an electronics engineer and IT historian from London, for whom hardware hacking is both work and play. In addition to designing electronic equipment, he lectures and broadcasts about computer history. He also regularly performs comedy science shows, where advanced scientific principles are used to do ridiculous things.

PROGRAMMABOWL VCR: HOW IT WORKS

Cats need a regularly controlled food supply, but can otherwise look after themselves for a few days. Hijack a motor from inside an old VCR, and you can use its timer-recording system to dispense scheduled meals.

A gearbox converts the fast-spinning VCR motor to a much slower rotation with correspondingly higher torque — enough strength to turn the crank of a food chopper or other auger mechanism. Some gearboxes, like the ones shown here, reduce the rotation step-by-step with a series of planetary gears, where the box's total ratio equals the product of the gear ratios of each element. Other gearboxes, like traditional music boxes, use a single screw-shaped worm gear. You can also reduce rotation with different width spools and rubber-band pulleys.

Fed by gravity, the food chopper's auger conveys the yummies into the bowl. Depending on the mechanism, it may also do some chopping in the process.

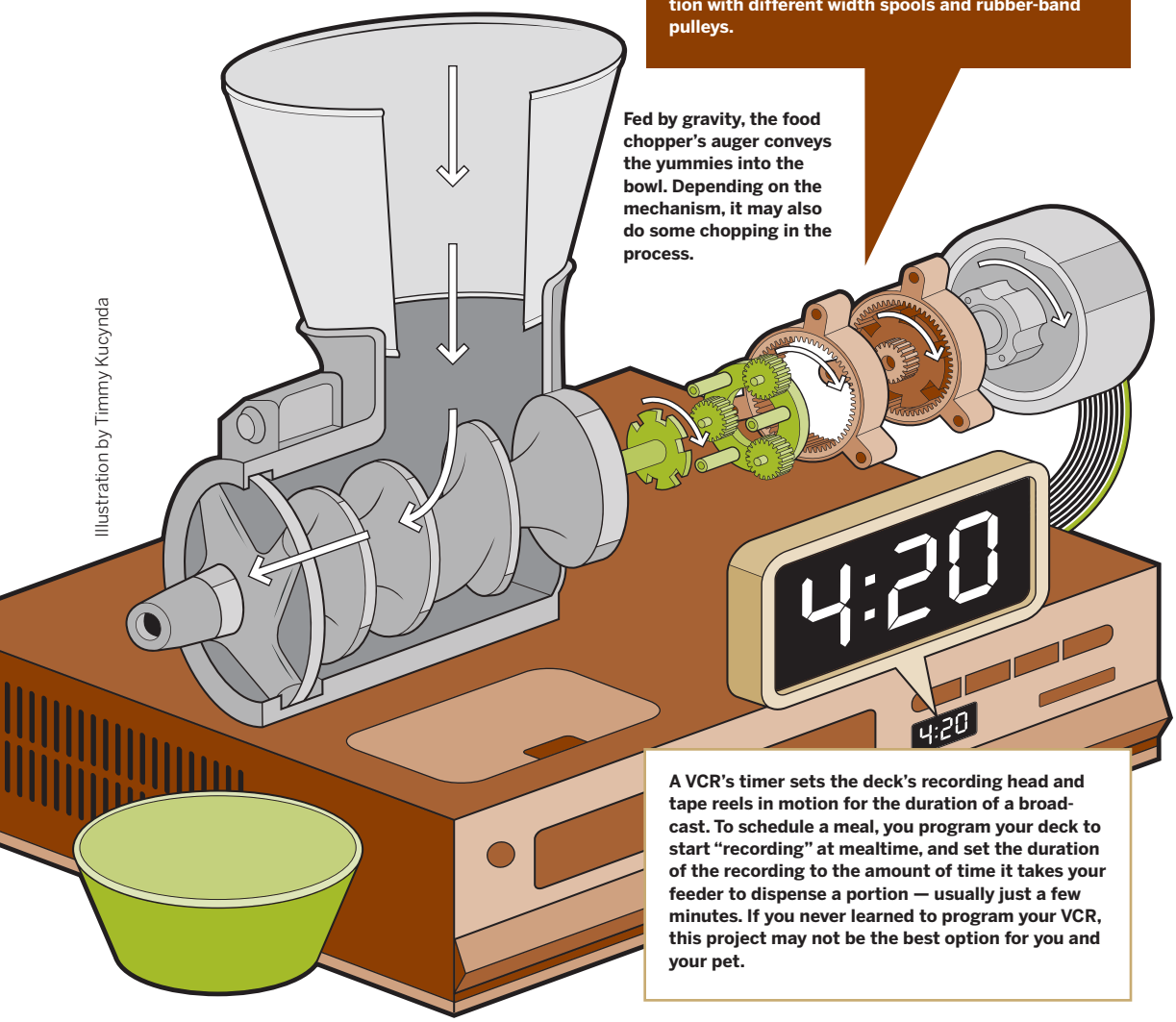
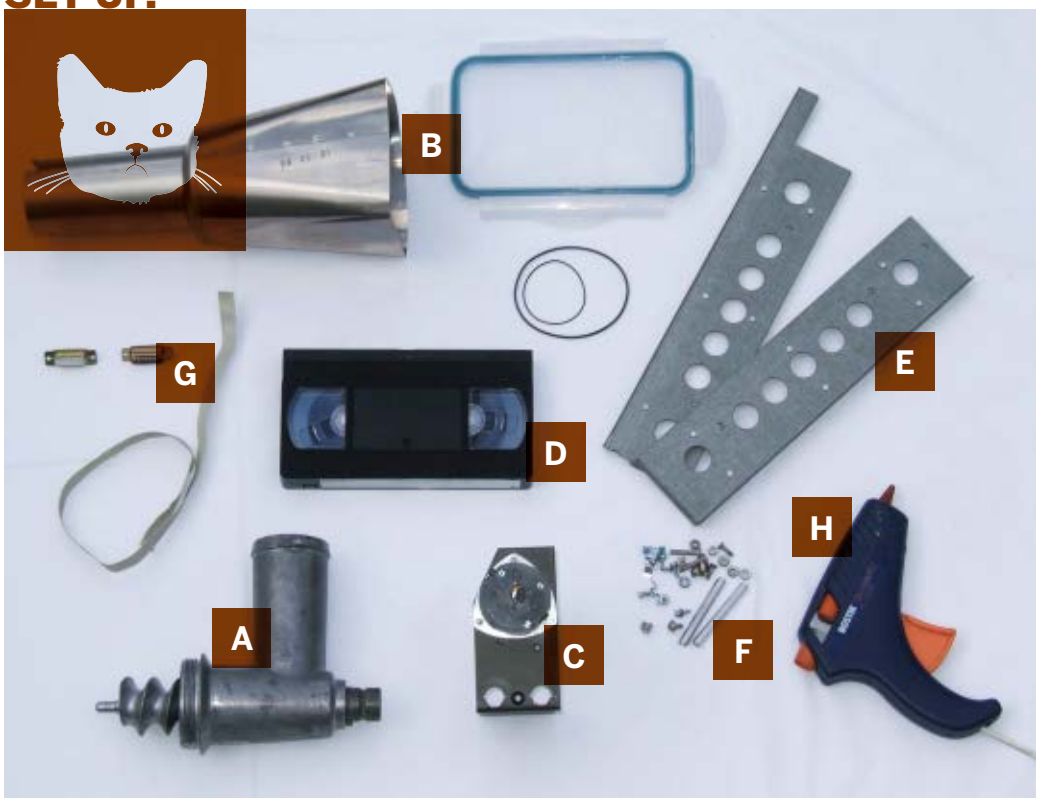


Illustration by Timmy Kucynda

A VCR's timer sets the deck's recording head and tape reels in motion for the duration of a broadcast. To schedule a meal, you program your deck to start "recording" at mealtime, and set the duration of the recording to the amount of time it takes your feeder to dispense a portion — usually just a few minutes. If you never learned to program your VCR, this project may not be the best option for you and your pet.

SET UP.



COMPONENTS

A VCR that still more-or-less works. Test the VCR first to make sure its timer and tape transport mechanisms still function, even if it doesn't produce a watchable picture. The VCR should activate its mechanism at the set time, run the tape for the set period, then stop.

If you have a choice of VCRs, go for one that you can program entirely from the front panel — this project gets cumbersome if you need to program the VCR with a remote control or via on-screen menus.

[A] Some kind of auger system. I used an old meat grinder with a helical shaft, with the cutting blades removed.

This propels the food from a container into the bowl. Make sure it works with the type of pet food you want to dispense. When choosing your auger, bear in mind that your hungry pet might try to eat, paw, or lick the system while it's in motion, and, if so, you don't want it to cause any injuries.

[B] Some kind of container that will connect with the auger system. I fashioned a sort of metal hopper head out of the magnetic shielding from an oscilloscope tube.

As with the auger, you'll need to make sure this is pet-safe — and also pet-proof. The system won't help if your cat can jump into the hopper or knock it over. I covered mine with a plastic lid, to keep the cat out.

[C] A small gearbox (or pulley system) which can reduce the standard 1800 RPM counterclockwise rotation of a video head motor into rotation suitable to drive the auger. A turn ratio of about 600:1 typically produces the right speed and torque. I used a gearbox from a defunct cam sequencer, but you can also get these from hobby retailers. Some good ones are made by Tamiya.

The "fast side" of the box must be able to couple to a shaft of approximately ½ cm in diameter. Also, make sure that the "slow side" of the gearbox can connect solidly to your auger and rotate it in the correct direction (remember the "fast side" will be going counterclockwise).

[D] A videotape you don't mind sacrificing. Make sure the recording-enable tab is unbroken.

[E] Something that can hold the assembly of auger, gearbox, and video head motor all together. I used a metal card frame.

[F] Electrical tape, nuts, bolts, screws, strong glue, etc.

[G] You might also need a multiway electrical connector and some hook-up wire. This will depend on what you find inside your VCR and how you arrange things.

TOOLS

[H] Hot glue gun

Screwdrivers

Soldering equipment

Ability to improvise

Photography by James Larsson

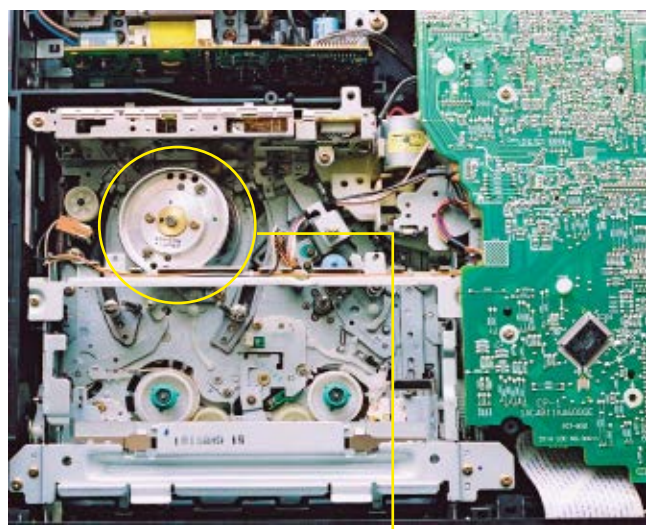
MAKE IT.

BUILD YOUR VCR CAT FEEDER

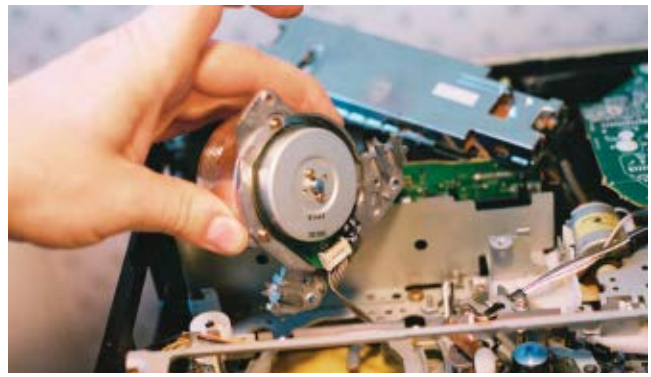
START **Time: A Weekend** **Complexity: Medium to High**

1. UNPLUG THE VCR AND OPEN IT UP. To do this, you'll probably just need a Phillips screwdriver. WARNING: As with all 110V AC-powered equipment, once you open the cover of your VCR, you are exposing yourself to the risk of serious and possibly fatal electric shock. Generally speaking, this risk is confined to the power supply and any associated switches, cables, or connectors. This article only involves the safe, low-voltage sections of a VCR. Nevertheless, it is crucial that you know WHERE NOT TO TOUCH, especially since some of the experiments involve switching on the VCR while the cover is off. It is a good idea to place some sort of insulating shield (e.g., a piece of plastic) on top of the power supply area. Hacking a VCR is only to be attempted by people with a good knowledge of electricity and its risks.

2. IDENTIFY THE VIDEO HEAD DRUM. Find the motor that drives the rotating video head drum. This motor works independently from all the other mechanical systems in a VCR, so you can disconnect it with impunity, without affecting the VCR's control systems. VCRs contain several timer-controlled motors you could use, but these other ones are often linked to sensors and interdependent systems, and their absence or misuse might stop the VCR from doing what you want. That's why I chose to use the video head motor.

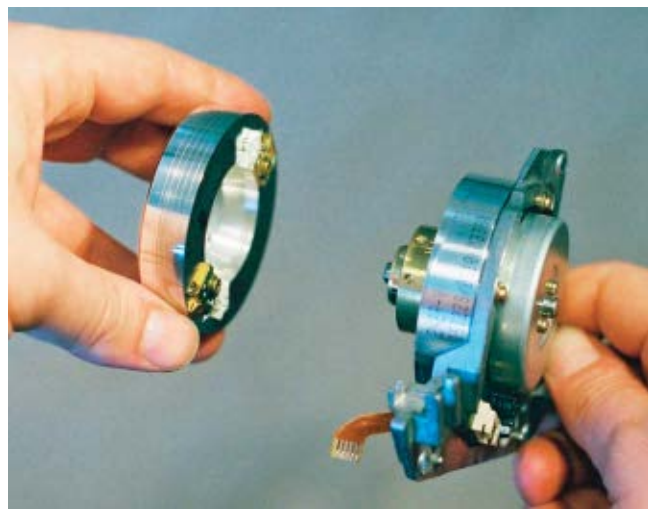


3. REMOVE THE VIDEO HEAD DRUM ASSEMBLY. Remove the screws that hold the video head drum assembly in place, but don't disconnect any of the wires leading to it. You'll be pulling the video head motor outside of the VCR and using it to power the auger via the gearbox.

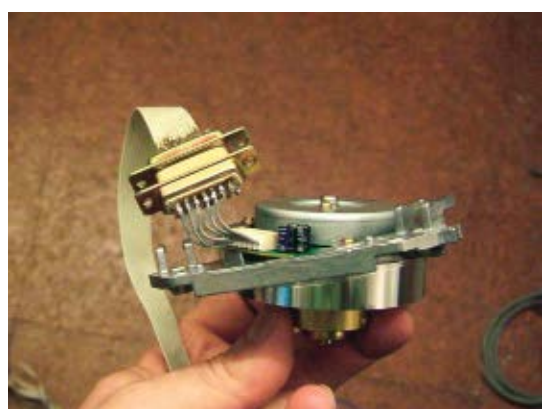


4. DETACH THE DRUM FROM THE MOTOR. To reduce the load on the motor, remove the actual video head drum. These are usually attached to the motor by screws on top, but you might have to unsolder connections to the heads.

Video head motor assemblies carry a drive system, a feedback system, and more, so they need a lot of wires. Newer models have small controllers on an integral PCB, but even with these, numerous wires still lead out to other parts of the VCR. Since all you care about is the motor, you can cut away any other wires you identify as unnecessary. They are usually the cables nearest the top of the head assembly, a short distance away from the motor connection.



5. EXTEND THE MOTOR CONNECTIONS. You need to get the motor out of the VCR and into a location where it can drive the gearbox, and, in turn, the auger. To do this, you may have to splice some additional length into the wires that feed the motor. If so, keep the length as short as possible; I sited the whole motor/gearbox/auger/catfood assembly directly on top of my old VCR for this reason. It's also nice to solder in a multiway connector, so that you can unplug the feeder assembly from the VCR, thus making it easier to clean.



6. ASSEMBLE THE FEEDER. Connect the motor to the "fast side" of the gearbox. How you do this will depend on the gearbox you have chosen and the length of shaft available from your VCR's motor. For my feeder, I cut off the cog from my gearbox's original, attached the motor, and, making sure it was dead central, simply glued the VCR motor on with strong glue. Similarly, connect the "slow side" of the gearbox to the shaft of the meat grinder (or other auger mechanism). I attached the two using a cog from an old lawn mower and more glue. Finally, attach the motor/gearbox/auger assembly to whatever you're using to hold it in place. I secured it to my metal frame with a combination of bolts and glue.

7. TEST. First, make sure everything is aligned and that the couplings on each side of the gearbox turn smoothly. Power up the VCR, insert the sacrificial video tape, and press Record. Ideally, the video head motor will rotate and drive the auger. If so, you're lucky; your feeder is ready to roll. Just be sure the tape is sufficiently rewound before each use; if it reaches the end, your pet will go hungry!

Don't worry if the motor slows a bit under load, but if the motor stalls completely, the VCR's microcontroller will sense this and shut the system down, probably forcing you to switch the VCR off and then on again. If you have persistent problems with overloading, you might need to swap in a gearbox with a greater reduction ratio. Alternately, you could try using one of the other motors in the VCR. If you do this, you'll have to take into account the motor's original role, and arrange a kludge for any sensors associated with it, as discussed later.

VCRS AND TRASH TECH

VCRs have been around for about 30 years, and in that time they have gone from being suitcase-sized machines stuffed with motors, belts, and PCBs to small boxes that seem relatively empty. What you see when you take the cover off your VCR will have more to do with its age than with its brand or model. As a general rule, older machines are better for hacking. Their designs are less integrated; fewer systems are locked away in chips, and there's simply more stuff to alter and adapt.

You might simply scavenge these junked machines for individual components, but it's more interesting to use whole, functioning sections for some entirely new purpose. If you wanted to build a pet feeder from individual pieces, you'd have to assemble a power supply, a timing system, and a mechanical control system. In a VCR, not only are all of these subsystems ready-made, but they already work together. Sure, you could rip the timer out of an old VCR and use it to trigger any electrical device, but it's connected to tape transport and read-head motors — so why not base a project on more of the original machine? This high-trash approach saves effort and minimizes the number of new components you need to buy, adding to the project's trash-tech value.

Note that trash-tech projects like this one require more improvisation than ordinary construction projects, because you probably won't be using the same old VCR model that I used. You'll have to find your own way with your trash, and in some places, I can only describe the principles, theories, examples, and pitfalls, rather than give a step-by-step. Working with junk technology is rarely going to produce a device of great engineering elegance or optimal performance. Nevertheless, it's fun, interesting, and inexpensive — and it works!

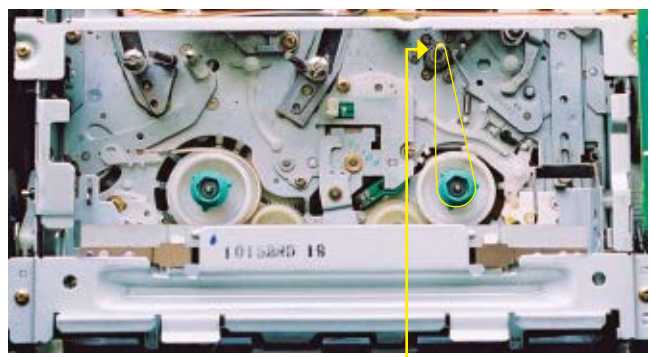
8. TRICK THE SENSORS AS NECESSARY. Your cat feeder still may not work due to its sensors reading abnormal conditions. Or you might want it to operate continuously, with no tape to rewind. The following tricks might make it work the way you want. See next page for explanations and other strategies.

Trick #1. Disassemble your sacrificial videocassette and remove the tape reels. Reassemble, cover the holes on each side with opaque tape, and load it in. If your VCR accepts this empty shell and still "records" without stopping, consider it conveniently gullible!

Trick #2. With your sacrificial videocassette partly rewound, remove its screws and reassemble it with adhesive tape. Load it into the VCR. Once it's happily loaded, unstick the tape, take the top half off, and remove the reels. If your VCR precludes you from disassembling the videocassette *in situ,* remove its windows so you can get your fingers inside.

Stretch a rubber band from the right-hand spindle to the capstan. Then press Record and see what happens. If all goes well, the spindle will turn at the correct speed and your VCR will continue "recording." If it does not, try placing another rubber band between the left-hand and right-hand spindles.

This is a fiddly operation that you won't want to repeat very often. Moreover, your VCR might need to stay powered up afterwards (so that it remembers that it's been through the tape loading procedure). Thus, you might want to finish all other aspects of your pet-feeding system and treat this as the last stage before use.

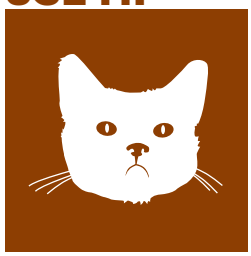


Connect the right spindle to the capstan, and it rotates as if a tape is loaded.

FINISH X

NOW GO USE IT »

USE IT.



FEED ME.

TROUBLESHOOTING.

A typical VCR presents several obstacles to hacking attempts. Here are the most common problem sources, and ways to get around them:

Hack-resistant circuitry. Many VCR subsystems are surprisingly distributed, and some microcontrollers sense the absence of any circuitry. Don't disconnect or remove any PCBs or other systems, even if they appear to play no part in your project.

Weak signal. Some VCRs won't record a show if the signal is too weak. To avoid having to connect your pet feeder to a TV aerial, set it up to record from a (nonexistent) camera or other external line source.

Various optical sensors. These can be sensitive to ambient light, and will trigger the VCR into doing spurious things when the case is open or there's no tape inside. You may have to work in subdued light, or locate and shield all of the offending sensors.

Tape-loaded sensors. These sense the presence of the videocassette, and are usually linked with the mechanism that loads and ejects it. The easiest kludge is to load a tape or modified tape case.

Tape-end sensors. These detect the start and end of the tape using light. Put opaque adhesive tape over the two sensors that flank the cassette, or cover the corresponding holes on a cassette itself.

Recording tab sensor. This detects whether a videocassette's record-enable tab is present. It's usually a little leaf switch. Use adhesive tape to hold it in the "pressed in" position, or else connect or break the switch's contacts as appropriate.

Spindle motion sensors. These sense whether the cassette's reels are moving at a normal speed, triggering shutoff if the tape jams or breaks. The right-hand spindle always has one of these, but the left may not. One workaround is to drive spindles from the capstan by using rubber bands as pulleys.

Mode switch. This usually looks like a cog with electrical connections, and it tells the VCR's microcontroller the device's current state (Play, FF, REW, etc.). For this switch, as well as some tape-loaded and spindle motion sensors, there's too much variation among VCR models to permit any sure advice. Different models of VCR exhibit huge variations in system design and in what sorts of misuse they will tolerate. You'll just have to experiment both electrically and mechanically to get around these.

If nothing else works, try to determine what happens when an ordinary videocassette is loaded, and re-create these events by manually twiddling the spindles with your fingers, simulating the tugging that a tape would do. You'll need to observe your VCR operating, and identify which bits of the mechanism are in what position, and which internal switches, sensors or optical systems are in use. I like to think of it as a puzzle which gradually teaches you how your VCR works. And once it's done, your pet can look forward to happy days of automatic

FEEDER OPERATION.

You'll schedule feedings as timer recordings on the VCR, but first you will need to figure out how long each "recording" should last. After filling the hopper with food, put the VCR into the Record state and time how many minutes it takes for it to dispense a single portion. This is your program time. With my meat grinder auger, it takes only two minutes to fill the bowl.

Photograph by Casimir A. Sienkiewicz

THE NIGHT LIGHTER 36

By William Gurstelle

Launch potato projectiles 200+ yards with this stun-gun triggered, high-powered potato cannon with see-thru action. (Good thing potatoes are biodegradable.) >>

Set up: p.112 **Make it:** p.114 **Use it:** p.118

POTATOES, BEWARE

The potato cannon, a.k.a. the spud gun, is a popular and very entertaining amateur science project. It's simple to make, and few devices offer such bang for the buck. You can use the Night Lighter both day and night, but when it's dark, the clear PVC provides an excellent view of the interior ballistics. Also, the stun gun gives better performance than weaker sparks from piezoelectric or flint/steel igniters. It's fun both to fire and simply to watch in action.

A basic spud gun can be built with plain, white PVC for less than $25. The Night Lighter 36 costs more, but I scrounged leftovers from plastics suppliers and built mine for less than $50. After mastering basic gun construction, the intrepid potato cannoneer may want to design and assemble more complex and artistic devices.

William Gurstelle enjoys making interesting things that go whoosh then splat. He is the author of *Backyard Ballistics* (2001), *Building Bots* (2002), and *The Art of the Catapult* (2004). Visit backyard-ballistics.com for more information.

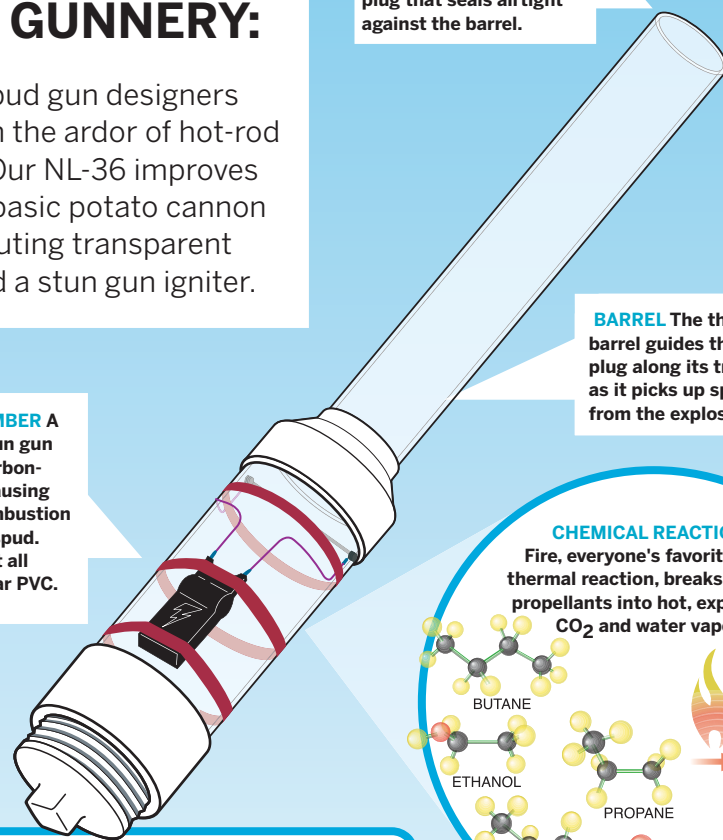
PRINCIPLES OF SPUD GUNNERY:

Serious spud gun designers tinker with the ardor of hot-rod builders. Our NL-36 improves upon the basic potato cannon by substituting transparent tubing and a stun gun igniter.

BEVELED EDGE Load a spud, and the sharpened front edge cuts a plug that seals airtight against the barrel.

BARREL The three-foot barrel guides the potato plug along its trajectory as it picks up speed from the explosion.

IGNITION CHAMBER A spark from a stun gun ignites hydrocarbon-rich aerosols, causing the internal combustion that sends the spud. You can watch it all through the clear PVC.



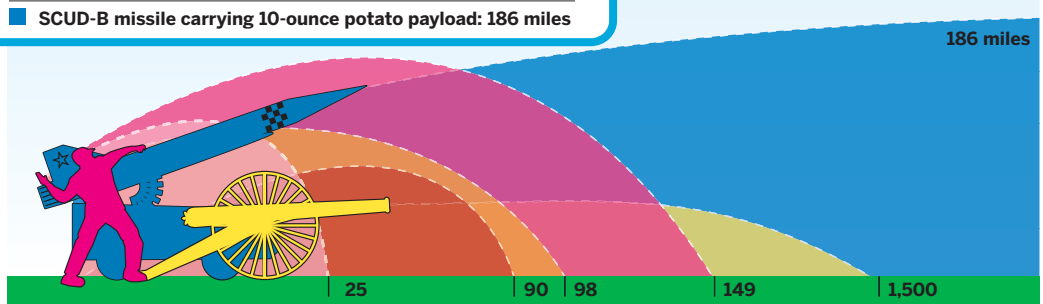
CHEMICAL REACTION

Fire, everyone's favorite exothermal reaction, breaks aerosol propellants into hot, expanding CO_2 and water vapor.

RANGE COMPARISONS WITH OTHER FAMILIAR PROJECTILES

Our spud gun propels a 9-ounce potato plug approximately 200 yards. Here's how this compares with some other launch events.

- Shot put: 16 pounds, 25 yards (Olympic record)
- Cell phone toss: 4-5 ounces, 90 yards (Savonlinna record)
- Football punt: 14-15 ounces, 98 yards (NFL record)
- Baseball throw: 5.25 ounces, 149 yards (Guinness record, 1957)
- Civil War cannon: 6-pound ball, 1,500 yards
- SCUD-B missile carrying 10-ounce potato payload: 186 miles



Not to scale.

Illustration by Tim Lillis

SET UP.

Visit makezine.com/03/spudgun for source list.

MATERIALS

36-inch length of 2-inch diameter transparent Schedule 40 PVC pipe (1)

14-inch length of 3-inch transparent schedule 40 PVC pipe (1)
Used mainly in the food-processing industry, transparent PVC is available from industrial plastic suppliers such as Harrington Plastics or Ryan Herco. Check your local business listings. You can also order it from McMaster-Carr (www.mcmaster.com). Transparent PVC is generally expensive, but you might find reduced-price remnants at plastics suppliers or food-processing companies.

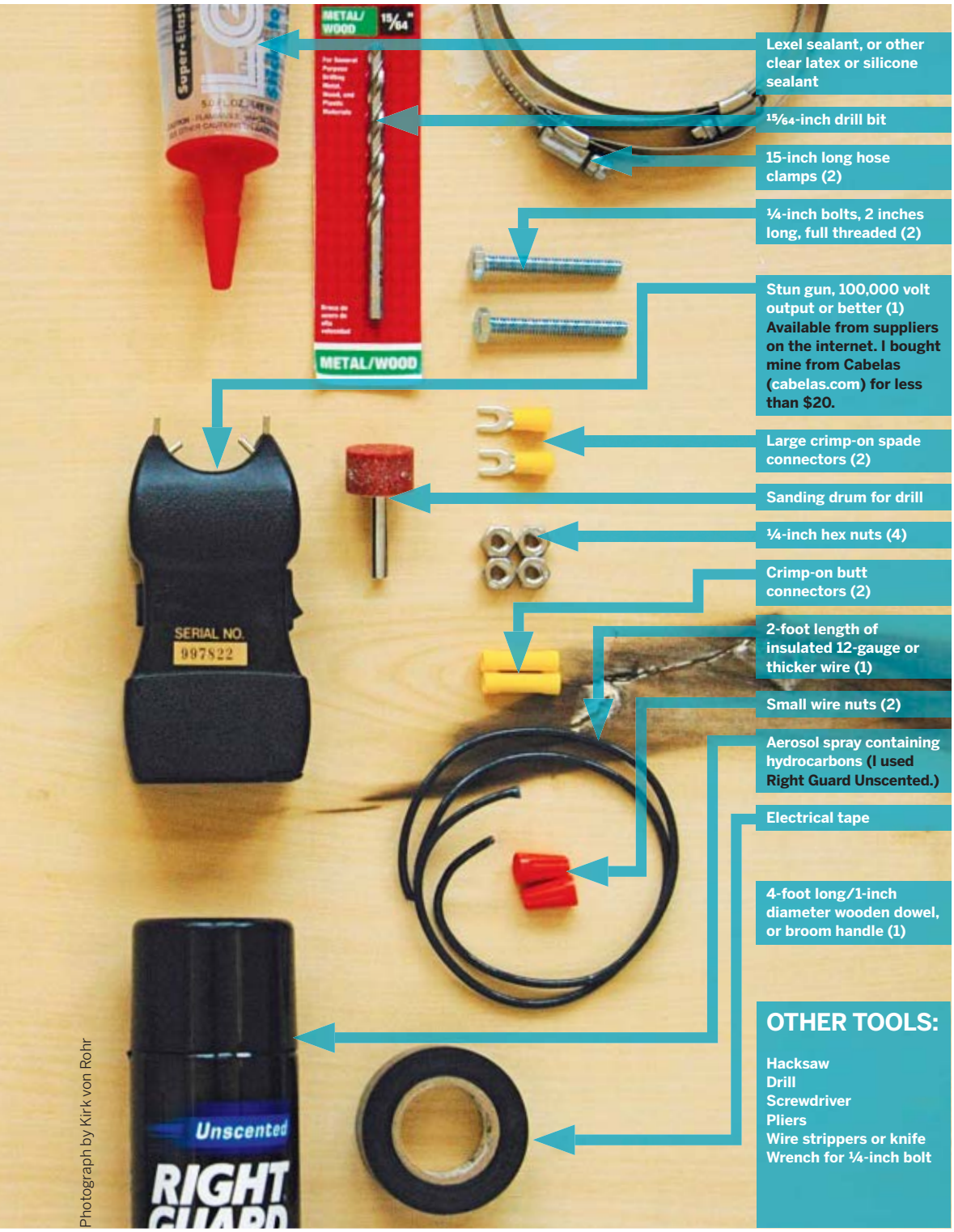
Large potatoes

3- to 2-inch diameter PVC reducing fitting socket a.k.a. reducer coupling or bell reducer (1)

3-inch PVC female adapter (1)

3-inch PVC end plug (1)
Use Schedule 40 grade for all PVC fittings. Source from large home or hardware stores or plastics suppliers.

PVC primer and cement
Available wherever PVC is sold.



Lexel sealant, or other clear latex or silicone sealant

15/64-inch drill bit

15-inch long hose clamps (2)

¼-inch bolts, 2 inches long, full threaded (2)

Stun gun, 100,000 volt output or better (1) Available from suppliers on the internet. I bought mine from Cabelas (cabelas.com) for less than $20.

Large crimp-on spade connectors (2)

Sanding drum for drill

¼-inch hex nuts (4)

Crimp-on butt connectors (2)

2-foot length of insulated 12-gauge or thicker wire (1)

Small wire nuts (2)

Aerosol spray containing hydrocarbons (I used Right Guard Unscented.)

Electrical tape

4-foot long/1-inch diameter wooden dowel, or broom handle (1)

OTHER TOOLS:

Hacksaw
Drill
Screwdriver
Pliers
Wire strippers or knife
Wrench for ¼-inch bolt

Photograph by Kirk von Rohr

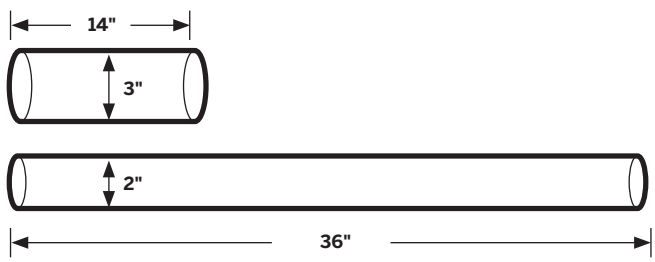
MAKE IT.

CONSTRUCTING THE MIGHTY POTATO CANNON

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

1. PREPARE THE PVC

1a. Cut pipes. Measure and mark a cutting line 14 inches from one end of the 3-inch diameter PVC pipe. Use the hacksaw to cleanly and squarely cut the pipe. This will be the cannon's combustion chamber. Then measure, mark, and cut a 36-inch length of the 2-inch diameter PVC pipe. This will be the cannon's barrel.



1b. Taper end of gun. Use a file or a drill and sanding attachment to taper one end of the long 2-inch diameter pipe, so that it forms a sharp edge. A clean, sharp edge is important, since it should cut the perfect-sized potato plug projectile as you ram the potato into the muzzle of the gun.

When PVC gets hot, it releases poisonous chlorine gas. Perform this step in a well-ventilated area.

2. ATTACH THE ELECTRODES

2a. Drill electrode holes. Four inches from one end of the 3-inch diameter pipe, drill a slightly undersized hole for the ¼-inch bolt. Drill a second hole directly opposite the first hole, four inches from the end.

The 3-inch pipe will contain the fuel and the spark, and act as the combustion chamber.

Photography by David Albertson

2b. Attach electrodes. Screw in the 2-inch long bolts, with nuts attached (two per bolt), into the holes in the 3-inch pipe. The nuts go outside the barrel. The bolts should tap themselves into the softer plastic, but don't over-tighten or you'll strip the PVC. Position and adjust the nuts as needed so there is a ¼-inch gap between the bolt ends inside the barrel.

This is the spark gap that will ignite the fuel, firing the cannon.

3. SOLVENT-WELD THE PVC

The spud gun is composed of PVC pipes and fittings that are solvent-welded in place using PVC cement and primer. To prevent leaks and weak spots where the parts are joined, the solvent welding must be done properly. Meanwhile, the primer and cement are toxic and flammable, so you need to work in a well-ventilated area, keep the chemicals away from open flames, and follow all safety precautions on the labels. First, we'll solvent-weld the reducing connector to the front of the combustion chamber. Then we'll follow the same procedure to attach the threaded adapter to the back of the chamber and to connect the barrel.

3a. Inspect parts. Check the 3-inch pipe ends and 3- to 2-inch reducing connector for cracks, dirt, and abrasion, and remove any plastic burrs with a knife. Don't use damaged PVC pipe or fittings.

3b. Weld parts. Following the procedure at right, solvent-weld the 3- to 2-inch reducing connector to the end of the 3-inch pipe closest to the electrode bolts. Then join the unthreaded side of the female adapter to the other end of the 3-inch pipe, and attach the 2-inch barrel to the narrow end of the 3- to 2-inch reducing connector.

3c. Let the cannon dry for several hours in a well-ventilated area before using. You don't want to fire it while the solvents are wet and flammable.

3d. Screw the 3-inch PVC end plug into the back of the chamber after drying.

How to Solvent Weld

1. Clean the weld surfaces with PVC primer. Apply the primer with a dauber or brush (usually inside the cap). The primer cleans and softens the PVC and allows the cement to penetrate the surface.

2. Brush on a thick coat of PVC solvent, first to the end of the pipe, and then to the fitting socket. Leave no bare spots.

3. Immediately join the pipe and the fitting socket, pushing the pipe to its full depth and making sure it's seated squarely with a slight twist. If you've used enough solvent cement, you should see a small, continuous ooze of cement around the fitting. Once joined, you can't reposition the pipes or otherwise fix errors. If you accidentally put the wrong fitting on a pipe, you need to trim it off and start over.

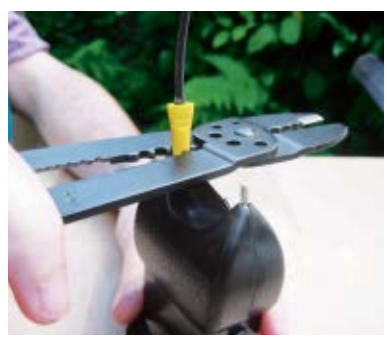
4. WIRE THE IGNITION

4a. Test-fit butt connectors. Using a sharp utility knife, remove excess insulation from each crimp-on butt connector. With the stun gun turned off, test-fit the trimmed ends of the connectors over the gun's main electrodes. These are the twin electrodes that point forward, rather than toward each other, and we're hooking these up to our ignition wires, in order to bring the spark into the combustion chamber.

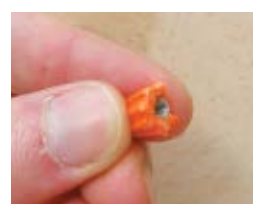
(Depending on the make and model of the stun gun, you may need to modify these directions and connect the wires in other ways, such as with wire nuts or soldering.)

4b. Prepare ignition wires. Cut the wire into two, 1-foot wires. These are the ignition wires. For each, attach a crimp-on spade to one end and the untrimmed end of a butt connector to the other end.

4c. Attach ignition wires to stun gun electrodes by crimping on the modified butt connectors.



4d. Cover the stun gun test leads (inboard electrodes) with wire nuts cut down to size, or other high-voltage insulators. Insulate all exposed metal areas of the ignition path on the stun gun and bolt electrodes, with electrical tape or silicone glue. It's easy for electricity to find its way underneath any insulation gap at the base of the electrodes.



Wire nuts need to be trimmed to fit onto the test electrodes.

5. ATTACH THE IGNITER

5a. Attach the stun gun body to the rear of the chamber using two hose clamps. Do not over-tighten. Position the stun gun body at a 90-degree angle to the axis of the electrode bolts.

5b. Attach ignition wires to electrode bolts, securing the spade connectors underneath the bolt head or between the nuts. You may have to bend the spades to widen them enough to fit around the bolt.

6. FINAL INSULATION

6a. Cover bolt connections with globs of silicone sealant. To further insulate, wrap the whole ignition area with bubble wrap, and tape down. The stun gun operates at such high voltage that the wrap still may not completely prevent shocks. Avoid contacting electrodes when operating the cannon. Don't be the path of least resistance!

Congratulations! Your Night Lighter 36 potato cannon is complete.

FINISH X

NOW GO USE IT »

USE IT.

HOW TO USE YOUR SPUD GUN RESPONSIBLY

FIRING THE NIGHT LIGHTER 36 POTATO CANNON

1. Remove the end plug.

2. Center and push a potato into the cannon, keeping your hand clear of the edge. You may want to wear a leather glove. The muzzle's sharp edge will cut the potato into a plug that should fit snugly on all sides. Any gaps will reduce performance.

3. Use the stick to push the potato plug 30 inches down into the barrel.

4. Direct a stream of aerosol into the firing chamber. Unscented deodorant works well, but check the label to make sure your choice contains hydrocarbons such as alcohol, propane, butane, or isobutane. Start out with a one- to two-second burst, and determine the optimal amount by trial and error.

5. Immediately replace the end plug and screw it in securely.

6. Turn the stun gun on, and double-check that the firing area is clear.

7. Press the stun gun's ignition button. Enjoy your work. For a tracer, stick a glowstick into the spud.

If you have a misfire, and the projectile is not ejected, carefully remove the end cap, and ventilate the combustion chamber thoroughly.

MAINTENANCE

Aerosol chemicals can gum up the inside of the cannon. Every few shots, clean it out with a rag and cleaner. The residue can also make the end plug hard to unscrew. If necessary, use pliers.

SAFETY AND LEGALITY

During construction, don't take shortcuts or substitute inferior materials. The vapors from PVC cement are flammable, so allow all joints to dry fully before exposing the gun to ignition sources.

When using the potato cannon, exercise extreme caution. Wear eye protection, and check the area in front of you before firing. Never look down the gun's barrel, or point it at anything you don't want to hit. Excess fluid stays in the chamber and evaporates slowly, so you should always treat the gun as if it can fire. Check frequently for signs of wear, and never operate a damaged gun. Avoid contact with (or proximity to) the ignition path. Stun guns hurt.

PVC is more brittle in cold weather, so don't use the cannon in temperatures below 60°F.

Neither the author nor this magazine assumes liability for your spud gun or your actions.

Potato cannons may not be legal in your area (even if it is legal to tote a 12-gauge down Main Street). Check with local law enforcement regarding the rules in your area, and obey them. Also, check the laws regarding stun gun usage.

Editor's note: Author William Gurstelle uses PVC for his Night Lighter 36 and other designs, but some spud gunners believe this is unsafe, since PVC can shatter and is not recommended for piping compressed gases. They advise using materials made out of ABS (with ABS cement), which is more flexible than PVC, but not available in transparent.

Alternatively, you can use Schedule 80 transparent PVC, which is thicker and stronger than Schedule 40, but more expensive.

RETROVISION 2000 AV CABINET

Building a home entertainment center in the form of an Atomic Age TV set. By Steve Lodefink

I really like the 1950's vintage enameled steel and wood cabinet TVs. At one point, I had a collection of half a dozen classic sets, but they proved a less practical thing to collect than, say, wheat pennies or comic books. Eventually, I jettisoned them all but I could never quite shake my affinity for the mid-century sets.

A lot of people probably consider a brand new Sony 27-inch television a stylish addition to their environment, but for me it was a big ugly plastic assault on my sensibilities. I decided to build a cabinet that looked outwardly like a Populuxe television set, but inside held our entire stack of AV gear. I had been toying for some time with the idea of building a custom housing for a modern television.

This project is very straightforward, but requires some basic cabinetmaking skills and tools. At the very least, you will need a drill, table saw, jigsaw, and a router.

Layout and Design

Design your cabinet based on the dimensions of the equipment that it will house. To preserve the illusion that it is an old TV, the cabinet should be as tight fitted

Photography by Steve Lodefink

Behind this mid-20th veneer is your 21st century entertainment setup.

to the television set as possible. For best effect, take care to position the television screen directly behind the window of the upper door so that the maximum amount of screen is visible, without revealing the plastic TV case inside. Take into account the height of the lazy Susan, if you use one.

Construct the Cabinet Box

I cut the top, bottom, sides, center shelf, and lower vertical separator from ¾-inch hardwood plywood on the table saw. To provide this large cabinet with adequate rigidity, these pieces need to be assembled and glued up as an interlocking unit.

Use a router with a ⅜-inch rabbeting bit to make the edge joints for the top, sides, horizontal shelf, and vertical separator. Cut slots in the side panels to accept the shelf. Similarly, slot the bottom and horizontal shelf pieces to accept the vertical separator.

After gluing this assembly, rabbet the backside of the box to accept a ¼-inch plywood back panel. I nailed and glued the back into place before cutting ventilation holes and strategically placed access ports. Use a hot iron to apply preglued veneer edging to exposed plywood layering.

Build the Base

Fully loaded, this unit is a heavy beast and calls for a sturdy stand. You could use prebuilt furniture legs to save time and effort, but I made a Noguchi-looking base out of maple. If 2-inch-thick maple stock is available, the stand could be made with just two parts. I had some ¾-inch stock on hand, so I built it up out of eight separate components. The X-shaped stand is glued and screwed to the bottom of the cabinet. Nylon glides on the bottom of the feet protect the floor and aid in moving the cabinet.

Make sure the base of the unit is well-supported.

The cabinet is basically a big birch ply box with three sections, one up top for the TV, and two down below, one for all the other components, and a smaller, vertical compartment for media storage. The knobs on the front are just for show, but your kids, and maybe your parents, will never tire of twirling them.

Upper Door

I used 1"x6" poplar to build a frame for the upper door. The four frame pieces were glued together with half-lap joints, and then the old-school cathode ray tube shape was cut out.

I used clear silicone to adhere the glass, which fits into a recess that I cut into the backside of the door with the router. You can mount the door using inset European-style cup hinges. A 1-inch wood ball serves as a discreet knob for opening the door.

Lower Door

The lower door is made from ½-inch plywood covered in reproduction antique radio grille cloth (which I ordered from *grillecloth.com*) to give the illusion that it houses a speaker. Some 3M 777 spray adhesive applied to the front of the door will keep the fabric in place while stapling it to the back, and prevent it from shifting over time.

I built a mock "control panel" from ½-inch poplar and mounted it to the top of the door. Knobs salvaged from old radios are hot-glued to anchoring screws that I first attached to the panel. The knob on the left serves as the handle for the lower door. A chrome Chevrolet Belair fender script bought on eBay provides a touch of Hi-Fi to the lower panel and really makes if feel like a speaker grill.

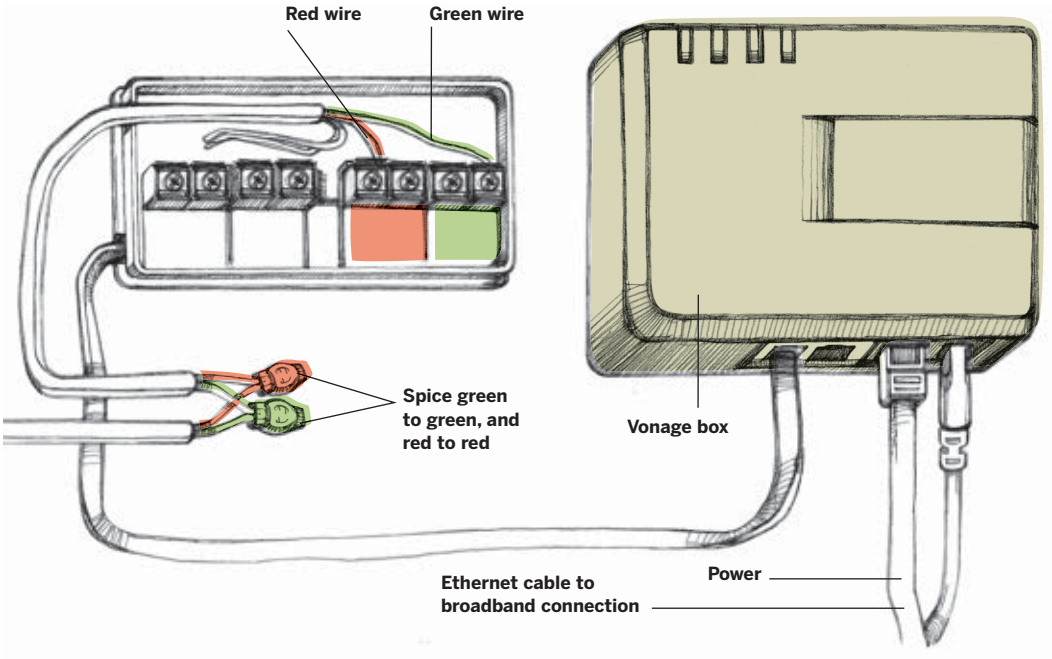
Finish

I finished the main cabinet body and base stand in a clear waterborne acrylic, which provides a durable, clear finish without the yellowing that occurs with polyurethane products.

To create a nice two-tone effect, the poplar upper door and control panel received a dark mahogany color stain with a polyurethane topcoat.

We typically open the upper door for viewing, but occasionally, I'll cue up a tape of some old black and white commercials, close the door, put on an Esquivel or Henry Mancini record and let it flicker in the background while we have martinis and chat about the space race.

Seattle-based designer Steve Lodefink describes himself as a "broad-spectrum dabbler" who always has to be building something. See everything he makes at *finkbuilt.com*.



VOIP PHONE WIRING

Connecting multiple phones to a Vonage connection. By Jake Ludington

I have no complaints about my Vonage experience so far. The call quality is great. Getting voice mail messages in my email is probably my favorite feature. I can send faxes using a traditional fax machine. I'm able to place calls using a 900 MHz cordless phone or any other standard landline phone. I activated 911 dialing on my account so that emergency dispatchers could determine my location. The only thing that had me perplexed was how I could connect several phones the way I would in a normal landline configuration.

I had a revelation during a walk to the drugstore. The phone wiring in the house could be terminated at my Linksys Phone Adapter the same way the phone company brings their lines to the house and ties in to all the internal wiring of the house. Both scenarios route all the wiring in the house back to a central office. The traditional landline service routes underground or to a pole along the street back to the company while the VoIP method connects to my router headed for the servers at Vonage.

I currently live in an 80-year-old house. The phone wiring has been updated, but the routing of the wiring is a jumble of three different incoming lines routed to different sections of the house. This didn't matter to me when I moved in because we don't have a landline phone. In newer houses, this won't be a problem because all phone wiring should terminate at a central location.

Most home phone wiring is made up of two pairs of wires: red/green

Wiring all your phones to your Vonage account involves terminating the lines at the adapter.

and yellow/black. In most cases, the primary line you'll want to connect to route your VoIP service throughout the house is the red/green pair. If the house was wired using Category 5 cabling, green might be replaced with white-with-blue-stripe wires and red with blue-with-white-stripes. The yellow and black wiring pair will not be needed.

Required Tools and Supplies

Before starting, I needed a few supplies from the hardware store. I purchased a roll of Category 3 cable, a box of 3 port telephone splice connectors, and a phone wire junction box with a modular plug. You could get by without using the junction box, but I'm lazy and don't enjoy connecting RJ-11 ends to raw wire. The junction box makes it easy to quickly connect your household wiring to the phone adapter. Note: If you plan on connecting the VoIP phone adapter directly to a wall jack, you probably won't need these supplies.

Several tools are also required. To make the connections, you need a Phillips screwdriver and wire strippers. To finish up, you may want a cordless drill to fasten the junction box and phone adapter to the wall, as well as some coaxial cable straps to router your Ethernet cable along the wall between the phone adapter and your router. Make sure there's an outlet in close proximity to your phone wiring (to power the phone adapter) or get an extension cord long enough to reach.

Making the VoIP to Cat 3 Connection

First, find the location where external phone lines come in to your house. Determine which lines are internal and which lines route back to the phone company. Disconnect the phone lines coming into the house from the phone company because they might cause noise on the line (or damage the VoIP adapter), and they aren't being used anyway. Word of Caution: Do not attempt this if you still have an active line with the phone company; it will cause your landline service to cease functioning.

Connecting VoIP via a Wall Jack

If your phone lines all originate on the same copper pair from the phone company, this is potentially your stopping point. With the lines from the local phone provider disconnected, simply plug the VoIP adapter into any wall jack in your house and you should be able to make calls from any of the other wall jacks in your house.

Connecting VoIP at the Origin

Depending on how your home is currently wired, you may need splice connectors to combine all of the various ends throughout the configuration to a single wire that ultimately connects to the junction box. An alternative is to connect each individual line to the junction box. Red wires connect to red wires; green connect to green.

Once all the internal wiring is connected, plug in the phone adapter, connect the Ethernet cable to the appropriate port on the adapter, and connect the RJ-11 modular plug from the junction box to the phone adapter.

Test your connections by plugging a phone into one of the wall jacks in your house. If you get a dial tone, you're probably set. It's not a bad idea to place a call to your cell phone just to make sure everything is working.

The final step is to mount the junction box to the wall with the two bundled screws, secure the VoIP phone adapter so it won't come unplugged accidentally, and fasten the Ethernet cable to keep it out of the way.

Avoid Power Surges

VoIP phone adapters are susceptible to power surges due to lightning strikes, just like a modem might be. To protect your phone adapter, use a surge protector for the power brick and route the phone wiring through the surge protector in reverse. Connect the wall side of your phone connection (the part coming out of the junction box) to the phone/modem port on the surge protector. Connect the VoIP phone adapter to the line side of the surge protector.

Troubleshooting

It's a good idea to test your connections by placing a call to the VoIP phone number. For my tests, I used my cell phone so I could quickly verify the call.

Jake Ludington is the author of *Podcasting Starter Kit* (*PodcastingStarterKit.com*) and hacks media gadgets from his home in Seattle, Wash.

Illustration by Damien Scogin

RECORD CLONING

Make a plastic cast of an LP or 45. By Dan Mikesell

Let's make a copy of Marvin Gaye's classic song *What's Goin' On*. Instead of going to our computer and burning an MP3, we're going to be making a copy of a 45 record. To understand how we can do this, you have to know how a record works. A record is just the physical embodiment of sound etched into the surface of a flat piece of soft material. What we're going to do is make a copy of those grooves onto a much harder material by making a mold and using that mold to make a plastic casting.

Molding

First, make a form to hold both the record and the molding material you want to use. I built a simple box out of wood that I am setting on a sheet of glass (Fig. 1). Next, you need to choose something to make the mold with. Silicone is a good choice because it can pick up the smallest of details. There are many kinds of silicones, but make sure that you buy one that does not require a vacuum chamber (unless you have access to a vacuum chamber). I used Smooth-On OOMOO 30 to make my mold because of its excellent self-degassing characteristics (*smooth-on.com/liqrubr.htm*).

Once you have built the form, you need to put clay around any gaps that the silicone might get through (Fig. 2). Modeling clay works well for this because the silicone doesn't stick to it. Next, you need to apply a release agent to your form. There are several universal release sprays available that work well; however, if it is a very porous material such as wood, you should use petroleum jelly. Coat the inside of

Old school file sharing: Making a duplicate record by casting it in plastic.

Fig. 1: Place the record you want to duplicate in a box that has been taped up along the corner edges to prevent leakage. You'll then pour enough liquid silicone into the box to cover the record. After the silicone cures, you'll use that to make as many plastic castings of the record as you desire.

the mold and lightly brush it to assure there are no high spots. Use a bubble level to get your form perfectly level.

Put the record on the bottom of the box with the side you want to copy facing up. Use clay to affix and weigh down the record when you begin pouring the silicone.

Mix up your silicone following the manufacturer's directions. Slowly pour the silicone over the record assuring that no air bubbles remain in the record grooves. Gently tap the side of the molding form to dislodge any air bubbles. Wait until the rubber has cured.

Remove the original record from the mold being careful not to get dirt in the mold or touch the grooves of the silicone mold. You should be looking at an exact reversed copy of your record.

Casting

Now that we have a mold, our next step is to cast a copy. It's a good idea to use a high performance plastic as the casting material; this way, your copy will be much more durable than the pressed wax original. I used Smooth-On Task 4 for the casting — it has a higher degree of wear resistance than normal casting plastic. Because silicone already has significant self-release properties, I am not applying a release to the mold so that I can get the most accurate representation of the grooves on the record.

BEWARE: This technique can backfire; silicone sticks to some casting materials.

Level the mold and carefully pour the plastic after mixing it according to the manufacturer's instructions (Fig. 3). Make sure there are no air bubbles on the grooves of the mold. If the mold is level, the plastic should stay in the mold and not run over (Fig. 4). Gently tap the mold to dislodge any air bubbles.

Wait for the plastic to cure according to the manufacturer's directions. If everything went well, you now have a super durable copy of your favorite record (Fig. 5) and the mold to make as many more as you want!

Dan Mikesell lives and works in New York City where he is a professor and co-founder of Moddities toy design.

Your silicone mold (above) is a reverse copy of the record. You make the mold by placing the record in a wooden box and pouring silicone over the record (Fig. 2).

You'll then pour plastic into the silicone mold. Be sure to allow the plastic to cure (Figs. 4 and 5) before playing your duplicate!

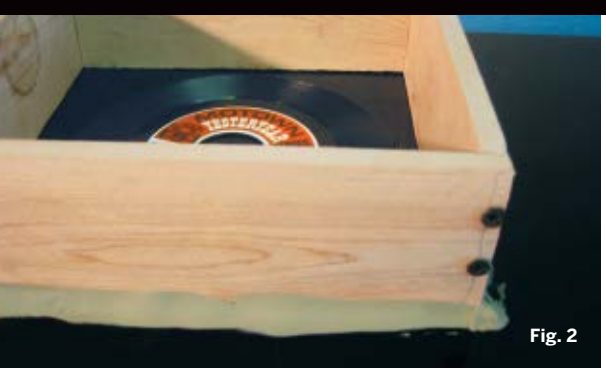


Fig. 2

Fig. 4

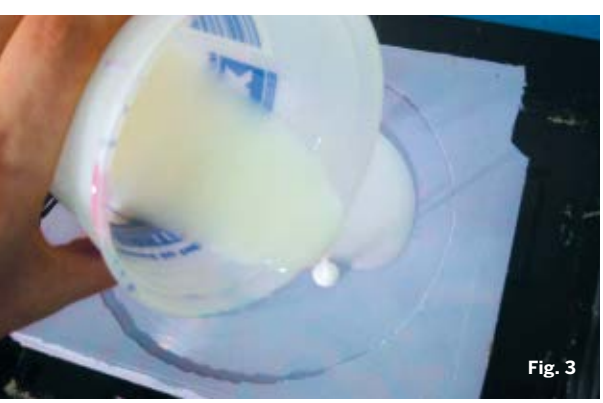


Fig. 3

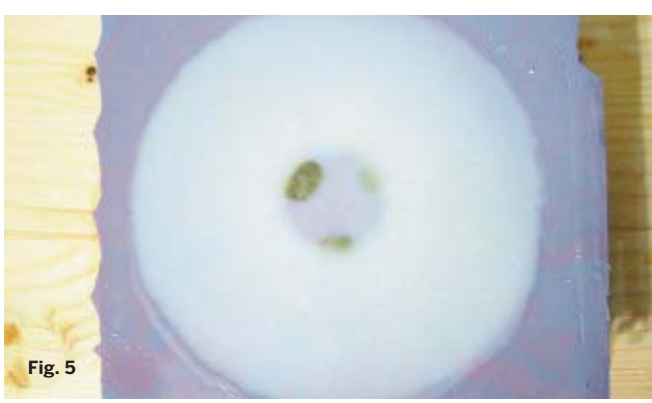
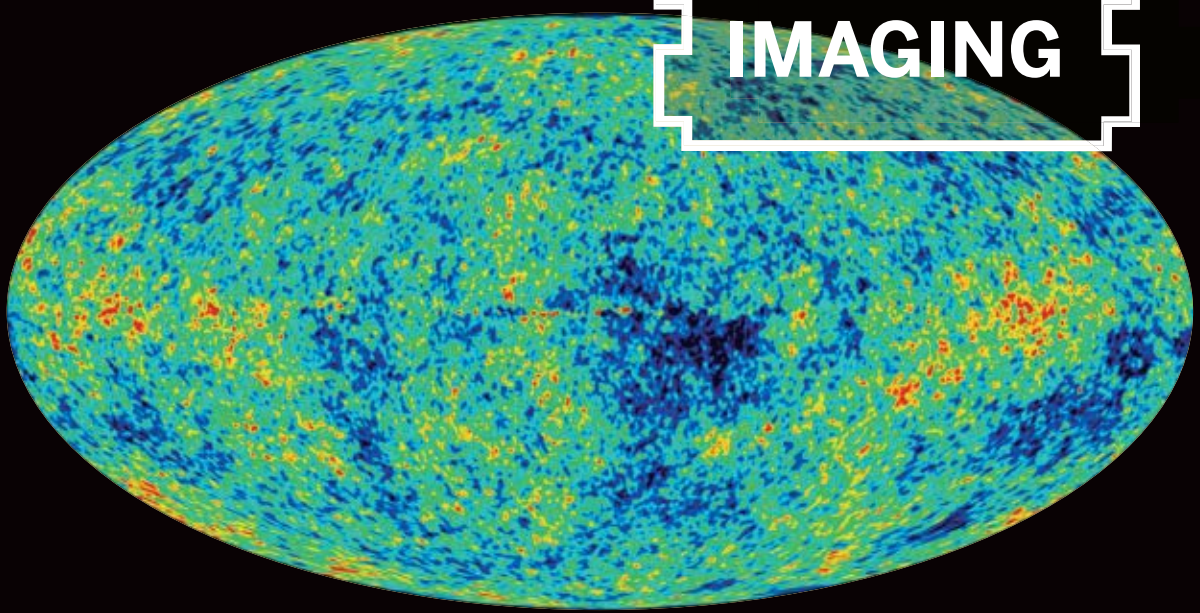


Fig. 5



This thermograph of the universe as it appeared 13 billion years ago makes a great poster.

Photograph by NASA/WMAP Science Team

PRINT THE UNIVERSE

Make gigantic posters with a free web service.

By Phil Torrone

The Wilkinson Microwave Anisotropy Probe (WMAP) observatory is a 1,850 pound, 15-foot-diameter satellite that orbits the Earth at a distance four times farther than the moon. It detects 13-billion-year-old temperature fluctuations from the early universe by recording microwave radiation from 379,000 years after the Big Bang. These fluctuations are the seeds from which galaxies eventually formed.

I've always wanted to print out some of the amazing WMAP images (*map.gsfc.nasa.gov/m_or.html*) but I couldn't find a way to print them large enough to do them justice. Then I discovered the Rasterbator (*homokaasu.org/rasterbator/*).

This web (and PC standalone) PDF-creating application can take just about any image and make it as large as you want, even completely covering an entire wall. To use it, make sure your image is under the 1-megabyte limit, and then upload it. I used Macromedia Fireworks to compress my file enough to squeak it in under the limit. After it uploads, you can crop and size the image. For my wall I used U.S. Letter (8½"x11"), horizontal, 6 by 4 sheets (24 sheets) for a total poster size of 66"x34".

In the final options, you can choose outlines for the poster to make trimming easier, dot size, and color (black and white, monochromatic, multicolor). I chose the smallest dots, multicolor, and didn't need outlines. Once you finish, you'll get a PDF to print out.

Phil Torrone (*pt@makezine.com*) is associate editor of MAKE. Read his blog at *makezine.com*.

You can ask friends and even strangers in far-off locales to do the filming.

MAILBOX MOVIE

Make a movie that's shot in many locations around the world without leaving your house.

By Michael W. Dean

By using the internet and postal mail, you can create a "Mailbox Movie." Getting other people to shoot your movie for you, and having them send you the tapes when they're finished, lifts a burden from your shoulders so you can concentrate on writing and editing.

This process works especially well for documentaries, but could conceivably be done with a drama or comedy.

It works well for documentaries because there is less "directing" involved.

A well-shot interview is a well-shot interview. Most of the "directing" in documentaries is really done in the writing and editing. (Well, also in the choice of interviewees, and in the questions you ask them.)

Making It Happen

In 2002, I made a movie called *D.I.Y. or DIE: How To Survive as an Independent Artist* (*diyordie.org*). This documentary is an exploration of the D.I.Y. ethic in art. The movie not only covered this concept, it utilized it throughout the production.

I didn't have the money to fly a crew to all the other shooting locations involved. So I asked friends (and strangers) in these locales to do the filming, to my specifications, and mail me the mini-DV tapes. I shot the local interviews myself, gathered all the music, still photos, and archive footage (I did a lot of this over the internet and through the mail also). I wrote the outline for the film and the copy for the narration. Then I narrated the film in a friend's studio. My editor, Miles

Photograph of Michael W. Dean by Newtron Photo

Montalbano, and I made the tapes and all the other stuff into a kick-ass, great-looking movie.

Open Source Camera People

There are over 10 million mini-DV cameras in the world. Most people who have them have no idea what to really do with them and would love a little direction.

Most of the shooters on our project were kids who had read my filmmaking book, *$30 Film School* (*30DollarFilmSchool.com*), and had sent me unsolicited DVDs of the projects they'd made as a result.

New filmmakers are always interested in getting experience in higher-profile films. It's a win-win situation. I got the interviews shot quickly, for free, and the camera people got a credit in a cool film that got bigger distribution than they would be likely to get by themselves at first.

You can easily find help. Post on *craigslist.org* (you can post on the specific board for the city you want to film in). Also try *res.com* or my own web board at *kittyfeet.com/phpBB2* (and yes, that's case sensitive). And *shootingpeople.org* has a daily email list with call boards for both New York City and the U.K. You can also post on boards (both web boards and old-school cork-and-thumbtack boards) at film schools around the country. Try contacting film schoolteachers. Even community colleges usually have a television production or media department.

Logistics and Such

When making a mailbox movie, you should send emails to the people doing the interviews for you with all the info they'll need. Give them the phone number and address of the people they'll be interviewing, what time they should get there to set up, and how long they'll have. And you should phone the interviewees yourself the day before the interview to reconfirm. This is your job, not the job of the person working for you for free. Don't leave anything to chance. This may seem like a lot of work, but it beats having to fly there and do it yourself.

Giving Instructions

Give your shooters a short description of how you like to frame and light people. Email them some stills. Better yet, if you have time, send them a film you've shot. Make sure you tell them what aspect ratio you're shooting in, and make sure they know how to get good sound. I usually recommend they bring headphones to check the audio, and recommend the Audio-Technica Omnidirectional Lavalier Microphone, model ATR-35S. There are tons of them new on eBay for about 30 bucks a pop. And they get great sound, better than some $300 mikes.

I had a cut-and-paste document for telling people all this. I also emailed the shooters release forms for themselves, and for the interviewees, and for any helpers. (You can download the ones I used at the bottom of *30DollarFilmSchool.com*.) And don't forget to send them the list of the questions you want them to ask.

A week or so later, you should get a package in the mail from each interviewer with a tape of the interview and also all the signed releases.

Covering Your Ass

I also asked the shooters to make digital copies of the tapes as a safety measure before mailing them to me. This was very useful, as one of the 30 tapes got damaged in the mail, and the guy was able to overnight me a replacement. Without this forethought, we would have been screwed.

Also, you should put in your cameraman release form that they are not allowed to use the footage for any of their projects. It would be very embarrassing if this happened, would probably anger the interviewees, and possibly hurt your name as far as filming cool people later. The exception might be where people have already shot the footage, and you're using it as archive. This is negotiated on a case-by-case basis. But if you're getting them to let you use that stuff exclusively, you'd better have some kind of quid pro quo for them. It doesn't have to be money, but you'll have to offer them something they want.

The first rule of no-budget negotiation is to be able to figure out what people want. Everybody wants something. Maybe you have it. Or can get it. Hint: It's not always material.

Michael W. Dean lives in East Los Angeles. He is the author of a no-budget digital filmmaking book, *$30 Film School*. Michael's new film is called *Hubert Selby, Jr.: It'll Be Better Tomorrow*. View the trailer at *CubbyMovie.com*.

CHEAP SHOT

Turn a $10 single-use camera into a $20 reusable digital camera. By Charles C. Hoffmeyer

After you take 25 pictures with Dakota's single-use digital camera ($11), you're expected to take the camera back to the place you bought it and get the images developed. The camera is not returned to you. I bought one, and after opening the package, I noticed a blue sticker on the camera that said, "Camera does not connect to home computers." Whenever someone says that something cannot be done, that always gets me in the mood to prove them wrong.

The interface (hidden under the sticker) looked fairly simple, and I went online to see if there were any electronic schematics that would define it more clearly. Much to my surprise, I found a website (*cexx.org/dakota/*) that said it was as simple as cutting a USB cable in half and soldering the four wires onto the interface. The necessary software had already been created as well!

With the cost of this camera being so low, it's perfect for places I wouldn't dream of taking a more expensive camera. I intend to use it for kite aerial photography (see MAKE Volume 01, page 52) this spring, and in the summer I plan to use it for timed photos from the front of a kayak.

The packaging indicates that this camera can be purchased at Wolf Camera, Kits Camera, Ritz Camera, The Camera Shop, and Inkleys Camera. This camera comes in a couple of different models, but I chose the older style because of the lower cost and because I didn't need an LCD screen.

Most of my supplies came from RadioShack. I used a 25-watt electric soldering iron, with standard rosin core solder (0.39 dia) for this project.

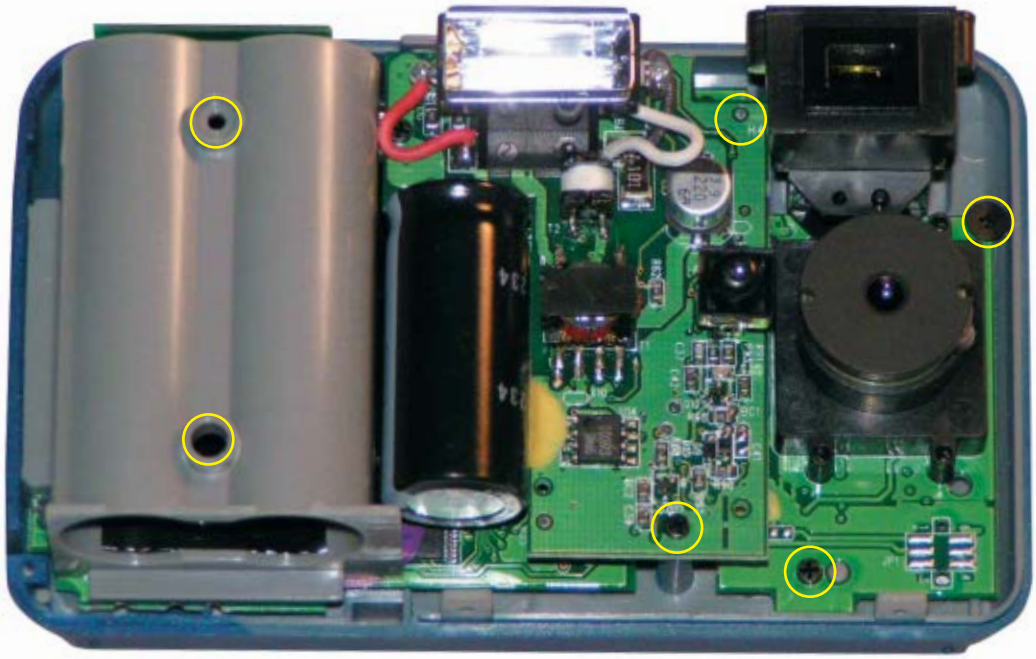


Fig. 1

Converting the Dakota single-use digital camera into a reusable digital camera involves attaching a USB cable to the camera's interface. Don't be fooled by the sticker that reads "Camera does not connect to home computers" — it's not true, and the sticker covers a screw you need to remove to open the camera. Once you solder on the USB cable, you'll need to download some free software that lets you extract the photos stored on the camera.

The wire strippers should be able to handle a 22-gauge wire or smaller. For the USB cable, I purchased a car charger on clearance from RadioShack ($2.99), which had a USB cable in the packaging. Avoid high-cost USB cables to keep this project as wallet-friendly as possible.

Procedure

Open package and remove front housing. The purpose of taking the camera apart is to get access to the interface so you can solder the USB wires to it. Start by removing the batteries from the battery compartment. On the bottom of the camera, you will notice two screws (Fig. 2).

TOOLS:

- Dakota single-use digital camera
- Soldering iron with solder
- Small Phillips screwdrivers
- Wire strippers
- A USB cable
- Electrical tape
- Hot-glue gun (optional)
- Hot glue (optional)

Remove these screws. Now look at the right side of the camera. Remove the sticker saying, "This sticker should only be removed by a Big Print Central Sales Associate" and remove the screw. Pull the camera apart; it will split into two pieces.

Fig. 2

Remove rear housing. Fig. 1 (top photo) identifies six locations where the screws should be removed (yellow circles). Remove those screws, and pull the rear housing off the circuitry.

Remove battery compartment. Fig. 3 identifies two screws that need to be removed. Fig. 4 identifies two more screws to remove. The wire holding the shutter switch is very thin, so be careful not to let it wobble around too much, or you will make more work for yourself re-soldering the wire back in place. Gently pull the two pieces apart (Fig. 5). The interface will be clearly visible on the left-hand side of the lower assembly.

Photography by Charles C. Hoffmeyer


Fig. 3

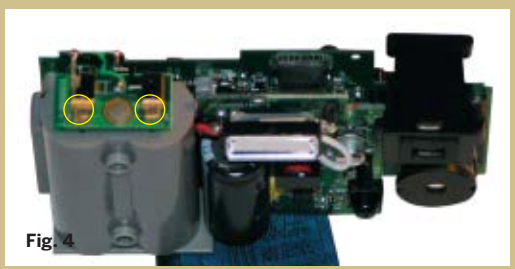


Fig. 4


Fig. 5

Strip wires on USB Cable. I used the cutting tool on my wire strippers to do this. Regular scissors would work as well. Gently strip back the outer rubber cover and shielding. Leave yourself about an inch to work with the four wires within the USB cable. Strip the four wires so that between half to three-quarters of an inch of color is visible.

Solder the wires to the circuit board. Fig. 6 shows how the wires should be connected to the board. Because of the thinness of the wire, I found that it was easier to solder the wires by using the soldering iron to put solder on the wire directly and letting it cool. Then set the soldered wire directly on the circuit board and touch the iron to the wire. Make sure the wires do not wiggle and touch. I covered them with electrical tape on top and bottom and then also wrapped the remaining exposed cable with electrical tape (Fig. 7).

Reassemble the camera. Perform the disassembly steps in reverse to put the camera back together.

Use hot glue to fill in empty space. I used hot glue to fill in the remaining empty space around the interface connection after reassembly because I accidentally pulled on the cable too hard at first, and the wires I soldered in place broke off. After the glue dried, I finished wrapping the cable with electrical tape to ensure stability.

Install software on computer. Visit *cexx.org/dakota/* and download the software for your camera. With the Windows software, be sure to read the "readme" notes included with the software. There is a specific process for configuration before connecting the camera to the computer.

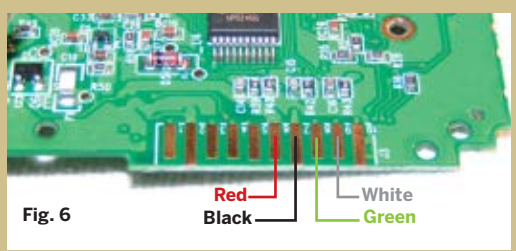
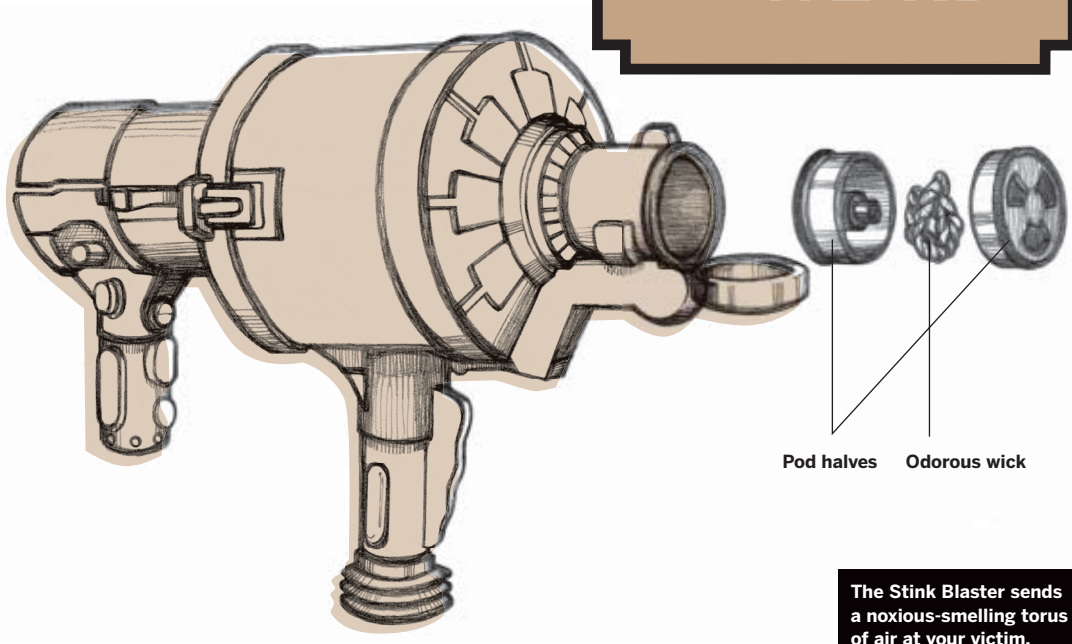


Fig. 6


Fig. 7

Connect camera to computer. If you did everything right, the camera will power up and the rear text LCD will show "PC" to indicate that the computer is connected. Congratulations! You now have a multiple-use digital camera for under $20!

Charles Hoffmeyer (*cchoffme@well.com*) is a programmer/analyst for the Michigan Department of Information Technology.



The Stink Blaster sends a noxious-smelling torus of air at your victim.

GET FUNKY

Make custom stink pods for your Stink Blaster.

By Paul Spinrad

The Stink Blaster (*stinkblasters.com*) lets you shoot fast-moving pockets of smelly air over distances of 20 feet or more. Using the weapon is a two-step process. First, you pull back the piston, drawing air through a maximum-scent Stink Pod positioned in front of the barrel and filling the chamber with smelly air. Then you pull a front trigger to drop the pod out of the way, and the main trigger to let 'er rip.

The piston snaps forward and pushes the miasma out of the chamber and into a self-contained mass that travels like a smoke ring, with the leading edge of the torus wrapping around outside and filling the vortex created by its forward motion. Under still conditions, the whiff reaches its target in a fraction of a second, making hair flutter and noses twitch. Fun!

Stink Pods come in four scents: garlic, skunk, vomit, and fish, and the company has no plans to expand the options further. It's a good selection, but limited because the pod contents must all be non-toxic, follow federal toy safety standards, and pass a battery of tests. (That way, it's no problem if some kid gives a cracked Stink Pod to his infant brother to suck on.)

Also, despite the product's general physical principle, the Stink Blaster identity disallows nice scents. That's a problem. What if you want to propel whiffs of lilacs into the smiling faces of the hippies conked out in the "chill room" at a party?

Pinch Nose, Open Pod

Fortunately, it's easy to open up a Stink Pod and make it reusable, so it will carry any odor you

Illustration by Damien Scogin

To replace a pod's garlic, skunk, vomit, or fish smell, you must cut it open along the seam with a knife.

The pod contains a wick soaked in an odorous chemical. Remove and replace with your homebrewed smell.

want. A pod consists of a central container that's sandwiched between two discs, which rotate like the top of a spice shaker to open or close the pod's vent holes.

You start the simple pod conversion by rotating the two edge discs slowly in opposite directions, breaking the plastic connection between them. Remove the discs and slowly cut the container open along the seam with an X-Acto knife. This is the hard part, so consider it a 20-minute meditation. Eventually, you'll be able to pry the halves apart.

Note the small peg and notch inside, which demand that you join the halves back together in the same relative rotational position. Packed inside the container, you'll find an odor-infused length of yarn that you should remove and may do with as you wish, as long as you thoroughly wash your hands with strong soap afterwards.

The plastic pieces will still carry the original scent. To get it out, soak them overnight in a dilute solution of bleach and detergent, and then scrub them clean. Upon close olfactory inspection, you'll find that the last vestiges of the original smell won't come out, but this will not affect later performance.

One of the edge discs will have the central hub attached. Reattach the other one (the plain disc) to the outside of one of the container halves. I originally tried reconnecting this disc using a small metal snap, so it could continue rotating in place. After grinding out the plastic to make room for each side of the snap, I cemented the discs on. This worked for a little while, but the snap-half on the pod side kept coming off — metal-to-plastic is a tough bond, and because the back of the snap only touches the outer edge of the pod's central hole, there isn't much contact area.

I later simply attached the disc directly onto the side of the container in a permanently "open" position, without the snap, using plastic repair epoxy. It's worked fine ever since, although this approach makes it more important to store the pod in the little airtight container it comes in, to prevent it from losing scent.

May I Take Your Odor?

As for the scent itself, I twisted and folded three-foot lengths of wool yarn into little donuts that fit into the pods, and then used an eye dropper to infuse them with essential oils (grapefruit and peppermint). Reassembling the pod and firing the Blaster with them successfully delivered the new smells, and now I'll never look at the essential oils shelf at my local natural products store the same way again. I also tried packing the pod with a solid odorant: crushed mothballs (para-DCB).

But despite the noxiousness of the material during handling, its ballisto-olfactory results were disappointingly weak. The liquid wicking liquid approach seems to be the way to go — although I don't think I'll be soaking any yarn with Doo Drops, an offensive-smelling fluid I've seen sold on various spy and revenge websites.

Paul Spinrad is projects editor for MAKE.

The squeezable nightlight has a silicone top, an LED circuit, and a resin base.

SQUEEZABLE NIGHTLIGHT

Soft silicone outside, tasty electronics inside.

By Sparkle Labs

Silicone is a handy substance found in a wide range of devices, including drip irrigation emitters, gaskets, breast implants, and sex toys. Although it isn't typically used for lighting, silicone is translucent and nonconductive — properties which make it great lamp material. We're going to show you how to cast the stuff into any shape you want to create a squeezable, rechargeable nightlight/Boogieman detector with its electronics enclosed inside the base.

Like cooking, molding silicone is a complicated process, and you may have to try it a few times before it comes out perfectly. But we'll take it step by step. The process starts with building the electronics. That way, you'll know everything will fit inside the base, and you can sculpt spaces for the switch and power cord.

Build the Electronics

You can use any small light circuit you want; we built ours with an IR sensor, a microchip-controlled RGB LED, and a rechargeable battery. When the light's on, it cycles through ambient rainbow colors, and in detect mode, it blinks for five seconds whenever a pet (or Boogieman) comes near. *(See page 140 for a barebones LED flasher you can use with this project. — Ed.)*

Gather Your Materials

Nitrile or latex gloves Nitrile is preferred, since latex inhibits the curing process.

Plasticine, Castaline, or other sculpting medium We used Castaline to sculpt the components. We

Illustration by Sparkle Labs

The squeezable nightlight consists of three components: a hollow base made from resin, the lighting circuitry and 9-volt battery, and a top part made from solid, translucent silicone rubber. Note the small indentation in the silicone top. This allows the top to fit snugly on the base.

used Plasticine as part of the mold-making process. Don't use oil-based clay; it contains sulfur, which interferes with curing.

Silicone Available at art supply stores, this comes as two liquids that you mix before use. We used platinum-based silicone with a 20 "Shore A" hardness value for the molds and a 10 "Shore A" hardness for the final piece.

Mold release Silicone-to-silicone.

Silicone dye if you want to color the silicone. Available at art or sculpture stores.

Resin This is for the lamp's hollow base. Also comes as two liquids, available at art stores. We used Magic Smooth resin and hardener.

Clean, dry, plastic containers for mixing the silicone. Don't use glass, or the silicone will stick to it.

Sculpt the Base

You can use Plasticine or Castaline to sculpt your "positive" (the mold is the "negative" from which you will cast "positives" out of silicone or resin).

You'll make a mold from your sculpted Castaline base.

Plasticine is a non-drying clay that comes in hardness levels ranging from 1 (the softest) to 4. The general rule is that the harder stuff is better for small, more detailed shapes, while softer is better when you're going large. Plasticine remains soft, so you can always keep working with it, but it cannot be sanded, so it's more difficult to produce a smooth surface.

Castaline is a clay/wax hybrid that comes in soft, medium, and hard, colored either pink or

Photography by Sparkle Labs

Flowchart: Making the molds and castings for the nightlight

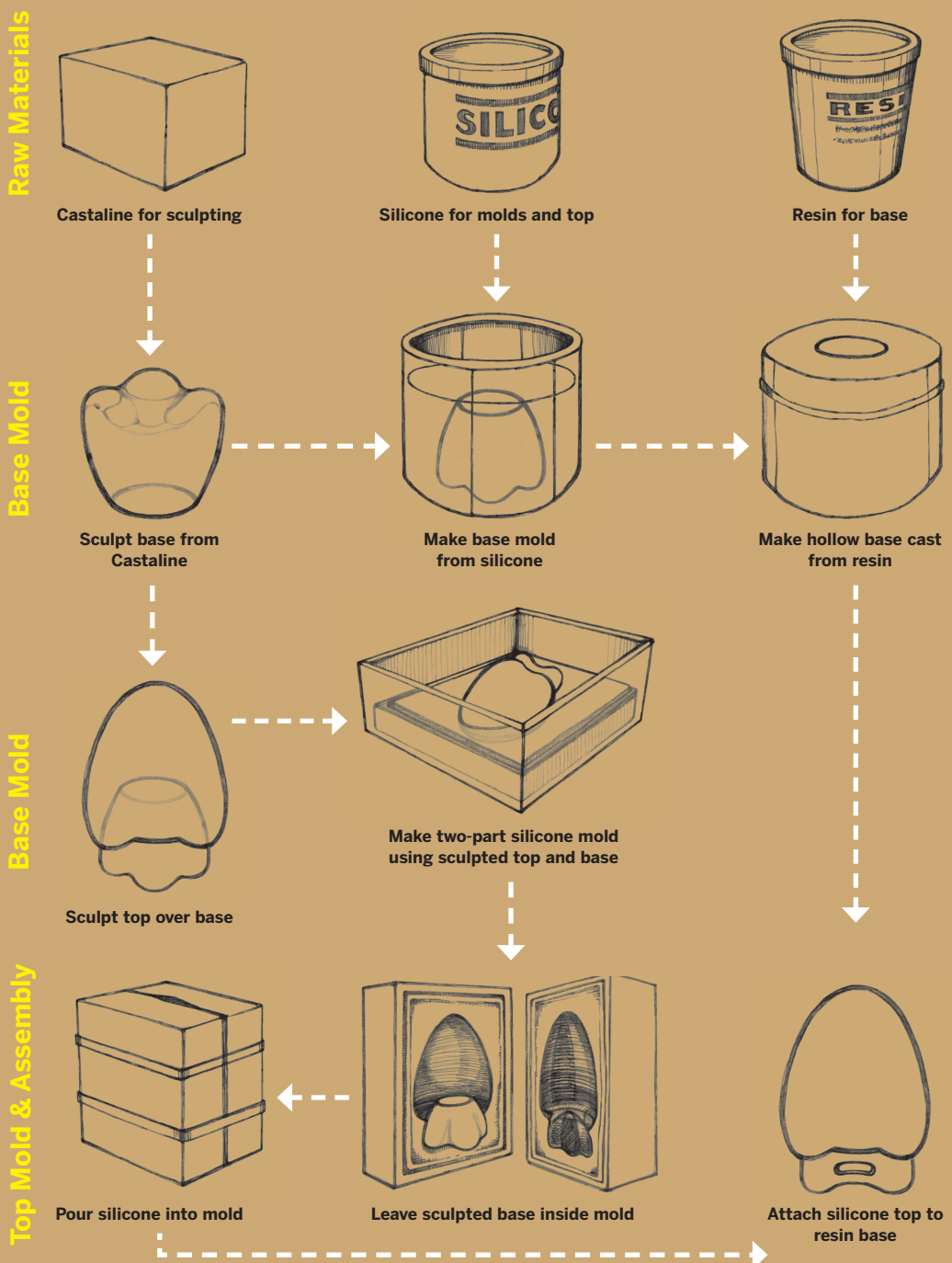


Illustration by Damien Scogin

Make the top mold: Sculpt the top form from Castaline, attach it to the sculpted base, and embed it in a bed of Plasticine as shown. Enclose it inside walls of cardboard sealed with tape or hot glue. Pour liquid silicone into the box. Allow silicone to cure before removing cardboard.

green/grey. We recommend the hard green kind; the lighter-colored pink gets grimy easily and makes it hard to see details.

Castaline is too hard to sculpt at room temperature, and you need to soften it up by heating. We put ours in a Pyrex dish in the oven for an hour or so at the lowest setting, but you can also heat it in a Crock-Pot, or more quickly in the microwave — so long as you don't burn it. When it's melted, stir the Castaline to get an even consistency, then let it cool until you can handle it. The stuff should stay soft for about an hour while you're working it, and you can soften it again by holding it up to a light bulb or other heat source.

Using the sculpting medium, create a shape for your lamp's solid base. Make sure it's big enough so that a hollow cast of it will carry all of your electronics. Don't worry about the top surface of the form; that won't affect the mold you make from it, and it might as well be flat.

Once you have your shape, if you're using Castaline, you can put it in the freezer to harden and then polish the surface under cold water with a fine-grade sanding sponge, 100-320 grit. Whichever medium you use, you should spend a lot of time sculpting and smoothing; we spent three hours to get the rounded, three-legged shape we wanted for our base. The resin base will be cast from a mold made from this Castaline form, so you want to make sure it comes out well and is as smooth as possible.

Make the Base Mold

Terminology: "Molds" are the hollow forms that you pour liquid material into, and "casts" are the impressions made by such molds. You just sculpted a form that you'll use to create a mold made from silicone, and from that mold, we'll then make a cast from resin.

Silicone is less toxic than polyurethane and resin, but it's still important to read the warning labels and work with adequate ventilation. Silicone is also messy, sticky stuff that can get all over you, so you need to wear Nitrile gloves if available — if you use latex, you need to avoid touching the silicone. Follow the silicone package directions about applying mold release.

We made the mold for our base with a silicone called Platsil 71-20. This product cures very fast, but you can add a retardant to prolong the cure

time if you don't want to be rushed. You can also use a silicone such as Smooth On's Dragon Skin, which takes 16 hours to cure.

Position the base bottom-up in a cardboard enclose, mix the silicone, and then pour it in so it covers the entire base. Since our mold has no real undercuts and we're using flexible silicone, we can create a one-piece mold with an open top and just pop the base form out when it's ready.

Once you've poured the silicone, knock the container on the table or floor a few times to release most of the bubbles.

Professionals avoid bubbles by doing pressure-casting rather than pouring, but for home projects this isn't necessary.

Sculpt the Top

Using more of the sculpting material, create a top form directly on top of your sculpted base, so that you have a combined form that's shaped like the final light.

Make sure that the top fits onto the base like a cap — that is, it shouldn't be a simple flush fit; the base needs to penetrate the top by a half-inch or so (see image on page 138). Keep in mind that you'll need to separate the two pieces later.

Make the Top Mold from Silicone

Now, make a new mold of this combined form. This time, we are making a two-piece mold. For the first piece of the mold, stick Plasticine around one side of the form and build it up flat so that the form is sunk halfway into a bed of Plasticine.

Then surround the bed with cardboard walls (sealed with tape or hot glue), and pour in the silicone. After it's cured, turn the whole thing over, remove the Plasticine, apply mold release to the silicone, and then mix and pour the other half of the mold.

Cast the Base in Resin

Create the final base by mixing the resin and applying it to the inside of the base mold with a wooden Popsicle stick. This creates a hard, hollow base structure that will hold the electronics and support the light's translucent top.

Then drill and Dremel holes as needed to expose the switch, IR detector, power cord, and any other exterior components.

After the resin cures, you can use a Dremel tool to machine the base.

Cast the Top in Silicone

Now you're ready to cast the translucent top of the light in soft silicone, using the two-piece mold. We used PlatSil Gel-10, which also has a one-hour curing time. Place the base form in one half of the mold; then add the other half and secure the two together with rubber bands. Pull the two halves apart at the top, and pour silicone in to fill up the mold. After curing, separate the halves, and remove the silicone top and the base form. Silicone shrinks a tiny bit when it cures, so now it fits snugly on top of the hollow base.

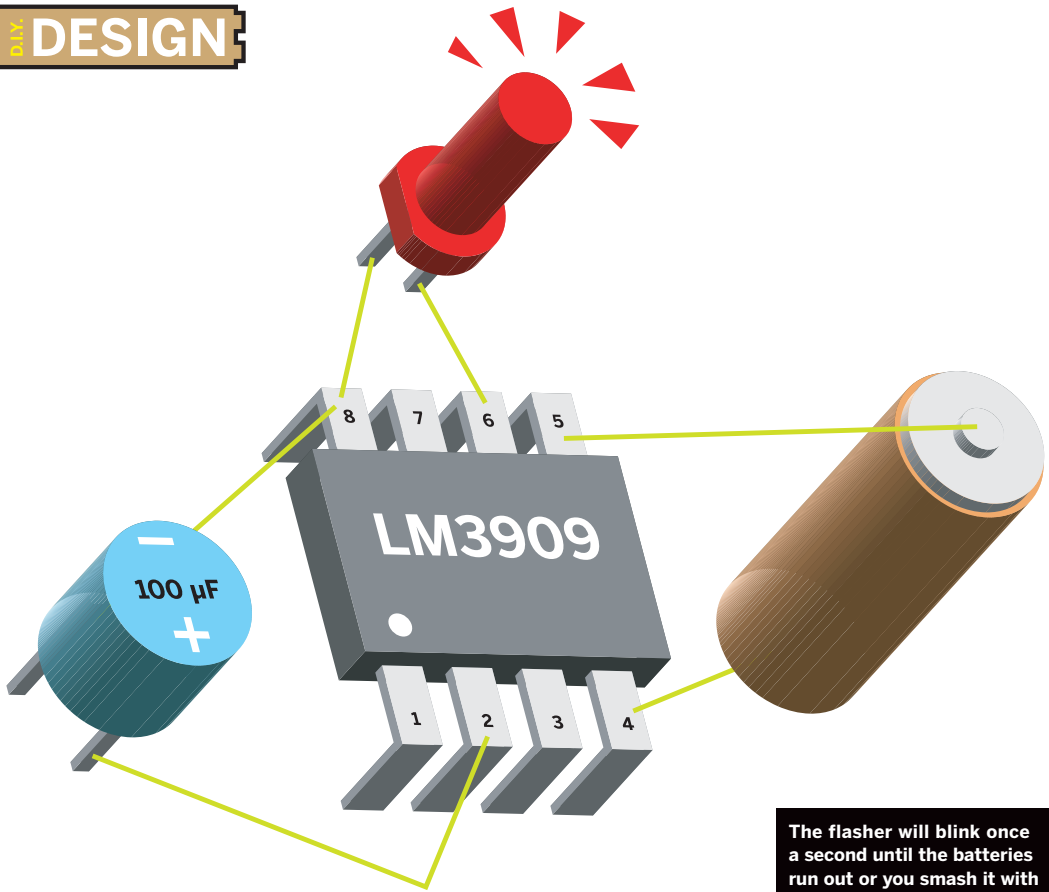
Assemble the Light

Now you have all the pieces. Position the electronics into the base, put the top on, and you're done!

After you're finished with your molds, you should store them in a plastic bag or sealed container to prevent dust contamination or other damage. We found this out the hard way when we learned that our cat, Miss Jiggs, loves to feel the smoothness of the silicone in her mouth.

Many thanks to Brett Klisch for lending expertise for this article and to The Compleat Sculptor (sculpt.com) *for providing materials.*

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.



The flasher will blink once a second until the batteries run out or you smash it with a hammer.

BAREBONES LED FLASHER

A simple circuit to go with your silicone nightlight enclosure. By Mark Frauenfelder

If you'd like to make a flashing light source for the Squeezable Nightlight project on page 135, this simple circuit will do the trick. In addition to a AAA battery (plus a soldering iron and solder), you need just three components:

LM3909 LED flasher/oscillator This integrated circuit will set you back about a dollar at *americanmicrosemiconductor.com.*
Light emitting diode (LED) About 50 cents, or free if you scavenge one from a broken gadget.
100 µF capacitor If you paid 25 cents for one, you got cheated.

Use the dot next to pin 1 on the LM3909 to determine which pin is which. Solder the component leads to the pins. You can add a switch if you'd like, but don't worry about battery drain — the LED will last a year with the same battery.

Once you build this basic circuit, you might want to try some variations. National Semiconductor's spec sheet for the LM3909 has several example applications, such as a variable speed flasher, a parallel LED flasher, and a "buzz box." You can download the PDF at *alldatasheet.net*.

For more information, find a copy of the out-of-print book, *Sound, Light, and Music: Projects for the LM3909* by Delton Horn.

Mark Frauenfelder is editor-in-chief of MAKE.

Illustration by Mark Frauenfelder

Whistle while you work: this set of tiny tools will get you out of many a tiny jam.

KEYCHAIN SURVIVAL TOOLS

Whether you're facing a parachute drop into the High Sierras or a jammed button on your mobile, some handy keychain gizmo can be there for you. By Bob Scott

Although my daily routine doesn't include as many parachute drops as it probably should, I still like to be prepared. Here's what's keeping my keys company.

Lighting

Whether reading a menu at your local diner or coping with a blackout in a high-rise office, a reliable light is a must.

LRI's Photon (*photonlight.com*) series are probably the best-known keychain lights and for good reason. They're reasonably rugged, light, and dependable. I've been using the white LED version of their latest Freedom light, which features easily adjustable brightness, extended run time, and doubles the light output of earlier models, all for about 20 bucks.

If you want something really tiny, check out the hearing-aid-battery-powered Firefli. Barely big enough to find, it features a clever valve arrangement in the on/off switch that extends the normally short "use it or lose it" life of the zinc air batteries. (*keygearcorp.com*, about $25).

Signaling

Unless you're an opera star or door-to-door cymbal salesman, you can't bet on being able to signal for help in a crisis. If you've ever enjoyed

Photograph by Bob Scott

an evening stuck in an elevator, you know you can shout yourself hoarse in a few minutes. A good whistle, on the other hand, can attract attention over a wide area and weighs next to nothing.

My old standby is a $5 Fox 40 Mini (*fox40whistle.com*) with the cosmetic side plates dremeled off to reduce its size. Fox has recently released a new Micro model that features a flatter profile than my hacked version, and it's reportedly just as loud. Both have no moving parts and work even after being submerged.

Tools

The Micra and Squirt from Leatherman (*leatherman.com*) are pleasant standouts in an otherwise bleak sea of cast metal junk. Both pack a good selection of tools centered around a clever set of spring-action scissors or needle-nose pliers. Also check out RadioShack's version that replaces the standard pliers with a wire stripper. $30 to $40.

Compass

I've used this more than I care to admit. My favorite is the liquid-damped Pocket Compass manufactured by old-school knife maker Marbles (*marblesknives.com*). About $15. If you insist on spending more, the $50 Traildrop II Digital Compass & Temperature Keychain (*www.highgearusa.com*) offers a backlight and all the functions you'd expect from a gizmo with a microchip and an LCD.

Test Gear

How about a $160 nuclear radiation detector? Looking vaguely like a car alarm remote, the NukAlert (*nukalert.com*) operates continuously, sounding an alarm when it detects a life-endangering amount of gamma or X radiation. By listening to the ten distinct alarm levels, you can plot a quick course out of a danger area or, better yet, avoid entering one.

Does it work? Beats me. My lease is vague about storage of high-level radiation on the premises, so I wasn't able to evaluate the manufacturer's claims. Their status as a state-licensed nuclear calibration facility is reassuring, though.

Bob Scott is a statistical construct of various consumer electronics marketing departments.

USB Thumbdrive Fill Up

Rather than haul around a bunch of wasted space on your keychain drive, why not keep some useful data on there between big file transfers? For instance:

Browser: Either a standalone installation of Firefox (see Volume 01 of MAKE) or at least a current copy of your bookmarks, exported from your browser as an HTML file. Add a copy of your RSS news and podcast feeds for access on the road, or to share with friends.

Data: Besides the current project information that you're sure you'll need, grab a copy of all documents less than 90 days old from the "My Documents" folder on your computer. Add a PDF version of your contact list in case your PDA packs up.

Email: If you haven't converted to a web-based email service, you may want a copy of your relevant mailboxes or a critical subset of your Outlook .pst file.

Photos & Music: Interesting photos you've shot in the last few weeks, a couple from the last vacation, and some sentimental favorites can all be big hits at the office or when visiting friends. Throw in your top 20 MP3s as a boredom antidote.

Manuals: Having a PDF copy of the manuals for your cellphone, camera, and car can come in very handy on trips. (Check the relevant OEM's website for these gems.)

Software: You've probably got a list of your "go to" programs, but before dragging all those zip files over, see what you can get from the web (e.g., online virus checkers like Trend Micro's Housecall). You may be better off with just a bookmark.

ID: Put a "Please Return Me To.txt" file containing your contact information in the root directory. You may get lucky.

If you've got any particularly sensitive data, consider encrypting it and keeping a copy of the decryption program (but not the password!) on the drive as well.

Once you've got the drive set up to your satisfaction, copy the files back to a dedicated file folder on your PC. Then you can erase the thumbdrive if you need the space for a big file transfer, and quickly restore it when you get back to your PC. *— BS*

ROLL YOUR OWN RINGTONES

Why waste money on ringtones when you can use your audio collection? By Ewan Spence

Commercially available ringtones often cost twice as much as the songs they're based on. Once you learn how easy it is to convert songs from your existing music library into ringtones, you'll never buy another ringtone.

While some phones can handle WMA, AAC, or MP3 files, every major smartphone can handle the WAV file format. You'll probably want to create ringtones from songs in your MP3 collection (though there's nothing to stop you from using something other than a piece of music — for example, recording a voice shouting "Ewan, Ewan, your phone is ringing!"), so you'll need an application to decode the MP3s into the WAV format.

Audacity (*audacity.sourceforge.net*) is an excellent sound recording and editing application that can export MP3s to WAVs. It's free and is available for Mac OS X, Windows, GNU/Linux, and other operating systems.

To get started, open a sound file in Audacity. Most mobile networks will ring your phone for a maximum of 30 seconds. Highlight the section you want and select Edit --> Trim from the menu. Export the remaining snippet as a WAV file. Now let's get it onto your phone.

Symbian OS Series 60

The easiest way to get the ringtone onto a Series 60 phone is via Bluetooth. The WAV file will appear in the Inbox of the Messaging Application. Open the WAV file and select Save from the Options menu.

Now exit Messaging and go to your Profiles application. Each profile can have a different ringtone, so select one of them and, from the Options menu, select Personalize. The first dialog box is "Ringing Tone." Select this, and then scroll through the alphabetical list to find your saved WAV file. Choose this and your ringtone is set.

Palm Treo 600 and 650

You'll need to purchase third party software for the Treo 600 and 650. LightWav ($20) at *www.toysoft.ca* allows you to associate sound files to any Treo application. To get started, drag and drop the WAV file onto the Palm Desktop Installation Tool (or copy it onto an MMC card).

Launch LightWav, go to Preferences, and select Enable LightWav so it can control the ringer. The main screen lists events you can customize. The two you want to change are "Known Caller Ringtone" and "Unknown Caller Ringtone." Select each one in turn to edit it. There is a dialog box you can tap (under "Play this ringtone when I receive a call") to select your WAV file.

MS Pocket PC Phone Edition

Connect your phone via ActiveSync, and then use Windows Explorer to put your WAV file in the PocketPC/Windows/Ringtones/ directory.

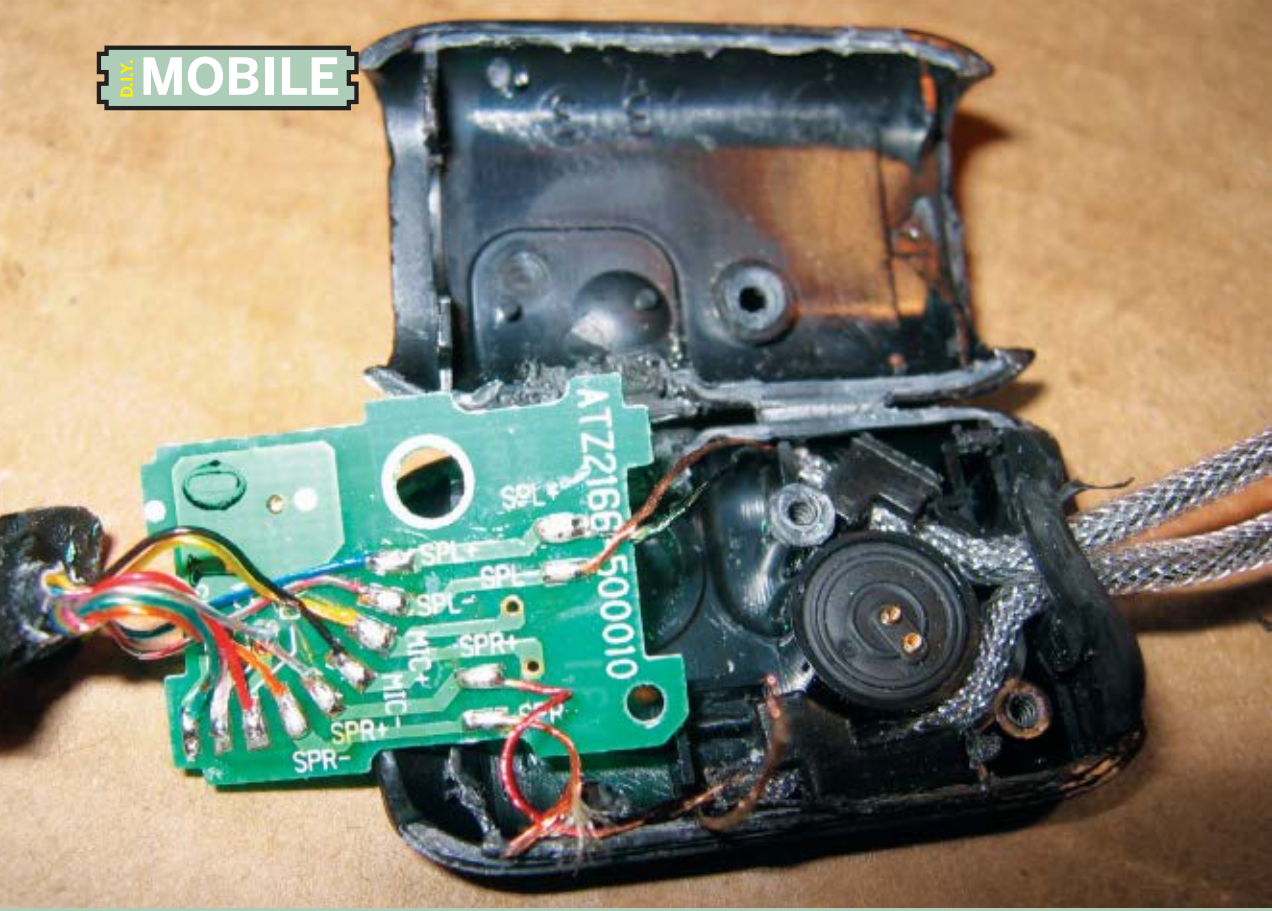
Disconnect your phone from your PC. Hit the start button from your home screen, select System, and then select the Sounds/Notifications icon. There is a pull-down selection box for ringtones. Scroll through this list until you find your WAV file and select it as your ringtone.

MS Smartphone

Connect via ActiveSync, and then use Windows Explorer to put your WAV file in the Smartphone/Storage/Application Data/Sounds/ directory.

Disconnect your phone from your PC, and call up the Start menu. Go into Settings, then Sounds. Scroll through the ringtone list till you find your WAV file and select it to set it as your ringtone.

Ewan Spence loves mobile technology, the PDA, the phone, and the music player, and spends most of his working day exploring the high ground where these technologies mix.



HACK, PLUG, AND PLAY

Use your favorite headphones on a Nokia Pop-Port phone. By Carlo Longino

Today's mobile phones can do a lot of cool stuff, and the ability to play MP3s and other digital music files is becoming a common feature. Frustratingly, many of today's so-called music phones don't feature standard 3.5mm headphone jacks, forcing users to make do with low-quality and often uncomfortable headsets that use proprietary plugs.

Pop-Port: Good News, Bad News

Nokia has implemented something called the Pop-Port interface (*oreilly.com/go/popport*) on many of its recent devices. It's a useful addition for many things, but connecting headphones to listen to music isn't one of them. The stereo headset that came with my Nokia 6630 didn't sound nearly as good as my favorite earphones, nor did the buds even fit in my ears. Nokia has announced its own Pop-Port headphone adapter, but I thought I'd beat them to the punch.

Getting Started

It's a pretty straightforward hack: start with a Nokia stereo headset. I used the HS-3 model that came with my phone. You'll also need an adapter plug. I used an airline headphone adapter from RadioShack (which lets you use your favorite headphones on a plane), since it's already split up into left and right channels (*oreilly.com/go/rsheadphones*). Finally, you need a soldering iron, some solder, and a pair of pliers or cable strippers. What you'll

Nokia's Pop-Port interface doesn't accept a standard headphone jack. Here's a fix.


Fig. 1


Fig. 2


Fig. 3


Fig. 4

How to use your own headphones on a Nokia phone: "I took the Nokia hands-free adapter with the proprietary connector, and opened up the little box with the microphone inside. I removed the standard headphones from their solder connections, and soldered on a plug I got a RadioShack."

do is crack open the little box that holds the microphone, disconnect the earphones, and wire up the adapter to the circuit board inside.

Do it this way not only because it's easier than trying to isolate the correct wires coming off the Pop-Port, but also because the circuit board is necessary for stereo sound: a connection made below here would just be dual mono. This also has the added benefit of retaining the original headset's hands-free functionality, since the microphone is in that case.

Step One: Void Your Warranty

The first step is to open the small box. Start by peeling off the sticker on the back and removing the screw hidden underneath. The box is then glued together, so you'll need to break the seal along the edge somehow; I worked in a very small flathead screwdriver and pried it apart (Fig. 1). Once it's open, remove the screw holding the circuit board in place, and clip the wires that go to the headphones (Fig. 2).

Step Two: Clip and Solder

Now, take the headphone adapter and clip the male plug ends off and strip the coating from the cables. I did this quite close to the female end, but the length doesn't really matter. I also put some heatshrink (also available from RadioShack) around the wires to make it neat later. Inside each cable is one wire with white insulation, and one bare wire. Simply solder a white wire to the "SPL+" and "SPR+" contacts and a bare wire to the "SPL-" and "SPR-" contacts (Fig. 3).

Step Three: Finishing Up

Rearrange everything back into the case, and screw the circuit board down. Snap the case shut, insert and tighten the screw on the back, and enjoy music from your phone with your favorite headphones (Fig. 4).

Interested in hacking the Pop-Port? Get the pinouts at pinouts.ru/data/nokia_pop_pinout.shtml.

Photography by Carlo Longino

Carlo Longino is the publisher of *MobileMusicBlog.com* **and executive editor of** *TheFeature.com*. **He can be found in Austin, Texas, barbecuing in the dark with a miner's headlamp.**

HANDHELD KNOW-IT-ALL

Installing Wikipedia on a Sharp Zaurus.

By Tom Owad

I wanted an encyclopedia I could hold in the palm of my hand and carry with me everywhere — something I could whip out at just the right moment with the words, "Why yes, I can tell you how many acres there are in the Amazon rain forest." Commercial encyclopedias were not forthcoming, so I was pleased to find that Wikipedia makes its data very accessible. The breadth of articles in Wikipedia (539,219 to date), and the technical slant (what other encyclopedia has an entry for the MOS 6502?) made Wikipedia an excellent choice for my project.

I considered installing MySQL, Apache, and PHP on a Sharp Zaurus so I could run the full Wiki installation, but then I found the open source ZBEDic project (*bedic.sourceforge.net*), a dictionary reader for the Zaurus that allows easy switching between dictionary files.

ZBEDic supports very large dictionary files with long entries such as Wikipedia. The program's interface is very clean, and preferable to a web browser on the small display of a handheld. The active dictionary is selected via a pull-down menu. Not only are Wikipedia and Wordnet available, but also Wikibooks, Wikiquote, Wiktionary, and 20 translation dictionaries for such languages as Spanish, French, Chinese, Danish, Latin, and many others.

The Sharp Zaurus SL-5500 generally sells for under $150 on eBay. On its own, it doesn't have enough storage space for the Wikipedia, but microdrives as large as 6GB are now available. Used, 512MB, compact flash cards sell for well under $50. The English Wikipedia is 412MB. I ended up purchasing a new 2GB Hitachi microdrive for under $100. Since the other dictionaries are all a fraction of the size of Wikipedia, a 2GB microdrive can hold all of them, several times over.

Though the Sharp Zaurus is Linux-based, its synching software is Windows-centric. AJZaurus-USB, a USB driver by Andreas Junghans, implements TCP between the Zaurus and a Mac OS X computer. The Zaurus has an FTP server installed and running, so it's easy to transfer small files.

Transferring large files to the Zaurus via USB is unreliable on any platform, so if you have a CF card reader for your computer, it's best to copy Wikipedia to your microdrive using that. I don't have one, but I was able to transfer the file using the interface built into my digital camera. After the transfer, I did have a handful of camera-created directories to delete, but the transfer went very smoothly otherwise.

I used the built-in "Application Key" app to configure the "mail" button to open ZBEDic. This eliminated the need to click around on-screen to open the program. Launch time can be reduced by clicking and holding on the application icon to bring up the application details window. Checking "Fast load" will keep the program always loaded in memory, greatly shortening the time needed to open the app.

That's all it takes to carry a 500,000-article encyclopedia, a book of quotations, an English dictionary, and several translator dictionaries, all in your shirt pocket. Sure, some people may think you're a geek, but won't they be impressed when you whip out your Zaurus and give them the etymology of that term!

Tom Owad (*owad@applefritter.com*) is a Macintosh consultant in York, Penn., and editor of Applefritter (*applefritter.com*). He is the author of *Apple I Replica Creation* (Syngress, 2005).

No exotic screw head is a match for someone wielding some Silly Putty and a Dremel tool.

FREEDOM TO UNSCREW

Make tamperproof driver bits by molding the screw heads. By Johnathan Nightingale

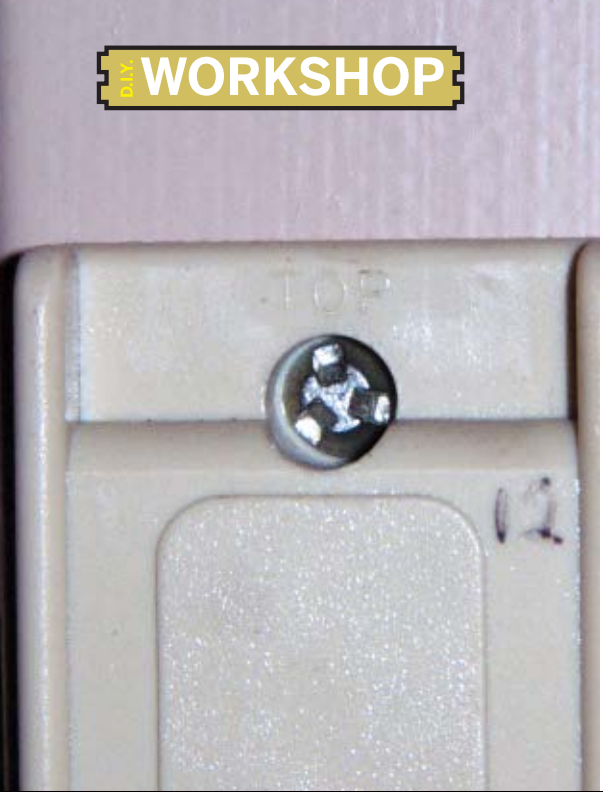
When a friend asked for my help removing some nonstandard screws from his doorframe without damaging them, I expected a little resistance. Many manufacturers use so-called tamperproof or security screw heads to prevent casual would-be hardware hackers; tamperproof Torx, spanner bits, and Tri-Wing being some of the more popular types. This security-by-obscurity approach can usually be foiled with a security bit set available in most hardware and electronics stores, though, and I assured him we'd have that panel off in no time.

The screws in question, however, were not of the standard varieties. Rather than having a bit pattern cut into the center of the screw head, this was basically a round head with three notches removed from the edges to form an equilateral triangle. Some research online revealed that the screw was a Tri-Groove design (for an excellent reference on standard security screw types, see *lara.com/reviews/screwtypes.htm*). What's more, individual driver bits for this head type can cost up to $10 a piece. When our attempts to use pliers and brute force failed, I decided to make a bit myself. I would need to get a cast of the screw head for reference, find a suitable source material for the driver, and then use a Dremel to handle the metalwork.

TOOLS:
- One "egg" of Silly Putty
- One set of dollar store hex keys (a.k.a. Allen keys)
- Dremel
- Polyfilla drywall compound, or some other quick-drying spackle

There are better molding compounds than Silly Putty, but few are as cheap, and its weaknesses,

Photograph by Amy Nightingale



First impressions: Make a mold out of the tamperproof screw head with Silly Putty. From this, you'll make a cast out of ordinary wall spackle.

particularly its tendency to "flow" and lose definition, shouldn't matter for the short timespan required. Work the putty to soften it, and then press it onto the panel. One advantage of such a soft casting material is that it easily fills countersunk holes. Once removed, I covered the reverse mold of the screw head with spackle and let it dry. It gets fragile once dried, so handle it carefully; it should be mostly an eyeball reference anyhow.

Grinding Away

I took the cast back to my shop. The decision to use Allen keys was automatic — they are excellent, self-contained tools, they're cheap, and are made of solid, uniform metal. Since the Tri-Groove screw head is basically just three notches, I had to remove metal from the head of the hex key until only three "posts" remained, to match the notches of the head. The fact that the keys are hexagonal in shape helped here with the equilateral spacing of the posts.

Using the Dremel with a cut-off wheel, I began the process of removing material from the hex head to create my bit. It is essential whenever doing metal work like this to have a glass of water handy, so you can quench the key every few seconds. If the metal starts heating, it gets harder to hold, of course, but the greater problem is that you can overheat a section and temper the metal. This will make it very hard but also brittle, which is not a desirable feature in a driver bit. Make a cut, quench, make another cut, quench. Of course, eye protection is essential as well.

Throughout the process, I referred to the cast I had made to ensure that the posts were positioned and shaped correctly. Several times, I thought I was finished only to find that when I tried to match the key to the spackle cast, the posts were too fat. I was leaving too much material from the center of the key on the posts, so they would have impacted the screw head instead of sliding into the notches. Eventually though, the driver matched the cast, and after some sanding with medium grit sanding cloth to remove any burrs (a tstep altogether), I had a functional, if unbeautiful, Tri-Groove driver.

Johnathan Nightingale is an IBM software maker by day, tinkerer by night.

Photography by Johnathan Nightingale

There are at least a dozen ways to make round holes square on aluminum sheet metal.

SQUARE DEAL

How to make square holes in aluminum sheet metal. By Nick Carter

Why would you want to make a square or rectangular hole in aluminum sheet metal? The short answer is that engineers are perverse, thus they design components with square or rectangular dimensions, which require you to mount them in a square or rectangular hole.

You may also want to keep a component that slides in or mounts on a hole from rotating, make a picture frame, or perhaps you just happen to have a round peg that seems lonely.

Here are five methods for making square holes, depending on the tools you have, the size of the hole, and the thickness of the sheet metal.

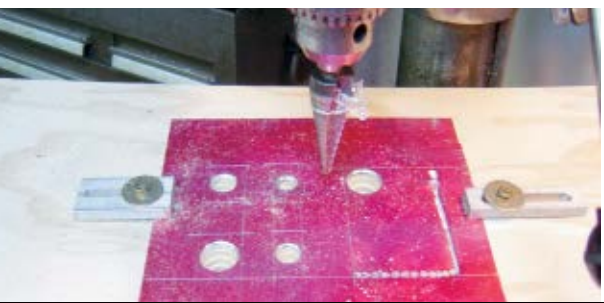
The first step for all these methods is to mark where on the sheet you want your square hole, and sometimes, you'll want to mark the center of the square. Use either a fine-tipped Sharpie or a metal scriber, depending on your tolerances.

In these pictures, I have covered the sheet metal with layout dye, which is a thin ink that you can brush or spray on metal to make a scribed line stand out.

1. If the aluminum is thin (soda can thickness), you can just pierce the metal with scissors and cut out the square. For slightly thicker metal, you can use sheet metal shears to cut out the inside of the hole.

2. You can shear the hole with a hammer and metal-cutting chisel (don't ruin your wood chisels). Place the work in a vise with the edge to be cut just slightly above the vise jaws, and hammer the chisel into the work so the edge of the chisel






Chisel, drill, or nibble: Depending on the size of the rectangular hole you need, you can use a variety of tools and methods to make it.

is parallel to the edge and held horizontal at about a 45-degree angle out from the sheet. Do each edge and the square should pop out.

Deburr the edges with a file and then hammer any distortions flat. Notice that you do get a rather large burr on the cut edge with this method.

3. Drill a series of small holes around the periphery of the hole, inside the edges, and use a shear, saw, or chisel to remove the waste. Then file the edges again. This is a good technique to use on larger holes.

4. Drill out the center of the hole using a Unibit sheet metal step drill and then file the edges square. A power file (air or electric) or a "die filer" could be used to your advantage on thicker metal.

I always mount the sheet metal to a piece of plywood. It's important to never, ever hold sheet metal in your hands for drilling it — if the drill catches on the metal, you will end up with a rather scary saw blade whizzing around that will cut your hands to ribbons!

Use a square file to remove the rest of the metal from the rectangular opening. This method is surprisingly fast.

5. Drill a starter hole and use a hand nibbler like the Klein 76011B Nibbler tool. The Nibbler tool is a hand-operated square punch and die that closes on the material when the handle is squeezed.

The Nibbler works well for electronic panels that need small square openings. When using it, you "nibble" along the edge, staying on the inside of the line.

If the square hole is relatively large, you could also use sheet metal hand shears or an electric or air-powered nibbler.

Powered sheet metal tools are relatively expensive but very versatile. Most major manufacturers make them.

Discover nine more ways to make square holes at *makezine.com/03/diy_squareholes*.

Nick Carter (*cartertools.com*) is a jack-of-all-trades who divides his time between selling machine tools online, machining, making jewelry, and enjoying family life in idyllic Philomath, Oregon.

Photography by Nick Carter

READING AND DRAWING SCHEMATICS

Understanding schematics is a good baseline skill for makers, and not as hard as you think.

By Joe Grand

Many times, before hacking something, you'll need to reverse-engineer part of a product to understand what it's doing. Or, if you're designing a circuit, you'll need a way to convey your thoughts onto paper. What's the best way to describe a circuit? With a schematic!

A schematic is essentially the electrical road map of a circuit. Reading basic schematics is a good skill to have if you plan to experiment with electronics. Even if you don't understand what the circuit is necessarily for, learning how to read the written form of a circuit will pay off in spades.

On a schematic, each component of the circuit is assigned its own symbol, unique to the type of device that it is. People in the United States and Europe sometimes use different symbols, and there are even multiple symbols to represent one type of part.

A resistor has its own special symbol, as does a capacitor, a diode, or an integrated circuit. In a future issue of MAKE, we'll look at the details of some of the most basic, and arguably most crucial, electronic components, so you'll be able to understand (if you don't already) how an actual circuit works. For now, simply think of schematic symbols as an alphabet for electronics.

The table on the next page shows a selection of the most common components and their corresponding designators and schematic symbols. This is a good starting point, but it is by no means a complete list, and, as mentioned, a particular component type may have additional symbols that aren't shown here.

A part designator is also assigned to each component and is used to distinguish between two parts of the same type and value. The designator is usually an alphabetic character or two followed by a unique numerical value (R1, C4, or SW2, for example). The part designator and schematic symbol are used as a pair to define each discrete component of the circuit design.

Figure 1 and Figure 2 on the next page both show example circuits using some of the basic schematic symbols.

Figure 1 describes an LED powered by a battery and controlled with a switch. When the switch is open (off), no current is able to flow from the battery through the rest of the circuit, so the LED will not illuminate. When the switch is closed (enabled), current will flow from the battery, BT1, through the current-limiting resistor, R1, and into the LED, D1. The LED will illuminate until the switch is released.

Figure 2 shows a not-so-basic schematic of a PC-based level shifter circuit used for decoding Mobile Data Terminal (MDT) and POCSAG pager transmissions (*oreilly.com/go/transmissions*).

The circuit connects to the PC's RS232 serial port and is used in conjunction with the appropriate decoding software. The schematic shows the important items in a schematic, including component, part value, part designator, connection, net name, ground node, and power node.

Reading and drawing schematics is much easier than it may appear, and with practice, it will become second nature.

Joe Grand (*joe@grandideastudio.com*) is the president of Grand Idea Studio, Inc., a product research, development, and licensing firm, where he specializes in the invention and design of consumer electronics, video game accessories, and toys. Joe is the author of the books *Game Console Hacking* and *Hardware Hacking: Have Fun While Voiding Your Warranty*.

SCHEMATIC SYMBOLS

Ground
Earth
Chassis
Signal

BT Battery

LS Speaker

L Inductor
Air-Core

C Capacitor
Non-Polarized
Polarized

R Resistor
Regular
Variable Resistor, Potentiometer

T Transformer
Iron-Core

U Digital Logic
AND Gate
OR Gate
NOT Gate

F Fuse

Y Crystal, Oscillator

SW Switch
Regular
Momentary-Contact

D Diode
Regular
Light-Emitting
Photosensitive
Zener

Q Transistor
MOSFET, N-Channel
MOSFET, P-Channel
Bipolar, PNP
Bipolar, NPN

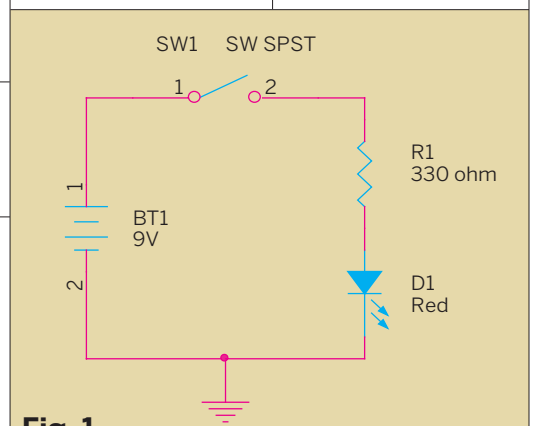


Fig. 1

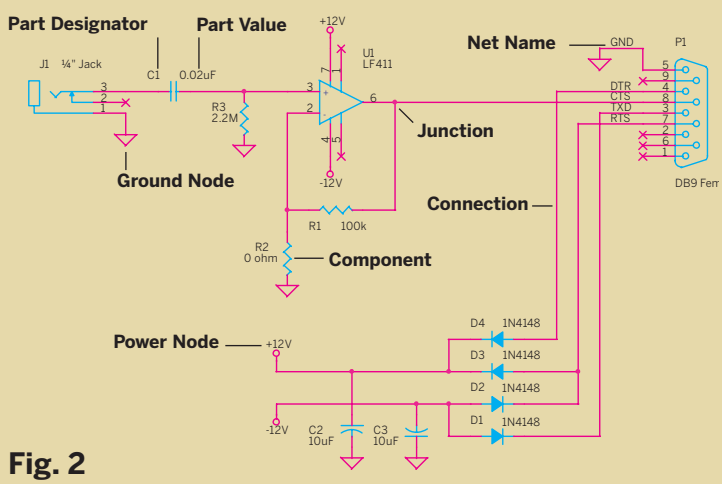
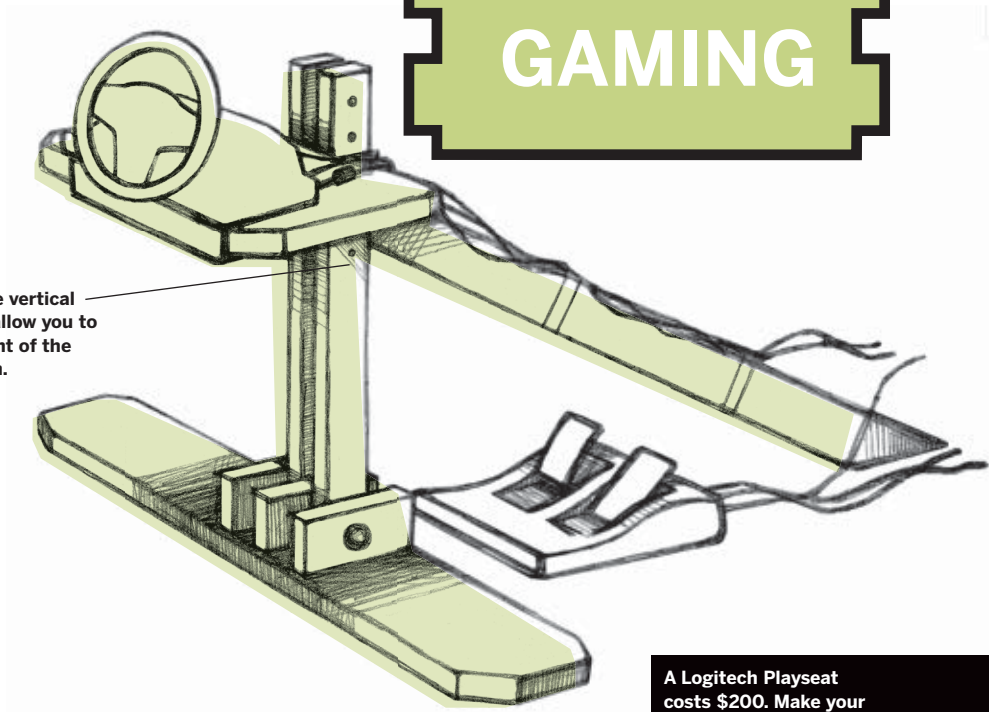


Fig. 2



A Logitech Playseat costs $200. Make your own for one-tenth the price,

SPIN TO WIN

A steering wheel mount for gamers.

By Cameron Mallory

I've always wanted a steering wheel to play Grand Turismo, but I wanted a better arrangement than having the wheel in my lap. So I built a wooden mount for the Logitech Driving Force Pro Steering Wheel. The nice thing about it (and my wife is extremely happy about this feature also), is that it folds up compactly, and can be put just about anywhere.

You'll need a drill and a power saw (or a mitre/saw box).

The System Has Three Basic Components:

1. The shelf for the steering wheel: cut 18" from a 1"x4"x4' piece of pine.
2. The floor base: cut 30" from the 1"x4"x4'; use a 1"x2"x4' for the vertical supports.
3. A diagonal support beam: use a 1"x4"x4'.

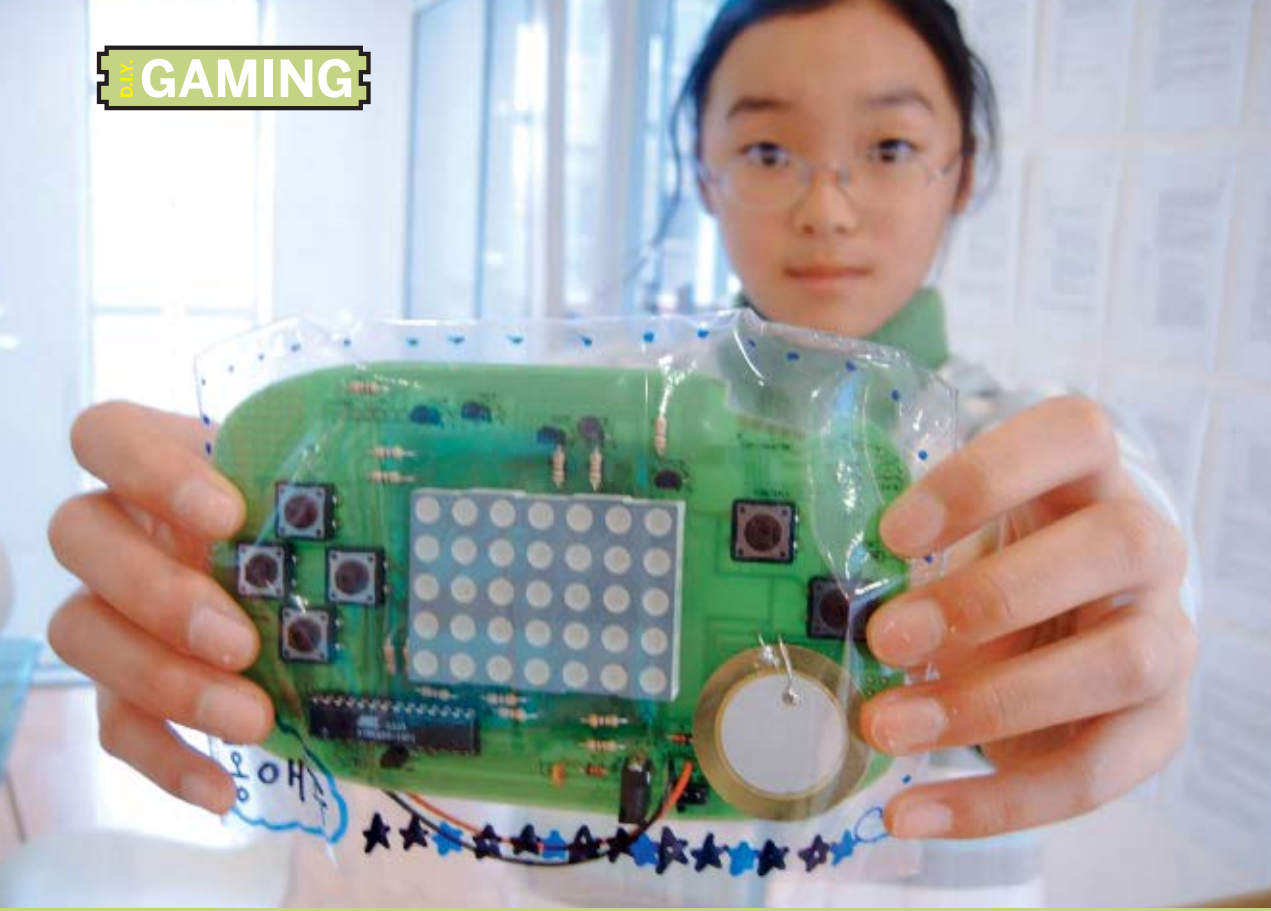
Total cost of materials: $13.

I sort of cheated by using my entertainment center as a "mounting" spot. I just push the end of the diagonal support under it, and use another piece of wood to get a nice snug fit. If you don't have this as an option you can make a front mount exactly like the rear support mount.

For more photos, a complete list of materials, and detailed instructions (along with a video of the system in action) visit my website: *berserk.org/gt4/*.

Cameron Mallory is a software developer and technology enthusiast. He lives with his wife and son in the Pacific Northwest.

Illustration by Damien Scogin



YOU BUILT IT, YOU PLAY IT

The Mignon is a kit for a handheld game player.

By Brian Jepson

Although 5x7 pixels aren't a lot to work with, it's easy to get lost in Olaf Val's Mignon Game Kit. This minimalist handheld gaming system is hands-on in more ways than one: the first step is to put it together; second is to hack code for the Atmel ATmega8 microcontroller that powers it; and third, you get to play with it. With a 4-way directional pad and two function buttons, the Mignon is ready for some serious, if extremely basic, gaming.

The Mignon site (*olafval.de/mignon/home.htm*) has no shortage of photos and videos showing young people wielding soldering irons. It's been used for several inexpensive workshops around the world that blend DIY hardware hacking, some 8-bit programming, and a little bit of gameplay. It put in an appearance at the ALT-CTRL Festival of Independent and Alternative Games in Irvine, California (2004), was used in a game-making workshop at the Museum of Art in Seoul (2005), and also at the 18th Stuttgarter Filmwinter Festival for Expanded Media in Stuttgart (2005).

Build a Kit, or Make From Scratch?

The Mignon is complex enough to be interesting, but not so complex that a child would have trouble with it. It's a perfect microcontroller kit for hardware hackers of all ages (provided you've got the appropriate supervision for the soldering at the lower end of that age scale). The Mignon website suggests four students to each instructor and

Less is more: The Mignon's 35 pixels are a perfect platform for creating your own games.

hosts companion materials for workshop organizers, including a skeletal timetable that you can customize.

There are two ways to get your hands on a Mignon: order it direct from the Mignon website or build it from scratch. The basic Mignon kit is 39 Euro, with 15 Euro for worldwide shipping, and the Mignon website includes a complete parts list and circuit board layout for true DIY heaven.

With just over one hundred solder joints, make sure to set aside a few hours for assembly, especially if this is your first major soldering endeavor. (If this is your first soldering endeavor of any kind, be sure to see Joe Grand's Soldering and Desoldering Primer on page 162 of MAKE's premiere issue.)

Thankfully, most of the Mignon's parts are fairly hardy, and the most sensitive part, the ATmega8 microcontroller, is socket-mounted, so there's no need to ever expose it to extreme heat. There are four different types of resistors, and while they are not labeled, there is a key you can use in the Mignon instructions. However, the color matching in the printed instructions is not perfect, so visit the Mignon website and click "content" in the navigation bar to see the parts list with photos.

Programming

Once the Mignon's assembled, it's time to power it up (power comes from either four AA batteries or an AC adapter). There are two games stored in the ATmega8's nonvolatile RAM, which hopefully will get overwritten soon with your own programs. The user interface is simple, although some might mistake it for a game at first. Once it powers up, the Roman numerals I and II appear on the screen with a dot in between them. Use the directional pad to move the dot to the I (to select the first game, Maze Diver) or to the II (to select the second, Min Pong).

You can program the Mignon using any compiler that supports the ATmega8 — BASIC and C are popular choices. The Mignon website has links to a number of programming environments and plenty of sample code in BASIC. Although the website doesn't list any development environments for the Macintosh, the GCC-AVR cross compiler is available through Fink (in the unstable repository), and this compiler produces code for the ATmega8. The same GCC-based compiler can be found in WinAVR, a collection of developer tools that works great with the Mignon.

You access the Mignon's bootloader through a 9-pin D-Sub serial port, so a USB serial adapter will come in handy for computers that don't have serial ports. Windows users can load compiled programs onto the Mignon using the MigPrg utility that's available from the Mignon website.

In keeping with the idea that the Mignon should be simple, Val designed an extremely simple interface for programming the Mignon that avoids the need to use a tricky-to-use hardware programmer. In theory, Linux and Mac users could look into the AVRDUDE and uisp utilities, but they will not talk directly to the Mignon. Happily, the Mignon supports an alternate hardware adapter interface; see the Mignon website for more details.

Brian Jepson is an O'Reilly Media editor, programmer, and co-author of three O'Reilly books.

Photography by Olaf Val and Brian Jepson

Your new PowerBook allows you to waste even more time with the fun of Bubblegym.

TILT INTERFACE

Having fun with Apple's hard drive protection system. By Tom Owad

Throw your PowerBook off a cliff. As it tumbles, sensors will detect changes in orientation and gravitational force. With this data, your PowerBook will wisely ascertain that all is not well. Faster than you can knock a laptop off a desk, it will swing the hard drive's head away from the platter and park it, preventing a deadly collision with your data.

The "Sudden Motion Sensor" in Apple's latest PowerBooks implements this technology. It's possible to read the sensor output yourself.

Amit Singh's Amstracker (*kernelthread.com/software/ams*) is a simple command-line utility that returns the values for the sensor's x, y, and z axes. X is left/right tilt, y is forward/back, and z is the change in G force.

Singh has written another entertaining demo: StableWindow. You can tilt your PowerBook any way you like, but the window refuses to tilt with it.

A game called Bubblegym (*balooba.se*) gives the player a marble on a board. Tilting the computer tilts the board and causes the marble to roll. The objective is to roll the ball into the cloud. With each success, a new cloud appears and the allotted time grows shorter.

Where will Apple's motion-sensing technology go from here? Hopefully, an adaptation of the arcade game Neverball will soon be in the works. Others have suggested using it to build an inertial navigation system.

Tom Owad (*owad@applefritter.com*) is a Macintosh consultant in York, Penn., and the editor of Applefritter (*applefritter.com*). He is the author of *Apple I Replica Creation* (Syngress, 2005).

Photograph by Kirk von Rohr

ONLINE POKER FOR GEEKS

If Poker Tracker has taught me one thing, it's a reminder of the obvious: knowledge is power.

By Chris Hanel

My computer does more than download music and manage my email. It's a lean, mean, profit-making machine that helps me take other people's money. But before you accuse me of being a spam overlord, let me explain: I play online poker. And I win.

Tonight, like any other night, my computer screen has become a battlefield. Four different games of poker are running at the same time. I'm hopping from one window to the other, watching hands being played at the rate of 280 an hour. Keeping track of my cards, the money, and the 36 opponents can be daunting at times, but I've got a battle plan.

Choose Your Battlefield

With poker becoming the greatest trend in entertainment since reality television, the internet has responded by making sure anyone wishing to wager a few dollars can find a game online 24/7. Some networks boast up to 75,000 players online at any given moment, from the just-for-fun hobbyist to the degenerate gambler. And with the growing exposure on television and the prizes always getting larger, the growth shows no signs of slowing down.

PartyPoker.com is a good first choice for a wide selection of games, frequent tournaments, and the sheer number of players. Online poker enthusiasts have also come to call Party Poker "The Aquarium" because it's home to more novice "fish" than any other website. The software might not be tops, but anyone with a head for money will sacrifice little inconveniences for a chance to play against people who have to ask if a straight beats two pair. Other top websites include PokerStars, UltimateBet, and FullTiltPoker.

Choose Your Weapon

If you're committed to improving your game and maximizing every hand you play, you need Poker Tracker (*pokertracker.com*). It automatically imports your hand history and tells you how much you've won, who you've won it from, and how you won it. It also finds the weaknesses in your game and ranks the opponents you've sat across from, so that you're armed with all the info you need the next time you sit across from them.

To take it even a step further, Poker Tracker plug-ins like GameTime and PlayerView will display this information in real time over the game window. This combination of software makes for a powerful assistant and does everything except tell you how to play (which would be cheating).

Computer Does the Boring Stuff

Geek gamblers like PokerTracker because they can set it up to record hand histories while they sleep — simply open up a few tables to observe and open Poker Tracker to record the progess. When you wake up in the morning, you'll have data by the truckload. If you find a player who seems especially lacking in skill, throw them on your buddy list so you can sit across from them the next time they're online. Or, you can use the data to analyze who does well and how they play their hands. It's one thing to sweat the rails at a casino and watch over a pro's shoulder — it's much different to be able to take that info and extrapolate it to your heart's content.

One must always remember, though, that even with the advantages these steps present, poker is still a risk and involves plenty of dedication and study to master the game. A person who watches a few episodes of the *World Poker Tour* and exclaims, "Hey, I can do that!" is probably destined to end up in someone else's "fish" file.

Chris Hanel is a writer and filmmaker in Los Angeles, Calif. You can read his daily poker writings at *thepokergeek.net*.

PRIMER

Welding

By Mister Jalopy

Photography by Mister Jalopy

If you need metal stuck together, there is no quicker path than buying a portable 110-volt wire-feed welder.

Being a snob, I used to scoff at these small welders as not being serious machines. Then I started seeing them everywhere — at every auto body shop and every metal gate installer; even hooked up to a generator at drag races.

Having used a Lincoln 135 Plus wire-feed welder (about $600) for a month or two, I'm not scoffing any longer. Granted, it is not structural. You can't weld a bridge, skyscraper, or engine mounts to a car frame. But you can weld steel up to 3⁄16", which is thick enough to make furniture, wrought iron gates, and bad art.

The beauty of the small Lincoln welders is they are light and portable. And when you get to wherever you are going, you can plug them into a standard 110-volt 20-amp outlet. If you use the flux core kit, you don't even have to carry around a tank of compressed shielding gas.

This article is not a replacement for the manual or the many excellent books devoted to welding. This is a primer to explain the process and show how you can be a welder by the end of the weekend — and end up with a couple of jigs for the effort.

THE BASICS

THE SP-135 PLUS WIRE-FEED WELDER
With attached ground clamp and welding gun.

SOLAR-POWERED, AUTO-DARKENING LCD WELDING HELMET
Within 1/16,000 of a second, the auto-darkening LCD helmet changes from a cheap pair of sunglasses to nearly pitch black. Without an auto-darkening helmet, it is *possible* to learn to weld, but the helmet will improve your learning curve by a factor of five. It makes a huge difference. And if your helmet is as ugly as mine, I suggest you immediately cover it with decals.

DIAGONAL WIRE CUTTERS FOR TRIMMING THE WIRE FEED

LEATHER GARDENING GLOVES

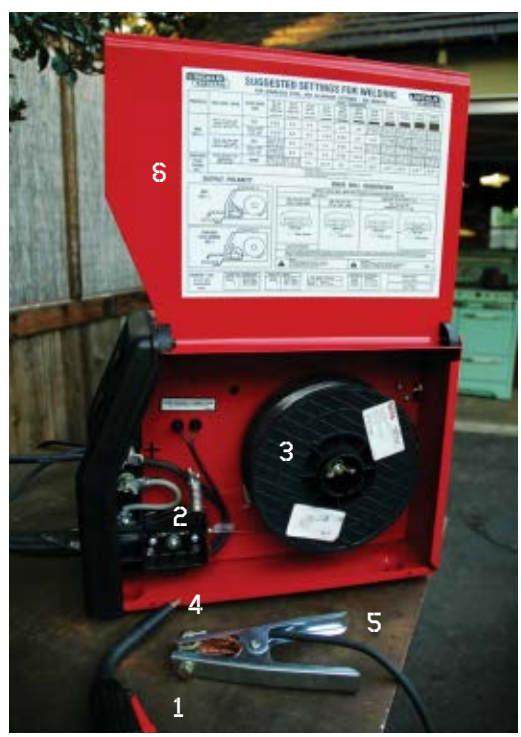
How the Lincoln Works

When you squeeze the trigger (1), the rollers (2) pull the wire off the spool (3) and force it out the gun (4). Along the way, the welder applies power to the wire and it is charged.

The ground clamp (5) is attached to the metal that you are going to weld (a.k.a. "the work").

The charged wire streams out the end of the gun and when it gets very close or touches the grounded metal, a super hot electric arc is created between the feeding wire and the work. The work melts, the wire melts, and the resulting weld is the joining of the two.

And the cheat sheet (6) means the manual is rarely opened after Day One.



Flux Core (FCAW) vs. Shielded Gas Welding (MIG)

Though welding is a dirty operation, strong welds need to be clean and contaminant-free. Shielded gas welding uses a cylinder of compressed gas (generally an argon/CO_2 blend) so the welder can deliver a stream of shielding gas through the gun. This provides a "cone" of gas to shield the weld from atmospheric contamination.

Flux core also drives contaminants from the weld but in a very different way. The feeding wire actually has a metal cleaning flux inside the wire that keeps the weld clean in the same way as soldering with flux. At risk of oversimplification, the flux "floats" contaminants out of the molten weld.

Both methods have their merits and the Lincoln SP135 Plus is capable of both flux core and shielded gas welding. Inevitably, you will end up using both processes depending on the project, but for this article we will focus on flux core. The projects can be completed with MIG if you adjust the welding amperage and wire speed per the cheat sheet.

Whatever you decide, buy your welder at your local welding shop. Besides setting your welder up for you, they know welding and will look at your garbage welds to tell you why you suck. Doesn't sound fun, but the advice is invaluable.

Flux Core (FCAW)
(Requires flux core kit)

PROS
- Can weld outside
- No hassle/expense of the gas cylinder
- Can weld thicker metal
- Tolerates rust better

CONS
- More persnickety, requires more fine tuning to get machine set up just right
- Ugly welds with lots of spatter
- Welds need to be cleaned up
- Can't weld thin metals
- No stainless or aluminum

Shielded Gas (MIG)
(Requires shielding gas cylinder)

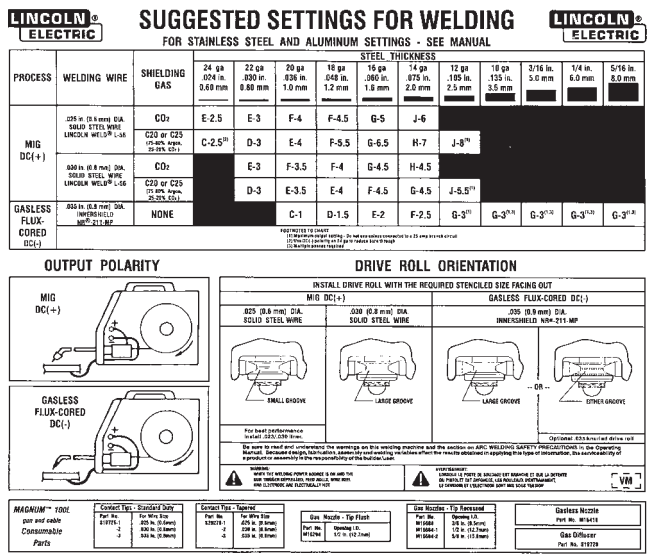
PROS
- Pretty welds
- No spatter or clean up
- Easier to learn, more forgiving
- Can weld thinner metal
- Can be set-up to weld aluminum and stainless

CONS
- Shielding gas blows away if you are welding outside and won't shield as well
- Can't weld thicker metal
- Not as portable with the cylinder

The prettiest "tube-of-toothpaste" welds are accomplished by using shielding gas.

Your First Weld Beads

Just Two Dials – Speed of wire and amperage. Inside the welder side panel, there is a handy cheat sheet with wire speed and amperage (heat) recommendations for different thicknesses of metal.



LINCOLN ELECTRIC

SUGGESTED SETTINGS FOR WELDING

FOR STAINLESS STEEL AND ALUMINUM SETTINGS - SEE MANUAL

PROCESS	WELDING WIRE	SHIELDING GAS	STEEL THICKNESS 24 ga .024 in. 0.60 mm	22 ga .030 in. 0.80 mm	20 ga .036 in. 1.0 mm	18 ga .048 in. 1.2 mm	16 ga .060 in. 1.6 mm	14 ga .075 in. 2.0 mm	12 ga .105 in. 2.5 mm	10 ga 135 in. 3.5 mm	3/16 in. 5.0 mm	1/4 in. 6.0 mm	5/16 in. 8.0 mm
MIG DC(+)	.035 in. (0.9 mm) DIA. SOLID STEEL WIRE LINCOLN WELD® L-56	CO_2	E-2.5	E-3	F-4	F-4.5	G-5	J-6					
		C20 or C25 (25-40% Argon, 75-60% CO_2)	C-2.5[1]	D-3	E-4	F-5.5	G-6.5	H-7	J-8[1]				
	.030 in. (0.8 mm) DIA. SOLID STEEL WIRE LINCOLN WELD® L-56	CO_2		E-3	F-3.5	F-4	G-4.5	H-4.5					
		C20 or C25 (75-80% Argon, 25-20% CO_2)		D-3	E-3.5	E-4	F-4.5	G-4.5	J-5.5[1]				
GASLESS FLUX-CORED DC(-)	.035 in. (0.9 mm) DIA. INNERSHIELD NR®-211-MP	NONE			C-1	D-1.5	F-2	F-2.5	G-3[1]	G-3[1,3]	G-3[1,2]	G-3[1,2]	G-3[1,2]

FOOTNOTES TO CHART
(1) Maximum output setting. Do not exceed rated current for a 25 amp branch circuit.
(2) Multiple passes required.
(3) Multiple passes required.

OUTPUT POLARITY

DRIVE ROLL ORIENTATION

MAGNUM™ 100L gun and cable Consumable Parts

Contact Tips - Standard Duty Part No.	For Wire Size
S19775-1	.025 in. (0.6mm)
-2	.030 in. (0.8mm)
-3	.035 in. (0.9mm)

Contact Tips - Tapered Part No.	For Wire Size
S19776-1	.025 in. (0.6mm)
-2	.030 in. (0.8mm)
-3	.035 in. (0.9mm)

Gas Nozzle - Tip Flush Part No.	Opening I.D.
M16294	1/2 in. (12.7mm)

Gas Nozzle - Tip Recessed Part No.	Opening I.D.
M16588	3/8 in. (9.5mm)
M16588-1	1/2 in. (12.7mm)
M16588-2	5/8 in. (15.9mm)

Gasless Nozzle Part No. M16418

Gas Diffuser Part No. 819278

Warning! Welding is dangerous! RTFM and see American Welding Society (aws.org/technical/facts/index.html) to learn about hazards from fumes to pacemaker risks to dropping something on your foot!

Practice – Trim "stick-out." The distance between the welding gun and wire end is called stick-out. Squeeze the trigger and run the wire out an inch or two. Be careful! The wire is energized and will weld to any grounded metal. Without touching the trigger, trim the wire stick-out to ⅜" beyond the copper gun tip.

Practice – Tack welds. Tack welds are small, temporary spot welds that hold the metal together until you lay the final welding bead.

I am welding a pretty thick piece of metal (⅛" steel angle to a 3⁄16" steel plate) so I set the welder to G-3. The G represents welding amperage or heat and the 3 is the speed the wire is fed from the gun. Hold the gun tip at a 45-degree angle to the corner joint. Touch the wire to the work.

Weld! With the wire touching the work, your gun is ⅜" from the work. As the wire feeds, there is a natural tendency to follow right into the weld and dip your gun tip in the molten pool. Don't do that! When you pull the trigger, keep the gun at ⅜" from the weld.

Make sure your welding hood is turned on! Make sure your welding area is clean and inflammable as the sparks are going to fly! Make sure ground clamp is attached to the work.

Squeeze trigger. Release trigger. How long? The puny weld on the left is about ½ second, while the whopper on the right is about 2 seconds. About 1 second seems right.

Re-trim the stick-out between each weld.

TIP: To keep from burning your house down, make sure your work area is swept clean of flammables and make sure you're standing on dry ground. Even if your rose garden or wood pile is eight feet away, sprinkle it with water, because sparks fly. Ideally, a steel welding table is swell, but that is a future welding project for you. A stack of bricks will work for now.

START »

1. WELD BEADS, DRAW LINES, DIFFERENT HEATS/SPEEDS. Now try welding some final beads. As opposed to small tack welds, a bead is a continuous line of welded metal. According to the cheat sheet, this 3⁄16" steel should be welded at G-3, but I drew sample lines at other voltage and wire speed settings to gauge the effects of different settings.

2. WELD BEADS: READY, SET, GO! If you're right handed, weld beads from left to right. Angle the gun slightly into the direction of travel at about 45 degrees from the work. Remember to trim the stick-out before every weld.

Before you pull the trigger, run the gun over the path a couple times to make sure you are comfortable and you are not going to run into anything.

Pull trigger with your dominant hand, brace with the other, and weld away from you, so you can watch behind the weld and see how it's going. Move gun from left to right. The correct speed depends on the material, the wire, the heat, the wire speed, and your skill. In time, you can watch the weld and figure out if you are going too fast or too slow, but to start, try moving along at about an inch per second.

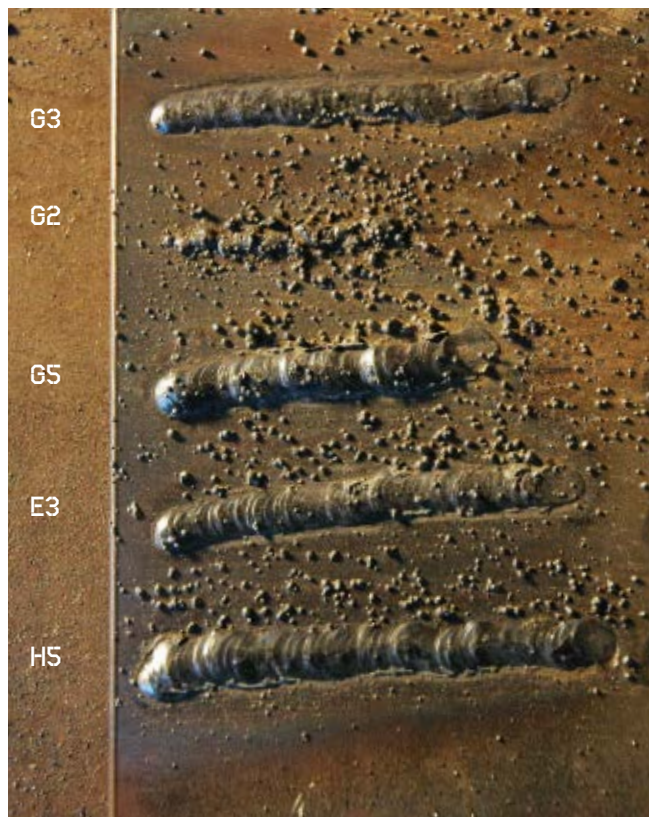
3. WELD BEADS – HOW DID IT GO? Flux core welding is a messy operation that creates lots of little metal droplets called spatter. And the weld is partially covered with slag. Scrub and pick the beads with a wire brush to get them as clean as is practical.

Does your weld have lots of little bubbles, skipped spots, or is it just too thin? That was too fast.

Is the weld really wide and with a high crown? Too slow.

4. WELD BEADS. The ideal bead is a perfect union of the wire (filler material) and the work (base material). Through experimentation, you can find the right amperage, wire feed speed, and the rate that you move the gun over the metal.

G3 » Recommended heat and wire speed looks pretty good. A deep weld that is bonded to the work.
G2 » Lower wire speed just didn't put out enough wire. Most of the spatter was from that weld.
G5 » Lots of wire speed really cranked out a big bead, but it is not really stronger as it is not deeper. Just a higher crown.
E3 » Turned down the heat and the bead did not get as deep in the work. Sorta sitting on top of the metal.
H5 » Hot as July and spitting out lots of wire, this setting is just too much for the base metal. The bead got narrower toward the end because my hands were getting hot and I wanted to be done!



Pick your best weld and practice welding a bunch of beads with the same settings.

Make a 90° Angle Jig

A joint that is not clean and tight will end up having an ugly, weak weld. Let's make a jig (shown here), an invaluable tool that holds two chunks of metal at right angles while allowing ample room to weld tacks in the corner.

Be sure to pick up angle iron with square inside edges.

JIG 1 — MATERIALS

If you are lazy like me, your local steel shop will cut the metal to length. If you buy extra, you can practice and screw up. And if you buy a square foot of metal plate, you can practice welding beads until they are perfect. Metal should be clean, paint-free, rust-free, and any burrs should be filed.

TWO 4" LENGTHS OF 1"x5/8"x1" MILD STEEL ANGLE IRON (Though there is nothing wrong with round inside edges, for this project a square inside edge is needed.)

ONE 6" LENGTH OF 1"x1/8" MILD STEEL FLAT BAR

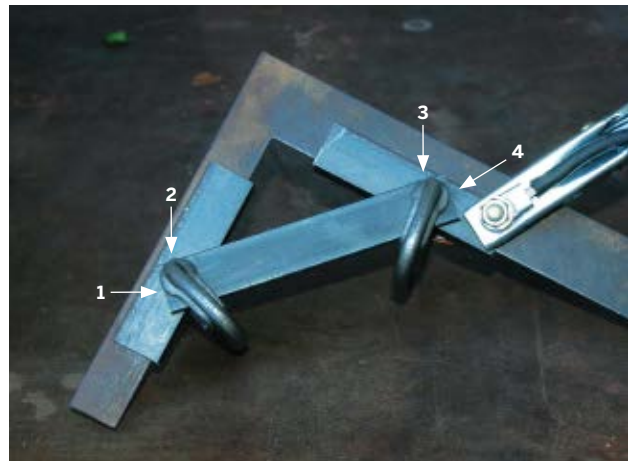
TWO 2" FORGED STEEL "C-CLAMPS" (Cast iron has its own welding peculiarities, so make sure the clamps are forged, not cast.)

START »

1. **LAYOUT AND CLAMP.** Don't use your granddaddy's favorite square. Anything could happen! Lay out the angle iron on the inside of the square and measure 1" from the inside corner. Clamp the cross bar behind it at about the 3" point.

When welded, the diagonal cross bar will hold the angle iron at 90 degrees until California falls in the ocean.

2. FLIP IT AND WELD IT. Make sure the clamps are right and flip it over. Weld tacks at points 1, 2, 3, and 4. Tack weld. A nice, hot tack at each of the points. Try G-4 for about 1 second at each point. The tack welds don't have to be gigantic, since they are just holding it together so you can remove the clamps and weld a bead. Re-trim the wire stick-out to ⅜" after each weld.



3. TACKS. A pair of not great-looking tacks, but it will hold. The left tack is particularly puny and I should have continued welding for another half second.

4. WELD BEADS AND TACK THE CLAMP. As with the sample beads, start on the left and drag across to the right. With a ⅜" stick-out, touch the wire joint between the angle and flat bar, pull the trigger, and keep at a 45° angle. Like laying a bead of caulk, just fill the joint with metal!

Before tacking the clamp, make sure to remove any paint from the clamp edges that will be welded. Then, tack it like you tacked the angle iron. Repeat both sides, both clamps.

Jig 1 done!

Make a Pair of Stands

Before we start on our second jig (which will be made with the help of our first jig), let's look at square-tube steel. Since the walls of square tubing are much thinner than angle iron, there is a greater likelihood of "blowing a hole."

JIG 2 – MATERIALS

TWO 4"x4" MILD STEEL PLATES (Available precut as they are commonly used as bases for welded fences.)

TWO #18 5/16"x1" THUMBSCREWS

TWO #18 5/16" HEX NUTS

TWO 12" SECTIONS OF MILD STEEL 1" SQUARE TUBE for the base uprights.

TWO 12" SECTIONS OF MILD STEEL 3/4" SQUARE TUBE for the top section uprights.

TWO 9" SECTIONS OF MILD STEEL 3/4" SQUARE TUBE for the top crossbars.

Be smart and shop the remnant bin! It's a fraction of the cost and a lot easier to haul smaller pieces home.

Welding Square Tube

The heat and wire speed need to be turned down or your work will be Swiss-cheesed. Standard steel tube is about 16 gauge, so I set the welder to E-2 per the cheat sheet.

The horizontal tube resting on the table acts as if it is thicker because you are welding into the side of the tube rather than the edge. Since the vertical tube is being welded on its very edge, it has less metal to absorb the heat and is much quicker to melt away.

To compensate, hold the gun at a steeper angle, which will direct more of the heat to the horizontal tube.

It's like lighting a sheet of notebook paper on fire. If you hold a match to the center of the paper, it will take longer to catch fire than if held at the edge or the corner.

Same principal, shallower angle. This time the thin edge is on the base of the T. Again, angle the gun into the more substantial piece of metal.

Practice welding square tube. Use the scrap metal and practice welding some tacks and beads. Be sure to tack on all four sides, as the square tube will want to wander when it gets hot. These fresh tacks have yet to be wire brushed.

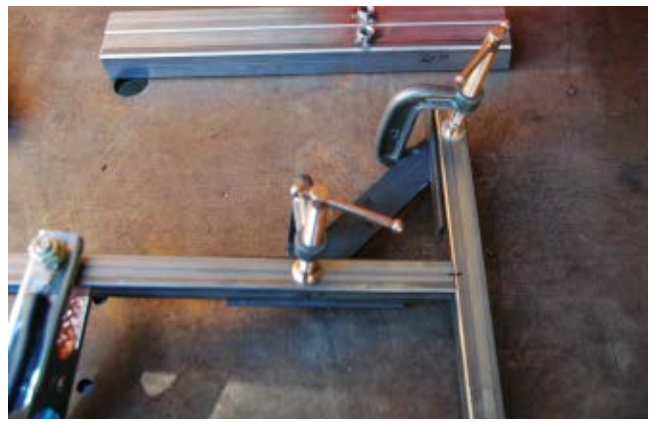
START »

1. CLAMP STAND TOP IN JIG AND TACK WELD. Clamp the stand upright (12" long, ¾" tube) in the jig.

Measure the center of the stand top crossbar and align to the center of the stand upright. Certainly, without measuring, you could align these pretty close and it wouldn't affect usability. You might be a bad person, but the stands would still work fine.

Clamp (and center) the stand crossbar in the jig.

Weld a tack on each of the four sides of the T-joint.

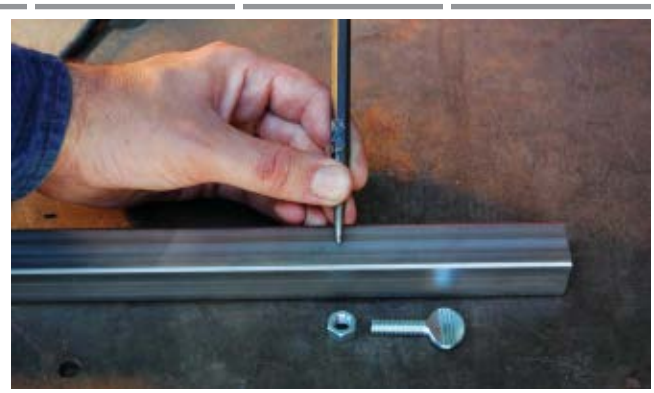


2. WELD STAND TOP. After the stand top is tacked on four sides, it can be removed from the jig and the final beads can be laid down.

When you are welding beads on square tube, weld a little further around each corner. That wraparound will assure that the bead is continuous.

3. CENTER PUNCH AND DRILL HOLES. Drilling steel is more difficult than drilling wood as the drill bit tends to skate along the top of the metal. Center punching the steel first solves the problem by creating a tiny divot for the drill bit to get its start.

Once center punched, drill a ⅜" hole for the 5⁄16" thumbscrew to pass through.

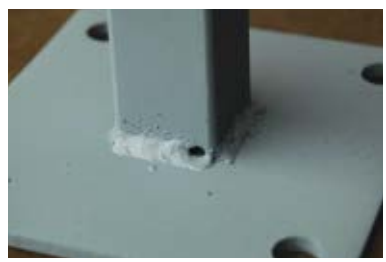


4. WELD NUT. After drilling the hole, position the hex nut over the hole. Make sure it is lined up so that the thumbscrew can pass through. Proud of my new jig, I used it to hold the nut to the stand. A bead on two or three of the sides of the nut should be adequate.

A note of caution: zinc fumes are hazardous. These tiny tacks will not create much in the way of fumes, but do it outside.

5. WELD BASES. The most difficult weld saved for last. The base plates are much thicker metal than the square tube that sits on it. I cranked the heat to right between E and F (E-3 to F-3) to get a little better penetration in the base plate. Angle the gun at a steeper angle to direct more heat and metal into the base plate. Four tacks, four beads, and you're done.

6. WHAT A HACK! I didn't realize that I had blown a hole in the vertical tube until it was primed. And I didn't make it around the corner! I should have filled the hole with a tiny tack weld, but instead, I will live with the humiliation.



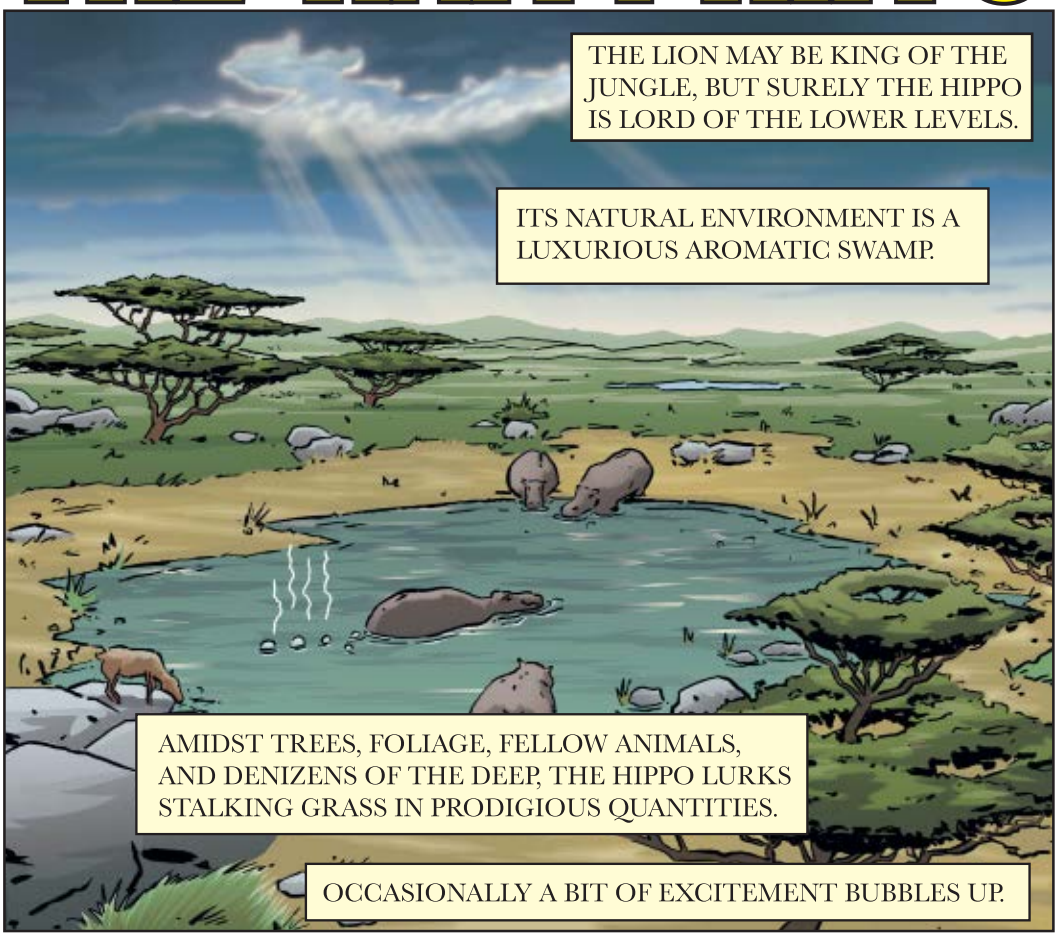
There are no perfect welders. Just welders who are better at fixing their mistakes.

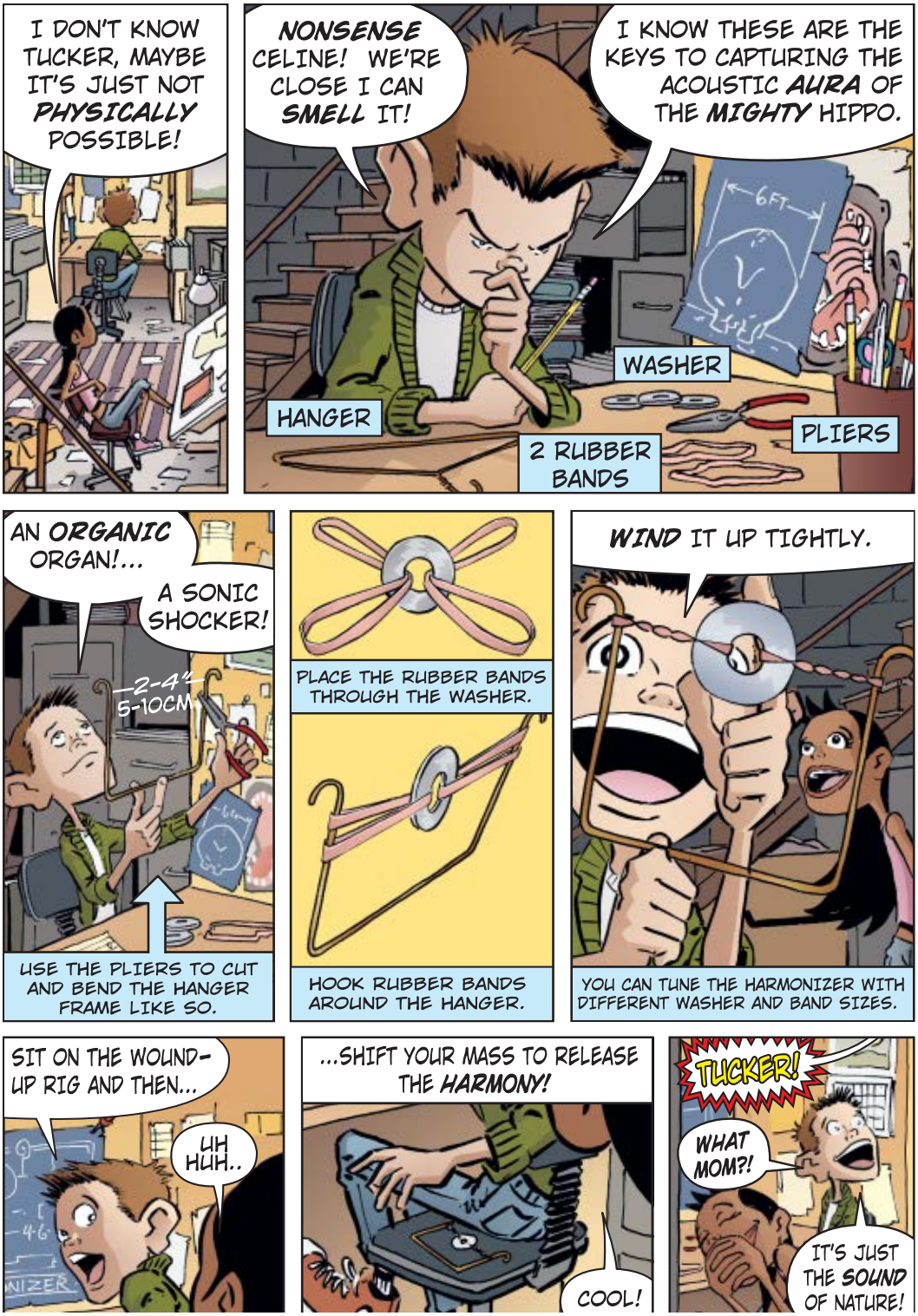
7. DONE! My color choice was the mercilessly fast, black/gold made famous by the Smokey Yunick racecars and the Hurst "Hemi Under Glass" experimental wheelstanders. These stands look like they are going about 200 miles an hour!

HOWTOONS.COM

BY SAUL GRIFFITH, NICK DRAGOTTA & JOOST BONSEN '05
THANKS TO THE KING OF WIND, ROSS GRIFFITH

THE HAPPY HIPPO





From the forthcoming book *HOWTOONS Book 1* by Saul Griffith, Nick Dragotta, and Joost Bonsen. Published by arrangement with ReganBooks, an imprint of HarperCollins Publishers, Inc.

The best tools, software, gadgets, books, magazines, and websites.

TOOLBOX

1. **Access to audio out jack**
2. **Screen protector**
3. **Access to touch functions**
4. **Syncs and charges through travel cable**

Security for Your iPod

iVod case for iPod
$80 and up, vajacases.com

My name is Jason, and I’m an addict. I’m hooked on Argentine leather, quality craftsmanship, and amazing electronics cases.

Years ago, when I bought a Handspring Visor Deluxe, I searched for a case that would be both useful and protective. I was working in a technology position and had to look up dozens of passwords and project details on a moment’s notice. The Vaja Visor case was perfect for holding the info. It had a great belt clip, screen protection, and good padding, as well as slots for ID and credit cards, so it doubled as a wallet.

Happy with my Visor case, I bought a Vaja cellphone case. It, too, is made of the same incredible leather as the Visor case, with protection on the corners in case of drops and padding on the front to protect it from hitting something as I walk.

When I bought an iPod I went straight to Vaja. The iVod case was perfect for my needs: screen protection, security for the iPod, and an incredibly strong belt clip.

— Jason Griffey

website

A Better URL Shortener

Metamark
metamark.net

I'm writing about Metamark for purely selfish reasons: I don't want anyone to ever send me a long URL again. I know it's only a few seconds of my time, but it is a true, chronic pain in my center of Zen to have to cut and paste those interminable strings of characters into the browser in two rounds. The shortened URL tag doesn't break in emails, and, as long as someone uses it every couple of years, will be a permanent shortcut. While there are other shortening services (tinyurl, snipurl, makeashorterlink, etc.), which Metamark humbly even links to on their "about" page, Metamark allows you to assign a nickname to your shortened URL, so it's easier to remember and keep track of. Plus, I like the name of the service: it addresses the larger issue here, which is as much about the metaphorical, metaphysical, metamorphosing reality of the internet as it is about the saving of my time. It's a sort of beautiful way to remind you that the internet really is just a huge system for calling things by other names, and I love it.

— Arwen O'Reilly

One-Stop Bot Part Shopping

Robot Builder's Sourcebook, by Gordon McComb
$25, ISBN 0071406859, McGraw-Hill/TAB Electronics

Every techie subculture has its chief instigator. For hobby roboticists, that guy is Gordon McComb. In 1987, McComb published *Robot Builder's Bonanza* (TAB), the first serious book to tackle do-it-yourself robotics projects. The book was rough around the edges, but it was a start, as it sent many budding hardware hackers into their garages to cannibalize the old family mower. Things have come a long way in the field of garage robotics since then, a fact reflected in one of McComb's more recent efforts, *Robot Builder's Sourcebook*. McComb is an obsessive networker and resource collector, and it shows in the hefty 711 pages of this book. Every component one might imagine needing for robot building, from literal nuts and bolts to plastic and metal stock to sensors, motors, and microcontrollers are covered in over 2500 listings. The book also includes some 250 sidebar articles with introductions to robotic systems, tips on choosing various components, how to find the best parts deals, and robot construction tips. If you are not a robot enthusiast, don't be put off by the title. This directory deserves a home on the workbench of any maker who tinkers with electromechanical systems.

— Gareth Branwyn

Digital Photo Vault

Epson P-2000 Multimedia Storage Viewer
$500, epson.com

I have a Canon EOS 20D digital SLR that I carry around on my trips. Since I save in the RAW format (6 MB+ per photo), I need a good hard-drive-based wallet that I can use to offload images on long trips. There's a Belkin iPod connector that isn't practical since it drains the iPod battery dead and takes forever to sync. There are also other digital wallets and media players that take CF cards, but the Epson P-2000 digital media wallet, with a speedy USB 2.0 connection, is the best I've tried. On a two-week trip to Brazil last month, I used it to hold over 2000 RAW images on its 40 MB drive. It performed superbly with more than half the drive left; the unit holds up to a full day of usage. You can transfer over 10 gigabytes of images before reaching for that A/C adapter at the end of the day. The 640x480, 3.8-inch screen is amazing, and so is the battery life.

— Joe Fung

Keep Your Money Like a Cabby

Taxi Wallet
$50, Hammacher Schlemmer plans to discontinue, but you can find one on eBay

Like so many hipster throwbacks these days, the compact taxi wallet arrives with a backstory. This unit was the supposed preference of cab drivers in the 30s, because it's slim, roomy, and can snap onto your belt. Now, why you'd ever want to wear your wallet on your belt escapes me, but those depression-era taxi guys were probably a pretty colorful bunch.

This cowhide wallet has a very lightweight bi-fold design with rounded edges and includes a snap-open accordion pocket on the front for change or credit cards. A middle pocket behind that can be used to slide in a driver's license and ATM card (just like in the 30s!). Another snap opens the inside where two billfold areas allow you to separate currencies or just keep your receipts sequestered from your cash.

I love this wallet because it's light, durable, and very small, yet oddly expandable when you need it to be. Unlike the massive George Costanza models that some folks love ("a filing cabinet under half of your ass"), this little guy encourages you to do more with less. It slips easily into even a front jeans pocket, and the rounded edges make it easy on your pants.

Doesn't make me want to drive a taxi necessarily, but my ass sure is grateful for the symmetry.

— Merlin Mann

Outsmart the Idiot Light

AutoTap
$180, autotap.com

The "check engine" light on our car has come on a few times, and I've always wondered what exactly was going on — and why I had to pay a mechanic $75 to turn it off.

Turns out that most cars made after 1996 have a special port called the OBDII interface (On Board Diagnostics, level 2). This is what the mechanics plug their scanners into when you bring your car in, and it's the same port the $180 AutoTap diagnostic scanner plugs in to.

I had no trouble using AutoTap. I installed the software on my laptop (there's a Palm version, too), and plugged it in. It revealed plenty of hidden data: AC system, Aux input, catalyst, ECT, EGR, engine load and speed, fuel systems, timing, 02 sensors, throttle and vehicle speed, and so on.

If your car currently has a problem, AutoTap will display Diagnostic Trouble Code (DTC) and what it means.

Depending on your car's make and model, you can pay another $100 to access "enhanced" parameters for even more data.

I used AutoTap with a Tablet PC mounted on the dash. While I drove, AutoTap logged real-time data. The AutoTap software let me configure all types of "virtual instrumentation" to display.

AutoTap does also clear the "check engine" light. There's no sense in paying the mechanic $75 to do that if you've already fixed the problem that set it off in the first place.

— Phillip Torrone

High-Powered Pocket PC Phone

HP h6315 iPAQ
$600, shopping.hp.com

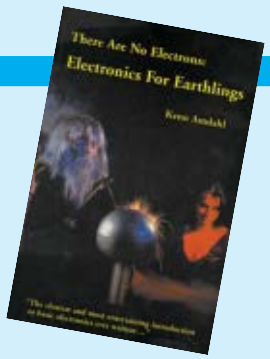
When I activated my HP h6315 iPAQ, I felt as though I were holding the sum of all digital communication in my hand. The stats on this new iPAQ model are staggering. Integrated quad-band GPRS mobile phone, 802.11b Wi-Fi, Bluetooth, 640x480 resolution camera, and an SD-MMC slot — in a package only slightly larger than most other Pocket PCs — make this one of the pinnacles of the mobile computing world. Battery life is also more than adequate, especially when throttling the use of Wi-Fi by manually disabling it when not in use. Prior to this device, I carried a cellphone, digital camera, MP3 player, and an older generation iPAQ, all contained in my Dockers "Mobile Pant" garment, and held up by a tight belt to prevent any accidental indecencies from occurring. Now I can ditch the pants and the belt, and carry around all those gadgets in a single device, in a single pocket.

— Mike Riley

ELECTRONICS FOR EARTHLINGS

High-Voltage Reading

There Are No Electrons: Electronics for Earthlings, by Kenn Amdahl
$12.95, ISBN: 0962781592, Clearwater Publishing



I have a confession to make: I'm not a REAL geek. At least, I'm not if you have to have the mind of a mathematician, logician, and engineer to be a geek. I'm more of your arty-farty type; I'm a writer first, a geek wannabe second. I'm obsessively visual and have a hard time understanding concepts that aren't graphical or story-driven in nature. Give me the stats on something and I'll tilt my head like a dog hearing a high pitch; show me a handsome chart of the same information, or give me a workable analogy, and I'll never forget it. Given this "handicap," I wish I'd had Kenn Amdahl's book *There Are No Electrons: Electronics for Earthlings* when I was first learning elementary electronics.

There Are No Electrons teaches its often intimidating subject matter through storytelling — really funny, bizarre, memorable storytelling. You'll enjoy this book as a hilarious read as well as an electronics primer.

You'll also wonder if Mr. Amdahl has been properly ventilating his workspace. This is trippy-ass stuff. Right from the start, Amdahl asks you to throw out everything you think you know about electronics — a grand, dark conspiracy perpetuated by engineers and high school science teachers — and embrace the truth, which is that horny, partying gremlin-like beasties called Greenies are what make electricity happen. The male Greenies (a.k.a. electrons) love to party, and they'll do anything to connect up with the female Greenies (protons). All the basic components in an electronic circuit are explained through this fractured fairytale of the male Greenies and their unquenchable thirst to party. Along the way, we learn such eye-openers as the fact that magnetic lines of force are actually caused by Bruce, a fast-swimming Greenie duck (and millions of his kind); that heat in a circuit is caused by Greenies getting pissed off at being forced to move through tight spaces; and that there's a relationship between capacitance and lutefisk (sorta). We also learn that almost all electronics pioneers were Norwegian: George Simon Ohm's real name? Lars Thorvillson.

Okay, so some of *There Are No Electrons* is just plain inane, but I guarantee that, if you read it, you'll never look at a circuit the same way again.

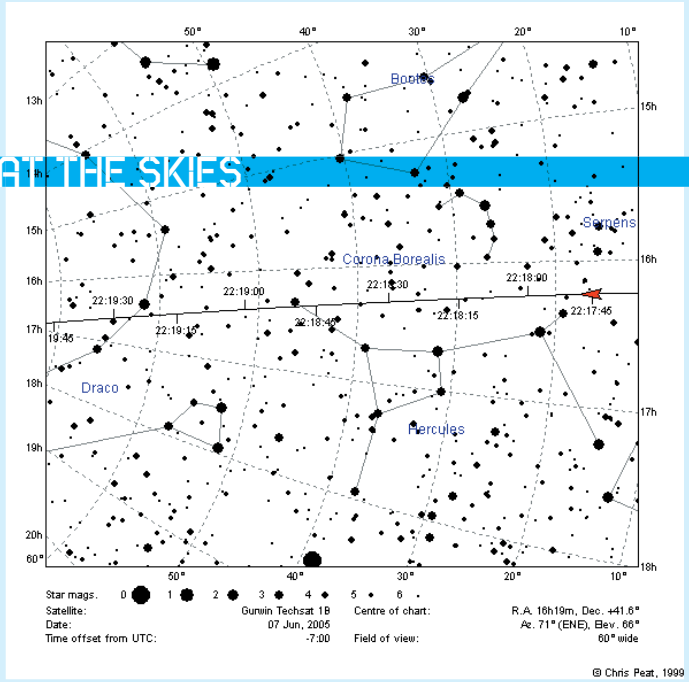
— Gareth Branwyn

What's Up?

heavens-above.com

Have you ever looked up in the night sky and wondered if that was a satellite you just saw?

I recently stumbled upon a website that did more for my budding interest in artificial satellites than several trips to the planetarium. Heavens-above.com gives the time and sky position of Iridium satellites, amateur radio satellites, the Hubble telescope, and other orbiting gadgets that reflect the sun's rays as they streak across the sky above your house. And it's easy to use. Start by entering your latitude and longitude from one of many map sites (I used the Tiger Map Server: *census.gov/cgi-bin/gazetteer/*) and sign up.



Each time you log in, you can peruse a long list of upcoming fly-bys, illustrated with beautifully minimal maps, definitions of terms, and links to the various space agencies and military bases that launched these things. I was surprised when I climbed onto my roof at exactly 20:00:42 to witness the brief but brilliant flash of Iridium 31, just as predicted. Now that's cool.

— David Albertson

(with thanks to Kurt Clement)

+ Stargazing Via the Web

Slooh

$8/month, slooh.com

It was a dark and stormy night. At least it was in New Jersey, but over the Canary Islands off the northwestern coast of Africa, it was a nice, clear, dark night. Perfect for an evening of stargazing, so I turned to slooh.com.

This is a relatively new website that allows stargazers to access live images from 14-inch-diameter telescopes perched 8,000 feet up on Mount Teide. Far from the light pollution of city lights and blessed with stable weather, it is an ideal site for astronomical observatories. To boot, one can do an entire night of observing from 2:00 p.m. to 2:00 a.m. Eastern Time, due to the time difference between here and the Canary Islands.

All one needs to participate is a computer, a web browser and either dialup or broadband access to the internet. Beginners will enjoy the "Group Missions" offered by the company. These are like peering over the shoulder of an astronomer while he or she is observing. You can see a live image from a digital camera attached to the telescope. Slowly as the camera collects more light and switches to different filters, you can see the image build up. After 5 to 10 minutes, the result is a nice color picture of a planet, galaxy, star cluster, or other celestial object. Along the way, you can even take "snapshots" of the object and download them later. Although you can't control the telescope, you can pan around and zoom into the images, switch to a high-magnification view or "All Sky" camera to see where the telescope is pointing. The interface features "Storytellers," which are audio clips that describe each object. Live narration during missions is offered, and you can listen to sounds in the observatory as the telescope moves around the sky. There's also a chat room where you can ask questions about astronomy.

For advanced users, Slooh offers "Solo Missions" where one can reserve time on a second telescope that will allow you to choose from a list provided, or enter the coordinates of your favorite objects.

— Kevin Conod

+ USB Thumb Drive Fill Up

Essential applications and data to keep with you.

Rather than haul around a bunch of wasted space on your keychain drive, why not keep some useful data on there between big file transfers? For instance:

Browser: Either a standalone installation of Firefox (see MAKE, Volume 01, page 179) or at least a current copy of your bookmarks, exported from your browser as an HTML file. Add a copy of your RSS news and podcast feeds for access on the road or to share with friends.

Data: Besides the current project information that you're sure you'll need, grab a copy of all documents less than 90 days old from the "My Documents" folder on your computer. Add a PDF version of your contact list in case your PDA packs up.

Email: If you haven't converted to a web-based email service, you may want a copy of your relevant mailboxes or a critical subset of your Outlook .pst file.

Photos & Music: Interesting photos you've shot in the last few weeks, a couple from the last vacation, and some sentimental favorites can all be big hits at the office or when visiting friends. Throw in your top 20 MP3s as a boredom antidote.

Manuals: Having a PDF copy of the manuals for your cellphone, camera, and car can come in very handy on trips. (Check the relevant OEM's website for these gems.)

Software: You've probably got a list of your "go to" programs, but before dragging all those zip files over, see what you can get from the web (e.g., online virus checkers like Trend Micro's Housecall). You may be better off with just a bookmark to the relevant tool.

ID: Put a "Please Return Me To.txt" file containing your contact information in the root directory. You may get lucky.

If you've got any particularly sensitive data, consider encrypting it and keeping a copy of the decryption program (but not the password!) on the drive as well. Once you've got the drive set up to your satisfaction, copy the files back to a dedicated file folder on your PC. Then you can erase the thumbdrive if you need the space for a big file transfer, and quickly restore it when you get back to your PC.

— Bob Scott

+ Stealth Screwdrivers

Snap-On GSDDX80 Screwdriver Set
$87, snapon.com

There is something terrifically romantic about late-night border crossings with red filtered flashlights, or racing through suburban subdivisions, drifting around every corner just 100 feet ahead of helicopter searchlights.

The whimsy soon gives way to practical concerns, like what kind of shoes do you wear with a black ski mask or what if you break down, risking detection from light reflected off chrome-plated tools?

I recommend wingtips and a set of Snap-On GSDDX80 screwdrivers in the black steel industrial finish. Snap-On sells wildly expensive professional tools, but that should not keep modestly budgeted, covert agents from owning ultra-precision screwdrivers of unsurpassed durability. Fortunately, a set of 8 industrial-finish Snap-On screwdrivers is not only completely badass, it is also 41% cheaper and 1000% less reflective than the same set in chrome.

Lamentably, life is full of neglected machines, and it is impossible to apply maximum pressure while turning a screwdriver as hard as you can. The Snap-On screwdriver solves this problem with a hex nut at the top of the shaft, just below the handle. With a wrench on the hex nut, turning leverage skyrockets and you can apply maximum downward force.

Sure, the Craftsman Professional $59, 10-piece set has the same hex nut, but wouldn't you rather spend the extra couple bucks to evade capture?

— Mister Jalopy

Turn Your Wall into a Giant Post-It

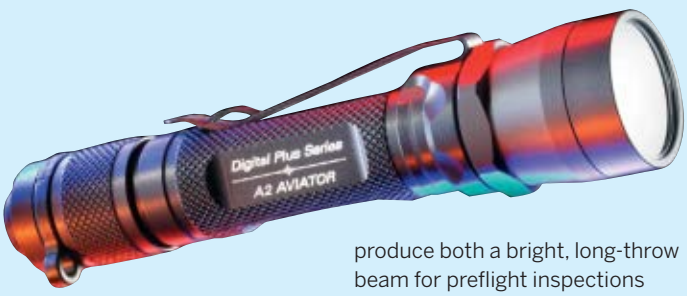
Gripping Stuff! for Cards
$9 for an 18"x24" sheet, gripping-stuff.com

Summer after my sophomore year, my friend Chris decided that he wanted to pare down his belongings until everything he owned could be visible while standing in the middle of his room. If it couldn't hang on a hook or fit on a shelf? Gone. If memory serves, this monastic phase didn't last long into junior year, but I do remember being tempted by his vision of a completely exposed and manageable physical world. Well, wherever he is now, Chris definitely needs to hear about "Gripping Stuff! for Cards."

This ingenious roll of felt-like fabric tape is just sticky enough to adhere to your wall and hold up most paper and light card items. It's marketed as a way to display rows of holiday cards, but I've invested three full rolls (that's 6 cut-up meters) in the service of a very intimidating-looking system for organizing index cards. Since the tape functions sort of like a Post-It note in reverse, you could also use Gripping Stuff! for brainstorming sessions, an office in/out board, or even to display photos and paper ephemerabilia.

It's an excellent present for the spastic index card nerd in your life.

— Merlin Mann



Bright Lights, Big Price

SureFire A2 Aviator Flashlight
$185, surefire.com

Referred to by aviators as "convenient metal tubes for storing dead batteries," flashlights are one thing most of my pilot buddies hate to fool with. They want them to light up when they need them and not to bother with them the rest of the time. SureFire's A2 is an excellent answer to that specialized problem and a surprisingly handy addition to my more ground-based existence as well.

The A2 "Aviator" is designed to produce both a bright, long-throw beam for preflight inspections and a much lower-intensity flood for general cockpit use under low light conditions. This is accomplished by a combination of three LEDs and a high-intensity bulb sharing the compact, "orange peel" finish reflector. Similar in size to a generic hardware store penlight flashlight, the A2 is constructed of machined aluminum, finished with a considerable amount of easy-to-grip knurling and coated with a rugged, grey-green, hard anodizing.

In use, the light is usually held in an "ice pick" grip with the rubber button on the end under the user's thumb. Pressing it part way in activates the low-intensity LEDs. Further pressure kicks in the 50 lumen (read "way bright") bulb. For continuous use, the tail cap can be screwed in to activate either mode without requiring button pressure. Similarly, the cap can be backed out to prevent any light activation or to just lock out the high-power bulb, to prevent accidentally ruining your night vision with an over-enthusiastic button press.

Why not use an LED for both tasks? High-power LEDs have an emitting surface several times the size of a comparable bulb, which consequently requires a larger reflector to produce an equivalently tight beam. If you want a long throw beam in a compact package, an incandescent bulb is still the best choice.

The A2 enhances its tech credentials with a unique digital power supply. This circuit provides voltage regulation to the incandescent bulb to ensure uniform light output over the life of the batteries, and it does a remarkable job.

— Bob Scott

Degrease Anything for 99 Cents

LA's Totally Awesome All Purpose Cleaner and Degreaser
$.99, 99¢ Only Stores

Los Angeles is awesome. A paradise. And I would probably use LA's Totally Awesome even if it didn't work — just to give props to my favorite city. But LA's Totally Awesome is totally awesome. Forget those petrochemical solvents that melt gloves and leave your hands poached like a boiled chicken, this 99¢ Only Store miracle works remarkably well.

In a bottle that would make Dr. Bonner proud, there are dilution ratios for everything from cleaning aircrafts to removing vomit. I am sure it is wonderful at cleaning conveyor belts at 10:1 or smoke damage at 2:1, but I believe it is at peak utility when cleaning greasy, oily, filthy mechanical parts. A 50:50 mix for warm water and LA's Totally Awesome in a coffee can is a very effective parts cleaner. Add your nuts, bolts, shackles, and cotter pins and just roll it back and forth like a front-load washing machine for a few minutes.

— Mister Jalopy

Netflix for Nerds

website

Technical Video Rental
$10/week, includes 2-way postage, technicalvideorental.com

Technical Video Rental rents VCR tapes and DVDs by mail. Hundreds of tapes and DVDs are available, and are focused on such practical and fun hobbies as woodworking, metalworking, gunsmithing, claymation, beermaking , plus many others. The tapes are all made by noted industry experts — no lightweights here. I'm an unabashed admirer and repeat renter (over a dozen to date). The service, in a nutshell, is outstanding, and the choice of videos/DVD improves every month. As a long-time woodworker, my interests have recently shifted to metalworking. Renting the machining tapes is almost as good as taking a class at the local community college. Over the last year, my skills have steadily improved, and I keep coming back for more tapes to learn more about the intricacies of using a metal lathe and mill.

— Steve Koschmann

Ultra Cheap Meter

Cen-Tech 7-Function Multi-Tester
$2 and up, harborfreight.com

By most measures, the Cen-Tech 7-Function Multi-Tester is not a groundbreaking piece of equipment. It measures AC/DC voltage and DC current. So what? Even your dad's analog sweep meter can do that. But it also has a battery checker, diode tester, and little socket for testing transistors. Handy features, but the Cen-Tech feature set is hardly revolutionary.

At the time of this writing, the Cen-Tech is available at Harbor Freight for $5. Two months ago, I paid $4 for mine and I've heard rumors of it selling for $2 on super-mega-loss leader sales. The price is revolutionary. For the price of a fancy cup of coffee, you could buy two and throw one out of the car on the freeway.

So, does it work? Sure. Works swell. I've overloaded it, dropped it, found electrical shorts, and resolved issues just like it was a Fluke. And, it costs less than a fuse for a Fluke.

The Cen-Tech is worth the price just to open it up and look at how they can build it so cheap. Instead of a ribbon cable to the LCD, there is a multi-contact rubber gizmo (1) that connects to the circuit board (2) by pressure. And forget fancy switches soldered to the board; the plastic selector knob has contacts (3) that dial in your selection on a circuit board crop circle (4).

— Mister Jalopy

MAKE LOOKS AT MATERIALS

Miniature World Materials

Plastruct Catalog
$5, plastruct.com

The next time you're watching a sci-fi flick, especially a low-budget one, and they show a miniature F/X shot, say an asteroid mining colony or a spaceship fly-by, chances are, you're actually looking at a significant portion of the Plastruct catalog. For nearly 40 years, Plastruct has been the go-to source for all types of plastic components used by hobbyists and professionals building everything from dollhouses and miniature train layouts to architectural models and art installations. Plastruct's 155-page color catalog contains over 4,000 components, from plastic stock, to scaled renderings of natural and man-made components.

— Gareth Branwyn

Gesso Simple

Gesso Priming Compound
About $12 a pint, available at art supply stores

Ever tried to use spray paint on styrofoam? The formerly pristine surface will shrink, blister, scab, and dissolve like the flesh of a blowtorch victim in a Herschel Gordon Lewis epic. Though fun to watch as far as toxic amusement goes, pigmented fissures may not be your desired result. I suppose it's the odd/visionary/unfortunate individual who is faced with a dilemma like this one, but nonetheless, when I want to put a metallic spray finish (or any otherwise non-acrylic based paint) on a styrofoam form, acrylic polymer emulsion — or gesso — is my genie in a bottle.

Used primarily as a preparation on artist's canvas, Gesso seals and stiffens the surface to which it's applied, providing a medium for paints and finishes. Two or more coats can be sanded to provide more bite, or mask the texture of the sealed surface.

— Matt Maranian

Pour It on Thick

EnviroTex Lite Pour-On Gloss Finish
$14 for a pint can, available at art supply stores

Sometimes, one layer of varnish just doesn't cut it. Depending on the project, sometimes 30 or 40 layers aren't enough either. In fact, you may find that you're the exacting sort who just isn't satisfied with anything less than 50 coats.

If 3 days of drying time and hand-brushing seems a bit daunting, rest assured that all you need is a plastic cup, a stir stick, and my favorite short cut: EnviroTex Lite Pour-On Gloss Finish.

It's traditionally used over wood to get that high-sheen-cowboy-saloon-bar-top-luster, but I've coated stone construction, plaster forms, sea grass webbing, and even (unsuccessfully) tried to make a lighting fixture by coating a blown-up colored condom. Some paper and printed matter becomes translucent when coated. Thin objects can be layered into the finish and coated again.

Whether it's a cedar wall plaque or a motorized sculpture, a finished product is always ratcheted up a notch when sealed under a coat of this reactive polymer compound — and it's waterproof, too!

— Matt Maranian

Plaster Faster

Plaster Cloth
$6.50 for a 10' roll, available at art supply stores

Once you've discovered Plaster Cloth, your creative life may never be the same. Virtually identical to the material used by doctors to encase broken limbs, the art store variety is a fine cotton mesh saturated with dry plaster. It's sold rolled, up to four feet wide, and can be cut and trimmed easily with a pair of plain scissors. Generally, the cloth is dipped in water and then formed over an armature, although my preferred method is to position the material first, and then run a sopping wet paintbrush over its surface. When cut into narrow strips, triangles, or diamond shapes, rounded forms and biomorphic contours are a cinch. The plaster begins to harden in minutes, and once it's dried, additional layers can be applied. Several layers thick, the hardened shell can be sanded, sawed, or drilled — I've even secured pieces together with bolts. The strength to the dried form is almost bulletproof.

— Matt Maranian

+ Mold It

Mix-a-Mold
$35 for 2.5 lbs., available at art supply stores

What do root canals and taxidermy have in common? In a word: alginates. Whether pressed into unwilling mouths for the replication of a rotted-out tooth or smeared over the tongue of the black bear you bagged last hunting season, alginate — a powdered derivative of algae and kelp — is a body caster's best friend.

Mix-a-Mold, available in virtually any well-stocked art supply and craft store, is the easiest-to-obtain and simplest-to-use kit on the market. Casting is a just-add-water proposition and certainly need not be limited to body parts; if an item can be submerged into the gelatin-like mixture for a couple of minutes, you can replicate and cast virtually anything. Maybe you've had a life-long dream of building your own automaton or you'd simply like to duplicate the face of a treasured tiki mug. In any case, Mix-a-Mold is your first step.

Although the molds will keep for repeated use, after 24 hours, they begin to shrink and change form, which, depending on the project, might be a plus.

Alginate is a nontoxic casting material and it's harmless to the skin, so if it was good enough for Jimmy Hendrix (the most notable subject of the celebrated groupie/artist team, The Plaster Casters of Chicago), it's good enough for you.

— Matt Maranian

Have you used something worth keeping in your toolbox? Let us know at *toolbox@makezine.com***.**

David Albertson is creative director of MAKE.
Gareth Branwyn writes about the intersection of technology and culture for *Wired* and other publications, and is a member of MAKE's Advisory Board. He is also "Cyborg-in-Chief" of *Streettech.com*.
Kevin Conod is on the Board of Directors of the Middle Atlantic Planetarium Society and writes a weekly astronomy column for *The Star-Ledger*, the largest newspaper in New Jersey.
Joe Fung is the managing director of software product development for Burgiss Group.
Jason Griffey is an aspiring academic librarian, gamer, and computer geek who currently earns his living as a web specialist for Middle Tennessee State University.
Mister Jalopy breaks the unbroken, repairs the irreparable, and explores the mechanical world at his website, *hooptyrides.com*.
Steve Koschmann is president of Fluid Forms, Inc., in Boulder, Colo.
Matt Maranian is a writer and designer who spends way too much time with toxic compounds.
Merlin Mann helps people make interesting things for the Global Interweb.
Arwen O'Reilly is MAKE's editorial assistant.
Mike Riley (*mike@mikeriley.com*) is an advanced computing professional specializing in emerging technologies and new development trends.
Bob Scott is a statistical construct of various consumer electronics marketing departments.

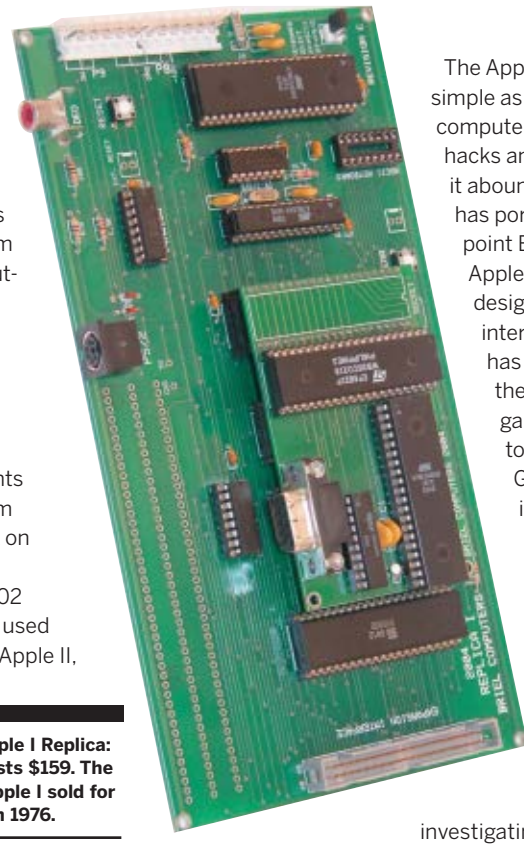
Cloning an Apple I

By Tom Owad

Many hobbyists are beginning to rediscover the appeal of classic microcomputers from the 70s and early 80s and reproductions such as Briel Computers' Replica I (based on the Apple I). The Apple I Owners Club has seen a surge in interest from hobbyists eager to tinker with computers at their fundamental level.

Briel Computers (brielcomputers.com) sells the Replica I assembled ($159), as a kit ($119), or as just the motherboard and specialized chips ($60). Alternatively, the schematic, PCB layout, and fabrication documents — enabling you to build a system from scratch — are included with my book on the subject, *Apple I Replica Creation*.

The Replica I is built around the 6502 microprocessor, the same processor used not only in the Apple I but also in the Apple II, Commodore 64, Atari 2600, and NES. The design has three parts: processor section, video section, and PS/2 interface. (The PS/2 interface is peripheral and only necessary for those who want to use a PS/2 keyboard. An ASCII keyboard works just as well and can be connected directly to the processor section.)



The Apple I Replica: The kit costs $159. The original Apple I sold for $666.66 in 1976.

The processor section is very simple. It consists of the 6502 processor, a 6821 peripheral interface adapter for controlling I/O, a 32KB RAM chip, an 8KB ROM chip, and three TTL chips. All the in/out goes through the 6821. The keyboard provides the 6821 with ASCII input, which it then passes along to the processor. To display text on the screen, the processor sends an ASCII character to the 6821. The 6821 holds the character until the video section is ready and then passes it along (as ASCII) to the video section. The Apple I had no graphics support and was even unable to edit text once it was sent to the video section. The video section served as a dumb terminal. There are hacks to redirect video output so that it goes to a printer or teletype.

The Apple I is about as simple as an 8-bit microcomputer can get, and hacks and projects for it abound. Larry Nelson has ported a floating point BASIC to the Apple I. Vince Briel designed a serial interface card and has also ported the classic 70s game of Star Trek to the platform. Grant Stockly is working on a reproduction of the cassette interface, which will allow original Apple I programs to be loaded from tape. Others are investigating the possibility of replacing the cassettes with an iPod. Joe Torzewski has scanned hundreds of early papers. Joseph Carter is looking at ways to bring graphics to the Apple I. David Cohen is using Apple I Replica Creation to teach digital electronics to his fifth grade daughter. Several enthusiasts have built custom wooden cases to house their replicas. Evan Koblentz has even connected his Replica I to an LCD and built it into a custom laptop case.

The Apple I Owners Club (applefritter.com/apple1) serves as the meeting place for retrocomputing enthusiasts. Ideas are exchanged, hardware is built, and software is written. If you're interested, I hope you'll join us.

Tom Owad (owad@applefritter.com) is a Macintosh consultant in York, Penn., and editor of Applefritter (applefritter.com). He is the author of Apple I Replica Creation *(Syngress, 2005).*

Photograph by Tom Owad

Rock On!

newer technology inc
NewerTech.com




Rock on with your iPod now that you have a High-Capacity Replacement Battery!

Get Up to Over 20 Hours of Playing Time!

Dealer & distribution inquires welcome!

NuPower™

iPod Battery Replacement Kit for iPod from **$24.95**

70% more capacity vs. original Apple batteries

Options for 1Gen, 2Gen, 3Gen, 4Gen, Photos, and minis!

Christopher Breen of Playlist Magazine had this to say about his 2100mAh NewerTech High-Capacity iPod Battery, "*I've yet to find a $40 accessory that adds as much value...*"

WIRED NEWS ExtremeiPod

A highly recommended

MacUser

playlist

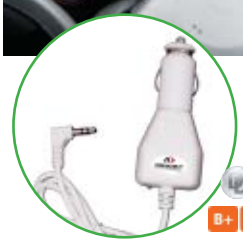
Or take your iPod on the road.

RoadTrip!+™

NEW FM Transmitter + iPod Charger **$27.95**
For iPod mini, 3rd Gen, 4th Gen, and Photo Models. Charges and broadcasts clean and clear – all in one.

RoadTrip!™

FM Transmitter **$14.95**
For any iPod or music player - Listen to your music through your car's FM radio. Choose either the 87.9MHz or the 107.7MHz version! (not a power adapter or iPod charger)



B+ highly recommended

MAKEZINE.COM

Makezine.com is the companion website for MAKE magazine. Gadgeteer and hacker Phil Torrone blogs daily on the site, pointing out DIY projects as well as showcasing his own how-to solutions. Torrone also produces lively podcasts and video how-to segments. You can find blogs, podcasts, and images from the home page of makezine.com.

Blog Highlights

A jet-powered backpack! A contestant on a Japanese game show gets shot over a lake with pressurized water bottles strapped to his back. It looks like they're all pressurized with bicycle pumps and then released at the same time. He goes really far and high.

Run homebrew apps on your PSP. Learn how to run emulators, games, and homebrew applications on your U.S. PlayStation Portable PSP. I cooked up a quick how-to, pictures, and screenshots as well as a video to watch on how to do all this. We're going to be able to play thousands of games and run hundreds of cool applications — all for free and all from the community of tinkerers out there looking to do more with their PSPs.

Upgrade and Unlock a Cingular GSM Treo. Here is a step-by-step guide to unlocking your Cingular Treo and making it unbranded. This will also give you the option of choosing another GSM provider.

See

The MAKE Flickr photo pool has hundreds of members, and you can see what we're reviewing, hacking, and tweaking. Anyone can join and post their photos, too. To join the MAKE Flickr photo pool, visit flickr.com/groups/make. If you don't have a free Flickr account, sign up and join the group. Usually, it's a good idea to "tag" your photos with the project you're building, and then add them to the group pool from your photo page.

"Part of the social goo that holds all our online efforts comes from the magic of tagging," writes Torrone. "When I uploaded a photo to our Flickr group pool of a new biodiesel pump in Seattle, Wash., I tagged it 'biodiesel.' Little did I know that Rob Elam, the cofounder of the company that distributes the fuel, would discover my photos on Flickr and ping me. Within a day, we had scheduled a conversation and recorded it via Skype."

Be sure to check out makezine.com; we'll have multimedia content along with extras that compliment the magazine.

An image uploaded to MAKE's Flickr group

Hear

MAKE: Audio is a weekly interview and audio series, available as podcasts. Download them or subscribe with a podcast fetcher. Recent guests included Josh Paul, author of *Digital Video Hacks*, and Christian Einfeldt from DIYParts.org, who talks about keeping computer hardware out of landfills. Torrone also talks with his wife, Beth Goza, about the Lexus RX400, a hybrid SUV, which gets 600 miles a tank.

MAKER'S CORNER

San Francisco Bay Area Maker Faire (November 2005): Join your fellow makers at the first Maker Faire, scheduled for the San Francisco Bay Area on the weekend of November 12 and 13 at the San Mateo Fairgrounds in San Mateo, Calif.

Like a science fair, the Maker Faire will have lots of DIY tech projects from the magazine and elsewhere. It will be a celebration of makers of all kinds and a great opportunity to learn and explore your interests. We're still cooking up the program, so find the details about the event at makezine.com/faire. Grab a neighbor, a kid or two, and a teacher from your local school, and make your way to the Bay Area Maker Faire for two days of hands-on project ideas, inspiration, and fun.

Questions and Comments

How can I subscribe to MAKE?

1. Visit makezine.com and click "Subscribe" to fill out the web order form.

2. Visit amazon.com, where you can subscribe to MAKE as well as purchase a single copy of any issue.

3. Call 866-289-8847 (U.S. + Canada) or 818-487-2037 (all other countries) between the hours of 5 a.m. and 5 p.m. Pacific Time.

4. Grab a subscription card in this magazine, fill it out, and drop it in the mail.

Can I give a MAKE subscription as a gift? Yes, indeed. Visit makezine.com/subscribe and select the "Give the gift of MAKE" option.

Which stores carry MAKE? Can I buy older issues? Many stores, like Barnes & Noble, Borders, and Amazon carry the current volume on newsstand, and all other volumes in books. Visit makezine.com/newsstand for information about stores that we know carry MAKE.

For more information, see our FAQ at makezine.com/faq.

Free MAKE Newsletter: MAKE's weekly newsletter is a great way to stay abreast of the latest DIY tech projects that we publish on our website, as well as online extras and updates for the print magazine. To subscribe to our email list, visit makezine.com/newsletter.

MAKE's Digital Edition: With this issue, MAKE offers a digital "companion" available online to all of our current MAKE subscribers absolutely free. MAKE's digital companion looks just like the print version; you need only a web browser to connect to it. Go to makezine.com/digital.

MAKE AMENDS

Tom Jozwiak's name was inexplicably left out of the last volume of MAKE, even though he and his R2-D2 clone appeared in four images, including the cover, table of contents, and in the article, "R2-DIY".

On page 116 of Volume 02, in the "This Old Amp" article, step 3b incorrectly says to switch the meter to DC and then test the voltage across the dummy load. Step 3b should read:

Reconnect the capacitor, switch the meter to DC voltage, turn off the input signal, and measure across the capacitor. Ours read 74 volts (V). The voltage rating on the capacitor is 75 volts, so there is not much margin in this old amp.

On page 150 of Volume 02, in the "Hacking the C64 DTV" article, the reference to a big and small PS/2 connector and an old AT-style keyboard should be:

1. The small PS/2 connector
2. The big XT/AT connector
3. The really old XT-style keyboard

On page 183 of Volume 01, the byline was left off the article "Candid Digicamera." The author of the piece is Robert Stribley.

Photograph by Dan Goldberg

1+2+3 4-Bit Binary Card Sorter

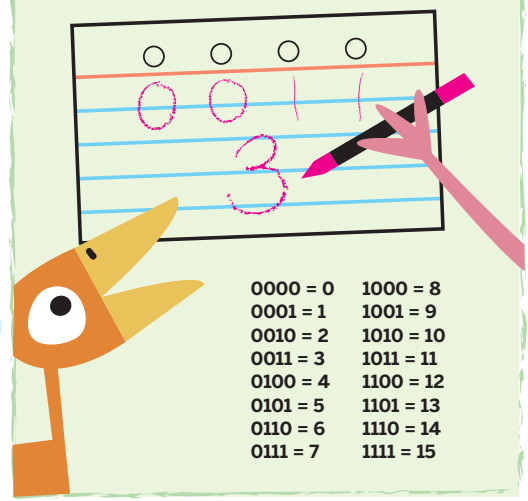
By Nigel Hall

Purpose: To demonstrate a 4-bit binary sort using a chopstick and 16 3"x5" index cards.

You will need: 16 index cards, chopstick, scissors, holepunch, pen, and ruler.

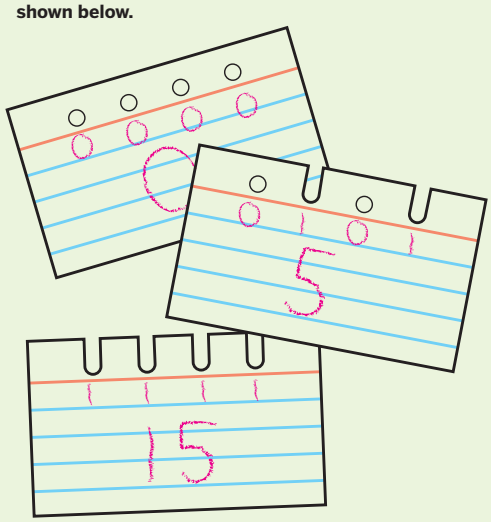
Punch 4 holes in each card, 1" from the edge and 1" apart along the top of the cards. Make sure your holes line up when you stack the cards.

Number each card from 0 to 15. Write the binary value below each hole, as shown. The values of the holes proceed from 8, at left to 4, 2, and 1, at right.



0000 = 0	1000 = 8
0001 = 1	1001 = 9
0010 = 2	1010 = 10
0011 = 3	1011 = 11
0100 = 4	1100 = 12
0101 = 5	1101 = 13
0110 = 6	1110 = 14
0111 = 7	1111 = 15

Now take a pair of scissors and for every punch hole that represents a binary 1, cut it open so the hole becomes a slot. The cards for 0, 5, and 15 are shown below.



Shuffle the cards. Starting with the right hole moving left, insert chopstick, lift out cards, and place lifted cards in front of pack. Repeat until done with left hole farthest left.

Cards will now be sorted from 0 at front to 15 in back.

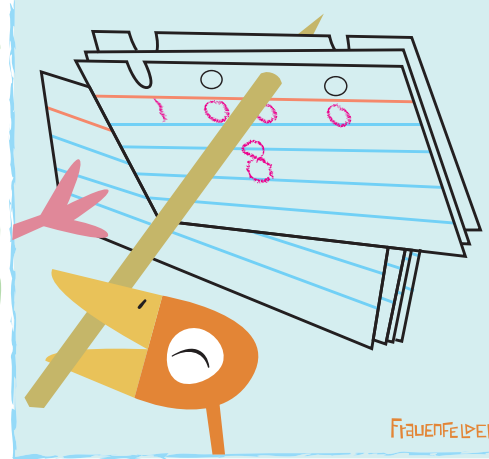


Illustration by Mark Frauenfelder

MakeShift

By William Lidwell

The Scenario: A commercial real estate mogul wants to put a life-size sculpture of a cow made to look like Superman atop a tower crane at his latest development. A local artist fabricated the bovine. However, the engineers she has contacted to design a mounting solution are scared to touch the problem for under $50,000. Here is why: the cow needs to stand proud on a 40-story tower crane throughout summer and fall in a city that is at high risk for hurricanes. You boast that you could do it for $20.

The Challenge: Create a makeshift solution to securely mount Super Cow on top of the tower crane (no details about where "on top" were given). The cow is a shell structure made of ½" fiberglass and weighs 100 lbs. Tools and materials at your disposal include materials that can be reasonably extracted from the environment and items on the supply list. Once you deliver your solution, the site crew will get everything where you want it using another crane.

Supply List:

- **1 life-size fiberglass cow**
- **1 roll of chicken wire**
- **2 rolls of duct tape**
- **6 1-liter bottles of cola**
- **$20 budget**
- **Surplus of cardboard boxes and packing peanuts**
- **Variety of tools (drills, saws, etc.)**
- **Simple welding and woodworking equipment**

Send a detailed description of your MakeShift solution with sketches and/or photos to makeshift@make.com by Sept. 30. 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 a MAKE T-shirt and a SWISSMEMORY™ USB Victorinox 512MB. Think positive and include your shirt size and contact information with your description. Good luck! For winners' names plus 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*.

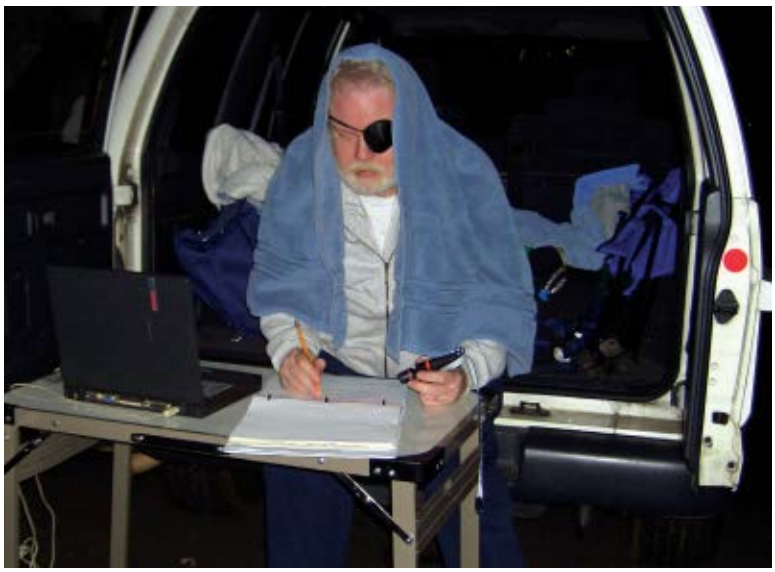
Photography by Jill Butler


MAKE

HACKS

Cover Up to See in the Dark

By Robert Bruce Thompson and Barbara Fritchman Thompson



Amateur astronomer Robert Bruce Thompson protects his night vision.

Photograph by Barbara Fritchman Thompson

Our eyes function in two entirely different modes, depending on how much light is available. In daylight or bright artificial light, our eyes function in day-vision mode. After dark, our eyes shift to night-vision mode. The physiological changes that occur in our eyes during the shift from day vision to night vision are called dark adaptation. Dark adaptation occurs slowly, typically requiring 25 minutes for 80% adaptation and 60 minutes for 100% adaptation. That's why astronomers get upset when someone shows a bright light.

Night vision is all-important when you observe Deep Space Objects (DSOs). For those fortunate enough to have access to a truly dark observing site, it's not difficult to preserve night vision using standard methods — red LED flashlight, covering your computer screen with red film, and so on. But for many astronomers, the only sites within easy driving distance are, at best, semi-dark. The problem with these sites is often not so much general light pollution as local light pollution — the presence of streetlights and other nearby bright light sources.

For example, our regular "dark" observing site routinely offers mag 5.5+ skies, and on good nights mag 6.0 or better. In terms of general light pollution, that's a respectable DSO observing site, at least by eastern U.S. standards. Unfortunately, there are half a dozen mercury-vapor lights within a few hundred yards of the site. Their combined light makes it impossible to become fully dark adapted. Because the site is on private property, it is impossible to install permanent screens against the local light pollution. Portable screens are impractical for various reasons.

Fortunately, there is a cheap, easy solution to such local light pollution problems, as long as you don't mind looking like a complete idiot. All you need is an old towel and a pirate's eye patch. The photograph shows Robert working at the chart table, looking like an idiot, but with his night vision intact.

Dark adaptation occurs individually for each eye. That means you can keep one eye completely dark-adapted by covering it with the eye patch whenever you are not using it to look through the eyepiece. The other eye is never fully dark-adapted, but that doesn't matter. You use it for other purposes, such as locating objects with your computer or charts, or recording observations on your log sheet. Robert sometimes uses his "regular" eye to locate objects in the finder, for which full dark adaptation is less important.

As you prepare to observe an object, position the towel to screen your face and the eyepiece from local light sources and slide the eye patch out of the way. When you finish observing the object, cover your dark-adapted eye with the eye patch before you remove the towel. At particularly bright sites, you may need to use the same procedure when you use the finder.

Excerpted from *Astronomy Hacks* by Robert Bruce Thompson and Barbara Fritchman Thompson (O'Reilly Media, Inc., 2005)

Photograph by Mike Thomas

EXTREME Hack-O-Lanterns

By Arwen O'Reilly

Pumpkin-carving websites are usually family friendly, but a few take pumpkin carving to the extreme. Probably the funniest one out there is extremepumpkins.com, which proffers advice for avoiding the tedium of classic carving.

Wielding jigsaws, routers, Sawzalls, and the like, Tom Nardone and his buddies hack their way through literally dozens of pumpkins. The site includes sections like "Power Tools" and "Fire, Light, and Pyrotechnics," which advise such things as "What a Regular Person Would Use. Why You Shouldn't" and "Road Flares. Awesome." This site will give you all the resources you need to hack up, blow up, and light up your pumpkin. He also has tips on preserving your jack-o-lantern, his favorite roasted pumpkin seed recipe, and an amazing gallery of images from his popular pumpkin carving contest (check out the Balinese pumpkin for a little global perspective).

Other websites add to the mix by suggesting linoleum tools for surface detail, handsaws, and different Dremel tool tips to use. Everyone has a different opinion on his or her favorite tool, but most agree that since pumpkins are 90% water, torching is nearly impossible. *Extreme Pumpkin Carving* (Fox Chapel Publishing) is also the title of a recent book by Vic Hood, an authority on historical restoration, and Jack Williams, a woodcarving expert. These guys disdain power tools (you sacrifice control), but do amazing things with everything from kitchen knives to carving gouges and chisels. Think gargoyles at Notre Dame rather than foaming brains and flaming heads. The book has two step-by-step projects as well as instructions for many more, plus tips on bringing out the Renaissance craftsman in you.

And if you get hit with post-Halloween depression, there's always Funkins, a carvable styrofoam pumpkin alternative, or the world of competitive gourd carving to sustain you until next October.

For more great pumpkin-carving resources go to makezine.com/03/pumpkin**.**

Arwen O'Reilly is MAKE's editorial assistant.

READER INPUT

Where makers tell their tales and offer praise, brickbats, and swell ideas.

Spencer and I went to the Ace Hardware store ¼ mile from O'Reilly in Sebastopol to get the parts for the marshmallow gun. When we got to the counter, the clerk not only reads MAKE but had gotten the second issue before me.

There are now a lot of marshmallows scattered around the neighborhood ... and we only used half of one bag. What a wonder, really, that marshmallows were on sale: ten bags for $10. I restrained myself, and bought five bags.

I also made a compressed air "tank" out of the valve from an old bike tube and some PVC pipe and fittings, then hooked it up to a solenoid valve, but it isn't really ready for prime time. It does make an impressive sound, and shoots pretty far, but the "trigger" mechanism right now is to touch a bare wire from a 24-volt transformer to a tab on a solenoid valve ... hardly elegant. :-)

— Rich Gibson

I wanted to comment on the blessed lack of advertisements in MAKE. By my count, there are only 8 pages of ads among 192 pages in the premiere issue. That's a signal-to-noise ratio of 24:1. Phenomenal! You keep those pesky over-thick ads to a minimum, there are only a couple of those business reply cards, and you don't interrupt articles with ads — you put 'em between the articles where they belong. I truly believe that people will pay for that quality, just as they will pay for commercial-free cable and radio stations.

Thanks again, and keep up the good work. Long live MAKE!!

— Dan Wiley

Dunno whether you're into low-tech "makes," but our gang of urchins in Texas used to make canoes out of roofing tin. Fun, easy, and, for us, free.

We'd pick up discarded corrugated roofing tin, fold over and crimp the long edges to make them

less knifelike, then fold the entire piece into the shape of a canoe. We'd flatten the corrugations out of the front and rear and nail the prow and stern to 2x4 uprights. The seats were two additional 2x4s nailed across the top.

To plug leaks and nail holes, we used tar that we pried up from asphalt roadways (the sun's heat used to make tar ooze out toward the shoulders). And we'd fashion paddles out of discarded 1x6s.

I love your magazine, but please tell your art director not to run black type over dark color blocks, like brown and blue. Impossible to read.

— Mike Lamm

Yo just wanted to drop a line & say SICK magazine!! I read about it in *Wired* & picked up a copy today. I put it down just to hit up the site & subscribe. Now (maybe it's cuz I'm a *Maxim* reader) I feel like I deserve something more — a gift for taking advantage of this great offer ... I'd say maybe send me some glowsticks or somethin', but Bunnie seems to be taking care of that for me. So never mind a gift. Oh yeah, propz on the recycled paper too....

— Basefiend

LOVE THE MAGAZINE ... especially the second one with the R2SRs. I was wondering if you guys could do one on building your own microphone arm? It would go great with the podcasting. Thanks for your time. Keep up the GREAT work!

— Bob

Vol. 03, August 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.

Safety in Numbers

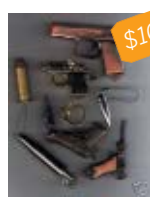
What the TSA takes away really adds up on eBay.

By Chris Smith

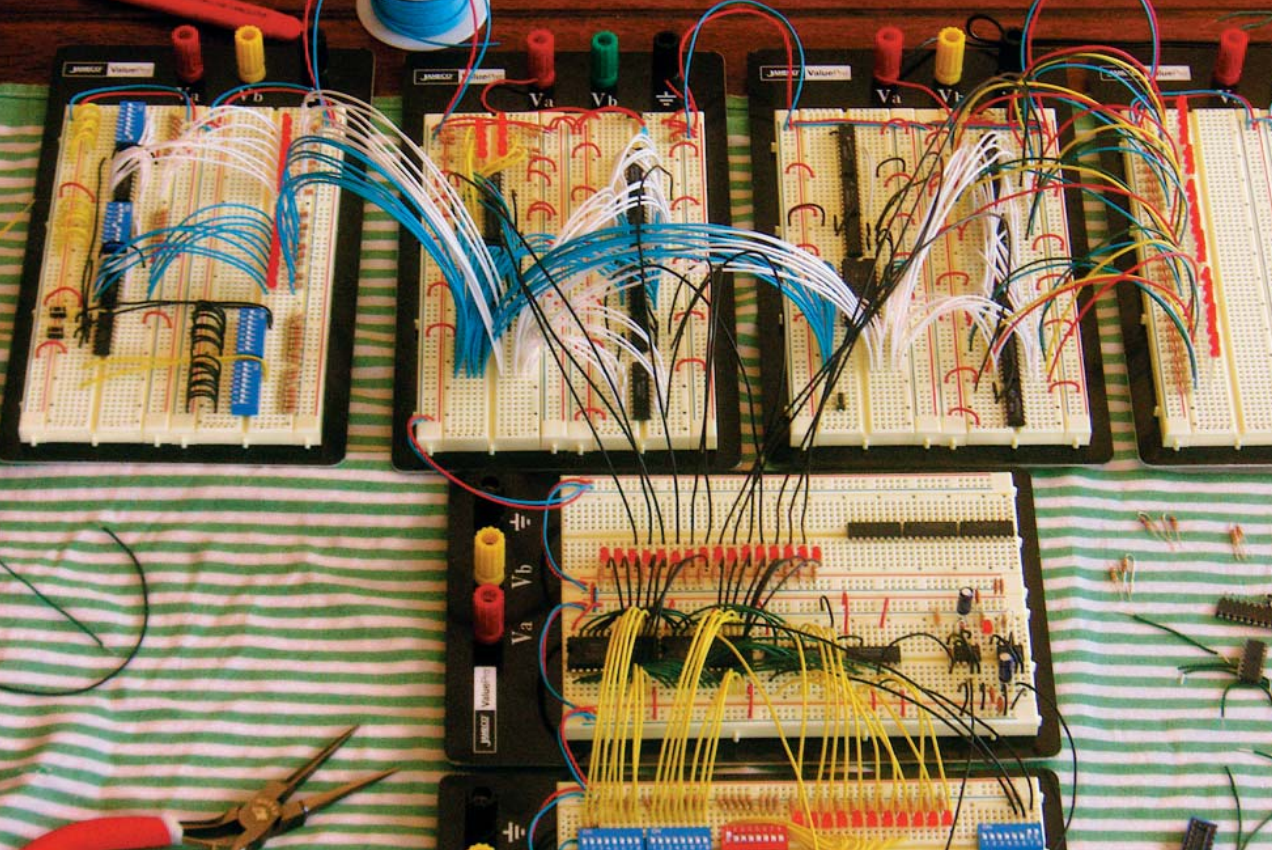
What really happens to personal items confiscated by the Transportation Security Administration (TSA)? They end up on eBay. In a three-month period (Feb-Apr 2005), $72,494 worth of goods appropriated by the TSA were sold on eBay. It's not surprising that pocket knives were confiscated more often than anything else. They were the most valuable for resale, too. Plenty of lighters, nail clippers, multi-tools, scissors, box cutters, and corkscrews were also nabbed and sold by the pound. Less obvious were hand tools, padlocks, cigar cutters, money clips, letter openers, staple guns, and kitchen utensils like cake cutters. Oddest of all: a large purple sombrero, which sold for $67.22.

	Total Sales	Number Sold	Average Price
Victorinox Knives	$19,132.00	9,654	$1.98
Swiss Style	$2,650.79	2,376	$1.12
Other Assorted Knives	$11,071.00	3,721	$2.98
Gerber, Old Timer, Buck, Wenger, etc.	$11,522.00	8,379	$1.38
Leatherman Tools	$5,354.00	520	$10.30
Other Multi-Tools	$4,769.00	1,349	$3.54
Hand Tools (pounds)	$4,750.00	2,103	$2.26
Scissors	$1,367.00	609	$2.24
Corkscrews	$1,603.00	5,009	$0.32
Lighters (pounds)	$415.00	153	$2.71

If you were one of the people who purchased these confiscated items on eBay, please don't try to bring them with you to the airport again.



- *Gun and bullet-shaped keychains: $10.50.*
- *A 5-piece BBQ set: $7.64.*
- *A studded leather bracelet and bullet-adorned leather belt: $8.*
- *A very large purple sombrero: $67.22.*



HOMEBREW

My Microprocessor

By Joe Holt

I didn't set out to build a microprocessor. It just sort of happened. We were building logic circuits in my Logic Machines course at Bennington College. Nothing complicated, just adders and flip-flops made from 70s-era TTL chips. We even wired eight big flip-flops on breadboards to make one whole byte (we estimated 16 square miles to make the memory in my PowerBook).

Over midterm weekend, I brought home parts and breadboards and spread them out on the coffee table. I'd been thinking about how a microprocessor is just a bunch of simple circuits tied together by a common interface (address and data buses) and controlled by some kind of clever sequencer. I started by building a register: a single byte of memory with eight data lines in/out and two wires to control whether it's recording or playing back. I wired up LEDs and switches to the data lines. By setting a value on the switches and pressing the record button, I could set the byte, and by pressing the play button, I could see the value on the LEDs. Amazing.

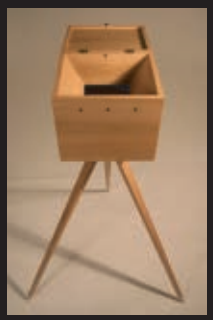
Emboldened, I built a math unit with two registers as inputs and an 8-bit adder and latch to put the sum back on the data lines. I built a program counter out of binary counters. The address bus needed somewhere to go, so I added a RAM chip. I made another register just because they're easy.

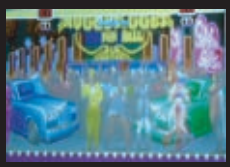
I sequenced the whole thing with more RAM, an instruction register, and a 4-bit counter. The RAM bits go to the different components' controls. By sequencing the bit patterns, I can, for example, tell the math unit to place its sum on the data bus and tell a register to record it. Another sequence can increment the program counter and load the next RAM value into the instruction register. My big insight is that a machine language instruction is just a reference to a sequence of controls, like a band leader reading notes and calling out musical chords.

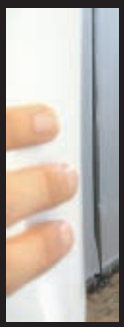
The whole project came together over the weekend. By Monday, I had a wiry bunch of breadboards that were busy figuring square roots. I think I'll add a serial interface, make a GCC back end, and port Zork.

Do you have your own Homebrew story to share? Send it to us at homebrew@makezine.com.

Photograph by Joe Holt






make anything

MAKING THINGS

www.makingthings.com/make

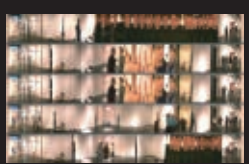
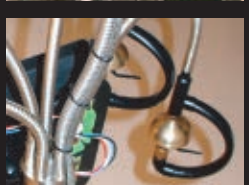
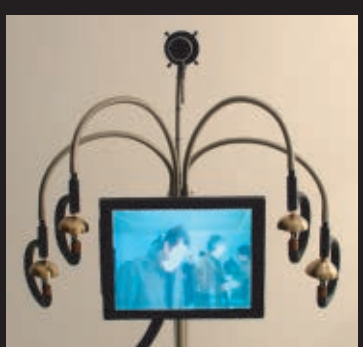
Tools and Solutions For People Who Make Things That Interact With The Real World









LEARNING TOOLS
Low cost, simple components, beginners' guides, educational material,workshops and other services

PROTOTYPING TOOLS
Broad range of hardware and software, accessories, user guides, project examples and how-to's. Compatible with Flash, Max/MSP and C/C++

COMPLETE SOLUTIONS
Full range of engineering services from quick prototyping to final products for artists, hobbyists and professionals

ISBN 0-596-10080-9

US $14.99 CAN $20.99

9 780596 100803

6 36920 10080 5