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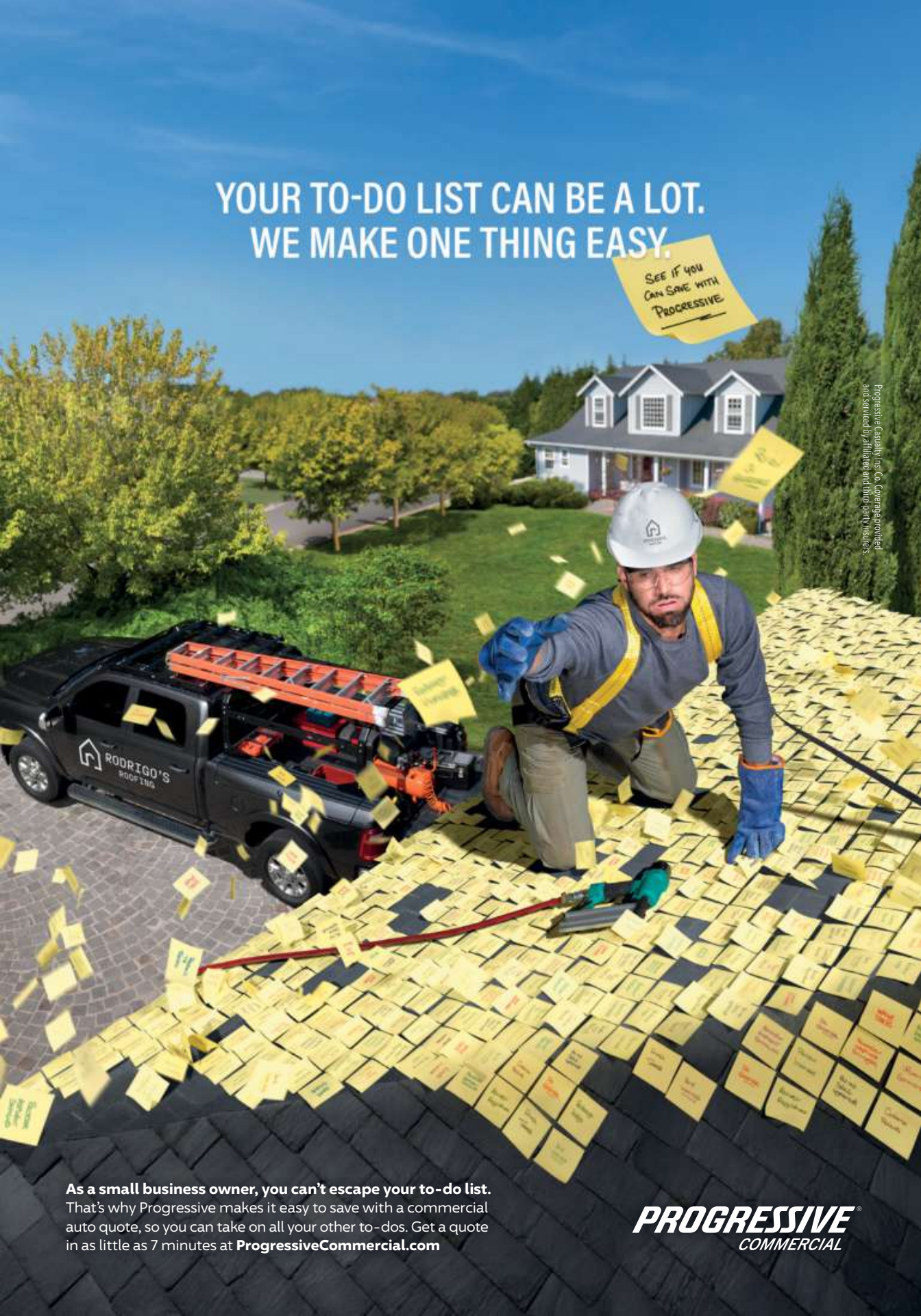
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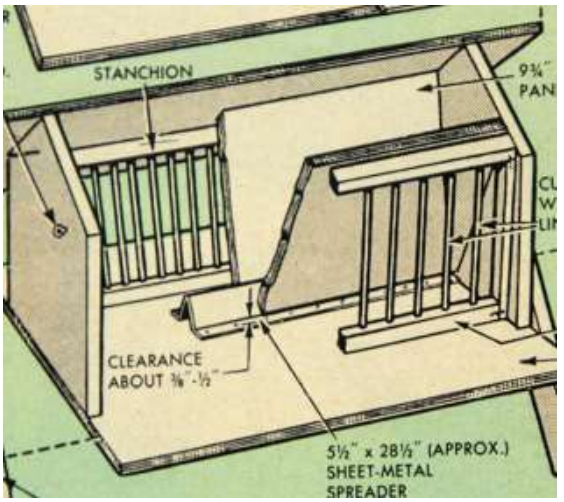

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ARI KANKAINEN (CAN'T STOP); THOMAS HENGGE (60 YEARS AGO)

FINDING MY NEXT GEAR

Everyone has aging pains, but CBD can help

By: Beth Giles

Life really does fly by. Before I knew it, my 50s had arrived, and with them came some new gifts from dear ol' Mother Nature—frequent knee pain, stress, low energy and sleeplessness. Now, I'm a realist about these things, I knew I wasn't going to be young and springy forever. But still, with "golden years" nearly on my doorstep, I couldn't help but feel a little cheated. That is until I found my own secret weapon. Another gift from Mother Nature.

It began a few months back when I was complaining about my aches and pains to my marathon-running granddaughter, Jen. She casually mentioned how she uses CBD rub to help with her joint pain. She said that CBD gave her more focus and clarity throughout the day and that her lingering muscle and joint discomfort no longer bothered her. She even felt comfortable signing up for back-to-back marathons two weekends in a row this year. That made even this self-proclaimed skeptic take notice.

But I still had some concerns. According to one study in the Journal of the American Medical Association, 70% of CBD products didn't contain the amount of CBD stated on their labels. And, as a consumer, that's terrifying!

If I was going to try CBD, I needed to trust the source through and through. My two-fold research process naturally led me to Zebra CBD.

First, I started calling my family and friends. Call me old fashioned but I wanted to know if there were people whom I trusted (more than anonymous testimonials) who've had success using CBD besides my granddaughter.

Secondly, I wanted cold hard facts. Diving deep into the world of CBD research and clinical studies, I came across Emily Gray M.D., a physician at the University of California at San Diego (UCSD) Medical School and medical advisor to Zebra CBD who is researching the effects of CBD. Dr. Gray wrote "early results with CBD have been promising and we have a lot of research underway now. I've had several patients using CBD with good success. It's important that you know your source of CBD and how to use it properly."

After hearing it from the doctor's mouth, I returned to my research, asking more people and was amazed by the number of close friends and family who were already on the CBD train. Apparently, I was the only one without a clue! And funny enough, a couple of friends who commented were using the same brand as my granddaughter—Zebra CBD. There was no consensus as to why they were using CBD, but the top reasons given were for muscle & joint discomfort, mood support, sleep support, stress and headaches, as well as supporting overall health & wellness.

Eventually, even the most skeptical of the bunch can be won over. With a trusted CBD source in mind, I decided to give it a go.

When I viewed Zebra CBD's selection online, I was impressed by its array of products, including CBD oils called tinctures, topicals, chewable tablets, mints and gummies. After reading on their website that all their products are made with organically-grown hemp, I ordered... and it arrived within 2 days!

The first product I tried was the Rub. Now this stuff was strong. Immediately after rubbing it on my knee, the soothing effects kicked in. It had that familiar menthol cooling effect, which I personally find very relieving. And the best part is, after two weeks of using it, my knee pain no longer affected my daily mobility.

The Zebra Sleep Gummies, on the other hand, had a different but equally positive effect on my body. To take it, the instructions suggest chewing thoroughly. This was simple enough, and the taste was, well, lemony. After about 15 minutes, a sense of calm came over my body. It's hard to describe exactly; it's definitely not a "high" feeling. It's more like an overall sense of relaxation—and then I fast asleep. Needless to say, I slept great and woke up refreshed. I haven't slept like that in a long time.

While it hasn't been a catch-all fix to every one of my health issues, it has eased the level and frequency of my aches. And it sure doesn't seem like a coincidence how rejuvenated I feel.

All-in-all, CBD is one of those things that you have to try for yourself. Although I was skeptical at first, I can safely say that I'm now a Zebra CBD fan and that I highly recommend their products.

Also, I managed to speak with a Zebra CBD spokesperson willing to provide an exclusive. If you order this month, you'll receive $10 off your first order by using promo code "**PM10**" at checkout. Plus, the company offers a 100% No-Hassle, Money-Back Guarantee. You can try it yourself and order Zebra CBD at ZebraCBD.com/PM or at 1-888-762-2699.

Can't Stop Thinking About

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FASTER-THAN-LIGHT TRAVEL

THE CREW OF THE USS *ENTERPRISE* starship streaks to a new adventure in every episode of *Star Trek*, somehow traveling at several times the speed of light. This sci-fi mode of practical interstellar travel inspired Mexican physicist Miguel Alcubierre to investigate the feasibility of a real method for light-speed propulsion.

Eventually, Alcubierre published his cutting-edge research to an astonished community of theoretical physicists. The eponymous Alcubierre warp drive hypothetically contracts the spacetime in front of a spaceship while expanding the spacetime behind it, so that the ship moves from Point A to Point B at an "arbitrarily large" speed. By dis-

Can't Stop Thinking About

torting spacetime—the continuum enfolding space and time—an observer outside the ship's "warp bubble" would see the ship moving faster than the speed of light, even though observers inside the craft would feel no acceleration.

If a faster-than-light warp drive like this worked, it would revolutionize humanity's endeavors across the universe, allowing us, perhaps, to reach Alpha Centauri, our closest star system, in days or weeks even though it's four light years away.

However, the Alcubierre drive has a glaring problem: The force behind its operation, called "negative energy," involves exotic particles—hypothetical matter that, as far as we know, doesn't exist in our universe. Described only in mathematical terms, exotic particles act in unexpected ways, like having negative mass and working in opposition to gravity.

Now, researchers at the New York City–based think tank Applied Physics believe they've found a creative new approach to overcoming this roadblock. Along with colleagues from other institutions, the team envisioned a "positive energy" system that doesn't violate the known laws of physics.

Imagine you are an astronaut in space, pushing a tennis ball away from you. Instead of moving away, the ball pushes back, to the point that it would "take your hand off" if you applied enough pushing force, Gianni Martire, CEO of Applied Physics, told *Popular Mechanics*. That's a sign of negative energy, which the Alcubierre drive design requires.

Regular old positive energy is much more feasible for constructing the "warp bubble," a spherical structure that encloses space for a passenger ship using a shell of incredibly dense matter. The bubble propels the spaceship using its powerful gravity without causing the passengers to feel any acceleration. "An elevator ride would be more eventful," Martire said.

Building on a paper authored by the Applied Physics team in 2021, the researchers were able to model the complexity of the system using their own computational program, Warp Factory. These experiments led the first general model of a positive-energy warp drive.

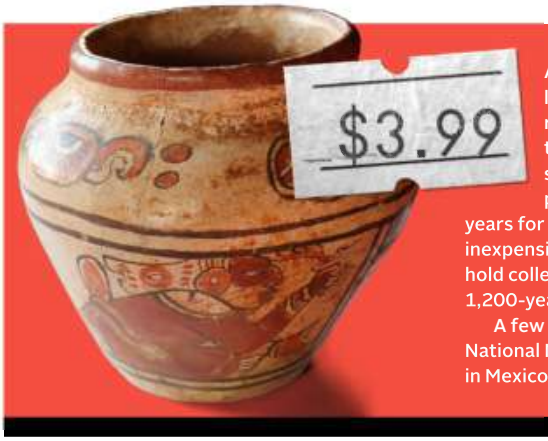
While Applied Physics' current solution only outlines a warp drive that travels below the speed of light, the model still requires a mass equivalent to about two Jupiters. Otherwise, it will never achieve the gravitational force and momentum high enough to cause a meaningful warp effect. But no one knows what the source of this mass could be. Some research suggests that if we could harness dark matter, we could use it for light-speed travel. But Martire is doubtful, since dark matter is currently a mystery.

Despite the many problems scientists still need to solve to build a working warp drive, the Applied Physics team claims its model should eventually get closer to light speed. And even if a feasible model remains below the speed of light, it's a vast improvement over today's technology.

Of course, as you approach the actual speed of light, things get truly weird, according to the principles of Einstein's theory of special relativity. The mass of an object moving faster and faster would increase infinitely, eventually requiring a similarly infinite amount of energy to maintain its speed.

"That's the chief limitation and key challenge we have to overcome—how can we have all this matter in our [bubble], but not at such a scale that we can never even put it together?" Martire said.

The Applied Physics team believes future innovations in warp travel are inevitable. "Humanity," Martire said, "is officially, mathematically, on an interstellar track."—*Manasee Wagh*



A $4 vase sitting on a Maryland thrift store clearance rack looked interesting to Anna Lee Dozier, so she decided to make the purchase. It took about five years for Dozier to discover that this inexpensive addition to her household collection was in fact a roughly 1,200-year-old Mayan artifact.

A few years later she visited the National Museum of Anthropology in Mexico City while on a work trip. "Some of the things I was looking at looked awfully like what I had at home on my shelf," she said.

Experts believe that the vase dates between A.D. 200 and A.D. 800, during the height of Mayan influence. Dozier was more than happy to put such a find in its rightful place.

"Giving it back," she said, "feels so much better than it would if I put it on eBay and I got a bunch of money."—*Tim Newcomb*

EMBASSY OF MEXICO IN THE U.S. (VASE); GETTY IMAGES (STICKER)

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A New Super-Bomb

AN AIR FORCE BOMBER WAS RECENTLY spotted with one of America's newest munitions: the GBU-72 Advanced 5K penetrating bomb. The bomb is designed to help penetrate hardened underground defenses, destroying targets buried under earth and concrete. The weapon appears just as the UN's nuclear agency warns that Iran is accelerating efforts to manufacture enriched uranium—an essential component of nuclear bombs—at underground facilities.

→ **A TORCH Sighting //** According to The Aviationist blog, aviation photographer Ian Recchio was in California's Mojave Desert earlier this year when he overheard chatter on his scanner that referred to an aircraft with the TORCH call sign. Recchio looked up and saw a KC-135 Stratotanker "dragging" a B-1B Lancer bomber—a term used by enthusiasts when an aerial refueling tanker is seen in tandem with another aircraft, typically in the lead. The two planes continued to loiter in the area for two hours.

Recchio took several pictures, not suspecting anything that was unusual. He later went back and noticed that the B-1B had a munition on one of the mounting points of its fuselage. The munition appeared to be a GBU-31—a 2,000-pound (1-ton) GPS-guided bomb—but upon further examination, the bomb carried by the B-1B was discovered to have a second set of fins along the length of its body. That matched the GBU-31's bigger brother, the much larger GBU-72.

→ **Two and a Half Tons of Bomb //** The GBU-72 replaces the GBU-28 in Air Force service. The bomb entered development sometime around 2017, with a projected cost of $36 million for 125

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FROM THE U.S. STANDPOINT, IT IS USEFUL FOR IRAN TO SEE A B-1B BOMBER FLYING AROUND WITH A WEAPON THAT CAN HOLD ITS UNDERGROUND FACILITIES AT RISK.

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bombs. The first test was in October of 2021, during which the bomb was released from an F-15E Strike Eagle at Eglin Air Force Base. At the time, the Air Force revealed that the GPS guidance kit was actually the same one from the 2,000-pound GBU-31 bomb. The Air Force has not disclosed how improved the GBU-72 is over the GBU-28, but at the time of the tests, the program manager said he expected the new bomb's lethality to be substantially higher than the old bomb's.

This new weapon is a glide bomb—it is released from midair and glides to the target, its tail fins making minute corrections to compensate for wind and other factors that might blow the bomb off course. The higher the bomb's release, the farther it can glide to target, allowing an aircraft to deliver ordnance on targets while remaining out of reach of short-range air defenses. The GBU-72's actual range is unknown, but the GBU-31 bomb can glide up to 15 miles. The presence of additional fins on the bigger bomb's body may indicate that it is capable of a greater release range, which would be useful, as a GBU-72 would typically be used against a heavily defended target.

→ **A Not-So-Subtle Sign? //** The B-1B bomber is one of three heavy bombers in the U.S. Air Force's inventory. The Air Force has 45 B-1Bs, and although the "Lancer" originally had a nuclear mission, the fleet was stripped of its ability to carry nukes to comply with U.S.–Russian nuclear treaty obligations. The B-1Bs are purely conventional aircraft which will be retired in the 2030s and replaced by the new B-21 Raider.

The B-1B has three internal bomb bays, each of which can carry eight 2,000-pound bombs or eight AGM-158A Joint Air-to-Surface Standoff Missiles. So, with all that room internally, why was the bomb captured in the recent photos on the outside of the aircraft? The B-1B is probably forced to carry the bomb attached to its fuselage because it is just too long: The GBU-28 is 19 feet long, and the B-1B's bomb bays are 15 feet long. If the new bomb is as long as the old bomb, it would need to go on one of the B-1B's original eight external hardpoints.

This flight test has also taken place as the U.S. and Iran are trading blows in the Middle East, and Iran is drawing closer to manufacturing weapons-grade uranium. From the U.S. standpoint, it is useful for Iran to see a B-1B bomber—an aircraft with the range to strike virtually anywhere in Iran—flying around with a weapon that can hold its underground facilities at risk. Having the press reveal the incident can be perceived as less directly threatening than if the Air Force did, but Iran sees it all the same. This is known as signaling, and is done frequently by many countries. Will we see more signaling in the future? Almost certainly.—*Kyle Mizokami*

What the Equal Sign Really Means

MATHEMATICIAN KEVIN BUZZARD IS grappling in a recent paper—uploaded to the preprint server arXiv—with a simple coding idea that becomes a "thornier concept" when translated into math: What does the equal sign actually mean?

"Six years ago, I thought I understood mathematical equality," Buzzard wrote in his paper. "I thought that it was one well-defined term, and that there was nothing which could be said about it which was of any interest to me as a working mathematician with a knowledge of, but no real interest in, the foundations of my subject. Then I started to try and do master's-level mathematics in a computer theorem prover, and I discovered that equality was a rather thornier concept than I had appreciated."

In coding, there are different kinds of "equal," and you have to completely work through some of the steps the human mind easily skips over when doing math in order to code properly. "The three-character string '2+2', typed into a computer algebra system, is not equal to the one-character string '4' output by the system, for example; some sort of 'processing' has taken place," Buzzard wrote.

So, figuring out the true meaning of the equal sign is not a question of redefining anything in mathematics—it's one of precision and intention.

→ **Strongly and Loosely Typed //** According to Buzzard, the meaning behind the equal sign leaves something to be desired in the "precise and intentional" department. In fact, he describes the current state of the symbol in his paper using a key term: loose.

In our minds, and in the "minds" of the computers we've programmed, there are more steps taking place behind the scenes of an equation than what meets the eye—it's just a matter of how we arrange them. Some programming languages, known collectively as the "strongly typed" languages, require you to specify what a variable is. An "x," for example, could be an integer, a long decimal number, or a string of mixed symbols like a password. Each of those categories is referred to as a "type," and that type is stored along with the value of the variable. If you try to do a math operation, or equate two variables of different types, the coding language won't allow it.

But in some other languages (known as "loosely typed" languages), and in most actual mathematical practices, "type" is more contextual. Instead of checking the assigned type, the language checks whether what's inside the variable can complete the math question being asked. When you look at Buzzard's example of 2+2=4, in our heads we turn the string that is 2+2 into the integer that is 4. Then, we can compare the integers that now exist on both sides of the equal sign.

"In practice," Buzzard wrote, "we use the concept of equality rather loosely, relying on some

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> *"I DISCOVERED THAT EQUALITY WAS A RATHER THORNIER CONCEPT THAN I HAD APPRECIATED.*

kind of profound intuition rather than the logical framework which some of us believe that we are actually working within." In his chosen proof verifier software, known as the Lean system, steps must be defined much more discreetly.

→ **Back to Math Equality //** In his paper, Buzzard uses mathematician Alexander Grothendieck as an example. Grothendieck was a luminary in 20th-century math who laid out a number of foundational ideas in algebraic geometry, and arguably made his name by doing "loosely typed" mathematics.

Buzzard points out a specific moment where Grothendieck doesn't just loosely type—he asks math peers to understand when he uses an entirely new term, "canonically isomorphic," as a new variety of equality. "Lean would tell Grothendieck that this equality simply isn't true and would stubbornly point out any place where it was used. Let me emphasize once more: Grothendieck was well aware of what he was saying, but Lean would argue that he was confusing = and ≅," Buzzard explained. (The latter of those two symbols is the congruence sign: a symbol which means that two sets of points form the exact same shape with the exact same size.)

Buzzard concludes that if math wants to be "formalized"—in other words, to be seamlessly turned into the tiny individual steps represented by code and formal proofs—there are many skips or "holes" (like Grothendieck's) that will need to be filled. He's not claiming that any of this work isn't correct—just that it isn't yet fully broken down into all of the required steps.

As mathematicians continue to tip the scales with 100-plus-page proofs that even their colleagues aren't able to parse, it's probably a good idea to have as much certainty as possible about what equals what.—*Caroline Delbert*

REGROWING HUMAN TEETH

The average adult human body contains 206 bones—the hardened mixtures of calcium, minerals, and collagen that provide the biological scaffolding that walks us through our day. Bones are incredibly resilient, but if they do break, they have this nifty trick of regrowing themselves.

Teeth, however, are not bones. Although they're made of some of the same stuff and are the hardest material in the human body (thanks to their protective layer of enamel), they lack the crucial ability to heal and regrow themselves. But that may not always be the case. Japanese researchers are moving forward with an experimental drug that promises to regrow human teeth, and human trials are set to begin this year.

This development follows years of study around a particular antibody named Uterine sensitization–associated gene-1 (USAG-1), which has been shown to inhibit the growth of teeth in ferrets and mice. Back in 2021, scientists from Japan's Kyoto University discovered a monoclonal antibody (usually used in fighting cancer) that disrupted the interaction between USAG-1 and molecules known as bone morphogenetic protein, or BMP.

This fall, humans will undergo a trial to investigate the efficacy of this antibody. Lasting 11 months, this study will focus on 30 males between the ages of 30 and 64—each missing at least one molar. No side effects have been reported in previous animal studies.

If all goes well, Kitano Hospital will administer the treatment to patients between the ages of 2 and 7 who are missing at least four teeth, with the end goal of having a tooth-regrowing medicine available by the year 2030.—*Darren Orf*

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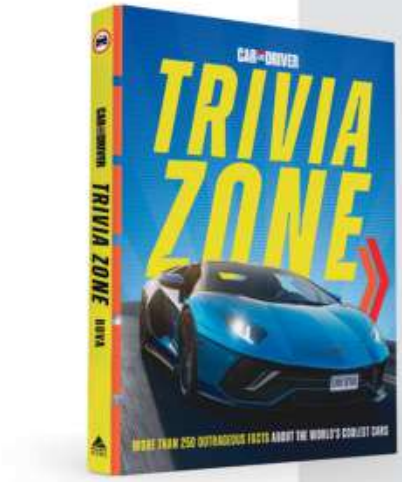

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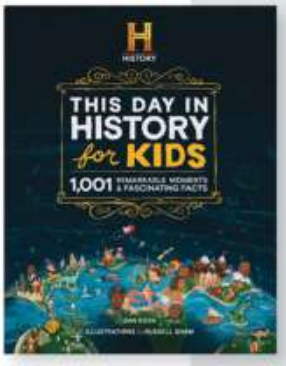

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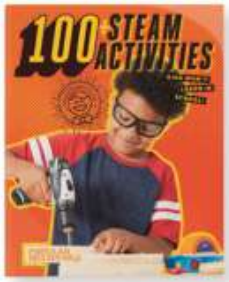

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Mysterious Microwave Signals

SPACE IS A BIG PLACE. But despite our diminutive size among the hundreds of billions of stars in the Milky Way (which is itself among hundreds of billions of galaxies), scientists have slowly pieced together a long list of all the strange stuff we might encounter throughout the cosmos. However, sometimes humanity's collection of observational equipment comes across as a real head-scratcher.

Meet the latest one, identified in a paper published in the journal *The Astrophysical Journal Letters*—the millimeter ultra-broad-line object, or the MUBLO for short.

The object in question lies near the center of the Milky Way Galaxy, which the researchers describe as containing "tens of millions of solar masses of gas, a supermassive black hole, a tenth of our galaxy's ongoing star formation, and an extensive graveyard of stellar remnants."

While gazing at our galaxy's center, researchers stumbled upon a compact source subsequently labeled "G0.02467–0.0727," otherwise known as the MUBLO. Made of cold dust and fast-moving gas, the MUBLO also exhibited another strange behavior—it only emitted microwave radiation. Adam Ginsburg, the lead author on the paper, and his team went through the long list of celestial explanations and came up short.

"We consider several explanations for the [MUBLO], including protostellar outflow, explosive outflow, a collapsing cloud, an evolved star, a stellar merger, a high-velocity compact cloud, an intermediate-mass black hole, and a background galaxy," the paper reads. "Most of these conceptual models are either inconsistent with the data or do not fully explain them. The MUBLO is, at present, an observationally unique object."

Of the various celestial phenomena examined in the paper, the authors point out two that could explain the MUBLO—a stellar merger or an intermediate-mass black hole (IMHO). However, neither of these hypotheses are perfect. While the stellar merger idea is compelling, the MUBLO "dust mass is substantially larger, by more than an order of magnitude, than observed toward any other merger remnant." As for the IMHO suggestion, it "does not explain all of the observed features of the MUBLO."

For now, add another galactic mystery to the list.—*D.O.*

GETTY IMAGES

This Brand-New Cat Color

ARI KANKAINEN

YOU'VE PROBABLY HEARD OF spooky black cats, distinguished-looking tuxedo cats, and chaotic orange cats. If you're really into cats, you might even have heard of lesser-known color variants like seal point and ticked tabby. But there's officially a new cat color in town—salmiak, or "salty liquorice," named for a popular snack food in Finland, where this coat color has been making itself known.

The pretty black, white, and gray shade is thanks to a fur strand that starts off black near the root but grows whiter and whiter toward the tip. Since 2007, researchers at the University of Helsinki have been trying to determine exactly what causes this shade—and they think they've finally figured it out.

Technically speaking, cats come in only two colors—black and orange. Any other color is either a combination of those two colors, a faded version of one of those colors (which is caused by the dilution gene), or both. So when experts started seeing kitties with fur that was gray at the root and white on the tip, the assumption was that this was a new expression of the dilution gene.

But after digging through all the known genetic variations that control the expression of that dilution gene in coat color, the team came up empty. So they began sequencing the entire genome of two of these special felines, and it turns out that the answer was in what *wasn't* there.

"There was a huge chunk of sequence missing downstream from the KIT gene," feline geneticist Heidi Anderson told *New Scientist*, referencing a gene known to affect white patterns in the coats of animals. These cats were just…missing a piece of DNA right nearby. And the mutation was recessive—the cat would only express this color if it inherited the mutation from both parents, which explains why this coloration isn't a common one.

> *" THERE WAS A HUGE CHUNK OF SEQUENCE MISSING DOWNSTREAM FROM THE KIT GENE.*

Now that they've solved the mystery, the team is happy to sit back and admire their pretty kitties along with the rest of the world.—*Jackie Appel*

Sacred Stone of the Southwest is on the Brink of Extinction

Centuries ago, Persians, Tibetans and Mayans considered turquoise a gemstone of the heavens, believing the striking blue stones were sacred pieces of sky. Today, the rarest and most valuable turquoise is found in the American Southwest— but the future of the blue beauty is unclear.

On a recent trip to Tucson, we spoke with fourth generation turquoise traders who explained that less than five percent of turquoise mined worldwide can be set into jewelry and only about twenty mines in the Southwest supply gem-quality turquoise. Once a thriving industry, many Southwest mines have run dry and are now closed.

We found a limited supply of turquoise from Arizona and purchased it for our ***Sedona Turquoise Collection***. Inspired by the work of those ancient craftsmen and designed to showcase the exceptional blue stone, each stabilized vibrant cabochon features a unique, one-of-a-kind matrix surrounded in Bali metalwork. You could drop over $1,200 on a turquoise pendant, or you could secure 26 carats of genuine Arizona turquoise for **just $99**.

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How to Be Super With Super Glue

EVERY ADHESIVE REQUIRES YOUR PAR-ticipation. Not every glue works in every application. Super glue (cyanoacrylate) is no exception. There are hundreds of applications for this material, and probably several dozen common applications and techniques that you need to know. We'll boil it all down to a few basics.

→ **Don't Glue These Materials** // Never use cyanoacrylates to bond cotton, wool, burlap, or blends of those materials with synthetic materials such as polyester. Cyanoacrylates can react exothermically with these materials, and the reaction is so powerful that it can produce smoke (maybe even catch fire).

→ **Use the Right Glue** // Super glue can have a thick or thin consistency, up to the point of being a gel. Use thick glue where you need the adhesive to stay put, such as on a vertical surface, as well as on surfaces that absorb the adhesive such as leather, cardboard, and the end grain of wood. It's also handy on surfaces where, when pressed together, there will be some squeeze-out.

→ **Read the Package** // Super glue is formulated for both broad and specific applications. If you haven't read the package, it won't be obvious which one. Some formulations work across a broad range of materials and applications; other super glues are somewhat specific. The package will tell you how quickly the glue sets, whether it's thick or thin, and whether it offers good shock resistance. It will also tell you what materials it can be used on and what materials it cannot.

→ **Mind the Gap** // Some cyanoacrylates are specifi-

TREVOR RAAB

1920s Style for a 1920s Price

It was a warm summer afternoon and my wife and I were mingling with the best of them. The occasion was a 1920s-themed party, and everyone was dressed to the nines. Parked on the manse's circular driveway was a beautiful classic convertible. It was here that I got the idea for our new 1920s Retrograde Watch.

We carefully climbed into the car's long front seat. Among the many opulent features on display was a series of dashboard dials that accentuated the car's lavish aura. One of those dials inspired our 1920s Retrograde Watch, a genuinely unique timepiece that marries timeless style with modern technology.

With its remarkable retrograde hour and minute indicators, sunburst guilloche face and precision movement, this design is truly one of a kind. What does retrograde mean? Instead of displaying the hands rotating on an axis like most watches, the hands sweep in a semicircle, then return to their starting point and begin all over again.

Retrograde watches by the big brands can set you back thousands; one recent offering from a big French fashion house is selling for more than $150,000! But because we've designed the 1920s Retrograde Watch in-house, we can offer it to you for just $99!

This watch is so wildly popular with our customers that we're actually concerned about running out; we only have ~~937~~ 729 left for this ad!

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Can't Stop Thinking About

cally formulated to form a bond across gaps—some of them pretty large. We've seen product specs of industrial versions that will bridge a gap as large as 0.200 inch. In most cases, gap filling is somewhere in the range of 0.004 to 0.008 inch.

→ **Surface Prep Matters //** Super glue is no different than any other adhesive in that the smoother and flatter the two joining surfaces, the better the bond. When bond strength is critical, grind, sand, or clean the surfaces to remove paint, rust, mill scale, dirt, grease, and wood finishes.

→ **Hold Steady //** Even slight movement is enough to break the bond that super glue is forming. You need to either hold steady or use a clamp to provide consistent pressure to the joint.

→ **Use an Accelerator //** When you need a perfectly glued joint, use an accelerator to freeze the joint in position. Accelerator is a catalyst that can be applied on one side of the joint while super glue is applied to the other. In other cases, it can be applied to the glue that squeezes out of the joint, hardening it nearly instantly.—*Roy Berendsohn*

1. We took two pieces of square tubing and ground their surfaces flat, then applied a medium-viscosity super glue to one side. 2. We pressed the second piece into position and moved in a circular motion to distribute the glue on the joining faces. We did not clamp other than by pressing with our hands. After about 30 seconds we let go. About a minute after making the joint, we could lift the sample by the upper piece. Approximately two hours later, the sample could withstand three heavy blows from a ball-peen hammer.

ALL THESE DIFFERENT PORTALS

PORTAL TO HELL → OceanGate's cofounder wants to explore one of the deepest **"blue holes"** (sinkholes filled with water) on Earth. Dean's Blue Hole—which local legends say is actually a portal to hell—is a staggering 663 feet deep, and is ripe for exploration.

PORTAL TO THE UNDERWORLD → A "portal to the underworld" statue depicting the Olmec jaguar god Tepeyollotlicuhti returned to its Mexican home in May of 2023.

After a year of work, the statue—which had been broken into smaller pieces by looters—has finally been restored to its former glory.

PORTAL ANOMALY → A new study has revealed an L-shaped structure and accompanying anomaly right next to the Great Pyramids of Giza.

Although it's impossible to know for sure what the anomaly is, the researchers guess that the L-shaped discovery could be a portal, or entrance, to a deeper structure.—*D.O.*

TREVOR RAAB (SUPER GLUE); GETTY IMAGES (PORTALS)

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This Missing WWII Plane

MAJOR RICHARD BONG WAS THE TOP flying ace of World War II for the United States, credited with 40 aerial victories against Japanese aircraft. For his heroism, General Douglas MacArthur presented Bong with a Medal of Honor in December 1944. According to the Congressional Medal of Honor Society, Bong undertook dangerous combat missions and downed enemy planes, despite being "assigned to duty as gunnery instructor, and neither required, nor expected, to perform combat duty."

Bong, who was known as the "Ace of Aces," took down all 40 of those Japanese fighter planes while flying the same aircraft: a Lockheed P-38 Lightning fighter that he named for his sweetheart, "Marge." And for 80 years, that historic plane was lost to time.

But now, Marge has finally been found, thanks to a joint venture between the Richard I. Bong Veterans Historical Center and Pacific Wrecks, a charity that helps to "locate and document Missing In Action (MIA) personnel."

Explorers located Marge in the Madang Province of New Guinea, according to Heritage Daily. The search crew found Bong's P-38, serial number 42-103993, after just two days of trekking through the jungle.

Although Bong's plane crashed in that New Guinea jungle 80 years ago, it wasn't Bong who was actually in the aircraft when it went down. But about a year after that plane's crash, Bong was testing out a Lockheed P-80A Shooting Star when a fuel pump malfunction occurred. Bong bailed out, but he was too low for his parachute to properly deploy and was killed upon impact with the ground. He was only 24 years old.

For his remarkable career, Bong was posthumously inducted into the National Aviation Hall of Fame in 1986, and the Richard I. Bong Veterans Historical Center was created in his honor. The Center, located in Bong's birthplace of Superior, Wisconsin, boasts a museum, a screening room, and even a replica of the pilot's legendary P-38.

Now, through the Historical Center's efforts, in tandem with the not-for-profit 501(c)(3) Pacific Wrecks that undertook the search, the museum no longer needs to only settle for a facsimile of the famed fighter plane.—*Michael Natale* PM

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BY DAVID HOWARD

For years, treasure hunters have tried to solve the **Beale ciphers** and unearth a cache of staggering riches. These amateur sleuths think they've finally cracked the codes.

A MASSIVE TREASURE LIES HIDDEN IN A MANSION IN PHILADELPHIA.

Ken Bauman is certain of it, and he spent 22 years in law enforcement—most of it as a railroad detective with the Norfolk Southern Railway police. He has pursued this historic stash—said to include nearly 3,000 pounds of gold and 5,100 pounds of silver, among other highly valuable items—for nearly two decades.

Bauman can pinpoint exactly when he began searching: July 30, 2005. That's the day he learned of the Beale ciphers, a three-part, nineteenth-century code said to be the key to the vast treasure. At 63, Bauman has a crew cut and gray beard and plainspoken Midwestern style that reflects his Indiana heritage. He'll say things like, "I'm an out-of-the-box thinker. This is why I was very good at detective work in law enforcement, and I was very successful. I received awards for that." He doesn't come across as bombastic in any particular way. But when he talks about Beale, he says the most incredible things: It involved Edgar Allen Poe and, later, members of the Confederate Army.

Since the 1800s, the Beale ciphers have lured tens of thousands of searchers: treasure hunters who have combed countless hills throughout the country; computer geeks who turned to processing power to crack the mystery; career government spies; historians who have plunged into archives in search of clues; and many others. The notion that a treasure of such magnitude could stay hidden for so long against such an outpouring of resources is no deterrent. Nor do the Beale seekers seem discouraged by the various parties who have stepped forward over the past century-plus with evidence that the ciphers stand for nothing more than an elaborate hoax. "I tend to stay away from those people," Bauman says, "because I know differently, and they're a waste of my time."

To him, in fact, the failures over nearly a century and a half are validation of a sort: No one has solved the puzzle precisely because no one who came before has developed and followed the right set of clues—the ones only he has identified.

A cipher is a system for encrypting or decrypting data—most often words, as is the case with Beale. Many are made up of sequences of seemingly random numbers, all of which, in theory,

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correspond to letters that spell out a message, or a piece of information. Bauman says he cracked the first of Beale's three codes, known as C1—which reveals the location of the treasure—within about two hours. Instead of corresponding each number with the first letter of each word in the Declaration of Independence, long believed a key to one of the three ciphers, Bauman used the *last* letter of each word. This technique revealed a nonsensical string of letters, but Bauman knew from research that sometimes cryptographers hide their messages backwards. He flipped the order of the letters, which produced the phrase "Ere fen due red knee."

Nonsense? Maybe not, he thought. Bauman found that an old definition of "ere" is to dig or plow. A fen is a low-lying marshy spot. "Red knee" is a species of tarantula, and there's a tarantula mentioned in the first sentence of Edgar Allen Poe's story "The Gold Bug." Bauman contends that the first Beale cryptogram sends codebreakers to the Poe story, which in turn reveals the location of the gold to be Mount Pleasant, an 18th-century mansion situated alongside the Schuylkill River in Philadelphia.

Bauman sought permission to search the building for the loot, but was turned down by representatives of its owner, the Philadelphia Museum of Art. He is undeterred by this obstacle as well. He believes there will eventually be a way in.

"The thing is with Beale, anything is possible," Bauman says. "It is a mystery story that is incredibly developed." He's not sure he will ever run a finger over a piece of gold from the treasure. All he knows for certain is that the hunt for this historical prize has become his defining purpose—one that, in a real and tangible way, saved his life.

THE STORY OF THE TREASURE GOES LIKE THIS. AROUND 1819, A party of explorers located a vast trove of gold and silver near what is now Santa Fe, New Mexico. The group's leader, Thomas Jefferson Beale, hailed from a distinguished family with roots in upper-crust Britain, though research has revealed him to be something of a scofflaw—a womanizer and gunslinger. According to legend, a dispute over a woman escalated into a pistol fight with a neighbor. Believing his rival was dead, Beale bolted for the West, where he fell in with the crew that eventually found the stash of precious metals.

The men realized they had unearthed an ungodly sum; today, the gold alone would be worth more than $60 million. But rather than hide it there, the tale holds that the group shuttled it back east on wagon trains, eventually navigating the Blue Ridge Mountains to reach Bedford County, Virginia, where they buried it in 1820.

Despite this effort and the staggering value of their haul, the group headed back west for a second expedition. Purportedly Beale left behind a locked iron strongbox with Lynchburg tavern keeper Robert Morriss, then sent instructions to open it if he hadn't returned within a decade. Morriss forgot about the box for 23 years. When he finally broke the lock, he found two letters, along with "some unintelligible papers covered with figures"—the three ciphers. The missives described the treasure and said the code keys were in the mail—but they never appeared. Morriss spent the next 17 years trying to make sense of Beale's bequeathal. Beale himself was never seen again.

In 1862, a frustrated and aging Morriss handed the documents to family friend James Ward, then a prominent citizen of Lynchburg. Ward announced he had solved C2, claiming it was a substitution cipher based on the Declaration of Independence. It described the supposed treasure and indicated that directions for locating it were in C1, and that C3 listed the next of kin of Beale's crew, should folks who might find the loot want to hand it over to their heirs. Ward commenced hunting for key texts for the other ciphers, experimenting with every readily accessible document Beale might have used. Exasperated after 20 years, he published the codes and the story of their provenance in a pamphlet called "The Beale Papers."

The document proffered a warning: "Devote only such time as can be spared from your legitimate business to the task," Ward wrote, "and if you can spare no time, let the matter alone."

Treasure hunters of all types have spent the subsequent 140 years flouting that counsel, hunkering in libraries, driving bulldozers, wielding shovels, digging countless holes across the Virginia countryside, and in the process becoming so ubiquitous that some Roanoke-area farmers took to shooting at trespassers. One Alabaman who began searching for the treasure in 1964 worked on the codes every night from 10 p.m. to 2 a.m.—then, over about 17 years, put in 150,000 miles of driving throughout the Blue Ridge, shoveling holes. All these searchers were and are united in the belief that the solution was sheathed only by our lack of imagination and deductive acumen—that enough clever prodding and massaging would eventually lead to a treasure of unimaginable proportions. *Smithsonian* magazine in 1981 called Beale "one of the largest and most costly treasure hunts in U.S. history, baffling the finest mathematical minds in the country and defeating their computers…while inducing frustration, despair and bankruptcy."

One such mind belonged to Carl Hammer. In its online tribute to Hammer, the Institute of Electrical and Electronics Engineers Computer Society calls out two career highlights: He was an educator and lecturer "who conveyed the exciting message of computers and their mind-boggling future applications early on to audiences worldwide," and he was obsessed with the Beale Papers. To that end, in 1968 he formed an organization that became the Beale Cypher Society, recruiting a colorful cast of fellow nerds along with cryptanalysts from the CIA and National Security Agency. The nonprofit held international symposia in Washington, D.C., that were open to the public, in hopes someone might walk in off the street with a new idea for piercing the opacity of the puzzle. "You never know what insights and special knowledge you might get from strangers," he told the *Washington Post* in 1979—but mostly the meetings devolved into heated

arguments between supposed code breakers. Others opined that the whole thing was a fraud.

But after conducting computer work so extensive that it would have taken "a million men a billion years to duplicate with pencil and paper," Hammer was convinced the numbers in Ward's pamphlet were codes, and not just random figures.

THE TREASURE IS STASHED IN AN ARIZONA gold mine. James Simpson is sure of it.

Simpson, 47, is an obsessive tackler of historic mysteries. He grew up in New Jersey and Atlanta, where he landed several architecture apprenticeships. In 1995, while in his 20s, he followed his girlfriend to Burlington, Vermont, where he did architectural work on construction projects. He eventually began designing and engineering bicycles for bike-share programs, and in 2014 he moved into the warehouse where he developed prototypes. "I've got big prospects in the future for big bike rental hubs in New York City and other places," he says. But winter in northern New England is a tough time to road-test such innovations, so when the weather turned, he focused on his favorite pastime: breaking ciphers. Simpson claims to have cracked many such puzzles over the years, including ciphers related to the American Revolution, Jack the Ripper, and the Lindbergh kidnapping—all his theories laid out on a series of public Facebook pages. This fascination inevitably led him to Beale, and when he absorbed the size of the potential jackpot, he dug in deep, hopeful he might make enough money to fund a full production line for his bike-share initiative.

The Beale mystery struck him as "kind of like a big adventure," he says. "I was like, oh, this is gonna be cool if I ever nail the ciphers."

With Beale, his epiphany was that the cipher includes numbers up to 2,906, which is an unusually high number for a substitution cipher. "You're saying to yourself, if somebody was just going to encrypt something, they would be able to easily do it and spell every word correctly, because they've got a key to it," Simpson says. But he and others have pointed out problems with even the part of the cipher James Ward supposedly solved: the part with the Declaration of Independence as the key. When people analyzed the effort, they found Ward had miscounted words and factored in misspellings. "When you see something like that," Simpson says, "that means it's encrypted in another way."

He developed a theory that Beale is a box cipher, a grid on which the words (or shorthand versions of them) extend horizontally, vertically, even diagonally. He also opined that for a key, Beale simply used an ascending set of alphabets: A through Z is 1 through 26; for the next sequences, A is 27, then 53; and so on, with the numbers and their associated letters climbing all the way to 2,906.

A copy of an original page from the Beale Papers, published by James Ward in 1885.

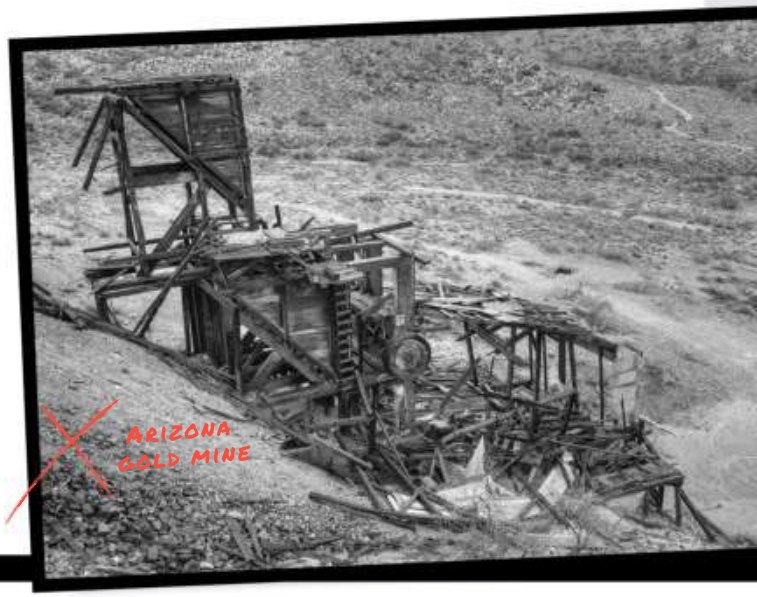
Doing that much plotting and decrypting would be an enormous amount of work, so Simpson deployed ChatGPT to help, telling the artificial intelligence tool to create a series of ascending alphabets associated with corresponding numbers up to 2,906. With this key in hand, he applied letters to every number in the ciphers. From there he made many calculations and suppositions and deductive leaps, but the gist is that he claims to have uncovered messages he matched to landmarks and mapping systems around a network of Arizona gold mines.

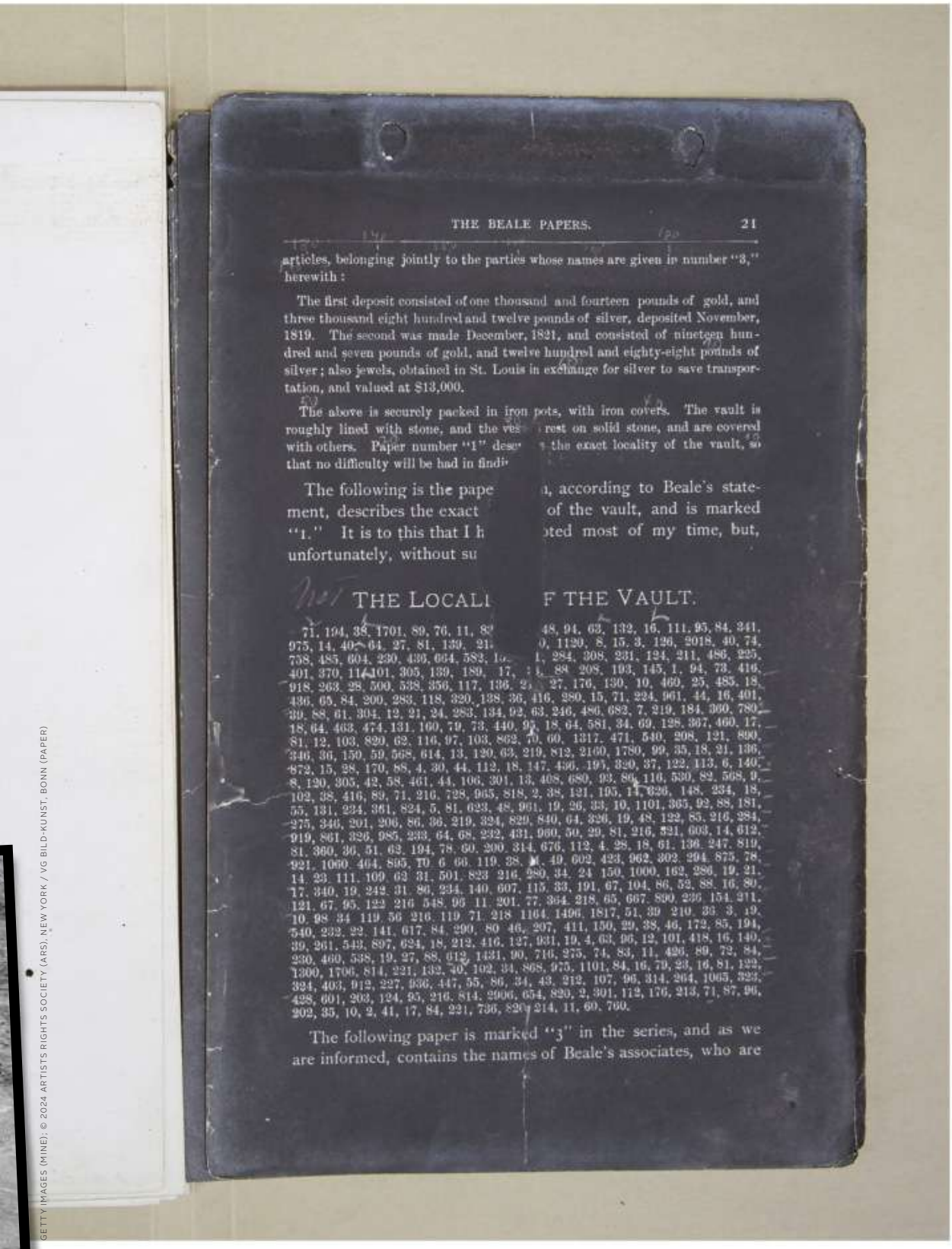
In 2022, Simpson moved to the Phoenix area, where he acquired Bureau of Land Management claims for mines northeast of the city, with the intention of extracting the Beale treasure—or at least mining gold. "We found everything on the map, and matched it to a Google satellite photo," he says. "So everything kind of laid out exactly as the map was designed, of all the river channels and everything."

As he intuited early on, the hunt has made for a burly adventure. Simpson's father was an early leader in the Boy Scout Explorers, and James himself has long been an avid outdoorsman, so he considered the challenging landscape part of the joy of the hunt—to access mines, he has often called upon his rock-climbing and caving skills and gear. Simpson plans to return with foot-long hammer drill bits and other tools, hoping to inspire a documentary and write a book about his quest for history. "Everything I'm working on has either an educational value to it, or it has a physical value to it, as far as the extraction of the gold from the mine," Simpson says.

DURING HIS TIME AS A PROFESSOR OF PSYCHOLOGY AT THE University of North Dakota, Alan King has mostly studied childhood development. But in 2015, his interests took an unexpected turn.

King was drinking coffee with his wife one weekend that year when *CBS Sunday Morning* featured a segment about a treasure





THE BEALE PAPERS. 21

articles, belonging jointly to the parties whose names are given in number "3," herewith:

The first deposit consisted of one thousand and fourteen pounds of gold, and three thousand eight hundred and twelve pounds of silver, deposited November, 1819. The second was made December, 1821, and consisted of nineteen hundred and seven pounds of gold, and twelve hundred and eighty-eight pounds of silver; also jewels, obtained in St. Louis in exchange for silver to save transportation, and valued at $13,000.

The above is securely packed in iron pots, with iron covers. The vault is roughly lined with stone, and the ves rest on solid stone, and are covered with others. Paper number "1" dese the exact locality of the vault, so that no difficulty will be had in findi

The following is the pape , according to Beale's statement, describes the exact of the vault, and is marked "1." It is to this that I h ted most of my time, but, unfortunately, without su

THE LOCALI F THE VAULT.

71, 194, 38, 1701, 89, 76, 11, 83 48, 94, 63, 132, 16, 111, 95, 84, 341, 975, 14, 40 64, 27, 81, 139, 21 0, 1120, 8, 15, 3, 126, 2018, 40, 74, 758, 485, 604, 230, 436, 664, 582, 1 1, 284, 308, 231, 124, 211, 486, 225, 401, 370, 114101, 305, 139, 189, 17, 88 208, 193, 145, 1, 94, 73, 416, 918, 263, 28, 500, 538, 356, 117, 136, 2 27, 176, 130, 10, 469, 25, 485, 18, 436, 65, 84, 200, 283, 118, 320, 138, 36, 416, 280, 15, 71, 224, 961, 44, 16, 401, 39, 88, 61, 304, 12, 21, 24, 283, 134, 92, 63, 246, 486, 682, 7, 219, 184, 360, 780, 18, 64, 463, 474, 131, 160, 79, 73, 440, 95 18, 64, 581, 34, 69, 128, 367, 460, 17, 81, 12, 103, 820, 62, 116, 97, 103, 862, 70, 60, 1317, 471, 540, 208, 121, 890, 346, 36, 150, 59, 568, 614, 13, 120, 63, 219, 812, 2160, 1780, 99, 35, 18, 21, 136, 872, 15, 28, 170, 88, 4, 30, 44, 112, 18, 147, 436, 195, 320, 37, 122, 113, 6, 140, 8, 120, 305, 42, 58, 461, 44, 106, 301, 13, 408, 680, 93, 86, 116, 530, 82, 568, 9, 102, 38, 416, 89, 71, 216, 728, 965, 818, 2, 38, 121, 195, 14, 626, 148, 234, 18, 55, 131, 234, 361, 824, 5, 81, 623, 48, 961, 19, 26, 33, 10, 1101, 365, 92, 88, 181, 275, 346, 201, 206, 86, 36, 219, 324, 829, 840, 64, 326, 19, 48, 122, 85, 216, 284, 919, 861, 326, 985, 233, 64, 68, 232, 431, 960, 50, 29, 81, 216, 321, 603, 14, 612, 81, 360, 36, 51, 63, 194, 78, 60, 200, 314, 676, 112, 4, 28, 18, 61, 136, 247, 819, 921, 1060, 464, 895, 10 6 66, 119, 38, 4 49, 602, 423, 962, 302, 294, 875, 78, 14, 23, 111, 109, 62, 31, 501, 823, 216, 980, 34, 24, 150, 1000, 162, 286, 19, 21, 17, 340, 19, 242, 31, 86, 234, 140, 607, 115, 33, 191, 67, 104, 86, 52, 88, 16, 80, 121, 67, 95, 122, 216, 548, 96, 11, 201, 77, 364, 218, 65, 667, 890, 236, 154, 211, 10, 98, 34, 119, 56, 216, 119, 71, 218, 1164, 1496, 1817, 51, 39, 210, 33, 3, 19, 540, 232, 22, 141, 617, 84, 290, 80, 46, 207, 411, 150, 29, 38, 46, 172, 85, 194, 39, 261, 543, 897, 624, 18, 212, 416, 127, 931, 19, 4, 63, 96, 12, 101, 418, 16, 140, 230, 460, 538, 19, 27, 88, 612, 1431, 90, 716, 275, 74, 83, 11, 426, 89, 72, 84, 1300, 1706, 814, 221, 132, 40, 102, 34, 868, 975, 1101, 84, 16, 79, 23, 16, 81, 122, 324, 403, 912, 227, 936, 447, 55, 86, 34, 43, 212, 107, 96, 314, 264, 1065, 323, 428, 601, 203, 124, 95, 216, 814, 2906, 654, 820, 2, 301, 112, 176, 213, 71, 87, 96, 202, 35, 10, 2, 41, 17, 84, 221, 736, 820, 214, 11, 60, 760.

The following paper is marked "3" in the series, and as we are informed, contains the names of Beale's associates, who are

hunt created by a man named Forrest Fenn. An art and antiques dealer, Fenn in 2010 claimed he had stashed a chest filled with gold and other items worth at least $1 million somewhere in the Rocky Mountains. Soon after, he published a memoir titled *The Thrill of the Chase*, containing a 24-line poem that revealed clues to the loot's whereabouts. Hundreds of thousands of people pursued it.

Something about Fenn and his prize caught King's attention and wouldn't let go. Soon after switching off the TV, he found himself googling. It seemed ludicrous to even consider getting involved. "I'm not a thrill seeker," he says.

But over subsequent days and weeks, he continued researching, thinking about Fenn, chatting about the treasure with other interested parties online. "After about a month, I said, 'I know as much as these people,'" he recalls. "'I can compete in this as well as any of them.'"

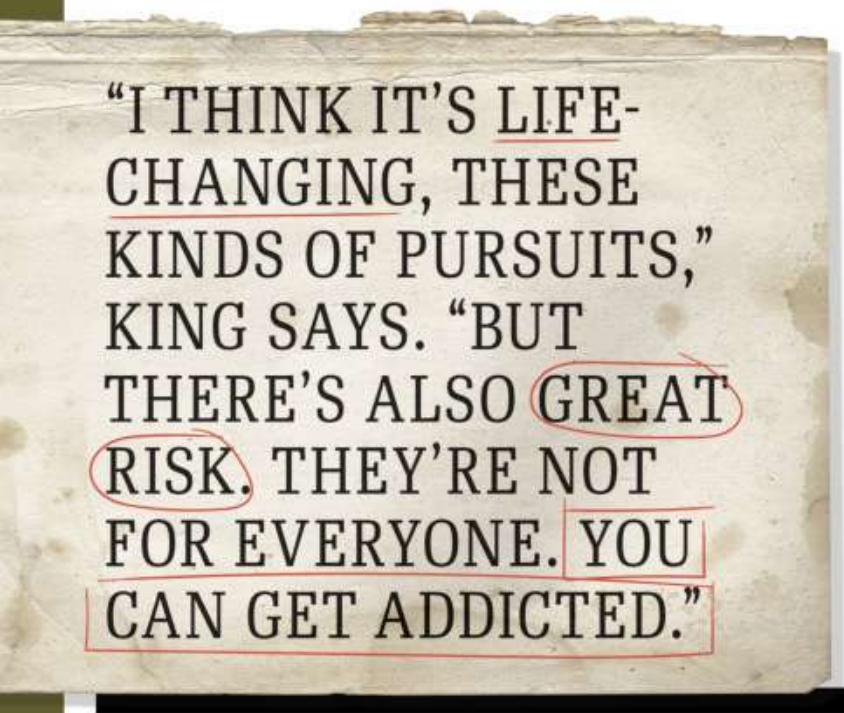
Within 12 to 18 months, he was driving from North Dakota to Wyoming, plunging into a swath of wilderness in the Bighorn Mountains where he theorized the treasure might be located. His family accompanied him on some of these forays, which he describes as the "thrill of my life." But on his third trip, he and his youngest son became lost at about 9,000 feet elevation and spent a harrowing day dehydrated and trying to reorient themselves. "I took unnecessary risks there," he says, "and we're lucky it wasn't tragic." He thought to himself, *Alan, you gotta quit playing these games. This is crazy stuff.* But he went back 13 more times.

The risks proved all too real: Five people died pursuing the Fenn treasure before it was finally discovered in 2020. Along the way, King became interested in what was driving his fellow hunters. He noticed that it takes certain personality traits to persist through the impasses every treasure seeker encounters. "I think it's life-changing, these kinds of pursuits," King says. "But there's also great risk. They're not for everyone. You can get addicted."

Puzzled and fascinated by his own behavior and that of his fellow seekers, King did what he knows best: He began conducting studies. Among other things, he wanted to identify the forces motivating people to chase Fenn's treasure into the wilderness—or, more improbably, pursue a mystery more than a century old that could well be a hoax. He began circulating research requests among what he'd come to refer to as his "community." Although the work built on a long history of psychological concepts, King believes he arrived at an original insight, called the Liminal Commitment Theory—essentially, the psychology of people pursuing the unattainable.

LCT traces the behavior back to psychologist Abraham Maslow's hierarchy of needs. Maslow's theory was that human motivation arises from a hierarchy of five basic categories: physiological, safety, love, esteem, and self-actualization. He opined that as people progress through these levels—famously depicted as a pyramid—they experience a greater sense of fulfillment and motivation. King noted that individuals who struggle with the first levels of the pyramid—having enough food, for example, or feeling safe from crime—don't do treasure hunts. Of the remaining U.S. population, he estimates, 10 to 20 percent fit the emerging treasure-hunter profile: About 75 percent are male, and they're often older. A significant number have what he calls hypomanic personality traits: high energy, boundless optimism. And he believes that about 10 percent of his community is at risk of clinically defined addiction—people who "are really paying a very high price for their pursuit…and they're out of control. They're having trouble leaving it alone."

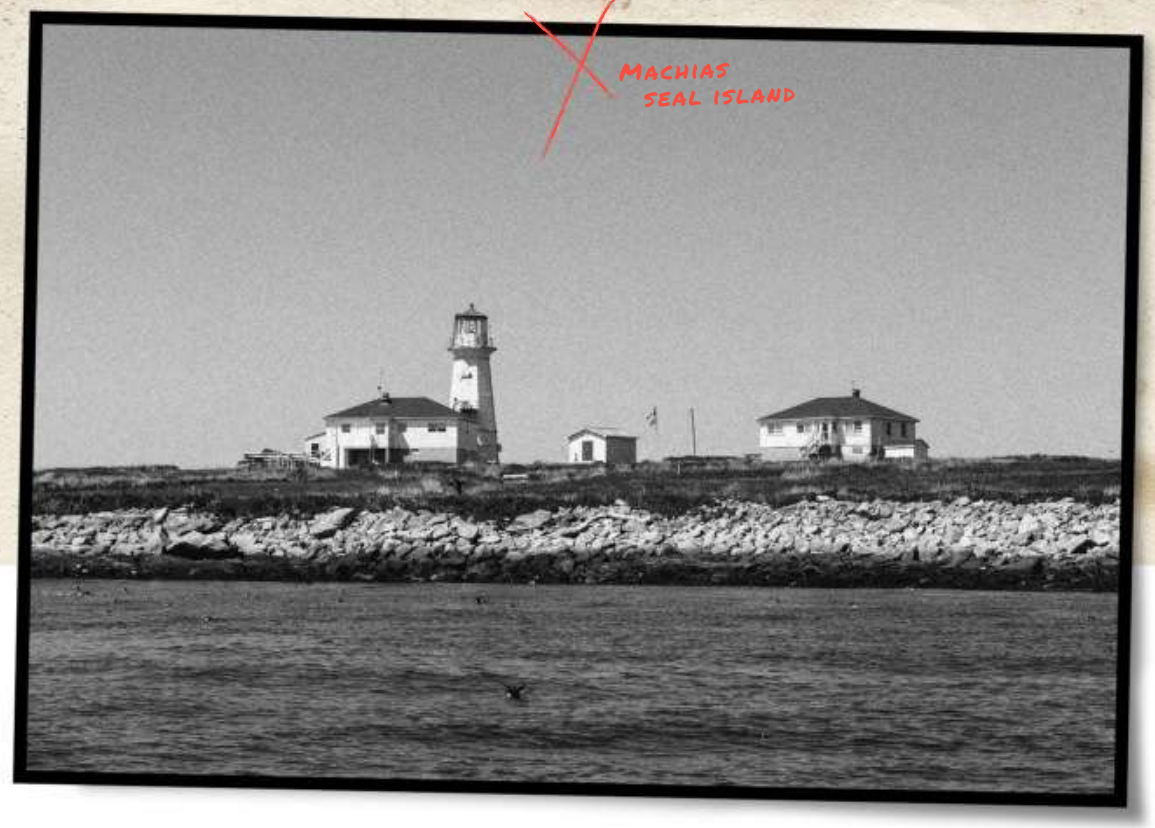
"I think it takes a certain personality constellation to embrace those goals and to pursue them," he says, "and to be able to do so over a long period of time without lots of negative consequences."



THE TREASURE IS ON MACHIAS Seal Island, a remote 15-acre treeless splotch of land off the coast of northern Maine. Ron Gervais is sure of it. So is Ken Bauman.

Why would Bauman advocate for a location so far from the Philadelphia mansion where he also believes the trove is stashed? He argues that the Beale Papers are so expansive that they point to four locations where the treasure may be dispersed: Mount Pleasant, Machias Seal, a second location in Pennsylvania, and a site in Virginia they can't yet discuss.

This is partly a function of Bauman



GETTY IMAGES

teaming up with Gervais, a Canadian living near Montreal. Gervais, now 80, briefly crossed paths in the late 1960s with Carl Hammer when they both worked at Sperry UNIVAC, an early computer manufacturer. Gervais was a fan of historic ciphers, and upon his retirement he took to reading about them online. "The Beale story came up," he recalls, "and that rang a bell with Hammer." This was more than 20 years ago. Intrigued, Gervais read the 23-page Beale pamphlet, began scouring the internet for more, and has puzzled over it ever since. He's reluctant to say how much time he's put into it, but he concedes that it's "hundreds and hundreds of hours."

What he found was mostly treasure hunters "holding their cards pretty close to their chest," Gervais says. He found this perplexing, given that the mystery had gone unsolved for more than a century, so he opted for a new approach: transparency. Gervais launched a website in 2003 with the intention of publishing theories and inviting people to share information. One of those people turned out to be David Oxford, now 66, who runs a construction business outside of Atlanta and became interested in the Beale pursuit because of a friendship with Paul James Smith, a retired NSA cryptologist who worked on the ciphers for more than three decades.

After becoming friends, Oxford and Smith met every week to brainstorm the ciphers—or rather, for Oxford to absorb Smith's theories. "It was always a mountain of stuff," Oxford says. "He talked very fast and was always excited about everything he was doing." Oxford took notes, and when Smith left, he would spend the days up until their next meeting trying to corroborate his theories. After a few years, Smith trusted Oxford enough to show him his decryption of C1—the location of the treasure. The effort filled nine pages, and even Smith wasn't sure what it said. Smith, who died in 2021, eventually wrote a letter to Bauman and Gervais sharing his decipherment. That brought the three of them—Oxford, Bauman, and Gervais—together.

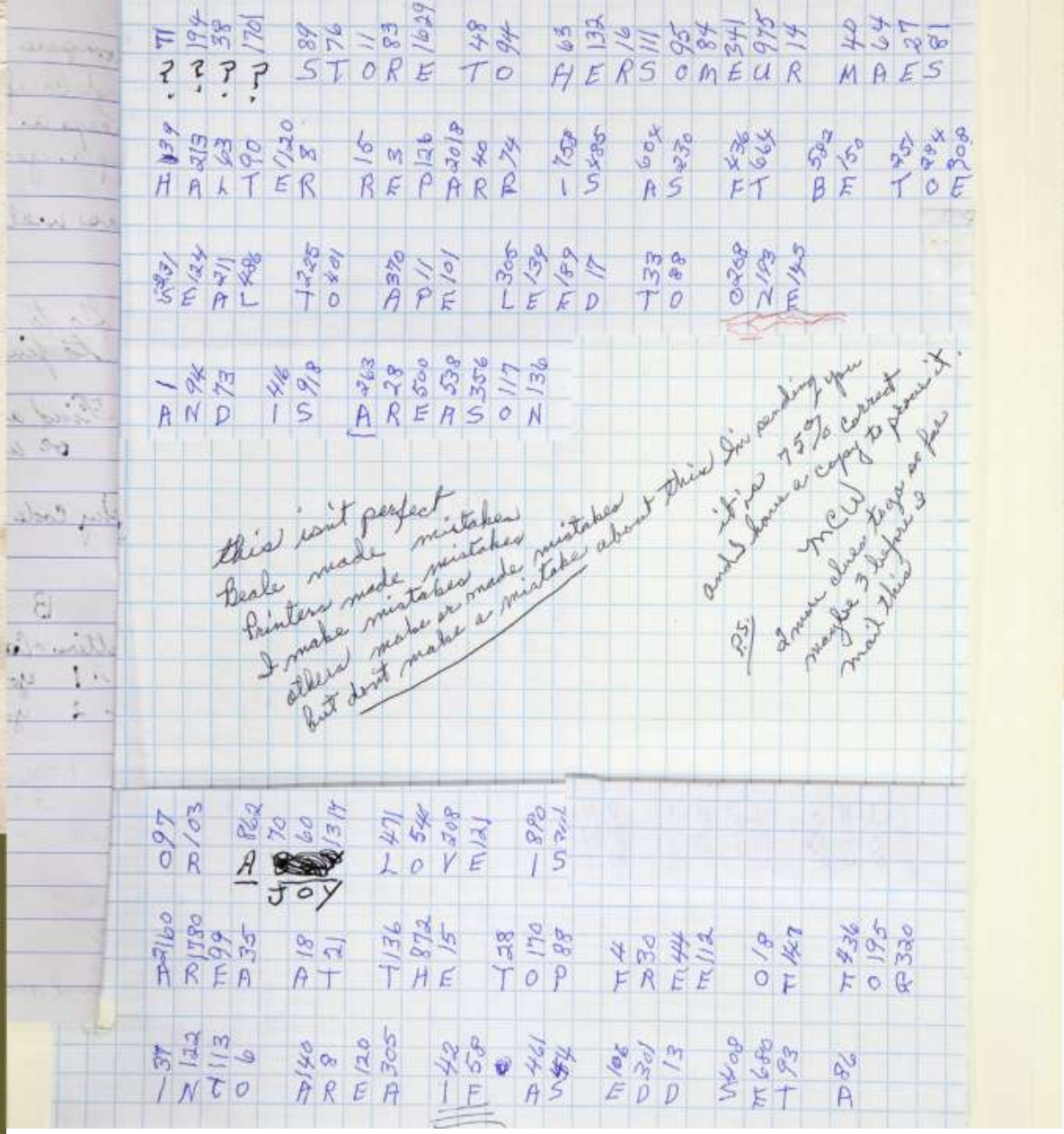
If you read Smith's decryption out of context, Gervais says, "it looks like a lot of gobbledygook." It took about 15 years for the men to start, as Gervais puts it, "connecting the dots between Paul's decryption and what we knew was historical fact."

This exercise eventually helped them make sense of Smith's decryption, and it revealed that at least some of the treasure was on Machias Seal Island. In 2023, they published their research on Gervais's website under the headline "Major Beale news: Beale Cipher #1, The Locality of the Vault, is now solved."

Rather than excitement, the larger treasure hunting community responded with either dismissals or, as Oxford puts it, "outright hostility from people that are crazy."

The spirit of collaboration that Gervais had envisioned can, in fact, be rather elusive. "They just, they laugh it off—I don't know, scoff at it, whatever you want to call it," Oxford says. "If it doesn't fit their personal scenario, they just pass it off as nonsense."

This has not shaken the trio's confidence. But because of their advancing ages, they all feel they're not physically up to what would be an arduous expedition to the remote island. Unless someone takes up their mantle, their decades of work will go untested.



THE OVERARCHING TENET OF ALAN KING'S Liminal Commitment Theory is that treasure-hunting obsessions occur sort of organically. Rather than instantaneously co-opting their lives to pursue the proverbial X on the map, people get lured in by incremental gains. They discover a new thread of history, a new landmark. They hit upon some revelation. The hunt is entertaining; there's learning involved, time spent outdoors.

In this way, King opines, treasure hunts may provide unexpected benefits. "While searchers seldom attain the unattainable," his study says, "displaced rewards can be found along the way if disaster can be avoided on these metaphorical adventure trails."

Searchers will remember their pursuit with pride because the rewards, he wrote, "will justify the sacrifices of their failed pursuit. For those transcendent searchers, the thrill of the chase will be an extended moment in time when they realize their potential."

The key, he says, is for the chase to make sense and offer plausible clues, so the leveling-up occurs. King experienced this with the Fenn treasure, and with his longstanding interest in the search for D.B. Cooper, a man who in 1971 hijacked a plane bound for Seattle. Cooper was paid a $200,000 ransom, then parachuted out before the plane landed and was never found—creating an enduring mystery that has morphed into a cultural phenomenon. But as entranced as he is by this and other pursuits, King is not willing to chase every unsolved historical puzzle. "I need to see some evidence that the treasure I'm seeking actually exists," he says.

And that's the wall skeptics often hit with the Beale Papers.

Notes sent by an anonymous researcher to Jones Memorial Library, Lynchburg, Virginia, which houses a small collection of Beale documents.

They point out the many red flags in the origin story: How did Beale and his party get the loot across the Mississippi River and over the Appalachian Mountains? If the idea all along was to bury it, why go through an arduous cross-country journey first?

Then there are the problems pointed out by various researchers. In 2002, Roger Grambihler, a now-retired Microsoft software engineer who studied the Beale Papers extensively, posted a treatise highlighting various irregularities. He noted that in the original 1885 pamphlet, the C2 solution contains counting errors involving corresponding words in the Declaration of Independence. He also observed differences in the version of the Declaration published in the Beale Papers compared with the original. Lawren Smithline, a mathematician at the Center for Communications Research in Princeton, New Jersey, has also dismissed the legend. Smithline has the distinction of legitimately decoding a cipher—the one found in an 1801 letter from Robert Patterson to Thomas Jefferson; the feat was published in the journal *American Scientist* in 2009. "The Beale ciphers are probably a hoax as far as actual treasure," he says, "but they may be an interesting slice of Americana."

One party unlikely to shed any light on the Beale question is the American Cryptogram Association. In response to a request for perspective from *Popular Mechanics*, the organization's editor/publisher, identified only as "Honeybee," offered nothing. "The members I know that might know something about the Beale Papers do not talk about them or answer questions," Honeybee replied. "I'm sure there is information on the internet about most of the history."

Experts like Smithline and Grambihler suggest the Beale Papers are more of an oracle through which treasure hunters and weekend warriors unpack their fantasies, rather than a true treasure. It's a numerical Rorschach test; people see what they want to see.

Even Alan King, the academic turned eager treasure hunter, finds the proposition presented in the Beale Papers to be preposterous. "Beale sounds [like] lunacy to me," he says. "I've looked into it briefly. I just can't be a believer."

KEN BAUMAN CALCULATES THAT HE'S SPENT ROUGHLY three-quarters of his life pursuing a web of interrelated historical intrigues, culminating with the Beale Papers. He has self-published three books, including the 2022 tome *Red Knee…Itsy, Bitsy Spider*; the title refers to the tarantula in the Poe story he believes to be connected to the Beale saga, and the book encapsulates his grand unified theory in all its labyrinthine glory. He has traveled to Virginia and Pennsylvania, and he asserts that on multiple visits to the Mount Pleasant mansion in Philadelphia, he was close to the treasure—it was on the other side of a wall he has not yet been able to breach. "They know it's there," Bauman says. "They cannot allow me to validate because they know I'll publish." The museum doesn't want its secret to come out, he contends, or to become a subject of a groundswell of public fascination around the treasure. (The Philadelphia Museum of Art did not respond to a request for comment.)

Is the hunt unhealthy for Bauman? Does he fall into the group King defined—the ones for whom treasure hunting can become problematic? Bauman shared an outline of a screenplay he wrote in which the main character drives a car into a wall at Mount Pleasant, causing coins to start raining down.

This fictional scene conjures a denouement that will never actually come to pass, Bauman says. But his devotion has come at a cost far beyond the actual travel expenses and the three self-published books. His wife and four kids, he says, "have a love-hate relationship with [the Beale pursuit]. They love me. They know I'm crazy"—he puts air quotes around the word—"but they realize this has value for people outside of our home, and they understand that it takes a unique individual to observe what I have observed and written about. But they don't like it…and everything can get explosive at any time."

Bauman's story—like the story of every treasure hunter—isn't just about what he's given up in pursuit of something he'll likely never get. It's not a substitution cipher, where each minute spent pursuing the goal is a minute that could have been spent playing catch with a kid or walking with his wife. Bauman left police work because stress overwhelmed him and, he says, "I became unwell. I had to be medicated for mental issues." During this crisis, he says, the search for Beale and its related mysteries "saved my life."

Maybe King's research is spot on. The lucky ones aren't the ones who find the treasure—an outcome with infinitesimally small odds. Maybe they're those who emerge with their lives intact, with gratitude for the experience and an appreciation for the less tangible ways in which the hunt enriched them. The computer scientist Carl Hammer proclaimed that he wouldn't care if the Beale Papers turned out to be a hoax, because the hunt had helped advance and refine computer research. And beyond that, he said, the "whole affair has been fascinating and just plain fun."

What's Bauman's endgame? Would finding the treasure provide a satisfying conclusion to his decades of searching?

He hesitates for a few beats. "Yes, that would be a very nice icing on the cake," he says. "And I don't mean stuffing it in my pocket. I mean, just the mental fruition."

But then Bauman adds something surprising, given how much he's invested, how much of a price his obsession has extracted: "Believe you me, I have come to fruition all the way through," he says. "If I were to pass tomorrow, I'm so happy with where I am today. That's a cudgel to be picked up by somebody else. That would be fine."

For Bauman and many others like him, it's not about the treasure. It probably never was. PM

HOW TO BUILD AN ELECTRIC GUITAR

IMPRESS YOUR FRIENDS WITH THIS RETRO HOLLOW BODY, MADE FROM BLACK WALNUT.

An electric guitar can be a rewarding woodworking project that doesn't require a bunch of experience. Compared to an acoustic guitar, whose body construction and materials vastly affect its sound, an electric guitar's sound is generated by the parts screwed to the body. A simple rectangular slab of wood can be effectively used as an electric guitar body—in fact, most electric guitars commercially available are solid-body construction.

Building an electric guitar can be as complicated or as simple as you like, as long as you follow some basic principles for component placement. Our design was retro-inspired, with a hollow body, traditional F-holes, and a top (front) and back like many modern guitars. You can build this guitar exactly as we have, using the templates provided at popularmechanics.com/guitar, simplify it making a solid body, or use it as inspiration to design your own shape, with components you choose.

To ensure success on your first electric guitar build, focus on the body, components, and dimensions. Guitar necks can be fussy to build—getting all the frets laid out right means the difference between an instrument that can be played and one that can't. For this reason, we sourced a pre-built neck from Warmoth Guitar Products. We also selected tried-and-true components, with tuning machines and bridge from Grover, vintage-style PAF 57 pickups from DiMarzio, and a pre-wired harness with tone and volume controls from Gunstreet Wiring Shop.

BY **BRADLEY FORD** / PHOTOGRAPHY BY **TREVOR RAAB**

PARTS

- Book-matched set of figured black walnut ¼" thick (x2, for top and back)
- Black walnut slab 14" x 19" x 1¾"
- Warmoth Hombre, Strat design, 25½" scale, guitar neck
- Grover 502G Rotomatic Tuners
- Grover 520G Bridge, with notched saddles
- DiMarzio PAF 57 neck and bridge humbucker pickups
- Flat black pickup mounting rings
- Gunstreet SG Classic wiring harness
- Kluson #7 tailpiece
- Black Fender-style 4-hole neck plate
- Gold, round recessed jack plate
- Black guitar knobs (x4)
- Ernie Ball Super Slinky electric guitar strings
- Miscellaneous screws

TOOLS AND MATERIALS

- Bandsaw or jigsaw
- Drill press or hand drill
- Set of standard drill bits
- Set of Forstner drill bits
- Router, ½"
- ⅜" x 1" flush trim router bit, with bottom bearing
- 60-degree bevel-edge router bit, with bottom bearing
- ⅜" flush trim pattern router bit, with top bearing
- 5⁄16" rabbeting router bit
- Acrylic humbucker routing template
- Acrylic Stratocaster neck pocket routing template
- Spectape double-sided tape
- Oscillating spindle sander
- Assorted wood clamps
- Razor knife
- Coping saw or scroll saw
- Titebond II or III glue
- Zinsser SealCoat Universal Sanding Sealer
- Minwax Polyurethane Warm Satin, in spray can
- Sandpaper, 80–600 grits
- Soldering iron
- Template printouts

DOWNLOAD THE TEMPLATES AT: POPULARMECHANICS.COM/GUITAR

NOTES ON GETTING STARTED

It might be hard to find a 1¾" slab of walnut commercially—we found ours locally, from a guy specializing in live edge slabs. We used a router sled to flatten the slab and planed it down to the right thickness. Alternatively, you could glue up a slab out of a couple pieces of wood.

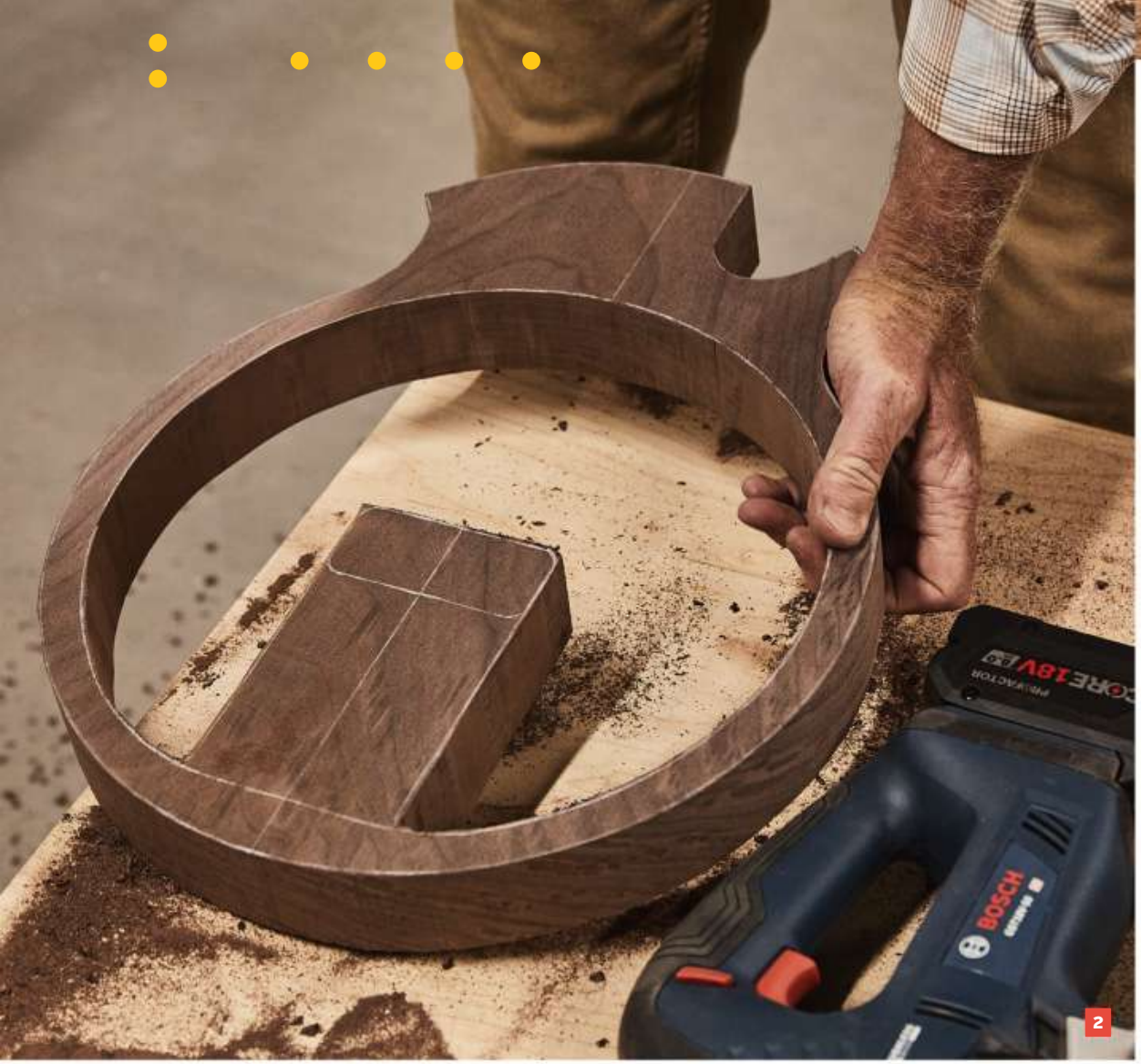
The templates can be printed out, full size, at most Staples stores or copy centers for less than $10.

Throughout the build, it's important to keep the centerline reference on the top, back, and body until the neck pocket and pickup cavities are routed, and the bridge and tailpiece mounting holes are drilled. These need to be aligned with the neck so that the strings are centered on it and over the pickups.

STEP 1: GLUE THE BOOK-MATCHED TOP AND BACK

Determine which sides will face out, and which edges will be glued by laying them flat on the bench as you want them to appear on the guitar. Prepare the edges for gluing.

Build a simple jig, like the one pictured above, to press the two halves together. Line the face of the jig with packing tape to keep the book-matched pieces from sticking to it. Glue the joint, tap the wedge in the jig to tighten, and weight the top to keep everything flat. When the glue has dried, sand the seam smooth. Do this for the top and the back.



STEP 2: CUT OUT THE BODY

Trace the template onto the 1¾" slab of wood and use a bandsaw or jigsaw to cut it out, staying just outside the line on the outside of the body, and just inside the line on the inside. Use an oscillating spindle sander to sand to the line to get the edges perfect and perpendicular to the top and back.

Drill a ½" hole to give you a starting point with a jigsaw to cut out the inside cavity. Clean up the edges with the spindle sander, but don't go too crazy—when the guitar is complete, nobody will see inside.

To rout out the area between the bridge and tail of the guitar, place the center cutout back into the body to help support the router as you remove the material. Leave about ½" to ⅜" at the bottom, connecting the bridge and tail of the body. Rout a ½" channel on the centerline of the guitar through the bridge.

STEP 3: PREPARE THE TOP AND BACK

Trace the templates for the top and back onto the respective book-matched panels. Align the glued seam with the template centerline. Cut out each one, staying at least ⅛" outside the lines.

Use Forstner bits to drill holes for the volume and tone controls and the pickup selector switch. Then drill starter holes for the sound holes and use a coping saw, jigsaw, or scroll saw to cut them out. Clean up the edges with sandpaper glued to a Popsicle stick or wrapped around a dowel. If you want the edges of the sound holes to look softer, gently sand around them with 80-grit to thin out the top around them, then switch to progressively higher grits until you get to 220.

On the back, drill a starter hole for the electronics access. Then use a jigsaw to cut inside the line and use the spindle sander to clean up the edge.

STEP 4: ASSEMBLE THE BODY

Fit the guitar top to ensure you can easily align the book-matched seam with the centerlines on each end of the body. If necessary, sand both ends of the top to make it easier to align. Once you get it aligned, spread glue on the top edge of the body and clamp around the edges, using scraps of wood as cauls to protect the top.

Wait 24 hours, remove the clamps, and repeat the glue-up process for the back.

When the glue has cured, use a flush trim router bit to trim both the top and back even with the body.

STEP 5: ROUT THE NECK POCKET AND MOUNT THE NECK

Align the router template along the centerline of the guitar, using dimensions on the template. Use double-sided tape to hold the template in place and rout the pocket 9/16" deep with the 3/8" flush trim pattern bit. Be extra careful when routing along the edge of the cutaway. Test-fit the neck in the pocket to make sure it fits snugly.

Use card stock to make a template of the neck heel and transfer the location of the mounting holes. Use an awl to punch through the center of each hole. Place the template in the neck pocket and use the awl to mark where to drill. Use a 3/16" bit in a drill press to make the holes—be sure to back up the body with a block of wood so the bit exits cleanly and doesn't cause blowout. Now, use four black #8 x 2½" flathead screws to mount the neck.

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STEP 6: DRILL HOLES FOR THE BRIDGE, ROUT THE PICKUP CAVITIES, AND MOUNT THE TAILPIECE

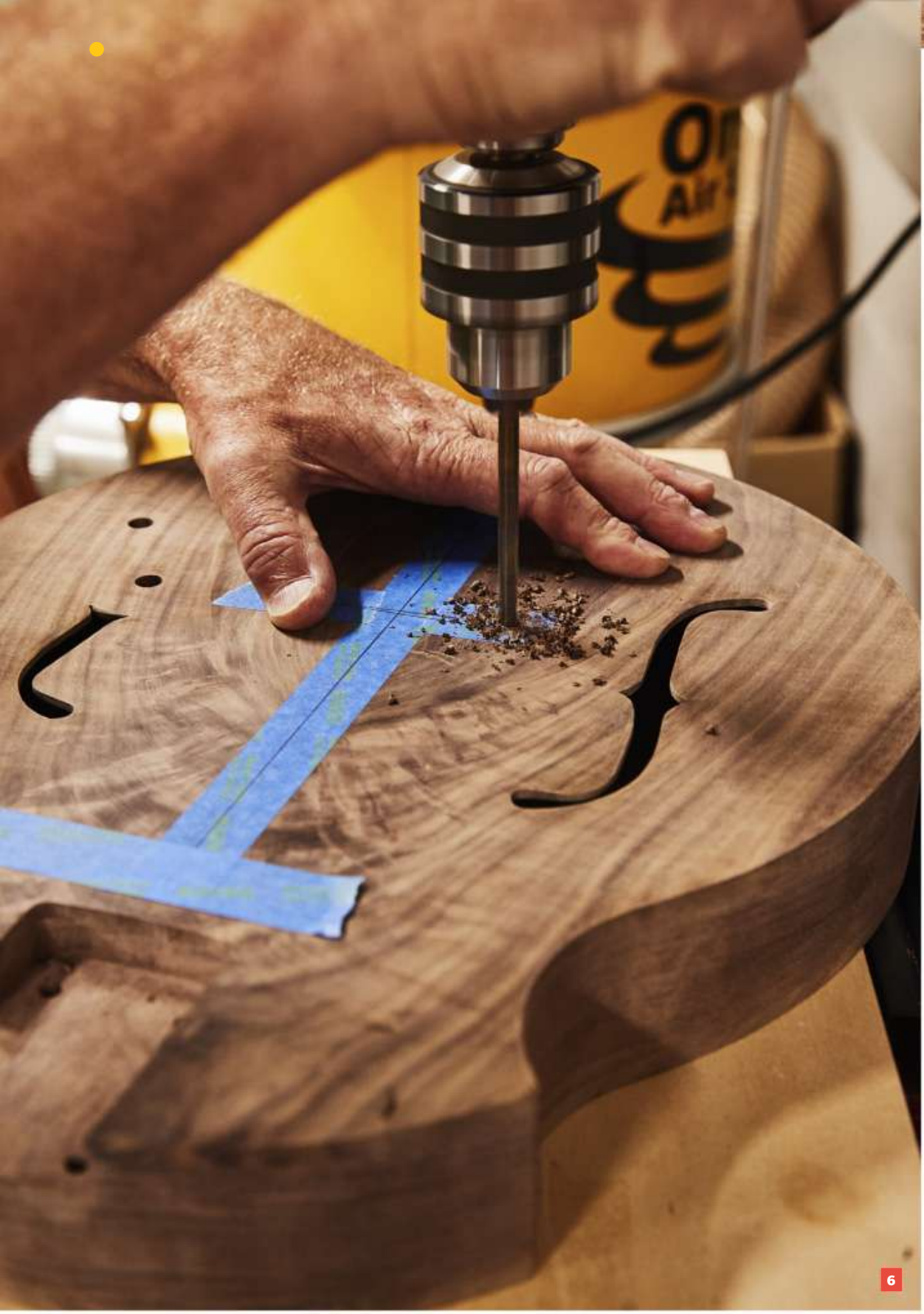
Along the centerline of the guitar, measure 25½" from the nut down onto the body and draw a perpendicular line—this is the end of the scale length of the guitar. Position the bridge on this line and mark where the posts are at each end. Note: To compensate for the three heavier, low strings, they'll need to be longer. So the bridge will need to be angled toward the tail of the guitar. Draw a line through your mark for the lower post, angled 3 degrees toward the tail. Place the bridge over this line, keeping the middle of the bridge, over the centerline of the guitar. Mark the locations of the posts on the body. Remove the neck, then use a 17/64" bit to drill both holes. Drop the threaded post mounts into the holes, but don't press them in. Slip the bridge over the posts to test the fit.

For the neck pickup, locate the center of the routing template 1½" from the end of the neck pocket, along the centerline. Use double-sided tape to hold it down and rout the cavity with the flush trim router bit. Before you drill mounting holes for the pickup rings, be sure the holes in the rings line up with the holes in the template.

For the bridge pickup, locate the center of the template 1⅝" from the perpendicular line you previously drew for the bridge, at 25½" from the nut. Stick the template to the body and rout the bridge cavity.

Drill holes to mount the pickup rings, then mount the pickups in the rings, and the rings to the body.

Align the tailpiece with the cen-



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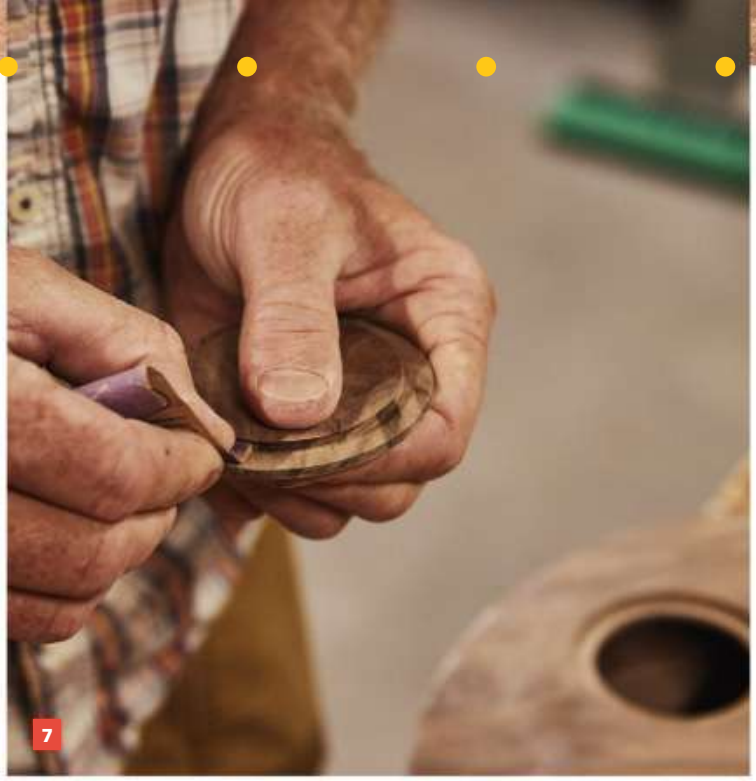
terline on the end of the guitar and mark the mounting holes with an awl. Drill the three holes, then fit the tailpiece with the screws provided.

You'll need to drill two holes for wires to ground the tailpiece and bridge. For the tailpiece, drill the hole centered between the mounting holes, making sure to go all the way into the body cavity. For the bridge, drill an angled hole through the side of the lower bridge mounting hole, toward the controls.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STEP 7: MAKE THE COVER FOR THE ACCESS HOLE ON THE BACK

Use a rabbeting bit to rout a shoulder about half the thickness of the back around the access hole. Measure the diameter of the rabbet around the hole—the cover will need to be 1/16" smaller than this. From the scrap of the book-matched back, find an area that closely matches the color and grain around the hole. Cut a circle for the cover from this scrap. The cover should drop into the rabbet with just a little clearance around the edge. Now rout a rabbet half the thickness of the cover around the edge so that it sits flush with the back when fitted.

Center the cover in the hole and tape it down. Drill a hole on each side of the cover into the back. Remove the cover and use a bigger bit to enlarge the hole on the cover. Next use a countersink bit on the cover holes so that a small, black, flat-head screw sits flush with the cover. Test-fit the cover, screwing it down—then disassemble.

STEP 8: INSTALL THE JACK PLATE

Locate the jack plate about 4½" from the centerline of the tailpiece, on the side of the guitar—this should be just below the back cover and controls on the top. Use a 7/8" Forstner bit to drill a hole, centered between the top and back, all the way through the side into the body. Insert the jack plate and use a 5/64" bit to drill

ANATOMY OF AN ELECTRIC GUITAR

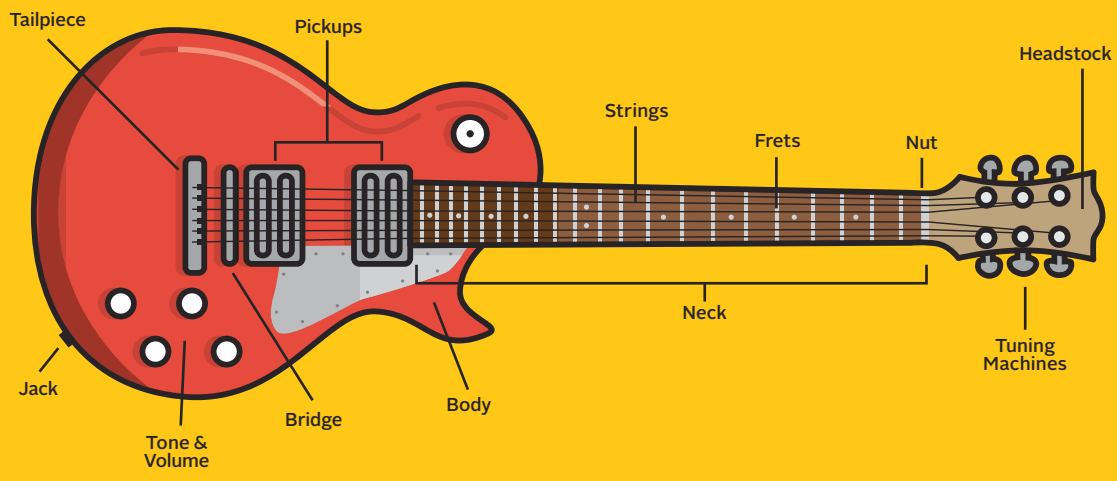


ILLUSTRATION BY ALYSE MARKEL

the mounting holes, at an angle. Use the screws provided to mount the jack plate. Then disassemble.

STEP 9: BEVEL THE BODY

Use the 60-degree bevel-edge router bit around the outside of the body on both the top and back. Use some of your book-matched scraps to test and set the depth. The bevel should end just before it meets the tailpiece and neck, so go slow and take great care in these areas. With the tailpiece installed, mark where the bevel should end, about ¼" away. The same goes for the neck on the top of the body and the neck plate on the back. Working around the cutaway, slowly pull the router away from the body as you approach the neck to get a graceful taper—practice this a few times on scrap first.

STEP 10: SEAL AND SAND THE BODY

Create a temporary neck/handle to hold the guitar when you apply the sanding sealer. Use a brush and give the body a generous coat. Don't forget to coat the cover, too. Wait an hour and then sand with 220-grit sandpaper. Vacuum off the dust, apply a second coat, and then sand again with 220, followed by 320. Vacuum off any dust and wipe with a clean, lint-free cloth.

STEP 11: APPLY FINISH

Using the temporary handle, carefully spray the guitar, starting with the outside edge, then the back and top. Wait about 30 to 40 minutes between coats. Apply 3 to 4 coats, then let cure for 24 hours. Gently wet-sand using as little water as possible, and wipe away the slurry with a soft rag as you go. When you're satisfied with the surface, wipe down with a clean, damp rag and let dry for at least an hour. Repeat the finish application with another 3 to 4 coats and let cure for 24 hours.

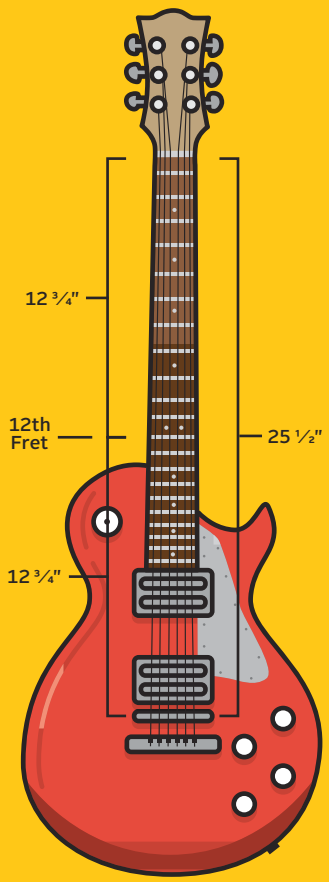
STEP 12: ASSEMBLE

Strip the end of two 12", 22-gauge pieces of wire to ground the bridge and tailpiece. Pass one through the lower bridge mount hole into the body, leaving the stripped end in the hole. Use a drill press with a bolt

SCALE LENGTH

Possibly the most important thing to understand when building a guitar is scale length. It's the foundation of getting the frets in the right positions so that the notes can be played all along the neck. If the frets are in the wrong place, you'll never be able to tune the guitar.

Scale length is simply the length of the strings, from the nut to the bridge. The 12th fret should fall exactly in the middle of the scale length. A string played on the 12th fret should produce the same note as the open string, but in a higher octave.



in the chuck as an arbor to press in the threaded mounts for the bridge, then thread in the posts.

Take the second wire and pass it through the hole in the end of the guitar between the tailpiece mounting holes. Leave the stripped end bent flat along the body so that the tailpiece traps it when mounted. Screw the tailpiece down—put a soft rag under it so it doesn't scratch the body.

Install the neck and bridge pickups, feeding the wires for both through the channel under the bridge and out through the back access hole.

Feed the wiring harness into the body and orient the volume and tone controls where you want them, then pull the jack out the hole in the side of the body. Solder the ground wires for the tailpiece and bridge to one of the tone controls—there should already be a ground soldered on the control, so you can add these to that joint. Follow the instructions included with the harness for soldering the pickup wires to the harness. Push the shafts of the controls through the front of the body and secure with the washers and nuts provided and install the knobs.

Thread the jack plate onto the jack and tighten the locking nut on the back. Then install the jack plate with the screws included.

Install the tuning machines on the neck and rotate them into position. Drill through the mounting tabs with a small drill bit, then install the screws. Carefully tighten the nuts on the front. Install the truss rod cover on the front of the headstock, using an awl to mark the center of each hole. Use a small drill bit for these holes and screw it on. Now, install the neck.

Install the guitar strings and check alignment over the neck and pickups. You may need to loosen the neck bolts and tweak the neck slightly one way or the other to adjust string position. Finally, tune the guitar as you normally would, in the tuning you prefer. PM

ILLUSTRATION BY ALYSE MARKEL

KIDNEY DIALYSIS IS TIME-CONSUMING.

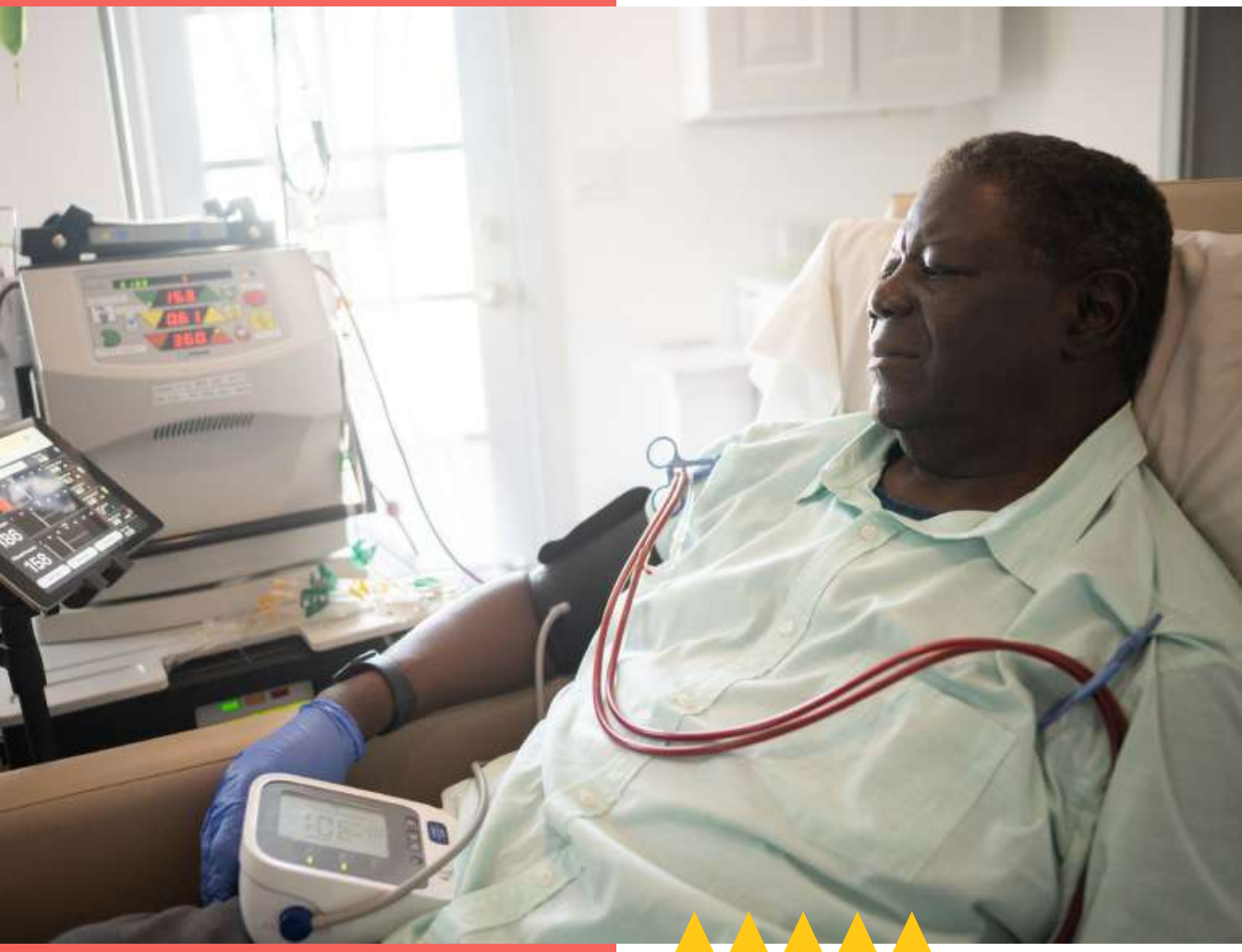
UNCOMFORTABLE.

CONFINING.

EXPENSIVE.

For the almost 520,000 Americans who will undergo treatment this year, the process leaves little room for a full life. **An innovative new device could change everything.**

BY **CARRIE ARNOLD** / PHOTOGRAPHY BY **BRIAN L. FRANK**



ARCHAIC.

WITH A SMALL CLICK, JSHON THOMAS connected himself to his life support. It was the last step in an hour-long process involving hundreds of steps that Thomas completed with the precision of an airline pilot prepping for a transcontinental flight. Even though the 59-year-old violinist and learning and development professional had heard this percussive snap hundreds of times—Thomas hooks up to the NxStage System One dialysis machine and Pure Flow water recycling system in his living room four times a week—he still checked off each step of the four-page list in black pen. If everything went right, Thomas's dialysis machine would easily remove toxins from his blood that his failed kidneys no longer could. Today was not one of those days.

For the first two hours of his treatment, the machine hummed along like a washing machine on a perpetual spin cycle. Thomas swaddled himself in layers of blankets and settled into his seat. Then a shrill alarm began beeping. Thomas's husband, Gary Carson, opened the machine, revealing a spaghetti platter of wires. The cause of the problem was somewhere in the miles of tubing, and if Thomas didn't want to stop his treatment early, he had to find it—quickly. A call to tech support didn't start out promising: "Have you tried turning it off and turning it back on again?"

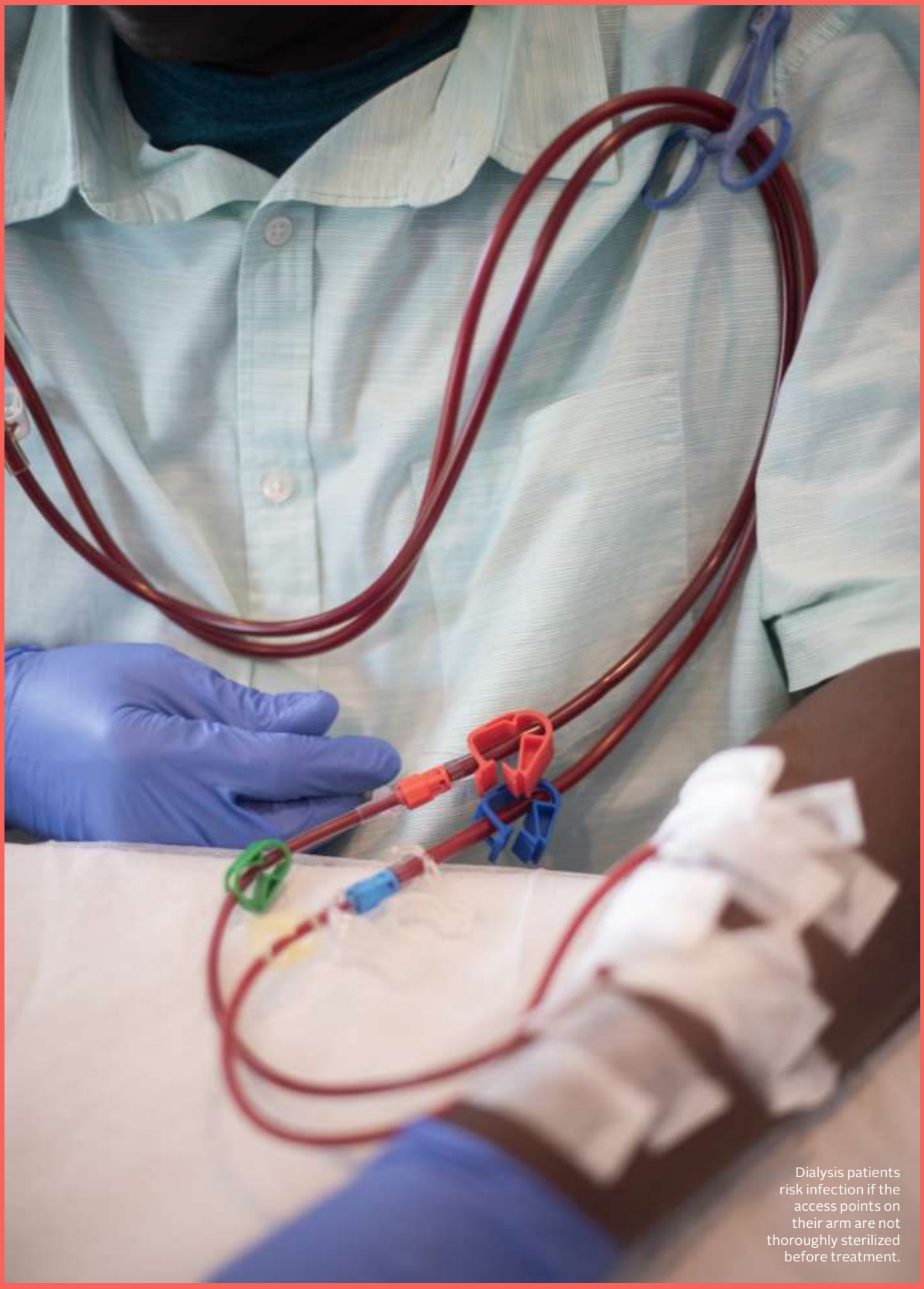
Thomas and Carson turned knobs and flipped switches, all while keeping an eye on the time. At least once a week, it seemed, Thomas's machine malfunctioned, and the Bay Area couple would have to problem-solve on the fly. Initially, Carson and Thomas remained calm. They had dealt with this scenario countless times before. But as the seconds ticked by, the duo grew tense. If the issue persisted, Thomas would have to record his vitals by hand—a tedious task. If it shut down completely and the pair couldn't restart it after four minutes, his blood could begin to clot. They would have to empty his blood from the machine and begin a new session. Thomas could do little but call out suggestions. Maybe it was the router and not the machine? A minute ticked by. Carson rebooted. Another minute passed. The pair waited with tech support. Then, as abruptly as it began, the beeping stopped. The only sound remaining in the den was the whir of the dialysis machine and two sighs of relief.

For Thomas and the nearly 520,000 Americans who rely on dialysis, the experience can be uncomfortable, time-consuming, and fraught with health risks. On the surface, dialysis machines are fundamentally simple. "It's a pump and a filter. Everything else is bells and whistles," says Jonathan Himmelfarb, MD, a nephrologist and cofounder of the healthcare startup Kuleana Technology. But that simplicity can be hard to design.

Take the dialyzer, a special filter that removes the bloodborne toxins. The dialyzer isn't like a coffee filter. Instead, it is made up of around ten thousand hollow polymer fibers only slightly thicker than a human hair. During dialysis, toxin-laden blood fills the mile of microscopic plastic tubing, which is bathed in a salty fluid called dialysate. The polymer allows toxins to diffuse across the filter into the dialysate, which is then dumped down the drain, while clean blood is pumped back into the body. A single dialysis session requires more than 100 liters of dialysate to remove the toxins that have built up between treatments.

Himmelfarb, 70, has spent decades caring for patients like Thomas who spend their lives astride the dividing line between living and dead. For nearly 40 years, Himmelfarb's professional life has been ruled by the reality that dialysis sucks. "It's very expensive, the patients are very unhappy, outcomes are relatively poor, and there's a rather short lifespan," says Buddy Ratner, a Kuleana Technology cofounder and professor of bioengineering and chemical engineering at the University of Washington.

Convincing investors and grant agencies that dialysis sucks is the easy part. Getting them to back an alternative is more challenging. Also hard?



Dialysis patients risk infection if the access points on their arm are not thoroughly sterilized before treatment.

Building a dialysis machine that is safe, portable, and easy to use. It's one of the reasons dialysis technology has changed little since Himmelfarb first donned a white coat in 1983. To alter the status quo, Himmelfarb and other innovators have to not only try to replicate the biological functions of the human kidney but also take on corporate behemoths raking in millions under the current system. Competitions like the Kidney X Prize have spurred interest, but the payoffs aren't lucrative enough to overcome the expensive hurdles in bringing a better dialysis machine to market.

Himmelfarb knows patients have long hoped for a miracle device that could make dialysis easier. "Then the light bulb clicked," he says. "We have to be that hope."

After years of work, Himmelfarb and Ratner brought their revolutionary new dialysis device, called AKTIV (Ambulatory Kidney to Increase Vitality), just inches from clinical trials. Rather than relying on hundreds of liters of special fluid, the machine uses a novel photochemistry approach to help neutralize toxins that have been filtered from the blood into the dialysate, thus reducing the amount of liquid needed for the treatment. Since it is the size of carry-on luggage, it would allow patients to dialyze anywhere.

But just as Himmelfarb's team was starting the last round of studies needed before they could begin testing in large animals, the center where he and his colleagues worked shut down. They would need a new plan—and additional funding—to continue pushing for a future with better dialysis.

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THE FIRST SYMPTOMS OF KIDNEY FAILURE ARE silent. Failing kidneys can't remove extra fluid from the body, nor can they filter molecules like urea, which can be toxic in high dosages, from the blood. Until disease has robbed the kidneys of 90 percent of their function, renal failure can often go unnoticed. What signs do appear—fatigue, anemia, swelling—don't carry a neon sign shouting "kidney disease." As the two fist-size organs continue to decline, the body swells—first the limbs, then the abdomen. By then the body contains so much extra fluid, sometimes as much as 50 pounds, it can become hard to breathe. Without medical intervention, coma and death eventually follow.

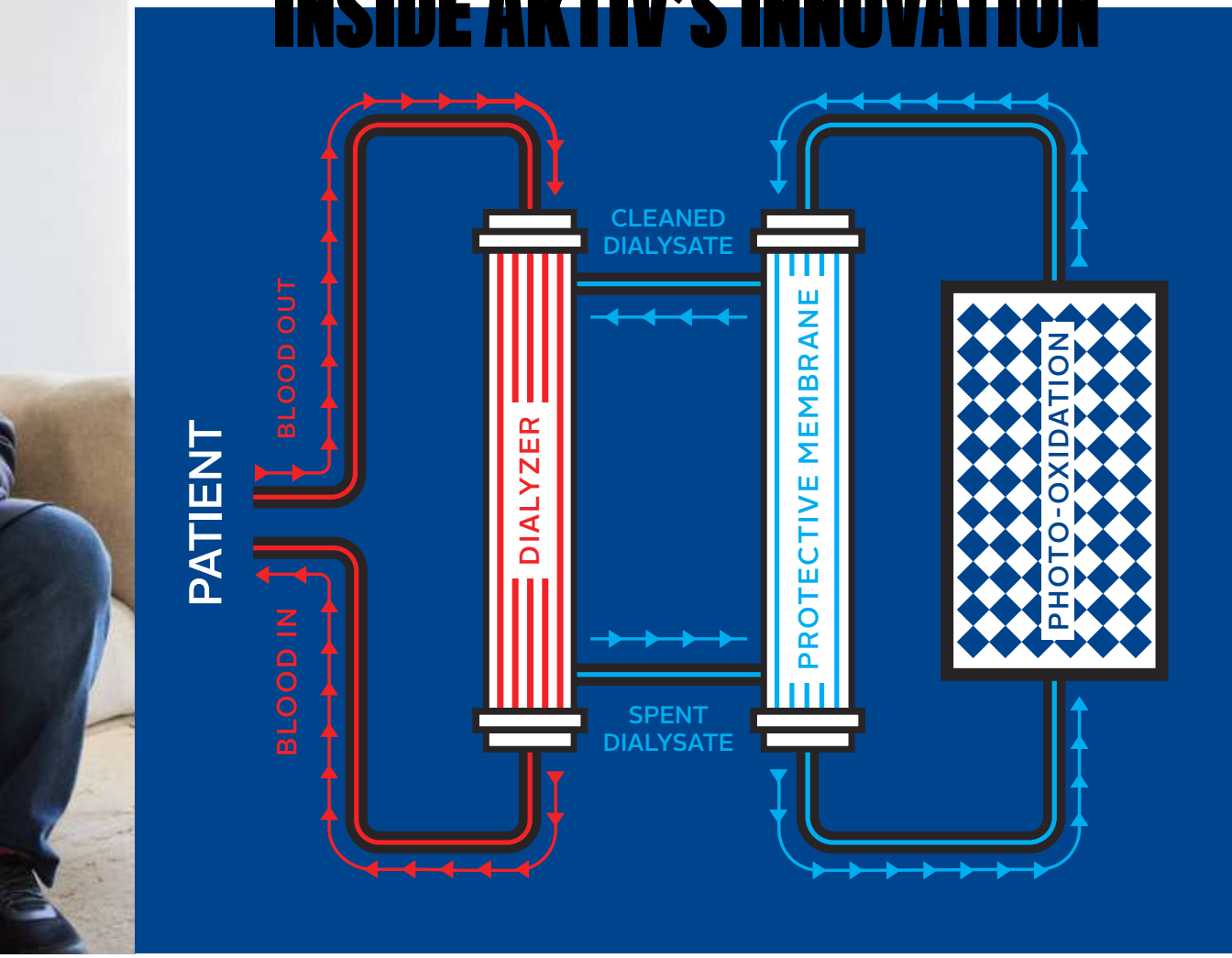
Dutch physician Willem Kolff knew the signs well. He and his colleagues didn't have many options for renal patients in the 1930s and '40s. But Kolff knew from other research that the high levels of urea in the patients' blood was killing them. He reasoned that if he could find a way to remove the urea, he could keep his patients alive. Building an artificial kidney, however, wouldn't be easy.

"The kidney is one of the most complex organs," explains Suzanne Watnick, MD, a Scholar in Residence at the American Society of Nephrology. "To replicate that is tough." The kidneys use a two-part process to filter blood. Each kidney contains a million individual tiny clusters of cells called nephrons, which are themselves made up of a glomerulus and tubule. First, the glomerulus filters the blood, removing small molecules, including urea, water, and electrolytes. Then the tubule returns everything but waste to the bloodstream. What Kolff needed was a way to remove urea from the blood without stripping off all the other components the body needed. His salvation came in the form of sausage.

Then, as now, butchers typically made sausage casings from animal intestines or cellophane, an early bioplastic made of cellulose. The latter option grabbed Kolff's attention because it could create what chemists call a semipermeable membrane. Experiments in animals told him that if

PHOTOGRAPH BY BRYAN BANDUCCI

INSIDE AKTIV'S INNOVATION



he filled a sausage-shaped cellophane tube with toxic blood and rocked it in a salty solution, the cellophane would allow the urea to diffuse into the solution while keeping other blood components, such as large proteins and red blood cells, inside. Kolff built machine after machine as World War II raged. (In his spare time, he helped hide around 800 people from the Nazis.) The result was a dialysis machine prototype that consisted of 20 meters of sausage casing wrapped around an aluminum drum. Kolff removed a patient's blood via a large hollow needle connected to a rubber tube, which would direct blood into the sausage casing. As the drum turned, the blood-filled cellophane casing would then be dipped in the salty dialysate bath, allowing urea to flow across the casing and into the dialysate by osmosis. Periodically, Kolff poured off the used dialysate and replaced it with fresh liquid. Clean blood would then be pumped back into the patient. His setup contained only a fraction of the nephron's complexity and responsiveness, but after a series of failed human trials, Kolff successfully dialyzed his first patient in a municipal hospital in Kampen, about 60 miles northeast of Amsterdam, on September 11, 1945. He chronicled his success in a 1947 treatise, writing that "With this patient we have in fact provided proof that it is possible to save the life of persons with acute uraemia by the use of the artificial kidney ... she gave us the decisive impetus to continue along the road we had set out on."

Kolff moved to the United States in 1950—four years prior to the first kidney transplant—and continued modifying his original design to make it more efficient. He cannibalized Maytag washing machines for their large drums and eventually used beer and fruit juice cans as makeshift drums. (Maytag, less than enthused about Kolff's misuse of its product, allegedly sent him a letter barring him from any future purchases.) Iterations of Kolff's

The complexity of the kidney drew Jonathan Himmelfarb, left, to nephrology.

Used dialysate is converted to nitrogen and CO_2 inside the photo-oxidation compartment.

many inventions—including the artificial heart and a component of the heart-lung machine—are still used today.

In the ensuing decades, inventors continued to miniaturize the process and developed a slew of new devices to address kidney failure, many of which now lie in state at the dialysis museum at the Northwest Kidney Centers headquarters, just south of Seattle. By the end of the 1960s, engineers had developed two machines, nicknamed the Monster and the Mini-Monster, that were used in the first home dialysis treatment and formed the basis of many of the machines used today.

Still, the thorniest problem was finding a way to remove blood from the patient and safely return the filtered product. The blood's natural ability to clot can be lifesaving if you have a wound, but it created major problems for dialysis equipment. And veins could endure only so much poking with giant needles before they collapsed. Physician-scientists had tried to circumvent these problems by using anticoagulants to thin blood, and in 1960 University of Washington nephrologist Belding Scribner debuted his game-changing "Scribner Shunt," which could be permanently installed in a patient's arm for easy and repeated access to the bloodstream.

What emerged was the modern hemodialysis machine that patients could use indefinitely, even from the comfort of their own bedrooms. But the machines were scarce, and the expertise to operate them even rarer, which made affordable dialysis a

Thomas's love of the violin has sustained him. Treatment can take a toll, leaving patients tired and dehydrated.

healthcare unicorn. It took a 1972 act of Congress to make dialysis a near-universal entitlement for Americans.

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HIMMELFARB BEGAN PRACTICING NEPHROLOGY roughly a decade after the landmark 1972 bill.

Himmelfarb, who has dark eyes and wisps of gray hair creeping along his temples, became fascinated with the renal system during his residency at Maine Medical Center in Portland. Soon after, he pursued two nephrology fellowships. "Dialysis, as a life-sustaining therapy, was pretty miraculous in those days—and yet very complicated," Himmelfarb says.

During one of his fellowships, he studied cellulose—which Kolff had used in his casings—to understand what happened when blood came in contact with a foreign surfaces. Blood clotted, yes, but the cellulose also switched on the inflammatory response. Over time, this frequent state of inflammation reduced the body's ability to fight pathogens—a major problem for dialysis patients. He was drawn to the complexity of nephrology and relished its technical challenges.

Then there were the patients. The intensity of the relationships that physicians formed with their patients over time—as those patients experienced chronic kidney disease, began dialysis treatment, and sought transplants—felt incredibly rewarding to him. But there was work to be done.

While Himmelfarb's patients all expressed gratitude for the artificial kidneys that were sustaining their lives, they also shared dismay as to how constrained their lives were. As a nephrologist, Himmelfarb could calculate whether his patients with end-stage renal disease were receiving adequate dialysis, but that didn't change the fact that dialysis itself was fundamentally inadequate. The United States now spends more on dialysis than any other country and has the worst outcomes. And, according to the Centers for Disease Control (CDC), more than half of the 800,000 or so Americans with end-stage kidney disease belong to a racial or ethnic minority. While 1972's landmark Public Law 92-603 ensured more people would gain access to life-saving dialysis treatment, there were still systemic issues in the field of dialysis care that needed to be addressed.

In the U.S., most patients go to a specialized clinic three days a week, four to five hours at a time, to receive dialysis. Two multinational corporations, Colorado-based DaVita Inc. and German-owned Fresenius, dominate the American dialysis industry. Insurers such as U.S. Centers for Medicare & Medicaid Services pay clinics a set rate for providing dialysis, creating an industry that market research has valued at $26 billion annually. "A number of organizations are making, let's call it, a pretty steady stream of guaranteed income coming in from the federal government," Ratner explains. "So why shake that up?"

Some dialysis clinics will even shorten sessions in order to increase the number of patients they can treat each day. These shortcuts can push patients to the physiological edge, according to Fokko Wieringa, a principal scientist at IMEC in the Netherlands. The blood becomes thick and the heart struggles to pump. Blood pressure plummets; the brain and muscles are starved of oxygen. If this happens repeatedly, the heart thickens and stop working. Perhaps not surprisingly, some dialysis patients say they tend to feel worse post-treatment than before.

Furthermore, patients face a significant risk of infection if the equipment and injection sites are not thoroughly sterilized before treatment. One 2023 study found that one out of every 10 deaths among dialysis patients resulted from infection. In 2020 alone, one in three of the 14,000 documented infections in dialysis patients were caused by the tough-to-treat *Staphylococcus aureus* (staph) germ, which can enter a patient's bloodstream through the access point on their arm, the CDC notes. In an effort to lower infection risk, U.S. government agencies have worked with clinics in recent years to update procedures, train staff, and raise awareness.

In many areas of medicine, like cardiology and diabetes management, competition has been transformative, says Diane Alexander, a health economist at the University of Pennsylvania. That there are really only two market leaders in the dialysis space could contribute to the lack of innovation, she explains, while noting the current system favors the in-center care these companies provide, and may not support breakthroughs, such as miniaturization, designed for in-home treatments. Other technologies in healthcare have miniaturized, she says, "We haven't seen that in dialysis."

The machines remain large, loud, and laborious to use. Patients learning to do home dialysis require months of intensive classes to learn the hundreds of steps to connect and disconnect from a dialysis machine. This complexity is one of the reasons that only around 10 percent of dialysis patients receive treatment at home.

What's more, Himmelfarb explains, dialysis doesn't replicate the full range of kidney functions. Kidney cells use specialized proteins to sniff out tiny changes in blood chemistry and make adjustments on a minute-by-minute basis. The greatest engineering minds in the world haven't been able to replicate this ability, says Ratner. Dialysis, which mainly removes toxic uric acid, doesn't even come close. For a long time, the fact that dialysis kept patients from dying led to an attitude of it being *good enough*. That attitude is slowly changing, but the industry has a lot of catching up to do. Dialysis hasn't "changed substantially in 40 years," says Watnick. "It's truly archaic."

Himmelfarb wasn't satisfied with the status quo. Few nephrologists were, he admits, but without the engineering chops to rebuild a machine from the ground up, they could make little headway. In 2016, however, Himmelfarb met Ratner, who had the requisite engineering know-how. The pair immediately geeked out over discussions of water purification, dialysis filters, and Italian food. They recognized that dialysis's biggest challenge wasn't the procedure itself but rather the vast volumes of water needed to filter the blood.

With a $15 million Northwest Kidney Centers grant, Ratner and Himmelfarb founded the Center for Dialysis Innovation (CDI) at the University of Washington. Their quest was as simple as it was ambitious: to make dialysis better.

"A NUMBER OF ORGANIZATIONS ARE MAKING, LET'S CALL IT, A PRETTY STEADY STREAM OF GUARANTEED INCOME FROM THE FEDERAL GOVERNMENT, RATNER EXPLAINS. **"SO WHY SHAKE THAT UP?"**

AS SOON AS HE LEARNED HIS KIDNEYS WERE failing, Thomas changed almost everything about his life. He began swimming laps at his local community pool to manage his hypertension. Dietary changes also helped him lose over 100 pounds. For nearly a decade, Thomas held the need for dialysis at bay until a blood test in late 2022 told him the day had come. Even for someone who'd already radically altered his lifestyle, dialysis came as a shock.

Thomas and his husband spent months learning how to dialyze at home. A vascular surgeon permanently connected the artery and vein in Thomas's left forearm, creating a fistula that would enable the rapid blood flow through the dialysis machine. First, he must ensure the water he will use is pure. He then boots up the dialysis machine, and checks his vitals. Next, he disinfects the injection site with alcohol and iodine wipes and multiple changes of nitrile gloves, gently threads two large-bore needles into his arm, and begins cycling his blood through the machine. After three and a half to four hours of dialysis, he repeats the process in reverse. More

Thomas, right, and his husband, Gary Carson, left, have spent hours training to use Thomas's home dialysis machine.

wipes, more gloves, more needles, more time. A total of six or seven hours will pass between the first step of his treatment and the last.

Thomas is grateful for dialysis. Without it he would die. But the process is also a huge burden. "It is a part-time job that I don't get reimbursed for," he says. Thomas and Carson hired contractors to redesign their basement. He needs a dedicated room to run his machine—a big ask in the pricey Bay Area—and bookshelves once crammed with vinyl records and stacks of sheet music are now filled with gloves, face masks, and alcohol wipes.

Then there are the demands on his time. If he didn't need dialysis, Thomas says, he could more easily work normal hours and travel. He wouldn't have the stress that accompanies a machine malfunction or have to plan his entire life around his treatment. Other than a transplant, for which he's currently waitlisted, a smaller artificial kidney is his only chance to untangle himself from the machine.

People in patient focus groups have shared Thomas's priorities. They want something that is small and portable, a machine that wouldn't anchor them to a room or clinic—qualities that are fundamentally incompatible with a machine that guzzles hundreds of liters of water per treatment. Any team working in this area would have to tackle the dialysis thirst trap and design a better way to remove toxins in the blood. It didn't take long for engineers to identify alternatives.

■■■

HIMMELFARB'S OFFICE ON THE 6TH FLOOR OF Harborview Hospital in Seattle provides us a panoramic view of the city when I visit him in February 2024. Droplets of rainwater sparkle like diamonds on the windows of nearby skyscrapers, giving the otherwise gray city a warm glow. This glimmer also inspired a CDI engineer and frequent collaborator of Ratner's and Himmelfarb's, Bruce Hinds, to create the innovation at the heart of the AKTIV device.

Cleaning the outsides of windows on a high-rise usually requires a lot of rope and a brave person

with a squeegee. Much of the dust and dirt encrusting these windows is organic material, including everything from bird droppings to pollen. Days baking in the sun only made the grime darker and harder to remove. To cut down on costly cleaning, glass companies began coating skyscraper windows with a thin layer of titanium dioxide. When UV light hit the titanium dioxide—the same compound used in many sunscreens—it spurred a chemical reaction that could break down the organic material and allow any remaining dirt to be washed away in the rain. If photochemistry could clean skyscrapers, the engineers thought it might be able to do the same thing for blood. "It was a breakthrough concept," Himmelfarb says.

In a traditional dialysis machine, used dialysate is discarded and replaced with fresh fluid. Instead of dumping it down the drain, the Seattle researchers ran spent dialysate through a special compartment crammed with titanium dioxide nanowires and LED lights. The resulting chemical reaction converts toxic urea into harmless nitrogen and carbon dioxide. Without the additional liquid, Himmelfarb and Ratner were able to shrink the refrigerator-size standard dialysis machine to the size of a carry-on suitcase. And when the team ran preliminary tests of the AKTIV's efficiency using cow's blood spiked with varying levels of urea in 2023, they found the AKTIV could remove 15 grams of urea (the average amount made by a human) in 24 hours with just a single liter of dialysate. By that time, Himmelfarb and Ratner had spun out a company, Kuleana Technology, to commercialize and test the device, which they hoped would move into human trials by 2025.

Ratner says the team is working to improve the photooxidation system's catalytic efficiency. In other words, can they squeeze more inches of titanium dioxide nanowires into the device? Additionally, he explains, they're using computer models to map the toxin-filled dialysate's flow and ensure it is efficiently transporting as much urea as possible to the catalyst for breakdown. Ultimately, Himmelfarb says his primary concern is funding: "Everything else is solvable."

Their $15 million grant was a one-time offer, so the team worked to cobble together additional funding. But then, in April 2024, the University of Washington decided to close the Center for Dialysis Innovation. AKTIV had earned media buzz and was approaching readiness for human trials, but Ratner and his colleagues would still need to scramble

University of Washington researchers developed the techonology responsible for the first at-home dialysis treatment.

to keep up the momentum. There was no guarantee the AKTIV would make it to patients.

WHILE HIMMELFARB AND RATNER CHARTED a new course, other startups are exploring methods to shrink the size of a dialysis machines.

Singapore's AWAK Technologies has developed a way to recycle used dialysate using special materials called sorbents. These compounds, designed to sop up specific types of molecules, can be found in gas masks and diapers. In dialysis, sorbents like ferric oxide hydroxide and activated carbon can be used to remove toxins and positively charged ions from dialysate, thus reducing the amount of water needed for a single dialysis session from 120 liters to just 1 to 2 liters. While many details about AWAK Technologies' design remain proprietary, the company uses an enzyme to convert urea to ammonia, and a sorbent mixture to remove the ammonia and other ions. In late 2023, AWAK pulled in a second round of funding worth $20 million in preparation for a U.S.-based clinical trial.

Qidni labs in Buffalo, New York, is also developing a sorbent-based device, dubbed Qartridge. Founder and CEO Morteza Ahmadi won't share specifics of how Qartridge works due to pending patents, but he says the device uses a variety of sorbents to clean the spent dialysate enough for reuse. To Ahmadi, the sorbent technology is a game-changer for dialysis. He built a mini-clinic test lab using Qidni equipment in under a week for less than $5,000. The machine "is truly portable and nearly waterless," he says. To date, the Qidni machine has been pilot tested in 15 patients and Qidni labs is currently recruiting for clinical trials.

To Kevin Longino, CEO of the National Kidney Foundation, the biggest challenge facing these innovators is figuring out how to turn a profit in the American dialysis system, where Medicare pays the bulk of the bills. Large dialysis clinics have spent a lot of time and money to work within the current system. Without a clear path forward, many investors hesitate to open their pocketbooks. "You're talking several hundred million dollars of capitalization required to do a dialysis machine," Longino says. "For decades, you just didn't have anybody that wanted to go into the space."

THIS SPRING, HIMMELFARB'S PHONE RANG. Mount Sinai Hospital in New York City—the first hospital to conduct dialysis treatment in the United States—was looking to build a kidney disease innovation center, and they needed a team of top-notch nephrologists. Would Himmelfarb be interested?

In this new role, Himmelfarb is co-directing the Mount Sinai Center for Kidney Disease Innovation alongside Kirk Campbell, MD, president-elect of the National Kidney Foundation. Though Himmelfarb has traded rain showers and rolling hills for the hustle and bustle of New York City, the collaboration with his colleagues at the University of Washington will continue.

So will Kuleana Technology. Himmelfarb and Ratner are optimistic the newfound distance won't slow their progress; meetings once held over coffee will now be conducted over Zoom. In 2023, the Department of Defense awarded Kuleana Technology, the University of Washington, and Brooke Army Medical Center, in San Antonio, Texas, a $4 million grant to conduct animal trials. Ratner anticipates AKTIV will be ready to test in sheep or pigs in a year or two and, if all goes to plan, in humans by 2026 or 2027.

"DIALYSIS TODAY LOOKS ALMOST IDENTICAL TO 40 YEARS AGO," WATNICK SAYS. "IT'S TRULY ARCHAIC."

Funding remains a perpetual issue, and researchers are wary of the potential for large dialysis organizations to snap up disruptive technologies and shelve them. It's the exact opposite of what Himmelfarb envisions for the AKTIV. "If it doesn't go all the way to patients, then it didn't succeed," Himmelfarb says, jabbing his desk with an index finger to add a percussive exclamation point to each word.

For Thomas, that progress can't come soon enough. He hasn't been able to travel home to South Carolina to visit family since he started dialysis, and his weeks are carefully planned so that he can fit in treatment, violin practice, and time at the gym and with friends. With transplant waitlists so long in California, Thomas and Carson have even contemplated a temporary move to Las Vegas to improve Thomas's chances at receiving a kidney.

Meanwhile, the mechanical symphony within Thomas's dialysis machine will beep and buzz and whir like it has hundreds of times in the past. It's not the orchestral swell Thomas dreamed of when he learned the violin so many years ago, but it will be the song that runs his life until he gets the call that, finally, a kidney is ready for him. PM

Top: Cut height can be set precisely in quarter-inch increments. Bottom: There's no guessing involved in setting the suspension seat—just dial in your weight and you're good to go.

PHOTOGRAPHY BY THOMAS HENGGE

GEAR OF THE YEAR

DIY projects often become a catalyst for acquiring new gear, and gear can be an integral component for getting these projects across the line. Whether you're mowing your yard, painting your house, or maybe even building a deck, it's no surprise we all want to buy the best tool for the job. **So that's why we spent the past year poring over the best tools, grills, knife sharpeners, generators, welders, and even dog collars to show and tell you which ones are the best. Here are our findings from 2024.**

Stihl RZA 760 ZTR Mower *$27,499*
Stihl's new RZA 760 Zero Turn Rider (ZTR) is the most remarkable electric mower we've ever tested—a professional-level machine built for daily use. Its expense is beyond what a typical homeowner might be willing to spend, but it is a window of what we can expect to see for residential mowers in a couple of years. With a 60-inch deck and a top speed of 16 mph, the RZA 760 can cover a lot of ground quickly. In testing, we were able to mow just over 4.5 acres in an hour and 45 minutes. This test area can take over 4 hours with a lawn tractor and about 3 hours with a typical 54-inch zero turn. Stihl claims a run time of up to 8 hours, in certain conditions, and that doesn't seem unreasonable to us—we hit about 7 hours mowing our test yard four times. Speed isn't the only thing we liked about it, though. Paired with an app, the machine lets you locate it via GPS, and set up a geofence that will disable it if moves outside the fence—in the event it is stolen. The app also tracks historic mowing sessions and total time and area mowed, so you can keep up with maintenance like sharpening the blades at regular intervals. The RZA 760 ZTR also features Stihl's deluxe suspension seat, which lets you dial in your weight to take the guesswork out of setting it up properly. We were disappointed to have to send this mower back.—*Brad Ford*

TurnX Tools Ult Multi *$65*
If you can integrate your hand screwdriver and impact driver, you've just taken a step forward to simplifying your tool kit. That's exactly what the Ult multi-bit driver is designed to do. Clipped into the Ult's handle are six double-ended screwdriver bits that fit into the screwdriver's chuck or that of an impact driver. Go from screwdriver to impact driver and back again in seconds. We tried out the tool, driving and removing screws, by hand and power, making use of various bit geometries in the process. The bits stand up to the abuse of an impact driver, and the screwdriver handle appears to be tough enough to withstand even two-handed turning force.—*Roy Berendsohn*

GEAR OF THE YEAR

Black & Decker Dustbuster HNVD220J *$45*
We used the newest version of the famous Dustbuster to suck up sawdust, wood shavings, and a blend of wood-hickory pellet fuel for grills. Despite the 2.4-pound power tool having only 8 volts to offer, it pulled these materials in so quickly that it would fill its dust cup in just a few seconds. If it does all that, then ordinary household dust, breakfast cereal, and food crumbs are no match. To empty the dust cup, hold the nozzle and twist the handle counterclockwise to unlock the two parts. Remove the air filter and dump out the captured debris. The filter is washable, but basic day-to-day cleaning is easy: Just tap it against the side of a trash can to release the dust built up on its surface.—*R.B.*

Diablo Amped Rebar Demon, ⅝ x 14 inch, DMAPLA4510 and Snap Lock Adapter, DMAPLAAD4900 *$66*
Do you like cleaning up dust and having it blow back at you? We didn't think so. Dust is unhealthy to breathe, and cleaning it up is a waste of time if having it settle on the floor and surrounding surfaces can be avoided. This SDS masonry bit, dust-removal accessory sleeve, and fitting are impressive for the amount of dust they grab. In the process, they contribute mightily to a cleaner, healthier, and more productive work area. It's hard to say exactly how much dust the setup captures. In our tests boring holes vertically through the solid webbing of concrete blocks, we'd say probably 90 percent or a little more. The three-part system works this way: A standard cross-point SDS masonry bit has two faces milled away, producing a flat-sided bit with two rounded edges. A steel sleeve fits closely to the bit, yet the bit can still spin freely. Attached to the sleeve is a plastic fitting to hook up a shop vacuum. Install the bit and adapter into an SDS rotary hammer as you normally would, but without masonry dust billowing around as you go.—*R.B.*

Moen Flo Smart Water Monitor
$500

While we may tire of new smart products, Moen's Flo Smart Water Monitor got our attention. Installed in your water supply line where it enters your house, it learns your usage patterns, tracking daily water consumption, noting high usage and low usage periods. Using this data, it can alert you to potential water leaks, burst pipes, or even if a hose has been left on. The Flo Smart Water Monitor has the potential to turn what could be a disaster into an inconvenience. Aside from the damage that can be done, it can also help save you money on your bill. We had no idea how much water we used washing dishes, taking showers, or flushing a toilet. Using the Flo, paired with the Moen app, you can monitor your consumption, set daily usage goals, and develop strategies to reduce the volume of water you use.—*B.F.*

GEAR OF THE YEAR

Rapid Rafter 1001 *$27*

One reason the Rapid Rafter is such a great tool is that it was developed by a carpenter with 40 years of experience. This U.S.-made tool consists of two identical plastic rafter squares hinged together. Why would you need that? Good question. Answer: It permits you to rapidly mark both faces and an edge of a piece of framing lumber or two faces of a 4 x 4. The design also permits you to rest a torpedo level on the square's spine, for increased accuracy in marking rafter plumb cuts. And when you unfold the square, you have a 15-inch-long straightedge. To us, that's a remarkable amount of versatility. Like other rafter squares, it can be used to do typical common and hip rafter layout, mark parallel lines along an edge, and mark off angles.—*R.B.*


GEAR
OF THE
YEAR
SpotOn

EcoFlow Smart Home Panel 2 (+Delta Pro Ultra) *$7,997*
EcoFlow's Smart Home Panel 2, paired with the Delta Pro Ultra, is one of our favorite products tested this year. When connected to your home's electrical service panel, the Smart Home Panel 2 supplies power to your critical circuits—up to 12, for one unit—and, in the event of a power outage, switches from the grid to supplying power from an attached power station. The panel connects to your home's network via WiFi, and you can view its status and change its settings from anywhere. Additional expansion batteries can be added to increase its capacity from 6 to 30kWh for each Smart Home Panel 2—and three panels can be installed to cover all of your home's circuits, with a capacity of up to 90kWh. Depending on the home, that could be several days of backup. For those with variable electric rates, the panel can be programmed to charge off the grid during low-rate hours, and then feed power-hungry circuits from the batteries during high-rate periods. To top it all off, the Delta Pro Ultra can also be charged via solar panels.—*B.F.*

SpotOn GPS Fence *$999*
SpotOn has modernized electric fence systems, doing away with underground wires or transmitters that have limited control over boundary shapes. It made setting up a boundary in our yard, leveraging GPS and a smartphone, simpler than ever. We found it incredibly easy to define an area boundary, test, and edit it. As with any pet containment system, training is key, and that time needs to be put in up front. The SpotOn app allows you to change fence and collar settings and will pinpoint your dog's location, giving you an alert if the pooch is on the loose. And in the event of an escape, SpotOn will allow the dog to return and cross the boundary without a correction.—*B.F.*

GEAR OF THE YEAR

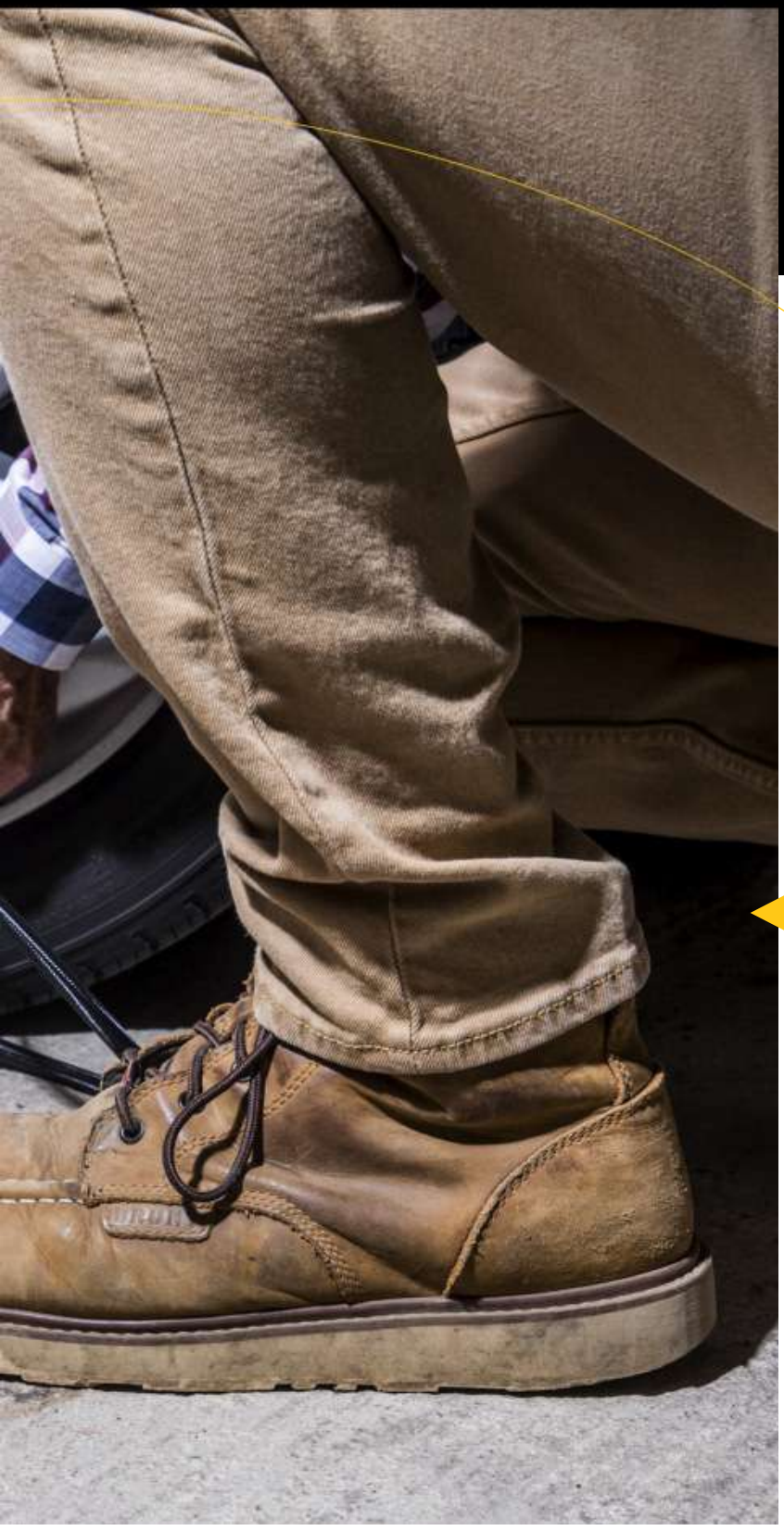
Horl 2 Knife Sharpener *$189*
Plenty of gadgets are intended to help sharpen your knives—some gimmicky, some legit. Unfortunately, many of them can be complicated, with multiple components. The Horl 2 consists of just two pieces that don't require any assembly. The first one is simply a strong magnet that holds the knife at one of two common angles for kitchen knives. The second is a cylinder with abrasive surfaces on each end. Roll the cylinder with one end against the blade to sharpen the length of the knife. It's simple, it works, and it's a legitimate shortcut to a sharp edge. The kit comes with 400- and 1,000-grit abrasive discs—we recommend getting the optional 3,000- and 6,000-grit discs for the sharpest edge possible.—*B.F.*

Repaint Tray *$40*
When we first heard about the Repaint Tray, we knew we had to try it. If you've ever been painting late into the night and knew you'd need to continue in the morning, you'll appreciate the Repaint Tray. There is no need to clean everything up when you'll be painting again in 10 or 12 hours. We used to wrap the roller in plastic wrap, and then press a layer of plastic wrap into the paint to keep it from drying out—which worked okay, but it was messy and wasted paint. Plus, paint around the edges still dried out. The silicone roller tray liner and cover keep the paint fresh and ready for your next session. You can even pop the roller off the handle and drop it in the tray. Cleanup is easier too—either wash it out right away or pour out the excess paint, let the paint on the liner dry, and peel it right off. Either way, the paint releases from the silicone easily.—*B.F.*

Yoder YS640S Competition Pellet Grill *$2,849*

Yoder's YS640S Competition is one of the heaviest-duty pellet grills we've tested. Its versatility will appeal to grillers of all stripes, as well as the smoker crowd. We were impressed with the wide temperature range and the ability to cook over live fire, and we couldn't find any limitations to what it could cook. While the max set temperature on the controller is 600 degrees Fahrenheit, cooking over the grill's firebox yields a much higher sear temp. And yet we could set the controller at 225 degrees to smoke a massive brisket. Yoder leverages the FireBoard app so you can monitor cooking sessions using the two included meat probes, set timers and alerts, view temperature fluctuations across the session, and review previously saved sessions. The YS640S's body is made in the USA, with large 8-inch flat-free tires. Despite it weighing more than 400 pounds, those large wheels make it easy to roll the unit around the patio, garage, or shed.—*B.F.*


Milwaukee



GEAR OF THE YEAR

Milwaukee M18 Inflator *$237*

We originally got the M18 Inflator because we had to deflate tires to access a muddy logging road far from any air compressor, and reinflate them when we returned to pavement. But over the past year it has proven useful in many other situations. For example, when picking up a load of lumber, we could add air on the spot to the helper springs on the truck to adjust for the weight. It uses the same battery as other Milwaukee M18 tools, so unlike other inflators, we're not tied to a typical 12-volt cigarette lighter socket. The M18 Inflator proved useful at home, too, and we found ourselves pulling it out for all kinds of jobs instead of going to the garage, uncoiling the air hose, and firing up the compressor.—*B.F.*

Brunt Marin Comp Toe Work Boot *$156*

Brunt really got things right on the Marin Comp Toe Work Boot. It's comfortable right out of the box, with absolutely zero break-in period. The company has somehow managed to make the thick leather soft and forgiving, but rugged enough for working a construction site. The composite safety toe seemed light enough that we rarely noticed its presence—until we dropped something on it. Moc-toe boots often feature a comfortable, soft, airy sole material that wears quickly on job sites. Brunt uses this type of material, but with a denser, longer-wearing material covering the bottom of the sole. The Marin Comp Toe is electrical hazard–rated and waterproof, and the sole is slip- and oil-resistant. I wore them nearly every day for over six months with no complaints. They're my new favorite boots.—*B.F.*

GEAR OF THE YEAR

Klein Tools Jobsite Fan *$60*
This 9-inch-diameter fan kept us cool in the workshop, and we used it in other places too—on a treadmill to combat sweat, and on the patio to keep mosquitoes at bay. The all-plastic fan has a head that rotates 360 degrees and turns on the base 360 degrees. And about that base: A strong built-in clamp lets you fasten it to boards and ladders, while four powerful magnets allow you to hang it off metal studs, steel duct, or an I-beam. The fan will run for five hours on its high-speed setting and up to 12 hours on low speed. Its built-in battery can be recharged using the included USB-A to USB-C cable.—*R.B.*

ESAB Renegade Volt Welder
$3,600
We get to test a lot of tools here, and there are always the latest versions of various tools, so it's rare to actually miss having a particular one around. However, the ESAB Renegade Volt is one we've missed ever since it had to go back. We found it to be one of the most significant developments in welders in recent years. It's powered by four 60-volt 12Ah DeWalt Flexvolt batteries, so you're not tied to an outlet or the availability of 240-volt service. You also don't need a truck to take it with you. At just over 50 pounds it's not light, but it is portable enough to carry out to the woods to repair broken equipment. We burned through 10 welding rods and used up just over a quarter of the battery, and in that time got completely comfortable laying down clean beads.—*B.F.*

Lasko Super Fan Max Multi-Purpose Compact Air Mover *$80*
Lasko's Super Fan Max is an affordable solution to quickly ventilate or dry wet areas. With three speeds and three blowing angles, it's easy to direct the amount of air where you want it. To cover larger areas, the fan includes an outlet so you can daisy-chain as many as three fans with their 10-foot cords. We measured air speed on the Super Fan Max's three settings at 38, 40, and 44 mph—which translates to a top volume of 542 CFM (cubic feet per minute). The affordable price, versatile air direction, durable housing, and air volume make the Super Fan Max a great choice for drying wet carpets, ventilating odors or fumes, and cooling large spaces.—*B.F.*

Klein Tools Precision Ratchet and Driver System 32787 *$50*
This is the best precision driver set we've tested, and we've tested some good ones. This little tool kit succeeded for several reasons, one of which is the variety of bits it provides (60). An accessory extension shaft is included to complement the slide-out extension shaft in the handle—and a ratchet wrench is tucked in, too. The wrench accepts ¼-inch hex shaft bits. It also succeeded for its build quality, which is surprisingly robust, given the tools' small size. We used it to drive and remove full-size wood screws (numbers 8 and 10), as well as some machine screws that are so small you need a magnifying glass to see what type of slot they have in their head. It's a lot of value packed inside a durable and well-designed case that provides a clear view of the tools and bits and a secure hold on them.—*R.B.*

Eufycam S330 Solar Wireless Security Camera *$770 for 3-cam kit*

There are plenty of wireless security cameras out there that use solar panels to charge. The Eufycam S330 Solar Wireless Security Camera has the panel built in—you have only one component to mount, and no connections to worry about keeping watertight. Plus, Eufycam's subscription-free service made choosing the S330 a no-brainer. The company claims the cameras need only two hours of sunlight a day, and we haven't had any issues with the three we've been testing in a wooded area for over two months—the batteries haven't dipped below 90 percent. That battery life will be affected by how frequently the cameras are triggered—more frequent triggers means more battery used. Eufy's app is easy to set up and lets you access the cameras, review recorded events, and adjust activity areas, motion sensitivity, and alerts. Why we love it: one up-front cost, no subscription fees, no recharging cameras, and, ultimately, peace of mind.—*B.F.*

Freud Track Saw Blades, Fine Finish, D0648TSF *$40* **and Laminate, D0652TSL** *$48*

The track saw revolution is picking up speed, transforming woodworking and carpentry much the way cordless drills have. Diablo (a Freud brand) is answering the call for top-notch blades for these saws with the introduction of a new line designed to deliver clean cuts and maximize battery life through smooth running and a lack of friction. We tested two—a fine-finish version for wood-based materials, with an alternate top-bevel tooth grind; and one for synthetic materials like vinyl flooring and PVC, with a triple-chip tooth grind. Both blades feature teeth fronted with high-density carbide and yield splinter-free cuts. Even running the blades on a saw and track that have some wear and tear, we were amazed to produce edges that look like they had been run over a jointer. The corners of the sawn parts were sharp and square, and the edges were straight and remarkably smooth.—*R.B.*

GEAR OF THE YEAR

DeWalt Framing Blade
DWA271424 *$10*

The best circular saw won't cut the mustard, let alone framing lumber, if you don't put a decent blade on it. We tested DeWalt's unusual new blade in an old-school 15-amp sidewinder circular saw and were pleased with its performance. Crosscuts at 90 degrees in framing lumber were sure and steady, as were full-depth crosscuts in 4 x 6 pressure treated. The blade and saw also aced 45-degree cuts in the pressure treated. We pushed the saw and blade hard, making cut after cut to the point that we were sure both would get good and hot. But the blade remained cool. DeWalt attributes that to the plentiful ventilation slots. We were amazed to see how much metal is removed for venting. The blade is reasonably aggressive, with an 18-degree hook angle, but it's not crazy either. You would have to try hard to overfeed a saw with this blade on it. As extra insurance, DeWalt equipped the blade with a substantial anti-kickback shoulder. For a framing blade, it delivers a reasonably smooth cut and tracks straight and predictably. The blade's anti-stick coating should help its longevity, as should the high-density carbide teeth.—*R.B.*

GEAR OF THE YEAR

Klein Tools 3-Piece Premium Electrician's Quick Release Step Bit Kit *$150*

Klein Tools is famous for equipping power-line workers and electricians, so it makes sense to get into the step-drill business. Electricians have loved these drill bits since they were introduced as the Unibit in the late 1970s. Electricians and all of us have found the multi-diameter bits to be particularly valuable for their ability to quickly put a clean, precisely shaped, and burr-free hole in sheet-metal boxes and thicker steel shapes such as square tubing. We tried out this bit set, making holes up to 1 inch in diameter in steel ranging from 16-gauge to ⅛-inch thick. Lubricated with the cutting oil packed with the bits, each bit cut a hole quickly and efficiently, using both an impact driver and a cordless drill. With both power tools, the three-bit set reliably makes holes from 3/16 inch to 1⅛ inch.—*R.B.*

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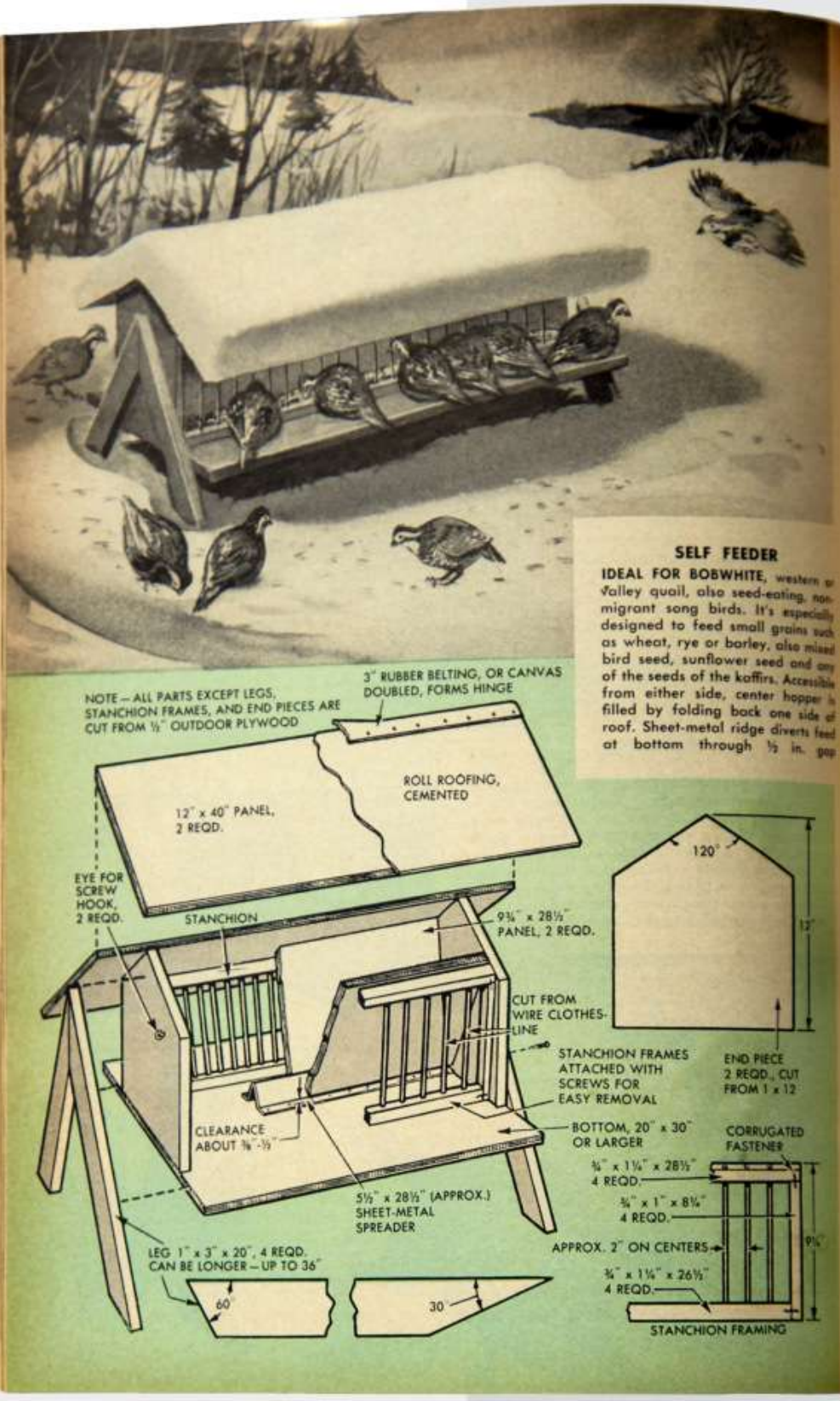
60 Years Ago in *PopMech*

// A PORTAL INTO *POPMECH*'S PRESCIENT AND OCCASIONALLY ABSURD PAST //



should be placed at leas
heavy snows and cold
make sure that the feede
ically located where n
must know the daily ra
their feeding habits mor
where they roost and h
range in search of food
ties. This is easily deter
ation or from landowne
will gladly grant you per
feeders on their propert
Several pointers in the
feeders are important t
make individual feeders s
near natural cover fre
birds, such as a ditch o
overgrown with shrubbe
normally shelter during
weather. In the open nea
the edge of a wooded ar
a good location. But befo
feeder take careful note
area, and remember th
which the most severe s
to come. Don't place th
drifting snow may cov
and remember to place it
heavy cover so that p
forced into the open befo
within striking distance
In some cases it may be
an otherwise favorable l
the feeder close to na
then erect a length of te
wire fencing which will
to make a detour and th
selves in time for the b
home. A few long stakes

STRING EAR CORN on a length
the wire attached to a spring t
of course, will attract other bi

JANUARY 1964

PHOTOGRAPH BY THOMAS HENGGE

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