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TECHNOLOGY IN YOUR HANDS

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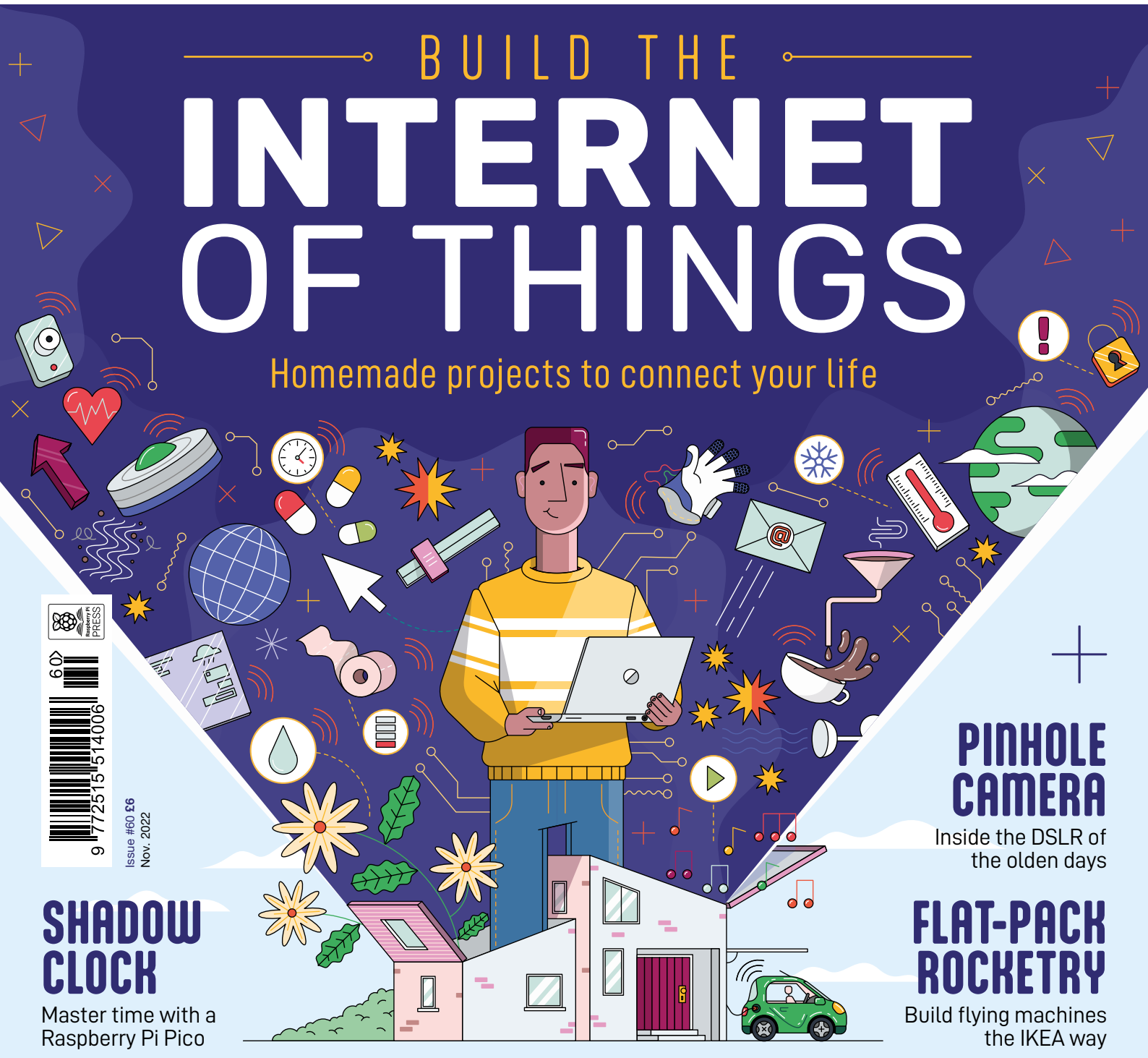
BUILD THE

INTERNET OF THINGS

Homemade projects to connect your life



Issue #60 £6
Nov. 2022

PINHOLE CAMERA

Inside the DSLR of the olden days

SHADOW CLOCK

Master time with a Raspberry Pi Pico

FLAT-PACK ROCKETRY

Build flying machines the IKEA way

TILES PLANTS **KEYBOARDS** LEDS

FEATURE

HOW I MADE A DIVE WATCH

Building some customised wrist bling

By Jo Hinchliffe

Lurking around watch communities there are lots of examples – you'll find people 'watch modding', where they customise a watch, or 'watchmaking', where they assemble watches from parts. I prefer the term 'watch assembling' as I think watchmaking describes the process of creating gears and pivots to make the watch movements.

After reading a few different accounts, I decided I wanted to assemble a dive-style watch, which basically means it's pretty large, waterproof, and has a rotating marked bevel. A popular starting point is to pick a movement: the mechanics that sit inside the watch, making it tick. I didn't want to go in at the cheapest level with a battery-powered quartz movement, but rather a mid-range mechanical/automatic movement. These movements can be wound, but they also self-wind when worn on a wrist as you

Right
The completed custom-built dive watch

move around. The classic movements for this are the Japanese NH35 or NH36. These movements are commonly found in watches that cost between £200 and £500 in brands such as Seiko and Invicta. However, the movement itself can be bought for £30 to £40 online. Before you go and grab one, though, there are a few variants to consider. You can get the NH35 with a single date dial, which just shows the date number, or the NH36 with a dual date dial, which has the day of the week *and* the date number. You can see both movements suffixed with the letter 'A', but this can be ignored as they are all the same. The other option to consider is the colour of the dials; you can get black text on a white background or white text on a black background. An NH35 or NH36 should come with a dummy stem and crown inserted into the movement. This will be replaced with another stem which will be cut to length and threaded into the crown that will be supplied with your case – the stem is the shaft that sets the time and date and also winds the movement. Sometimes the movements come with an uncut stem, and sometimes a case is supplied with an uncut stem – either option is OK, but you definitely need one, so check your product listings carefully (**Figure 1**).

Having settled on an NH35 movement, I set about case shopping. You need to search for watch-cases listed as compatible with your movement – there are plenty available for the NH35 movement. I wanted a watch-case that had two particular features. I've always liked watch-cases where the crown and stem are at the 4 o'clock position rather than the conventional 3 o'clock position. In terms of the NH35 movement, this is totally cosmetic, and it can be rotated to whatever crown position; however, you need to ensure your 'dial' – the face of the watch – is compatible with a 4 o'clock crown. I've never owned a watch with an exhibition case back – where the back of the watch-case has a crystal window so you can see the watch's movement. This attractive element was my second feature of choice. I bought a budget case for £34 that ticked both boxes.

When researching your case, you will find that it mentions the diameter needed for the dial or watch-face. Many NH35-compatible dive-style watch-cases will

"YOU CAN SEE THE WATCH'S MOVEMENT"

Figure 1
An NH35 movement with a dummy stem and crown; an oversize stem was also supplied with the movement

FEATURE

Above
The dive-style watch-case with the exhibition case back and a stick-on bezel cover

a plain black unmarked dial, which I love. However, it actually made things a little trickier when fitting the hands.

Hand choice again needs to be compatible with the movement. The NH35 movement needs an hour, a minute, and a second hand, and the tiny tubes/holes in the hands are very accurately sized to be fitted onto the NH35. I went with some chunky-looking hands, as I guessed they might be slightly easier to handle (**Figure 2**).

For the assembly of the watch, I've tried to keep extra tools to a minimum. In issue 31 (**hsmag.cc/issue31**), I made a bench block from a rubber hockey puck, which I occasionally used to place the watch assembly on as a no-scratch, non-slip platform. You can buy small leather stuffed blocks specifically for handling watch assemblies, but you could get away with a clean patch of a rubber cutting mat. I also don't currently own a movement holder, which is a sort of vice that gently holds the movement. This would make the job much easier and safer – it is on my list of things to make (or buy). A cheaper approach is to always place the movement onto the back cover of the case. Be extremely careful, if you need to place the movement face down, that the centre hand shafts or indeed the hands can't come into contact with a surface. The tools I did buy, in addition to those mentioned earlier, were cheap hand setting tools. These rods have plastic end caps, and each end has a hole. The holes and end cap diameters vary – you can find from the choice of six, one that will push the target hand onto the target shaft without touching the other smaller shafts.

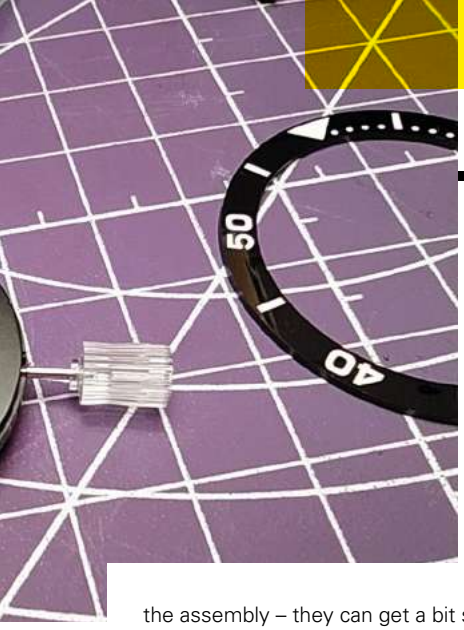
So to begin, I placed the brand new movement on top of the case back on top of my rubber bench block, and the first job was to fit the dial. It's important to work cleanly, so I wore vinyl gloves throughout

require a 28.5mm diameter dial. When choosing a dial, you need to make sure it has the correct aperture for the type of day and date dials you have on your movement. On the rear of the dial, there are some tiny pins that slide into holes in the band around the movement, and these pins need to be compatible with your case setup. So, for our build, we needed to check that the dial was compatible with a 4 o'clock crown position case. This is important as the date aperture still needs to be at the 3 o'clock position when the dial is fitted. Although there are thousands of dials out there in a wide variety of designs, I decided I wanted to go with

QUICK TIP

Using a dial with numbers or hour markers makes it easier to align the hands correctly.

Figure 2
A set of NH35-compatible hands chosen from a massive range of those available. They arrive well packed inside a solid case



the assembly – they can get a bit sweaty, so a lot of watch modders just wear 'finger cots', which are individual rubber gloves for fingers. A fingerprint on the dial can be removed with a lint-free cloth, like a lens wipe cloth, or you could buy some 'Rodico', which is a watchmaker's cleaning clay that you dab onto parts to remove oil, finger marks, and dust particles.

Removing our dial from the packaging, we inspected and then aligned the pins on the back with the correct holes in the movement so that the dummy crown and stem are at 4 o'clock and the date aperture complication is correctly positioned at 3 o'clock (**Figure 3**).

Next up is fitting the hands. Have a good look at the centre shafts using a loupe or other magnifier. You should see three different sizes: the widest diameter at the base receives the hour-hand, the middle shaft receives the minute hand, and the tiny, thinnest shaft will receive the second hand (**Figure 4**). Be very careful with these shafts – if they bend, it is near impossible to make the movement work correctly. Looking at the hands themselves, you'll see the underside of each hand actually has a short hollow tube; these tubes are press-fitted onto the corresponding shaft. Find the hand fitting tool that has a hole large enough to clear the two smaller upper shafts but will press onto the thickest shaft at the bottom. Don't press down with great force on these shafts – the forces involved are very small, particularly when it comes to the second hand. Before fitting the hour-hand, you need to get the date dial to the position where it has just clicked over to a new date. Pull out the dummy stem as far as it will go and wind the stem forward until the date begins to transition; as soon as the date finally slips into the correct position, stop turning the stem. When the watch is assembled, the date should begin to transition after 11pm and be fully transitioned at midnight. This means that if we now fit the hour-hand pointing to the 12 o'clock position, the date change and hour-hand will be correctly co-ordinated.

Use a pair of tweezers to place the hour-hand so that the tube is slightly over the bottom shaft. Gently push and move the hand fitting tool to manipulate the hand onto the shaft. You want to get it to catch onto the shaft in the first instance and then check that everything is looking OK before pushing it further on. Never rock the tool too far from vertical, certainly never more than 10 degrees off axis, as this is liable to damage the shaft. Slowly work the hour-hand down onto the shaft so that the flat section of the hand is flush with the top of the shaft. If you leave it too high, it will interfere with the fitting of the minute hand. Keep checking the hour-hand with a loupe as you fit it, looking →

"I WENT WITH SOME CHUNKY-LOOKING HANDS"

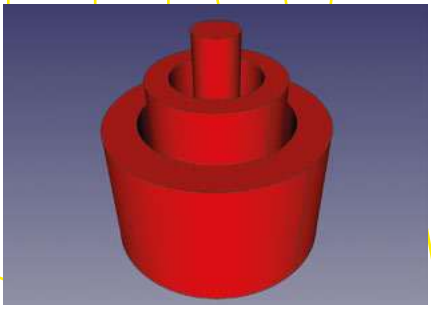


Figure 4 ↑
A representation of the tiny posts that you press the watch hands onto. The thinnest post for the second hand is less than a millimetre in diameter

QUICK TIP

It is preferable to fit the hands correctly first time; however, you can carefully remove them using either a set of hand lifting tools, or indeed placing tweezer tips either side of the shaft and gently pushing the hand off.

Right ←
Some budget watchmaker's tools; some hand setters, a dust blower, tweezers, and a bench block

Above
Using the correct hand fitting tool and tweezers, you need to exercise extreme care in handling and fitting the hands

both at the shaft fitment and also checking the hour-hand is horizontal and parallel to the dial face when observed from the side.

Once you are happy with the hour-hand, use the stem to wind it around the dial twice to observe if the hour and the date change align correctly. Then, accurately wind the hour-hand to the 6 o'clock position. Repeat the process to fit the minute hand onto the second shaft, again with the minute hand pointing precisely at the 12 o'clock position. Check that the minute hand is flush with the top of the shaft and parallel to the dial and not drooping down or rising upwards – this is critical as the hands obviously need to clear each other as they rotate when the watch is running.

"SLOWLY ROTATE THE HANDS USING THE STEM"

Once you are happy with the minute hand, slowly rotate the hands using the stem, and triple-check that they clear each other when they pass over each other in numerous positions. To fit the second hand, it's not too critical where the other hands are in relation to it. A common approach I used was to set the hour and minute hand to the 12 o'clock position, then fit the second hand over the top of them. The second hand is by far the hardest to fit – you need to be extremely careful to not bend the second hand shaft, which is a fraction of a millimetre thick. It can even be quite hard to see the second hand shaft using a loupe, as any shadow can suddenly render it invisible. So again, you need to find the hand fitting tool, probably with the smallest hole, which will again press onto the hand but not the tiny shaft. A good practice tip I found was to place the second hand on a hard surface and then rest the fitting tool on it and see how little pressure you need to cause the second hand to become horizontal on its tiny fitting tube. You can then practice gently rotating the second hand slightly to train your hand and brain with the necessary forces. Using the loupe, place the second hand so that the tube is resting on the top of the shaft. Before you press anything down, triple-check that it is in the correct position, as it's easy for this to end up incorrectly in the gap between the second hand shaft and the minute hand. Once you are happy, use a little force to bring the second hand horizontally over the shaft and gently push it down into position. Check it from all sides – adjust if needed. Once you are satisfied that it's correctly installed – horizontal relative to the dial and hands move freely – you can then give the stem a couple of winds and the assembly a gentle shake to get the movement running. Let it run for a while, checking that the second hand doesn't catch anything when it passes the hour and minute hands.

It would be best practice to let the watch movement stop before continuing again but, if you are like me, you may be impatient. The next step is to remove the dummy stem from the movement so that you can insert the movement into the case. You need to find a way to support the movement upside down without damaging the hands or centre shafts. I managed to do this using the v-cut out on my bench block, but this

Figure 5
Using a set of callipers to measure the amount of stem that needs to be removed to make it fit the case correctly

Below
Using a small pin tool to release the dummy stem from the movement

QUICK TIP

Almost all watch movements have instructions online, or sometimes they are marked with where to press to release a stem.

is where a DIY or a commercial watch movement holder would be useful. Press the release bar to release the dummy stem and withdraw it.

Taking care to align the stem position with the hole in the case, I placed the movement into the case. You might need to use a cocktail stick to gently press the edge of the movement to encourage it into position – obviously, limit this to the fitment ring around the movement; don't press down on any moving parts!

The stem of an NH35 movement watch is threaded, meaning it threads into the crown. Due to different case sizes, the stems are supplied oversized and need cutting to length. In my build, this was slightly more complex as I had a threaded sprung crown. This is a common feature in some dive watches that makes the crown and stem assembly more waterproof. The crown itself is internally threaded to screw down onto a threaded shaft protruding from the case. Inside the crown is a rubber gasket which, when tightened down, creates a robust waterproof seal. This means that the stem has to compress and elongate – it does this via a sprung piston inside the crown, into which the threaded stem is inserted. I threaded the stem into the crown and fitted the oversized stem and crown into the watch, ensuring the stem was fully engaged and sat in the winding position. I then carefully compressed the spring to push the crown closer to the case – when it wouldn't press in any further, the gap between the base of the crown and the edge of the case, where the crown should be touching, was the amount I needed to cut off the stem to bring it to the correct size. I measured this gap *many* times and concluded that I needed to remove 6.3mm to bring the stem to the correct length. To achieve the cut, I removed the stem and took the stem of the crown, and then I measured the complete stem, then took away 6.3mm from that value and locked my callipers into place at the required length (**Figure 5**). I then placed the inner tip of the stem against one jaw of the calliper and then rested the other end of the stem on the upper surface of the other jaw. I then placed some side cutters around the stem, with the flat side of the cutter flush to the calliper jaw. Checking everything twice, I performed the cut. Refitting the freshly cut stem to the crown, I test-fitted it once more, this time screwing down the crown to meet the case. Everything was in the right place with no gaps, so I disassembled the stem once more to place a tiny drop of superglue on the thread inside the crown to act as a thread locker.

I could now relax! All the challenging and potentially watch-damaging activity was over. I simply fitted the back of the case, stuck the bezel surround onto the double-sided bezel tape, and then fitted the strap. Watch-cases have different width straps – you measure between the lugs to discern the strap width you need. Both my watch-case and my watch strap arrived with telescopic pins, which you can compress to fit, and they expand into the lug holes. The ones with my strap arrived and were a bolt-action type, where they have a small handle that allows you to easily fit the pins without any tools. However, if you've made it this far into a watch assembly project, you'll fit the pins with ease!

I'm pleased with the watch and very proud to wear it. Be warned, though, it's addictive! I'm already planning and accumulating parts for another build! □

Above
The exhibition back case allows you to inspect the movement through the back of the watch

OPEN AND SHUT CASE

Opening and closing watch-cases is a basic task in watch assembling or repair. There are a couple of ways that case backs attach and are removed. A common case back is the press-fit type, where you need to use a thin tool to prise up the cover. Often there is a small lipped part that allows you to place a flat tool underneath. A common tool for this is a 'spudger', but you can also use a thin-tipped, flat screwdriver or a thin guitar plectrum. The other case back type is a screw down back. These often have a collection of small square grooves around them, and you can use a case opening tool which has adjustable tips. You can move the position of the tips to match three of the grooves in your case back and then use this as a wrench to open and close the case. It's a really good idea to cover the case back with masking tape to minimise the risk of you scratching it.

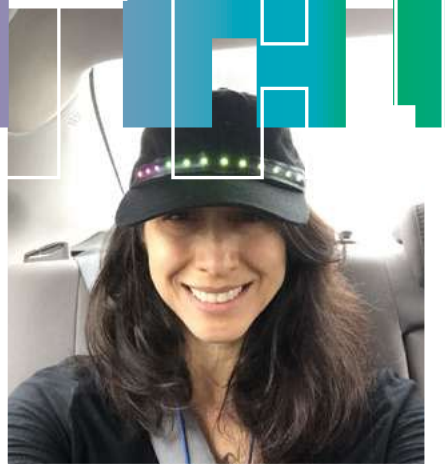
HackSpace magazine meets...

Debra Ansell

Why do art at all? Because we can!

You may have seen Debra Ansell's sound-reactive LED embroidered party dress. Or her internet-connected, intelligent edge-lit acrylic light paintings. Or you may have recreated one of her builds yourself – following the instructions she generously puts up on her site **geekmomprojects.com**. Alternatively, you may recognise the name because almost everyone we speak to nowadays cites her as an influence on their work. We spent an hour with her talking about everything from manufacturing, creativity, and how you get from a physics PhD program to teaching kids electronics.

Power to the pixels



Above
The LED bracelets are Debra's latest creation; they incorporate elements of electronics, laser cutting and 3D printing

HackSpace magazine **Morning Debra! Let's kick off with what is simultaneously the easiest and yet also the hardest question of all: who are you?**

Debra Ansell That's existential! I'm a maker. I was a stay-at-home mom, with a tech background, who's always loved science and learning and creating. I've always been very creative, but not at all artistic. I can't draw freehand; I really have no eye for colour or anything. But when I first saw that you could do something digitally, it was a revelation to me – I can get exactly what's in my head, into the real world, without the limitations of my lack of artistic ability and dexterity. And if it's digital, you can edit it and revise it infinitely, until you get what you want. Digital making really opened doors for me.

I love science. I love pure science. I don't necessarily love the nature of how to practice science – you pick a very small piece of a very big puzzle and drill down on it. And it's absolutely essential that you do that. But I find the big picture interesting, and the smaller practice less so. I still like to keep up with where things are going – string theory, Higgs boson – but I realised that if I was going to stay in academia, I was going to, you know, pick an integral and add a decimal place every few years or something of that nature, which did not appeal to me. So I ended up leaving the physics PhD programme I was working on. I had learned to code (mostly in Fortran) to analyse my data. And I started working as a software engineer. I liked the interactive, iterative nature of software. But, you know, I was working for an internet startup, and it was not at all family-friendly. Software isn't to begin with, but the internet startup was 25-year-old guys, and I came to the office pregnant and they had no idea what to do with me. So I retired, you know, to stay home with my kids, but I still love science. And, of course, kids are natural scientists.

That was my outlet for a long time – I was always the mom who volunteered during the science experiments at the after-school activities, things like that. And then my middle son discovered LEGO MINDSTORMS... from there, I discovered Arduino.

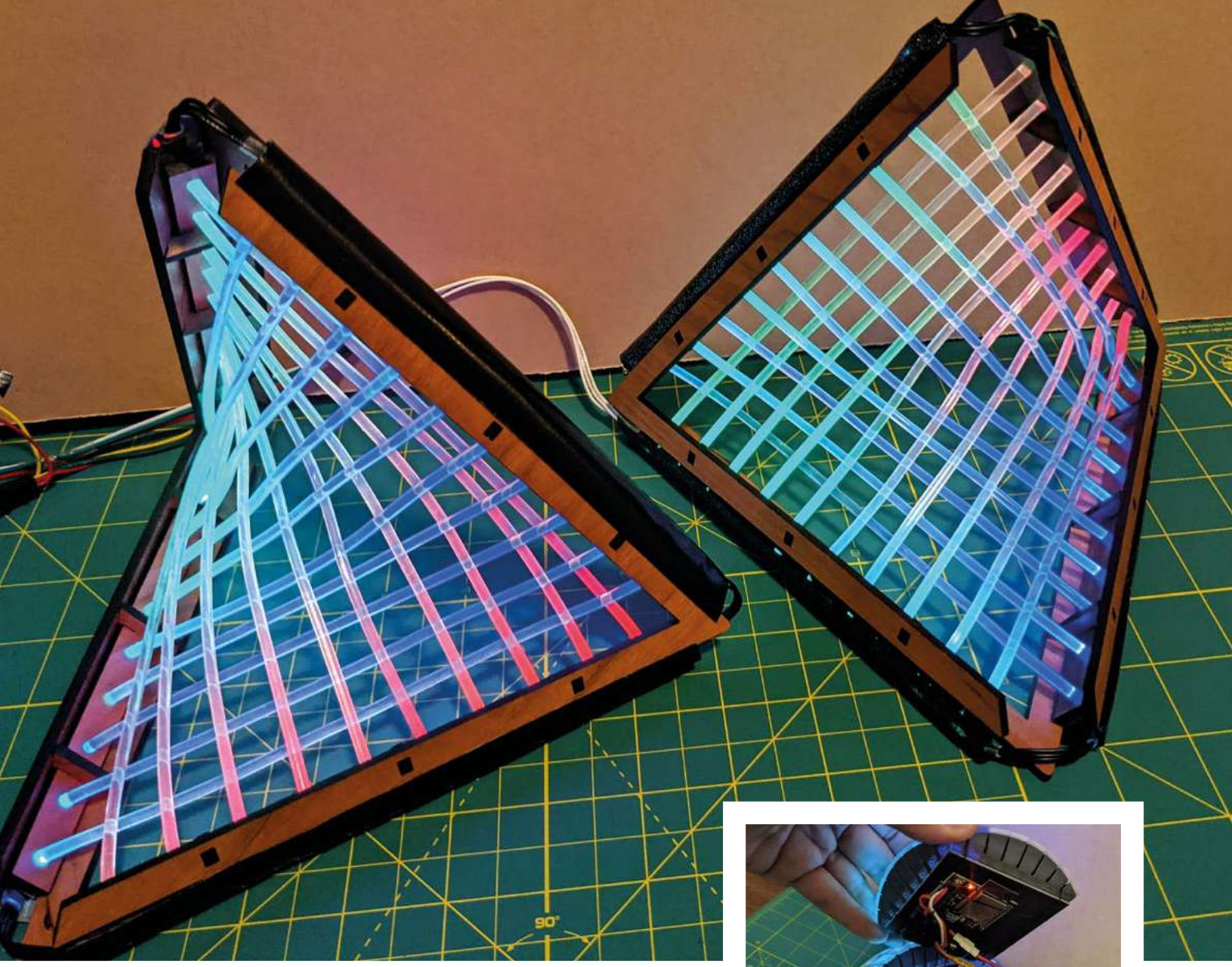
I'd never heard of it at the time, but I've looked into it. And coincidentally, I was booked in to do a workshop that was using a LilyPad and conductive thread: a wearables workshop, which is my sweet spot. I got lucky – it's fun, it's affordable, it doesn't take up too much space, and it progressed from there. I just kept seeing really cool projects online that people created and detailed for you to reproduce.

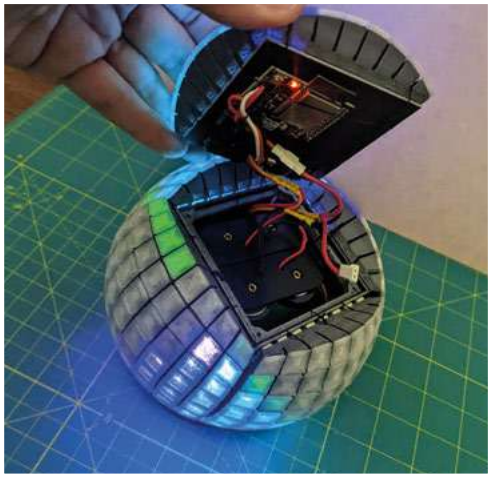
I had a strong physics background. I had taken electronics classes, but I'd never had hands-on experience of electronics before that. I mostly took observations of astronomical radio data and analysed it; I wasn't really in there with a wrench and a screwdriver.

So I learned hands-on electronics through Arduino, and eventually, I [became] comfortable enough making

Above ↑
It's hard to implement electronics on a sphere – Debra's done it by curving the diffusion, not the electronics

Below ↘
The smaller a sphere gets, tighter the tolerances need to be. This looks pretty jolly nice to us





Above
Debra's aesthetic is getting light to fill spaces in interesting ways

projects that I'd seen other people make, and I started to be able to improvise. It was a great creative outlet. There's a lot you can do with this that nobody's done before. So let's see what happens.

I love working with kids. I volunteer teaching kids to code. My job is to keep them from doing anything unsafe, but otherwise, let them go. And they're appropriately enthusiastic about really cool things that might not resonate with other people. I was so happy when I had my Code Club meet right after the Mars rover landed and we were talking about the code in the parachute. And the kids thought this was so cool [that NASA had encoded a message into the parachute]; then I walked around all afternoon talking to grown-ups – the reaction was not the same at all. It's really fun to deal with people who share your enthusiasm for whatever it is you're excited about.

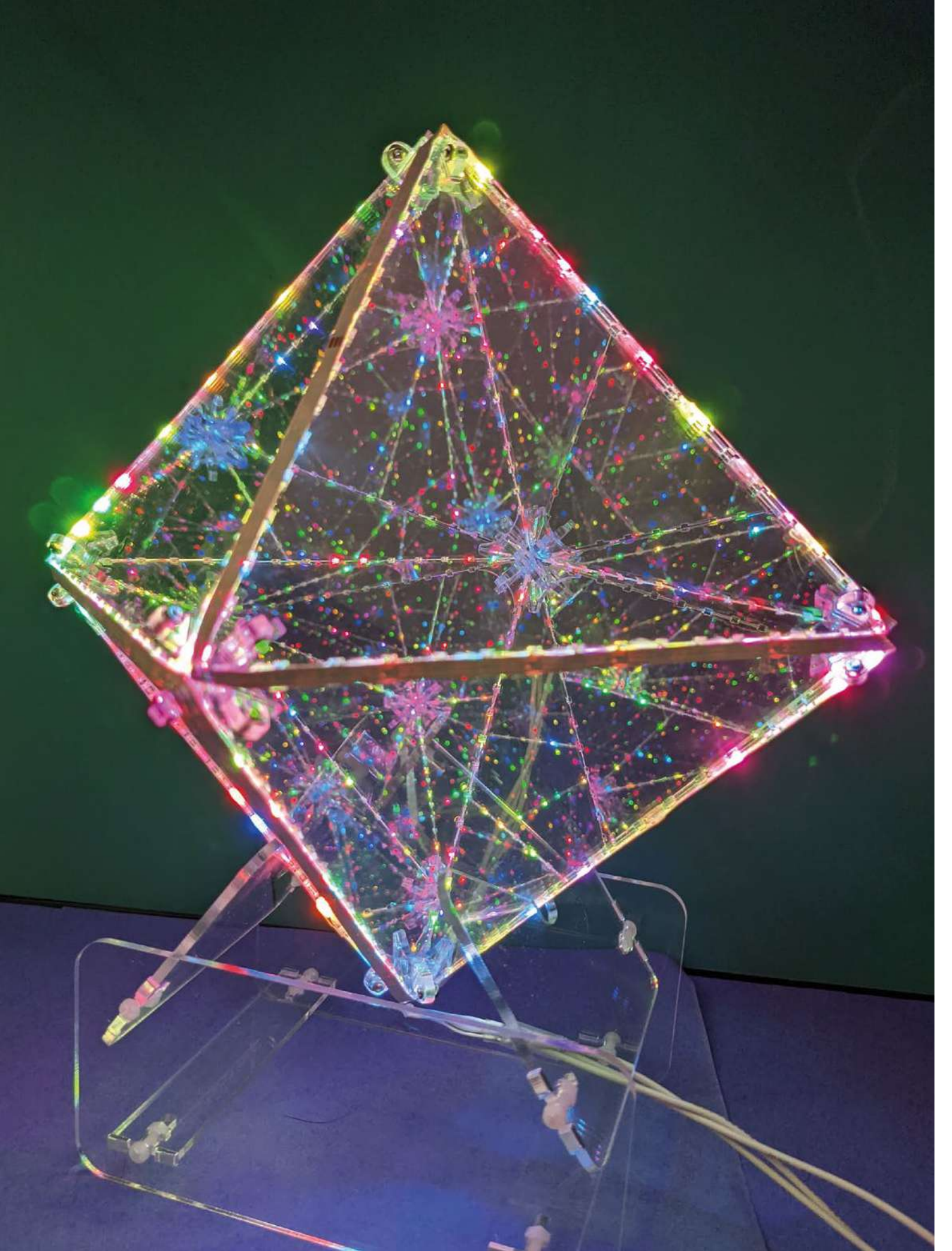
HS Do you think there's something inherently childlike about makers?

DA Oh, absolutely. There is an absolute sheer unfiltered joy in reaching vision and making it work. And there's definitely an appreciation for silliness. I think you don't have to take it too seriously. And in fact, because tech is such an innately serious subject matter, to kind of subvert it and do interesting things with it is appreciated. Like I love Jiří Praus and Mohit Bhoite's work with circuit sculptures. Take an inherently practical medium, and make it beautiful, but still functional.

Above
The lid of the sphere is held in place with magnets

There's no doubt that it's art, because why else would you do it?

HS You've touched on it already, but you go to a lot of effort to document your builds – why?



Left
Debra's been working with Jason Coon and Ben Hencke to create these animated LED pendants

DA That's the ongoing challenge for me. I don't love documentation. But in the beginning, I benefited so much from what everybody else would put out there. I want to make anything that I do that I think somebody else could make or learn from available. So I do try, because it's fun to create something. But it's even more fun to share that creation and watch other people experience that joy. I really try to not only make a project but, most of the time, I don't consider it done until I can make it buildable by somebody else.

And that's a challenge: it's often harder to make a project accessible than it is to make the project in the first place. I find it particularly satisfying when I can post a tutorial, and other people can experience the joy of making something really, really cool. A good example is the LED sphere that I'm currently working on.

I am so happy with this project. The joy of this orb is that it's far more reproducible than [any comparable project] that I've seen, because people have made LED spheres and they are a ton of work. Electronics go much more easily into a plane, and to make a sphere, you want to put them on a curve – there's the challenge right there. The breakthrough realisation for this orb was that you can have all your LEDs in a plane using standard LED matrices – you can just curve the light. I mean, I spend my whole time trying to pipe light into different places... my whole aesthetic has been to take the light and don't just make it a pinpoint; fill space with it instead, do something more interesting. It's nice to make things that are just fun to look at for no other purpose than just to look at them.

> "It's often harder to make a project accessible than it is to make the project in the first place"

HS When you say that the project isn't finished until it's in reproducible form, that really sounds like a scientist talking. I wonder if that's why your name keeps cropping up when I talk to other makers.

DA Well, there's a bit of coincidence in whom you've reached out to in a way – Jason Coon, Carrie Sundra, and I are all in a maker group – Jason and I developed a project together. Carrie has a business, and I admire her tremendously for it. So many makers are creative, and everybody wants to start a business, including me, and I did. But it's a very different animal, and the overlaps between making and running a business are not at all obvious: the skills that make you good at one are not the skills that make you good at the other. I do not love the business aspects of selling your creations, and I admire Carrie tremendously. I think she's very good at it.

I've decided from my experience with trying to run a business that I'm much happier leaving the business aspects to others. I'd be Steve Wozniak than Steve Jobs.

HS Another maker we've had in HackSpace mag, Odd Jayy, also mentioned you as an inspiration.

DA The funny thing about Jayy is that he and I share a kind of obsessive tendency to lock ourselves in a room with our creations. We met years ago, and he just wanted to build robots, cool robots that shared his aesthetic. And it wasn't for any other purpose than he liked and needed it obsessively. And it turns out, it's a really cool thing that others want to do.

I feel a certain familiarity with that story. I've been obsessively doing the →

things I like for a very long time. And after twelve years or so, I've gotten good enough that I can make them good. And people like them; it's not that I've tried to make projects that people are interested in, but I have obsessively focused on this one niche thing that, fortunately, turns out to be interesting to people – LED wearables in particular. I also think that the projects I build lend themselves very well to social media, because they're blinking and bright and colourful. So my work gets shared a bit on Twitter.

I do like to think that I'm putting novel ideas out there that inspire others, like LED string art. I hadn't seen that before. The internet craves novelty, and bright, blinky pictures, and I'm in the sweet spot, and it gets me widely shared.

HS Are you still using Arduinos? Or have you moved on to Raspberry Pis or Adafruit devices?

DA I hop around from project to project. I do have a lot of Raspberry Pis – I think I have one of everything. And I love my Raspberry Pi 400 because it's super-cheap and easy to take for tech demos; you can just plug it in and take it, and I take it places where I'm gonna be working with kids. When Raspberry Pi first started, I hadn't seen the idea that you make an accessible platform that was designed to bring education to places where it wasn't easily accessible. And it was brilliant. Really, really brilliant.

And so I've used Raspberry Pis a lot in my projects. As I've gotten more prolific, I've gone cheaper and simpler. I don't need an operating system, so even a Raspberry Pi Zero is overkill for a lot of what I do.

My favourite Raspberry Pi creation is a jacket with programmable LEDs – I put in a Raspberry Pi-based web server, so you can actually code your own patterns on the fly, as long as you have access to a device with a web browser. It has a drag-and-drop coding interface to create LED patterns. You can actually code your own LED patterns; you can be totally separate over there that run on my jacket while I'm wearing it.

It's fantastic. Everything I do is because this tech is so accessible. Any organisation that strives to make it more accessible is wonderful, especially to communities that don't get to see and play with tech in the way that more privileged communities do.

I volunteer for a Los Angeles-based non-profit that brings science into underserved elementary schools, because in Los Angeles, the public elementary schools don't have a science curriculum until middle school [when kids are twelve years old].

Now, most schools try to fill that gap by raising funds; the poor communities can't. So this programme brings a science curriculum to underserved schools. I managed to catch up with them and said, "Hey, I know you know a bit about coding; I like working with kids; maybe I can help with that aspect of your work". And right at that time, I think micro:bit had just come out. It wasn't big in the States, but it was this wonderful platform, and inexpensive – that was the best thing. The interface was good, but the price point made it a no-brainer. So I go into these classes; my own kids are very lucky, they've had iPads and whatever they want – they're digital natives. But you'd go into these classrooms and see these kids get so excited about the tech and coding. And I'd say, you know, well, even if you don't have a micro:bit, you can go home and use the interface in your browser. And they'd say I don't have a computer at home.

I'm a big believer in the saying that talent is equally distributed, but opportunity is not. Some of them are amazing, and if they don't get the opportunity to access these tools, you lose

Left
The diffusers (the dragon scale-like parts) are 3D printed onto a thin mesh, which is reinforced with leather for strength and flexibility

so much. [Messing about with electronics] is engaging and fun, but it's good for so much more.

I'm hoping that years from now that this will translate into something. I just want them to know that if they do manage to make it to a place where they could take a programming class, they'll say, "Oh, yeah, I can program; I've done that." Not, "Oh, programming is hard and weird." Programming is mysterious if you haven't tried it, but once you do it, it's really nothing special. It's laying out a series of instructions, which anybody can do.

You asked what platform I was using. I'm a big fan of anything that makes tech accessible. There's a reason I built my LED purses around micro:bit. But it started as a kids' project.

I wanted to make codable wearables that would maybe appeal to girls who are not so interested in robotics and traditional tech projects. There's no reason coding should be restricted to robots and video games and circuit boards – you can code your clothing. And so, I was trying to provide a platform and accessible again. I want to get back to accessible and inspired platforms for people to experience tech, that might not be what they expect and might reach people that weren't drawn to other uses of tech.

I'm drawn to controllers that make things accessible and easy. It's why I've got very into CircuitPython, because it has libraries that make it easy to do complex things with relatively little code, which lowers the barrier to people getting into it. And yeah, I'm drawn to inexpensive, of course. That's because at this point, I've accumulated so much. It gets expensive. [I like] inexpensive, accessible controllers, especially ones I think that people can get their hands on and use and enjoy and learn from.

HS What are you working on at the moment?

DA I have a lot of ideas. My brain's like a bubbling cauldron of soup with all these random things in it, and things keep popping up. I'll take an idea, look at it, and then push it back down into the soup. If it keeps resurfacing, I know it's generally a good idea. And I'll eventually tackle it.

I've been wanting to do a spherical LED project for a while, and when the idea of the flat PCB with a spherical shell clicked in, that took it into the realm of the practical.

And I'm working on a collaboration with Jason Coon and Ben Hencke [creator of the Pixelblaze LED controller] on an LED wearable. That's interesting, because we're now in the realm of producing ten of something – we've moved on from ideas, and we're stepping into production. My contribution to the design was the battery holder, which fastens with a magnet; it's also a switch that turns it on.

> "You asked what platform I was using. I'm a big fan of anything that makes tech accessible"

They're selling, which is wonderful. And, as I'm making the latest batch of battery holders, I'm thinking, what do we do if this scales? It's a really interesting problem. I'm thrilled with this design.

Above
You don't have to be interested in robots to get into programming

I love it. And I'm happy to make them. I'm happy to make one. I'm happy to make ten. I'm happy to make the 78 I just made – so it's doable, but it's relatively labour-intensive.

I don't want to be so arrogant to think that it's going to be wildly successful, but it's stupid not to prepare for potential success. So how do I scale this? So that's a kind of novel project for me.

I'm incredibly lucky. I get to come up with these projects and write them up. I get to design for the summer camp that we run for the elementary school kids, and that's fun, too. I'm doing workshops for other people, too. I have a workshop proposal in for Supercon. I've got a lot of ideas for fabric-based wearables that I'd like to try to execute. I'm super-excited about the potential for these LED cuff bracelets... I have a problem with prioritising, but there's certainly no shortage of things that I'd like to do. □

IMPROVISER'S TOOLBOX TILES

Tiles aren't just to stop your bathroom getting mouldy, they're a statement in their own right, says **Rosie Hattersley**

Rosie Hattersley

@RosieHattersley

Rosie Hattersley writes tech, craft, and life hacks and tweets **@RosieHattersley**.

Ever since we've been throwing up walls, we've been coming up with ways to cover them up or enhance them. Paint, plaster, wallpaper, and pictures all have their place, but tiles quite often outshine – and outlast – them all. Tiles can, in theory, be made to cover almost anything. For proof, look no further than the Sagrada Família church or Parc Güell in Barcelona, both dreamt up by Antoni Gaudí. Tiles and mosaics are also favourites of Spanish 'starchitect' Santiago Calatrava, whose soaring concrete structures are given beauty by their pristine white, light-reflective glazed coverings.

Tiled structures in ancient Egypt, Samarkand in Uzbekistan, Mexico, and Morocco all have distinctive designs that mark out their origins. The prevalence of tiled buildings across China, North Africa, and the Middle East points to the spread of this artisanal craft along the lines of the Silk Route, while European settlers subsequently brought their colourful decorative designs to Mexico and South America.

As with other decorative arts, tile design reflects the culture and interests of its makers. For example, Moorish designs, particularly those from Morocco, tend to feature complex geometric designs and there is still, just about, a tradition of hand-building beautiful zellige concrete tiles by hand. The skill involved can be appreciated in this YouTube video: **hsmag.cc/ZelligeTiles**. Relatedly, having been under Moorish rule for several centuries, southern Spain and Portugal have their own rich designs of ceramics known as azulejo.

Western versions of decorative tiles, meanwhile, tend to focus on figurative designs, whether religious – tiles were extensively used as striking, but fairly affordable, wallcoverings in churches – or secular. Nature and animals are common motifs in tiles from the Arts and Crafts/Art Nouveau period, neatly coinciding with the introduction of bathrooms in domestic settings; now, of course, the most popular rooms you're likely to want to tile.

As you might imagine, most of the alternative uses for tiles play to its decorative strengths: prettying up an otherwise plain table, wall, or garden walkway. However, one clever hack that caught our eye was this by the by reference to using an unglazed ceramic tile or two in a conventional oven, as an alternative to a pizza stone: **hsmag.cc/PizzaTiles**. If you've so far resisted the vogue for outdoor pizza ovens, this is a cheaper-than-chips option you might feel like trying.

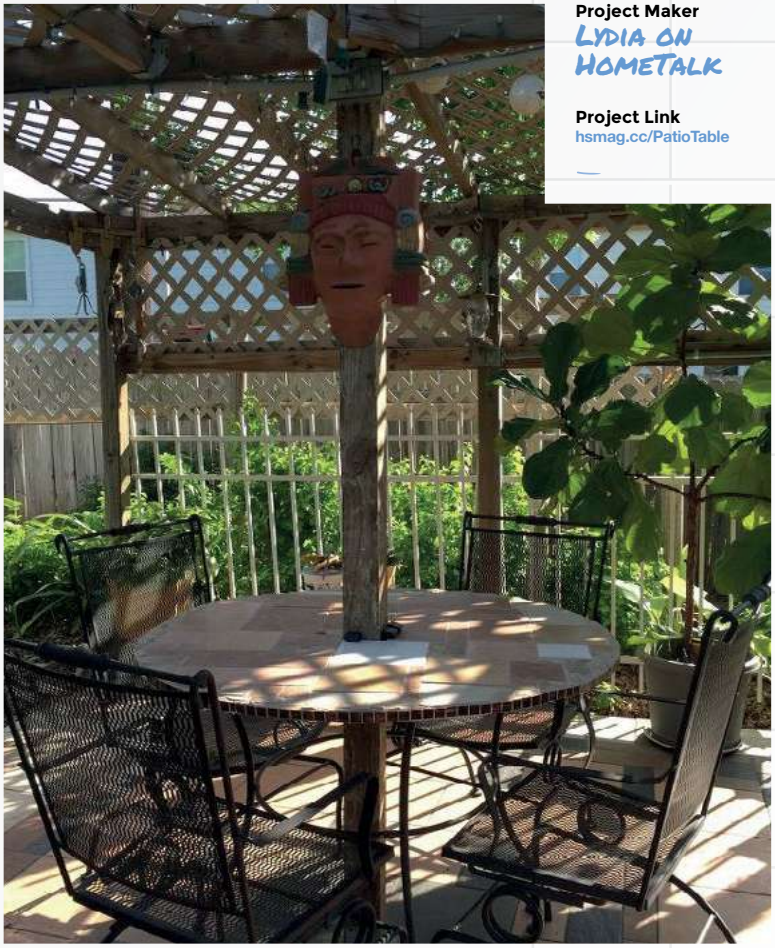
PATIO TABLE

Project Maker
LYDIA ON HOMETALK

Project Link
hsmag.cc/PatioTable

A tile-top coffee table or side table is the sort of achievable project that you can apply to nearly any style of furniture, updating its look while making the surface more durable and resistant to spills and scorch marks. If you really want to go to town, you could repurpose some old scaffold boards or pallet wood for the frame, as per this stylish, but pricey, example: **hsmag.cc/TiledTable**.

However, this new patio table from old, featured on DIY site Hometalk, is arguably a more sustainable option. The table was gifted to the couple who upcycled it. They promptly cut the tabletop in half, and removed two triangular pieces at the centre to accommodate a parasol post. The table was then spliced back together with extra supports underneath. Next, the couple set about arranging assorted leftover tiles, from redoing their patio, to fit the available space on their new tabletop. Once the tiles had been set in place, grout was added and finish applied to protect the patio table from showers. The design was completed with a line of small tiles around the edge of the table. In all, the project cost the couple $20. →



Above
Tiles don't only look good, they're a strong and sustainable material

TEXTURED CERAMIC TILES

Basic tile design can be as simple or as detailed as you choose, largely depending on whether you want multiple colours and whether you're introducing additional materials such as marble chips for a terrazzo look, using special glazes, or carving out the clay to create a relief design, as per the impressive handmade tiles showcased in this production video by Stow: hsmag.cc/HandmadeTiles.

For a more DIY approach to crafting individual tiles, look no further than the detailed video and accompanying Instructable by John Whitmarsh, who takes inspiration from the textures he notices around him, and sometimes takes impressions to use as moulds. For this project, he created ceramic clay moulds cast from old roadside guardrail posts in Sausalito, California. "I've always loved the texturing of old utility poles. No two look alike," he says. "Some are cracked and weathered from the sun and rain; some are charred; some have creosote and chemicals leeching out." He then takes a vertical block of clay, slices through it horizontally with cheese wire to create individual tiles, and presses each one on to the underside of the mould he's made. John then trims off any excess clay around the edges to ensure he'll end up with uniform-sized tiles. Having allowed them to dry slightly, he fires them and gives them a coating of melted wax to bring out the texture. Finally, he assembles each tile to form a unique textured tile wall: **hsmag.cc/CeramicWallArt**.

Project Maker
JOHN WHITMARSH

Project Link
hsmag.cc/TexturedTiles

Right ⬘
Like the wood grain, but hate wood? Then here's the tile for you!

LOST AND FOUND: PANEL 38120

Discontinued industrial tiles form the basis of this photomosaic by ceramic artist Rita João of Pedrita Studio. Together with her studio co-founder Pedro Ferreira, she produced the Lost & Found photomosaic series of tile portraits which began with, "a small, black and white photograph found, by chance, in the street, with the inscription 'my grandfather' scribbled on the back." The artists paired the concept of a discarded or lost object being rediscovered with a technique they developed known as Grão. This system sees them build up collage-like portraits from unwanted tiles based on the principle of the pixel or photographic grain. This example, from their 2018 Lost & Found series, is on display at Portugal's National Tile Museum in Lisbon.

Project Maker
RITA JOÃO

Project Link
hsmag.cc/PortugueseTiles

Left
Pixels don't have to be digital

REPURPOSED ELECTRONICS TILE SPLASHBACK

Maker miglarsh was on the lookout for a way to add interest to otherwise unadorned areas of the kitchen he'd recently refurbished. "I knew how many TVs, CD/DVD players, radios, computers, [and] anything with a circuit board wound up in the trash/landfill," he says of his decision to use salvaged electronics to create wall tiles. Having sourced the parts for free, he set about disassembling everything into constituent parts, organising it all by size so he could plan a rough pattern when he began to create the wall tiles. A palm sander and screwdrivers were used to dismantle and sand down parts, ready for arranging in a range of paraffin wax-primed formers where they were set in place.

At first, he planned to use the green circuit boards and discard the electrical components, but the range of colours convinced him to use more of the unwanted electronics in his design. " I found a treasure of colours and textures among the things attached to the boards," he explains. Having previously designed an epoxy counter-top, miglarsh combined his knowledge of epoxy with the traditional idea of tiles on the splashback. Referring to the "little gems" he found inside common electronics, which contain a lot of recyclable plastic that his tiles have kept out of landfills, miglarsh declares it a win-win! ◻

Project Maker
MIGLARSH

Project Link
hsmag.cc/ElectronicsSplashback

Left
Tiles don't have to be ceramic – with a bit of epoxy, they can be made out of whatever you like

FEATURE

IN THE WORKSHOP: The Fairy Lantern

By Andrew Lewis

Recreate a classic stage illusion in small-scale using a Pimoroni Pico LiPo and an SPI screen

You'll need

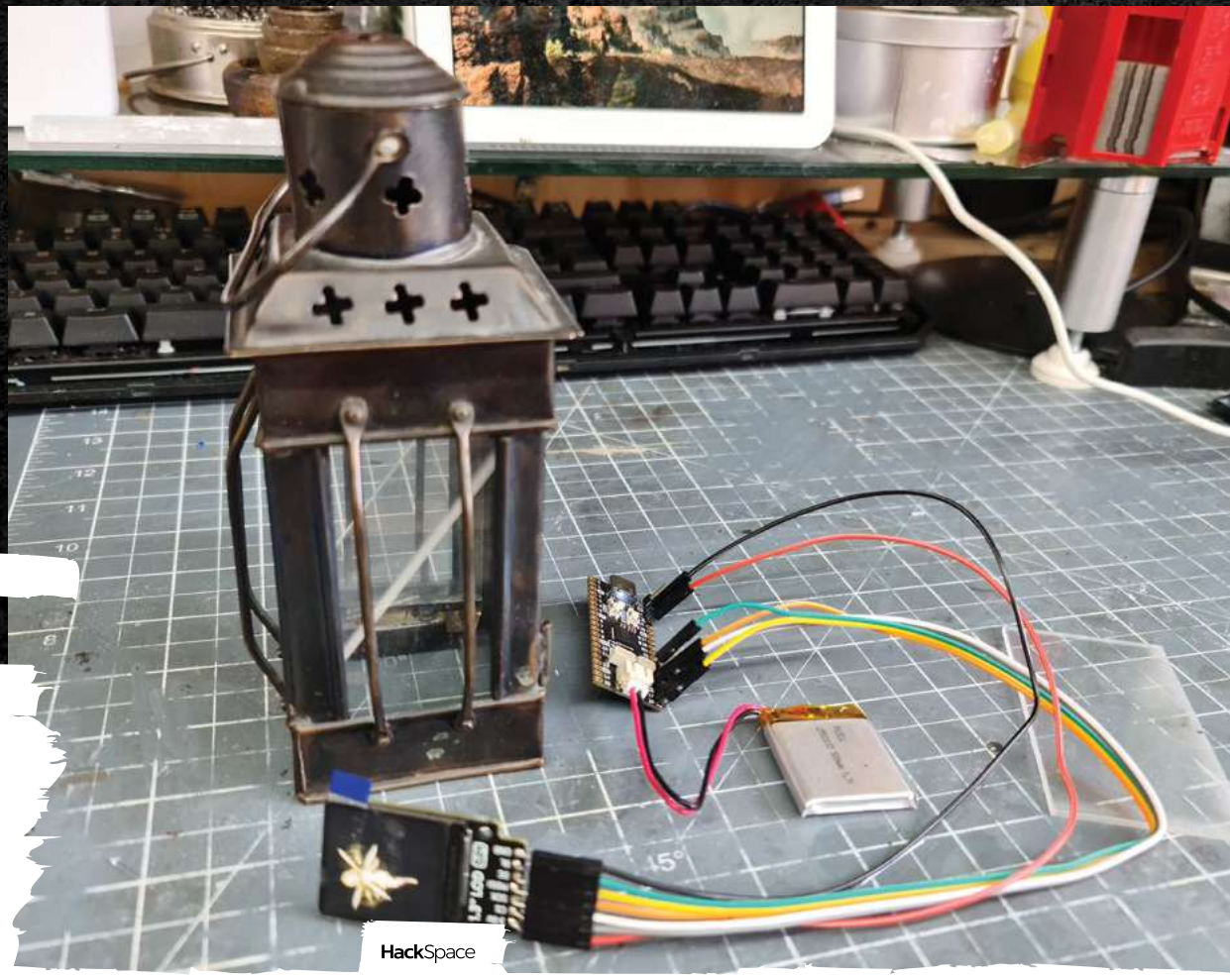
Pimoroni Pico LiPo
hsmag.cc/PicoLiPo

500 mA LiPo Battery
hsmag.cc/BattPack

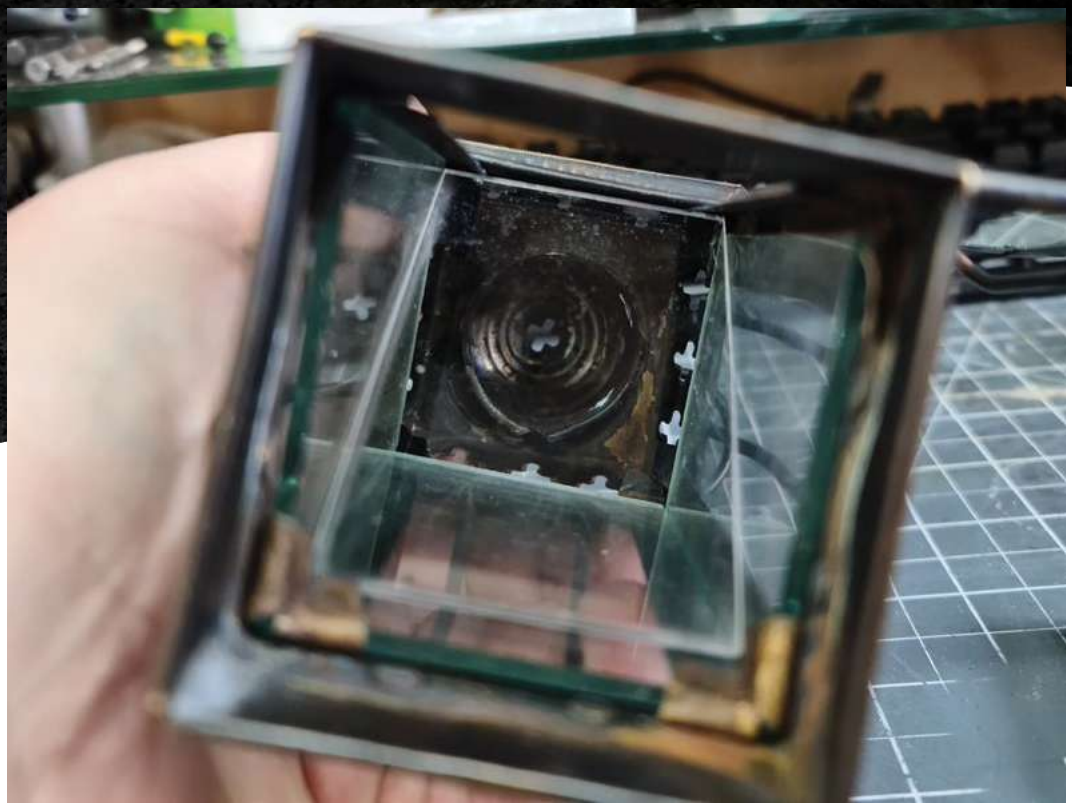
1.3" Square SPI LCD screen
hsmag.cc/ColourSquareLCD

Lantern or box with glass or acrylic sides

Sheet of acrylic the correct size to fit inside the lantern



Right
You don't need a huge list of parts to make a big visual impact. With these few parts, you can recreate one of the most famous stage effects of the 19th century



Left
The clear acrylic you use for the screen reflector should be as close-fitting to the lantern as possible, and free from scratches. You don't need to be at exactly 45 degrees for the illusion to work, so you have some leeway when it comes to finding the best position to reflect the screen

The Pepper's ghost illusion wowed the theatre-going public in the 1860s, spawning a slew of ghost-themed plays. With this project, you can create your own version of this popular illusion to capture a fairy inside a lantern, using the power of an RP2040 board, LCD screen, a suitable GIF image, and transparent acrylic.

The Pepper's ghost illusion is actually much older than you might expect, and was first described in the 1500s. Although it's not a true hologram, the eerie effect that it creates often gets called as such, and is occasionally seen as an advertising gimmick at trade shows and conferences. The illusion uses an artfully positioned pane of glass or plastic to reflect a concealed object or screen in such a way that the image appears to be floating, semi-transparent, in mid-air. The technique is also the basis of how an autocue works: since the illusion is only visible from a certain position, it's possible for a public speaker to look directly at the text of an announcement without the text being visible to those people behind the transparent screen.

IT'LL WORK IF YOU BELIEVE IN IT

To make your own version of the Pepper's ghost illusion, you'll mount an acrylic sheet at 45 degrees to a concealed screen inside a lantern. You'll want the lantern to have glass sides, so that the semi-transparent effect of the illusion is apparent to the viewer. If you try to project the illusion against a plain background, the power of the effect is lost and you might as well just put the screen up there instead.

Before you fit the hardware into the lantern, you'll need to solder the pieces together, choose a GIF image you like, size it to match the size of your screen, and then convert it into a format that the Pico LiPo can process fast enough to display as an animation. After choosing a GIF, the easiest way to resize and manipulate it is with an online service like **ezgif.com**.

Crop or resize your GIF to 240×240, and choose an appropriate compression level. Save the GIF to your computer. You can also apply different playback and effects for your animation, like reverse or ping-pong.

ALL AT C++

Converting the GIF into a useful format for the Pico LiPo is easy, thanks to the work of Larry Bank. Larry has produced some extremely useful code that lets us shortcut a lot of the issues around playing back a GIF and connecting to the screen. So, download the image_to_c application from **hsmag.cc/ImageToC**, and the code from **hsmag.cc/SPILCDCode**. The image_to_c application lets you automatically reformat the GIF file in a way that's more easily handled by the bb_spi_lcd code, which takes the reformatted GIF and displays it on an SPI LCD screen. Assuming that you're using Windows, there's a →

Quick Tip

It's easy to run out of memory quickly when you're dealing with animated graphics. The Pico LiPo has a generous allowance, but keep this in mind when choosing a GIF.

Right
It's worth creating a non-reflective black lining for the base of your lantern from felt or foam. The black base with a hole cut through to expose the screen will cut down any unwanted light or reflections from the concealed electronics

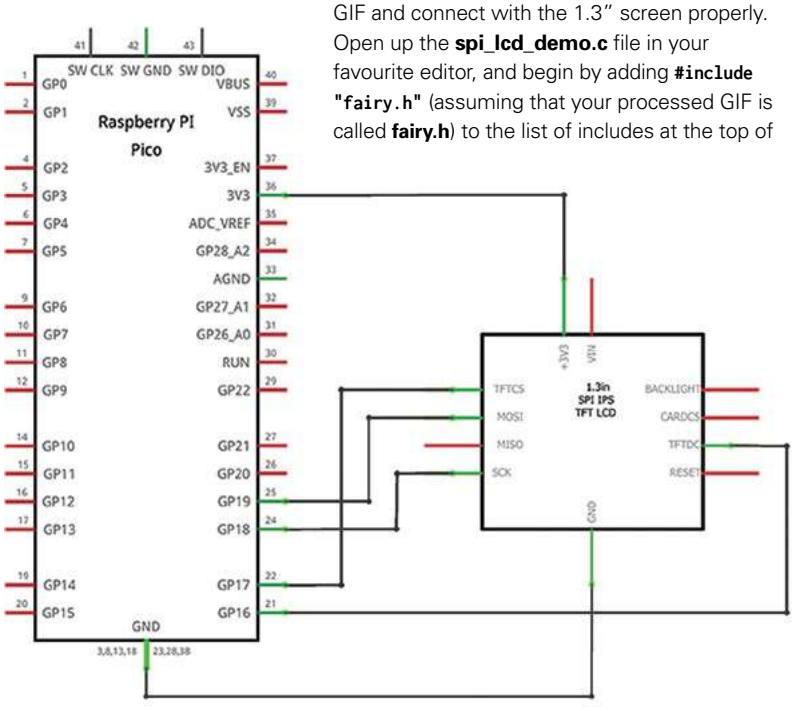
Below
Solder the screen to the Pico LiPo, as shown in this diagram. You don't need to connect the BL pin. It's used to turn the backlight off and on, but it isn't used in this project

C++

Capturing a fairy in a lantern is a difficult task, and so is displaying a GIF image on an LCD. You'll be using C++ on your Pico LiPo to process the animation fast enough. Don't panic, while C++ is more complicated to set up than CircuitPython or MicroPython, it's easier than you think to get started. There are some excellent guides about how to get started with Pico and C++ at **hsmag.cc/PicoC++** if you're using Windows, or **hsmag.cc/SDKC++** if you're using Linux. The rest of this article will assume that you have installed C++, the Pico SDK, and the example files.

precompiled **image_to_c32.exe** in the **dist** folder of the image_to_c repository. If you read through the notes for the image_to_c app, you'll see that the application outputs the modified GIF to stdout. That means that if you have a file named **fairy.gif** on Windows and you want to create a properly formatted header file for C++, you'll use the command `image_to_c32.exe fairy.gif >> fairy.h`.

You'll need to make a few changes to the example provided with bb_spi_lcd so that it will load the correct GIF and connect with the 1.3" screen properly. Open up the **spi_lcd_demo.c** file in your favourite editor, and begin by adding `#include "fairy.h"` (assuming that your processed GIF is called **fairy.h**) to the list of includes at the top of the code. Next, change the value of `#define DISPLAY_WIDTH` and `#define DISPLAY_HEIGHT 240`, to match the resolution of the screen.



Jump down near the bottom of the code and find the `setup()` function. You need to change the call to the `spilcdInit` function so that it uses the correct LCD driver settings. The correct driver is LCD_ST7789_240, so the full line should read:

```
spilcdInit(&lcd, LCD_ST7789_240, FLAGS_NONE, CLOCK_SPEED, LCD_CS, LCD_DC, LCD_RESET, LCD_BACKLIGHT, LCD_MISO, LCD_MOSI, LCD_SCK);
```

Finally, find the `main()` and look for the `if` statement that encapsulates a `GIF_openRAM()` call. Change the call to read `GIF_openRAM(&gif, (uint8_t *)fairy, sizeof(fairy), GIFDraw)`. The name 'fairy' here refers to the name of the const defined in the **fairy.h** file you generated from the GIF file, and is normally the same as the original GIF file name.

Save the changes, and you're almost ready to compile and upload the file to the Pico. You'll need to copy the **pico_sdk_import.cmake** file from your **pico-sdk/external** folder into the folder where you've downloaded the bb_spi_lcd repository. This file helps the compiler to locate the Pico SDK on your system. If it isn't the **bb_spi_lcd** folder, then you'll probably get an error when you try to compile. As is traditional, create a folder called **build** and navigate into it. Do `cmake ..` to create your build files, and then use `make` to build the project. After a few screens of hopefully green text have passed by, you should have a file named **spi_lcd_demo.uf2** in your **build** folder. Attach your Pico LiPo to your computer via USB, and put it into bootloader mode by turning it on with the BOOT button pushed down. Copy the UF2 file to the Pico LiPo (which should appear on your system as a drive

named RPI-RP2). Restart the Pico LiPo and you should see your GIF playing on the screen.

Now that the hardware is done, you can set about fitting it all inside your lantern. The exact instructions for this will vary depending on the size and shape of the lantern that you're using, but there are a few tips that might make the process a little bit easier. Firstly, pay attention to the location of the USB socket and the power button on the Pico LiPo. You'll need access to the USB port to charge the batteries, and the power button to turn the board on and off. You should also be aware of the lights on the board and make sure that they don't interfere with the illusion.

If the base of the lantern is too inaccessible, you could try fitting everything into the top of the lantern instead. As long as the screen is concealed from sight, the illusion should work fine. Keeping your cables short and soldering wires directly to the boards rather than using DuPont connectors can help to keep the footprint of the electronics small.

Chances are high that this project will get handled quite a lot, so more hot glue is probably better than less. If you're not interested in capturing a fairy, you could use the same effect to play a holo-message from the Rebel Alliance, revive a Hogwarts ghost, or visualise the great and glorious Oz in portable format. ◻

More hot glue is probably better than less

Quick Tip

If you got lost in all of the C++ speak, don't panic. Just copy the UF2 file provided with this project onto your Pico LiPo and it will start displaying a flapping fairy.

Above
Test-fitting the screen is important to find the best position for the illusion. Expect to assemble and disassemble the parts a few times to get things right

Left
Thanks to the small size of the Pico LiPo and screen, you can squeeze this project into even the most modest of tealight lanterns