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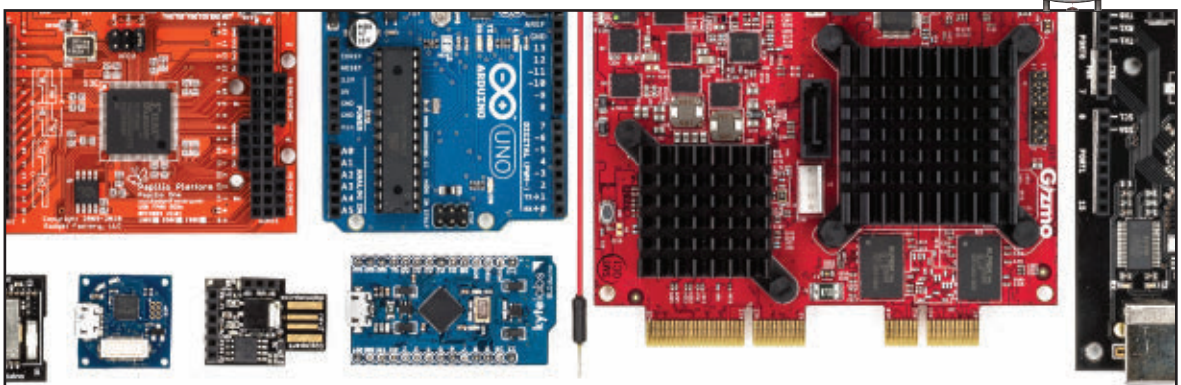

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Adapt a classic bike generator to charge your cellphone on the go.

MAKE contributing writer Alastair Bland first introduced us to this simple, effective circuit in 2009. It takes alternating current (AC) from a retro-style bike headlight generator, converts it to direct current (DC), and steps it down to a safe voltage for charging your cellphone or other mobile device while you ride.

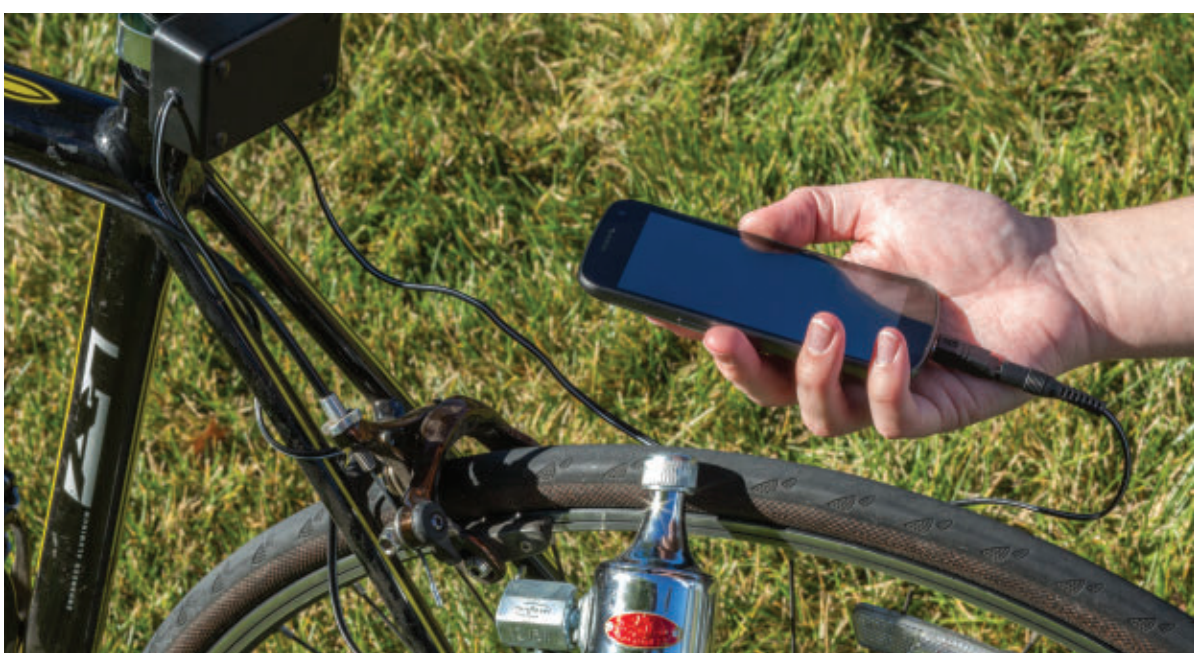
You may have one of these old "dynamo" or "bottle" generators lying around. If not, they can still be bought online and in some bike shops. Technically, this device is an alternator, a very simple, reliable generator that turns rotational momentum into AC electricity.

The charger circuit consists of a rectifier, a capacitor, and a voltage regulator. The rectifier contains four one-way electrical gates called diodes which, working together, convert the back-and-forth wiggling of the charges in AC to a series of DC charge pulses.

The large capacitor connected between the DC terminals of the rectifier smooths out the pulses, by charging up when there's more energy in the system and discharging when there's less. Finally, the voltage regulator holds the DC power down at a steady 5V, which is what most phones and other mobile devices are designed to accept. Now you're ready to pedal and charge anytime.

—Sean Michael Ragan

MAKE magazine Technical Editor



1. Drill out the box and attach the hardware.

2. Solder jumper wires and install the voltage regulator.

3. Twist the rectifier and capacitor leads together, and solder.

4. Crimp the connections and close the box.

5. Mount the box on the bike.

6. Connect the generator.

With a few parts, some quality tools, and a bit of know-how, it's easy to build this simple circuit and breathe new life into that old bottle alternator. Pump up your power supply with your pedals!

Parts list:

- 5V voltage regulator (not pictured)
- Bridge rectifier (not pictured)

Project enclosure 3"×2"×1"

Adaptaplug™ socket cable

1,000µF capacitor

Micro-USB Adaptaplug™

Ring-tongue crimp lugs

Round-head machine screw

Tools checklist:

- Drill with ¼" bit
- Mini long-nose pliers
- Gauged wire stripper/cutter
- 4-way crimping tool
- Soldering iron and solder

For complete instructions and details on this project visit:

radioshackdiy.com/pedal-power-phone-charger

radioshack™

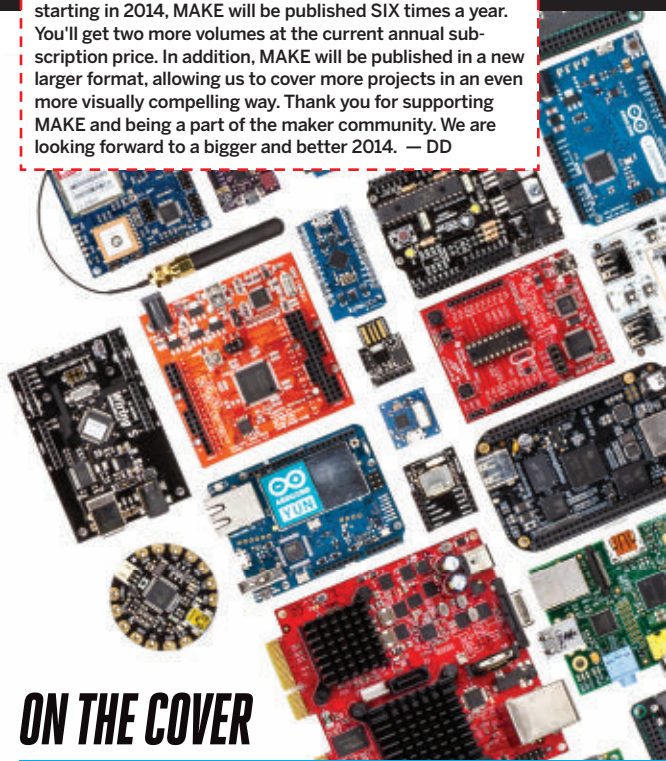
Make: Volume 36

COLUMNS

FEATURES

PUBLISHER'S NOTE - NEW IN 2014

Volume 36 completes the 9th year of MAKE magazine. Based on your feedback, we're happy to announce that starting in 2014, MAKE will be published SIX times a year. You'll get two more volumes at the current annual subscription price. In addition, MAKE will be published in a new larger format, allowing us to cover more projects in an even more visually compelling way. Thank you for supporting MAKE and being a part of the maker community. We are looking forward to a bigger and better 2014. — DD



ON THE COVER

Board Games: Loads of new microcontrollers and single-board computers vie for your attention. Photography by Gunther Kirsch **46**

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» PINOCCIO: Capitalizing on a probletunity.

PICK YOUR BRAIN

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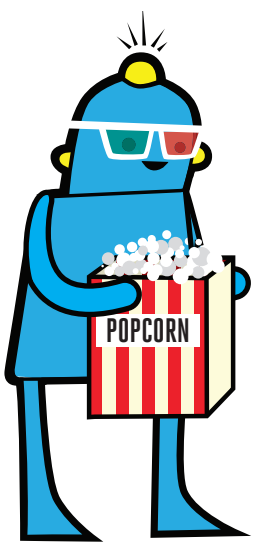
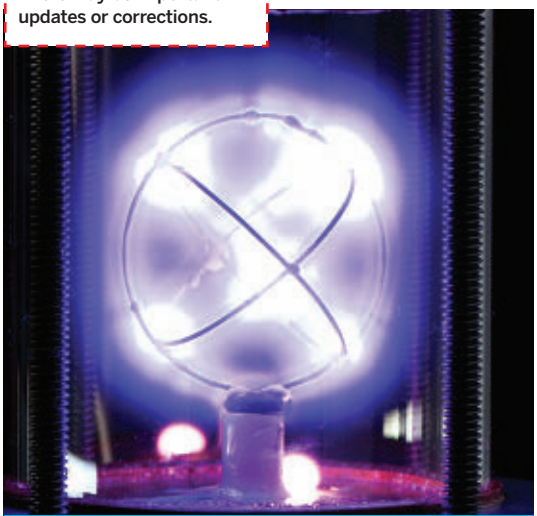
*Machine representation relative to Air Watts. Suction tested against upright market to ASTM F558 at cleaner head, dust-loaded as per IEC 60312-1.

Make: Volume 36

READ ME Always check makezine.com/36 before you get started on projects. There may be important updates or corrections.

PROJECTS





Squeezing Atoms: Build a purple-plasma particle accelerator and explore nuclear fusion on your workbench. **90**

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127
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» Feel the Fizz: Ferment a batch of grown-up juice.

"It's still magic, even if you know how it's done."
—Terry Pratchett, "A Hat Full of Sky"

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At MAKE, we're lucky enough to have some very talented engineering interns to test our projects. **Raghid Mardini** is a mechanical engineering student at University of California, Berkeley. He enjoys traveling, camping, learning about other cultures, and searching for the best sushi. His life goal is to eventually open a robotics institute in his home country, Syria, because he believes in technology's ability to change people's lives. **Kelley Benck** took the Project Make class at Analy High School in Sebastopol, Calif., and started interning last spring. She "was nervous about what sort of projects I would be asked to do, but those jitters were shaken away when I was handed the daunting Tesla Coil." She hopes to design and 3D print a model 1966 Austin Healey. **Eloy Salinas** has been taking things apart since he was 6; "I broke my first computer at 8 trying to see how the hard drive works." After a bicycling accident in 7th grade left him homebound, he started "programming and hacking everything." When not interning at MAKE, he is a freelance web developer who lives in Santa Cruz, Calif. with his yellow lab.

Albert den Haan (*Capstan Kite Winder*) started as a farm boy and studied computer science for air conditioning. He has shuttled across Canada in search of the perfect workshop to build, alternately the most complicated and the simplest things he can think of. Electro-mechanics blurs that spectrum while pulling cheap aeronautics into the practical. He likes to say, "The second one of anything is harder to build as well or as quickly as the first," so he makes each attempt another first item: different but related. Albert suffers from P.E.B.L.E.: Projects Envisioned Beyond Life Expectancy.

Taylor Levy (*Kickscooter Kickstarter*) is both "serious and smiley." She makes things in her Brooklyn, N.Y., basement with her husband, collaborator, and "partner in all things," Che-Wei, and this fall they're heading off to the MIT Media Lab. Right now they're working on a "really cool backpack that is super-close to launching"; their free time is spent working on their house. "It is mostly fun, but when it isn't, we eat ice cream," she says. Her favorite food is a green smoothie, her favorite color is fluorescent orange, and her favorite tool is a caliper.

After a long stint as a graphic designer, **Book Williams Jr.** (Boards section opener art) rented a small dark basement from a gallery, locked himself in, and experimented with paper for more than a year. He emerged with a unique, paper-crafty illustration style and scraps of card stock in his teeth. Born and raised in Chicago, he now resides in Denver with his girlfriend and wonders why mountains and camping are such a big deal. He digs comics. He digs his bone folder, and he hasn't driven a car in more than 10 years.

Sally Carson (*The Tale of Pinoccio*) is a cartoonist, a retired bike messenger, and the CEO of Pinoccio. She is a passionate bicyclist ("Bikes! Bikes! Bikes!"), and she and her husband Tommy live car-free in Ann Arbor, Mich., where they put studded tires on their bikes so they can ride through the winter. (Other bike enthusiasts can download a comic she made about fixing a flat at makezine.com/go/fixaflat.) She keeps bees, thinks about social insects and mesh networking, fixes bikes, draws comics, and feeds snacks to the chipmunk that lives under her porch.

WELCOME

By Dale Dougherty

Computers in the Mist

Carl Helmers was designing spaceships in kindergarten. He "lucked out" by learning computers in high school in New Jersey, where he eventually got a summer job programming at Bell Labs. Then, as a NASA contractor in Houston, he installed compilers and even wrote a landing program for the Apollo Lunar Module.

Computers were big, expensive machines in the '70s. At an Intel press introduction for the 4004 and 8008 microprocessors, Helmers realized he could now afford to build one from off-the-shelf parts: "A lot of guys like me who had experience working for other people with computers began building computers of our own."

Just what were these small computers good for? Hobbyists were searching for answers, so Helmers created a magazine for them called Byte. In its first issue in September 1975, Helmers wrote that for the hardware person "the fun is in the building," not using or programming. "The software is an exploration of the possibilities of the hardware." But the whole point of homebrew computers was "to come up with interesting and exotic applications." A computer experimenter was looking up at a large, unclimbed mountain with three possible ascents — the long, technical climb of hardware; the tethered, steep climb of software; and the guided, well-paced climb of applications — each of them dependent on the others and ideally converging at the peak. Nobody was sure what you'd find there.

The hobbyist revolution that Byte chronicled through the 1980s brought computers into everyday life, and our experience of computers today is largely defined by applications. Indeed, the revolution has come full circle so that networked computers have become what the mainframe once was — only now it's the cloud, and computers are hidden in the mist.

"The computer has become an appliance," said Jason Kridner, the developer of the BeagleBoard. "The machine loses relevance if it can't interact with the physical world, if it sits in the corner and just connects to the internet." Kridner remembers the computer that he had as a youth. "My mom took the floppy disks and put them in a safe, so I could hack that computer top to bottom." Like Eben Upton of Raspberry Pi, Kridner wants to bring that kind of computer back.

Kridner was an electronics hobbyist growing up, reading Forrest Mims. "Using a microcontroller to blink an LED would be the stupidest thing to do," he remarked. "I'd use a 555 timer." He started developing BeagleBone to satisfy his own goals and help out Texas Instruments as well. His target was Linux developers. "The goal was to put in their hands a platform that would allow them to do new things to advance Linux."

"I didn't know about the maker market, per se," said Kridner. "Yet when makers started picking up the board and doing crazy, fun things, the lights went off." At Maker Faire Detroit, near Kridner's home, there was a pick-and-place machine by Jeff McAlvay and a security device by Phil Polstra, each powered by BeagleBone. The OpenROV project, featured in Volume 34, also runs on BeagleBone.

In this issue, we chronicle a second hobbyist revolution that's starting small with new hardware — a growing number of credit card-sized microcontrollers and processors including Arduino, Raspberry Pi, and BeagleBone.

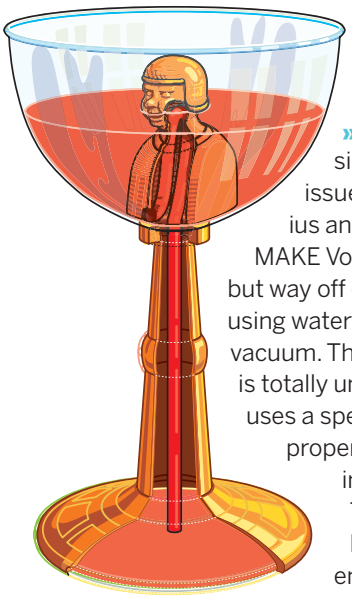
"What interests me is seeing technology connecting to everyday life, not just stuff in the cloud," Kridner said. "It's about taking away the mystery of computers and allowing people to build things out of electronics." Projects like ArduSat, an open source CubeSat satellite (see Volume 24, DIY Space), and the Earth-imaging satellites from Planet Labs demonstrate that it's possible to get above and beyond the cloud.

Dale Dougherty is founder and CEO of Maker Media.

James Burke

READER INPUT

Siphon Logic, DTV Antennas, Arduino Sound Synthesis, and Japanese Toolboxes Galore.



» Nice article on siphons in the latest issue of MAKE ("Ctesibius and the Tantalus Cup," MAKE Volume 35, page 134) but way off on science. A siphon using water will not work in a vacuum. The example you gave is totally unfair. The example uses a special fluid with extra properties not considered in a classical siphon. Take a tube 30 feet long, closed at one end. Put the open end at the bottom of a reservoir of water. Draw a vacuum in the top and the water seems to be pulled up the tube, but by what force, cohesion? No. It is pushed up by the pressure of the atmosphere. Though for the "super" fluid used in the video, cohesion works for that case; it is not correct to suppose that atmospheric pressure is not working in other cases. Bad logic and bad science. Tsk! Tsk! *—Dr. Arthur G. Schmidt, Evanston, Ill.*

MAKE TECHNICAL EDITOR SEAN RAGAN RESPONDS: Whoops! Our bad. The video Bill mentions does actually demonstrate a siphon that works under vacuum. However, it is not a water siphon; it's an ionic-liquid siphon. Ionic liquids have much stronger intermolecular attractions than other liquids, and it is likely this unusual property that makes it possible for them to siphon under vacuum. But we were wrong to infer, from that special case, that atmospheric pressure is not involved in the siphon effect with more familiar liquids like water. Thanks for writing and keeping us honest!

» Not everyone will take it the same way, but the "Water-to-Wine Cooler" project (Volume 34, page 46) could be construed as honoring (not disparaging) Jesus' first miracle, which itself had an element of humor in it (surprising a crowd).

—Michael A. Covington, Ph.D., Athens, Ga.

» A couple years ago I made your DTV coat hanger antenna (vimeo.com/2931902) — my shirts are still on the floor of my closet — but never hooked it up until last night when PBS was supposed to air the remake of Hitchcock's *The Lady Vanishes*. It worked great for picking up our public TV station about 35 miles away. Wish I had done this long before. Thanks for publishing even though the jerks at PBS sired something else during their pledge drive.

—Jock Ellis, Cumming, Ga.

» Thanks to MAKE and Jon Thompson for the "Advanced Arduino Sound Synthesis" article (Volume 35, page 80). Though I don't have much interest in sound synthesis, this was a little more in-depth than the typical Arduino article, making it more interesting. Please consider doing other more advanced Arduino articles. *—James Matthew, Sheffield, Vt.*

» I'm a professor of mechanical engineering at the University of Colorado. I really enjoyed Jon Thompson's article on using the Arduino and advanced interrupt code to synthesize waves. I like it so much that I used the article as a lab in my System Dynamics (senior level) course. Actually, it's kind of funny, I've been developing new labs for this course all summer and was at a point where I didn't quite figure out the next lab idea for the following week and then MAKE 35 landed on my door! Just in time!

—Shalom D. Ruben, Ph.D., Boulder, Colo.

EDITOR'S NOTE: Shalom shared the lab with us: makezine.com/go/lab.

Rob Nance

Richard White

Scott W. Vincent

Michael Levy

Greg Kent

EDITOR'S NOTE: Master woodworker Len Cullum's Japanese toolbox project (MAKE Volume 34, page 110) inspired a lot of readers, who shared their builds with us. Make your own at makezine.com/projects/make-34/japanese-toolbox.

» This was a great beginner's project. I didn't have a miter saw big enough to cut the 1×12, but it still worked out great. I also used red oak for my build. It cost a bit more and is heavier. Once I made the first box and did some reading and just studied the box, I was able to make the second one with my kids. The smaller one was made using only glue.

—Richard White, Bowie, Md.

» I really enjoyed this project and I'm very happy with my completed toolbox. Thank you Len for this wonderful project! Here's the information on mine: lungstruck.com/projects/japanese-toolbox. The only thing I did to make it a little more unique was chiseling my first name onto it in Japanese.

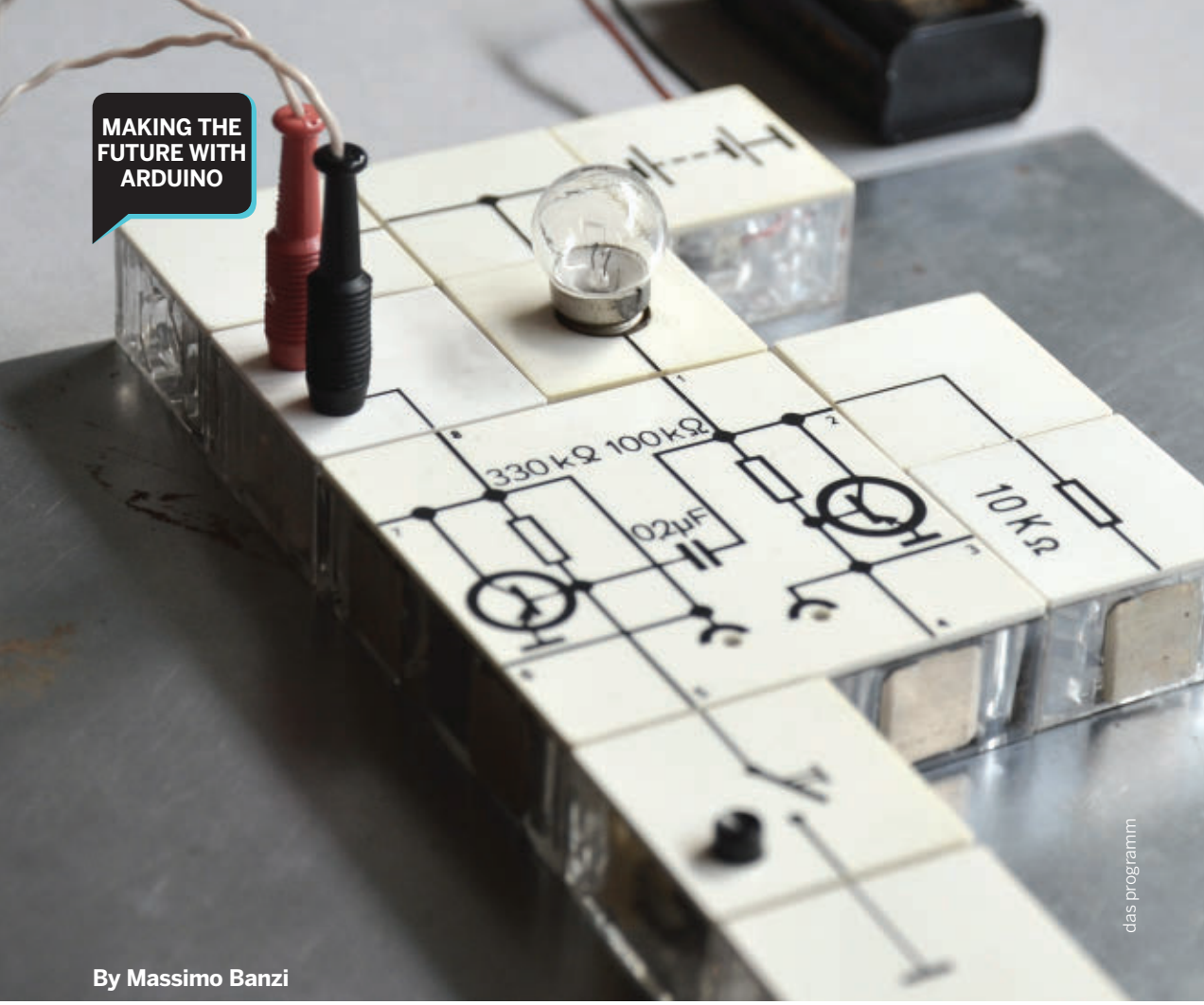
—Scott W. Vincent, Geneva, Ohio

» Really functional design. I made an 800×400×400mm toolbox for my van from a single sheet of 17mm ply. Total cost was $65 (Australian) and ~4 hours work. Much stronger than any of the sheet metal toolboxes you can buy for ~$200.

—Michael Levy, Wollongong, NSW, Australia

» I love it, my daughter loves it. Thank you MAKE! *—Greg Kent, Kailua, Hawaii*

AUTHOR LEN CULLUM RESPONDS: I can't tell you how this makes my day. Seeing that other people have been moved to make something because of an article I wrote is way more gratifying for me than the result of building it myself. Really. I am so honored that this is happening. I would happily shed my client work to get others to try woodworking/making for themselves. Thank you to everyone at MAKE for giving me the unexpected opportunity to experience this.



By Massimo Banzi

People Over MEGAHERTZ

When I was a kid I got into electronics because I started reading specialized magazines on the topic. At the same time it was hard for me to learn electronics from them because the content was not really beginner friendly and the projects were not very exciting. They were conceived more for people who were already into the technology and loved circuits than for explaining to newbies what circuits do and what you can do with them.

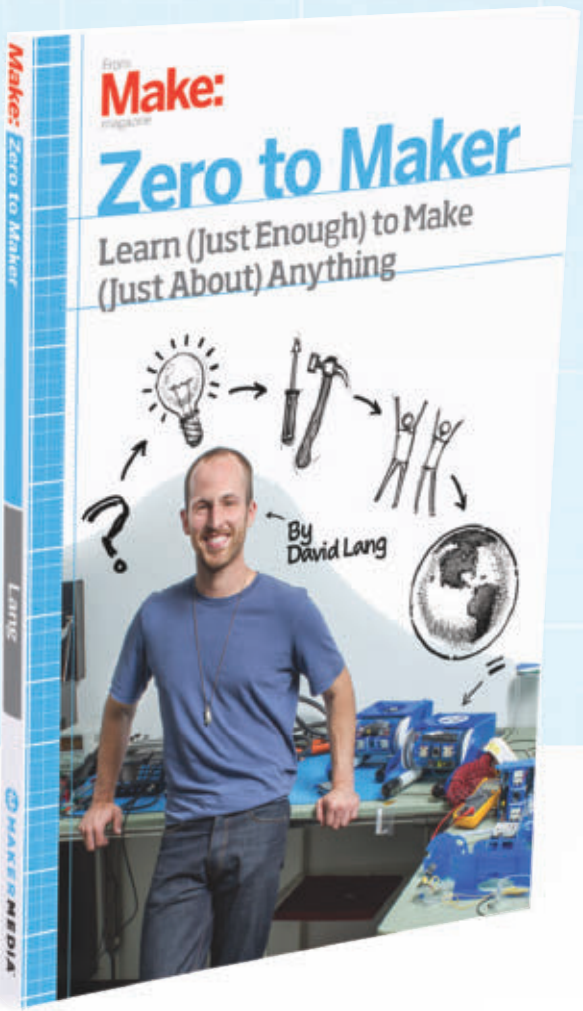
The way I really started learning electronics was when I received a kit as a present. It was called the Lectron System and was made by the German company Braun. It was composed of cubes you could snap together magnetically to build different circuits just by following some simple drawings and instructions. The cubes were transparent, so you could look inside to learn about the electronic parts.

The kit was a complete experience because it also had a book with great illustrations and simple explanations designed to look very appealing and make technology less scary through hands-on experiments. The original ad said: "Hey look, I just built a radio in two minutes" and it was actually true!

Go from Zero to Maker with David Lang!

"You don't need a research grant to be a maker. You just have to be curious about the world."

—David Lang, author, *Zero to Maker: Learn (Just Enough) to Make (Just About) Anything*



"David Lang is an inspiration to anyone who has dreamed of making, but has been hesitant to start because they feel they don't have the necessary skills. As David will show you, all it takes is curiosity, passion, and a willingness to learn from your mistakes."

—Mark Frauenfelder, Editor-in-Chief of MAKE magazine

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MAKING THE FUTURE WITH ARDUINO

Designing the User Experience

The most interesting aspect of this kit was the ability to shorten the time between starting a project and the moment you get a positive result right "out-of-the-box." Playing with it and learning from it got me into electronics and sparked my interest in design.

The kit was indicative of a design style championed by one of the most important designers of the period: Dieter Rams. He worked for Braun in the '60s and '70s and created many iconic objects (including the packaging for Lectron) and inspired a lot of contemporary Californian design.

Dieter's way of looking at design was expressed in a broader sense: He came up with a list of design principles, and many of those principles reflected the relationship of people interacting with objects and space. I think this point is very important when designing technology: We must care about the people who are using it more than the technology itself.

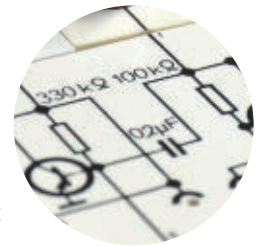
When I got my first computer in the '80s, it was the moment when people could finally afford a computer without mortgaging their home. To use it I had to punch hexadecimal numbers on a keyboard, resulting in numbers displaying on the LCD display. It was an Amico2000 (Friend2000), and it was not what I'd define as "user friendly."

My Sinclair ZX81 Basic was a great improvement. It had only 1KB of RAM, but I could do a lot of stuff with it. It was really simple and could offer a whole experience. Even when I took it apart (a habit I've had since I was a kid), the circuit gave me a feeling of simplicity from just a few components you could assemble yourself.

The book that came with it — even if you happen to read it now — offers a good way to learn the basics of the programming language by moving forward progressively toward more complex concepts.

The Birth of Arduino

Fast forward to 2002. I was teaching at IDII Design School in Ivrea, Italy, the city where Olivetti was born and a lot of the Arduino boards are still made. The school was focused on interactive design, a specific branch of design that looks at how people work and connect with technology—the idea is to not only design the shape of something but also how people will engage with that object. This is very important because you can have a nice product with a terrible interface, and the result is a less-than-beautiful user experience.



The school's students usually don't have a background in technology. They don't know how to program or to do electronics, and we only gave them two to four weeks to create physical computing projects. At that time, the tools you'd find in the market were mostly designed for engineers, with a lot of options, lots of jumpers, and lots of connectors. Students found them too complex and couldn't figure them out properly. Looking at the way we worked with students taught us a lot, and Arduino came out of that work.

Optimizing User Experience

If you look at it, you realize Arduino boards are a mashup of open technologies wrapped up in a unified user experience. From the out-of-the-box experience we want to know how long it takes you to go from zero to something that works. This is very important because it creates positive reinforcement that you are on the right path. The longer that time is, the more people you lose in the process.

I think we are all on the edge of a new step in the Maker Movement, and some of you are surely working on the next big thing. Please keep at it, but keep in mind the overall experience. You can put in a processor that is 100MHz more than another one, but the way you interact with it makes a huge difference to people. It's more important to take care of the experience people have when they learn than to give them power they don't know what to do with.

Massimo Banzi is co-founder of the Arduino project.

Pick up your Arduino Robot today at the Maker Shed (makershed.com).