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MAGAZINE

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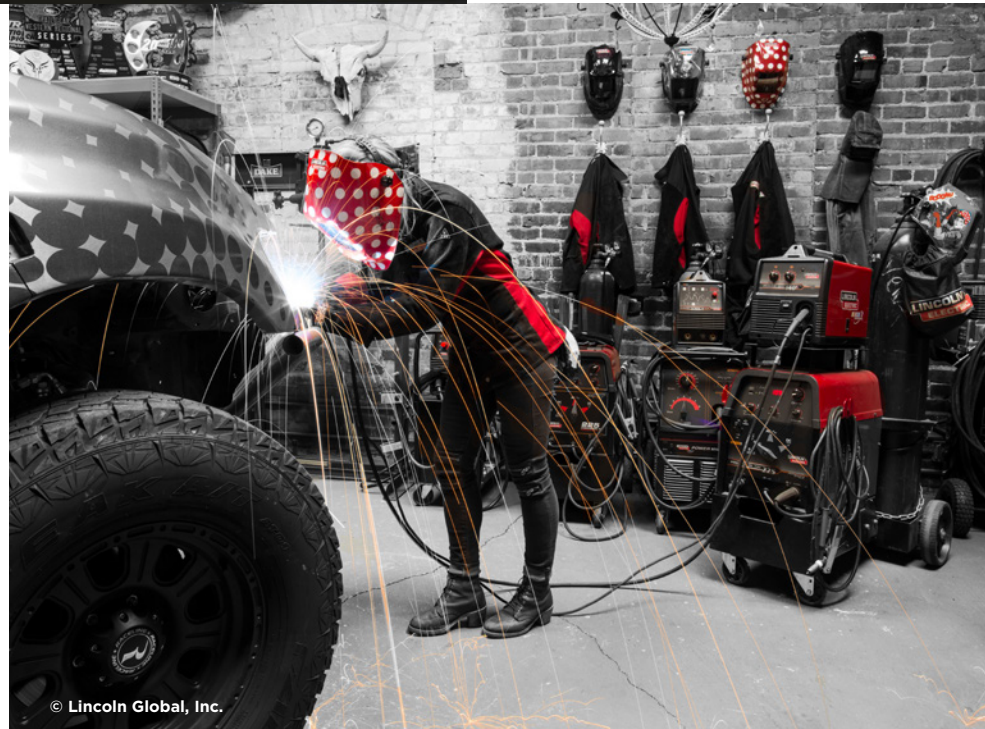
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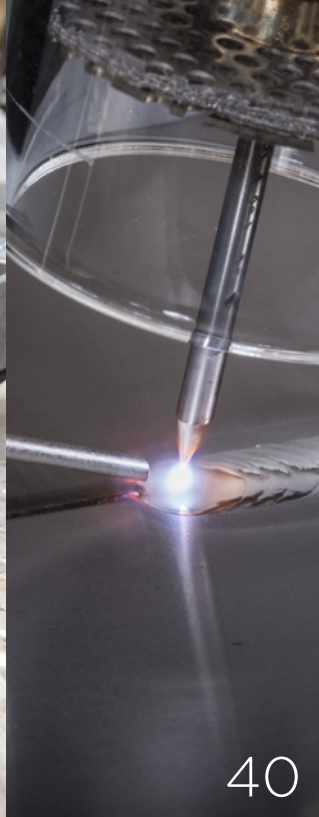
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## CONTRIBUTORS

### Publisher

Craig Coffey  
publisher@arcmagazine.pub

### Editor

John C. Bruening  
editor@arcmagazine.pub

### Associate Editor

Ken Krizner

### Art Director

Maggie Ryel  
design@arcmagazine.pub

Advertising Manager  
advertising@arcmagazine.pub

### Digital Media Manager

Rob Bruder  
apps@arcmagazine.pub

### Circulation Manager

circulation@arcmagazine.pub

### Production Manager

Erin Abed  
reprints@arcmagazine.pub


### Photography

Jenny Ogborn  
photos@arcmagazine.pub

### Designers

Travis Lefelhoc  
Karen Ludlow  
Emily Rigo  
Anthony Schneider

 facebook.com/LEArcMedia

 @LE\_ArcMedia



Kate Nicolosi **Writer**

Kate Nicolosi is a writer and communication consultant. She has worked with organizations in a variety of industries including corporate, non profit, pharmaceutical, telecom and financial services. Her work encompasses technology, banking, leadership, management and human resources. She has penned monthly features for an award-winning, internal print publication at JPMorgan Chase and reported for *The Ragan Report*, *Corporate Writer & Editor* and *Speechwriter's Newsletter*. She lives in Atlanta with her husband and three children.



Karl Hoes **Instructor**

Karl Hoes has been a welding instructor at The Lincoln Electric Company since 2003. He has taught many aspects of the welding school curriculum, including basic and advanced motorsports classes. He has trained welders and instructors at multiple welding schools and national union training programs across the country. Karl is a Certified Welding Inspector/Educator (CWI/CWE).



Jimmy DiResta **Fabricator**

Jimmy DiResta is a New York-based artist, designer, master builder and video producer. His work has been showcased on Discovery Channel, HGTV, DIY and FX, as well as YouTube. His goal is to educate and inspire people to embark on their own home projects in an entertaining way. His unique builds are comprised of many different materials and processes. With his artisan skills and a shop full of power tools, he lets the build process speak for itself.

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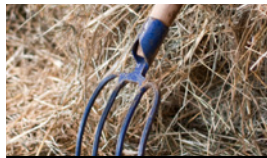
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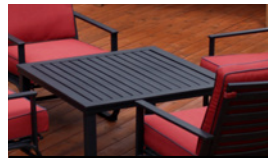
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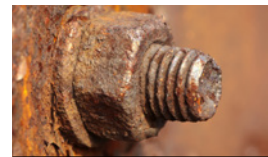
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# LETTERS TO THE EDITOR

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## DEAR EDITOR:

I have noticed that your covers usually feature a celebrity. In most cases if not all, these people are not true welders by trade or training. A few classes or a couple weeks' course does not make a welder.

It is fine that Vivian Beer [Fall 2016] won a furniture design competition put on by a TV show, but that in no way elevates her to the status of welding guru or leader in the field or trade.

What are the odds of any of her welds, or those of Steve Darnell or others you have featured, passing any type of welder inspection? What, if any, tickets or certification do any of these people hold? While they may be great rat rod builders and furniture designers, they are far from any type of leader in the welding trades.

There are many who have a lot of experience and have something to offer the people who work in the trades and those considering working in the trades. I'm referring to the people who spend 12 to 16 hours a day building pipelines, refineries, nuclear plants, or other structures on thousands of job sites every day of every year. Or the guy who crawls into a tiny, hot, dirty space to repair or weld a joint with a mirror, with little or no room to move or even see easily. These are the people who need the recognition, more so than someone who tacked a fender together or built a chair.

I understand your choices for the people you've put on your cover. I just feel that those who have actually contributed to the trade should get the

recognition more so than those who have benefited from it while skirting along the outer edges.

**Ian Butterfield**  
**Sarnia, Ontario, Canada**

► Thanks for weighing in, Ian. For starters, I think it would be unfair to characterize Vivian Beer, Steve Darnell, Jessi Combs – or the many other cover story subjects over the past two

“... it honestly makes a giant difference to see these other women in this profession be brought into the spotlight...”

years – as “not true welders by trade or by training.” Without digging into individual resumes and credentials, suffice it to say that all of these folks have built solid careers on skills that they've been perfecting for at least a couple decades — far more than “a few classes or a couple weeks' course” — and they've done the bulk of that training and learning away from the cameras and outside the public spotlight. I think you might be pleasantly surprised just how skilled or credentialed these folks are.

To your second point, you're absolutely right. The welding and metal trades are filled with unsung heroes who do all the things you mentioned and much more. We feature celebrities because

they provide a recognizable face for those readers who may still be new or relatively new to field. When high-profile welders tell their stories about working their way through the challenges of the early years, chances are good that readers who are early on the learning curve will find a way to relate and hopefully draw some inspiration.

Finally, *ARC Magazine* is aimed as much at promoting the welding culture as it

is building up the welding profession. As such, we target readers who see welding as a creative process as much as a means to make a living. That's why you're likely to see cover stories and feature stories about craftsmen, artists and innovators who are taking welding and related trades to places beyond the

more traditional parameters. Our intent is not to ignore the excellent work of professional welders, but rather to look at welding in a much larger context for a generation that's just getting on board.

**- John C. Bruening, Editor**

## DEAR EDITOR:

I would honestly like to thank you all for what you do. I'm currently a welding student at East Mississippi Community College, one of the best for welding in my state. I'm one of only three female welders at the school. The fact that your publication acknowledges the women in this industry such as Jessi Combs makes it so much more comfortable to be in

this field. I'm not much of a feminist — because once your helmet and gear are on, everyone looks the same — but it honestly makes a giant difference to see these other women in this profession be brought into the spotlight.

**Megan Traweek**  
*Starkville, Mississippi*

► Glad you're enjoying the magazine, Megan. We're constantly on the lookout for stories about individuals and institutions that are overcoming the gender barrier and creating opportunities for women in welding and metalworking trades. We invite you and all of our readers to keep us posted about any initiatives that are creating a more diverse and dynamic welding culture.



## WE WELCOME YOUR FEEDBACK!

Please include your mailing address. If we print your letter, we'll send you a free Lincoln Electric baseball cap or *ARC Magazine* t-shirt!

We reserve the right to edit responses for the sake of grammar, appropriateness and/or available space.

## We're back in touch

*ARC Magazine* has always encouraged reader feedback. Unfortunately, a technology glitch earlier this year knocked our email accounts offline for a couple months, and anything sent to us during that time was lost. The situation has since been corrected, so don't hesitate to get in touch at [editor@arcmagazine.pub](mailto:editor@arcmagazine.pub) — or depending on the specific nature of your question or needs, any of the other email addresses listed on the masthead (see page 6).

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# ASK THE EXPERTS

Welding experts at Lincoln Electric answer your questions about equipment setup, processes, techniques, safety and more.

Looking for guidance with technical issues? Contact us at [questions@arcmagazine.pub](mailto:questions@arcmagazine.pub)

## Is there any advantage to welding high-strength low-alloy grade 80 (A656 grade 80) steel with E80S-D2 filler wire, as opposed to E71T-1MJH4 flux core filler wire?

-John Hindelewicz, Chicago Ridge, IL

▶ With A656 grade 80, the tensile strength is 90 ksi and the yield strength is 80 ksi. So you want to at least match the base material in strength. So typically, if it's a 90 ksi tensile, you'll use an ER80S-D2 filler wire, which is 90 ksi tensile also. So the two strength levels will match in that case. But there are some situations where you don't have to do that. For example, you can make the weld bigger. You may be welding with lower-strength material, but you have more of it, so it will make up for the discrepancy in strength. You can do that with a fillet weld, but you really can't do that with a butt weld. And the weld may not require 90 ksi tensile, but you may be using that particular grade because you may want the hardness of it. But the weld doesn't necessarily require the strength level that it gives you. In that case, you could use the 71T-1MJH4.

## I just bought a new POWER MIG® 140C from Lincoln Electric this past summer, and I'm having some issues with the gun cable wanting to come undone and out. I have tightened the gun cable screw a number of times, and I checked the roller and the electrode feeds to make sure it stays in. Is there something else I should look at?

- Lynne Dehner, Tuscon, AZ

▶ For starters, make sure you're tightening the right screw. There are two polarity screws [wing nuts] near the bottom of the unit, but these are not intended for tightening the gun cable. The correct screw is the thumb screw on the front of the wire drive unit going into the brass connector. The only other



## IF YOU HAVE QUESTIONS ABOUT WELDING, HERE'S YOUR CHANCE TO GET CLARITY.

Submit your question to [questions@arcmagazine.pub](mailto:questions@arcmagazine.pub), and be sure to include your full mailing address. If we use your question, you'll get a FREE Lincoln Electric baseball cap or ARC Magazine t-shirt. Feel free to submit more than one question, but please be specific; the more details you provide, the more likely we are to use your question.

possibility is that the cable is being pulled out as a result of the friction that's created inside the gun when it's coiled up. To prevent this, store the gun in a looser coil when not in use. If neither of these methods resolves the issue, the unit may need to be serviced at an authorized Lincoln Electric service shop.

## What do I need for a MIG spool gun to weld aluminum?

- Jose Rivera, Adjuntos, Puerto Rico

► It depends on the compatibility between spool gun and feeder. Typically, if you get a spool gun that's designed specifically for a particular power source, it connects directly to the power source. The only thing you need is the small spool of wire for the gun, and the right gas for welding aluminum, which is typically 100 percent argon. If the spool gun is designed specifically for the power source that you have, then that's all you need — the wire, the gas and the spool gun itself. In some cases, the spool guns don't fit directly up to the power source. You can buy an adaptor for some power sources so the spool gun can interface with the power source. So the most important question you need to answer is whether the spool gun you're using is compatible with the particular welder that you have. That information is usually included in the instruction manual and other documentation that comes with the product.

## Can you explain the different types of tungsten and how they're used in TIG welding?

- Agustin Torres, Oakland, NJ

► There are many different types of tungsten, more than we can delve into here. Your best bet is to reference Lincoln Electric's GTAW guidebook, which lists all the different tungstens and what they're used for. This includes information about aluminum welding, appropriate polarities, the differences between pure and thoriated and zirconiated, etc. The GTAW guide is available from the James F. Lincoln Arc Welding Foundation website ([www.jflf.org](http://www.jflf.org)).

## I'm using the Lincoln Electric SP-125 welder to MIG weld the exhaust system on my old truck. The pipe is 2.5 OD aluminized mild steel, and all of the pipe connections are

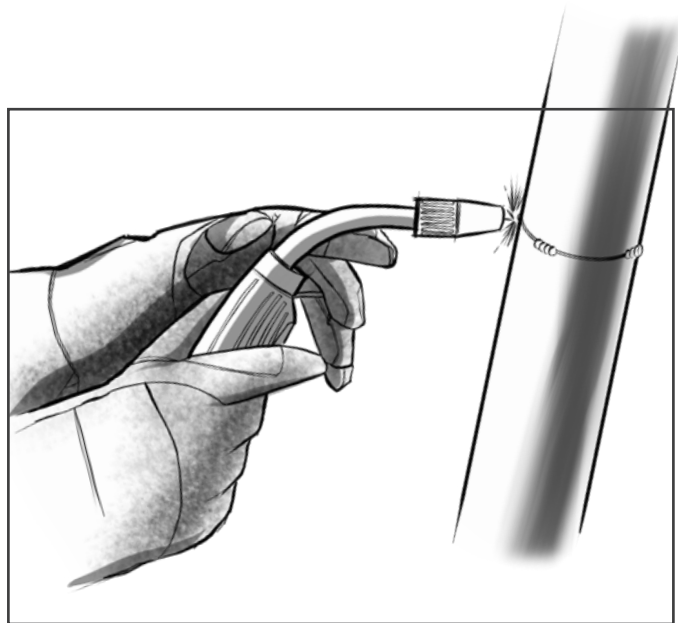


Illustration by Jeremy Lacey

## butt joints. With my hood down, I am having a hard time seeing the line where the pipes come together. What can I do to help me see this line better? Also, I tend to blow through the joint occasionally, so what would be the best bead pattern to avoid this?

- Jose Perez, Pueblo, CO

► If you're having a hard time seeing the weld line, your helmet lens may be too dark of a shade. Consult ANSI Z49.1 to see if you can switch to a slightly lighter lens by dropping your shade control down by one or two increments. You can also illuminate the welding surface with a high-intensity lamp.

As far as blowing through the joint, you'll have better luck if you do a series of skip welds around the circumference of the pipe. Start with a small, short spot weld – or maybe a half-inch weld – then move a couple inches around the pipe and put another spot weld there. Do this all the way around the pipe. That will give the heat time to disperse through the pipe. If you start at one side and continuously weld all the way around, the heat gets ahead of you, and it superheats the part of the pipe you haven't even welded on yet, and eventually you just burn right through.

This method will also keep the pipe straight, because you're basically managing the distortion all the way around the pipe. As it heats up, you're pulling in opposite directions from the previous welds. So it'll keep the pipe straighter than if you simply start at one end and go all the way around. **ARC**

A man with short brown hair and glasses, wearing a dark grey t-shirt with a white robot graphic and blue jeans, is focused on working on a large, complex metal chassis in a workshop. He is using a long metal rod or tool. The background shows various workshop equipment, including a forklift and shelves. The lighting is dramatic, with strong highlights and deep shadows.

# Robot Warriors Hit Prime Time

By Kate Nicolosi | Photography by Marc Oliver Le Blanc & Jenny Ogborn



The fascination with built-for-battle machines gains momentum and attracts unlikely followers, fans and future builders.

Consider some of the best-known robots of Hollywood: *Terminator's* T-800, Power Loader from *Alien*, the shape-shifting vehicles of *Transformers*, and of course, the fan favorite from the *Star Wars* saga, R2-D2. Hollywood movies regularly portray robots who wreak havoc on their enemies or save the day with human-like features and superhuman abilities. Robot warriors like these are also the stars of a real-life sport and could be the next big thing in reality TV.

From the mid-sized robots featured in ABC's *BattleBots* to their bigger cousins on the YouTube show *MegaBots*, the fascination with heavy-duty, built-for-battle machines is gaining the attention of more than just shop class students. This form of robotics brings metal bending into the mainstream for the pure joy of entertainment. It also has potential to inspire a new generation of scientists and engineers.

## BACK TO THE FUTURE

When you say the word "robot" to most people in the hard-core welding community, their immediate reaction is "job stealer." But the movement toward a class of battle-ready robots is actually attracting new practitioners to the field of metal fabricating, as well as electronics, hydraulics, programming, mechanical engineering — even ballistics. To find out why robot warriors are making a move into our popular culture and media, we have to look to the past.

Robot combat has been around for decades, popular mainly among techies and science club geeks. And then in the mid '90s, something changed. Film special-effects artist Marc Thorpe "put a chainsaw on top of a remote control tank and invited his friends over to watch," says Greg Munson, producer of ABC's *BattleBots*. A more diverse group of followers coalesced around this project, and a grass-roots robot warrior competition took shape.

Munson, a musician, entered Thorpe's battle with his cousin. Together they created an "ugly" robot shaped like "a door stop," he says. "It had great driving ability and great design." It was so effective, in fact, it won, beating a field of robots designed by college students and engineers.

Munson was hooked. Soon he was "hanging with a community of American

robot builders," he says, staging underground events — literally under San Francisco highways — and "planting a flag in the ground for robot combat."

Eventually, after starts and stops on a pay-per-view channel and Comedy Central, *BattleBots* was picked up by ABC. Over the course of two seasons it showcased some of the most technically savvy engineers who spend their free-time (most have day jobs!) designing, building and fabricating for the love of the sport — just as their predecessors did years ago on the streets of San Francisco.

## ROBOT WARRING: THE NEXT BIG SPORT

Today *BattleBots* — with coverage in more than 150 countries and an average of 4 million viewers per episode — is bigger and better. It appeals to the human fascination with "do-or-die moments," Munson says. "It's like a video game that comes to life."

*BattleBots* is a single-elimination bracket of 64 contenders who compete in front of cheering audiences, eagle-eyed referees and discerning judges. It incorporates extreme tech, craftsmanship and artistry. The 250-pound robots have three minutes to knock out a competitor in an arena fraught with obstacles like hammers and blades. Makers, all of whom are the masterminds and drivers (via remote control), steer their bots to victory by disabling or outsmarting their opponents.

Robot warriors come in a variety of weight divisions and classes. MegaBots, Inc., is a heavyweight contender. "Mega," just like its name implies, brings robot battles to spectators and viewers on a much larger scale.

Gui Cavalcanti and Matt Oehrlein are co-creators of MegaBots, Inc. It's an "entertainment company that makes robots," says Cavalcanti, a mechanical engineer. Their mission, according to Oehrlein, is to bring to life the giant robots they fell in love with as kids and "create a real-life epic battle of science fiction."

Through a series of popular, 8-minute YouTube videos, viewers can get up close and personal with a \$200,000, 6-ton, 15-foot-tall combat robot named *Mk.2* (pronounced *Mark 2*). The videos are snappy, inviting and lighthearted, and they demonstrate the advanced technology that goes into the design and build of these machines, which are piloted by Cavalcanti and Oehrlein.

The next big step for MegaBots, Inc., is the launch of an international sports league that will pit their giant human-piloted robot against a Japanese opponent. The prospect of an international battle is bringing even more viewers to *MegaBots* and building suspense among fans. "The challenge video is by far the most popular," says Oehrlein. "It's up to like 7 million views. When we filmed and released it we had an idea that it would go viral but not to the extent it did."

## PAGEANTRY AND PERSONALITY

At the heart of the robot battlers is the pure joy of entertainment. TV shows and movies wouldn't be nearly as entertaining if the audience didn't fall in love with the characters on the screen.

"R2-D2 has personality galore, a great sense of humor, he saves the day, he's pretty damn cute and has disco lights," says Munson. "What could be better?"

Enter *BattleBots* fan favorites: Witch Doctor, Bite Force, Bronco and Tombstone. Ray Billings, self-taught engineer, built Tombstone in his garage by hand, with the help of his son and a former rival. The robot has a signature blade known as an offset horizontal spinning bar. At 84 pounds, the blade



*Sparks fly as Tombstone — a BattleBots fan favorite — takes down an adversary in the competition's second season.*



*Rick Russ (left) and designer/builder Ray Billings — the team behind Tombstone — escort their contender into the BattleBots arena. The third member of the team (not shown) is Justin Billings, Ray's son.*

aims to “rip parts off or break things internally,” Billings says. Think: knocking off wheels, rattling electronic components or disabling batteries. Tombstone has lived up to its name, killing off competitors to win *BattleBots* in Season 2.

Chomp, another *BattleBots* favorite, is a self-steering, fire-breathing bot with an autonomous overhead hammer. Chomp, with her welded outer shell, is the brainchild of Zoe Stephenson, who, along with her small team of engineers, designed a hammer the bot can throw when it detects something “in the hit zone,” says Stephenson. “Because often even humans will screw that up” with slow reaction time or incorrect depth perception.

As for MegaBots’ giant *Mk.2*: It has the “most advanced military-grade hydraulics on the planet,” says Oehrlein. “We’re using some of the fastest and highest flow valves in

the world from Parker Hannifin that allow the robot to have very dynamic and fluid motion, and respond to commands ultra-fast. The track base was constructed by Howe & Howe technologies,” a prototype treaded-vehicle defense contractor.

The giant robot also shoots colossal paint balls from high-pressure air cannons at 120 miles per hour. “The shells are created with two-part expanding foam in a custom aluminum mold and are cast in two pieces that mate together,” says Oehrlein. “The payload is then added via a small hole and the shell is sealed.”

Surprisingly, 60 percent of the machine is made manually, according to Cavalcanti. “We do cool stuff where we laser cut all the plates that make up the links which are the arms and legs. We take a 4-by-8-foot steel sheet, put it



*MegaBots co-creator Matt Oehrlein in the shop, bringing giant robots to life one piece at a time.*

“Most people think of a reality show where you draw on a white board and then start welding. For us, the process looks a lot more like a military-grade design, where you spend two-thirds of your time on design [and] alternate the remaining time between fabricating and testing.”

*- Matt Oehrlein, MegaBots*

on a 5,000-watt laser cutter and get all the parts we need in about half an hour. We can ship them on pallets, take all the pieces, unfold them and weld them together," says Cavalcanti. "It's the IKEA version of giant robots."

### **COLLABORATION BEHIND THE SCENES**

Robot warriors appeal to our fascination with dominance and winning. But clearly, this movement requires innovation among metal fabricators, hydraulic and electronic technicians, programmers and mechanical engineers. And collaboration is key.

Fans may not appreciate the preparation — and the work of teams behind the scenes — that goes into a single battle, let alone an entire series. Reality TV makes it look easy.

"Most people think of a reality show where you draw on a white board and then start welding," says Oehrlein. "For us, the process looks a lot more like a military-grade design, where you spend two-thirds of your time on design and alternate the remaining time between fabricating and testing."

For MegaBots, testing can be fraught with issues, too. For example, "you wrote a ton of code that you think will control the robot well," says Oehrlein, "but then the limbs flail around and you [realize] you put a minus sign in the wrong spot in the code. You try to set up a control that is intuitive and lets you control it gracefully and not hurt yourself."

On the set of *BattleBots*, filming happens over the course of 10 days, so robots need fine tuning or repair after each battle. Quick repairs and welding are often necessary between episodes. Makers have to assess what's wrong with their robots and determine the best course of action. Experts and technicians from various sponsors are on hand to fix "anything you twist, bend or damage and help you weld and get it going again," says Billings. "It's like a dysfunctional family reunion. You get together once or twice a year and break each other's toys. We are there to tear each other up, but once the match is over, everyone is there to help fix each other up."

### **CLEAN-CUT ADRENALINE RUSH**

*BattleBots* is enticing viewers from all walks of life, including families who want quality entertainment without violence.

Ultimately, this rad use of tech inspires positivity and creativity, according to Munson. That's because kids who watch the show can "get out the Legos and build, or go to the garage and take something apart to see how it works."

Viewers skew more male than female. "However, we've received a tremendous amount of response and feedback from families," says John Remar, vice president of marketing for *BattleBots*. "A lot of whom are women on social media" saying they like the educational value of *BattleBots*.

"With all the talk of concussions in sports like football and boxing, *BattleBots* has created an outlet to capture that

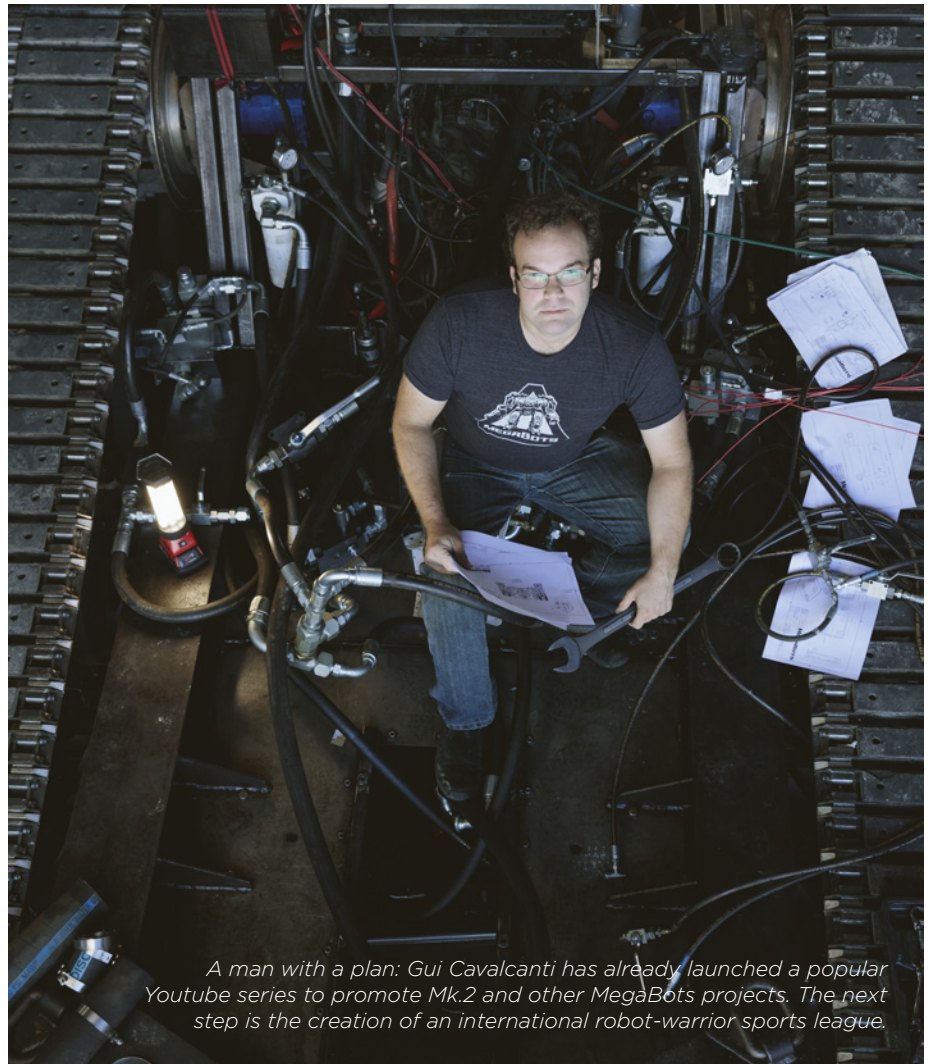
adrenaline rush without the violence," Remar says. "You have the action of combat with STEAM [Science Technology Engineering Art and Math], which wraps it up into a nice package that has something for everyone."

### **THE NEXT GENERATION OF WARRIORS**

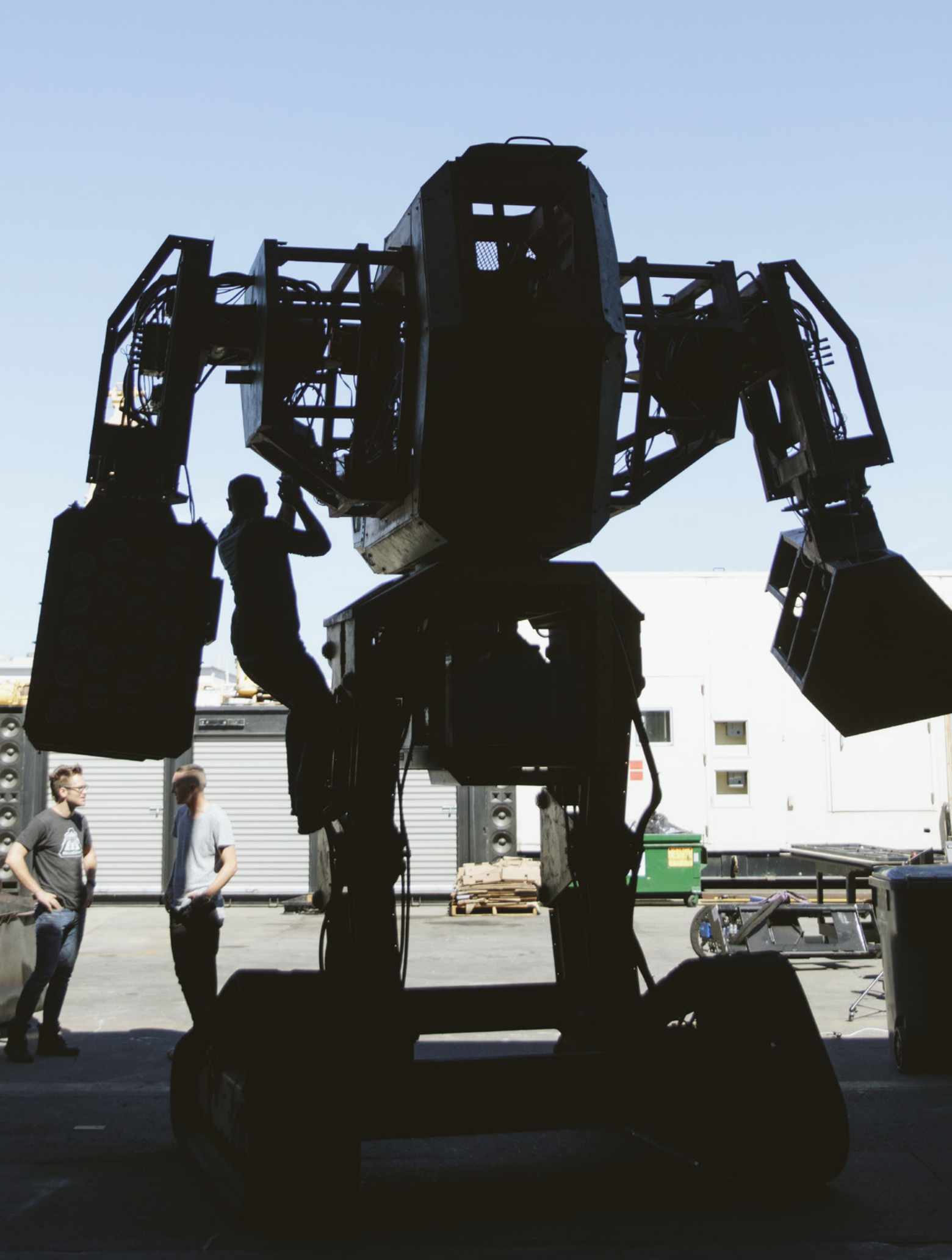
Science, technology, engineering, art and math are critical to the local robotics competitions happening in communities near you. All types of students are now accomplishing the skills that used to be relegated to the science club.

When James Lockman of Gorham, Maine, isn't working in his technology programming job, he's a coach and announcer at high school battles sponsored by FIRST Robotics.

FIRST Robotics, also known as FIRST (For Inspiration and Recognition of Science and Technology) is an international high



*A man with a plan: Gui Cavalcanti has already launched a popular Youtube series to promote Mk.2 and other MegaBots projects. The next step is the creation of an international robot-warrior sports league.*





*Above: MegaBots masterminds Oehrlein and Cavalcanti, perched atop Mk.2's 350-hp track base. Below left: Oehrlein fabricating in the shop. Below right: The place where the MegaBots magic happens.*



The mission is to  
"create a real-life epic battle  
of science fiction."

- Matt Oehrlein, MegaBots

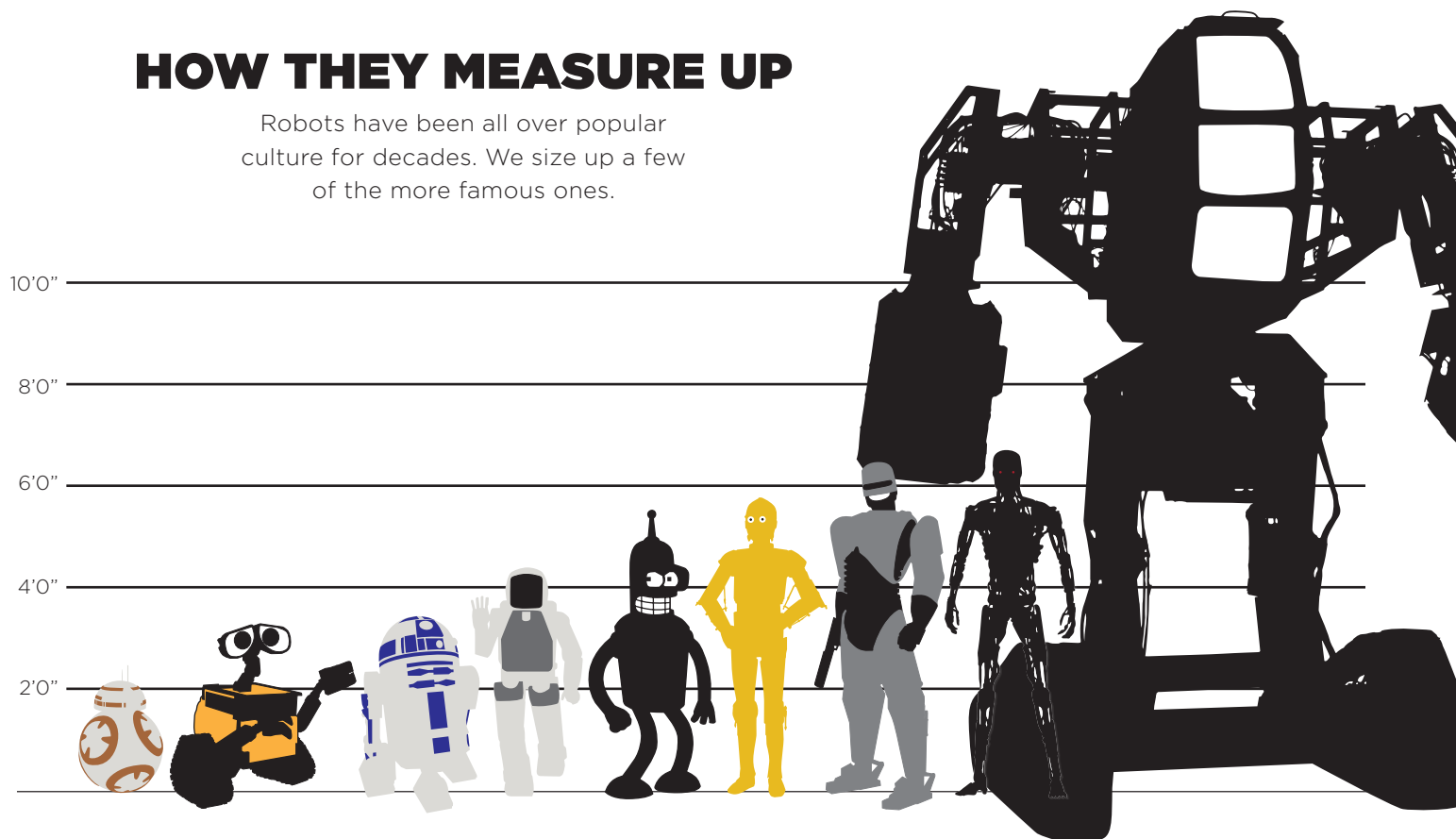




*Damage is inevitable at a BattleBots competition. Lincoln Electric keeps a crew on hand to help put things back together between bouts.*

## HOW THEY MEASURE UP

Robots have been all over popular culture for decades. We size up a few of the more famous ones.





school robotics competition developed to inspire students to be leaders in science and technology. In 2016, nearly 79,000 students from 24 countries assembled 3,100 teams with a common goal to invent, build, program, market, design, problem solve and compete.

Teams are given a budget but encouraged to raise money for robot parts through fundraisers and community events. In addition, many teams find professional mentors in the fabrication field. Lockman's team is working with a metal fabrication shop whose practitioners "teach welding and how to use metal saws safely," he says. Pros teach their craft to curious students who wouldn't otherwise have access to sophisticated tools and authentic maker spaces.

Each team has six weeks to accomplish a design and engineering challenge, which changes every year. Now in its 26th season, FIRST tasked this year's competitors with moving their robots across rough terrain the size of a basketball court and then shooting a ball into a tower. Points are awarded for a variety of skills, and winning robots move up in the bracket.

The FIRST Robotics Team 172 Northern Force is informally known as FalGor, because it's made up of students from two high schools in Falmouth and Gorham, Maine. A numeric designation is given to all FIRST teams. However, students can craft personalized team names to accompany their number, such as Beach Bots (Team 330 Hermosa Beach), Roboteers (Team 2481 Tremont, IL) and Cleveland's Team (Team 120, Cleveland, OH).

In April, Team 172 — now in its 21st competitive season — competed in district championships in New England and advanced to championships at the Edward Jones Dome in St. Louis. More than 600 teams participated. Winners of each division competed for the title of "world champion" among announcers, referees and a throng of cheering fans.

On game day for FIRST Robotics, one aspect of the competition is very different from their prime-time counterparts: "If you hurt another robot you get a penalty," says Lockman. The goal for this competition is to get every robot competing and to build confidence in students as they solve problems. Teams can also earn honors for design

excellence, research, website design and teamwork.

Similar to FIRST Robotics, *BattleBots* is launching *BattleBots IQ*, a curriculum for high school students that offers advanced engineering through the addictive fun of robot combat. Through the process of building robots, students can use their imaginations while gaining practical knowledge of the sciences. "We call it stealth learning," says Munson.

Chomp creator Stephenson nearly missed her mechanical engineering calling. She is grateful for robot competitions that tease our fans at a young age. "I love being a mechanical engineer," Stephenson says. "It's incredibly satisfying. You make a thing that functions and does what you want it to do. [The idea] was only in your head and now it's real."

Both programs capitalize on the growing intrigue of robot competitions and a young audience that is ripe for learning. These battles may pique the interest of a budding scientist, engineer or artist who could become the next big thing in robot warrior reality TV. Stay tuned. **ARC**



# 2016 BUYER'S GUIDE

The holiday season is upon us once again! To help you find the perfect gift for the welder, maker, craftsman or hobbyist in your life, the staff at *ARC Magazine* put together our 2016 Buyer's Guide. Now, everything they always wanted is at your fingertips—and can be found at your local welding distributor or direct from Lincoln Electric online!



## Stick Welding

**1.** The iconic **AC 225™** “Buzz Box” has been the go-to welder for a generation. **2.** Choose the right stick electrode for whatever you’re welding, like **Excalibur® 7018 MR®**. **3.** Show your colors in style with a **Shadow™ Split-Leather Sleeved Welding Jacket**. **4.** Sometimes it’s the simple things. Tackle slag removal with a **Chipping Hammer**. **5.** Clearly the best: **Traditional Clear Safety Glasses** from Lincoln Electric. **6.** Great optical clarity doesn’t have to come with a big price tag. Choose from three different designs with our **VIKING™ 1840 Series** welding helmets. **7.** When it comes to stick welding, moisture is the enemy. Keep your rod dry with a **Hydroguard® Portable Welding Rod Oven**. **8.** Good welds depend on clean surfaces. Get prepped the right way with the right **Wire Brushes** for your job. **9.** Hands down, the best welding gloves on the market, our **Traditional MIG/Stick Welding Gloves**.





## MIG Welding

**1.** Take it Everywhere. Plug in Anywhere.™ with the original “Ready. Set. Weld.”™ multi-process welder—the **POWER MIG® 210 MP**. **2.** The right accessory for the occasion? Your choice of **Premium Leather Stick/MIG Welding Gloves**, crafted for everyday duty or **Full Leather Steelworker® Gloves** for flexibility plus protection. **3.** We’ve got you covered, with fire retardant **Welding Jackets** for both men and women. **4.** Improve your welds by the spoolful with genuine Lincoln Electric MIG wire, like **SuperArc® L-56**. **5.** The **Radius™ Manual Hand Lifter** gives you magnetic control with a turn of the wrist. **6.** Tacking welds just got easier with the **Radius™ Pivot Angle Magnetic Fixture**. **7.** Designed to fit a smaller face, the **Women’s Starlite® Clear Safety glasses** from our Jessi Combs’s line of women’s welding gear. **8.** Add-on for Aluminum. Get more material options from your MIG setup with a **Magnum® PRO 100SG**. **9.** Snip wire. Ream torch tips. Or twist them off. The **Welper®** multi-tool is a must for any MIG welder. **10.** Whether you’re a woman welder or just a fan, “You can do it!” with the latest **Jessi Combs signature VIKING™ 3350 Welding helmet**.





## TIG Welding

1. More features than you'd expect plus an intuitive user interface make the **Square Wave® TIG 200** a great machine for beginner or expert alike! 2. Get a precision fit for precision welding with these **Leather TIG Welding Gloves**. 3. Stay protected and cool at the same time with **Split Leather FR Welding Sleeves**. 4. **Finish Line™ Clear Safety Glasses**—Lookin' good, stayin' safe. 5. Better to have them and not need them; the **Parts Kits** for your torch include collets, collet bodies, a back cap, alumina nozzles and tungstens in a variety of sizes. 6. Cover your dome with a stylish **Welding Doo Rag FR**. 7. Big or small, these **Radius™ Multi Angle Magnets** hold them all! 8. Keep your torches, tungstens and tools in one place with this handy **Canvas Accessory Bag**. 9. Old school, modern tech. The new **VIKING™ 3350 Steampunk™** welding helmet with 4C™ optical technology. 10. Whatever your next project is, turn to Lincoln Electric for **TIG Cut Length** consumables for any material.





2.



3.



4.



5.



6.



7.



## Plasma Cutting

**1.** The **Tomahawk® 625** is a hand-held plasma cutter that gets around. This lightweight but powerful machine is rated to cut up to 5/8-inch materials. **2.** A **Traditional FR Cloth Welding Jacket** or **Khaki FR Welding Shirt** are the ideal options for light-duty welding. Choose from two colors. **3.** What could go better with plasma cutting than a fire retardant **Welding Blanket?** In your choice of temperature ratings and colors (as long as your color is red or black). **4.** Cut circles around the competition with a **Circle Cutting Kit** for your Tomahawk® plasma cutter. **5.** There are lots of ways to protect your eyes when plasma cutting, but nothing makes a statement like these **Shade 5 Cutting and Grinding Goggles**. **6.** The **Radius™ Electric Hand Lifter** gives you magnetic control with the flip of a switch. **7.** Stock up on **Plasma Torch Consumables** so you can keep on cutting.

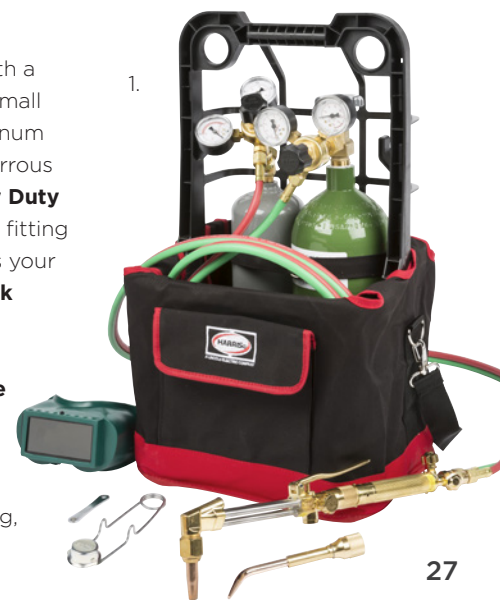
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## Oxy-fuel Cutting & Brazing

**1.** Get all the gas welding, cutting and brazing capacity you need in a small package with a **Port-A-Torch®** outfit from Harris®. **2. Multi-tool.** Maxi-usefulness. Designed with all the small stuff you need for welding close at hand. **3. Al-Solder 500** joins tough-to-solder aluminum alloys and all solderable aluminum alloys to each other and to dissimilar metals, both ferrous and nonferrous. **4.** Protect yourself from sparks and look good doing it with the **Heavy Duty Leather Welding Jacket**. **5.** The **Ten-Way Tank Wrench** comes with all of the common fitting sizes you need in a single tool for tight fittings. **6. Stay Brite® 8** lead free silver solder is your choice for brazing with all ferrous and nonferrous alloys. **7.** Regulator mount **Flash Back Arrestors** prevent hazards from reverse flow and flash backs. **8.** Prevent accidentally knocking the regulator off your cutting torch tank by protecting them with our **Gauge Guards**. **9.** If you want a regulator that is a lot easier to dial in, get a set of **25GX Single Stage Regulators** with ergonomic knob design. **10.** Protect your dome with a fire retardant, machine washable **Welding Beanie**, branded with the number one name in welding equipment. **11.** A shade above. **Shade 3 Cutting and Grinding Goggles** protect your face from sparks, spatter, particles, sand, dirt and heat, perfect for chipping, grinding and machining operations.

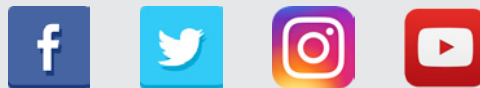


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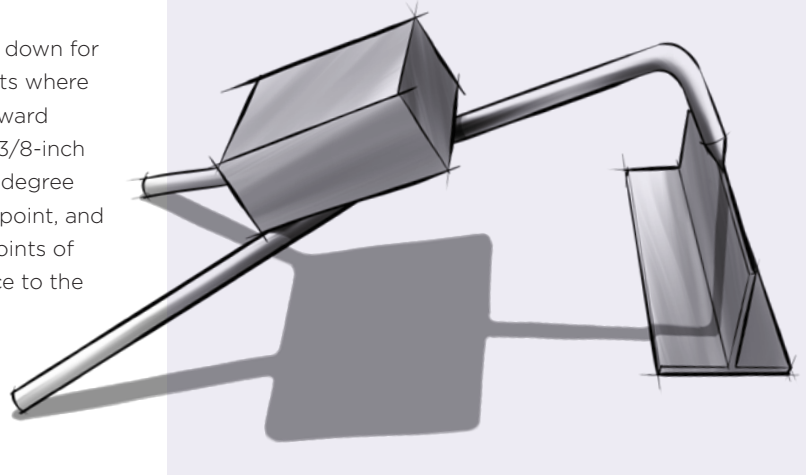
# BEGINNER TIPS & TRICKS

Make It Easier to Weld Your Workpiece.

## MECHANICAL FINGER CAN KEEP A PROJECT IN PLACE

— ERIK ARNESEN, CORVALLIS, OREGON

► Weld yourself a mechanical finger to help hold parts down for welding. This instrument is especially helpful for projects where magnets won't work (non-ferrous metals or small, awkward pieces). The mechanical finger can consist of 1/4-inch, 3/8-inch or 1/2-inch round rod roughly 15 inches long with a 90-degree bend on one end (the finger end), shaped to a conical point, and 2 feet (or legs) on the other end. This provides three points of contact when set on a table. You can weld a scrap piece to the bottom of the body (the long portion) to add weight.



Illustrations by Jeremy Lacey

## UNCOVER THE SHINY METAL

— JOSE RIVERA, ADJUNTAS, PUERTO RICO

► When you restart some electrodes, such as low hydrogen, give them a few good swipes with a rough grade file. This will expose the shiny metal hidden beneath the slag.

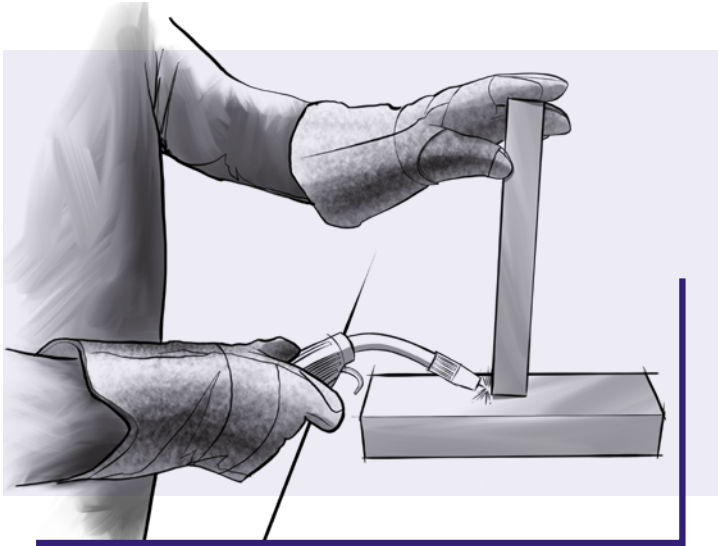
## HAVE A TIP OR A TRICK YOU'D LIKE TO SHARE WITH BEGINNERS? LET US KNOW!

Send us your tip or trick and we just might feature it in an upcoming issue!

Feel free to submit more than one tip, but please be as specific and detailed as possible. The more details you provide, the more likely we are to use your tip. Note: We reserve the right to edit responses for the sake of grammar, appropriateness and/or available space.

And ... if we do use your submission, we'll send you a FREE Lincoln Electric Welding Gear Ready-Pak®.





## SHRINK FORCE

- GREGORY STROHM, LEBANON, PENNSYLVANIA

- ▶ When tack welding two straight pieces of metal together and you want both pieces to be 90 degrees, hold the piece you want to tack slightly past 90 degrees. Tack the opposite side of the metal and the shrink force will square up both pieces.

## CONTAMINANT-FREE ZONE

- ANDREW CARTER, MUNCIE, INDIANA

- ▶ Quality welds is your objective, which means you don't want contaminants in the weld area. At a minimum, the area should be free and clear of rust, oil, water, paint and other contaminants that can be detrimental to the weld process. Since some of these elements can also contaminate the air, make sure you're utilizing the proper fume control equipment.

## TACK IN THE CORNERS

- J. SHILLING, HOMOSASSA, FLORIDA

- ▶ When tacking a project together, place all of your tacks in the corners. Start your weld in a corner and stop in a corner. You'll have a flat weld without a hump in the middle.

## CLEAN WIRE IS THE BEST WIRE

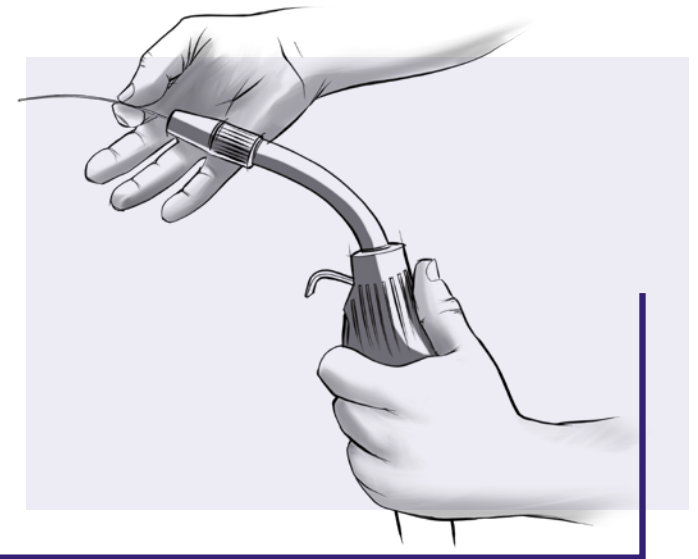
- CHARLES HINTON, FAYETTEVILLE, NORTH CAROLINA

- ▶ Keep your MIG and TIG wire in a clean, dry place when not welding. This will avoid picking up contaminants that eventually lead to poor welds. For example, leaving wire exposed in a garage can lead to condensation because of humidity. The condensation will render the wire useless, but you won't realize this until welding begins.

## FILLING SMALL GAPS

- JOHN EPPLER, KEY WEST, FLORIDA

- ▶ When fittings might be hard to come by, especially with pipe and tube in low-pressure applications, you can make spacers to help with less-than-ideal fits. Use a hammer to flatten out TIG filler metal on the anvil portion of a vise to fill small gaps and keep everything aligned while welding.



## CHECK YOUR TENSION

- DAVID ALEXANDER, MILAN, MICHIGAN

- ▶ If you're having difficulties properly adjusting your MIG welder, first check the tension of your drive rolls by pressing the trigger, then pinching the wire between your thumb and finger. You should just barely be able to hold it back.

# EDUCATOR SPOTLIGHT

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## ANDY KAVANAUGH

### THE PURSUITS OF YOUTH, THE BENEFITS OF A LIFETIME

By John C. Bruening

After several years of teaching language arts and social studies to elementary students, Andy Kavanaugh decided it was time to roll up his sleeves and get his hands dirty – just like he used to do when he was a kid. Four years ago, he changed gears and began teaching welding and metal fabrication at Fort Dodge Senior High School in Fort Dodge, Iowa.

The career move was the culmination of everything he'd learned about welding since he worked on a farm with his father, John Kavanaugh, in nearby Lohrville when he was just 10 or 12 years old.

"It was maintenance and repair type work," he recalls of the summer jobs of his youth. "You know, you've got your helmet on and you're watching your dad weld. He showed me the basics, and then when I got into high school, I got some formal training."

He spent much of his high school years tinkering with the engine of a small, 40-horsepower Farmall Super C tractor and competing in tractor pulls on weekends. But along came college, and Kavanaugh drifted away from his hobby to pursue the sensible career option of elementary education.

A couple years of teaching in Kansas made sense for a while, but some life changes – including an illness in the family and a layoff – brought him back to Iowa, where he took the job at the high school.

His classes include stick, MIG and TIG welding, plasma cutting, welding fabrication and metalworking. He teaches anywhere from 120 to 150 students

a year in grades 9 through 12. Student projects have included, among other things, benches and trail art for the Webster County Conservation Office – the kind of enterprise that results in an immediate and long-term community benefit.

"Exposure to the welding and metalworking trades is such good practical experience for the kids," says Kavanaugh. "Kids nowadays always wonder, 'Why do I need to know this?' But we don't have to spend a whole lot of time with them to get them to understand what they're doing and why. When they made the stuff for the county last year, I told them, 'You guys designed this. You cut it, you welded it, you built it. When you're older and have kids of your own, they're going to see this stuff around town. This will be stuff you'll see for years to come, and you can tell your kids you made this.' It's an eye-opening moment for the kids. It's pretty fun to see them get excited about it."

One of Kavanaugh's best and brightest over the past four years was Zach Lowery, now in his second year of the mechanical engineering program at the University of Iowa. Once Lowery and a couple other classmates demonstrated a deep interest in the trades, Kavanaugh pushed them to take on extra work and independent study projects.

"He took a more in-depth approach to teaching us," says Lowery. "We would have long conversations about processes and techniques, and he would give us the hardest parts to build because he knew we could get it done. He always encouraged me to push myself to do the best I could. He helped me understand that if I set my mind on a goal, then I should work hard to achieve it." **ARC**

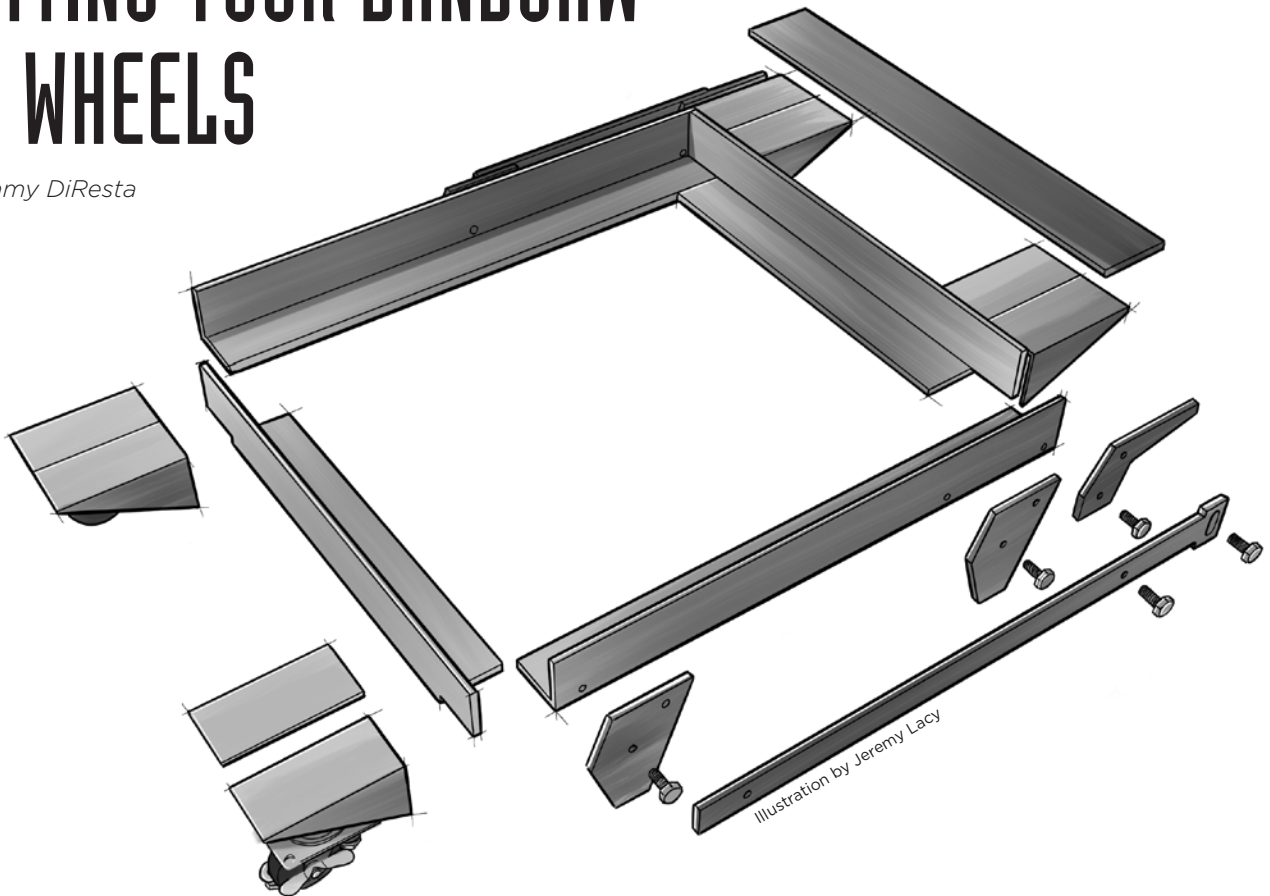




**"EXPOSURE TO THE WELDING  
AND METALWORKING TRADES  
IS SUCH GOOD PRACTICAL  
EXPERIENCE FOR THE KIDS."**

## PUTTING YOUR BANDSAW ON WHEELS

By Jimmy DiResta



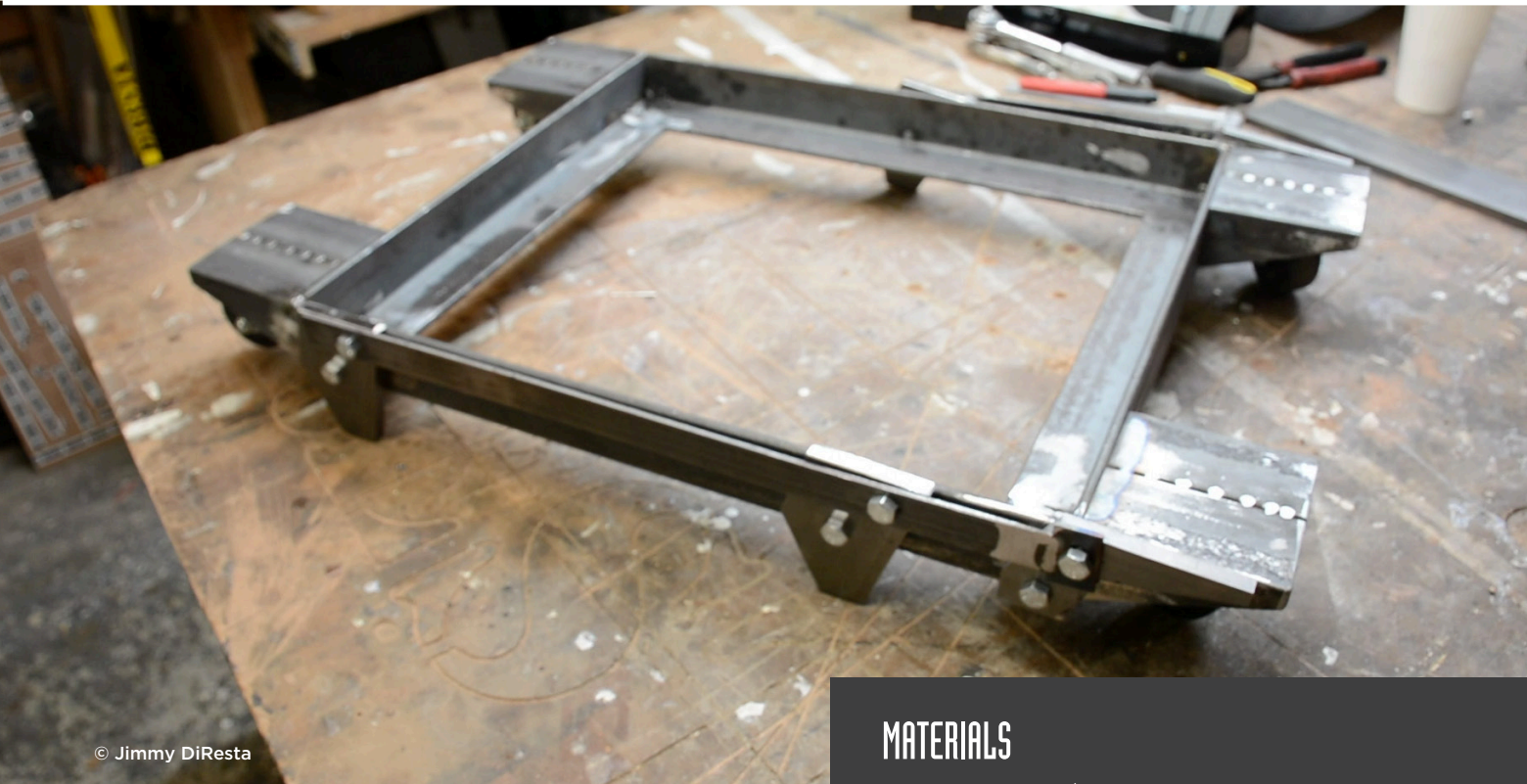
Adding mobility to any large, stationary tool increases its usefulness, because it won't be tethered to a particular spot in the workshop. In this project, craftsman and maker Jimmy DiResta adds a wheeled base to his shop's bandsaw so he can more easily place it to accommodate a project.

Bandsaws come in different sizes and configurations, so you'll need to adjust your measurements and cuts to accommodate your unit and workspace. Likewise, if you're thinking of putting other power tools on wheels, you can use this basic plan by modifying your dimensions accordingly.

Once you've built the bandsaw stand, you'll definitely see the benefits and wonder why it took so long to do this in the first place.



Watch exclusive footage at [arcmagazine.pub](http://arcmagazine.pub) or in the *ARC Magazine*™ tablet edition (download it for free).



© Jimmy DiResta

## SAFETY FIRST

Before you start any project involving welding, make sure you have the right Personal Protective Equipment (PPE), which includes, at least, an ANSI-approved welding helmet, safety glasses, appropriate welding gloves for the process you're using, and a flame-resistant shirt, jacket, or sleeves to protect from UV rays and burns. You should also keep a fire extinguisher close at hand. Use adequate ventilation when welding. A properly approved respirator should be used whenever fumes may enter your breathing zone and general area.

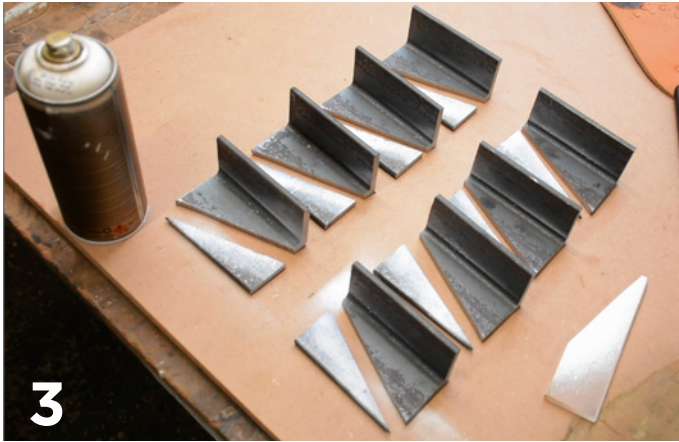
## MATERIALS

- 2 X 2 angle iron, 3/16-inch thick
- 3/8 X 2 cold rolled steel
- Wheels
- 3/8-inch bolts and washers
- CA glue

## WELDING/CUTTING EQUIPMENT

- Lincoln Electric POWER MIG® 210 MP
- Fume extraction unit
- Deep cut portable bandsaw with metal-cutting blade
- Electric drill/driver
- Angle grinder with abrasive disk
- Tapping setup for 3/8-inch bolts

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### Step 1: Cut the pieces for the frame

This base will be constructed on 3/16-inch thick, two inch by two inch angle iron. The thickness allows for the metal to be drilled and tapped later in the project. Using a portable bandsaw or other cutting method, cut notches in the angle iron where the pieces overlap.

### Step 2: Tack and weld the frame

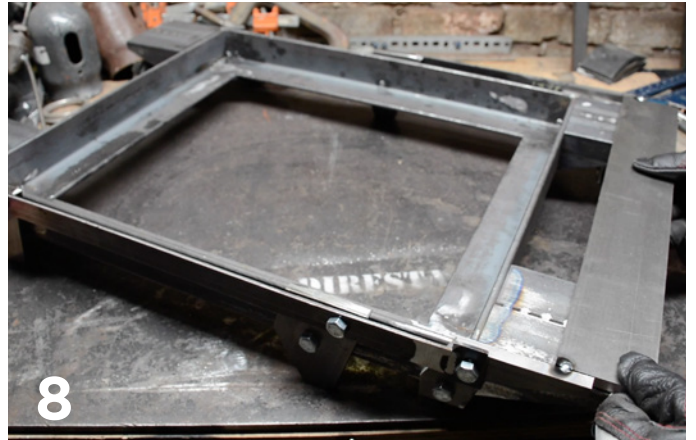
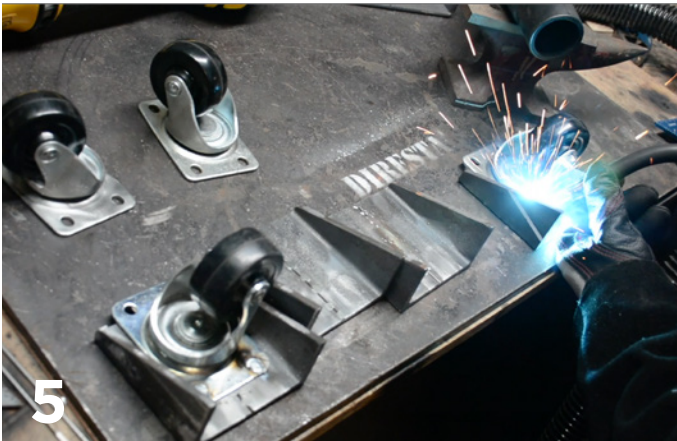
Weld these pieces together using lap joints rather than miter joints. It will allow more surface to weld and increase the rigidity of the frame.

### Step 3: Cut the wheel caddies

Using a can of spray paint to mark the angle, cut each half of one wheel caddy from 2 x 2 angle iron. Cut each piece along your mark to form one half of each of the four wheel caddies.

### Step 4: Tack weld the caddies

Tack welding these caddies is not just a personal preference; it minimizes distortion of the base metal caused by heat. The tack welds also give the cantilevers a “riveted” appearance rather than one long bead.



## Step 5: Adding the wheels

Be sure there's enough clearance for the wheels to freely spin 360 degrees. If you run into a problem with wheel clearance, this is the time to adjust. Once you are sure you have clearance, weld the wheels to the wheel caddies, then weld the completed subassembly to the frame.

## Step 6: Building the levers and linkage

The second phase of the project begins here — building the parts that will make up the lifting mechanism for the mobile base. Start by cutting 4 pieces of 3/8 X 2-inch thick cold rolled steel to length and drill two holes in each, one will be the carrier (pivot) hole and the other will be tapped to accept a bolt.

## Step 7: Assembling the levers and linkage

Using two pieces of bar stock cut to length, connect the lifters together and then connect each side of the lifting mechanism using bolts. To keep the bolts from backing out during repeated use, apply CA glue, or some other thread locking compound, to the threads of each bolt

## Step 8: Connecting the levers

Using another wider piece of flat stock, connect each half of the lifting mechanism. This lever will allow both sides to be engaged simultaneously when stepped on. The stand should move freely when the lifting mechanism is not engaged.

Once this project is completed, you can use your bandsaw to fabricate even bigger and better builds.

▶ A detailed drawing and cut list for this project can be downloaded at [arcmagazine.pub](http://arcmagazine.pub).

## MAKER FAIRE CREATES A MOVEMENT

Maker Faire is part science fair, part county fair and part something entirely new. It is a gathering of crafters, tinkerers, fabricators, hobbyists, tech enthusiasts and those in other disciplines who are eager to show the community at large what they make and how they make it.

“The Maker Faire reinvents the county fair,” says Dale Dougherty, founder, president and CEO of Maker Media Inc., which produces Maker Faire and *Make*: magazine. “But instead of pigs and pies, we bring rockets and robots.”

The first Maker Faire was held in 2006 in San Mateo, California. From that beginning, there are now more than 100 Maker Faire events held every year around the world.

In turn, Maker Faire has led to the maker movement. Makers, according to Dougherty, are people who make things for many different reasons using many different technologies and techniques. They explore new forms and technologies in a variety of fields, including metal fabrication.

Maker Faire events can provide a starting point for individuals who want to join the movement.

Thanks to Maker Faire, makers can share what they are creating and learning with a like-minded community. In the Maker Faire tent, Dougherty says, individuals in all disciplines belong next to each other. That’s because makers bridge the gap between manual and mental. Makers take practical skills and apply them creatively. Invention, innovation and prototyping are



© REUTERS/Andrew Kelly

paramount. “We use our hands and our minds,” Dougherty points out.

To become a maker, all a person has to do is start making, Dougherty notes. Research “making” online and you’ll find a host of projects and ideas. Or find a Maker Faire or makerspace (community spaces with tools) in your area. Even if there isn’t an event nearby, fabricators can always find one in the cyber community.

Bottom line, anyone and everyone can be a maker, Dougherty says.

“I believe we are all makers,” he maintains. “We can find all kinds of makers in our communities. Yet we also want to help create more makers. I know that the people who have the skills and knowledge to make things have the power to make the world a better place.” **ARC**

*Maker Faire events around the world give makers the opportunity to display their ingenuity.*

Photography opposite page, © Becca Henry



# MASTER CLASS

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A discussion of advanced materials and techniques for the seasoned welder.

## PREPARING TO WELD TITANIUM

By Karl Hoes, Welding School Instructor, The Lincoln Electric Company

*The color of the titanium weld indicates whether the weld is acceptable.*



Glossy Silver: Acceptable



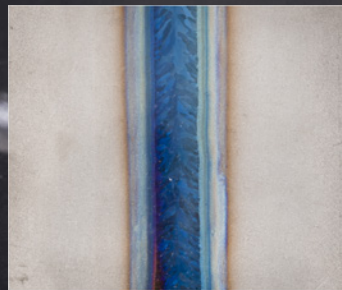
Light Straw: Acceptable



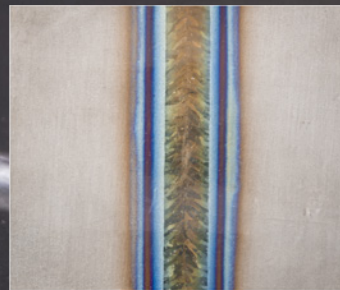
Dark Straw: Acceptable



Purple: Unacceptable



Blue: Unacceptable



Yellow: Unacceptable



Gray: Unacceptable



White: Unacceptable



Brushed: Unacceptable

Titanium alloys have about the same strength as steel but with slightly more than half the density, resulting in the highest strength-to-weight ratio of any structural metal. The alloys are most commonly used in the aerospace industry and are increasingly being used in motorsports applications. Their excellent corrosion resistance makes titanium alloys ideal for use in aggressively corrosive environments, such as heat exchangers, marine applications and chemical processing.

Although titanium can be welded using the MIG (GMAW) process, it is more commonly arc welded with the TIG (GTAW)

process using pure argon or helium shielding gas. Welding is accomplished with DC negative polarity and with a 2% thoriated tungsten electrode prepared with a blunted point.

Here are some suggestions that can help hobbyists and fabricators achieve the best results when welding titanium.

- **Clean the base metal.** Contaminants found on the base metal, like oil and grease, are detrimental. It is important to clean the surface of the base metal. This can be done by steam cleaning, using an alkali dip in a diluted solution of sodium hydroxide, or mechanically with a carbide tip to grind off the weld area. Use cleaning tools that are only for titanium applications.
- **Filler metal selection is important.** Use a filler metal that is from the same alloy category as the base metal. There are four categories of titanium alloys – commercially pure, alpha, alpha beta and beta.
- **The right torch setup.** The primary gas is delivered from the torch, often through an oversized gas lens collet body and nozzle. This helps protect the base metal from atmospheric gases, such as oxygen, which could contaminate the weld.
- **Use a trailing device.** Trailing gas is often applied by a commercially available or custom-fabricated trailing device, which shields recently solidified weld metal.
- **Back purge your welds.** Purging gas should be applied on the backside of the welds to protect the heated base metal from absorbing elements from the atmosphere. (See *ARC Magazine's* Fall 2015 Master Class on back purging for details.)
- **Weld inside a purge chamber.** The chamber is purged out with argon, and the titanium is placed inside. Welding is done through a glovebox. Thanks to the controlled environment, the entire weldment is protected from the atmosphere. A purge chamber eliminates the need to back purge or employ a trailing device.

Failure to properly clean and shield the weld and heated base metal can lead to corrosion and be detrimental to mechanical properties. Above about 800 degrees F, titanium is very reactive and will absorb atmospheric gases and contaminants rapidly. Elements absorbed into the surface of titanium at high temperatures can create a hard, brittle oxide layer that lacks in ductility and fatigue strength.

The depth and degree of embrittlement of the weldment is reflected by the characteristic color visible on the surface. For example, a glossy silver or straw colored weld and surrounding base metal is acceptable, while blue or white coloring is unacceptable (see color chart). **ARC**



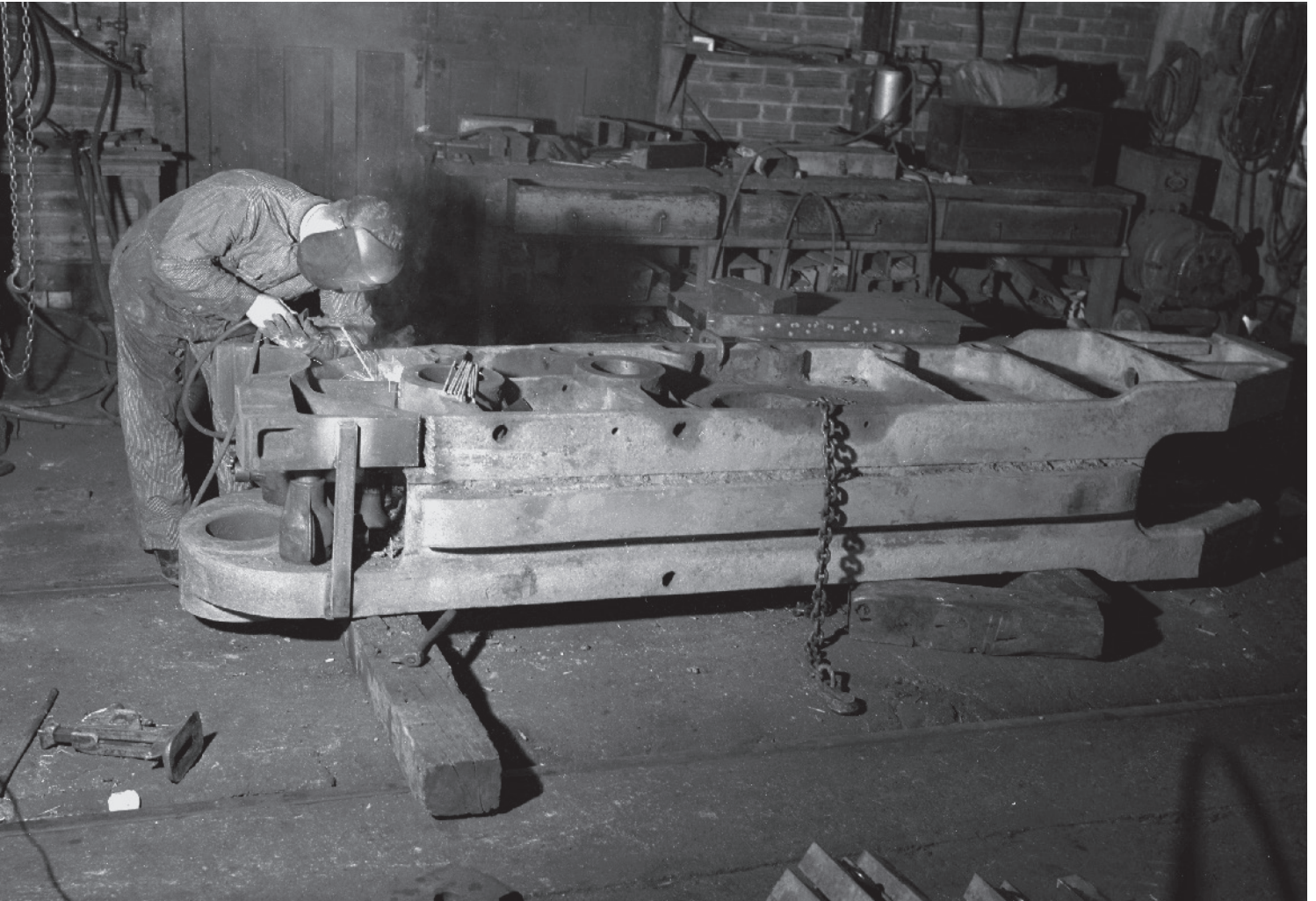
Watch exclusive footage at [arcmagazine.pub](http://arcmagazine.pub) or in the *ARC Magazine™* tablet edition (download it for free).



# FLASHBACK

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## Welding, Repairing and Saving



**July 1940** — A worker at the Northern Illinois Coal Corporation welds the crawler frame of a 17-cubic-yard power shovel. When the crawler's castings would occasionally break near the bearings, repairs were done with Lincoln Electric's 3/16-inch Fleetweld® 7 electrode. A new crawler frame in 1940 would have cost approximately \$1,500 (nearly \$26,000 in 2016 dollars), but a replacement casting would only cost \$165 (\$2,800 in 2016). After time and labor, the average savings would equal about \$1,300 (\$22,300 today) on this type of job.

*Have any vintage (pre-1975) photos you'd like to share? Email them in jpeg format to [editor@arcmagazine.pub](mailto:editor@arcmagazine.pub) with a date the photo was taken (actual or approximate), a brief description (three or four sentences), and an email address where we can reach you for additional information.*

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SHOW US THE ONE  
**WHO SHOWED YOU  
THE WAY**

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