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JULY-AUGUST 2019
ISSUE 85

**TWO WAYS TO
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Happy new year

New Year's Eve is great don't you think? The past is the past and how good is the next year gonna be? So much better, right?

Part of all the optimism many of us feel on 31 December is due to planning to make some changes and setting some goals. I rarely make New Year's resolutions but last New Year's Eve I did for the first time in ages. My resolution revolved around what I could do towards the cause of combating climate change. How did I do? Read on.

Climate change affects us all and as sheddies are very competent at solving issues and sorting problems, we often run articles in the magazine giving some insight into how we can look after ourselves better. This edition of *The Shed* has three articles on alternative energy, as it is something that is on our minds a lot here. There seems to be (and there will be even more in the future) a lot more power cuts than there used to be.

More frequent storms and stronger winds bring down trees and power lines, and losing power more often is something that we will need to get used to. If you live rurally this could mean you are without power for longer, as more repairs may be required for your district over a large area. Who wants to be without power for long stretches at a time?

So first up we have some good advice for those who don't currently have a generator and maybe should. We discuss what you'll need for different amounts of power usage and give some basic tips.

Another aspect of climate change is the need to use less of our precious oil for several reasons and to drive more electric cars. This increase in electric vehicles (EVs) means an increased drain on our electricity supplies, so really we should be decreasing what we draw down from the national grid, where we can.

Murray Grimwood has written two articles on this objective for this issue, one about harnessing your own electricity, and another about being clever with innovative design to heat your own home and, consequently, draw less electricity from the national grid.

Much of what is written about here will require an authorized technician to install but there are not many of us who wouldn't want to get stuck in and lend a hand where we can. We have a lot of the required skills and it'll also save money.

Back to my New Year's resolution. How have I done so far? Terribly. I have done nothing to help the cause. I'm not driving less, using less electricity, or consuming less. Fail. And I reckon that is probably the case for just about all of us. What are you doing to help?

I kept thinking that it was the job of a government to put laws and good practice in place but that's not all of it. Governments hate doing anything that makes them unpopular and as a result possibly lose elections. They are slow and often avoidant. It's down to us as individuals to do something and we need to start doing it quickly. When I was growing up a popular question was, "What did you do in the war, Grandad?" For our grandchildren it will be, "What did you do about climate change, Grandad?"

I hope I have an answer for them.

Greg Vincent

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ON THE COVER

6 Build a forge
Des Thomson shows how to build two types of durable forges, one powered by LPG, the other by used engine oil



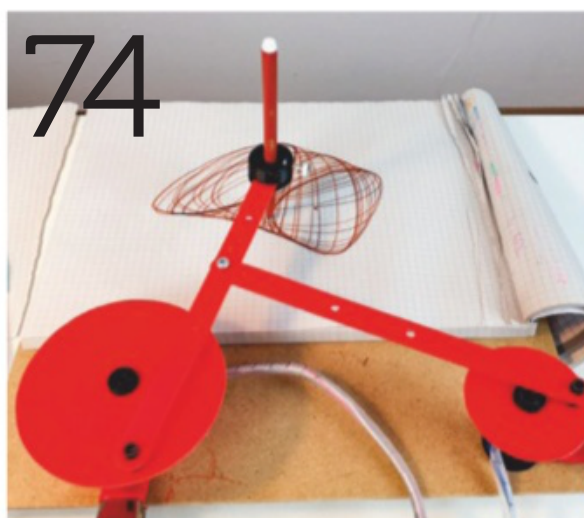
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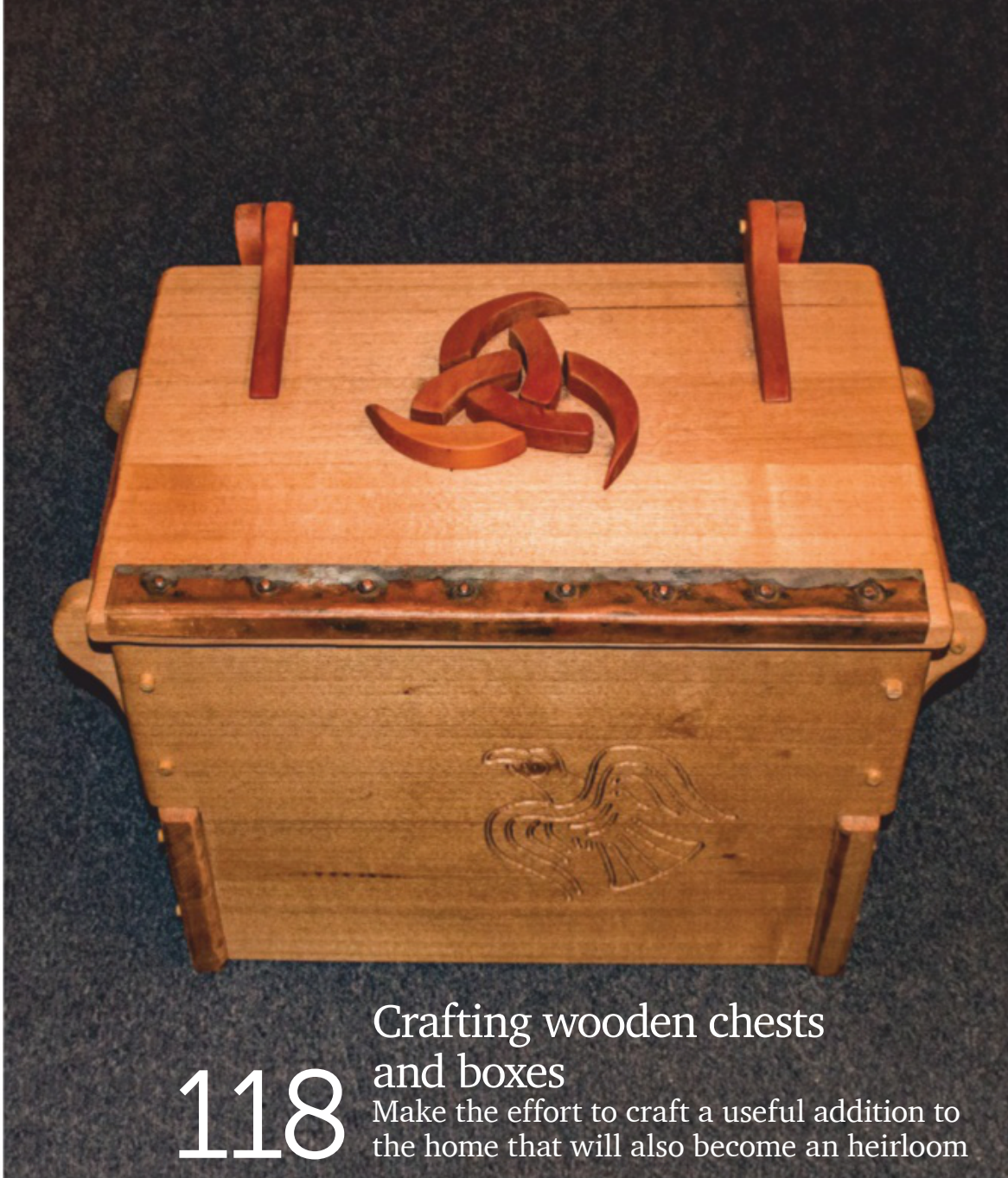
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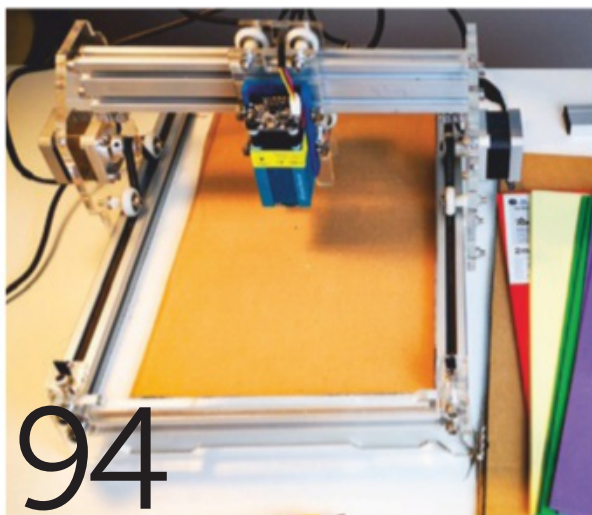
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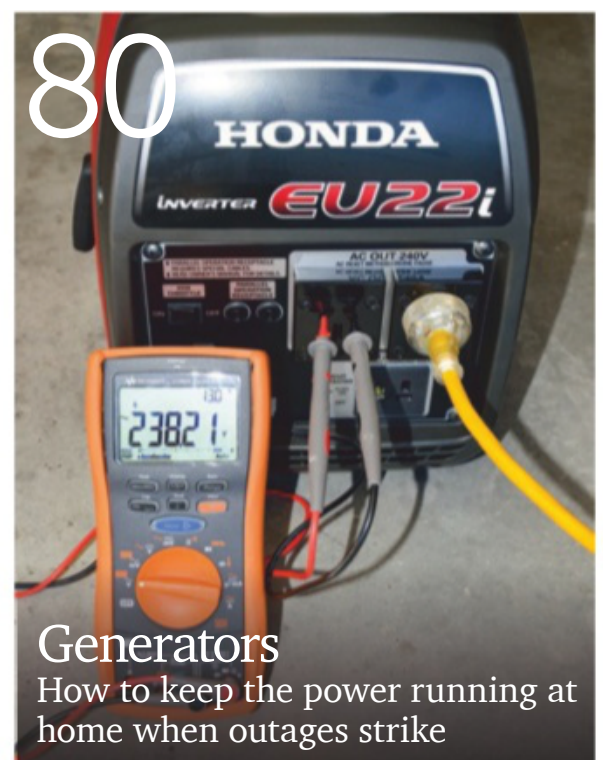
My shed
Living in a retirement home doesn't mean you can't have a shed!

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How good is it looking into a red-hot forge?

1

KNIFE MAKERS CAN HAVE A GO AT MAKING AN LPG BRICK FORGE OR A TANK FORGE THAT RUNS ON USED ENGINE OIL

By Des Thomson

Photographs: Des Thomson and Juliet Nicholas

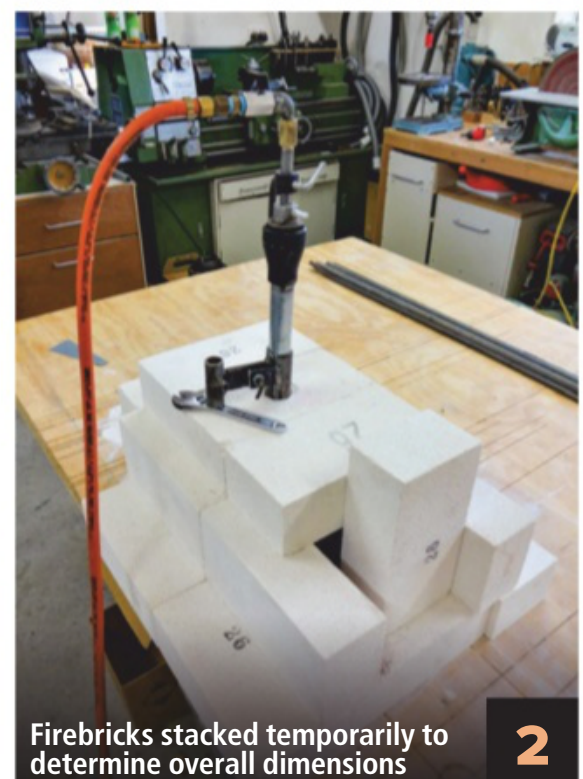
When my wife and I were in Japan in 2006 we visited a traditional Japanese knife maker on the island of Kyushu. He is one of a handful of traditional knife makers left in Japan, with the family business stretching back for 250 years. The interesting thing was that he heated his forge using used engine oil. The burner was a very simple oil-atomizing arrangement using compressed air blown over a nozzle. The oil was directed into a brick furnace in which he heated his knife blanks. You can see a video of his furnace on *The Shed* website. The furnace ran with no apparent smoke or smell and achieved temperatures in excess of 1100°C. It

inspired me to try to make my own.

There is always something fascinating about viewing the red-hot interior of a knife-making or blacksmith's forge (Image 1).

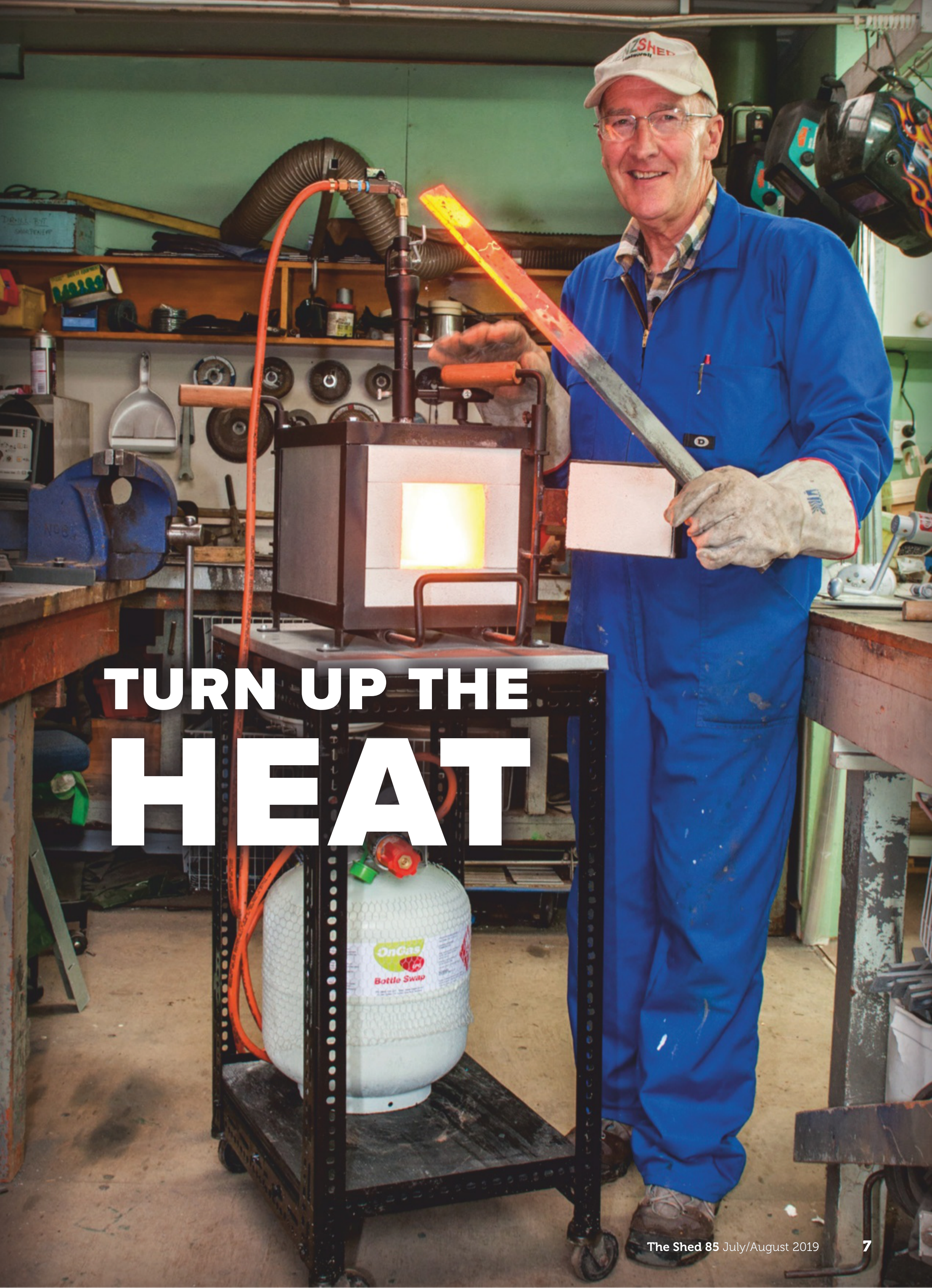
In this article I will explain how I made a brick forge that runs on LPG, and a tank forge that runs on used engine oil or LPG. ►

Forges should only be used where there is good ventilation



Firebricks stacked temporarily to determine overall dimensions

2



TURN UP THE HEAT

Hazards

There are a number of hazards that you need to be aware of if you want to run any forge.

The high temperatures can cause serious burns and hot metal will easily cause a fire if it dropped on combustible surfaces. Forges should only be used where there is good ventilation. Carbon-monoxide levels can rise wherever there is combustion, so don't use them in enclosed spaces.

Eye, body, and hearing protection is just common sense. A red-hot piece of slag from hammering hot steel could cause loss of sight if it gets into your eye. An old blacksmith that I spoke to recounted how he had several months off work due to a piece of slag dropping into his boot. By the time he had cooled it off in the water trough it had turned into a third-degree burn. A leather apron is also good insurance. Don't take any chances.

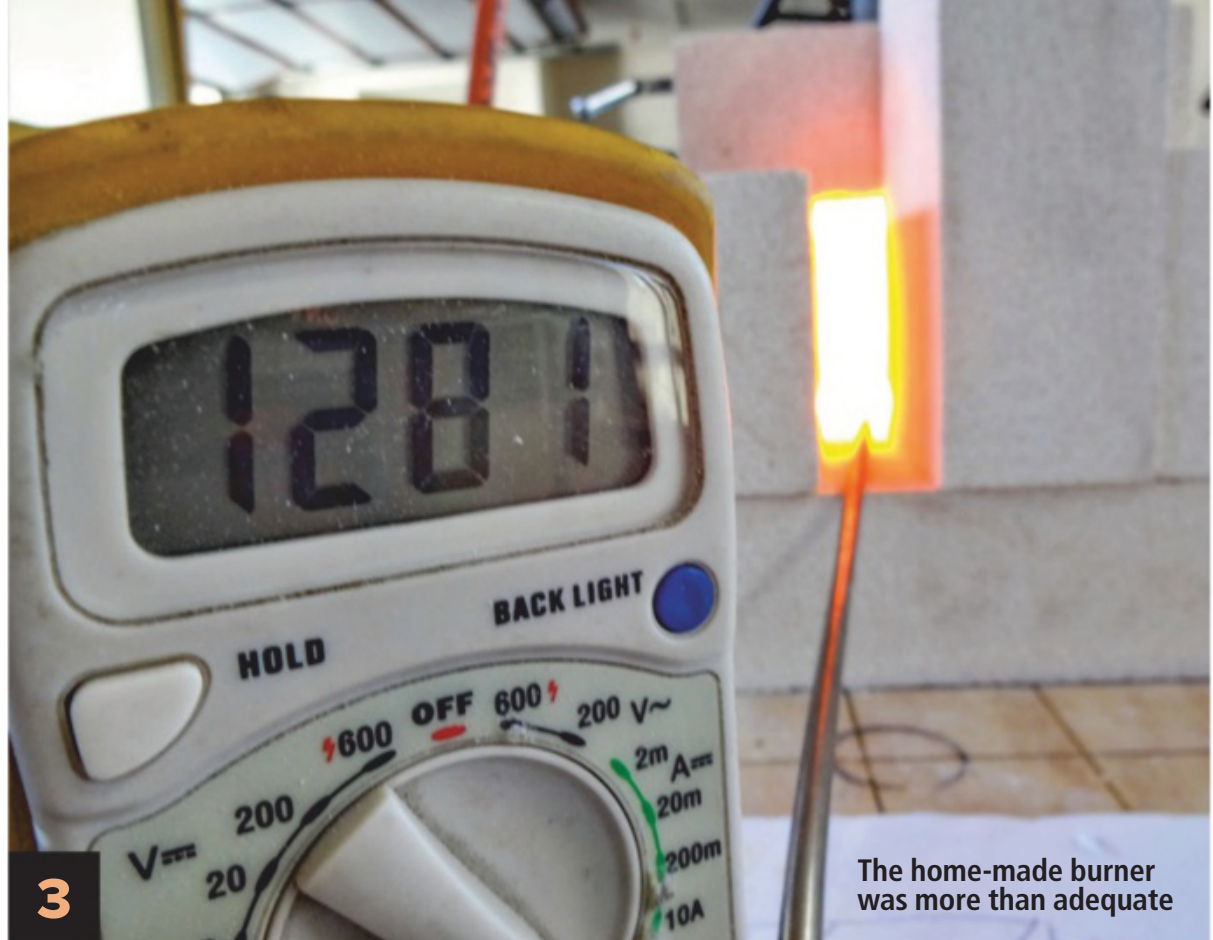
Brick forge

This brick forge has been built at the Halswell Menzshed shed and is constructed from lightweight insulating firebrick. Known as 'K26 bricks', they are available from Certec in Auckland (certec.co.nz/).

These insulating fire bricks are rated to 1426°C and measure 230x115x75mm. They are commonly used to line foundry furnaces, forges, and kilns.

They are soft bricks and can easily be cut to size with an ordinary wood saw, drilled to create burner openings, or routed to create channels. They have very low thermal conductivity and low thermal shock characteristics; however, because they are soft they will wear when used on the floor of the forge. Welding flux will also eat them away. To prevent this, you can apply a layer of fireclay or use a hard firebrick or unglazed porcelain tile on the forge floor.

Before starting construction of the actual forge I stacked the loose firebricks in the shape I wanted so that I could determine the overall dimensions (2). I figured that an internal space of 115x115x345mm (width x height x length) would be a good size for most heating and forging work.



The home-made burner was more than adequate



The insulating properties of the bricks are amazing

Before I committed to the forge interior size I also wanted to test-fire the burner that I had made to ensure that it would have sufficient output to get the forge up to temperature. I used the same burner in a metal-melting furnace where it will easily melt a crucible of bronze or aluminium.

I cut a burner hole in one of bricks and with the aid of a temporary burner support fired it up. Within five minutes the interior of the forge was a cherry

red, reaching 1280°C. The home-made burner was more than adequate (3).

The insulating properties of the bricks are amazing. With the interior of the temporary stack of bricks red hot, the exterior was still at room temperature, although there is some heat transfer after extended firing (4).

Angle-iron frame

The first step in constructing the furnace was to use 30x30x3mm angle iron to



5 Fabricating the top and bottom frames that will hold the bricks



6 Angle-iron feet were also cut and welded in place

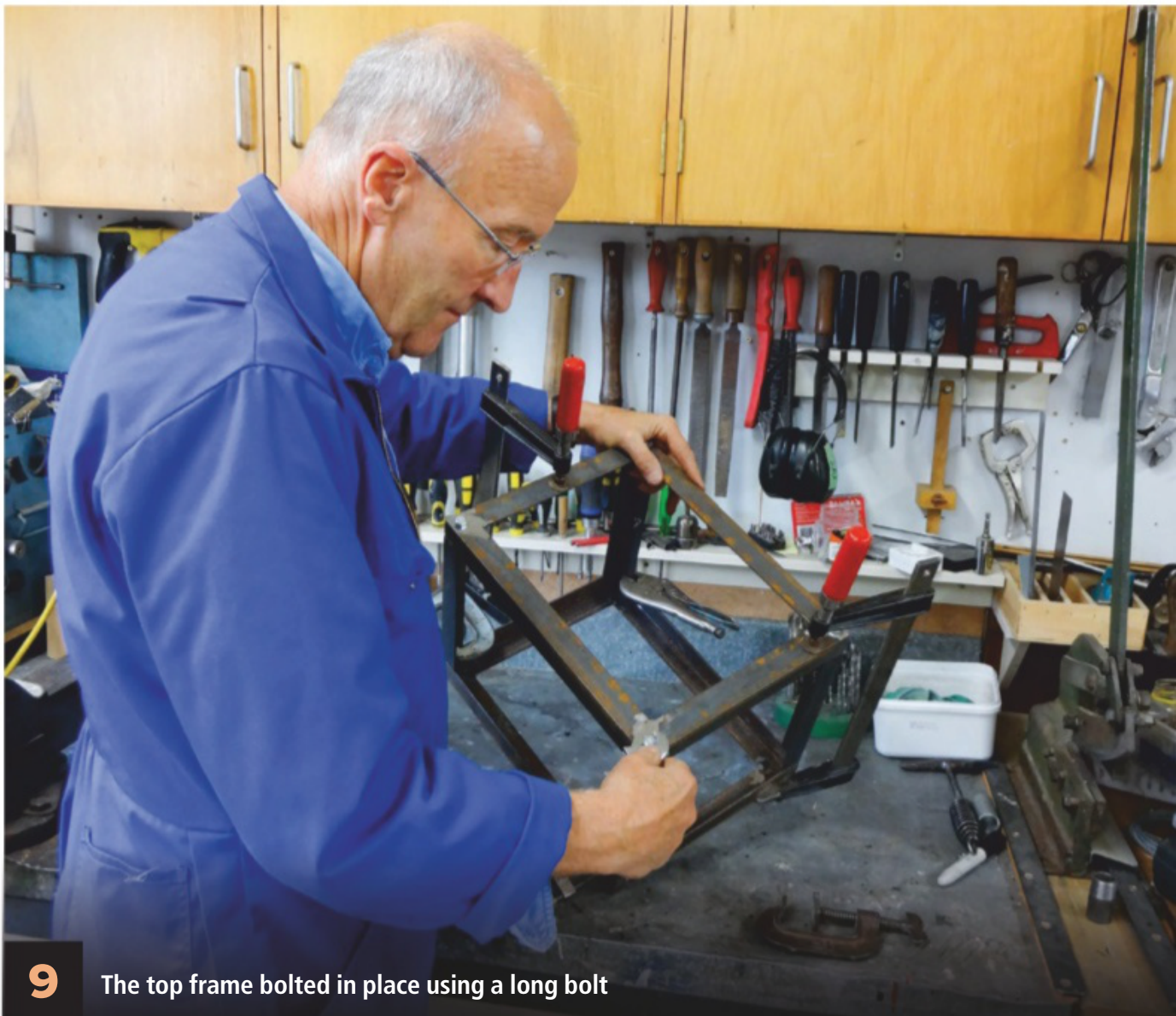


7 and 8: The four corner angle-iron supports have small locating lugs and M8 nuts welded at the top



8

As the burner that I made can be used on the forge and metal-melting furnace, I made it removable



9 The top frame bolted in place using a long bolt

fabricate the top and bottom frames that would hold the bricks (5). Angle-iron feet were also cut and welded in place (6).

I made the top angle-iron frame removable in case it was ever necessary to disassemble the furnace for any reason. The four corner angle-iron supports have small locating lugs and M8 nuts welded at the top (7 and 8). This enables the top frame to be bolted in place using an M8 x 50mm long bolt in each corner (9).

As we have a sheet-metal guillotine and folder at the shed I decided to finish the exterior in Zincalume to give a professional looking finish to the project. We get end-of-roll off-cuts of this from a local roofing supplier, and it is very handy

for all sorts of small projects. Panels to fit the inside of the frame were cut by Menzshed member Graham Weal (10).

The corner angle-iron frame supports the front and rear doors. The doors were made slightly larger than the interior of the furnace so there is some overlap. The doors are made from 25x25x3mm angle iron. Each door is mounted on a hinge pin made from 12mm bar. The bar is mounted in two lugs welded to the corner post (11 and 12). When operating, the forge must have one or both doors lifted above the hearth to allow the forge to breathe. A short piece of 15mm pipe sits above the top hinge lug so that the gap between the door and hearth can be ►



10 Panels are cut to fit the inside of the frame

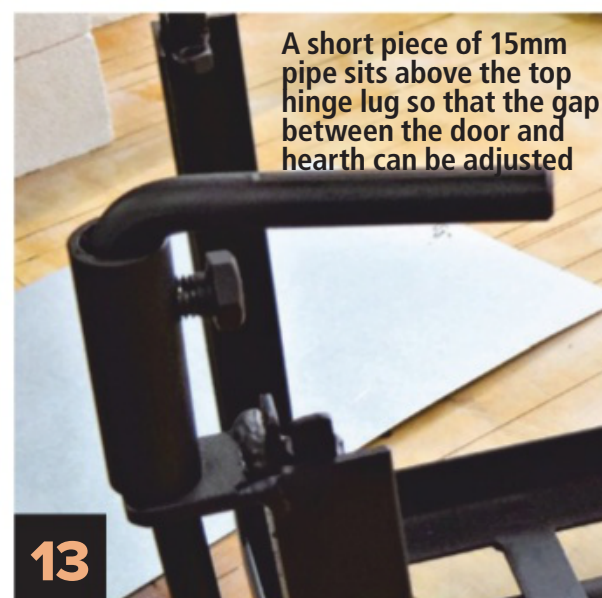


11 and 12: The bar is mounted in two lugs welded to the corner post

11



12



A short piece of 15mm pipe sits above the top hinge lug so that the gap between the door and hearth can be adjusted

13



14

The rebar work support holds the water pipe in the correct position while being welded in place



15

15-17: To get nice tight bends on the rebar we use a carbon arc torch to heat them up



16

Carbon arc torch used to spot-heat the 12mm bar

adjusted (13). The doors are able to be swung right out of the way if required.

For heating longer work in the forge, it is good to have adjustable work supports. I made these from 12mm plain rebar and they slide in 15mm water pipe. I bent the rebar supports up first and then used them to hold the 15mm water pipe in the correct position while they were welded in place (14). To get nice tight bends on the rebar we used a carbon arc torch to heat them up (15-17). This runs off the arc welder producing temperatures in excess of 3000°C between the carbon electrodes. It is a great tool for spot heating but you need to be careful not to melt the steel you are heating. As the burner that I made can be used on the forge and metal-melting furnace, I made it removable. The burner is held in a pipe clamp, which in turn is supported by a simple cross made from 15mm pipe. The cross piece is slid over a 12mm bar welded to the top angle-iron frame. All the sliding parts are clamped by 8mm bolts (18).

All the parts were then given a coat of black manifold paint ready for assembly (19).



17



18

All the sliding parts are clamped by 8mm bolts



19

All the parts are then given a coat of black manifold paint

Assembly of the furnace

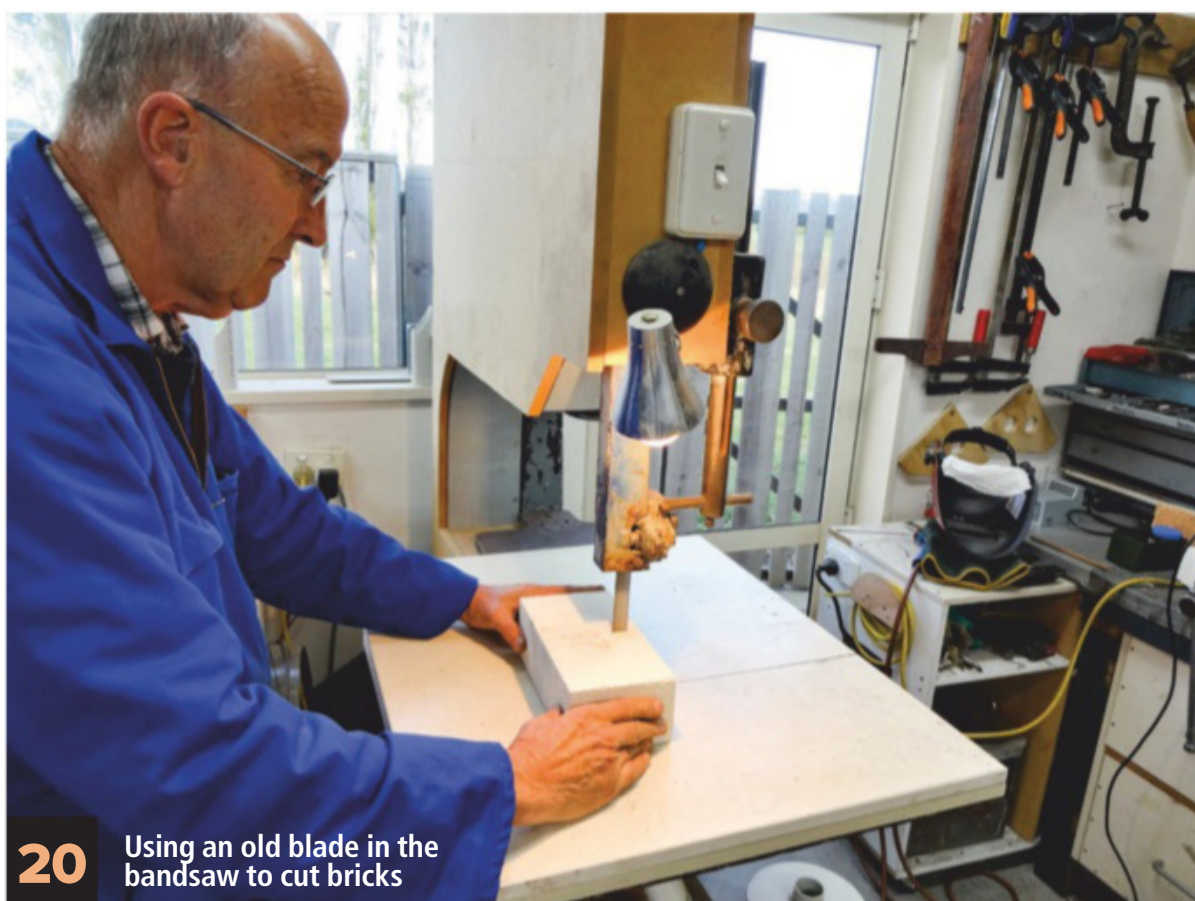
No mortar is required when installing the bricks. Just butt them together. If required, the bricks can be very easily cut with an ordinary wood saw or hacksaw blade. I used an old blade in the bandsaw to cut them (20).

The Zincalume base and side panels are held in place by the bricks (21–24).

To keep things simple I decided to use just one burner. On the internet you will find knife-making forges with two, three, or even four burners. It really comes down to what sort of work you will be doing. With doors at both ends of this forge, longer work can also be accommodated.

To cut the hole for the burner I used a hole saw working from both sides of the brick (25). The brick is very soft and cuts easily. An 8mm deep counterbore was done with a larger hole saw (26). This forms a recess to allow Kaowool to be packed around the burner tube to seal it.

I then formed a flare on the inside of the burner hole using a sheet-metal reamer that I made. The purpose of a flare at the end of a burner is to slow down the gas velocity to allow the flame to burn at the tip. If the gas leaves the burner at too ►



20

Using an old blade in the bandsaw to cut bricks

21–24: The Zincalume base and side panels are held in place by the bricks



21



22



25 To cut the hole for the burner I use a hole saw working from both sides of the brick



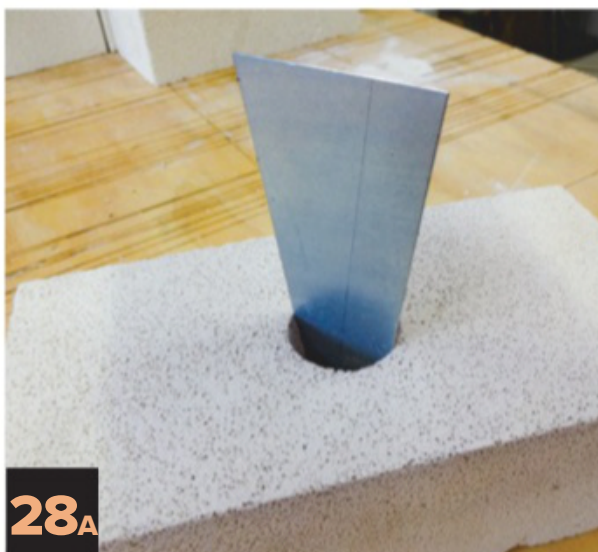
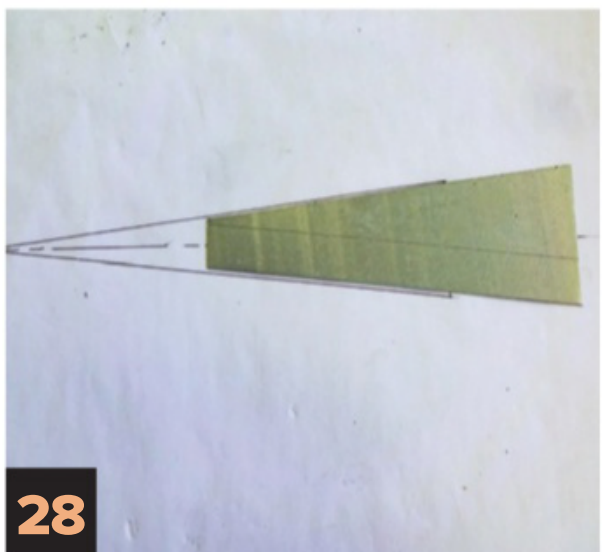
26 A counterbore is done with a larger hole saw

I decided to use a butt-weld fitting rather than a threaded socket because it gave a very smooth inlet for the air



27 With a flare fitted, there is a beautiful blue flame that burns outside the furnace

28 and 28A: I draw a flare taper on some paper and cut a piece of sheet metal to that shape and use it as a reamer on the brick



fast a rate the flame cannot consume the gas fast enough, and it will blow out. The principle of this is very easily demonstrated. On my metal-melting furnace burner I have a one to 1/4-inch union that acts as a flare to slow the gas. Without this in place the burner will not run out of the furnace. Put it back on and I have a beautiful blue flame that will burn outside the furnace (27).

The optimum flare taper is 12:1, so I drew this out on some paper and cut a piece of sheet metal to that shape and used it as a reamer on the brick (28). A flare is not actually necessary on a burner used inside a forge but it will help to give you a very stable flame.

The insulating brick for the doors was cut to 30mm thick on the bandsaw and then a shallow groove was filed in the top and bottom edges. A 6mm round bar was fitted into the groove and tack welded in place to hold the brick into the door frame (29–31).

Making the LPG burner

If you research online you will find a lot of very good resource material on burner ►

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29 29-31: A 6mm round bar is fitted into the groove and tack welded in place to hold the brick into the door frame



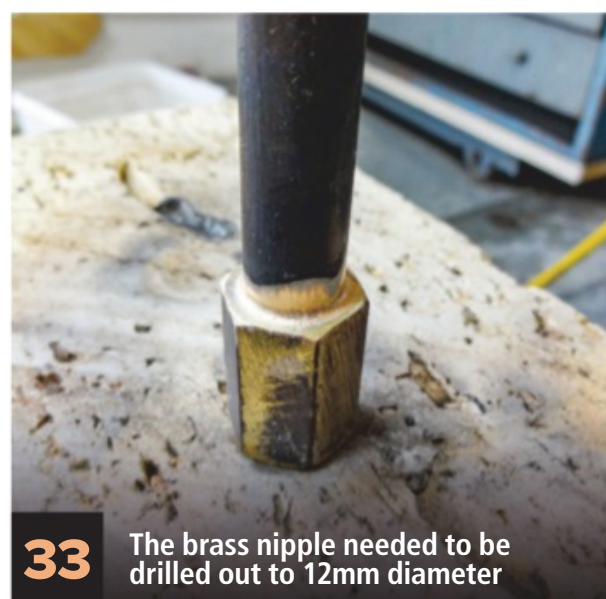
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31



32 An M6 nut hammered into the end and then Easyflo-ed in place



33 The brass nipple needed to be drilled out to 12mm diameter

design. Ron Reil has some excellent information on making burners and forges (ronreil.abana.org/Forge1.shtml).

You should not attempt to make your own burner unless you are sure that you have the skills to do it safely. LPG is potentially very hazardous. The burners I describe here work very well and I have not had any problems with them, but you build them at your own risk.

It is very important to check all joints in the gas line for leaks with soapy water. If bubbles form, immediately turn off the gas and fix the problem. As LPG is heavier than air it will drop down and collect in any low-lying places such as a drain or pit. All you need is approximately two to eight per cent of LPG in the air and a source of ignition and an explosion can occur.

Jet assembly

The first step in making the burner is the jet assembly. Access to a lathe will make building this much easier. This is made from 12mm OD x 1mm wall-thickness mild steel tube x 150mm long. This

needs to have a ¼BSP brass nipple fitted at one end and at the other have an M6 thread to enable a MIG-welding tip to be screwed in.

Depending on the wall thickness of your 12mm tube, an M6 nut can be hammered into the end and then Easyflo-ed in place (32). Alternatively you could Easyflo a steel plug in place and drill and tap an M6 thread in the lathe.

The brass nipple needs to be drilled out to 12mm diameter for half its length so that the 12mm steel tube can be Easyflo-ed into place (33). I use 45-per-cent silver Easyflo as a good general-purpose rod.

A ¼BSP ball valve can now be fitted to the nipple using thread tape suitable for LPG. A 0.6mm MIG-welding tip is screwed in at the other end. This completes the jet assembly (34).



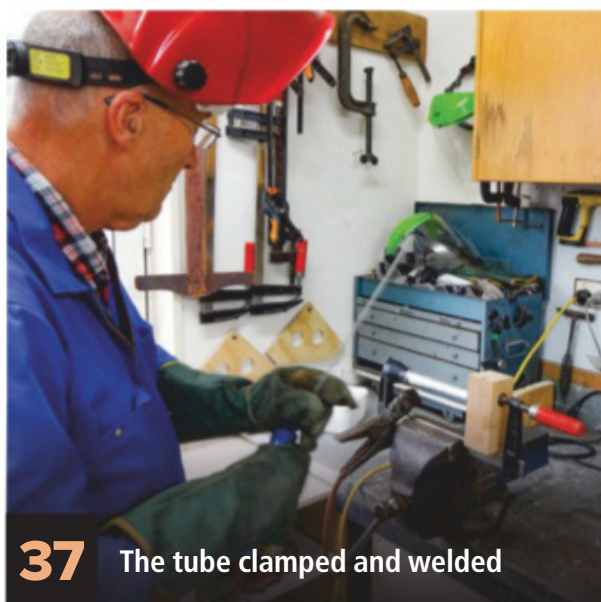
34 The completed jet, burner tube, and choke parts



35 I decided to use a butt-weld fitting rather than a threaded socket because it gave a very smooth inlet for the air



36 The inside of the 20mm tube was also given a small taper



37 The tube clamped and welded



A threaded rod through the assembly was used to hold everything in alignment as it was welded

38

Burner tube

The burner tube can now be made. I got all the fittings for this from Steel and Tube.

The first step is to turn one end of the 200mm long 20NB pipe nipple to be a neat fit into the 40x25NB concentric reducer. I decided to use a butt-weld fitting rather than a threaded socket because it gave a very smooth inlet for the air. The inside of the 20mm tube was also given a small taper (**35 and 36**). It was then clamped and welded (**37**).

I then turned up a 20mm OD x 12mm ID steel bush to hold the jet-assembly tube. It is important that the jet-assembly tube is concentric with the burner tube. By using a length of 12mm threaded rod through the assembly, I was able to hold everything in alignment as it was welded (**38**).

To adjust the air-gas mix, I made a sliding choke with a locking screw. With this, all the burner parts were complete, and it could then be fully assembled (**38A**).

Tuning the burner

To get the burner to run you will need a heavy-duty adjustable regulator (**39**). The gas demand is too great for a standard LPG regulator for a barbecue. I also recommend that you get a gas supplier to make up the LPG hose and fittings for you. It is a small cost compared with the possible consequences of a leak.

Once you have assembled the regulator, hose, and burner it is time to check for leaks. Set the gauge to 100kpa. With the ball valve on the torch closed, turn on the gas cylinder to pressurize the hose. Check all the joints with soapy water. A bubble will indicate a leak. If all is well, move on to lighting the burner. If you want to be able to use the burner outside the furnace then you will need to screw a 25x20NB socket in place to act as a flare.

To get the burner running in the furnace, you will need to mount the burner tube approximately 25mm into the burner hole. At that point it should be just at the beginning of the internal ►



38A This completes all the burner parts and it can now be fully assembled



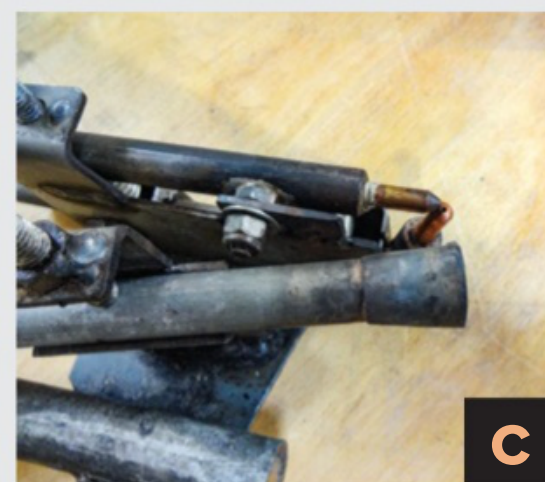
39 To get this burner to run you will need a heavy-duty adjustable regulator



A I found that a litre of diesel in 4 litres of used engine oil made it run much better than just straight engine oil



B The oil spray is made using two 0.9 mm MIG-welding tips



C

After seeing the Japanese forge running on used engine oil I was very keen to try my version of it on this little forge. The principle was very simple. If you spray oil into a hot forge it will burn very well without any smoke or smell. I found that a litre of diesel in four litres of used engine oil made it run much better than just straight engine oil (Image A).

The oil spray is made using two 0.9 mm MIG-welding tips (B). The fixed bottom one is the oil supply, which goes into a four-litre container of used engine oil. The top tip blows compressed air across the oil tip creating a vacuum that sucks the oil up from the container. It is adjusted by the screw so that the distance from the bottom tip can be varied. By raising or lowering the tip, more or less oil is put into the furnace and this controls the heat. I ran it on about 20psi of air pressure but it will take more if required.

The secret to getting a clean burn from the start is to ensure that the furnace is hot before introducing the oil spray, so I mounted a small home-made LPG burner on the side of the oil burner. I used the same jet assembly as I used in the forge in a much smaller burner tube. The burner tube is 12mm ID with a sheet-metal flare on the end (C-E). Easyflo was

used to fix it in place. Four 6mm holes were drilled in the pipe for air to mix with the gas.

When the furnace is hot the air to the oil burner is turned on and the gas burner can be turned off.

It is a little bit tricky to get the air and oil nozzles in the correct position for good suction but once everything is adjusted it works well. You can watch a video of it operating on *The Shed* website. A friend in Australia has the forge now. He is using it to heat up railroad spikes to make into



D

knives. Prior to getting the oil-burning forge he was using LPG but was finding it just too expensive.



C-E: The secret to getting a clean burn from the start is to ensure that the furnace is hot before introducing the oil spray, so I mount a small home-made LPG burner on the side of the oil burner

E



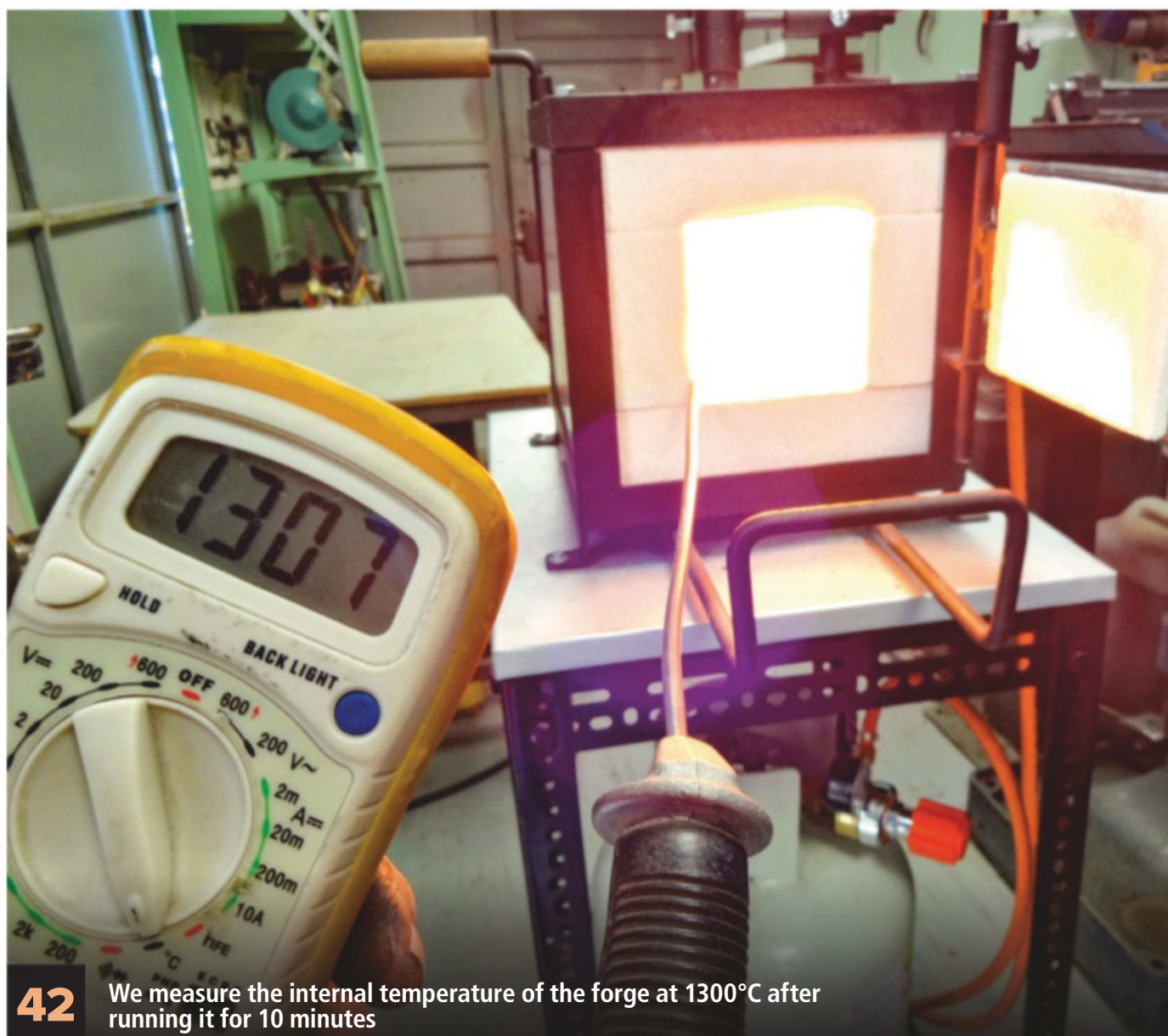
40

The gap around the burner should be packed with some Kaowool to prevent air entering



41

To minimize scale formation on steel it is important to have a neutral flame running in the forge



42

We measure the internal temperature of the forge at 1300°C after running it for 10 minutes

flare taper in the brick. The gap around the burner should be packed with some Kaowool to prevent air entering (40).

Open up the front and rear forge doors. *Important:* Always do this before lighting!

Close up the choke till it is just level with the top of the intake reducer, turn on the gas slightly, and light the furnace using a barbecue spark igniter.

The burner should now be running with a very soft yellow/blue flame. Carefully adjust the choke to admit more air until the flame is a strong blue colour. To minimize scale formation on steel it is important to have a neutral flame running in the forge (41). We have

measured the internal temperature of the forge after running for 10 minutes at 1300°C (42). I mounted the forge on a mobile stand made out of some old Dexion angle framing that I had lying about.

Cylindrical forge running on used engine oil

The cylindrical forge that I made uses the interior steel casing from an old mains pressure water cylinder. The steel casing is 3mm steel plate with a glazed lining. The first job is to remove the outer sheet-metal skin off the cylinder to expose the insulation (43).

If you are lucky you may strike one

that has loose glass-fibre insulation, which is easy to remove. If not you may get one that has expanded polyurethane foam insulation, which will take a lot more work to get off. In any case a dust mask should be worn while removing it. The cylinder I had had a 300mm diameter internal steel casing. Using a cutting disc in an angle grinder, I removed the top and bottom to give me a 400mm long cylinder (44).

I cut and welded four 50x50x6mm angle-iron feet to the cylinder and also welded four lengths of ½-inch water pipe internally. These function as guides for the extendable 12mm rebar work rest (45). ►



43

The first job is to remove the outer sheet-metal skin of the cylinder to expose the insulation



44

I removed the top and bottom to give me a 400mm long cylinder



45

These function as guides for the extendable 12mm rebar work rest



46 The spaces between the supports are filled with Kaowool



47 I secure it by welding four tabs onto the forge wall



48 Two layers in place to give 50mm of insulation



49 The end walls are made from the lightweight insulating board fixed to 12mm rebar

In the side of the cylinder, about 100mm down from the centre line, I cut an 80x80mm square hole. This is where the gas or used-engine-oil burner will enter.

Insulation

The cylinder is now ready for installing the insulation. I used 25mm thick Kaowool and 25mm thick high-temperature lightweight insulating

board. 'Kaowool' is a ceramic fibre insulation capable of withstanding more than 1200°C. Kaowool is not considered to be hazardous but a dust mask should be used when handling it.

I first cut some of the insulation board to fit between the water pipe. The purpose of that was to give support to the insulating board that was going to serve as the floor of the forge. The spaces between the supports were

filled with Kaowool (46).

When that was done a larger piece of insulating board for the floor was cut and fitted. I secured it by welding four tabs on to the forge wall (47).

With the base in place the Kaowool could then be installed. By carefully cutting it to length it was self-supporting when pushed into place against the floor. I put in two layers to give 50mm of insulation, which left

“*‘Kaowool’ is a ceramic fibre insulation capable of withstanding more than 1200°C*”

me with approximately 200mm of internal diameter (48).

A 60mm diameter hole was cut in the Kaowool for the gas/oil burner port.

If Kaowool is exposed to the direct flame of a burner it will erode away, releasing fibres into the atmosphere, so it must be coated with a refractory to prevent that happening. I got what is known as a ‘rigidizer’ from the supplier of the Kaowool. This is a colloidal silica compound that you paint onto the Kaowool. When it dries and is hardened with the heat of the furnace, it puts a thin, eggshell-like coating on the surface.

A 12mm rebar handle was made and welded to the body of the forge. The end walls were made from the lightweight insulating board fixed to 12mm rebar. These were made adjustable so that the right gap could be determined to prevent the burners from being restricted (49).

The work rest was bent up from 12mm rebar. I did not install a locking screw because friction between the bar and pipe was sufficient to hold it in place.

A 100mm long x 12mm rebar rod was welded to the side of the forge for mounting the burners.

At the Halswell Menzshed we have a number of enthusiastic knife makers. Ian has made a forge that uses two LPG gas burners, and we have also experimented with using diesel to fire a forge. It ran very hot but the noise level was over 100dBA (50).



50 This diesel-fired forge runs very hot with its noise level over 100dBA! Ear muffs will be required

Another member, Ross, has produced a number of knives and his furnace is a very simple pile of bricks that he quickly assembles and dismantles as required. He uses an LPG weed burner for heat. He has produced knives from old files beaten into

shape and carefully ground while others are made from old hand shears (51).

With the new brick forge up and running, I suspect that we will see a lot more creative knife-making in the shed. 📁



Knives made from old hand shears and files

51



Liam Croft's swords and knives

Knife makers forum

ENTHUSIASTS' EVENT A BIG SUCCESS

By Jude Woodside

Photographs: Jude Woodside

The Gameco building in Villa Street, Masterton was the venue for a forum of knife makers and knife enthusiasts from all over New Zealand on Easter Saturday.

The event, which is intended to be an annual gathering, was held last year in Taupo. Gameco is the largest outlet for specialist tools and materials for knife making and blacksmithing in New Zealand and Australia.

Among those presenting and demonstrating their techniques was Brent Sandow, one of New Zealand's premier knife makers, and Shea Stackhouse, who demonstrated his technique for making Damascus steel. Callum Davidson, a young local blacksmith, demonstrated his craft outside where a small forge and anvil had been set up. Liam Croft, from Tinui, showed examples of his intricate swords, complete with rune-engraved handles and detailed scabbards, and Nick Rowney exhibited detailed dragon's head handles carved from horn and antler.

Attendees came from as far as Auckland and Napier, and among the luminaries of the knife-making fraternity present was Matt James, who makes Damascus steel and held the event at his workshop last year.

This year's event attracted more than 40 participants and manager Brett Miller said: "I think it's been a great success. We are looking forward to running these events somewhere in the country every year."



Brent Sandow demonstrates his grinding technique



Callum Davidson demonstrates blacksmithing



The future on display

By Ritchie Wilson

Christchurch Robotics firm Design Energy's stand. Sara Wells on the right.

Southmach, a two-day technology trade show, was this year held on 22–23 May at Christchurch's Horncastle Arena.

Large manufacturing companies are the logical customers, but a lot of the gear and services would be suitable for the home workshop. Tiny, efficient stick welders for around \$1K were on a couple of stands, and bottled-gas suppliers were prominent. It was interesting to discover how things are changing (and improving) in these two areas.

A number of exhibitors displayed stuff made by 3D printers. It is possible to produce extremely complex items in small numbers by 3D printing. Plastic, titanium, and silver items were shown and it is obvious that the price of these processes is becoming much more affordable. What this means for traditional manufacturing is anybody's guess, but printed items are sure to become much more common.

There were also numerous robots and other automated machinery. The huge German Sick company had a slick mini-production line (like a large, hugely expensive child's toy) with its laser

scanners monitoring the products. The scanners could tell if the tops were on bottles or if there were other faults. Sick sensors are used in self-driving vehicles at Auckland Airport and in the automaton behemoths used in the Western Australian mining industry. The company is family owned, and the advantage of this is demonstrated by the fact that 10 per cent of turnover is invested in R&D — which amounted to about €170M in 2018.

The Ministry of Awesome, The Manufacturer's Network, University of Canterbury, and patent attorneys PL Berry and Associates all had displays.

Sheddies who are tired of cutting steel plate by hand could consider getting it cut to shape by water jet. Islington's Precision Water Jet Company (a very new start-up business) can cut shapes in many materials using the garnet-loaded water stream from its brand new five-axis, 2.5x1.5m water jet. The company had complex-shaped objects cut in steel, stainless, aluminium, wood, and pounamu on display. Send Precision a dimensioned drawing and it will make it in the material of your choice to an

accuracy of a 10th of a millimetre.

There aren't many places where the future is on display in this part of the world, but Southmach would be one of them.



An example of the work produced by 3D printing firm RAM3D, based in Tauranga

A vicious Beetleweight (11lb) combat robot, ready to battle

Bot power

By Daron Robinson

What sort of people go to the trouble of building complex and dangerous robots and then smash them to pieces? The crazy builders from Combat Robotics NZ, that's who.

Combat Robotics organizes events where small but destructive robots fight to the death in arenas clad with enough polycarbonate and steel to actually be bulletproof. These robots are often 3D printed and use motors and electronics adapted from the multicopter and radio-controlled (RC) community. People of all ages and abilities produce different types of machines — some simple wedges that get under another bot and force it into the pits, others with nasty spinning blades or flipper arms intended to control the opponent or, preferably, destroy it.

At their nationals in Auckland on 25 May, more than 30 competitors fought in two size classes: Antweight, for 150g

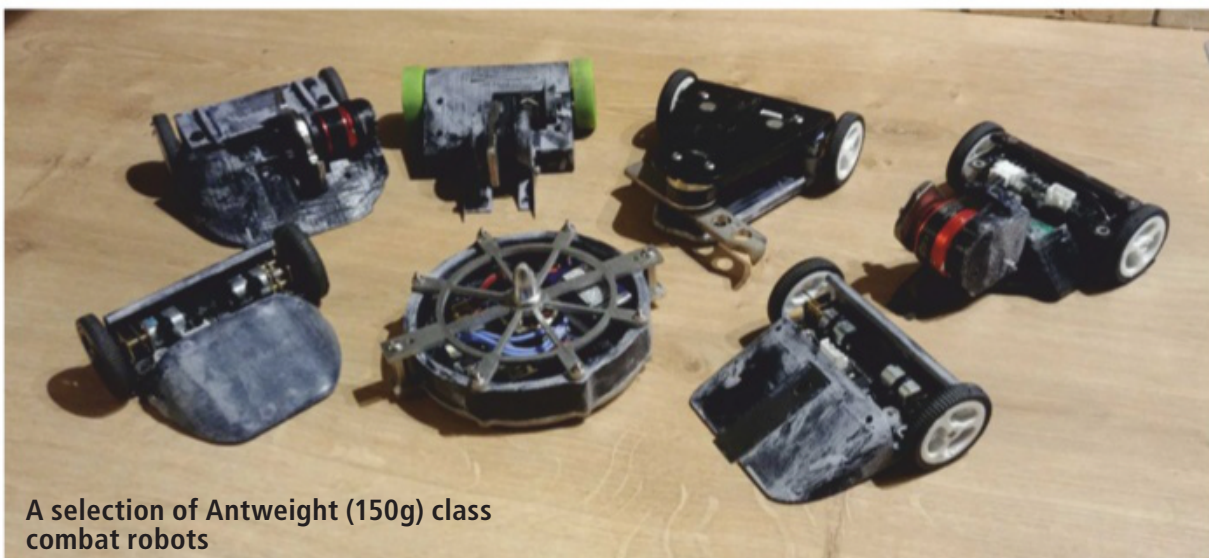
machines that are cheaper to build (and repair), and the bigger 1360g Beetleweight class that can pack a powerful punch.

Machines were bouncing violently around the arenas ripping chunks off each other in the spirit of TV programmes like *Battlebots* and *Robot Wars*.

A large audience enjoyed a great day of violent combat, but the builders and drivers were kept busy doing desperate running repairs with glue guns and duct tape, trying to keep the machines functional for the whole event.

At their next big event at Big Boys Toys in November, Combat Robotics NZ is challenging the Australian clubs to join us for a trans-Tasman throwdown. It'll be just like the Bledisloe Cup but with more robots and even more big hits!

Join the battle on Facebook @comabotroboticsnz and keep a look out in *The Shed* for more information.



A selection of Antweight (150g) class combat robots

The Shed online

What's happening online at theshedmag.co.nz?

Every week we upload new content on *The Shed* website to join the 100s of articles and videos already on the site for readers to discover, learn from, and enjoy. The past two month's new uploads include:



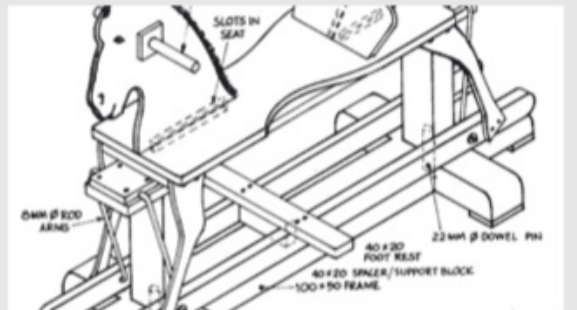
- sharpen your drills
Blunt drill? First think about buying a new drill for the most efficient work in your shed, or you could try sharpening the drill bit



- an engine imagined — puzzling out aviator Richard Pearse's engine. Sheddie Ivan Mudrovich attempts to solve the riddle



- build a backyard tandoor oven — Robin Overall shows how to build this version of an Indian barbecue



- build a rocking horse — see how to make one of those toys that never seems to lose their appeal!

These are just some of the new uploads to our website in the past two months. Visit theshedmag.co.nz to enjoy even more.

The Shed is now on Instagram: search 'theshedmag'.



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We forgot about waste

I recently read the painting article in my wife's *The Shed* magazine (Issue No. 83). A pretty useful article but one aspect that did bother me was what wasn't covered in terms of proper washing practice for buildings, roofs, or brushes, etc. Not once was there any mention of actions intended to avoid contaminating the storm-water system. Roofs, driveway sumps, street sumps, and the kerb and channel in the street all form part of the local storm-water network which drains untreated water to our streams and rivers.

The article referred to cleaning products to use but not that use of them potentially contaminates our waterways if it gets into drains. There was no mention of diverting downpipes if cleaning roofs, or trying to avoid wash water going into drains. There are no environmentally friendly detergents, whether marketers call them biodegradable or not, they are all contaminants in their own right, let alone the materials they are used to help remove.

Among other tasks I do pollution response and we still get many incidents involving paint being washed into storm-water drains, along with countless poor washing practice incidents and washing of concreting equipment (highly alkaline).

The single biggest cause is people not knowing better, not understanding where drains go, or failing to read the labels on the paint tins — we had Dulux and Resene change their instructions

over a decade back (they used to say wash up in water, now they are more specific).

If you are doing further articles that involve cleaning or washing of equipment (e.g., brushes) then it would be helpful if your magazine could assist in the education of the public and reinforce good practice.

A good guide I use for people is if you would not swim in it then why would you think it was OK for a storm-water drain and the fish downstream? I also note that people use detergents/cleaning agents to help them clean something they don't value from something they do value and send it somewhere they generally haven't thought about.

Thanks guys,

Gordon George (via *Shed* website)

Thanks Gordon and we have to take those comments on the chin. Our bad. We will schedule an article in a future issue re. waste products of all types and how we — responsible sheddies that we are — should deal with disposal issues. Appreciate you bringing this to our attention. — Editor

Stepping up

Excellent article by Ritchie Wilson in Issue No. 84 on building steps.

I spent half my working life making rock walls and steps in gardens, and found that for outdoor steps the simplest and best

dimensions were 150mm rise and 350mm going, modified slightly by sloping the treads by 15mm, so the 150mm rise was made up of 15mm slope and 135mm rise at the next tread. Sloping the tread prevented puddles and subsequent slime build-up,

and they became self-cleaning. I found two rules for designing stair dimensions ... and they gave slightly different results.

The stairs in my A-framed house are 250mm rise and 150mm going!

John Rogers, Warkworth

Letter of the month prize

Every issue, our Letter of the Month winner will receive this gift bag of seven great Selleys products. Remember, "if it's Selleys it works".



Letters should be emailed to editor@theshedmag.co.nz, or posted to Editor, The Shed, PO Box 46,020, Herne Bay, Auckland 1147.





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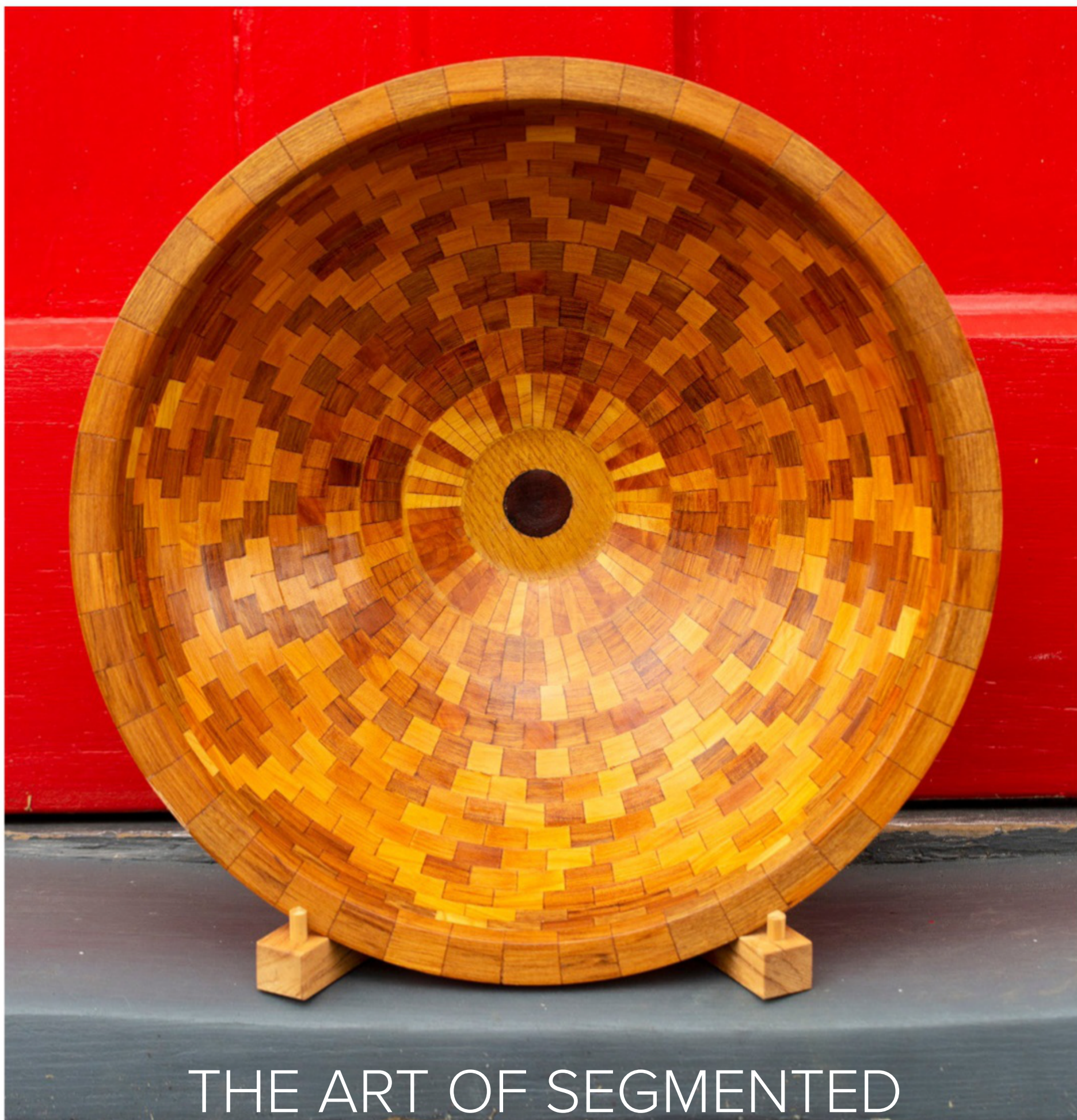
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Alby Redman outside the Red Door Gallery in Whanganui with some of his segmented woodturned pieces



THE ART OF SEGMENTED WOODTURNING

Rimu wood shavings curl up from the lathe, cling to Alby Redman's chest, and pile into the crook of his arm as he turns the top half of a segmented hollow form.

The Whanganui sheddie taught himself wood turning six years ago and went on to the meticulous craft of segmented turning.

The results of his work are stunning, displayed for sale in the Red Door Gallery

HARNESSING THE BEAUTY OF WOOD KEEPS THE BODY AND BRAIN BUSY

By Helen Frances

Photographs: Tracey Grant

on Putiki Drive in Whanganui.

"It's all about shapes. I love the shapes of vases and hollow forms, and the patterns," he says.

Selling his pieces is secondary to the enjoyment that he gets from making the hollow forms, bowls, and other objects. But the money does help to fund materials and equipment. He says that it took him a long time to acquire the equipment he needed. He bought his first lathe on ►



Left: Alby designs his own hollow forms with different patterns, inspired by new ideas while working on each piece

On the shelf

In his shed Alby has a collection of pieces, some of which he says are “failed, waiting to be redeemed”.

“That is the first bowl I made from a piece of wood from a tree that fell over in a storm,” he says indicating a bowl all in one piece with curved feet coming out from underneath. “It fell over a footpath near where we lived and the council cut the piece of stump off over the footpath and rolled it out of the way, so I went in there with my father-in-law and a wheelbarrow and picked it up.

“The wood was wet and it warped as it dried, which gave an undulating effect.”

On the floor nearby stands a stool or table that combines wood and a transparent blue resin, which he buys. Alby also makes wood and resin pendants.

Another bowl has a natural edge, and a platter made from wood that he acquired through a woodturner’s family selling things off came up beautifully when he sanded it.

“It was just a rough piece,” Alby explains. “The grain is like a map and the spalting [fungus that gets into dead wood] made it quite hard to turn, as the spalting area was less dense.

“Each piece of wood is so unique and individual. The beauty of working with a rough piece of wood is that there is always the surprise element. You never know exactly what you are going to find in terms of patterning, grain, texture, colours. Sometimes I’ll sandblast in between the rings in a piece of wood because it’s softer and you can bring out the rippled grain texture.”

A man-cave haven

“Going into that shed — it’s sort of like all life’s problems stop at the door. Because it captivates your mind, I guess, and you are always pushing the boundaries to try to make things better,” says Alby.

“When you are in there you’re always trying to figure out, how am I going to do this? It’s not an easy thing to do and takes your mind off other things. When I run into issues or problems I can’t solve, when I’m at work I’m still thinking about the form I’m working on and within a

“It was home-made, not very well balanced, and had a lot of vibration, but it got me started”

Trade Me for \$50 six years ago.

“It was home-made, not very well balanced, and had a lot of vibration, but it got me started,” he says. Now in his tidy, well-organized shed he has all the tools and machinery he needs: bench saw, thicknesser, a wedgie sled that he made to cut all the segments, a lathe and lathe chisels, a belt sander, a drill press, a hand drill with a sanding attachment, and much more.

Work on a hollow form can take 30 hours or more, four to five hours at a

stretch, and that’s before he gets to the turning stage, which takes around an hour and a half. He works varied shifts as a police constable, so he uses any free time that he has during the day to do his woodturning.

“I could quite easily spend all my time in the shed but that wouldn’t be healthy,” he tells us. “You do go through days when you feel quite inspired and have lots of ideas. Other days you don’t, so you leave it for a while. Then I’ll see something and come up with another idea.”



Segmented vessel of oak, walnut, and rimu



Alby makes the hollow forms in two halves, turning them as he goes. Here he shows two examples of the vase featured in the process photographs on the next pages

day or two the solution will come. It is a relaxing thing to do in that sense. It keeps my brain busy and working. And it keeps my mind off things I can't do anything about. These are problems I can do something about."

And there's a feeling of satisfaction when people appreciate his work.

"But I still see all the flaws," he says as he points out a slight gap at a join. "So I'm thinking, what can I do next time to make it a bit better? Quite often I wake up in the morning and can't wait to get out there. Or I wake up sometimes at

4am and go and work in my shed for an hour or two before I go to work."

Pyrography

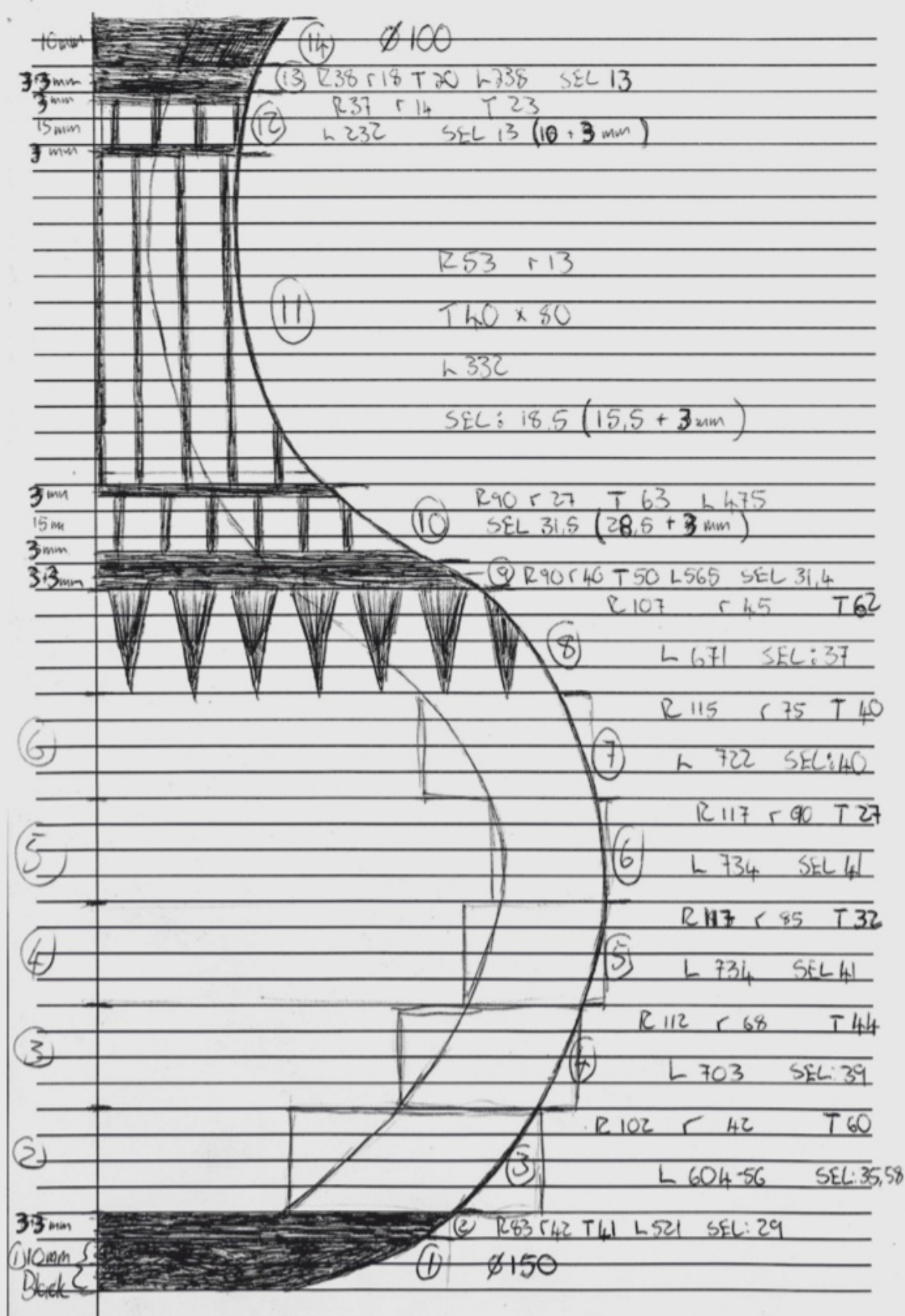
Alby has branched out into burning designs on pieces with a pyrographic tool. The patterns look remarkably regular, however he says that that is

because the pattern is so busy: "It takes your eye away from imperfections; it's not very accurate at all. Your brain gets distracted. Pyrography has made me look at wood with fresh eyes — it does become a blank canvas — you can add to the natural patterning and create a landscape." ►

"Each piece of wood is so unique and individual. The beauty of working with a rough piece of wood is that there is always the surprise element"



Gouging out and shaping the interior of the top half of the vase on the lathe



Alby draws the hollow form/vase and does calculations to work out the dimensions and angles of the segments, rings, and overall shape

1. Design

Alby does a lot of research, drawing inspiration from books and the internet. Then he designs his own version, building in the patterns and shapes that he wants, such as diamonds and stars, and deciding on the overall height and shape. "You have to draw it out; you can't just work out of your head: draw, plan, and work out the pieces you have to cut," he says. The design process involves quite a bit of mathematics: "From the top I work out how many different rings there will be.

Then I work out the circumference and how many pieces there will be in each ring. You make the rings different sizes and work out the circumference of each ring going down the form." The number of rings depends on the thickness of the timber used.

2. Calculations

While there are calculators online, Alby makes just four calculations, which he does manually, and says he finds this easier to do.

a. Section width = maximum radius – minimum radius

"At this step I add 5mm to the maximum radius and subtract 5mm from the minimum radius. This adds a centimetre to the section width to give room for any errors. It is nearly impossible to get the rings centred when you glue them together, so it's a good idea to add width here for error margin. For each ring you have to work out your maximum radius and your minimum radius. That tells you how thick each piece of wood has to be," explains Alby.

b. Cut angle = total angle ÷ 2

The total angle is 360 degrees divided by the number of segments. As each segment is cut with an equal angle on each side, the cut angle is the total angle divided by two.

c. Section edge length =

circumference ÷ number of segments

Section edge length = maximum radius (+ the 5mm for error margin) x 2 = maximum diameter. Diameter x Pi (3.14) = circumference. Circumference divided by number of segments = section edge length.

d. Stock length = circumference = section edge length x number of segments

This tells how long a piece of wood needs to be to cut the required number of segments from it — 18 here, for example.

Once he has cut the stock length he glues on any pieces of laminate that he needs for patterned effects before cutting the segments. Different coloured slivers of laminate create contrast on the joins and give a brickwork effect.

The rings are made of segments and the angles of the segments are all the same. "It depends how many you put in each ring," he says. "If you have 18 segments in a ring, which is 360 degrees, then 360 divided by 18 = 20 degrees. Then your cut is half of that angle."

The rings are different sizes and will be stacked and glued on top of each other to give the shape.



3. Materials selection and preparation

Alby uses native and other timber, recycled from old furniture and cabinets, buildings, fallen trees (oak, rimu, totara, walnut) and tends to avoid pine, which is too soft. Once he has sourced the timber he removes old nails and screws and rips the wood to size — rectangular batons about 20mm thick.

"I know that the timber I have is 20mm thick, more or less, so I divide it into 20mm rings. Each ring would start off as a little square block; so again that one's maximum radius is a little bit less than the next one's maximum radius. I can work it out exactly but I always add a little bit for error, which gives me a bit more to play with — more room to shape it. I always add on up to 1cm."

He buys new lighter and dark-coloured veneer laminate that he layers between larger pieces to make contrasting patterns.

The hollow form in these photographs is made from rimu recycled from a piece of furniture that someone threw out. The thin wood is veneer laminate that he bought and had in stock. The little light pieces are pine that also came out of a piece of furniture that Alby disassembled. "Recycled timber, even though most of it is rimu ... has come from different pieces of timber and varies in colour a bit. It gives extra interest," he says.

4. Making the segments

Along each wood baton the topside is first marked. The segments are then cut at the correct angles on a wedgie sled, which is set to the cut angle. There is no tolerance for inaccuracies, which would inevitably create gaps. "The method I use on the sled cancels out any error on the blade, so if the blade is not 100 per cent upright, the way I am cutting it doesn't matter so much. There would be gaps otherwise between the segments if there was any error," Alby says.

Next, any rough parts on the segments are lightly sanded to enable a smooth, tight join when glued together. ►



Above: Alby recycles timber, in particular New Zealand native timbers. He removes old nails and screws and rips the wood into rectangular batons about 20mm thick

Below: Alby cuts the segments on a wedgie sled, which is set to the cut angle. There is no tolerance for inaccuracies, which would create gaps



Making a hollow form (cont.)

The wood segments are glued together and compressed with one or more rubber bands while they dry



5. Making the rings

First, the segments are assembled in a ring without gluing to check accuracy. Then they are glued together with wood glue to form a ring (18 segments in the photograph) and secured with one or more rubber bands. The band is stretched around the ring on a board using nails that keep the band stretched wide. Alby stretches a number of rubber bands around each ring to keep up the pressure. Once a ring is dry, it is sanded flat with a belt sander to ensure that all the rings will stack together and there will be no gaps between them.

Quick drying glue is handy to use.

6. Putting the rings together

The rings are then glued together making sure that the segment join lines do not match up to get a staggering effect.

"It's like laying bricks — you space the gaps of the next ring up into the body of the ring below so the join lines are always alternated," Alby says.

There is a lot of wood jutting out around the rings that will be turned on the lathe to form a smooth surface once the glue is dry. The rings have to be compressed to dry tightly. Alby places two 10-litre paint buckets on top of the rings and leaves them overnight.

"I glue a couple of rings together, then



The top half of the hollow form before it is turned. The excess wood will be removed on the lathe to give the final, elegant form

when the glue is dry I put them on the lathe and start shaping," he explains. "You can imagine if you put all those rings together and try to work inside it would be pretty difficult. I usually make it in two halves and then put them together."

7. Top and base

Alby makes top and base (the two halves of the form) at the same time. He builds them up, gluing the rings and shaping both the interior and exterior on the lathe as he goes. Access to the interior of the form is easier when it is done in stages.

The thickness of the hollow form is around a centimetre for strength.

"If it's too thin, there's not enough glue or wood," he says.

The foot piece and the top lip of this hollow form are made from a solid piece of wood that was cut into a square, 12x12cm.

A circle is drawn on the wood and the corners cut off on the bench saw to give an octagonal shape. Both pieces are



Sanding a ring when the glued segments are dry to create a smooth, even surface before gluing to another ring. Sanding ensures that all the rings stack together and there are no gaps



Applying glue to a ring at the base of the top half of the hollow form prior to attaching the next ring. Alby makes sure that the join lines do not match up to get a staggering effect



Building the top half of the hollow form. Once the newly glued ring is in place, Alby compresses the rings using a 10-litre paint bucket



turned around when shaping the form. On the foot piece, an additional scrap piece of round wood, made to fit into the metal chuck, is glued so as to mount the workpiece on the lathe. This piece is cut off on the lathe once the whole hollow form is finished and sanded.

The solid top lip is the same as the foot, however a hole is drilled in the middle ready to be mounted on the lathe with a worm screw.

The neck of the hollow form is initially almost solid, made from long segments (in this case 100mm) glued together. This is mounted on the lathe and the drill chuck attached on the tailstock. Before shaping the neck, a hole is drilled through it. It is perfectly balanced.

8. Turning the hollow form

The top half is attached to the metal chuck and turned, using a bowl gouge initially to shape the interior.

The exterior is then turned, using a gouge and scraper. The same is done with the base half.

The chisels must be sharpened at regular intervals, as the lathe spins very fast and chisels get blunt quickly.

The diameters of both halves are matched with calipers and any differences adjusted by turning on the lathe.

The inside is finished by sanding and finishing with oil or lacquer.

The two halves are glued together, with both surfaces dressed with wood glue, before being left to dry. Once dry, the form is turned until a smooth, continuous curve is achieved.



Turning the interior of the hollow form on the lathe to remove excess wood and make a smooth, shaped surface

9. Finishing

Alby sands the hollow form using a drill with Velcro-backed sanding discs.

The Velcro makes changing between different grades of sandpaper easier.

"When it is spinning it sands a lot faster and doesn't make scratches on the wood. I use increasingly fine grades going from 100 to 140, 180, 240, 320, 600, 800, and for the polishing I'll

probably use 1500 to 2000," he says.

Lastly, lacquer or oil is applied — Alby does not lacquer all his pieces; he also uses an oil finish. With lacquering, the hollow form is sealed with a coat of sanding sealer, then sanded and resealed again two or three times to seal in any loose fibres. Finally, it is sprayed with a clear lacquer and left to dry for a week or two before being sanded again with a very fine sanding paper. 📁



Turning the top half, initially using a gouge to cut off extra wood



Turning the top half using a scraper to refine the surface



Sanding the hollow-form top using a drill with Velcro-backed sanding discs

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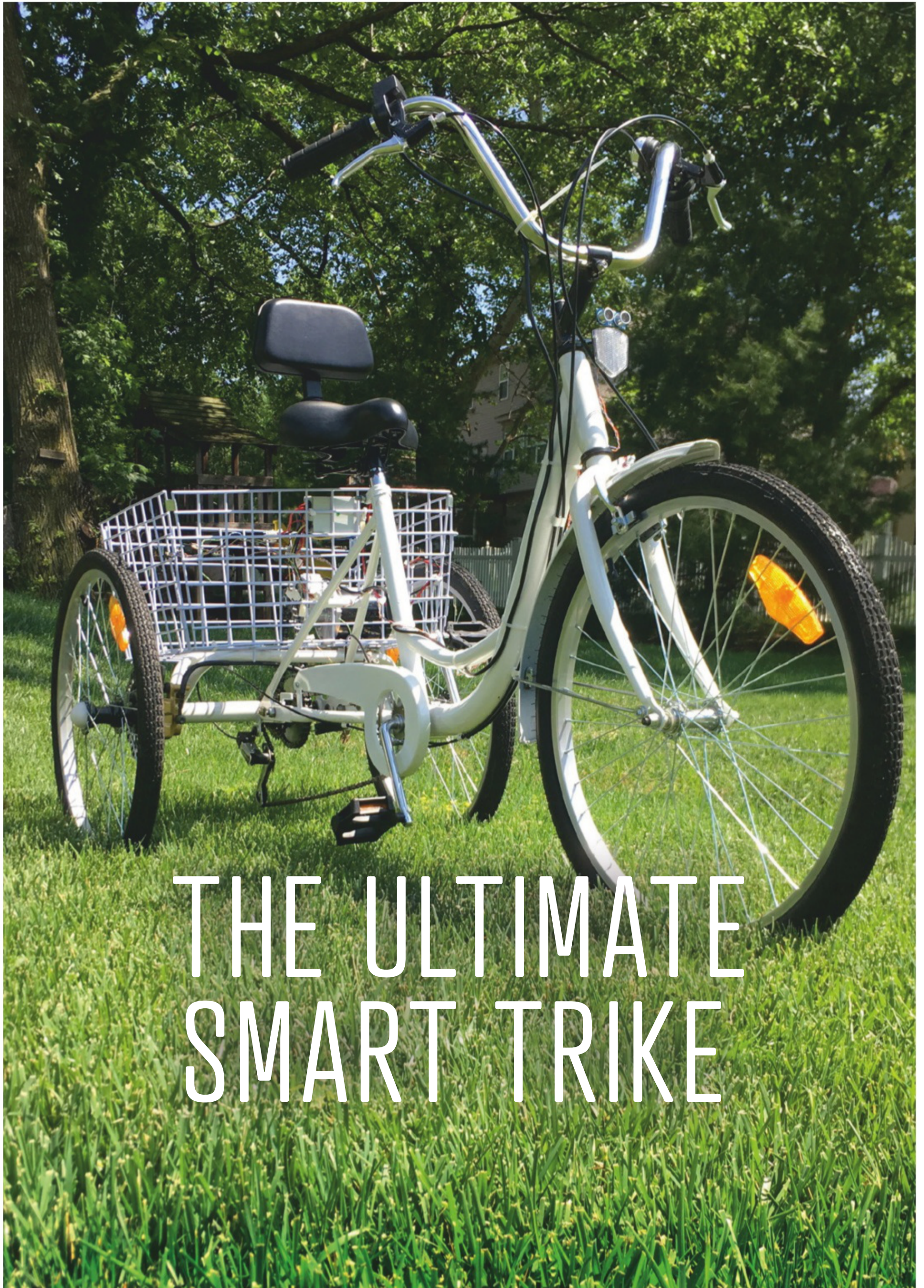


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THE ULTIMATE SMART TRIKE



USING TECHNOLOGY TO REGAIN EXERCISE AND FUN

By Sean and Connor Miller

Photographs: Sean Miller

Why would anyone ever want to build a motorized, three-wheeled, adult's tricycle with the intent to use for exercise? Well, there's a bit of a backstory.

When our son was just around two years old, we took a family hiking trip in the mountains of West Virginia in the US. On the final night of our adventures, we found a nice lodge on the way back where we elected to enjoy dinner and stay the night.

My wife seemed overly tired and, oddly, developed a sense of vertigo. I thought the uneven plank flooring of the old lodge was just messing with her balance. We decided to turn in early and get a good night's sleep. The next

I thought the uneven plank flooring of the old lodge was just messing with her balance

morning, on top of the vertigo, her left arm was numb.

Being just about an hour away from home, we headed to our doctor. Things moved quickly and within 12 hours, we were faced with the diagnosis of relapsing-remitting multiple sclerosis (MS).

Necessary changes

The new physical limits put an immediate halt to our outdoor recreation. Now, several years later, her physical condition is such that she can walk, though sometimes assisted with a cane, but her balance and left side are weak.

We ultimately moved from that side of the US to the Midwest. At our new location, we have over 128km of rail-grade, paved trails that allow electric bikes limited to 15mph (24kph). The trails are absolutely beautiful and that is what gave us the idea of making the motorized Ultimate Smart Trike. Using today's technology and some maker know-how, we set out to design a trike to assist exercising by overcoming my wife's specific physical challenges. ►

Right: We bolted a three- by 3/16-inch plate to the top bars of the carriage to serve as a motor base. The ideal location for the batteries worked out to be low and centred. However, we were so eager to get it on the road that we simply secured them in the basket

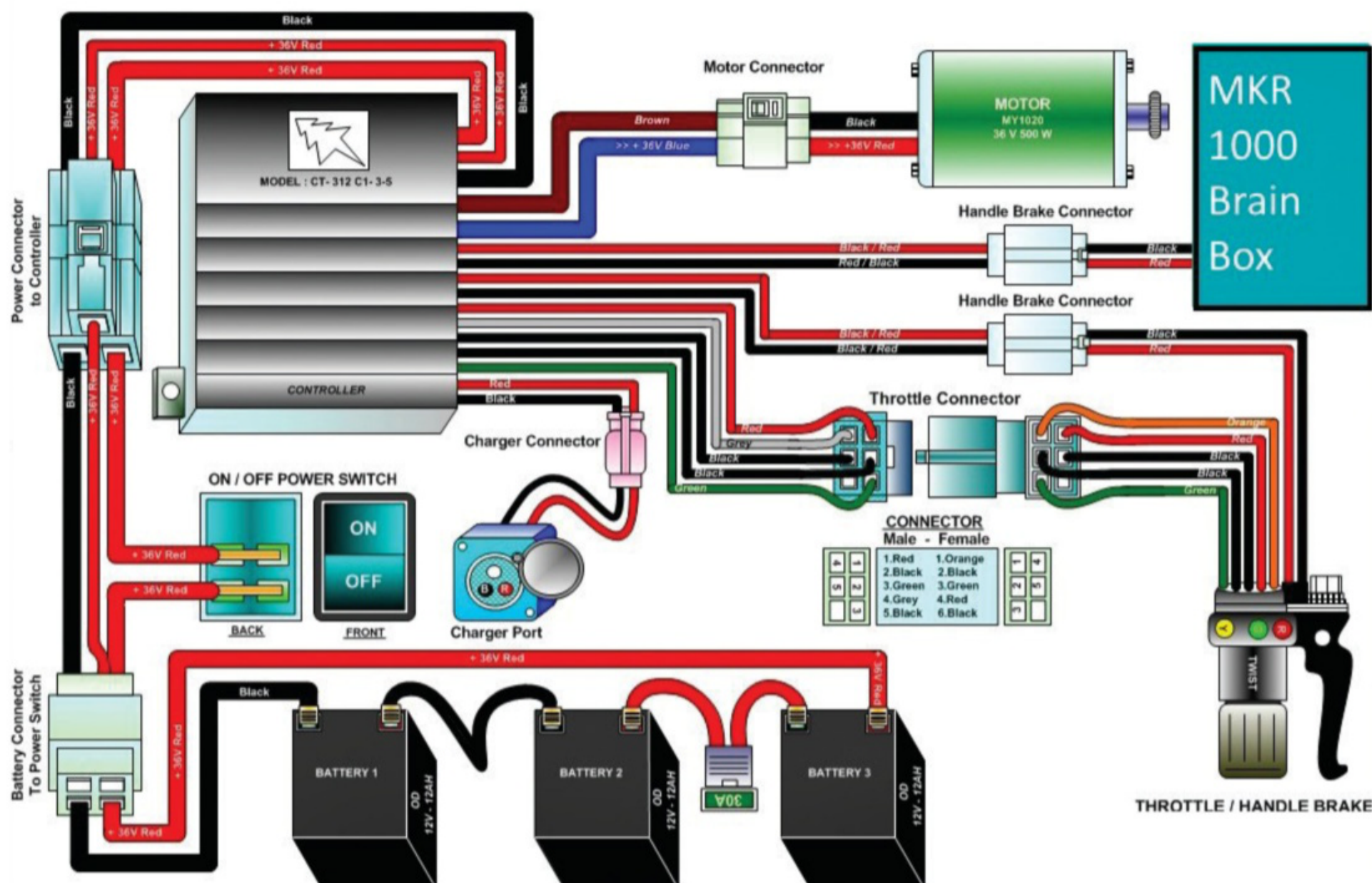
Design parameters

To get back on the trails, we needed to establish a means of cycling that addressed:

- poor balance, so difficulty in keeping the bike in one's own lane
- weak grip with the left hand when squeezing the bike brake
- inability to stand so as to 'torque' up hills
- inability to step high over the centre bar to mount the bike
- fatigue due to left-leg pain
- inability to open the garage door without dismounting.



Below: For the electrical design, we were able to purchase an online motor controller to link to our MKR1000 custom brain box. To interlock the motor, we simply simulated electronically the brake being pulled. This makes use of the off-the-shelf controller's brake interlock. Here you can see the full wiring diagram



BIKE ALARM

CALORIES-BURNED
COUNTER

GARAGE-DOOR OPENER

TRIP DATA LOGGER

36V MOTOR

FRONT COLLISION
DETECTOR

BRAKE INTERLOCK

SPEEDOMETER

ODOMETER

TILT INTERLOCK



Trike features

The smart aspect of our trike design is focused primarily on safety but also has a few other convenience features while still encouraging exercise. With a motor that is strong enough to assist up hills, we could not risk it introducing energy that could bring harm.

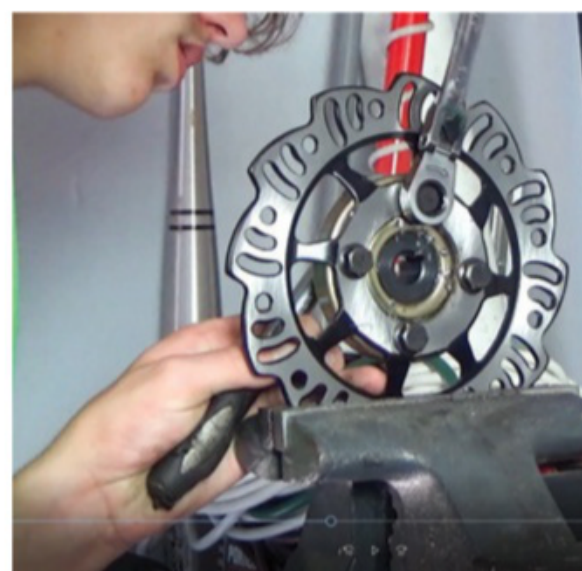
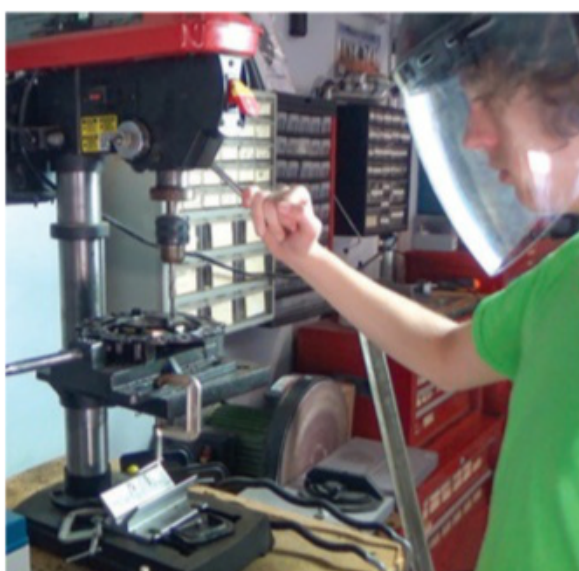
So my son and I came up with the following smart features:

- motor interlock due to over-tilt
- motor interlock when the brake is applied
- motor interlock when objects are too close
- motor interlock if pedalling is stopped or the rider has not yet started pedalling
- motor interlock if the rider has not yet travelled at minimum speed
- datalogging of speed, distance, travel time, tilt, calories burned, and interlock hits with identifying reason onto SD card
- LCD display of speed, distance, travel time, calories burned, and interlock-status information
- garage-door opener/closer
- bike security alarm.

While we were at it, we thought of a couple of additional mechanical improvements as well:

- the ability to pedal unassisted, shift gears, and freewheel while coasting
- improvement of the stopping ability using a hydraulically actuated brake. ►

Once we added the mass of the batteries and motor, the factory band brake on the trike was insufficient and too difficult to squeeze for my wife. So we modified the band brake to serve as a hub for a hydraulically actuated disc brake





Left: This much improved stopping power and allowed us to place a limit switch at the actuator to interlock the motor. The limit switch pulls a pin on the MKR1000 to ground. In our MKR1000 code, this signals to interlock the motor

Hardware

To address all of these design parameters and features, we determined the following major components:

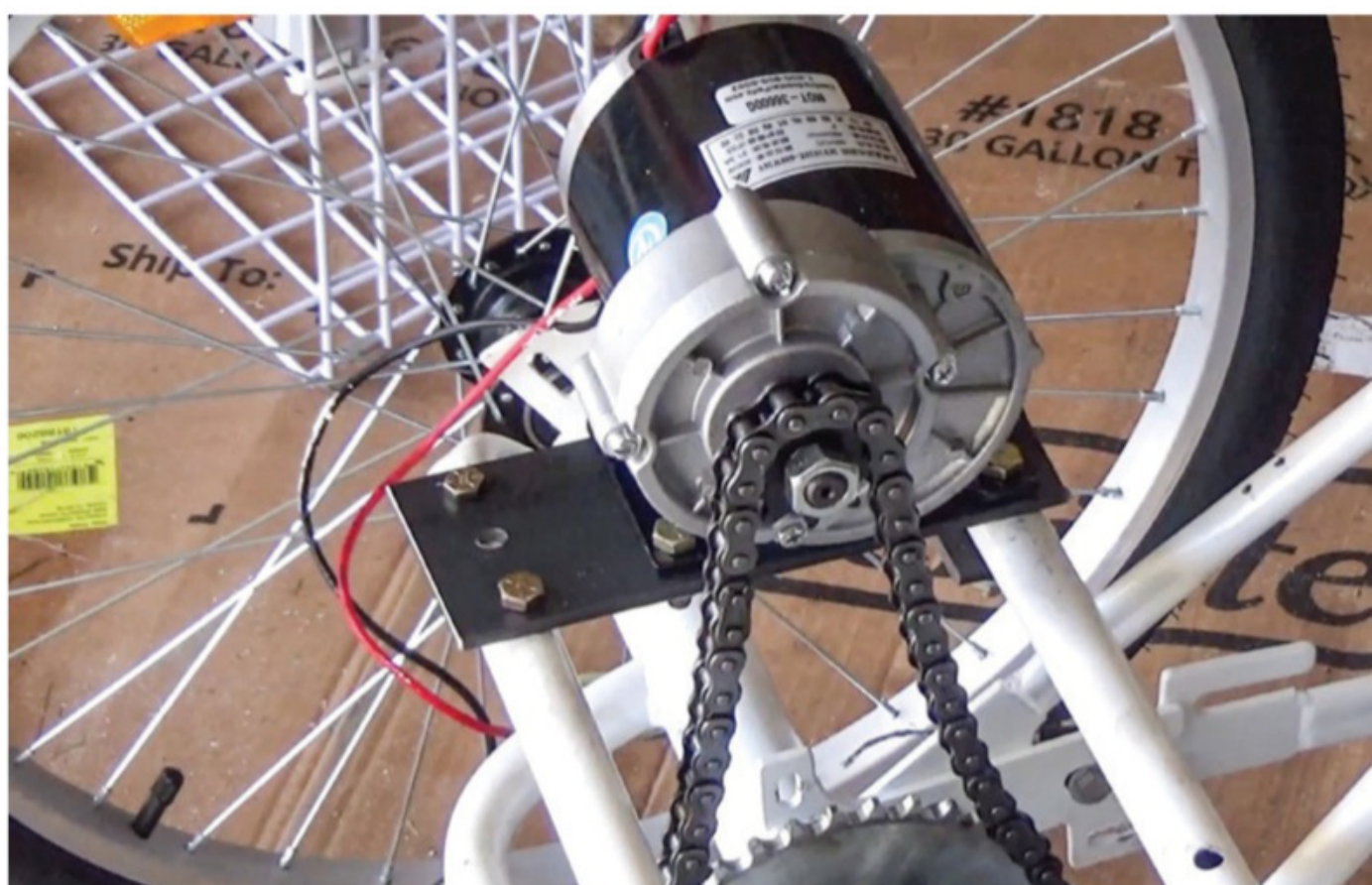
- inexpensive, six-speed, three-wheeled trike with a low centre bar to address balance
- 36V, 500rpm motor geared for 11mph (18kph)
- 36V motor controller and thumb throttle
- 34-tooth sprocket
- 15mm bore freewheel for the sprocket
- (three) 12V, 18AH batteries
- hydraulically actuated disc brake to reduce strength needed to squeeze the brake
- Arduino MKR1000 IoT (internet of things) kit for the brain box
- ESP8266 microchip to actuate the garage door
- ultrasonic proximity sensor
- tilt sensor to interlock the motor on hills or if tilting



Left: To install the disc brake and 34-tooth sprocket, we simply removed one wheel, loosened the original cartridge set screws, and drove out the rear axle with a wooden dowel. We then sleeved on our new gear assembly and disc brake

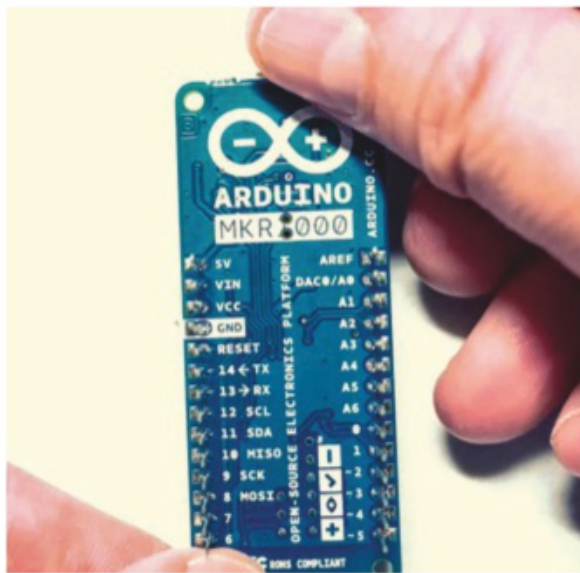
Below: With a $\frac{3}{16}$ -inch plate and a portable bandsaw, we were able to cut a plate to serve as a bracket to mount the brake caliper precisely on the installed disc

Right: We then fitted the No. 40 chain to the sprocket. We used a nail punch and a small rotary cutting tool to size the chain





The trail system allows us to get about anywhere in town, including to the grocery store, so we wanted to keep the basket. We used an air-driven cut-off wheel to make short work of a new opening



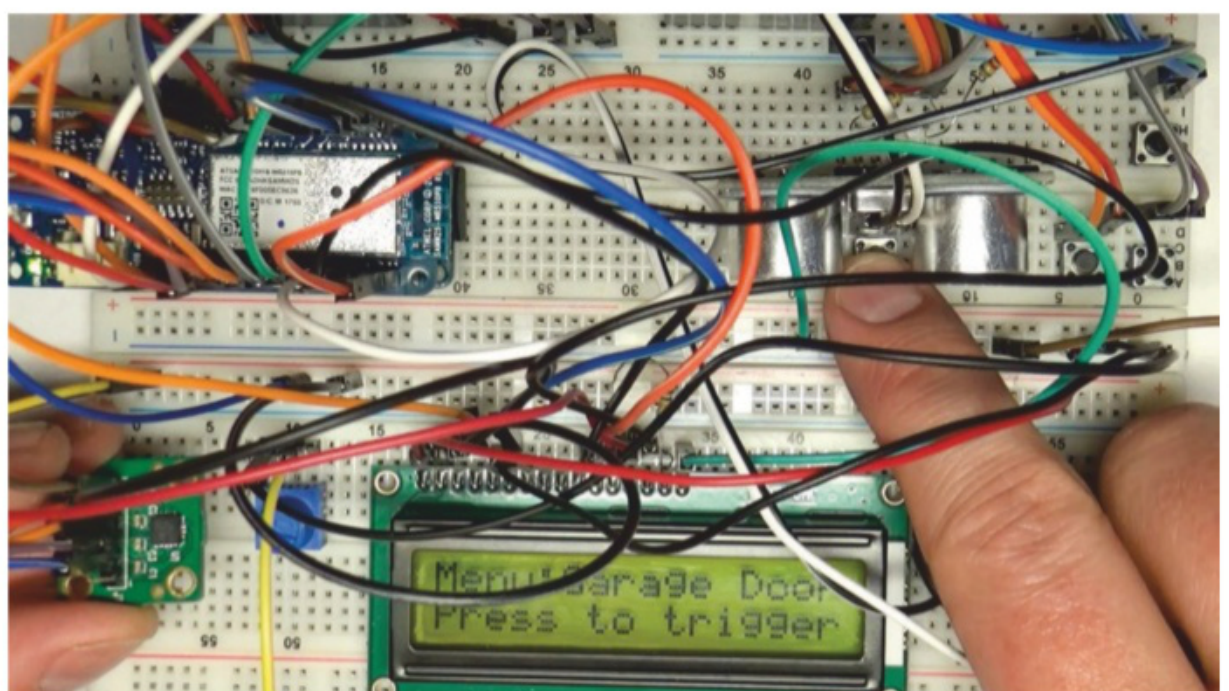
At the heart of the brain box is an Arduino MKR1000. This allowed us to apply various sensors to capture trip data and interlock the motor should there be an unsafe condition

We could not risk it introducing energy that could bring harm

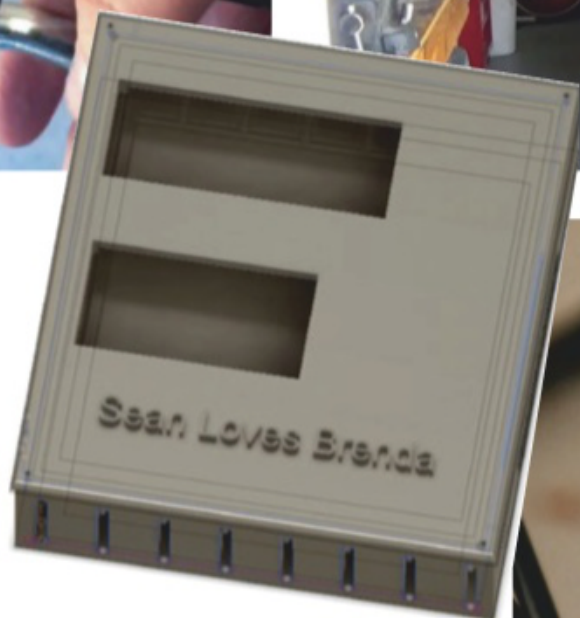
Below: We first breadboarded the overall circuit using momentary switches in place of Hall effect sensors. This allowed us to use our fingers to simulate pedalling, wheels rotating, and pulling the brake. With the breadboarded brain box, we were able to perfect the code for all our desired features, including triggering the garage door without having to dismount the trike, through the click of a button on the throttle

- Hall effect sensors to allow calculation of pedalling and speed
- Adafruit Trinket microcontroller to open the garage door
- 3D printer filament for the brain-box enclosure
- 3/4- by 1/8-inch bar stock for the battery rack

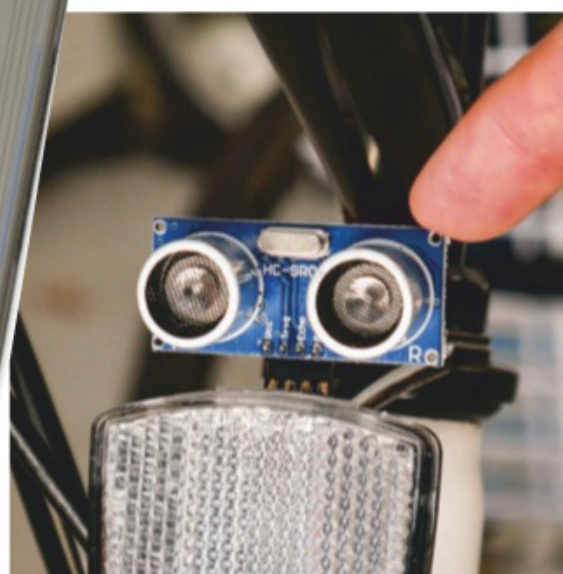
All in, it cost about \$US900 to build. However, to buy a trike from a manufacturer without nearly as many smart technology features is \$US2995. To get us back on the trails, this build was a definite go for us! ►



Above: To pull that off, the code in the MKR1000 monitors a dedicated pin. When the throttle switch is hit, the pin goes to ground. The code then sends a web client command to IFTTT.com. In turn it sends a command to our ESP8266, which is located at our door. It simply electrically switches one of our repurposed garage-door keychain buttons



Above: We designed a 3D-printed enclosure using Autodesk Fusion 360. On a side note, this software is great for designing just about anything, including furniture



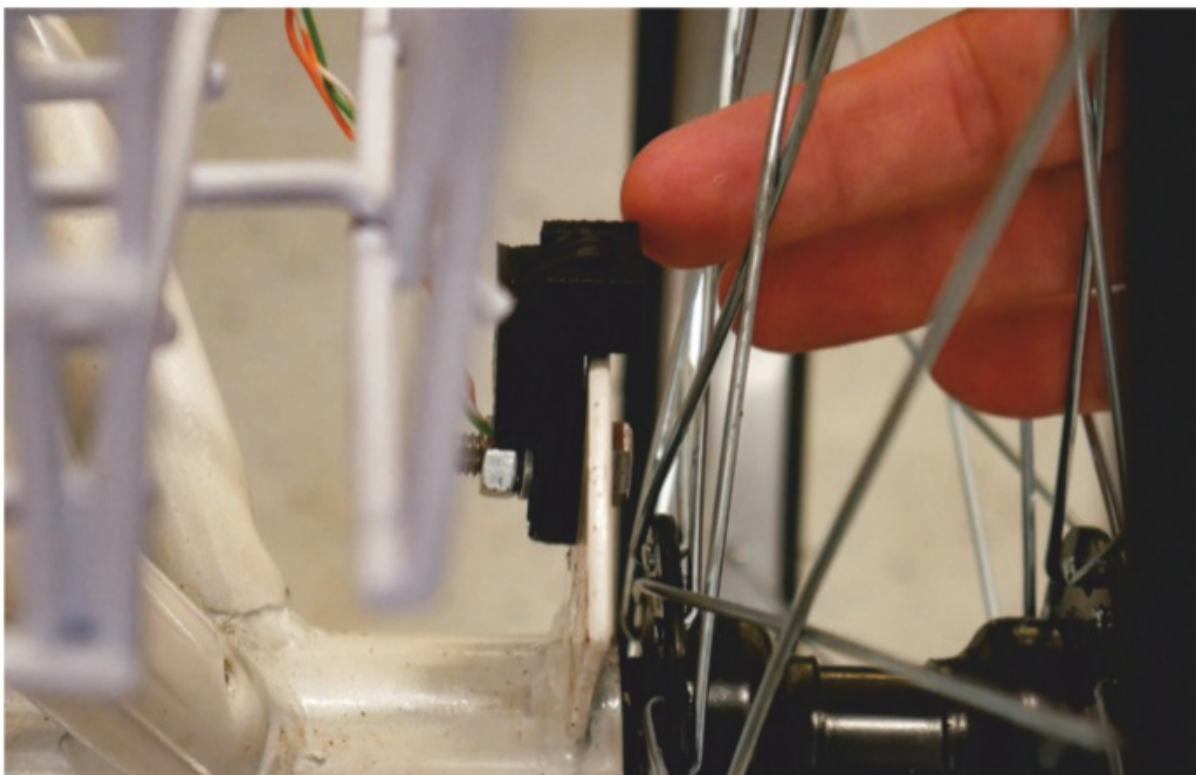
Above: Connor twisted cables to route to all the sensors mounted on the bike. To do so, we repurposed an old telephone landline cable we scavenged from the basement. Placing three individual conductors in a vice, he used a drill to twist all three neatly together

Left: An ultrasonic proximity sensor was mounted at the front of the trike. This feeds back to the MKR1000 to shut off the motor if anything is in front of the trike



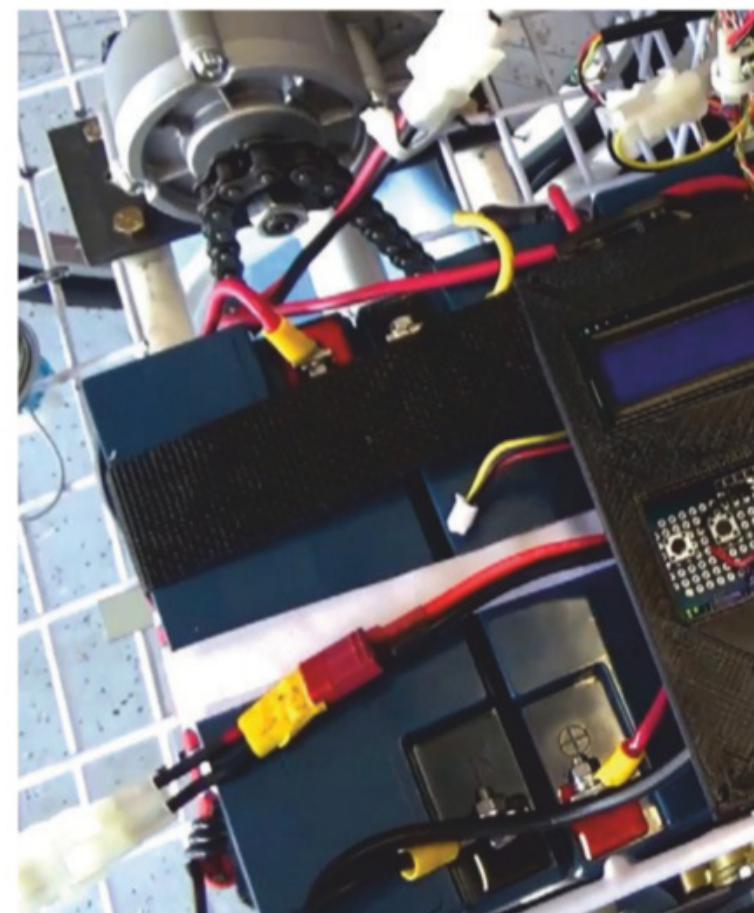
“All in, it cost about \$US900 to build. However, to buy a trike from a manufacturer without nearly as many smart technology features is \$US2995”

Left: Here we have the pedal sensor. It has a rare earth magnet that travels past a Hall effect sensor. This takes a pin to ground on the MKR1000, letting it know that the pedal is travelling. The MKR1000 code translates this to rpm. Once a minimum rpm is reached, it will allow the motor to receive power. This prevents accidentally hitting the throttle and causing injury when sitting idle and flat-footed. The Hall effect sensor bracket was 3D printed but actually could have been neatly duct taped in place



Left: On a rear wheel, we installed another Hall effect sensor to calculate speed. Our MKR1000 code also requires a minimum speed to be met before allowing power to the motor. This prevents a kick when the motor is first engaged

Right and below: With the board soldered together and in its enclosure, we then jacked the trike up and garage tested it



Engineering design

This project took many aspects of engineering design: mechanical for the drivetrain, electrical for the motor power, IoT for the garage-door opener, and programming for its safety and convenience features such as the calorie tracker.

Let's look at the electromechanical aspects. Although we designed the system to still require pedalling, my wife is assisted by a 36V motor. We first mocked up the trike's rear carriage in Autodesk Fusion 360 to get an idea of

how we would retrofit a motor.

In all, this was an amazing build for my family. My son Connor got great practice with all kinds of tools, software, and maker techniques. With the DIY targeted-assistive technology, my wife was able to overcome her physical challenges from MS to enjoy exercising and exploring our new region from the trails.

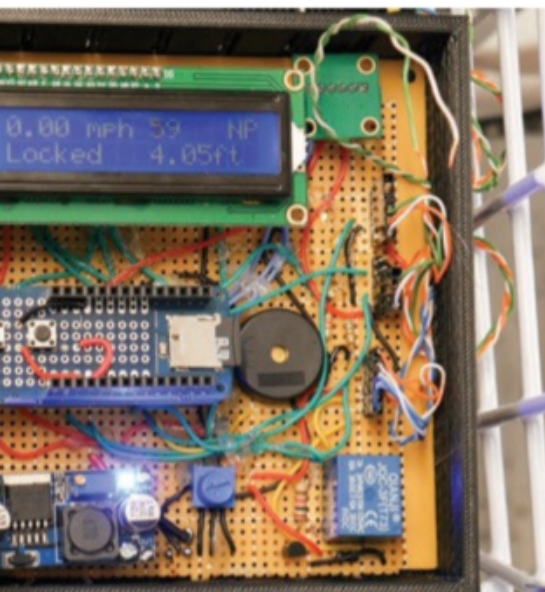
You can find the 3D files, schematics, bill of materials, and MKR1000 code on our GitHub repository at: github.com/RaisingAwesome/UltimateTrike. 



Above: For the bike alarm, we simply coded the MKR1000 to have a menu feature to enable the alarm. If the bike tilts, the pedals move, or a wheel spins, a piezo alarm will sound. Of course, we made it also interlock the motor in this state as well

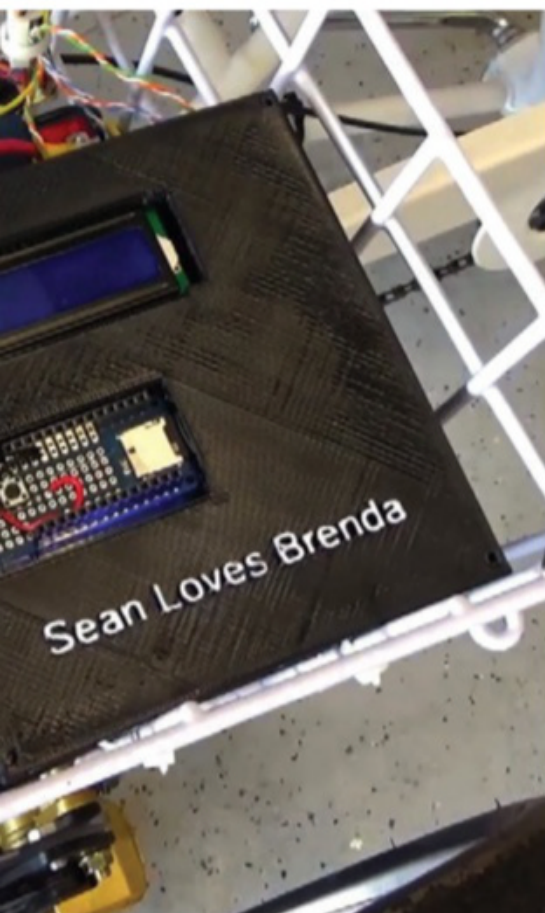


Right: On its maiden voyage, my wife took the trike on the steepest hills in our neighbourhood



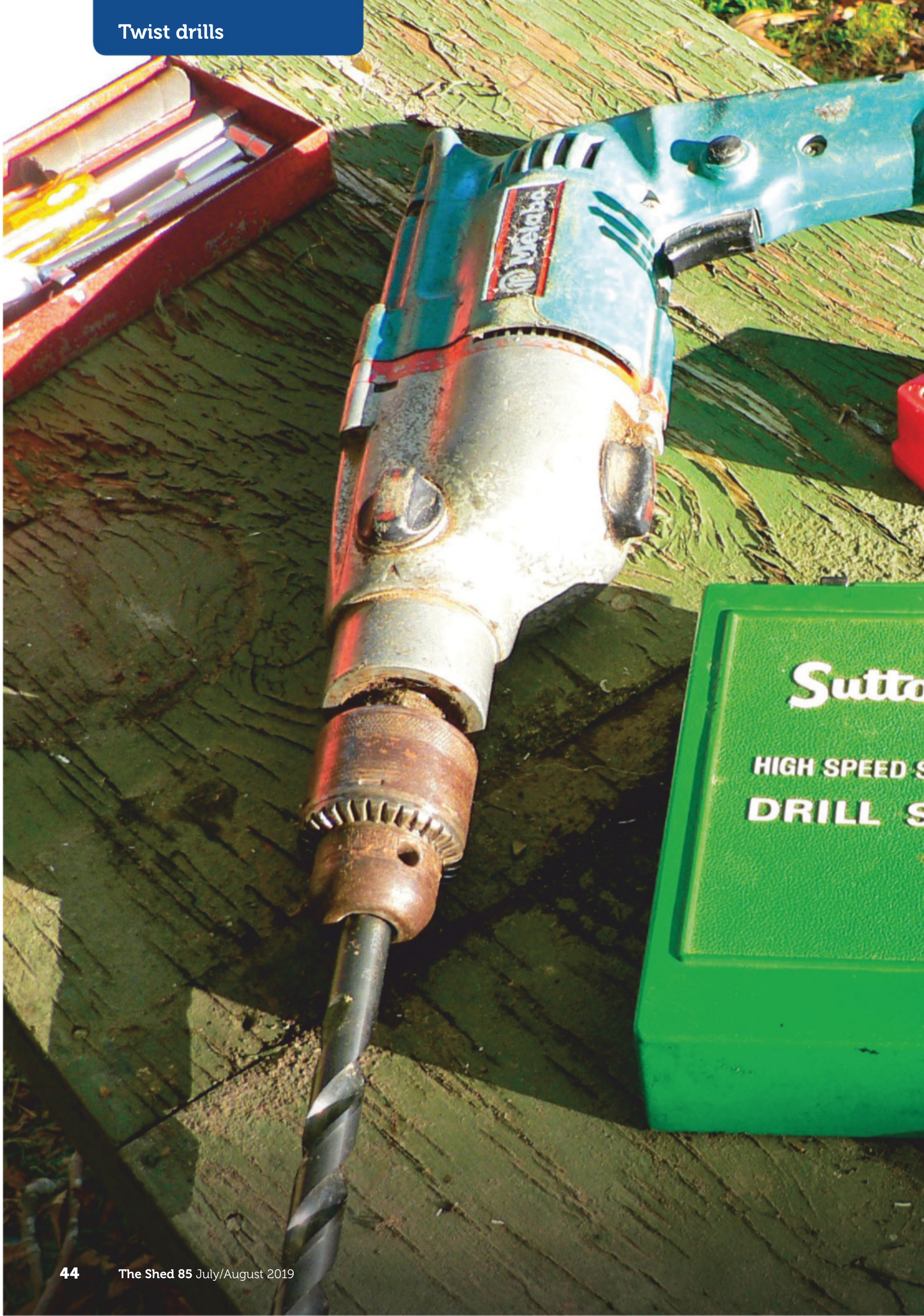
Time	Speed	Top Speed	Distance	Alt	Roll	Not Pedding	Not Slow	Interlock Count
Time 228	Speed: 0.00	Top Speed: 17.00	Distance: 0.00	Alt: 0	Roll: 0	Not Pedding: 1	Not Slow: 1	Interlock Count: 1
Time 249	Speed: 0.00	Top Speed: 17.00	Distance: 0.00	Alt: 0	Roll: 0	Not Pedding: 0	Not Slow: 0	Interlock Count: 2
Time 253	Speed: 0.00	Top Speed: 17.00	Distance: 0.00	Alt: 0	Roll: 0	Not Pedding: 1	Not Slow: 0	Interlock Count: 3
Time 259	Speed: 0.00	Top Speed: 17.00	Distance: 0.00	Alt: 0	Roll: 1	Not Pedding: 0	Not Slow: 0	Interlock Count: 4
Time 313	Speed: 0.10	Top Speed: 17.00	Distance: 0.11	Alt: 0	Roll: 0	Not Pedding: 0	Not Slow: 0	Interlock Count: 5
Time 318	Speed: 0.00	Top Speed: 17.00	Distance: 0.22	Alt: 0	Roll: 0	Not Pedding: 0	Not Slow: 0	Interlock Count: 6
Time 320	Speed: 0.00	Top Speed: 17.00	Distance: 0.23	Alt: 0	Roll: 0	Not Pedding: 1	Not Slow: 0	Interlock Count: 7
Time 323	Speed: 0.11	Top Speed: 17.00	Distance: 0.35	Alt: 0	Roll: 0	Not Pedding: 0	Not Slow: 0	Interlock Count: 8
Time 358	Speed: 0.40	Top Speed: 17.00	Distance: 0.50	Alt: 1	Roll: 1	Not Pedding: 0	Not Slow: 0	Interlock Count: 9
Time 361	Speed: 0.41	Top Speed: 17.00	Distance: 0.51	Alt: 0	Roll: 0	Not Pedding: 1	Not Slow: 0	Interlock Count: 10
Time 393	Speed: 0.34	Top Speed: 17.00	Distance: 0.43	Alt: 0	Roll: 0	Not Pedding: 1	Not Slow: 0	Interlock Count: 11
Time 401	Speed: 0.00	Top Speed: 17.00	Distance: 0.44	Alt: 0	Roll: 0	Not Pedding: 0	Not Slow: 0	Interlock Count: 12
Time 440	Speed: 0.10	Top Speed: 17.00	Distance: 0.70	Alt: 0	Roll: 0	Not Pedding: 0	Not Slow: 0	Interlock Count: 13
Time 500	Speed: 0.02	Top Speed: 17.00	Distance: 0.78	Alt: 0	Roll: 0	Not Pedding: 1	Not Slow: 0	Interlock Count: 14
Time 512	Speed: 0.00	Top Speed: 17.00	Distance: 0.79	Alt: 0	Roll: 0	Not Pedding: 1	Not Slow: 0	Interlock Count: 15
Time 513	Speed: 0.00	Top Speed: 17.00	Distance: 0.80	Alt: 0	Roll: 0	Not Pedding: 0	Not Slow: 0	Interlock Count: 16
Time 518	Speed: 0.10	Top Speed: 17.00	Distance: 0.90	Alt: 0	Roll: 0	Not Pedding: 0	Not Slow: 0	Interlock Count: 17
Time 548	Speed: 0.04	Top Speed: 17.00	Distance: 0.94	Alt: 0	Roll: 1	Not Pedding: 0	Not Slow: 0	Interlock Count: 18
Time 577	Speed: 0.00	Top Speed: 17.00	Distance: 1.00	Alt: 0	Roll: 0	Not Pedding: 1	Not Slow: 0	Interlock Count: 19
Time 585	Speed: 0.00	Top Speed: 17.00	Distance: 1.00	Alt: 0	Roll: 0	Not Pedding: 0	Not Slow: 0	Interlock Count: 20
								Interlock Count: 21

Above: Our MKR1000 brain box has an SD card that logs data for us throughout the trip. It allowed us to dial in the tilt sensor so it doesn't interlock the motors too conservatively



Right: With batteries removed, the weight of the trike comes in at 32.5kg, just under the maximum for a standard ceiling-storage system. So we didn't have to give up any space in our workshop!





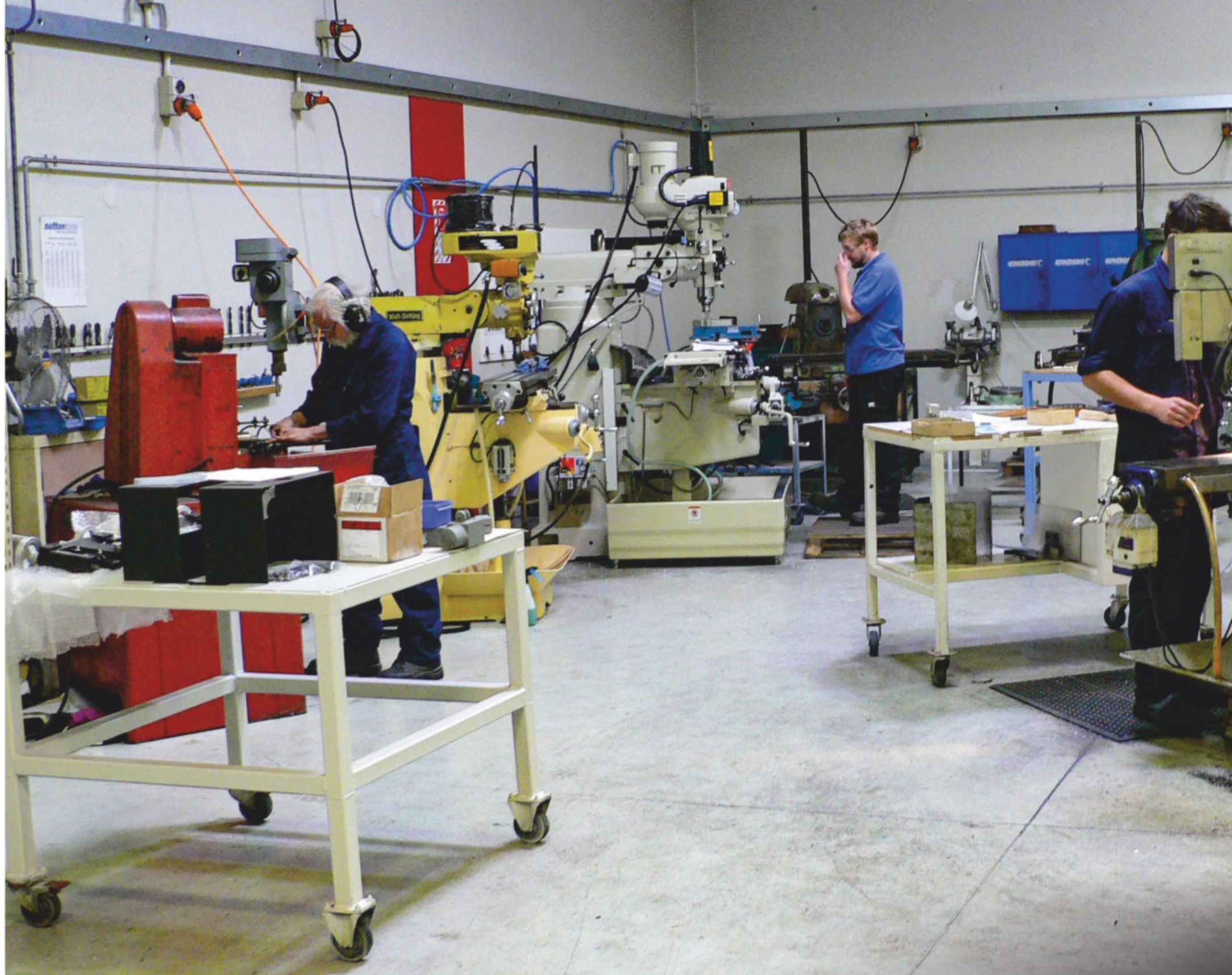
KNOWING THE DRILL

A NEW ZEALAND-BASED COMPANY HARNESSSES
YEARS OF EXPERTISE TO MANUFACTURE
TWIST DRILLS

By Ritchie Wilson

Photographs: Ritchie Wilson





Most shed-based activities — metalwork, woodwork, rebuilding old tractors, even jewellery making — require the drilling of holes.

The first power tool most sheddies buy is a battery-operated electric drill. The twist drills that are used to do the actual drilling last much longer today than they did in the days of muscle-powered egg-beater drills, but they do wear out or break eventually. They can be resharpened but generally not to the same accuracy as a new drill, so there is a continual demand for twist drills.

Our local drill maker

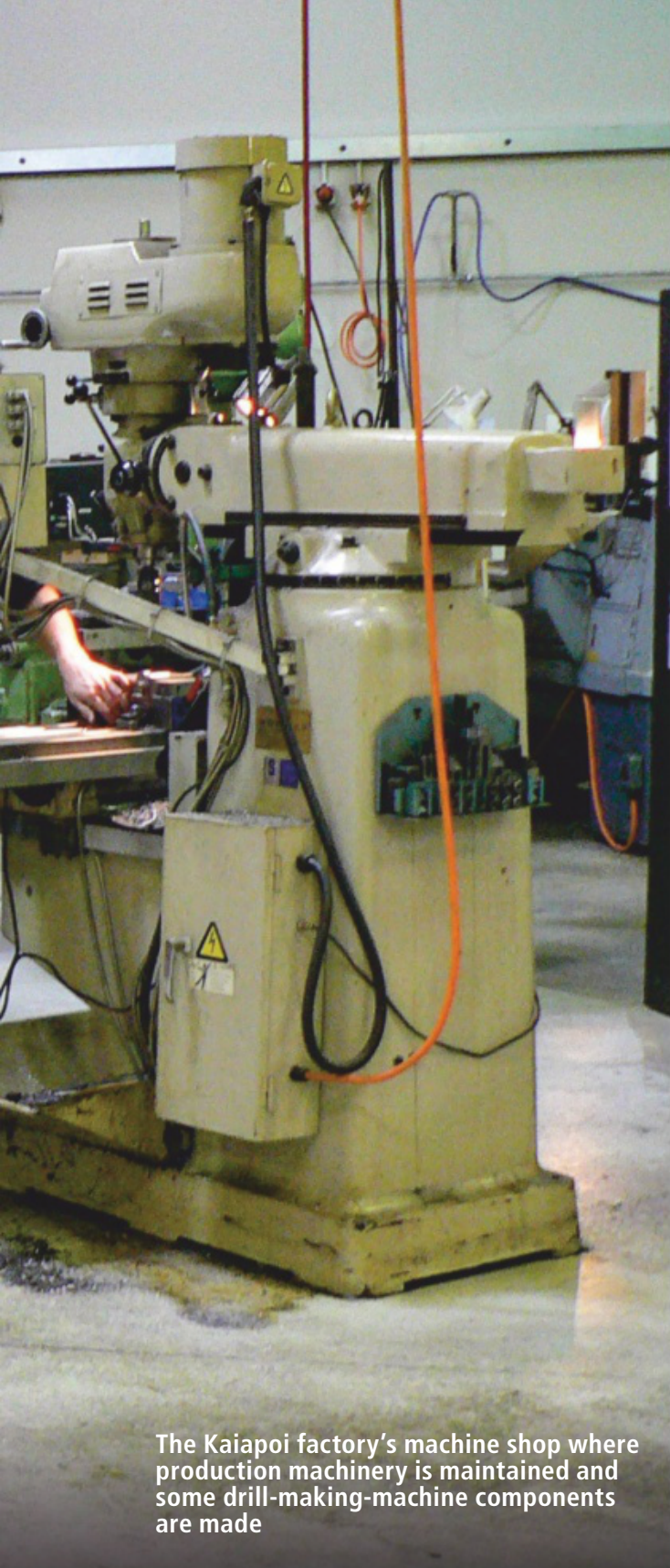
Before New Zealand adopted a more open economy, local manufacturers were protected by steep tariff barriers, so it made sense for overseas businesses to set up local manufacturing operations.

One company that did this was Australian-based Patience and Nicholson (P&N), which made metalworking taps, dies, and drills, among other things. In 1962, with a New Zealand partner, P&N set up a drill and hacksaw-blade plant in the Canterbury town of Kaiapoi.

The years since have not been kind to New Zealand manufacturers. The protected market was thrown open to international competition, including from very low wage economies, and profit margins were savaged. By the 1990s P&N was struggling, new equipment was financially impossible, and the factory plant was kept going with Kiwi ingenuity rather than money. P&N could have gone into oblivion in the same way that many venerable New Zealand companies with no competitive advantage in the new global economy did.



Electronic control system to run Sutton's drill-making machine made by Australia's Anca Motion



The Kaiapoi factory's machine shop where production machinery is maintained and some drill-making-machine components are made

The factory plant was kept going with Kiwi ingenuity rather than money

Upgrading machinery

Sutton Tools was established in Melbourne in 1917 as a one-man toolmaking shop. It grew into a considerable business, which is still owned by the Sutton family. It would be an unusual shed that didn't have some Sutton Tools' taps and dies in it. In 1994 Sutton bravely bought P&N and invested heavily in upgrading the Kaiapoi factory's machinery. In 1995 Sutton brought in Rick Smith from its Melbourne operation as factory manager. Sutton Tools' Auckland-based New Zealand manager, Kevin Donovan, says that "Suttons saved us". Today ►

The lifeblood of a drill-making factory



Magnetite-coated HSS (top) and reduced-shank HSS (bottom) twist drills

The grinding of HSS to make drill bits produces metal swarf, grinding-wheel particles, and heat. The drill blank is flooded with Houghton flute-grinding oil to reduce friction; reduce wear on the grinding wheels; carry away both heat and, suspended in the oil, the metal and alumina particles formed by the grinding process.

"You can't grind without oil," is one of Rick Smith's sayings. This means that the Kaiapoi factory is plumbed throughout for oil, just like the circulatory system of some gigantic beast. One set of pipes, like an animal's arteries, carries cool, filtered oil to the machines. These dangle from the factory's ceiling like outsized plastic umbilical cords. Another set of pipes, vein like, carries hot, debris-laden oil away to the pumps — the heart of the system. There are two separate networks, with each having a set of

filters, heat exchangers, and pumps. One system circulates 30,000 litres, the other 20,000 litres. The heat exchangers transfer the heat in the hot oil to the air, reducing the oil's temperature from about 100°C to 40°C. Cooler oil is more viscous so it evaporates less, collects heat from the workpiece better, and smokes less.

The particles filtered out of the oil are valuable because they are rich sources of scarce metals such as tungsten, chromium, and cobalt. The filtered metal and grinding-wheel particles are packed into drums and exported to Asia to be reprocessed. The grinding oil is sufficiently expensive to make it worthwhile to remove as much as possible from the filtered grindings by pressing. The high-tech and powerful presses used to do this are made in the Kaiapoi factory. So far they have made six.



Design Energy's Mike Shatford with a robot arm that stacks hot and heavy metal ingots on pallets. In the background is an automated portable analytical laboratory

Twist drills



Twist drills were invented in 1861 by Steven A Morse in New Bedford, Massachusetts, in the US. He made them by grinding straight flutes on opposite sides of the drill blank and then twisting the blanks to make the flutes wind around it — hence the name ‘twist’ drill. He then ground the cutting edges on the tip and hardened the drill. The name ‘Morse’ may be familiar as five years later he invented the tapered shank to hold twist drills securely in drilling machines, the familiar three-jaw chuck being at that time just a gleam in Mr Jacob’s eye. The ‘Morse taper’, or MT, is widely used today. In metalwork it is the method of choice to hold tooling in lathes and milling machines. In orthopaedic medicine it is used to secure artificial joints in bone.



the Kaiapoi plant makes two products only: twist drills and machinery to make twist drills.

The Kaiapoi factory’s manager, Rick Smith, has an encyclopaedic knowledge of drill making. He graduated in manufacturing engineering from Melbourne’s Swinburne University in 1980 and started work in Sutton Tools’ Melbourne headquarters testing drill bits in 1984. Leadership is Rick’s thing. He is the immediate past president of The Manufacturers’ Network in New Zealand.

Electronically controlled machines

The factory buildings in Kaiapoi are largely unchanged since 1962, but the

technology involved in making drill bits is radically different.

Drill-bit grinding machines used to be controlled by very complicated cams and gears that had to be manually readjusted for every different drill size, inevitably leading to variations in the sizing and finish of the bits. Today all the machines are electronically controlled, with a staff member responsible for three machines. The worker will load the hoppers in the grinding machines with drill blanks and monitor the machines’ operation. The drill production takes place inside closed cabinets in a spray of expensive Houghton flute-grinding oil, so it is very hard to see what is going on.

An advanced machine will operate



Above left: Hot salt mixtures are used to heat-treat the finished drills

Above: The base of a drill-making machine after being levelled by hand scraping

Left: Three drill-making machines in operation. The grinding oil is delivered by the ribbed plastic tubing hanging from the ceiling

It would be an unusual shed which didn't have some Sutton Tools' taps and dies

on eight axes and have three spindles to hold grinding wheels. The process to make the drill bits varies slightly depending on their size. For sizes smaller than about 4mm, it all happens inside one machine. With the carefully ground and heat-treated high-speed-steel (HSS) blank held in a collet, an aluminium oxide (alumina) wheel grinds a spiral groove, or 'flute', into it.

The factory's products



An oil press under construction

The Kaiapoi factory makes 280 types of drill. They differ in their diameter, length, shank type, coating, and tip. The shank can be straight, reduced, or tapered.

There are three series of diameter: metric, imperial, and 'number'. The metric diameters increase from 1mm to 3.5mm in 0.05mm increments, and from 4mm to 13mm in 0.5mm increments. Imperial drill bits increase in size by $\frac{1}{64}$ inch. Number drills have diameters from 68 (1.25mm) to 1 (5.76mm).

The tip can have different angles and be chisel point or split point.

Split-point drills are more expensive because they require an additional grinding operation to add another facet to the tip, reducing the size of the chisel point. They aren't as durable in more stable drilling environments such as drill presses, but they can drill a hole without a punch-mark without wandering. This makes them popular for the DIY market and they are the most popular type of twist drill sold in the US.

Another wheel then grinds a relief next to the flute to form a cutting surface on its edge. These actions are repeated on the opposite side, leaving two flutes winding around the blank. Another grinding wheel then forms the cutting edges at the tip of the drill — all in a few seconds. Larger drills have the tips finished in a separate process in a separate machine.

Quality control

Sample drill bits are regularly checked with specialized equipment to ensure that they are within specifications for diameter and cutting angles. The grinding wheels are automatically dressed at intervals inside the machine, which then compensates for the reduction in the wheels' diameter. The ground bits are heat-treated in red-hot molten ►



The Kaiapo factory - built in 1962

Coated drills can be better



Depending on the coating and the drill bit's use, coating drill bits can be very beneficial. Coatings can greatly extend the drill's useful life and be more than a marketing gimmick.

Rick Smith started his working life testing the durability of drill bits and found that some coatings extended

their life, admittedly under extreme conditions, by 100 times. The very thin ($3\mu\text{m}$) hard coating reduces both the wear of the underlying metal and corrosion.

Forming the coating can be very expensive. Some coating chambers cost NZ\$2M.

The colour of the coating indicates its composition:

Coating colour	Coating name	Chemical formula
Gold	Titanium nitride	TiN
Red	Titanium aluminium nitride	TiAlN
Black	Titanium carbonitride	TiCN
Black	Magnetite	Fe_3O_4

The Fe_3O_4 coating added to some of Sutton Tools' drill bits increases 'lubricity', or slipperiness, and reduces corrosion. When used for drilling in iron and steel, edge retention is increased. Uncoated drill bits are best in aluminium and brass.

A container load of product leaves for Australia every two weeks

salts, may be thinly coated with black magnetite in a furnace, are laser etched with brand and dimension, and are packed in various styles of packaging ready for shipping. Rick Smith says of drill-bit manufacturing: "Costs are high and margins are low."

The blanks are made in Sutton's Melbourne factory from HSS, which is mainly imported from France (Erasteel) or Germany (Böhler) and shipped to Kaiapoi by the container load. In Australia, HSS wire or rod is straightened, cut, ground to size, perhaps has the shank reduced, has a point machined on one end and is heat treated. The integration with Australia is completed with most of the finished drill bits being exported to the Australian market in the same containers. They are sold under the Sutton brand in Australia and the Evacut brand in New Zealand. Most local industrial-supply, fastening, and hardware/DIY retailers are very supportive of the locally made products.

Continual factory upgrading

The Kaiapoi factory's 102 staff runs three shifts each day, with an annual production of more than 12 million bits. A container load of product leaves for Australia every two weeks.

Sutton Tools is unusual in that a very large proportion of its profits is reinvested in the business by its owners. This allows for the continual upgrading of the Kaiapoi factory's plant. During the hard times, before Sutton took over, considerable skill in equipment maintenance and modification was developed and this has led to 'cutting-edge' drill-making machinery being designed and made on the Kaiapoi site. About 10 of the staff, including two apprentices, work on the design and fabrication of the machines ►



Britney Eichel loading twist drills into a hopper for the Design Energy's robots to laser-etch and pack (see panel at right)



At Sutton Tools' Kaiapoi twist-drill factory, three lots of industrial robots are used. Most of the operations carried out in the factory are too variable to be easily automated, but the laser etching and packaging of drills is undertaken by two pairs of robot arms. These dull and repetitive tasks are exactly the sort of jobs that are worthwhile to leave to machines. Most robots in New Zealand are used to 'pack and stack', especially when the items being moved are heavy.

Sutton Tools' robots were provided by Christchurch robotics company Design Energy. Managing director Mike Shatford says that as the cost of robots has reduced so dramatically over the past decade and their capabilities have increased, they have

become much more attractive to small- and medium-sized businesses. This is highly relevant in New Zealand because 95 per cent of local companies fall into this category. Mike spends most of his time visiting businesses and promoting robots as a possible answer to manufacturing problems. He says, "Robots are the solution." The return time for an investment in robots can be as little as six months.

Design Energy is the New Zealand distributor for two manufacturers of robots: one is the giant Japanese company Nachi; the other is Universal Robots (UR) from Denmark. UR has been credited with the creation of a new class of robots called 'cobots', of which nearly 30,000 have been made. These are designed to interact

safely with humans and to be able to be programmed amazingly easily, almost intuitively. Workers can be taught to programme the UR cobots in less than two hours. They cost from NZ\$30K to NZ\$50K, half the price of 10 years ago, and are very easily repurposed, being able to be switched between different tasks with minimal delays in production.

Design Energy works with customers like Sutton Tools to engineer processes involving robots. At present it is working on a large robot to stack heavy pieces of metal on pallets. The 11 engineers employed by the company work on the design of the jaws to hold the metal ingots and the software to control the robotic arm's movements.

The many variables in drill making require complicated control panels



A robot arm moves packaged drills from the film-sealing operation to cutting

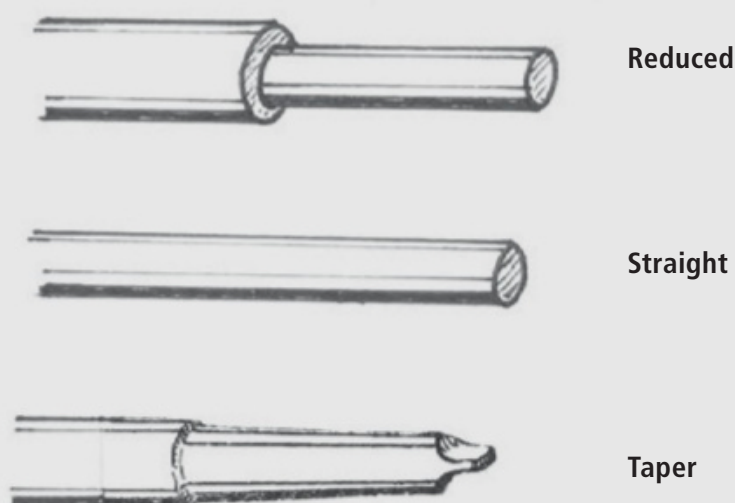


A Mitutoyo point-tip micrometer for measuring the core of a twist drill





Types of shank



Parts of a drill



Tip angle



A twist drill's most important parts are the tip (where the cutting edges are), the flutes, the core, and the shank. Different materials are drilled best by drill bits with different characteristics. The larger the angle of the tip — the more pointed it is — the better it suits softer materials. The angle of the flutes can be changed to work better in different materials. The flute's job

is to remove metal chips from the tip, like an Archimedes' screw, so that the cutting edges don't get clogged and stop working. Material that the drill cuts more easily, producing chips rapidly, requires flutes that remove cuttings faster. The edges of the flute are designed so that they cut and remove chips that are stuck to the edge of the hole so that they don't

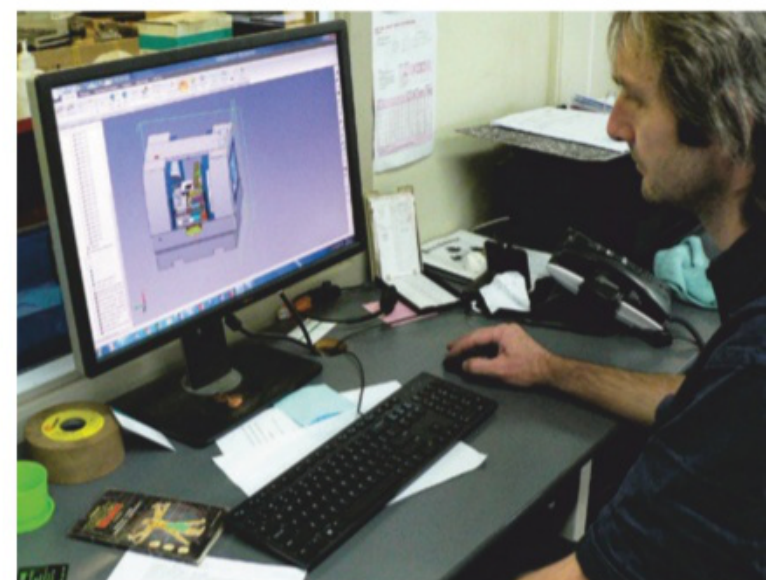
jam the drill. The core is the centre of the drill, untouched by the flute-grinding operation. This gives the drill its strength: the thicker the core, the less likely the drill is to break. Small-diameter twist drills are relatively easy to break so they tend to have shallow flutes, which result in a comparatively large core, making them as strong as possible.



Robots placing the finished twist drills into plastic sleeves



A drill-making machine in full cry. The observation window is almost completely obscured by grinding oil. The oil is delivered by the tubes above the machines



Richard Frew at work on drill-making-machinery design

under the direction of engineering manager Glenn Morgan. Richard Frew is chief designer. The engineers use Alibre 3D solid-modelling software, which is highly regarded, despite it being reasonably inexpensive. The machines' components are produced by Christchurch engineering companies such as Tatom Engineering.

The electronic control systems are the work of Anca Motion, a division of Anca, a large Australian manufacturer of CNC tool and cutter grinders. The

chassis of the machines are assembled with a polymer concrete and steel base. It has been found that hand scraping is needed to get a base that is sufficiently flat to make a machine which can produce drill bits with an accuracy of plus or minus $\frac{1}{100}$ of a millimetre. Milling machines flatten the steel base as far as possible and then an engineer spends three days of very hard work with a granite surface plate, engineer's blue, and a scraper to make it completely flat. The large and complex machined

components are assembled on the base, the sheet-metal case supplied by Jericho Walker Sheetmetal Engineering is fitted, and the electronic control system installed. The engineers have made 30 of these machines; the ones that they are currently working on are the third generation of the evolving design. The drill-making machines are made not only for the Sutton Tools factories, but also for outside customers, with one set to be exhibited at a trade fair in China in the near future.

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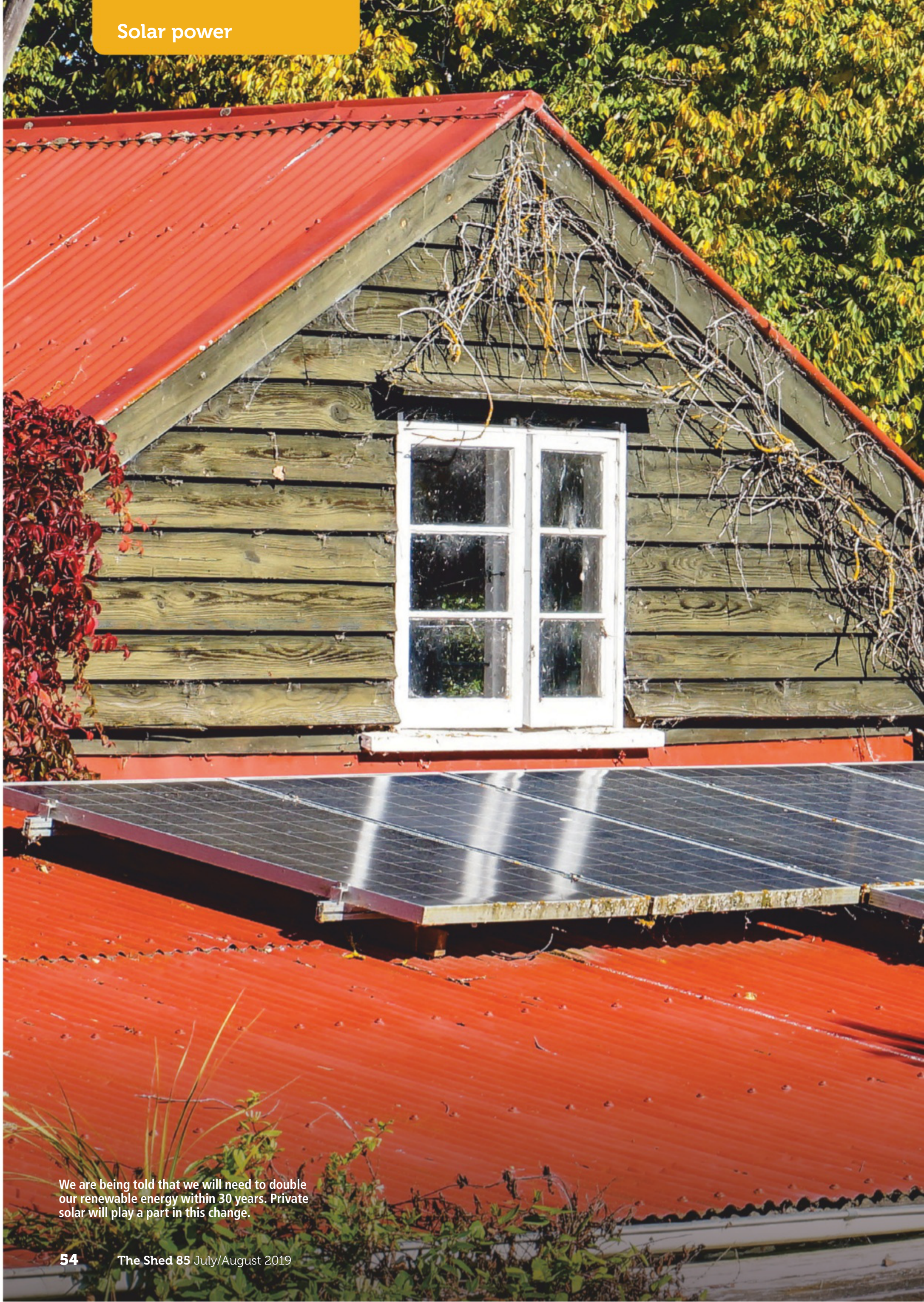
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We are being told that we will need to double our renewable energy within 30 years. Private solar will play a part in this change.

GO SOLAR

LEGEND HAS IT THAT THOMAS EDISON TOLD HIS FRIENDS HENRY FORD AND HARVEY FIRESTONE, "I'D PUT MY MONEY ON THE SUN AND SOLAR ENERGY. WHAT A SOURCE OF POWER! I HOPE WE DON'T HAVE TO WAIT UNTIL OIL AND COAL RUN OUT BEFORE WE TACKLE THAT." HE'D SHAKE HIS HEAD AT HOW LONG WE'VE TAKEN

By Murray Grimwood
Photographs: Murray Grimwood



An iconic roof-mounted array on a repurposed old church, familiar to anyone who travels State Highway 1 north of Dunedin



Tile roofs present no mounting problem



Walking the talk: Blueskin Energy HQ, suitably self-sufficient



These four 80W panels have powered a compact 230V home for many years

All the energy we use is solar in origin. Wind and hydro, food, firewood, and fossil fuels (coal being old trees; oil and gas being old oceanic plants and animals) can all be traced back to the sun. One canny commentator coined the phrase “sunlit acreage” and referred to fossil fuels as “down acreage”. The sunlight landing on our own acreages, properly harnessed, can displace the need to buy-in external ‘acreage’. The choices for private capture of solar energy are gardening, passive solar housing, and the two we investigate here: water heating and electricity generation.

A doubling is coming

Although we all dream of not having a power bill, the practical reality is that most

New Zealanders are grid tied and are better staying that way. Our grid is 80 per cent renewably generated and a hydro lake is a relatively benign battery. But change is afoot; there are clear indications that we will attempt to displace fossil fuels (60 per cent of our total energy mix) faster than their physical depletion would force us to abandon them anyway. While biofuels will be a minor contributor, estimations by the Productivity Commission, the University of Canterbury, and others, tell us that we will need to double our renewable electricity generation within 30 years. That’s massive, and it’s hard to see electricity getting cheaper during the build.

Addressing this change, Transpower

is expecting to be “an intermittent back-up to local generation” by 2050. They’re talking about wind and private solar (6GW and 5GW respectively, along with 2GW of geothermal). Wind can be neighbour-annoying, and geothermal is beyond private development, leaving us with the solar option. The good news is that solar photovoltaic (PV) panels are now cheap enough to reduce your power bill and insulate you from future energy trends.

Energy is money

Most evaluations of whether solar panels are economic, assume that the current cost of electricity will persist. They then arrive at a ‘payback time’ (typically 14–25 years) and many people decide that



Above and left: Clever use of an array, doubling as a veranda



*We will need to double
our renewable electricity
generation within 30 years*

it's not worth their while. The money-energy relationship is not what most people assume, though. Money is loaned into existence at a computer keystroke and those loans are then spent through the system. That debt has to be paid back with interest, meaning an ever-greater amount of work will have to be done in the future. And work requires energy. So future energy underwrites money (we can verify this by working it backwards: if there were no items available for future purchase, what would money be worth?). Given that fossil energy is becoming ever harder to obtain (a reducing energy return on energy invested — 'EROEI' for short) and that the remainder is becoming ever more competed for, having our own energy source is one of the better forward bets that we can make. Call it insurance. Call it money in the bank.

Solar panels

Ninety per cent of PV panels are made of crystalline silicon. The silicon is rated by purity, which really means the efficiency with which it converts sunlight to electron shifting.

'Monocrystalline', 'polycrystalline', and 'thin film' are the delineations you will hear about most often. Monocrystalline are the most efficient, the most expensive, the longest lived, and the most polluting in their manufacture (four-fifths of the material becomes waste). While monocrystalline are wafer-cut, polycrystalline panels are created by being poured into a mould, hence are more cheaply produced. Thin-film panels have the advantage of bendability. All panels will degrade

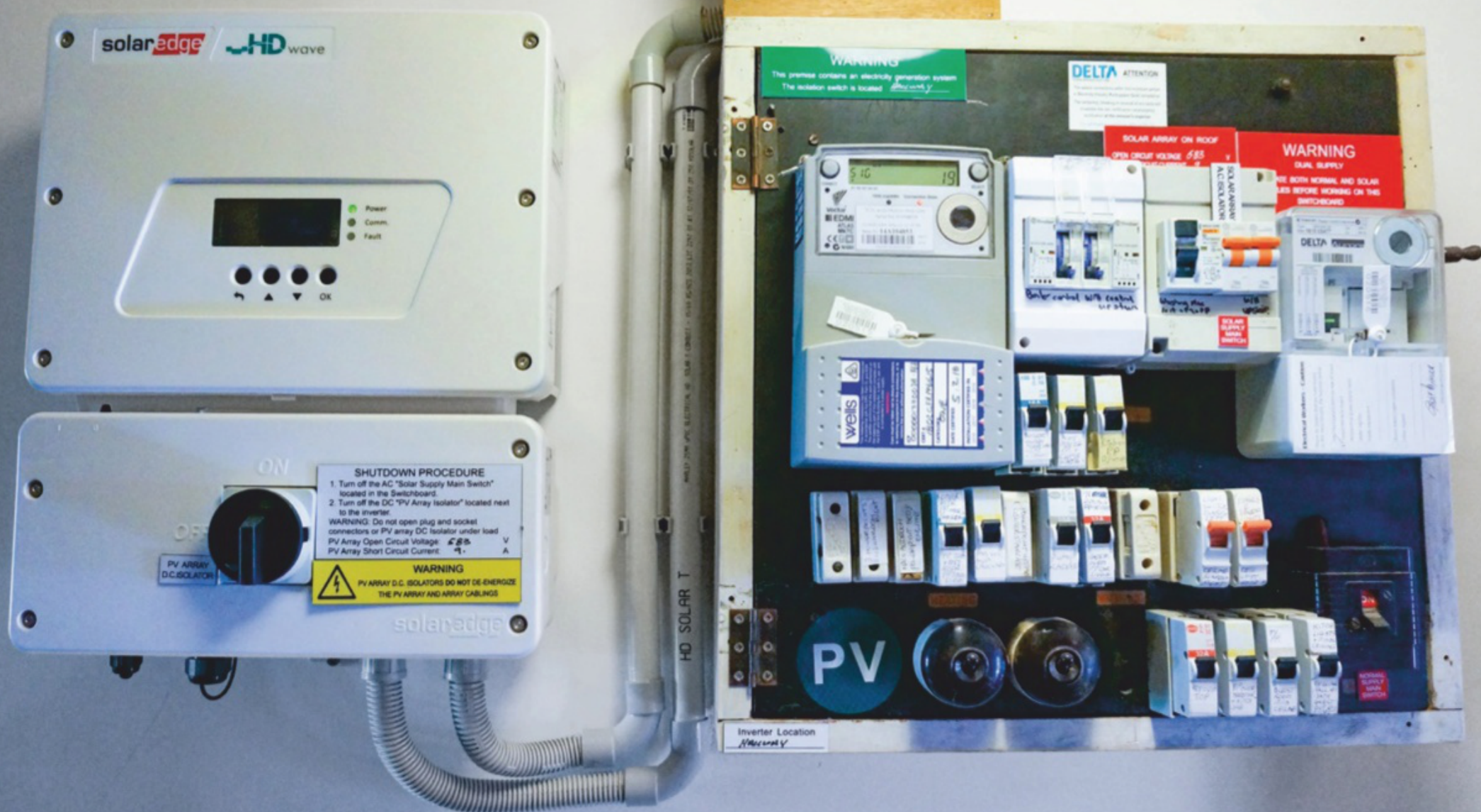
with time; some mention two per cent per year, others cite 80 per cent efficiency after 20 or 25 years. The efficiency difference is not huge: polycrystalline are 13–16 per cent efficient; monocrystalline claim 15–20 per cent.

You may hear people speaking of 'Tier 1', '2', or '3' panels. According to Solar Reviews (solarreviews.com):

"Generally speaking Tier 1 solar panel manufacturers are defined as those that: ►



Pole-mounted array on a difficult site



A tidy grid-tied connection. Inverter is on the left

- Have been producing solar panels for 5 years or more;
- Are either publicly listed on a stock exchange or have a strong and stable balance sheet;
- Have fully automated production and a high degree of vertical integration
- Invest significantly in marketing their brand.”

Tier 1 are typically 10–30 per cent

more expensive than Tier 2 or 3 — essentially there is more likelihood that the panels will last and that the company will be around to honour its guarantee.

At the end of the day, cost, longevity, and environmental damage in production are our decision drivers. The reason that panels coming out of China are cheaper is that the US and Germany have pollution controls.

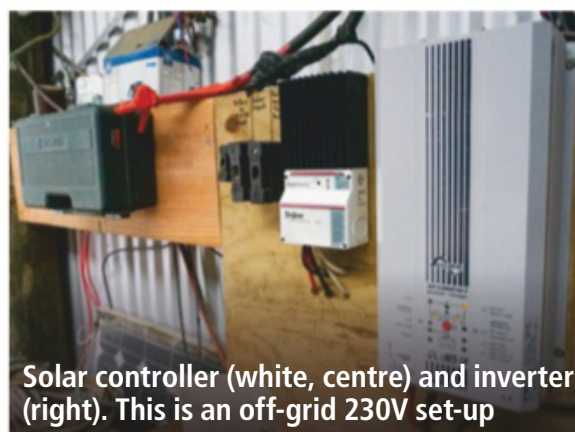
Panel placement

Ground-sited panels are more easily cleaned and accessed — and less wind susceptible — but many urbanites will be confined to roof mounting for space and shading reasons. Panels should face as near to the north as is practicable. A minimum of a 10-degree slope will ensure rain run-off: the more that you tilt your panels beyond that, the more they will be optimized for those least-sun winter days (the midwinter midday sun is a mere 22 degrees above the horizon in southern New Zealand). According to one installer, the best tilt angles in New Zealand are between 23 and 36 degrees in summer and 51 and 61 degrees in winter.

Other considerations are local sun-blockers. If there is a hill to the east of you, your sunlit traverse may be biased to the west (more afternoon sun). Some of us live in coastal areas where the mornings are clear but the afternoons get cloudy — good reason to bias our arrays to the east. Niwa has a useful calculator — solarview.niwa.co.nz — to help you work out your property’s potential.



A solar controller; this one runs a 5kW array



Solar controller (white, centre) and inverter (right). This is an off-grid 230V set-up



Grid-tied inverter — this one handles the pole array pictured on [pages 53 and 56](#)

The good news is that solar photovoltaic (PV) panels are now cheap enough to reduce your power bill

Storage

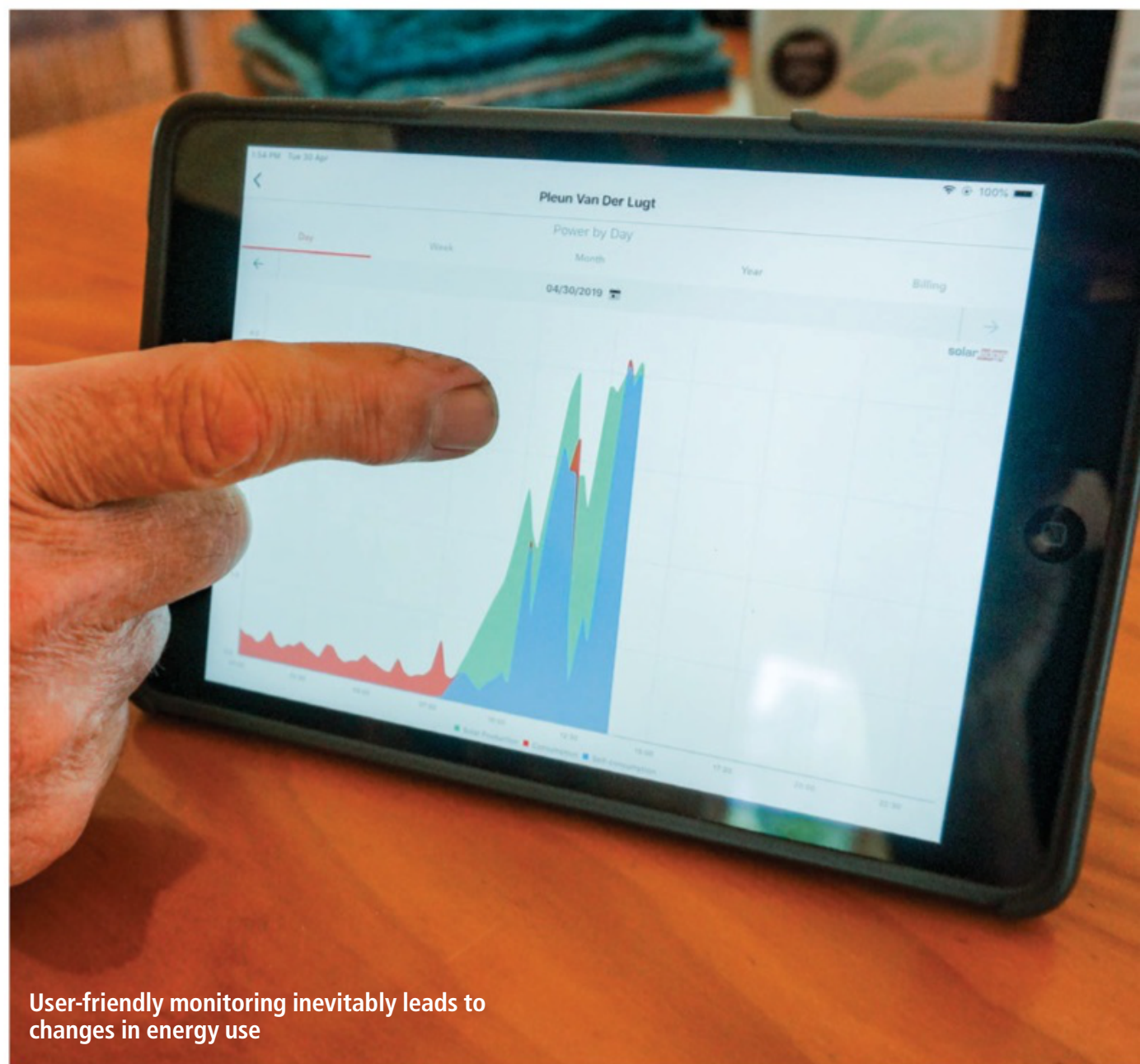
We are one of the very few countries where electricity storage is not a headache. Every time a grid-tied person uses their self-generated power, some litres stay in a hydro lake rather than careening through a generator. Think of those still-stored litres as money still in the bank. If enough people generate some proportion of their own power, the need to build extra generation plants and lines infrastructure is negated.

Water is also one of the most versatile ways to store and shift solar energy at home. Our hot-water cylinders are the first 'battery' to contemplate. Water heating is usually the biggest household electricity load and we can displace this with solar-derived energy. Traditionally this has been via roof-mounted water heating, but for the last few years PV panels have arguably been the cheaper option. Their upsides are their lack of weight, their lack of frost susceptibility, and the avoidance of pumps. Their downside is that they require more area (which for most people means roof area) per kilowatt produced.

Dual elements are available, so your cylinder can stay grid-connected for those sunless days, the beauty of this being that you don't need the complication of grid-tying your solar, thus avoiding contractual agreements with a power company. Safe thermostatic switching of this much grunt (off, to avoid boiling your water) needs to be left to the professionals.

Solar-heated water can also be stored for evening release through underfloor heating or radiators, although it makes more sense to explore passive solar options (more north-facing windows, for instance, extra insulation, or creating some sunlit thermal mass) before opting for such active systems.

Ownership of an electric vehicle (EV) opens up the interesting option of using



User-friendly monitoring inevitably leads to changes in energy use

the car battery as a solar storage and/or backup home-power device, but for many that will be counterproductive — just when the sun is shining most, their car will be away at work.

For those wanting cheap battery storage, there is a host of outfits keeping batteries (usually deep cycle, which is what we want) as backups in case of a power cut. Substations, mobile-phone towers, university labs, and data storers all have batteries, and they replace them on a protocol basis. These batteries have been discharged few, if any, times and can often be obtained for little more than scrap value. Ask around.

Grid tied

Beyond a separate PV-to-hot-water system, grid tied is the next logical step for most people. Grid-tied inverters are a mature technology, tricking-up 230V AC and phase locking it with the grid's 50Hz.

Gone are the days of a 1:1 payback — power companies have seen this groundswell coming and have disincentivized private generation, a rational move in business terms. At some

point though, local generators will grow to the point at which they will have collective negotiating muscle, and payback may increase. Government may regulate to hasten the rate of solar uptake too.

The downside of grid-tied systems is that they are no use in a power cut. Grid-tied inverters automatically disconnect to save the fault-fixing linesman from getting zapped with your power coming down the line. Currently it's not worth maintaining a bank of batteries (given the price of portable generators and the availability of fossil fuels) to cover such a rare event, but the option is always there. ►

Regulations

These are the regulations your PV system needs to comply with:

- AS NZS 3000: New Zealand wiring rules or regs
- AS NZS 4509: Stand-alone power systems
- AS NZS 4777: Grid-connected power systems
- AS NZS 5033: Installation and safety of PV solar arrays



Underside of pole array — note the ability to tilt and rotate

Power companies have seen this groundswell coming and have disincentivized private generation

Off grid

If you're building some distance from the grid (and it doesn't need to be very far), then off grid stacks up.

There are two common levels of approach: the frugal, low voltage, minimalist one, and the 'normal house' one. Both require self-discipline and an adaptive attitude. If the sun is shining you do the washing (it's more likely to dry on the line, anyway) and if it's not, you leave it until tomorrow. Unused lights and appliances get turned off, by everybody, and all the time. Voltage and amp-hour meters are read as often as car drivers read fuel gauges, and for the same reason. Many failed off-grid attempts can be traced to one or more of the occupants being unwilling to live within limits.

A normal house system will run from 3–10kW of solar PV, with large 48V battery banks. Expect to pay \$40K to \$80K for such systems. The batteries are the consumable item, and reward careful maintenance. These systems need to be installed by a qualified electrician, but you're best finding one who has experience in off-grid installations. It pays, too, to

question others who have gone before you and to define exactly what you want before laying down your money.

Low voltage systems can be owner-built, if they're below 50V DC. The caveat is that switching/arcing of low voltage DC can be more dangerous than switching 230V AC; indeed (as their initial champion Edison could have ruefully told us) DC has a lot of downsides and failed as a grid-distribution format for good reason. Low voltage systems need thicker cabling, given that volts are lost in transit and you're not starting with many (a good example of this is the thick cable from a car battery to the starter).

Commercial generation

Group ownership of remote solar generation is already viable (if they can do it in land-scarce Germany, we can do it here). Just as wind turbines are best placed in the windiest sites, solar is best placed in the sunniest. Why not a few acres of solar in Central Otago, somewhere near an existing distribution feed? At commercial scale, it need not be PV panels either — sun-tracking mirrors,

focused on a boiler driving a turbine, is proven technology too, and well within the capability of New Zealanders to build in-house. If a group of people can keep Pupu running (en.wikipedia.org/wiki/Pupu_Hydro_Power_Scheme) there's no reason others can't do something similar.

Peer-to-peer trading

Peer-to-peer trading is in its infancy. Outfits like [emhTrade.com](https://emhtrade.com) are beginning to facilitate the virtual connection of solar-panel owners, with particular users. The link isn't physical — it's just the grid — but the buyer can only use the energy when the sun is on the seller's panels. This makes sense in close localities (one prototype is the Blueskin Energy Network in Blueskin Bay, Otago) and has the potential to alter national peak-load profiles substantially. We can presume that the lines companies and Transpower will look to charge or limit this activity (the way formal accommodation businesses are currently trying to repress Airbnb). Watch this space: ben.p2power.co.nz/.

Conclusion

The world is changing. Out ahead of the pack, Elon Musk and Tesla are creating advanced batteries and solar-powered factories producing solar panels. They are the innovators. Slightly behind are the early adopters: people who realize that this is the path we will end up treading. Next will come the early majority, after which there is 50 per cent penetration (laggards come where you'd expect — last!). We are currently entering the early majority stage. The installation of seriously sized solar requires a qualified electrician, but the average sheddie can be a useful assistant. Energy is the driver of all real wealth, and all indications are that it will be in increasing demand. Having our own just makes sense. 📌

Online references

Niwa calculator: solarview.niwa.co.nz/
Pupu Hydro Scheme: en.wikipedia.org/wiki/Pupu_Hydro_Power_Scheme
Blueskin Energy Network: ben.p2power.co.nz/



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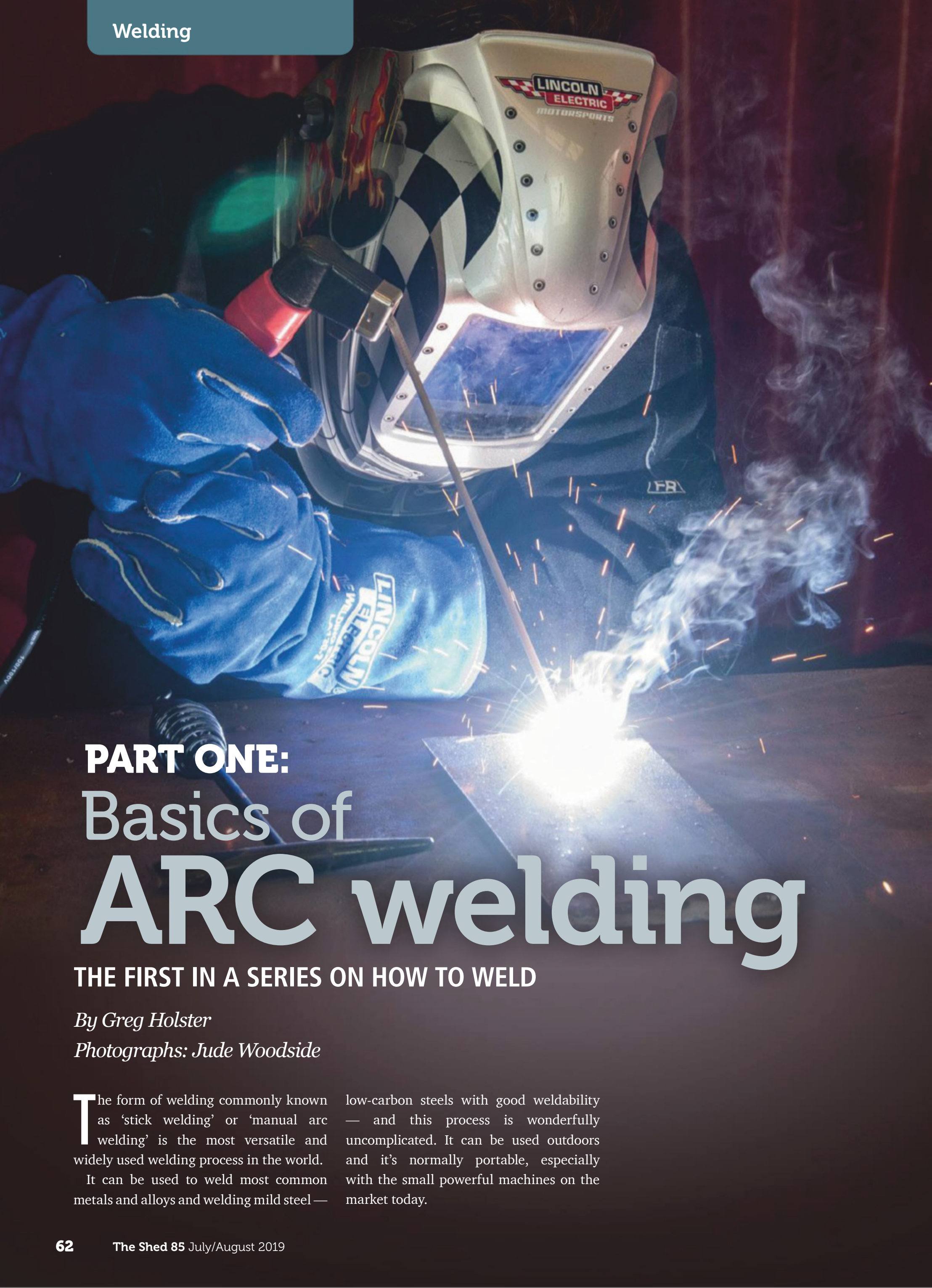
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PART ONE: Basics of ARC welding

THE FIRST IN A SERIES ON HOW TO WELD

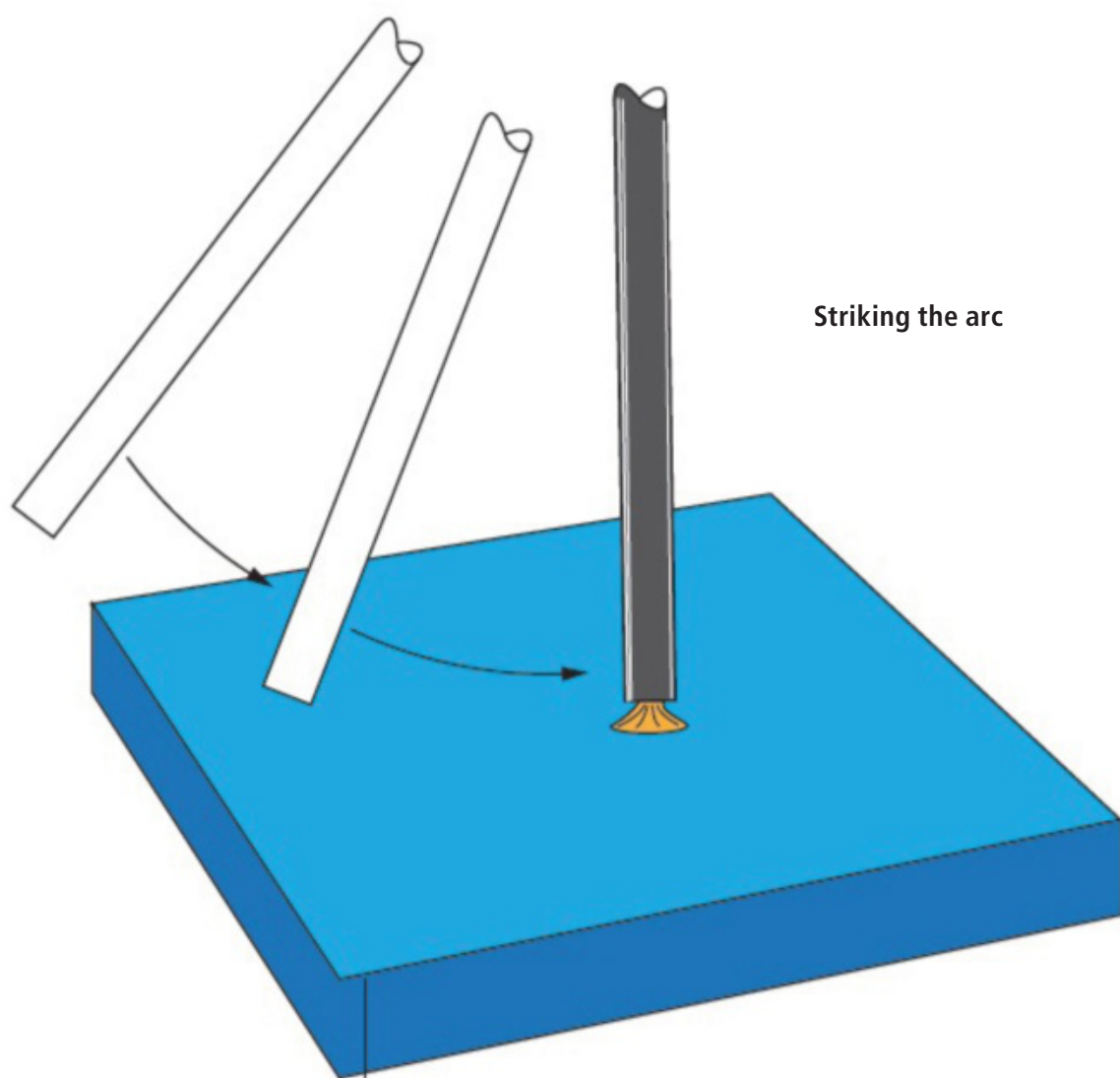
By Greg Holster

Photographs: Jude Woodside

The form of welding commonly known as ‘stick welding’ or ‘manual arc welding’ is the most versatile and widely used welding process in the world.

It can be used to weld most common metals and alloys and welding mild steel —

low-carbon steels with good weldability — and this process is wonderfully uncomplicated. It can be used outdoors and it’s normally portable, especially with the small powerful machines on the market today.



A complete welding set was first made by the Lincoln brothers in 1909 and in 1911 Lincoln Electric introduced for sale the first variable-voltage, single-operator, portable welding machine. The world of welding machines has changed since then yet the basics and the techniques remain very much the same.

Arc welding over the past few years has had a resurgence. It's very cost-efficient as well as simple to do once the basics are mastered. Successful arc welding is essentially about good position (it comes with practice) and choosing the best of many types of electrodes to suit a multitude of base materials and uses.

For this article on arc welding — more correctly, shielded metal arc welding (SMAW) or manual metal arc welding (MMAW) — I am dealing with the basics.

Many people ask me what they are doing wrong when arc welding but most problems they encounter are all related to things not being set up properly or being ignored.

How it works

The current flows from the machine or power source through the electrode cable to the electrode holder in the handpiece, down through the electrode, and across the arc to the base metal. This commonly is the positive side.

On the work side of the arc, the current

flows through the base material to the work clamp and back to the welding machine. This is usually the negative or earth side.

An arc occurs when the electrode comes in contact with the workpiece and completes the circuit ... like turning on a light. This electric arc between the end

of the electrode and the work reaches temperatures around 5500°C, which melts both the electrode and base metal.

Electrode

The electrode, with an inner core rod and a flux coating, carries the welding current and then becomes part of the weld. ►

Most problems they encounter are all related to things not being set up properly or being ignored

Terms

Some general terms you will come across in welding:

Bead or weld bead: A weld resulting from passing the welding electrode over metal.

Butt weld: A weld joining two pieces of metal butting up to each other in approximately the same plane.

Fillet weld: A weld joining two surfaces at right angles.

Fusion: The melting together of parent metal and welding electrode. The 'depth of fusion' is the distance that fusion extends into the base metal or previous bead from the

surface melted during welding.

Lap joint: Joint where metal pieces overlap.

Penetration: Also known as 'joint penetration' or 'root penetration', how far the weld metal extends into the metal joint itself.

Porosity: Holes inside a weld formed by gas trapped as the metal solidified.

Spatter: Surplus metal particles or drops scattered around outside the weld.

Weld pool: The molten metal in a weld before it solidifies.

The flux melting forms a shielding gas that prevents oxidization and porosity in the weld pool. Without this shield, we would end up with a very brittle weld-metal matrix. Chemicals can be added to the flux to enhance tensile strength, ductility, and user appeal.

As the core rod, flux coating, and workpieces heat up and melt, they form a pool of molten material referred to as a 'weld puddle' or 'weld pool'. The weld pool is what a welder watches and manipulates while welding.

Slag

'Slag' is a combination of the flux coating and impurities from the base metal that float to the surface of the weld. Slag quickly solidifies to form a solid coating, a bit like a mini lava flow.

Slag also slows the cooling rate of the weld while also inhibiting surface oxidization.

Once the slag has solidified, you can chip it away and clean the weld with a wire brush. Sometimes it will peel off by itself, but if it looks a bit like bird poo it's not going to be too easy to chip. How easy it is to chip depends on how smooth or rough your finished weld is. Often it's harder to obtain a good slag release from the higher tensile or more specialized electrodes. With standard, general-purpose Easyarc-style electrodes, a half-decent weld should be easy enough to chip.

Power

Selecting the correct amperage depends on electrode size and the size and thickness of the material. Thin metals require less current than thicker sections and small-diameter electrodes require less power also.

Depending on the accuracy of your machine, these settings will give you a reasonable start for a bead on a flat plate:

- 2.5mm thick = 85A
- 3.2mm thick = 120A
- 4mm thick = 150A.

If you can weld in the flat or horizontal position it will make welding a lot easier. I have a rule of thumb that for vertical-up welding, drop the amps down 10-15A; for vertical down, go up 15-20A.



Practice weld beads



Poor bead and spatter from too-high amps and too-long arc

Striking an arc

This is the part that frustrates most learners. An arc is started and maintained when the welding current is forced across a gap between the stick electrode and the base metal. But often it doesn't start; it just sticks to the plate.

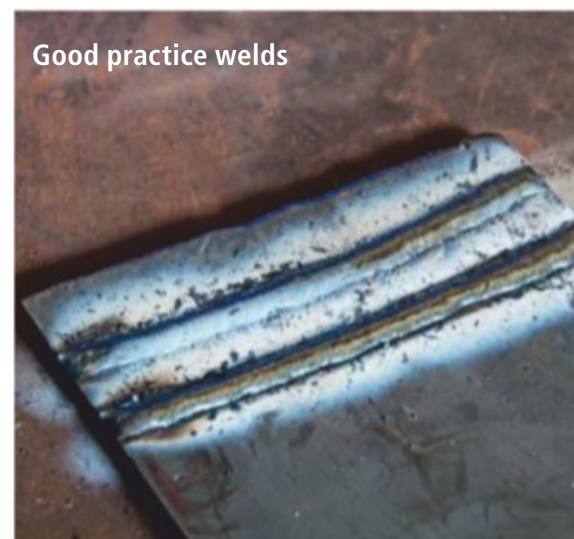
There are basically two methods of striking an arc using a non-voltage reduction device (VRD) machine:

- scratching, and
- tapping.

Be sure to have your helmet on and face shield down first. The 'scratch' start method is generally considered easier for beginners and when using some of the older AC machines. It's a bit like striking a large match or swiping a smartphone.



Chipping off slag with hammer



Good practice welds

A sudden burst of light will be produced on contact with the plate. Use this burst of light to get your direction and start position. In the 'tap' start method, the electrode is moved downwards to the base metal in a vertical direction. The problem with this is 'sticking', or 'freezing'. This is when the electrode fuses to the plate.

You can just about guarantee that you will lift up your shield just in time to flash yourself as the rod breaks loose. So, with your shield down, tap and pull up, as once again the burst of light will show you the way. When restarting half-way through a weld, check the end of the electrode. You

will notice the central rod will have burnt back up inside the flux, leaving a cone-shaped crater. With your glove on, break this flux off until the metal is showing. For the novice I would recommend the scratch technique for a restart.

Machines

Constant-current (CC) power sources are used in the manual arc welding process. A CC power source is one in which current or amperage remains constant even as changes in welding voltage occur with changes in 'arc length', the distance between the plate and the tip of the electrode. CC welding



Cone formed in used electrode

About to strike an arc. Note supported position



machines are either AC, DC, or AC/DC. Welding polarity will depend on the polarity of the electrode (written on the packet) or the limitations of the welding power source.

The popular multiprocess or three-in-one welding machines can perform many different welding processes (i.e., stick, TIG, and MIG). The stick and ►

Safety

Not all helmets are created equal. You invariably get what you pay for. But, whatever you use make sure you can see properly. Auto-darkening helmets are pretty much standard nowadays. These helmets darken instantly once the arc is struck and before the flash can do any harm to your eyes. They are an investment well worth the cost. You will also need safe, proper clothing,

such as sturdy welding gloves. A leather-welding apron is a useful investment if you plan to do a lot of welding. Don't try welding in your thongs/jandals or in shorts — you don't really know the meaning of a hot foot until you get a drop of molten weld metal between your toes. Burns from sparks on exposed skin are



common, and UV radiation burns from the welding arc, like severe sunburn, are guaranteed on bare skin.

TIG modes are CC. The Powercraft 180i (I used a 160 here) is a great example of this three-in-one aspect.

Bead

The 'bead' of the weld is a continuous deposit of weld metal formed by the arc on the surface of the base metal, creating a fused mixture of base-material and filler-metal chemistry. A smooth,

uniform weld bead in arc welding involves moving the electrode along the plate at the correct speed while hopefully achieving adequate penetration.

Notice how the arc digs into the base metal for penetration, how it fills the crater and builds up the bead shape.

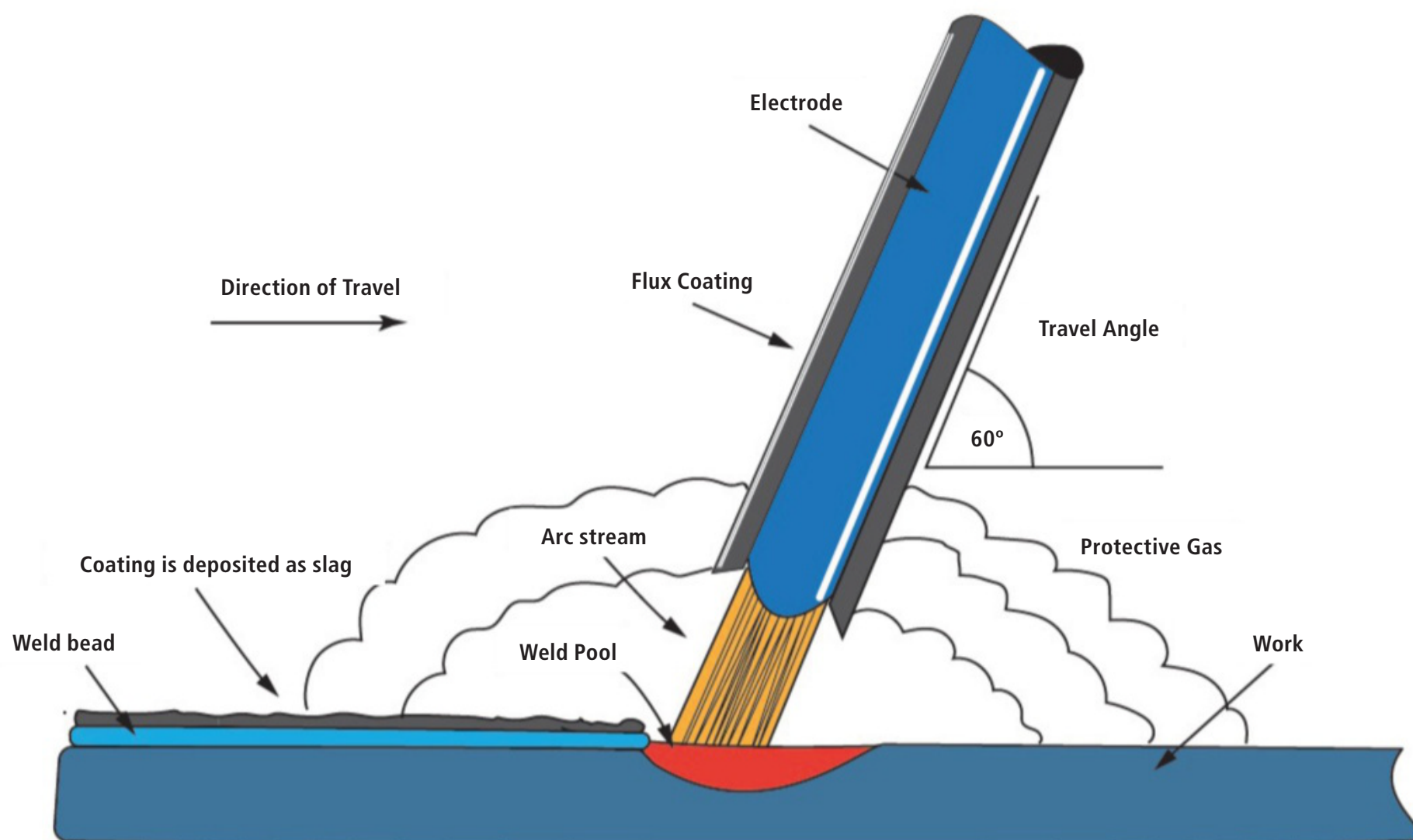
Practice will help you recognize the character of the slag and a good or bad bead while you are actually welding it.

Keep your eye on the back of the weld pool as the arc transfers the weld deposit and builds up the bead. You can then vary the arc length, electrode angle, or travel speed to correct a poor weld-pool appearance. A good arc length, which comes with practice, should be slightly less than the diameter of the electrode, usually around 1.5 to 3mm. If the arc length is too long you will notice an increase in spatter, matched with a hissing, spitting sound, not the nice, soft, even crackle that you should hear. Penetration will be poor, you may have undercut, and the slag will more than likely be difficult to remove. We have all suffered that problem.

Too higher amps can do this too. So don't be afraid to come down a bit if needed.

Travel speed

Travel speed affects the shape of the weld bead. Too fast and the bead will be thin and stringy, matched with poor penetration. Too slow and the weld metal will build up and roll over with an excessive overlap. Getting it just right is a matter of practice. Excess weld metal usually means excess heat. Excess heat, particularly on thinner materials, can make the parent material brittle and weak. ►



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Setting the amps

Power/Amps

Setting the correct amperage for any given electrode size or type is important to achieve an ideal bead shape, good penetration, and a minimum of spatter.

- A higher amperage setting results in a flat bead with an excessive amount of spatter, not to mention the possibility of porosity and the electrode becoming greatly overheated.
- An amperage setting that is too low will make striking the arc and maintaining a correct arc length more difficult. Low amperage settings also cause the weld metal to pile up into a rounded bead with excessive overlap and poor penetration. Often the electrode will also stick, or freeze, as the slag will envelop the arc.

Amperage settings on the electrode packets are often vague. A 3.2mm general-purpose electrode might have 80–140A indicated on the packet — a

big variation. Normally a down-hand fillet weld with a 3.2mm general-purpose-style rod will be in the vicinity of 120–125A, electrodes for vertical up 105–110A, and for vertical down 120–140A. Every brand is different so take the guesswork out by running the rod on a practice piece first. Buy decent electrodes and you might find you can weld better than you thought.

For example, the Easyarc 6012 and 6013 are fast-solidifying mild-steel electrodes. Great for fast welding on thin and sheet metals. They are also ideal for welding on dirty, rusty, greasy, or painted steel.

Good practice says clean your base material first. No manufacturer's specs on the packet allow for impurities. If dirt increased the tensile strength of weld metal, everybody would ignore it. But the cleaner the metal the better; it means that the flux won't have to work so hard.

Product spotlight

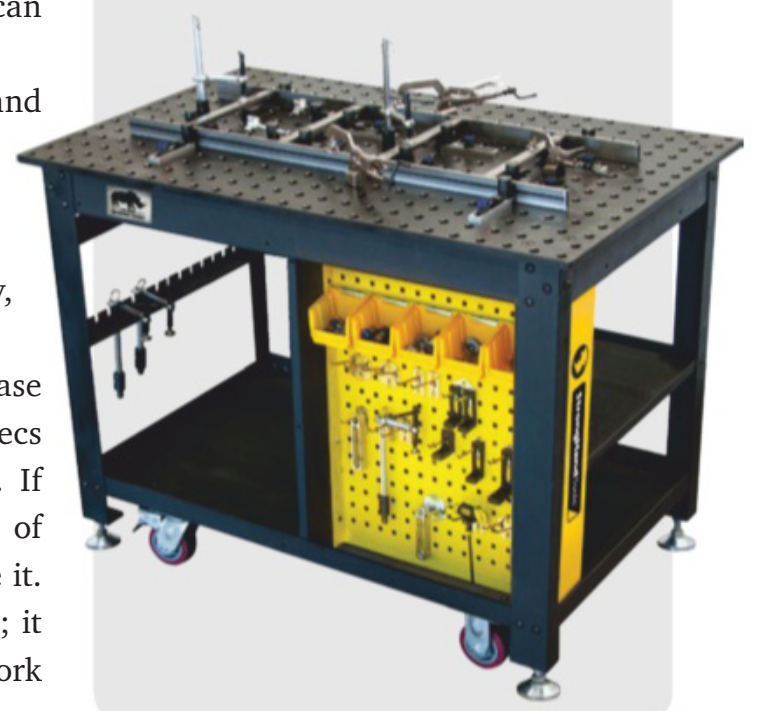
If you are going to weld something, and especially if you want repeatability, you owe it to yourself to get a Rhino Cart TDQ612075-K1 modular fixturing station.

This US-made welding table is special because of its system of stops, locks, chocks, and clamps that make it easy to fix and hold workpieces while you weld.

The 16mm thick, spatter-resistant reversible tabletop measures 1200x750mm and sits on a rolling chassis equipped with locking castors, which has room for your welder as well as the rack of attachments. The tabletop is drilled with 16mm holes at 50mm spacing into which you drop smooth-sided locating pins that are locked in place with a twist-top that pushes out locking steel balls under the table. They are secured with a hex key. Clamps and wedges then secure the workpiece in place, nicely elevated so that you don't accidentally weld it to the table.

The Rhino Cart package comes with a 66-piece fixturing kit suitable for grabbing hold of all kinds of flat, angled, round, and bent stock. If you need more complicated help, the Rhino Cart system is compatible with all Buildpro clamping kits.

The Rhino Cart is on special now at participating retailers nationwide for \$5405. For more information, email sales@isl.nz.



“Buy decent electrodes
and you might find
you can weld better
than you thought”

Penetration

Just a quick note on penetration. Usually you will notice the arc digging into the base plate. If you are not sure how much penetration you are getting, do a short weld 25–35mm and break it open in the vice. If the toe of the weld has fused, penetration has been achieved.

How to

To start, position your workpiece flat on a metal tabletop or plate and attach the clamp securely to the work (metal) or table. A good earth is important. Check the condition of the clamp and fittings. Set the polarity and amperage on the machine: DC+ (negative earth), say 110–115A for the E6013 electrode. Place the bare end of the electrode in the holder so that it is gripped securely at a 90-degree angle to the jaws. ►



Interior controls for helmet



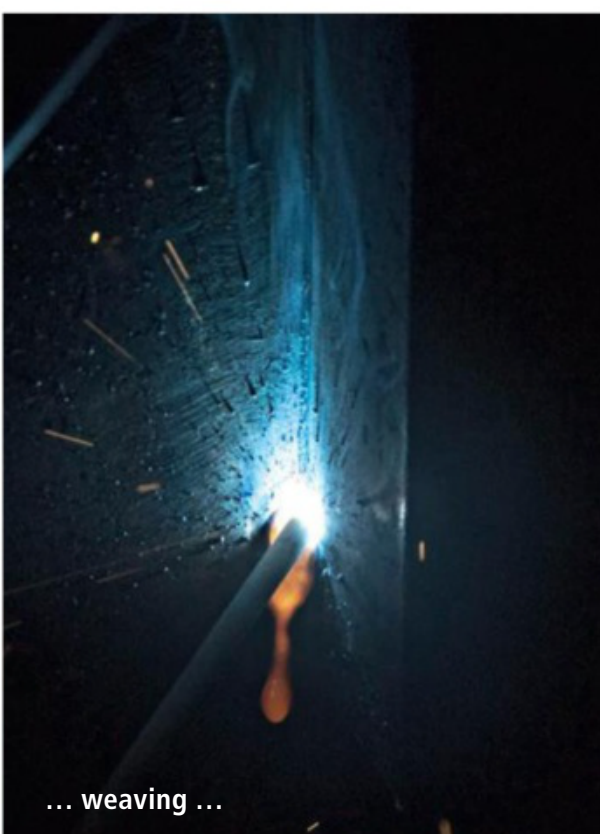
Cleaning ...



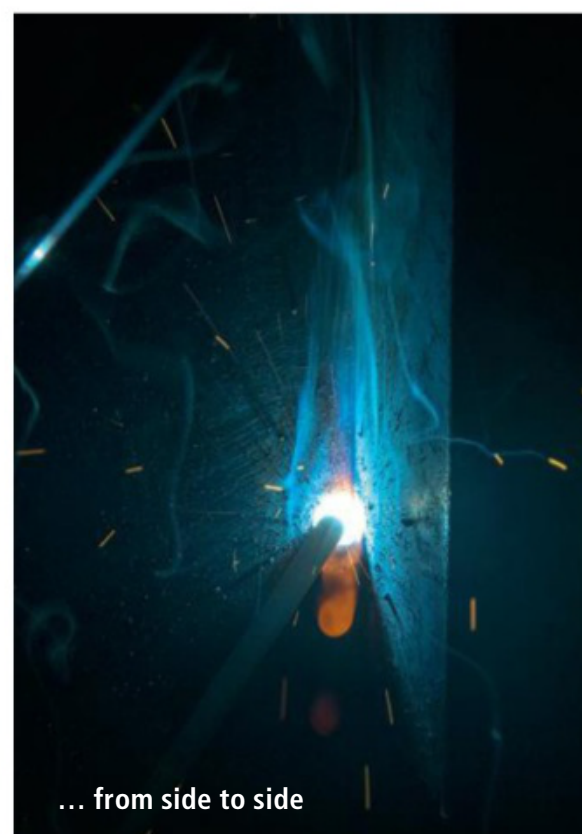
... good fillet weld



Vertical welding ...



... weaving ...



... from side to side

Don't forget to turn the welder *on*. Make sure you are comfortable; get yourself into a natural position and grasp the electrode holder firmly but comfortably by using either one or both hands. Using both hands helps to steady electrode and reduce fatigue. To use both hands (as I do), rest your left elbow on work table and, with the left hand, steady the right hand by holding the right wrist. The opposite if you are left-handed.

Move the electrode down until it is about 25mm above the metal plate, vertical to the plate, inclined at an angle of 65–70 degrees in the direction of travel.

Place the shield down in front of your eyes — you may ask why I've bothered to mention this: once you have flashed yourself a few times, you will know why. Strike the arc using the scratch method. A sudden burst of light will be produced on contact with the plate.

Prepare

A good exercise is to get yourself a decent piece of plate, flat bar, tube, or angle iron, etc. Not too small if possible.

Alert: the more you practise, the hotter your weld piece becomes and this affects your amperage settings.

Clean the base material by brushing the metal free of dirt and scale.

Set your machine to 110–115A, which will probably be a bit on the hot side, depending on the type of machine



Vertical weld



Weld pool

you have, your power supply, and how accurate the dial/power indicator is. We can always drop the power back if our arc is too fierce.

Get a 3.2mm 6012 or 6013 electrode, strike your arc using the scratch start method, pull a long arc length for a second or two (6–10mm). This will help you get your bearings and avoids sticking or freezing.

Welding

Begin welding very slowly, keeping a close arc length, which as already noted is the distance the spark travels between the end of the electrode and the base metal. Hold the electrode into the corner and drag the electrode while touching the parent metal. Let the weld pool build up behind you. Slowly speed up as the rod burns away.

If you find that you are moving the electrode at a uniform speed, you will also need to make sure you are feeding the electrode into the weld pool at a constant speed as it melts. This will come naturally.

The travel angle is 60–70 degrees, give or take. Eventually you will see a nice-looking weld, with a nice bead ►

VRD

More electrical equipment is coming out with safety or hazard-reducing components and welding equipment is no exception. Most welders have had a shock and laughed about it, but it can be serious. The voltage reduction device (VRD) is to welding machines as the safety airbag is to cars. VRDs reduce the hazard of electric shock by automatically reducing the open circuit voltage (OCV) between the welding output terminals when you are not welding. Welding machines for MMAW and similar CC processes, supply a higher OCV between the electrode and the work when the welding machine is switched on and ready to commence welding. The OCV is often higher (60–100V) than when the arc is established and welding current is drawn (15–35V).

Consequently, the greatest danger occurs when handling the electrodes and the electrode holder between welding operations, such as when changing electrodes.

RESISTANCE

The VRD will reduce the no-load voltage OCV to less than 35V for DC welding and for AC welding 35V peak or 25V AC rms ('root mean square', the effective value of alternating

current) when the resistance across the output circuit is 200Ω or greater. It must operate within 0.3 seconds for DC machines with an OCV of over 113V peak.

*The actual severity of each effect will depend on such things as the physical condition of the work area, the physiological condition and resistance of the body, and the area of the body through which the current flows. You *must* consider every voltage as being dangerous.

AC 60Hz (mA)	DC (mA)	Effect*
0–1	0–4	Perception
1–4	4–15	Surprise
4–21	15–80	Reflex action
21–40	80–160	Muscular inhibition
40–100	160–300	Respiratory failure
Over 100	Over 300	Usually fatality

shape and the slag will detach more easily. This won't come straight away.

The reason I say to start out slowly is that most learners/novices tend to start off going far too fast. Stick welding is certainly not racey.

Practise starting the arc, holding it, and breaking it until it is easy to strike an arc on the first try.

Beginners often weld with a long arc length. This will produce a rough bead shape and lots of spatter. So the tighter, controlled arc length will improve your bead appearance, give a narrower, more uniform bead, and hopefully minimize spatter.

End

When finishing the weld and breaking the arc, you may find you have a small crater. Good practice at the finish is to pause for a second or two. A slight back step with the electrode (12–15mm) at the end of the weld to fill in this crater is another option. Large craters can be the cause of weld cracking.

Vertical down

Vertical-down welding using a general-purpose electrode will give you low

penetration, which is not good for welding heavy sections, but really good for thinner, sheet metals. Note, not all electrodes will run vertical down. Check the packet, as normally it will be stated here.

A fast-freezing electrode is ideal. The Easyarc 6012 and 6013 are excellent for up or down.

When welding vertical down on thin sheets, speed is important. Move as fast as possible while maintaining a continuous bead. Use currents in the higher portion of the range.

Vertical up

Anyone who has tried vertical-up welding and made a mess of it will realize by now that gravity is not your friend. Everyone does this a bit differently but ends up with a similar result. So here is my version that I know works well.

Once you have struck the arc, let the rod burn for two or three seconds to build up a shelf at the bottom of the joint. Then add layer upon layer, using a straight weave, pausing on each side for about two seconds. This will ensure penetration and proper wash-in.

Do not whip or take the electrode out

of the molten pool. Point the electrode slightly upwards so arc force assists in controlling the puddle.

Travel slowly enough to maintain the shelf without spilling. The slag will run down each side of the electrode. But you should be concentrating on the weld pool. If the weld bead looks too convex, try pausing for three seconds on the side. Don't stop in the middle. Just concentrate on the sides; the middle will take care of itself, trust me. Use currents in the lower portion of the range.

Coverings

As stated earlier, galvanizing, paint, and rust should all be removed. But for those of us who know better, try a little flick-forward technique. As you are welding, flick forwards 3–4mm every second or so, as if you were sketching with a pencil. This will burn a little bit of foreign matter as you go. This works really well on galvanizing pipe. 

Greg Holster

Greg Holster learnt to weld at the age of 12 with his father teaching him gas and stick welding. From then on he has been hooked on the fire, the arc, and molten metal that comes with this trade. He started in the mining industry in Western Australia as a boilermaker first-class welding apprentice and later gained experience in the oil and gas industry with specialized aluminium

and stainless welding thrown in. He has had long experience with welding companies since then, particularly in the area of instructing welding-machine buyers how to get the best out of their equipment. After 40-plus years in the trade, Greg still has a passion for welding and the people who use it. He currently works for Lincoln Electric.





CHOOSING THE RIGHT FUEL FOR THE JOB

Bernzomatic manufactures dependable, safe hand torches as well as propane tanks and handheld propane, MAP-Pro™ and oxygen cylinders. Choosing the right fuel—and using it safely—depends on the task you're performing and what type of hand torch you're using. The following tips can help you make the right fuel selection.

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B Butane

Ideal for light soldering or detailed work, butane gas is compatible with smaller, handheld tools such as micro torches. It is also the fuel used to power Bernzomatic utility lighters.



P Propane

Ideal for soldering copper pipes, heating frozen pipes and rusted nuts, softening paint and other lower-heat DIY and art projects, as well as for use in the kitchen. Use with a variety of torches including self-igniting and manual ignition. Pick a wide flame torch for most applications which don't need pinpoint-type heat.



M MAP-Pro

Ideal for soldering larger size copper pipes, brazing and heat-treating, MAP-Pro delivers a higher flame temperature, which allow tasks to be completed more quickly. Choose a torch specially designed to work with MAP-Pro fuel such as the TS4000 High Heat Torch or TS8000 Max Heat Torch.



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CREATING A SOFTWARE-CONTROLLED DRAWING MACHINE

By Enrico Miglino

Photographs: Enrico Miglino

IN THIS ISSUE, WE ENJOY THE MATHEMATICS OF CYCLOID CURVES TO MAKE A DRAWING MACHINE — AN EASY-TO-BUILD PROJECT TO DRAW INCREDIBLE GRAPHIC TEXTURES AND PATTERNS

A cycloid geometrical movement has a number of applications in the study of equations, as well as in mechanics, science, and other fields.

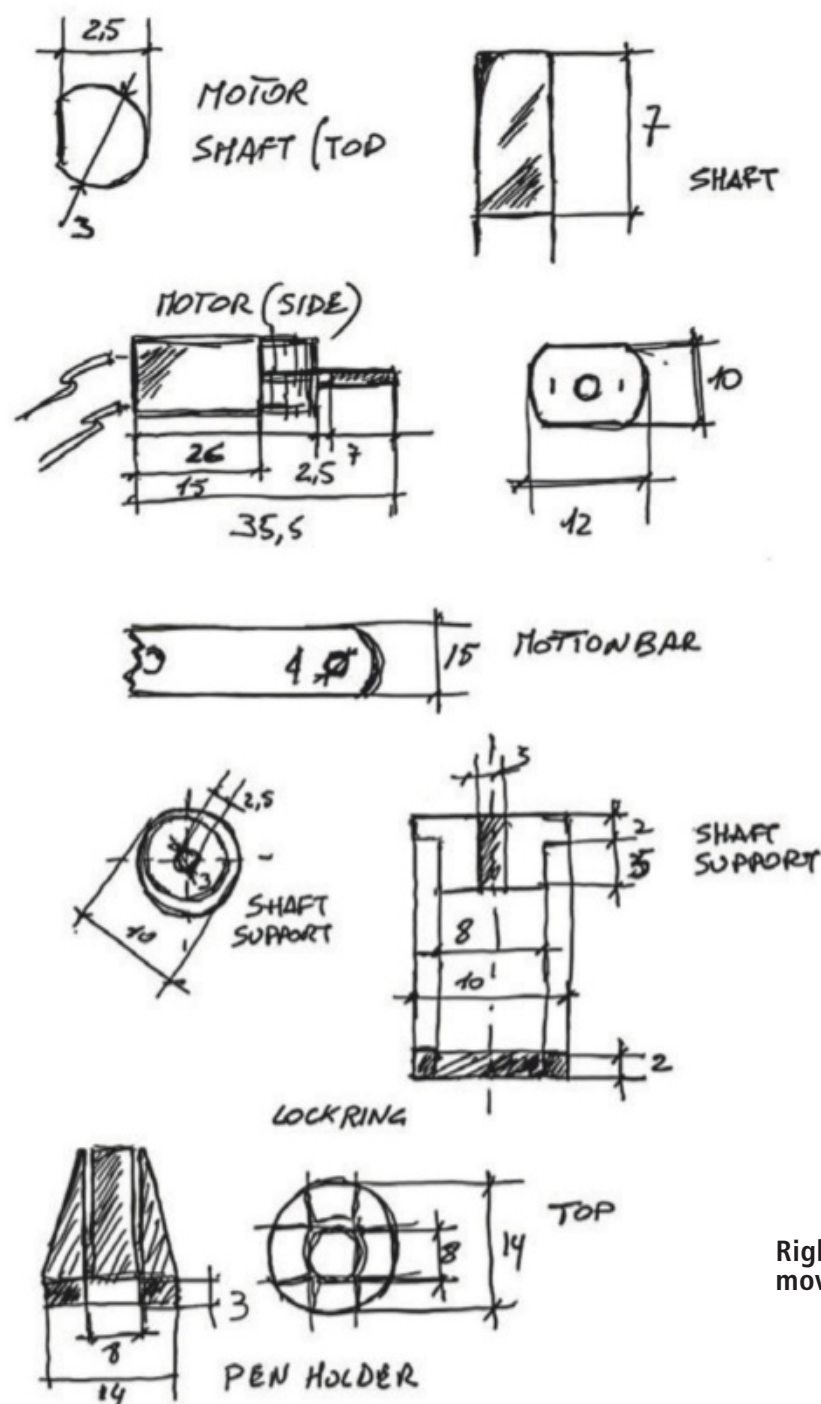
‘Cycloids’ — curves traced from a point on a circle rotating along a linear path — are involved in a number of equations in trigonometry and geometry. For example, cycloids are used in mechanics to calculate the movement and size of the gears to design gearboxes for speed reduction.

As shown in the cycloid scheme (page 73), if we ideally put a pen where the rotating point lays, it draws a series of chained arcs. Things become more interesting if we apply some constraints to the circle with the drawing point.

Suppose, for example, you add support to the rotating circle by placing the point external to its circumference — the design is more interesting than the previous scheme but is it always a series of repeated curves along a linear path.

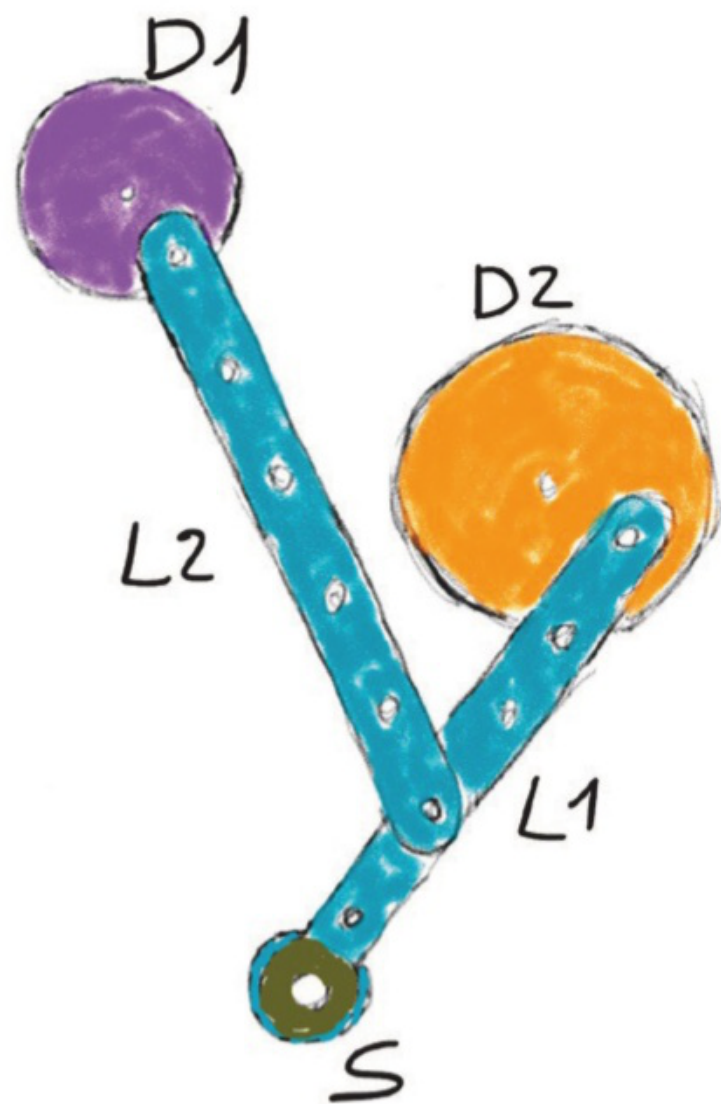
Toys from the '60s

Do you remember the Spirograph from the 1960s? When I was a child I spent hours making designs with this simple but fascinating toy. It is based on cycloid maths, where the ideal point on the circumference rotates inside a larger circle instead of a straight line; every full rotation the curve is replicated, shifted by some circular degrees, creating the drawing texture. Spirograph drawing tools are limited to creating circular drawings.

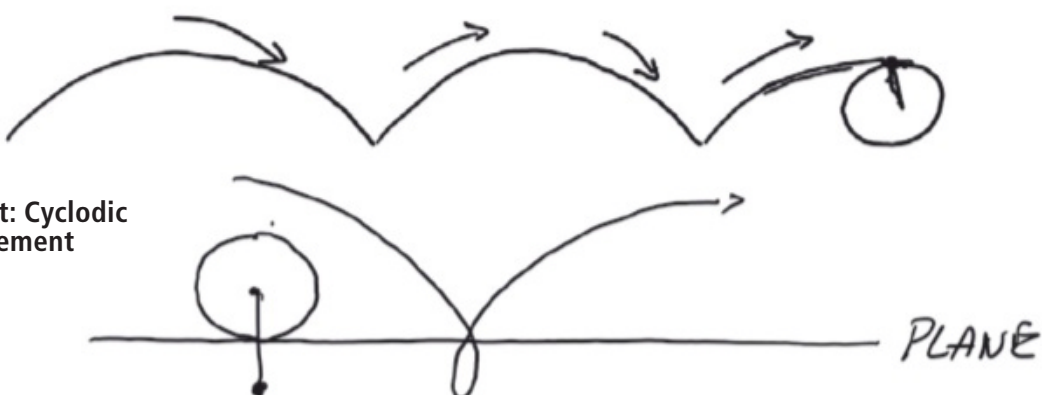


Left: Draft sketches of the mechanical parts and sizes for 3D design of the 3D-printed parts and the laser-cut flat parts (wheels and drawing bars)

Right: Schematic drawing of the mechanical parts. D1 and D2 are the two wheels generating the movement. D1 alters the simple rotation of the wheel D2 that drives the pen in S. The length of the two bars L1 and L2 change the pattern of the drawing, as well as the distance of the centre of the two wheels and the attach point of the bars to the rotating wheels



Right: Cycloidal movement



Following the same mathematical principle of the cycloid are the more complex curves of the same family, named 'hypocycloids'.

How can we make mechanical drawings over rectangular paper sheets? We should connect two cycloid movements

Do you remember the Spirograph from the '60s?

interacting together. Using a BBC Micro Bit and a few more components we can easily create a versatile drawing machine.

Mechanical principles

Before designing the parts in practice, let me explain the mechanical principle. ►



The Java source and the corresponding blocks programme from the Microsoft Makecode site. The full source is available on the GitHub repository



Above and left: Details of the 3D-printed pen holder. A screw is used to lock the pen at the right height. Note the nut inserted in the plastic part to drive the lock screw

Below left: One of the wheels with the motor shaft, top, and bottom side. The motor shaft hole has been 3D printed about 0.25mm smaller, then the shaft has been inserted by heating the metal

Below right: The motors connected for testing, and the motor supports with the motors assembled inside

References

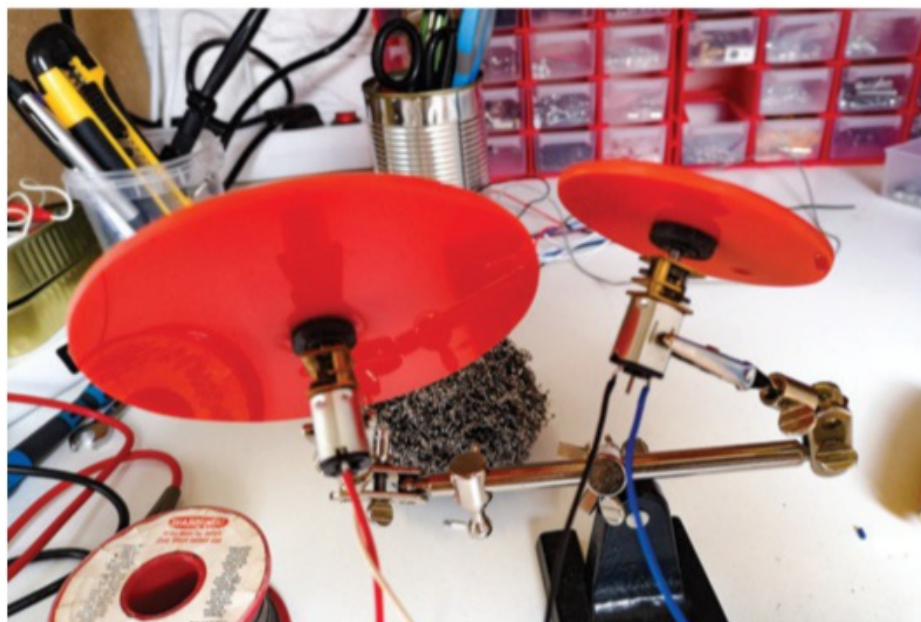
Micro-g geared metal motors by Kitronik: kitronik.co.uk/2586-n20-series-micro-metal-gearmotor-2981.html

BBC Micro Bit by Farnell: export.farnell.com/bbc-microbit?searchref=searchlookahead

All-in-one Micro Bit robotic board by Kitronik: kitronik.co.uk/5641-all-in-one-robotics-board-for-bbc-microbit.html

Material 3D printed on PLA with Elegoo Neptune 3D printer: amazon.com/ELEGOO-Neptune-Printer-Compatible-Filament/dp/B07MWXZGDN/ref=sr_1_fk_mrnnull_1?keywords=elegoo+neptune&qid=1558018534&s=gateway&sr=8-1-fkmrnnull

Drawing machine on YouTube: youtu.be/KT9U2xLkfqk



Based on the mathematical assumptions of cycloid movement, the drawing scheme (top right page 73) shows the minimal mechanical components to generate the movement. D1 and D2 are the two wheels generating the movement. D1 alters the simple rotation of the wheel D2 that drives the pen in S. The length of the two bars, L1 and L2, change the pattern of the drawing, as well as the distance of the centre of the two wheels and the attach point of the bars to the rotating wheels.

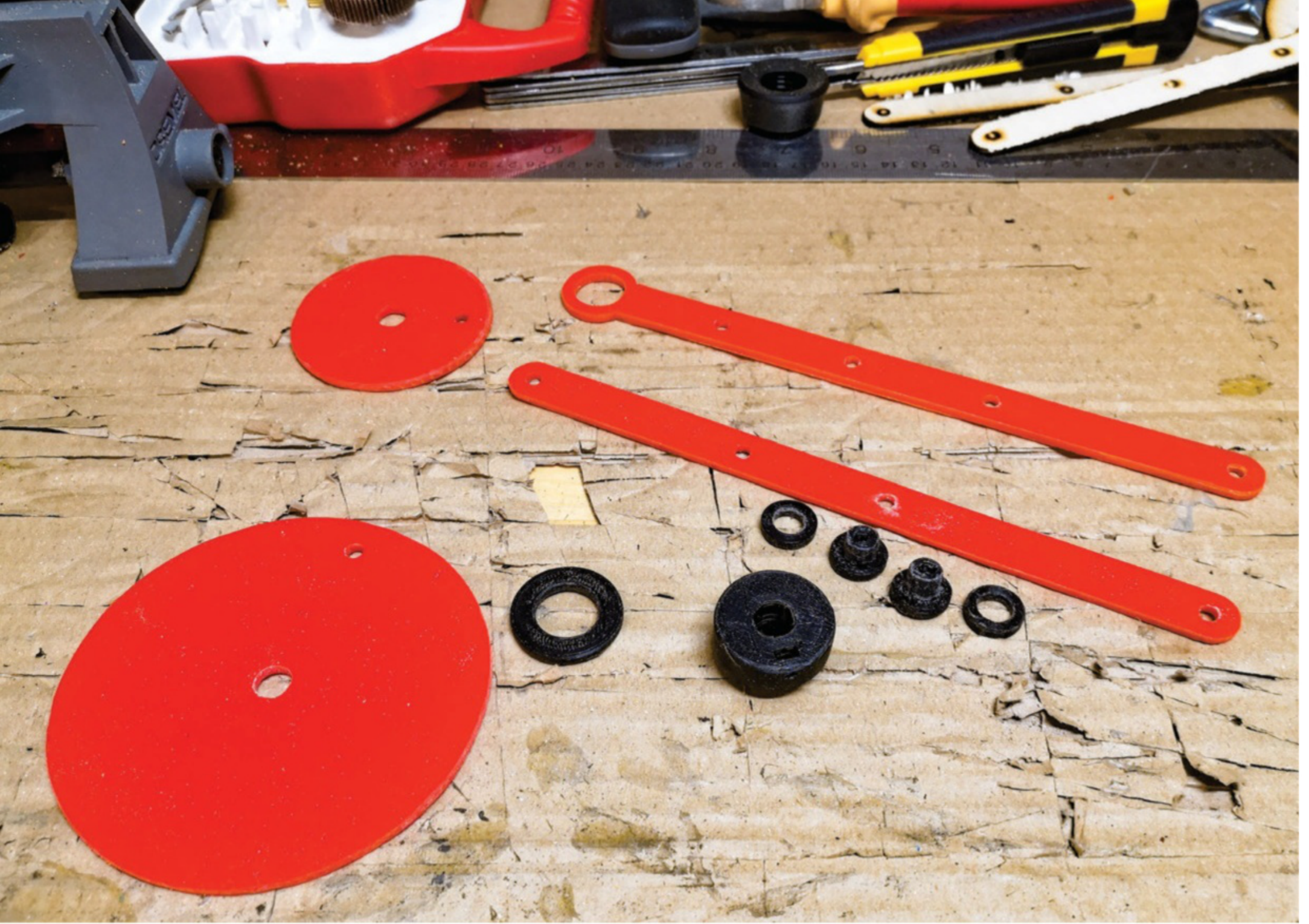
Starting from this essential design we can add other rotating wheels — and up to four motors — and bars, whose diameter and length can create new patterns of different sizes and shapes.

I designed the platform as a modular and general-purpose tool, easy to make and assemble, as well as modify or change some of its features. To move the wheels with a good speed control I have used micro-g geared motors from Kitronik, which I have used for other projects and found they perform very well.

Starting from the few geometric and mathematical concepts described I have designed the mechanical components to generate the recursive movement. I suggest exploring the possibilities for using this design with other wheels and bars to create different curves that can be customized to change the speed and rotation direction of the wheels.

Creating the components

Determined by the shaft diameter and the size of the motors, I designed a ►

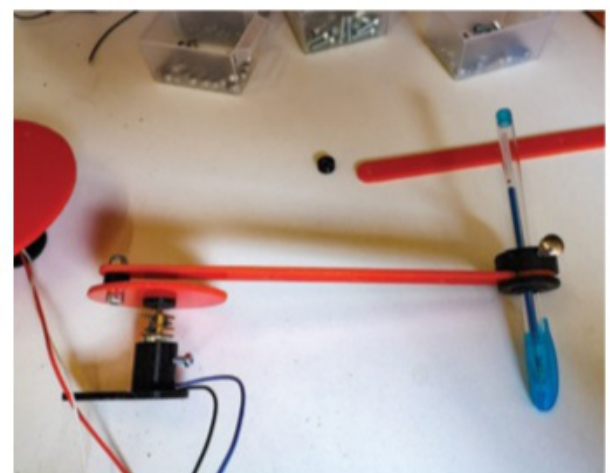
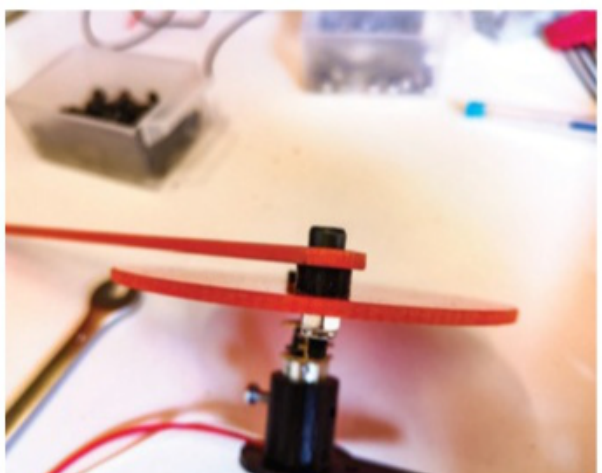


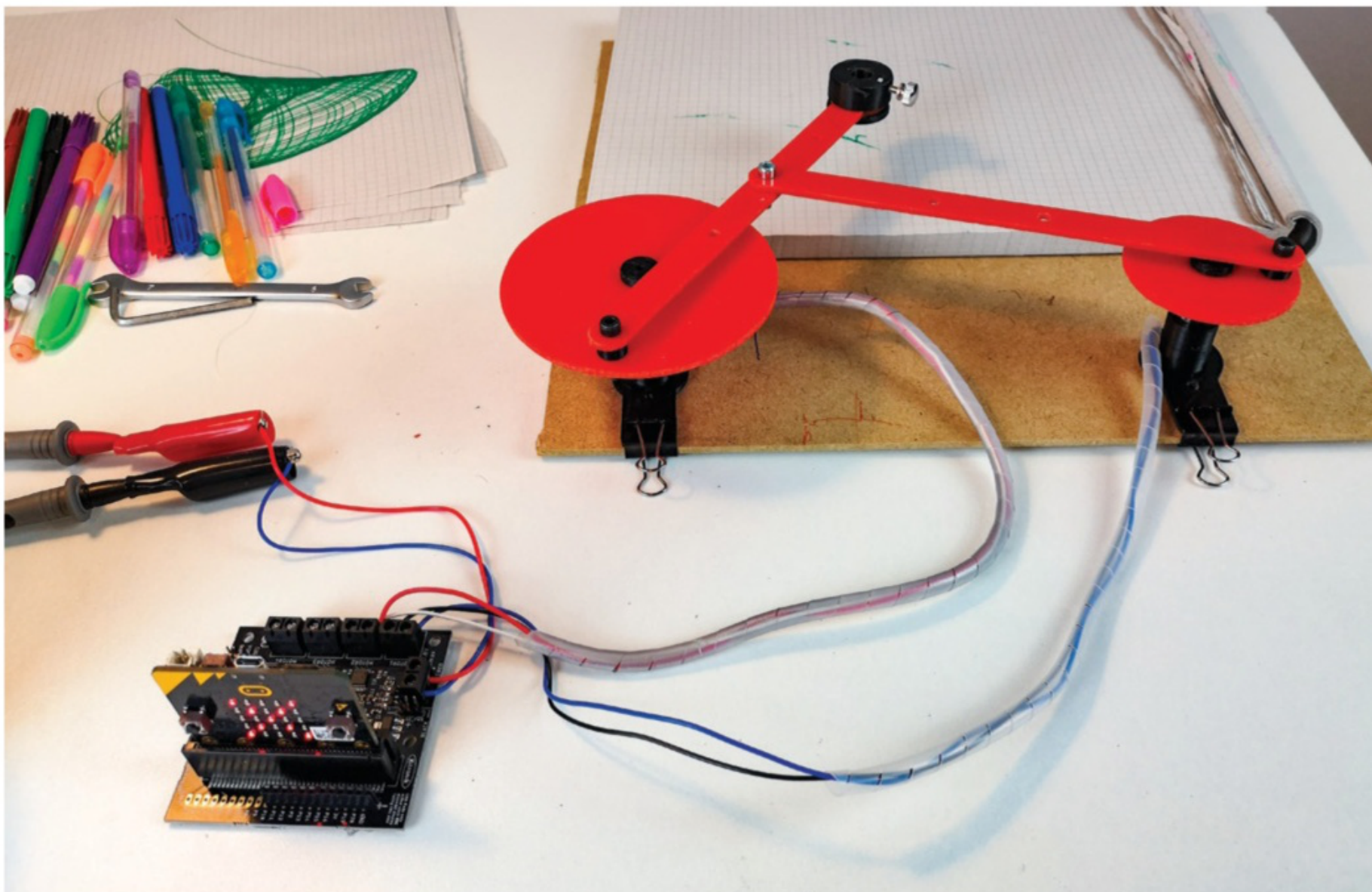
Above: The finished kit. The laser-cut pieces are red while the 3D printed are black. The holes have a diameter to hold an M2 Allen screw

Left and right: 3D printing the motor supports



Below, left to right: Assembling the mechanical parts of the drawing machine





first draft of the idea, then created the components with Fusion 360 for the 3D-printed parts, and Inkscape for the 2D vectorial designs for the parts that I have laser-cut using 3mm Perspex sheet.

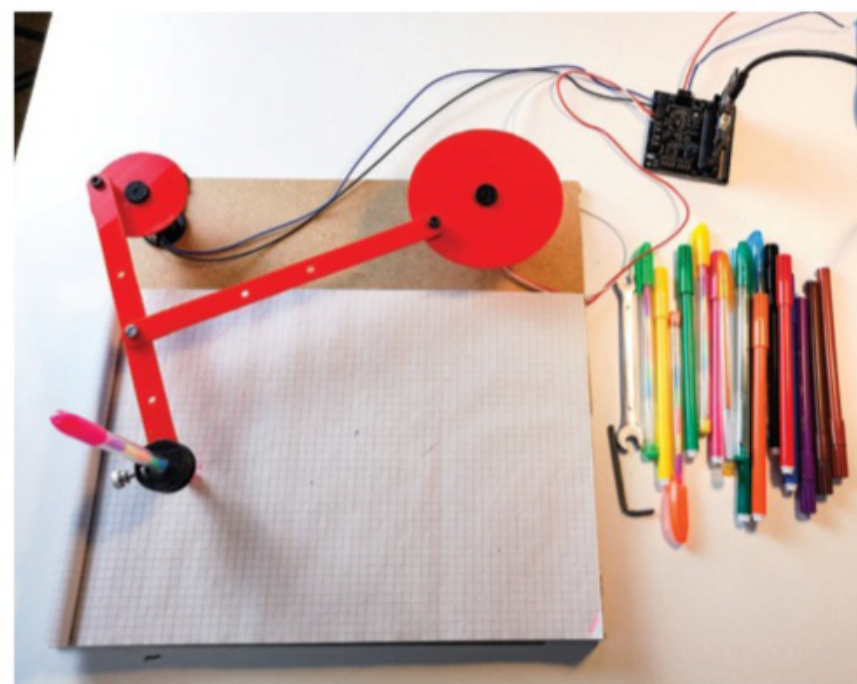
The Micro Bit software has been designed using the Microsoft Makecode web platform, accessible from the Micro Bit website. The same software, based on graphic blocks, has been converted to JavaScript (one of the features available from the web application). It has been saved on the GitHub repository, where you can also find the STL files to build the components (alicemirror.github.io/drawingmachine).

Programme usage notes

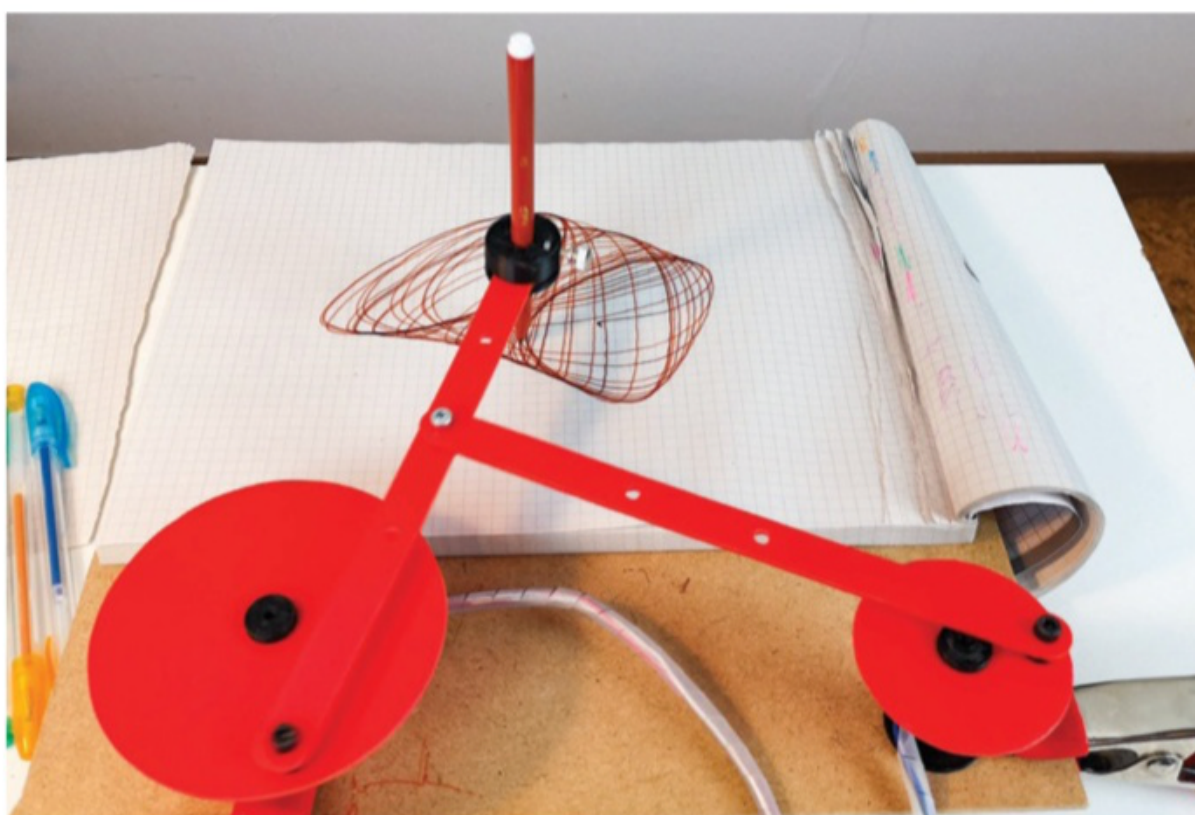
The drawing process can be controlled by the Micro Bit with the two buttons, A and B, and shaking the Micro Bit board:

- Press button A + B: Switch between controlling the big wheel or the small wheel.
- Press Button A: Decrease the motor speed.
- Press Button B: Increase the motor speed.
- Shake the board: Start/Stop the drawing process.

Above and right: The drawing machine finished with the set-up connected to the BBC Micro Bit. Everything is ready for designing



Below: The drawing machine at work



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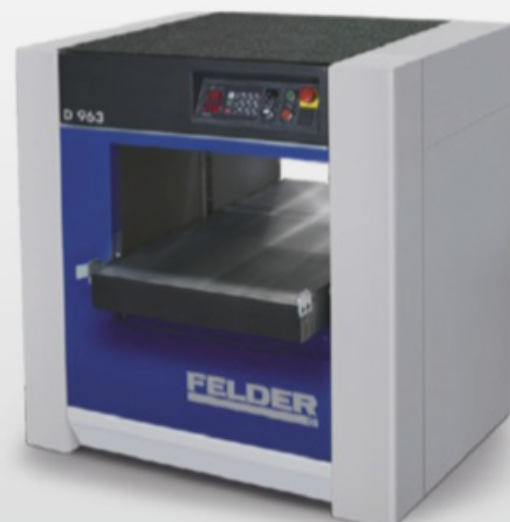
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LET THE POWER BE WITH YOU

BE PREPARED FOR OUTAGES AND CHECK
OUT THE LATEST GENERATORS

By Mark Beckett

Photographs: Mark Beckett



As winter approaches and power outages become more likely, we thought it might be useful to identify what you need to know about generators, safety, their uses, and how to connect them to your home.

A 'generator' is a motor driving an alternator to produce power, and with the advent of inverter generators (see my review of Honda inverter generators on pages 82 and 83) the basics haven't changed, but how they operate has.

Safety

Like all motors burning fuel, generators give off carbon monoxide. This is a colourless, odourless killer that makes you fall asleep and doesn't trigger any safety reflexes in the brain, so it will kill you. While the fumes are deadly, the heat from the exhaust outlet can also burn anything combustible if it's too close.

In addition, unless you bolt it down, your generator can and will move around, so you need to be extra careful and check it regularly. Refuelling is the same with any hot motor, but if you're struggling to pour fuel into a moving, vibrating hole, then think again and switch it off.

The standard mains supply ties the neutral to earth, so the voltage between phase and neutral/earth is 230V. A generator is floating, so the phase and neutral voltage wrt earth can rise (just as if you are using an old-fashioned isolation transformer). Always ensure that you connect the generator earth to the building earth if you're powering part of the house.

As with any rotating machinery, keeping fingers out of harm is performed with safety covers or design. Ensure that covers are left in place and replace them if damaged. ►

For extended power outages you can run parts of your house — I emphasize 'parts'

Power basics

Mains power in New Zealand is approximately 230V AC and the frequency is 50Hz. The regulation specifies that the voltage should be between 200 and 250V, but it should remain within six per cent of what you and your power company decide. That's not helpful, as I can't recall having any discussion with my energy retailer, and mine measures 240V. Modern electronics use switch mode supplies, so they tend to handle voltage ranges from 100 to 250V without any effort, but many other appliances and especially light bulbs are less happy with high (or low) voltage.

As mentioned, the AC frequency is 50Hz and the regulation specifies it shall be within 1.5 per cent. While it doesn't worry most electronics motors directly connected to the mains follow the frequency, so the speed will change. Thankfully the power companies do control frequency very tightly.

New Zealand houses tend to have 63A (or 40A per phase in multiphase installations). This equates to 15.12kW (or 9.6kW per phase), which is significantly more than the three generators in the review I undertook for this article.

There are permanently mounted generators that provide power during a mains outage. Airports have them for lighting, hospitals for keeping services running, and some large office buildings to allow the lifts to go to the ground floor and discharge passengers.

Most of these are large diesel units fitted in the basement, but I've also seen a number of smaller-sized units fitted outside in a self-contained cabinet.

Sizing

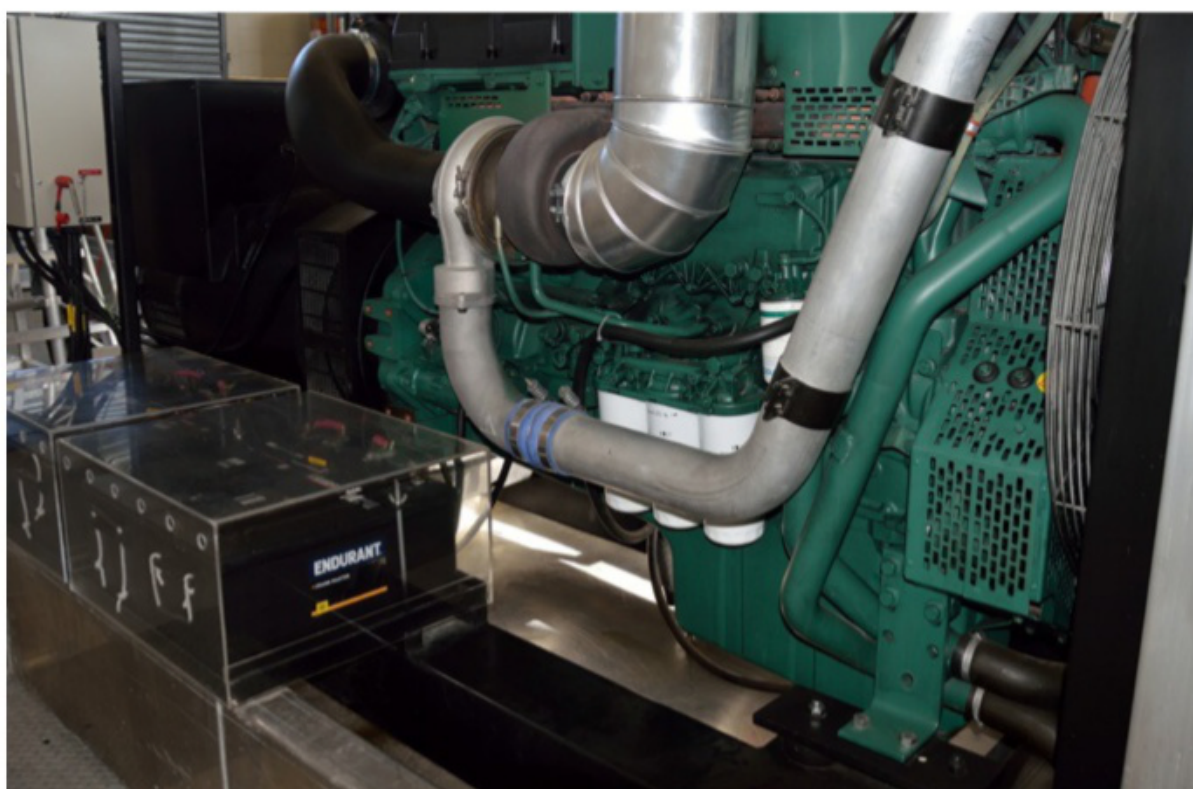
For this article we chose three of Honda's 'portable' inverter generators: EU22i, EU30i, and EU70i. These are all petrol powered, with the EU30i and EU70i also having an electric start.

The rating is covered in the review, but basically the number relates to the maximum kilowatts (or kilovolt amperes [KVA]), that is, EU22i is 2.2kW max. To check which size you need, you simply add up all the loads you wish to run at once.



Above: A generator rescued from the basement of a building being demolished after the Christchurch earthquakes

Right and below: Large generators to provide backup power



All portable appliances have a plate showing the voltage and either power (W) or current (A) that the appliance consumes when running. You multiply volts by amperes to get the power in watts. For example: $230V \times 1.5A = 345W$ (with 1000W equalling 1kW). Motors usually require two or three times their running current during starting, so unless it has some form of speed controller, include this in your sizing equation.

Uses

Many market stalls use a small 'silent' generator to provide power while they

run. You usually find these hidden out the back and unless you notice the power cord, sometimes you don't even realize they are there.

Until the advent of higher powered battery tools, if you wanted to do something where there wasn't power, you'd need a generator. Builders and other trades often use them when the site has no power or the renovations make it safer to have the power disconnected.

Camping (or glamping) at non-powered sites is another popular use, but unless you're on your own, it's best to use a quiet model like the Honda EU22i.



“Many ... appliances and especially light bulbs are less happy with high (or low) voltage”

provide water, but we’ve found that the bath provides 50–100 litres so filling the bath provides water to top up the toilet cistern after flushing.

Communications

It’s likely that the broadband connection will still provide signal, but the modem will need power. If your phone is still the old copper-pair, the cordless phone won’t work, so always keep a corded phone available (as the people of Christchurch discovered eight years ago). For us the phone line kept working but the local mobile-phone site stopped once the batteries went flat.

You’ll need to engage an electrician to provide a switch on or near the switchboard, and maybe swap a few circuits around inside the switchboard. He’ll also need to fit a socket somewhere to accept the power from the generator. This needs to be a suitable size to ensure that the protection circuits will trip if there is a fault.

Obviously this is easier when the house is being built, but it’s still possible later, and having lived in the house you will probably have a better idea of your needs. ►

There are baches and other off-grid locations that have solar (or wind) to charge batteries that connect to an inverter for light mains loads. They often have a generator to run larger domestic appliances and as backup to top up the batteries.

Run the house

For extended power outages you can run *parts* of your house. I emphasize ‘parts’ because even the EU70i can only provide 5.5kW, which could power a modern oven, a quick-boil jug, maybe the TV, and a few normal lights at the same time.

During a power outage you need lights for cooking, the toilet, and a central space. The TV might seem a luxury but it will update you on the weather and provides a welcome distraction. If you have gas hot water, the unit will require power and this assumes you still have running water.

Heating can be an issue, but extra layers, blankets, hot-water bottles, and thermals should provide some comfort.

If you live in the country, the septic tank will be fine for a week, and the chest freezer should stay cold for several days. The water pump may need to be connected to top up the header tank or



Honda EU30is and EU22i compared with a 20-litre fuel container



Exhaust outlets

Generator test



The biggest advantage of the Honda inverter range is the ability to connect two or three units together to double or triple the power output. This means that you can carry two EU22is to your site to provide power, as opposed to a helicopter trip with a larger unit.

The EU22i and EU30i also feature a separate 12V DC outlet. These provide 8.3A (99.6W) and 12A (144W), respectively, to boost charge your solar or automotive battery.

The EU22i provides 1800W (2.2kW max.). This is the smallest, quietest, and lightest unit at 21kg, and while it won't run your quick-boil jug (2.4kW) it will run a number of smaller appliances and power tools.

The EU30i provides 2.8kW (3kW max.). Weighing 59kg, it is heavier than the EU30i but has a larger fuel tank and slightly higher power output than its wheeled brother.

The EU70i provides 5.5kW (7kW max.) and at 118kg is not exactly portable. It does have handles and wheels so you can move it around when you want to run it.

'Eco Throttle' is the name that Honda has given to the system that adjusts the engine speed to suit the load. With the inverter technology the output voltage and frequency remain constant, regardless of the engine speed. This means that the motor runs more quietly and uses less fuel



To check which size you need, you simply add up all the loads you wish to run at once

Above left: EU70i with 32A plug fitted to allow full power on a single cable

Left: EU30i front panel



Above: Voltage (left) and frequency (right) of the EU22i

when the load is light. If you try this with any older cheap generator, you'll find the output voltage goes outside the range and can cause damage to electronics if it goes too high. I have an older 2.2kW generator and there is no comparison with the EU22i. This is quiet, light, doesn't walk everywhere, and is economical. I dread using mine as the voltage is never constant, so I'm trying to work out

how to make this new one 'disappear', rather than giving it back. Which model you need depends on what you're trying to do, and it pays to speak to your local dealer to find the model to suit your needs. They can also supply extra attachments to suit most needs. Part of my test was to check the output voltage and frequency, and these were surprisingly stable. The voltage will

dip a little when you suddenly load them running in Eco Throttle. This is to be expected, as the generator has to detect the drop, open the throttle, and stabilize. If you have voltage-sensitive equipment, turn off Eco Throttle, plug in the load, then switch it back on. The frequency remained rock steady regardless of speed or load, which is certainly better than the old-style generators that I've grown up with.

Below: Voltage (left and right) and frequency (middle) for the EU30is showing difference between loaded and unloaded voltage readings



When we moved out into the country we were warned that the power sometimes fails, and with few customers on the road, there could be delays in restoration. I had planned to wire the switchboard for a generator connection that would also power the water pump (120m away), but somehow the cable from the switchboard to outside got overlooked, and hence it never got completed. As such, during the last extended power outage, the camping gear got dragged out for lights, and the gas cooker worked just fine for cooking and hot water, and we used the generator to watch TV via an extension cord out the window.

Placement is important

Most portable generator electrics are not IP rated, so you will need to consider the placement to avoid them getting wet, remembering the exhaust fumes and heat, and the ability to top it up with fuel. Campbell at OMC Power Equipment showed me the exhaust deflector and extended fuel tank the company can supply. This helps with some of the preparations, but you need to ensure that you have spare fuel on hand and cycle it to make sure it doesn't go stale.

Testing

Having everything prepared and ready to go is great, but when it's cold, dark, and wet (or snowing) can you manage to get it working? Can your partner or children manage? Are the instructions clear enough?

There is nothing like having a test to prove it works, but see if you can make it close to reality. I'd also suggest running it for three or four hours, as you won't wear it out: while doing this article I was shown a picture of the hour meter from a Honda EU20 that had run 6100 hours and was still working perfectly. 📄

The author would like to thank Leon from Honda Power Equipment, Tim from Total Power Hire, and Campbell from OMC Power Equipment for their help and advice in writing this article.



EU70is showing handles and wheels for mobility

Unless you bolt it down, your generator can and will move around, so you need to be extra careful and check it regularly



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THE SUN TRAP

HARNESSING SOLAR ENERGY OPENS
UP A FIELD OF CHALLENGING
POSSIBILITIES

By Murray Grimwood

Photographs: Murray Grimwood





The grandad-built starting point



I grew up a petrolhead, in a petrolheaded world. As a teenager, I could discuss Nuvolari's 1935 German Grand Prix win, Jim Clark's jaw-dropping arrival at the Brickyard, Henry's iconic 1912 twin-cam Peugeot, Ettore Bugatti, George Eyston, two-stage superchargers on the Merlin ... Then I read the 1976 *McGraw-Hill Encyclopedia of Energy*, which still graces my bookshelf. And came across the writings of M King Hubbert, sometime petroleum geologist, sometime professor. And realized that not only do we use fossil fuels incredibly wastefully but that — very soon in human history terms — they would be moving away from us.



Above: Three wheels, lightened, partial fairing

Left: Long wheelbase, prone rider

Right: Final iteration — there's a youngster lying prone behind those tiller-clutching knuckles. Fairing is a catamaran hull, inverted and travelling stern-first, aerodynamics and hydrodynamics being somewhat similar ...



The chase begins

That spurred a lifetime of studying, and chasing, energy efficiencies. It can be a whole lot of fun and a satisfying mental challenge. Take the development of our downhill-racing trolleys as an example. It started with our six-year-old on a conventional grandad-built four-wheel rig, rolling on solid rubber.

The ensuing years saw rubber being removed in the lathe, wheels drilled for lightness, diesel being used as a bearing lubricant. Then we dropped to three wheels to reduce inertia and friction. Then we lengthened the wheel base to eliminate steerage energy waste, which sped us into aerodynamic-drag territory. This induced first a prone (head-first) rider position, and finally, a full fairing over a full roll cage.

Retaining solar energy

Tracing all energy back to solar and realizing the enormity of the challenge facing society, I read everything that I could on 'passive solar' housing, the object of which is to gain, then retain, solar energy. Passive solar has been around forever, but since 1944 (when Frank Lloyd Wright designed the Jacob house) we've had no excuse for not applying it to modern housing. The concepts are easily understood: maximize your north-facing glass, minimize your south. Deflect your prevailing wind (because it's a chill factor). Have some sunlit, energy-retaining thermal mass (concrete, stone, contained water). Insulate to the max. Simple.

When we bought an old bach (called a 'crib' down thisaways) as a first house, it was inevitable that we'd add to it in this manner. Being on a north-facing hill, we built above and behind it, open plan to allow the sun all the way into the 'behind' part. We were brave enough to use cool-store panel (steel/styrene/steel) as the super-insulative roof, but not the walls.

Lessons learned

In the spirit of those trolley improvements, we learned a lot of lessons from that build and were keen to put them to work when building our second house from scratch. The aim was to maximize the passive use of solar



How thick does a conservatory have to be?

It's called 'thermo-syphoning', and we figured that if we applied it to the air in the house we'd be tapping into free circulation

energy before adding active inputs (like photovoltaic [PV] panels). This time we'd use cool-store panel for the whole external envelope to minimize the loss of any energy that we'd captured. This time the mezzanine would be down-sun, casting less shadow. The solar gain from the all-glass north wall would shorten the period when lights would be required — lessening the need for battery capacity. The wood stove would be downstairs and dead centre, as far from the outside world as possible. It would wet-back-heat the water, effectively importing solar energy from outside the house.

We all know that wet-backing takes advantage of the fact that hot water rises from the firebox, enters the top of the cylinder, descends coolingly through it, returning at its coldest from the bottom of the cylinder to the firebox. It's called 'thermo-syphoning', and we figured that if we applied it to the air in the house we'd be tapping into free circulation. It was a simple thing to provide opening vents high in our north-facing conservatory to allow hot air into the house where it cools, sinks, and returns via the open conservatory doors.

What about the morning sun?

I was lying in bed one night, smugly contemplating how well that conservatory circulation worked and regretting that we couldn't build a conservatory on the east side of the house to grab that morning sun (there's stairs in the way and the solid wall is a bracing component). Then I thought, hang on, who says a person needs to be there? How thick does a ►



Conservatory vents from inside house

conservatory have to be, solar-capture-wise? You need the glass, then you need a back wall — they only need to be far enough apart to let the air move! I used old ranch sliders, 50mm offset from the wall, over a black sheet-steel backing. There's a kilowatt per square metre available (in theory) from square-on sun. I reckon we're getting about 1.5kW, allowing for losses through the glass. It blows in the top vents, of a morning, like a fan heater — for free!

Automatic vent control is next

After midday, of course, it reverts to being a back syphon, increasingly chilling the air in the column (and therefore the house) as night comes on. Currently we close the vents manually, but I'm working on an energy-free automatic control (an air piston driven by a sun-drenched bladder is one idea, a bimetallic strip being a maybe more practical other).

Given that society will be chasing energy efficiency in the years ahead, with most of the existing housing stock still in existence, someone should type/approve a proprietary version and sell/install it. There have to be so many old weather-board walls deflecting so much sunlight that, after double glazing and insulation, it might be the next best housing move we can all make.

There is a physical limit to energy efficiencies, of course, and a law of diminishing returns applies. That said, we've hardly scraped the surface of what's possible. As we have done with double glazing, we will groan about — then accept — efficiency-improving regulations, but efficiencies deliver permanent returns.

It's hard to beat that.



Conservatory vents, outside view



Currently we close the vents manually



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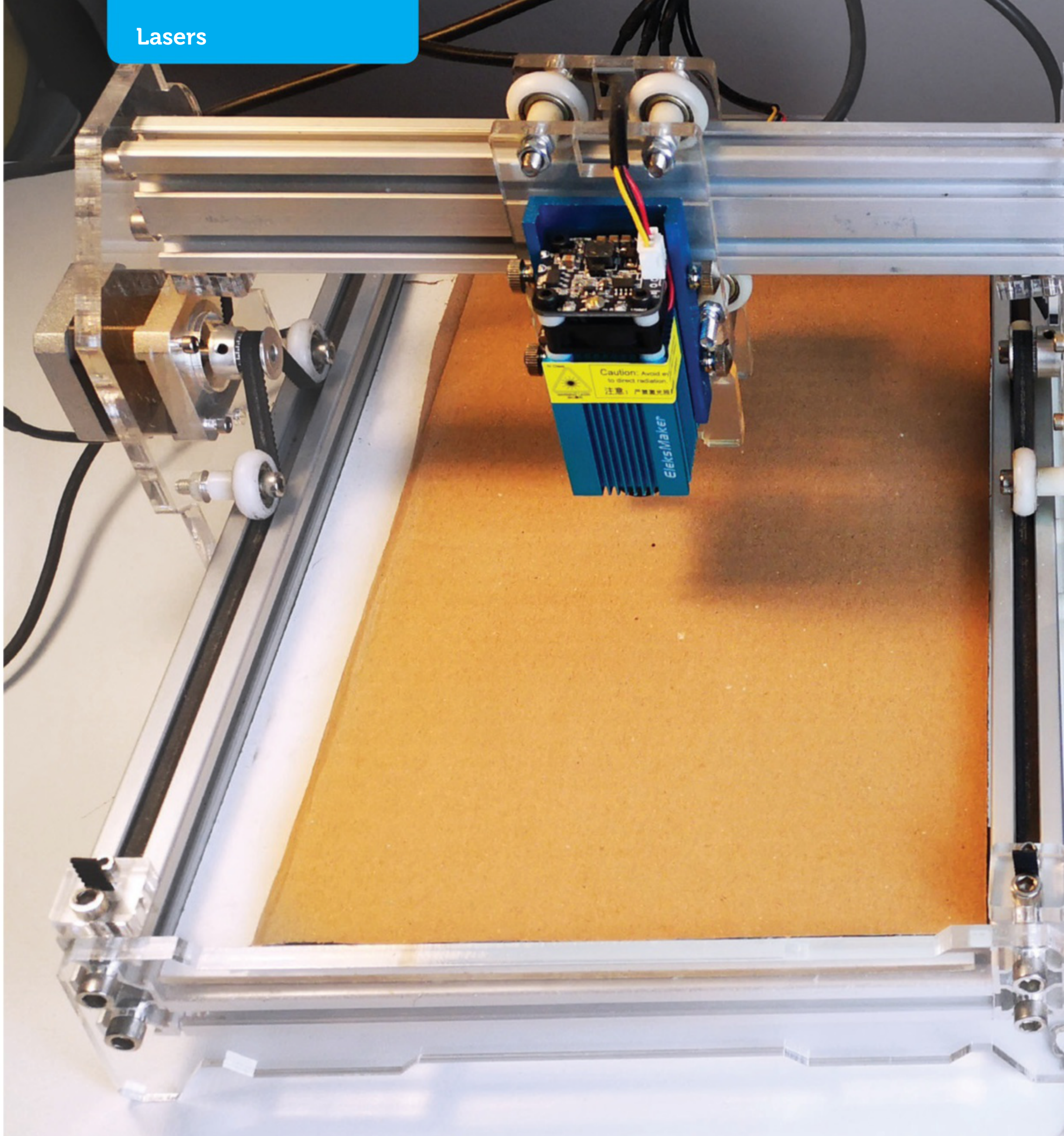
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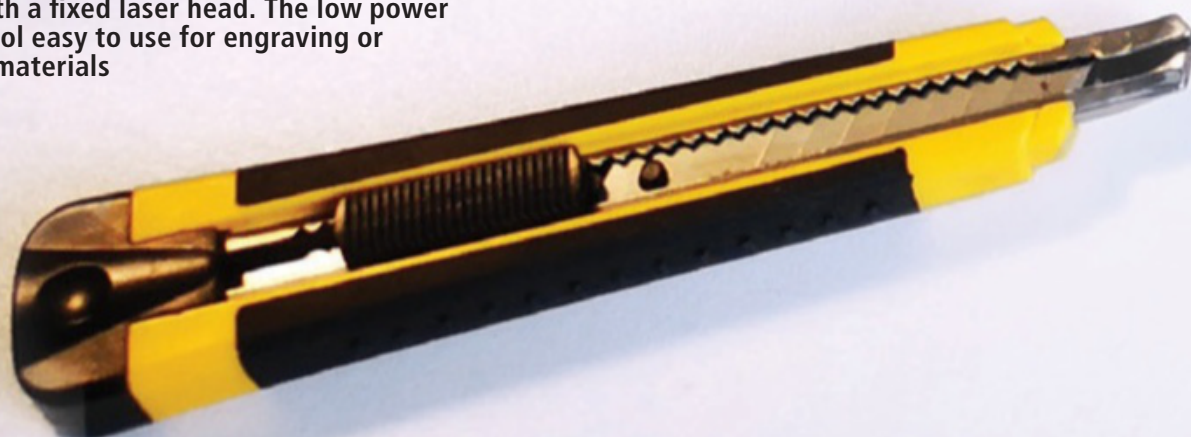
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The set-up used for the experiments shown in this article — a small A4-sized laser engraver equipped with a fixed laser head. The low power makes the tool easy to use for engraving or cutting soft materials





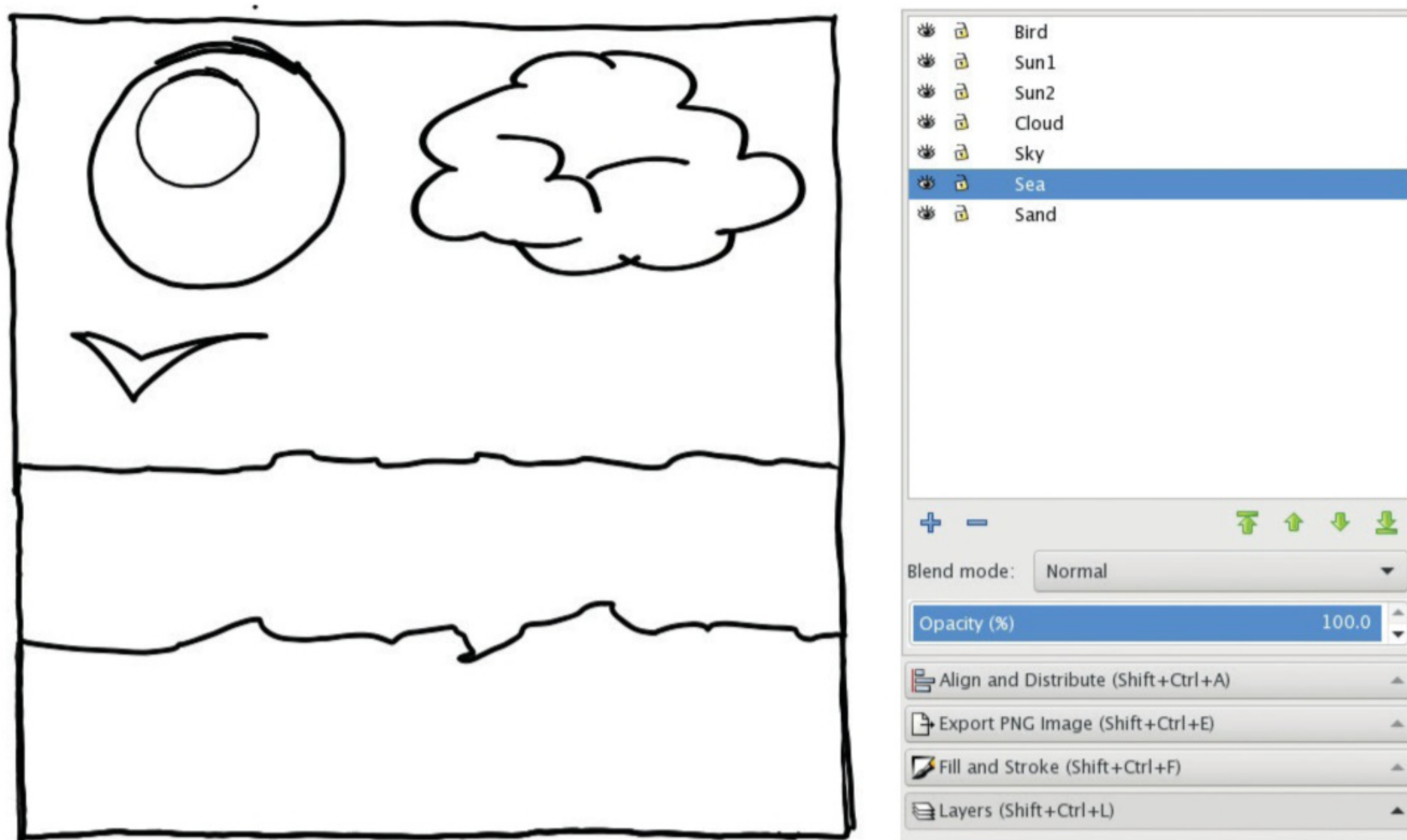
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DO SOME CHECKING TO MAKE SURE THAT
YOU'RE NOT BUYING SOMETHING THAT
WILL SOON BECOME OBSOLETE

By Enrico Miglino

Photographs: Enrico Miglino

The line-art drawing used for the laser collage example. Here the drawing is shown in SVG format (the drawing format of the 3D vectorial programme Inkscape)



In the previous articles of this introduction to laser cutting and engraving with domestic and DIY devices, we have explored the key aspects of the tool: laser power, materials, cutting thickness, and use of the Z-axis.

The use of the laser machine is fast growing as a good and cheap alternative to 3D printing technology for some types

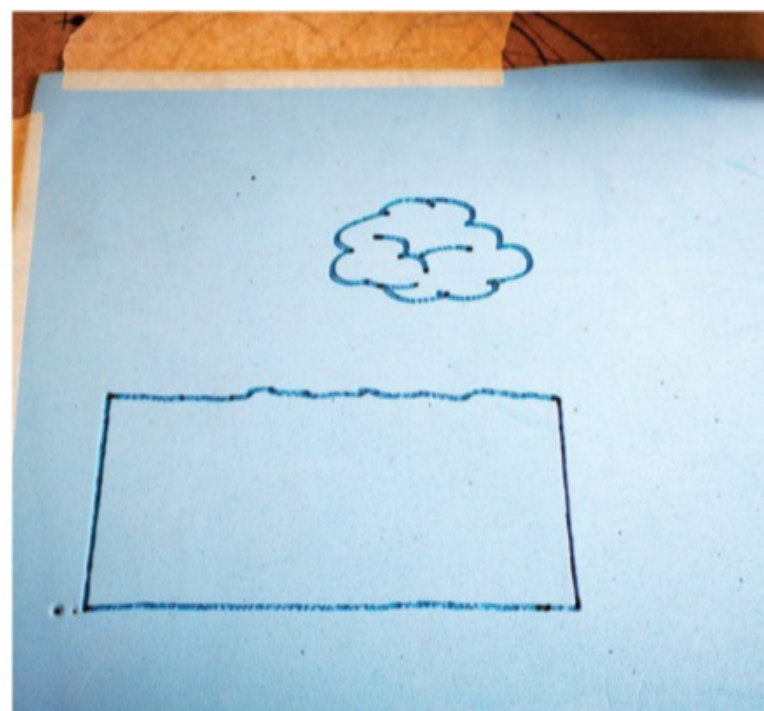
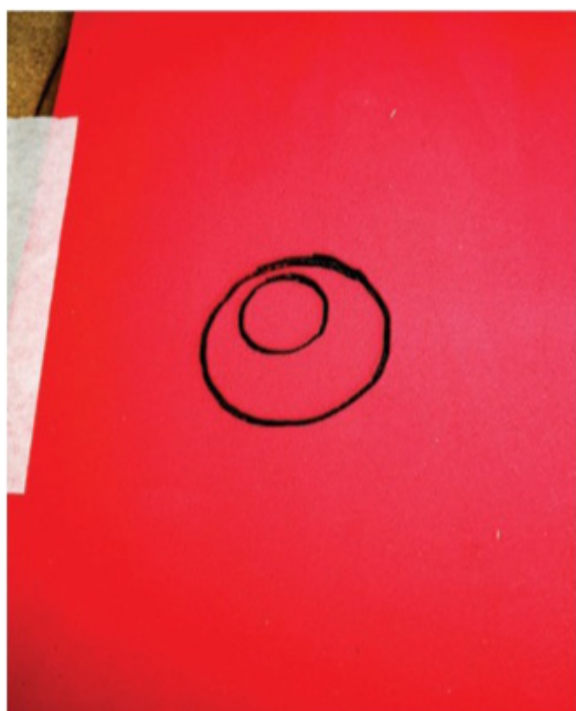
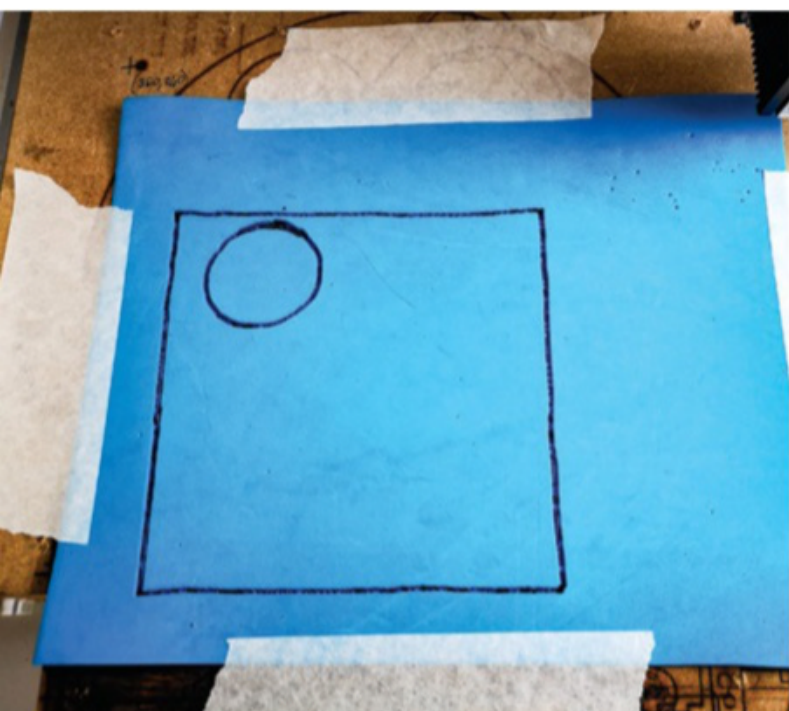
of tasks. The mechanics and electronics of domestic laser tools are relatively easy to manage and maintain, with fewer issues than 3D printers, but the most painful issue is the software. I started writing on laser technology more than six months ago and the software options currently available today are almost the same. Finding the right software is a key factor to achieving good results.

Lack of choice

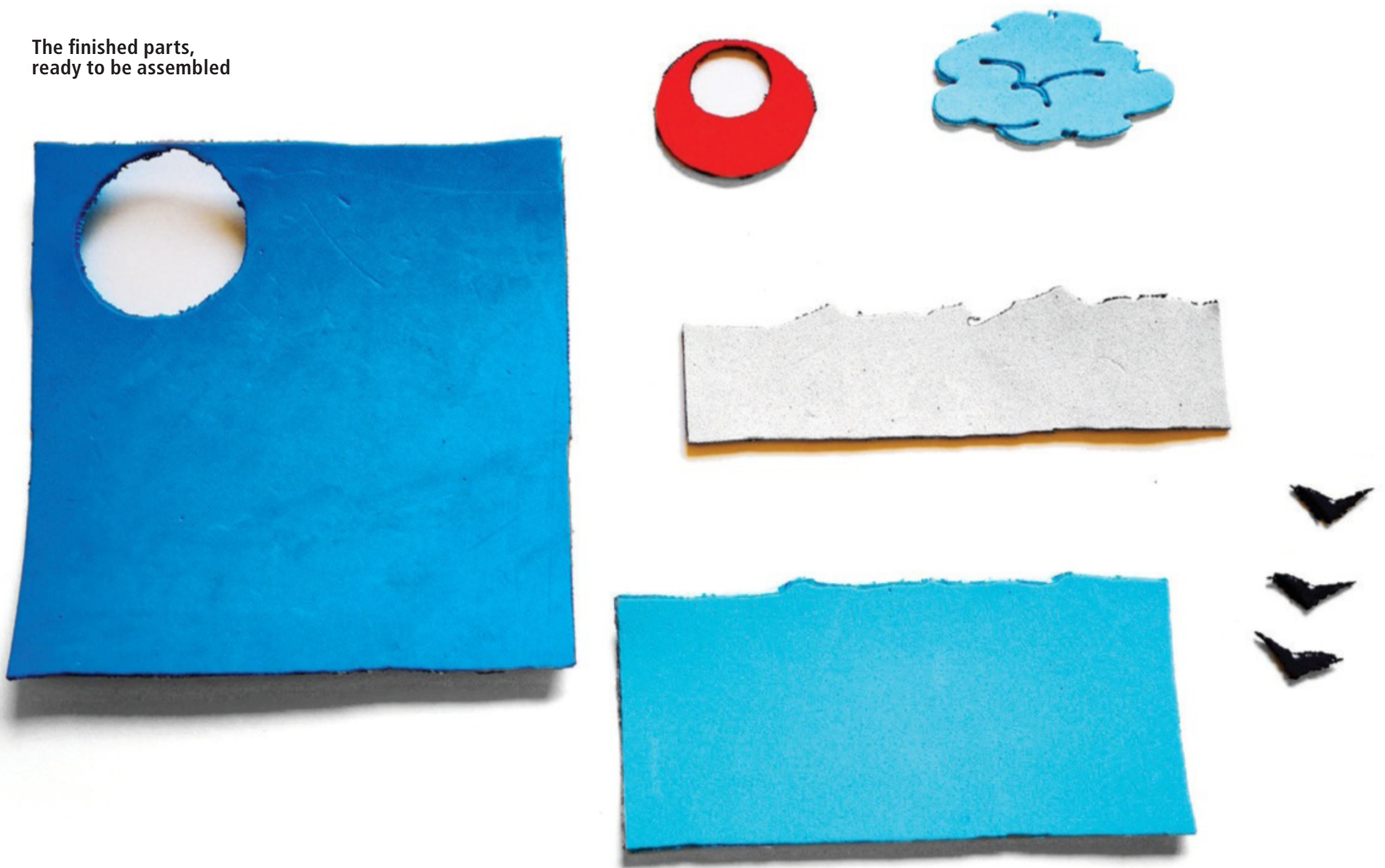
Chinese producers do not deliver good applications with their machines. Almost all domestic 3D printers, as well as most of the assembled commercial ones, are compatible with (at least) the popular Cura or Repetier programmes, released as open-source.

For laser machines, the only available software compatibility is with Grbl code.

Below: The collage components cut on 2mm sheets of coloured polyurethane



The finished parts,
ready to be assembled



Based on the universal G-code language adopted by most of CNC machines, Grbl software is an open-source programme designed to control moving machines. There are plenty of CNC routers, 3D printers, and lasers with microcontroller boards that include a version of the Grbl software as the job-control firmware.

The problem is that Grbl is a low-level programme and we also need a user interface to manage the graphic designs to send them to the tool. Without a user application with a good interface and graphics features, our laser tool is useless.

Avoid this software

Digging on the technical forums, all you can find is a version of the Benbox software. I used it — or tried to use it — and I strongly advise you not to download and install this application.

It is full of bugs and, even worse, it is no longer supported by the developers, and it is a primitive application designed to run on Windows XP (no longer available). Basically, all you get is a ►

Below: The simple and easy to make collage composition. The layers have been glued with vinyl glue and the bottom layer has been glued on a cardboard rectangle as a support





Left: The original image, engraved from the black-and-white conversion (on Inkscape). Using the appropriate speed the darkest parts tend to be burned creating a nice transparent effect

Right: The original photograph used to engrave the red sheet of polyurethane



crashing application with unstable USB drivers and if you try to install it on a Windows 10 computer you risk serious damage to your system software.

You can buy commercial laser programmes, but they're expensive and almost all are specific for branded, high-priced laser tools.

Before deciding on what sort of software is right for you, it is important to check the compatibility of your hardware.

When I choose a hardware tool, I make sure that the system is compatible with

a communication protocol and drivers based on a standard. Changes happen over time and technology evolves fast. One of the worst issues, which is not difficult to avoid, is adopting a non-standard system. Before you know it, you may find that the software or hardware company has stopped producing or maintaining its products. The system becomes obsolete.

Staying independent

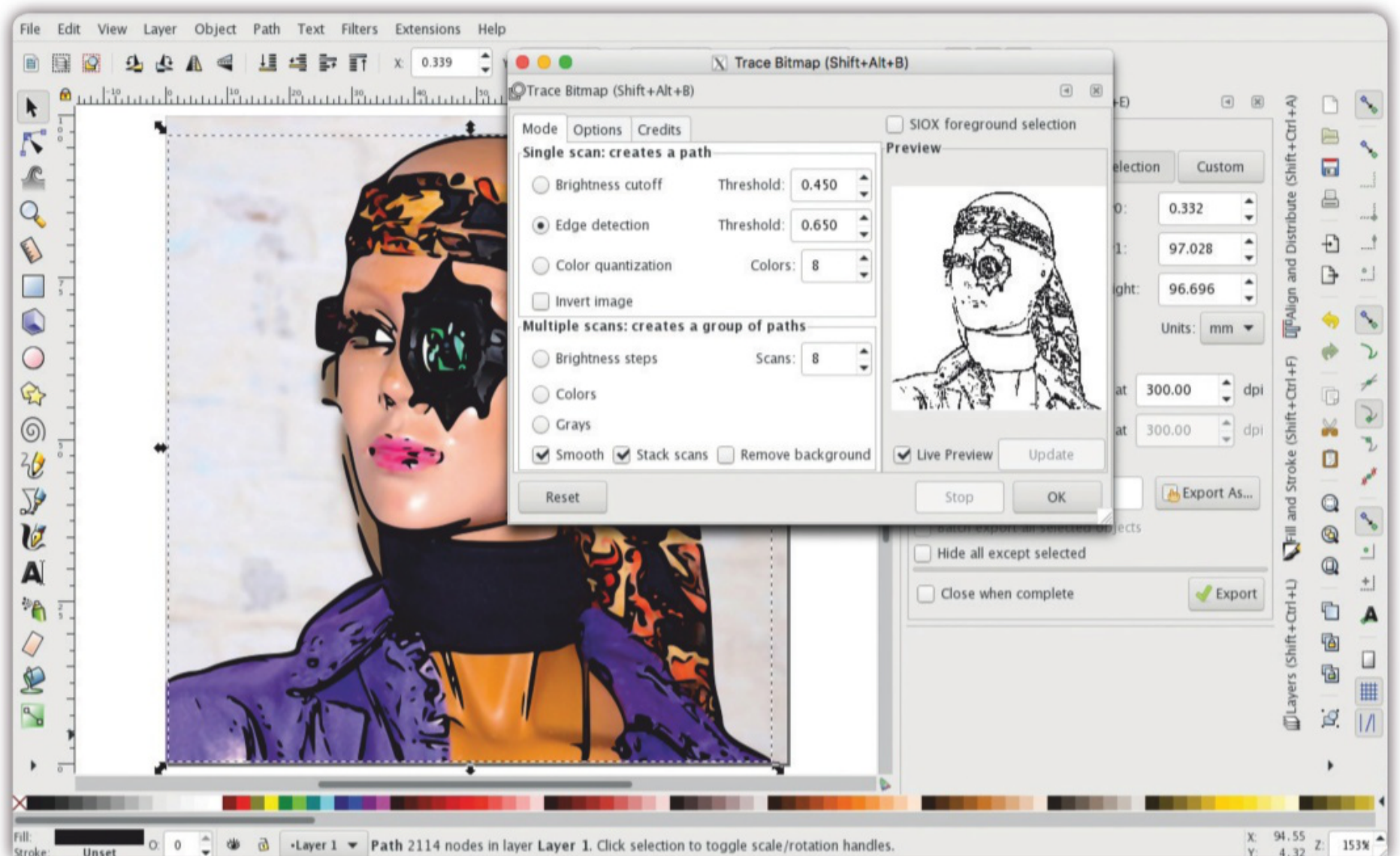
If the laser tool is based on the G-code protocol and the open-source Grbl

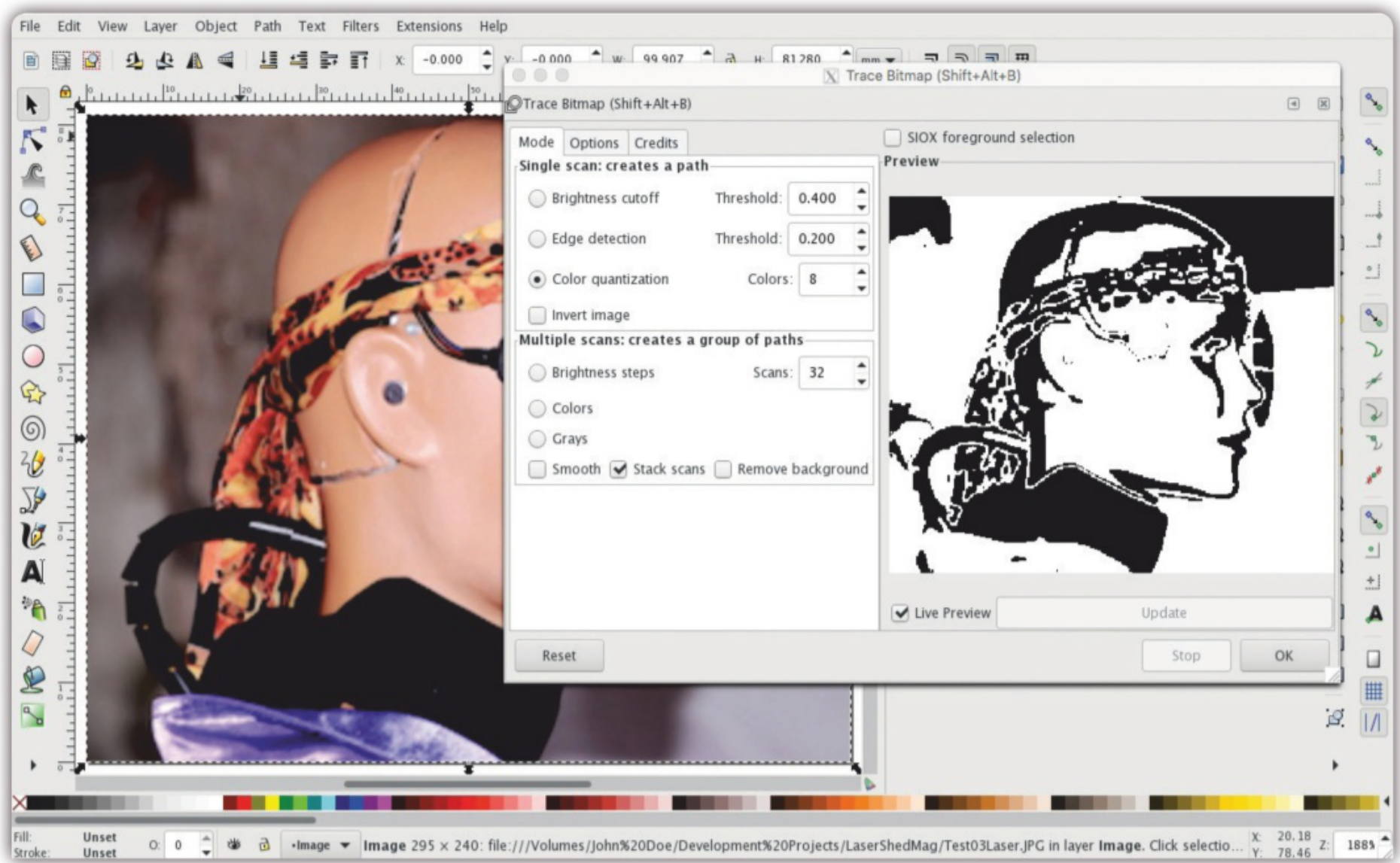
firmware you don't need to depend on the producer. I chose the software for the last cutters and engravers that I bought with this scenario in mind. After testing different applications I found two of them are worth experimenting with and using.

The first is T2Laser, a versatile system that works very well with many different laser platforms, as well as small CNC machines.

The second, which we will cover in detail in the next issue of ►

Below: Instead of using the standard black-and-white conversion offered by the T2Laser programme, the powerful Inkscape tool Trace Bitmap can create many vectorial variations of the same photograph to experiment with and achieve different results with the laser engraving tool





Basically, all you get is a crashing application
with unstable USB drivers

Above and below: After the line-art
conversion of an image using Inkscape,
we can use different layers to create the
final image



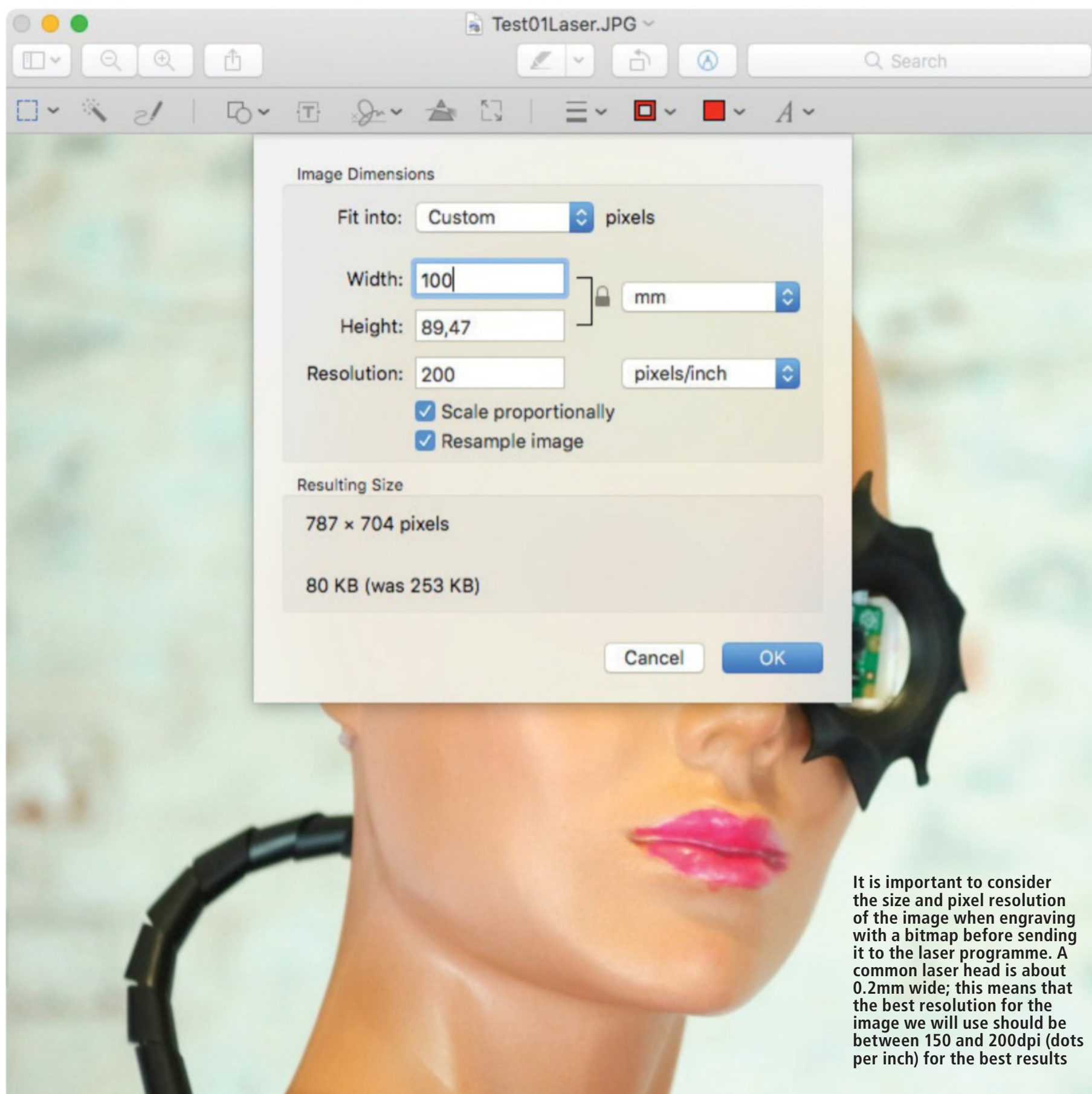


Above: The line-art conversion has been processed with Inkscape to extract the image contour. To do this (colours are only helpers for drawing), instead of exporting a bitmap the image is saved in DXF format, the portable 2D vectorial file that can be read by T2Laser and most of engraving programmes



Above and below: An example of how very different effects can be created from the same vectorial image, depending on the laser speed. Engraving materials like plastic surfaces, cardboard, and leather can be an efficient method to personalize handcrafted objects with your own artwork and logos





The Shed, is Laserweb. T2Laser is a commercial application sold at a very affordable price; it has been created and maintained by a single developer, Zax, who I have had the opportunity to know virtually. His development approach is reliable as he has a very good technical background.

Experimenting with a low-power laser

We have already analysed the most important factors involved in laser cutting, as well as the limits and possibilities of a relatively powerful home laser cutter for making technical components.

After testing different applications I found two of them are worth experimenting with and using

Now we will try working on a less powerful machine — one of the cheaper and popular laser heads: a 500mW laser with a surface of about one sheet of A3 paper.

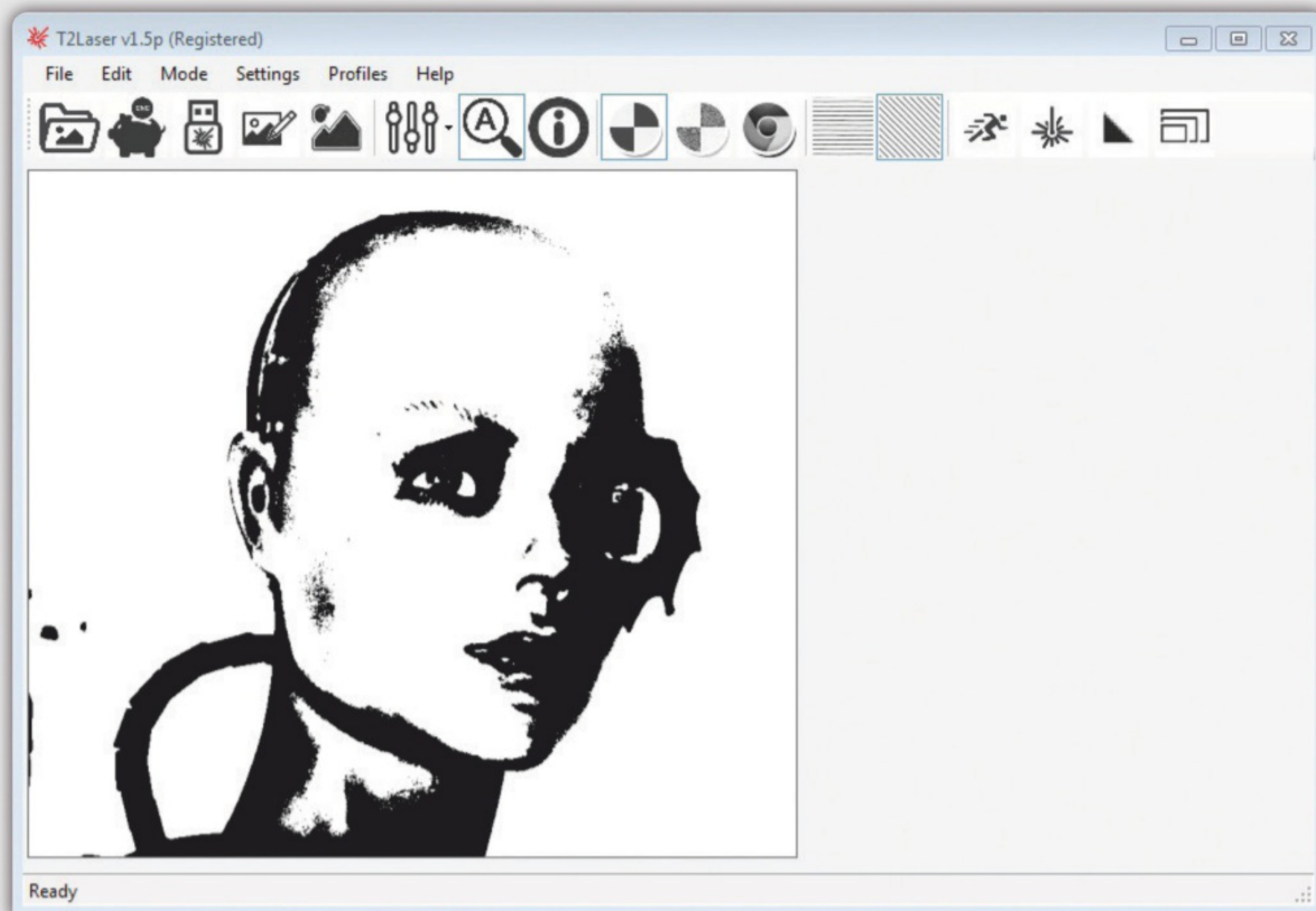
The most costly component is the laser head, so low-power machines can be relatively cheap — you can find DIY

models for \$US150 or less. You should not expect to be able to cut components with it as we have done with the 2500mW or 7000mW, but there is still a wide range of applications where the low-power laser can be proficiently used with very good results.

For our first experiments we will use low-power lasers to engrave images and cut very thin materials. As there is not a Z-axis motor, we are limited to cutting very soft surfaces or engraving images on harder materials.

Following, we look at how the T2Laser Windows application works. ►

T2Laser tips and tricks



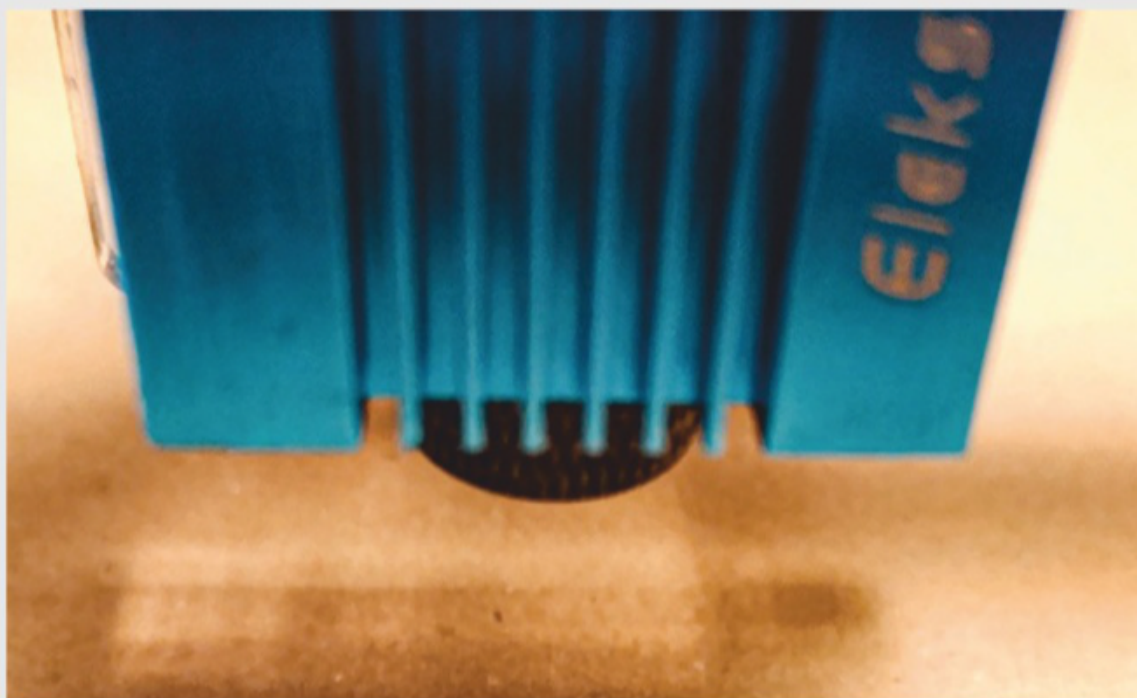
I asked the creator of T2Laser, Zax, about how the T2Laser Windows application works.

Enrico Miglino: One of the problems I always find when using programmes for controlling hardware is how to directly manage the settings. I thought it would be very useful to know when using

more than one tool how to save a series of presets to work with several tools.

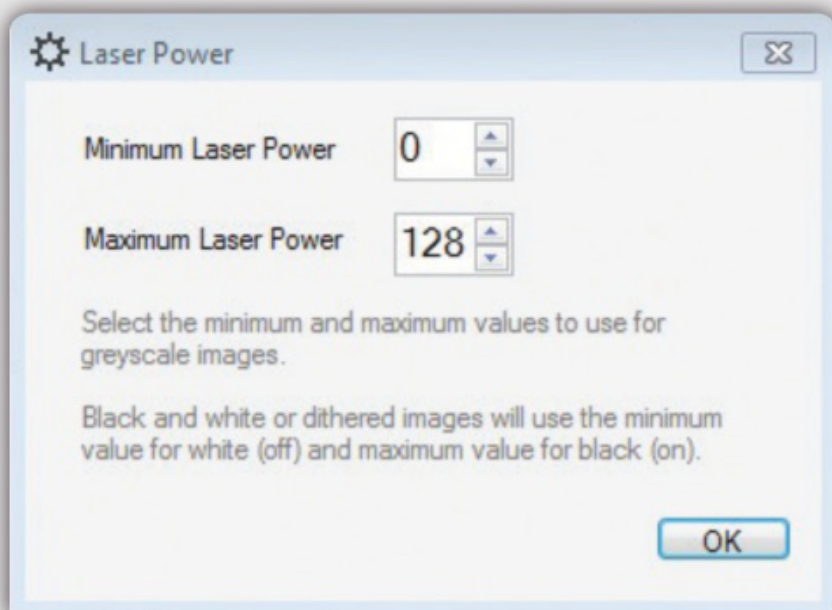
Zax: The profiles can be updated, if you left-click to load the values, then change whatever parameters you want (say increase from two to three passes) and then right-click to save. You can change the name if

you wish and it will override the new parameters. Alternatively you can edit the T2LaserProfiles.txt file directly. It is in the T2Laser install folder. You can find this in the Users AppData folder but the name is cryptic. The simple way is to use Task Manager, right-click T2Laser and select the open folder.



Above: The main screen of the T2Laser programme with the graphic area and a line-art image loaded

Left: The 500mW laser head. There is no motor for the Z-axis, which makes the tool better for surface work. The laser head has an adjustable lens to set the focus on the surface of the material before starting the job. You should find the smaller blue point on the surface by rotating the lens in both clockwise and counterclockwise directions



Above: The most important parameters of the programme are the beam intensity and the laser head speed. It is good practice to never set the speed over 2000mm/min to avoid compromising the quality of the job. At the highest speed, if the engraving is too dark, it is possible to reduce the beam intensity in a range between 0 and 255

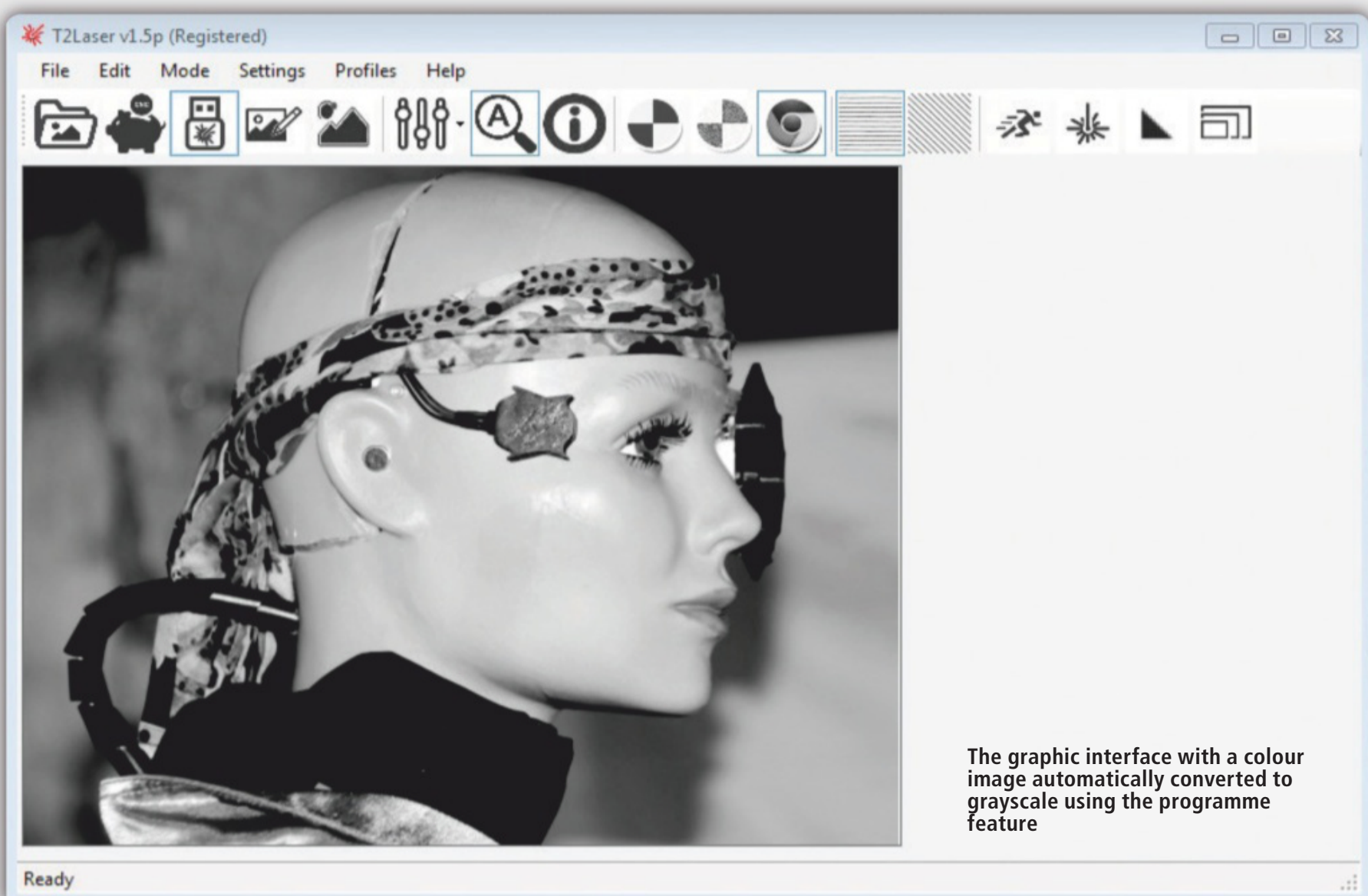
Below is an example of a configuration file:
Standard: 0, 255, 1000, 0.2, 0, 0, 1000
High Speed: 0, 255, 2000, 0.2, 0, 20, 1000
Fine Resolution: 0, 255, 1000, 0.1, 0, 20, 500
Cutting (two passes): 0, 255, 1000, 0.1, 2, 0, 500
Cutting (two passes with cool down): 0, 255, 1000, 0.1, 2, 20, 500
Cutting (one pass slow): 0, 255, 1000, 0.1, 0, 0, 200
Default 7: 0, 255, 1000, 0.1, 0, 20, 500
Default 8: 0, 255, 1000, 0.1, 0, 20, 500
Default 9: 0, 255, 1000, 0.1, 0, 20, 500
Default 10: 0, 255, 1000, 0.1, 0, 20, 500
Default 11: 0, 255, 1000, 0.1, 0, 20, 500
Default 12: 0, 255, 1000, 0.1, 0, 20, 500

After a few chats with Zax, I realized that he has a wide knowledge of a range of laser tools, far greater knowledge than mine. I asked him about some of his tools.

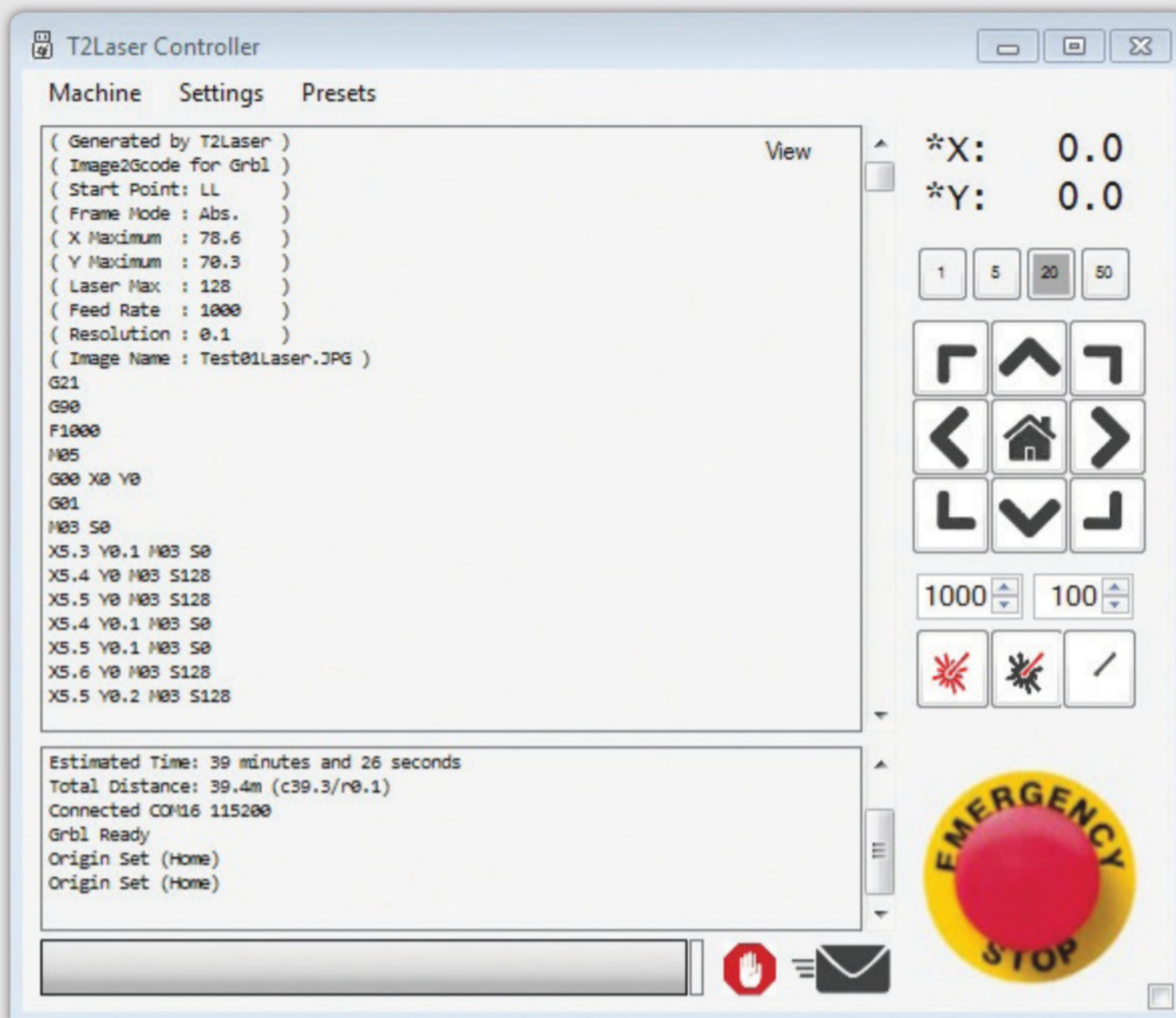
Z: I have many machines, and use T2Laser with all of them.

- EleksMaker A3 2500mW laser
- K40 CO2 40W laser with Eleks controller
- EleksDraw (pen)
- K2 CNC with Xylotex controller
- Mini CNC 3018 with Developer 2.0 (I also tested with Woodpecker board)

I just got the last one and will soon add ►



The graphic interface with a colour image automatically converted to grayscale using the programme feature



Z-probe features to T2Laser and I'm also considering some more CNC features.

The 2500mW laser can cut 3mm laser birch ply in six passes at 80mm/min, and it is essential to have air assist and a raised bed for the best results. I usually cut with the K40 as it is much faster, and I use the diode laser for engraving.

EM: One of the issues that stops me becoming truly enthusiastic about the T2Laser programme is that it runs only on the Windows platform. Why is that?

Z: I have done some research on this but think it is very difficult as much of my code is low level to improve performance and the rest is not so easy to port.

In the future, I hope to do a complete rewrite, as T2Laser has outgrown its original scope. In this case, I would

consider a cross-platform alternative.

EM: In the past, we have seen how material colour has a great influence on the cutting results, due to the higher or lower compatibility of the material colour with the laser beam colour.

It is not really a great solution to paint the surface before laser cutting but this may be a good approach if we only want to engrave the surface.

Z: It works [painting the surface] on many materials that would otherwise not engrave. Some acrylic comes with a paper backing, which can be used for the same purpose, or you can place a piece of coloured paper on or beneath it. Cutting is more difficult, as this method only helps with the immediate surface so for thin materials it may be sufficient but won't help in all cases. 📄

Above: The second interface view of the programme. After loading the image and setting the working parameters, we should swap the interface for controlling the laser tool. The image to engrave or cut is converted to G-code, the command language most used for any kind of CNC machine (3D printers, routers, and lasers). From this interface, we can set the axis direction and origin, position the laser head on the working area, and send the G-code file to the machine. Note that the G-code can also be saved to be reused without reloading the original file

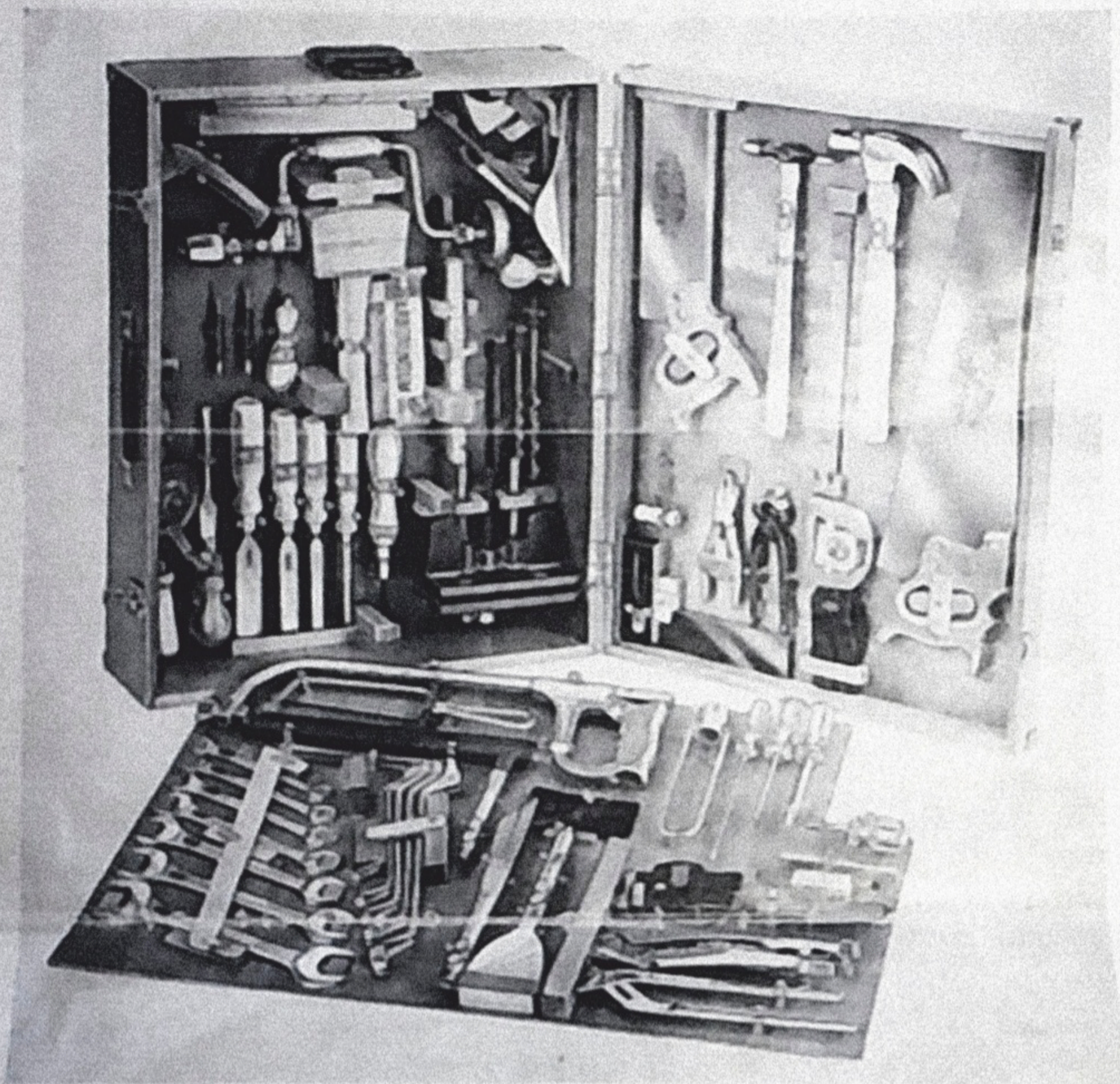


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The Gordon "Palm Tree" Combined Mechanic's & Carpenter's Tool Kit



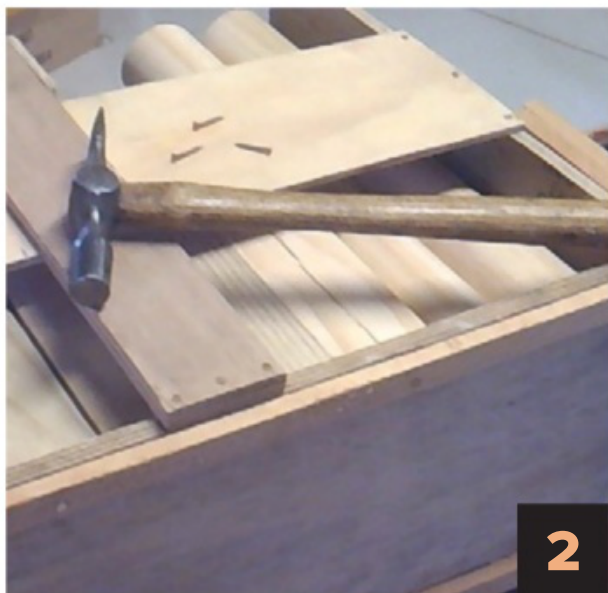
SIZE (CLOSED) 28" x 19" x 7"

WEIGHT 56 lbs.



ILLUSTRATION SHOWING LAYOUT OF TOOLS
FOR ASSEMBLY

MAWHOOD BROTHERS LTD., TRIPPET LANE, SHEFFIELD.



ALTHOUGH NOT ESPECIALLY FANCY, HERE'S A SHEDDIE'S SELECTION OF TOOLS THAT HAVE PROVED TO BE INDISPENSABLE

By Emil Nye

Photographs: Emil Nye



A FEW OF MY FAVOURITE THINGS

One of my problems is that I have Scottish as well as Swiss genes, a combination that drives me to fiendish economy!

It is really satisfying to have high-quality tools and I do have some — but a number of them are only used occasionally. There is also much satisfaction in achieving a good result without sophisticated or expensive tools.

My parents were busy GPs so my father's talents were hidden from me. I knew that as a medical missionary he made a wooden leg for a patient, the socket of metal and leather — and famously later added a foot a short way up the leg to enable the owner to cross a muddy river bed.

He taught me basic woodworking skills when he built a canoe with me, aged 13, and a few more, when, at 16, I built a kayak. This may be why they gave me a handsome tool set for my 21st birthday.

1. My Mechanic's and Carpenter's Tool Kit

What do I use and enjoy almost every day? Still (after all these years!) several tools from the Mechanic's and Carpenter's Tool Kit given to me for my 21st. The open-ended and ring spanners are nearly outmoded by a socket set but all the rest, including the brace and bits, still see occasional use and sometimes there is still no substitute for careful use of the Stanley hand plane.

2. My little cross-peen hammer

Coming from the kit, this is without doubt my most frequently used tool. It seems just the right weight for any number of little jobs, whether it is putting in fine pins or bending over some light sheet brass or copper in the vice. It's so useful that I bought a similar-size ball-peen hammer but I find I rarely use even its hammer end, and pick up the favourite instead — it may

be the balance. A lighter one of course has a quicker blow, and using a big one for greater effect isn't the whole answer!

3. My Goscut

Another particularly favourite tool is the Goscut, which my wife gave me years ago. I don't recall ever seeing one beforehand. Their history on Google is interesting.

I quite enjoy a little simple sheet-metal work. Very early I inherited a curved pair of sheet-metal cutters from the few in my father's toolbox in which there was also a brace and bit, and a set square.

Using curved cutters it is easier to see where you are going and you can face them the other way. There is a joke about surgeons who use curved scissors to cut straight. I later bought a straight pair and much later a set of three 'aeronautical' snips. These are great but still have limitations of access.

Goscut's great advantage is that ►



4



5

7

the cutting is done from the back and the other side of the cut doesn't get in the way. The adjustable throat allows for cutting different thicknesses of metal, a small strip of which it necessarily and sometimes usefully removes. The broad blade can cut accurately to a line and the narrow blade around quite small curves.

4. My Panasonic offset snap-fit rotatable chuck drill driver

My wife also spotted this years ago and I quickly bought it. It was a cancelled export order. I haven't seen any others with a similar chuck. It is getting quite dated and is only 9.2V but it's so quick and easy that I use it almost every day. I can change a drill or driver bit with one hand. Replacement batteries are still available, although I'm only on my second. No centrally driven chuck can get so close to an edge, and being able to change the angle is surprisingly useful. It's also lighter than the modern alternatives.

5. My vernier caliper

Yes, I do have an electronic one but the inexpensive, simple one comes in very useful for so many jobs, whether for checking a depth or the thickness of

something that I'm working on, as well as accurate measuring. If I am planing wood, I can set it to the required size and instantly check both if I am down to size and that the faces are parallel and at right angles to the sides. All at once it replaces calipers, tape or ruler, and set square.

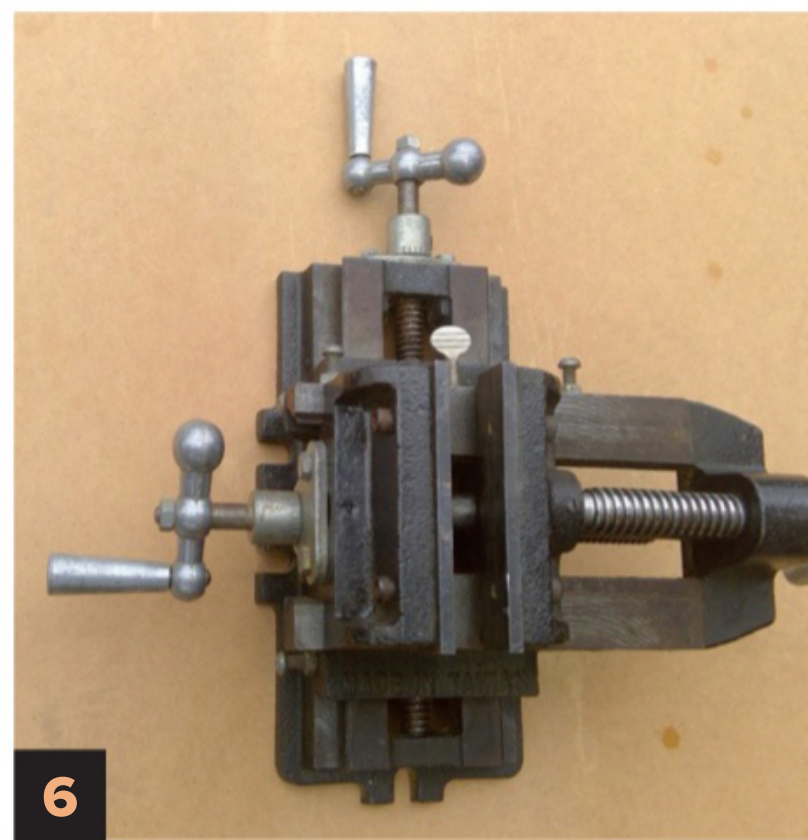
6. My adjustable drill-press vice

This allows fine adjustment for accurate placement of the drill in a way that hand adjustment can't.

7. My B&D Workmate

This extravagant purchase as a young married was because Black and Decker (B&D) Workmates had just been produced and it was clearly particularly suitable for any job that I might decide to do. It also provided a workbench that could be folded away in a small flat.

Although I now have a large workbench with an antique wood vice and other working vices attached, probably half of all my work is still done on the Workmate. To my lasting regret and on the basis that it was stronger, the salesman persuaded me to buy the steel-framed version rather than the lighter aluminium one. I am reasonably careful



6

and there was no price difference. The legs and stays anyway are aluminium and have stood up well in over 50 years. The blue paint is now peeling and I have replaced the holding lugs and screw-in feet.

I have plenty of clamps (you can never have too many) but the Gripmate holdfast is particularly useful. Though the top of current models may be the same, I feel the frame design and bent metal legs are less satisfactory. Mine is perfectly safe to stand on!



8. My Bosch jigsaw

I find this incredibly useful. I almost always use a T101B blade, which gives a very fine finish. The adjustable oscillation means that I can cut veneer or laminates without spoiling the edge. I even occasionally cheat a bit as I can use it almost like a mini planer to straighten an edge.

The angle baseplate works well. I

bought the fence as an extra and use it quite frequently although I often clamp a straight edge to the work. I cut large panels this way. The fence's facility for cutting circles is occasionally useful.

9. My Scheppach linisher/sander

This is a relatively recent addition. I should have had it long ago — my saw

table bears the scars of trying to use a belt sander on its side.

One with a longer flatbed would be useful but a lot can be done by offering the work slightly obliquely across it. If a much longer piece has to be straightened this can be done by scribing a line, holding it in the Workmate, using a planer or belt sander, and looking along the finished edge. ►





10

The disc with adjustable baseplate makes sanding small or even tiny things straight or to a precise angle a breeze. One can safely hold tiny pieces closely with the fingers using the down-going side of the disc. Caution though: nasty kickback can happen if one uses the up-going side!

10. My Ryobi table-saw bench

Why should I feel slightly ashamed of this?

Yes, it is cheap (and remember my genes). Yes, I would love a nice, solid cast-iron saw bench with extension rails and more sophisticated adjustments (which would take up a lot of floor space). I don't use a lot of large panels and seem to manage remarkably well with this. It is stable enough on its stand and light enough to be easily moved. Some of the other brands that are more than twice the price don't look very different.

The 5mm spacing of the ribs on the bench allows accurate adjustment of one or other side of the (reversible) fence to within 1mm. This applies also when I'm using my Bosch router, for which holes

are very conveniently arranged.

If I'm cutting a large sheet I can place it on this and the Workmate, using two lengths of 4x2 if necessary. Using a clamped straight edge and probably my Bosch jigsaw with smooth blade I can get an edge that needs barely any finishing.

11. My Bosch router

In its day it was quite modern. It has a 'plunge' feature and even a depth guide. As it's mostly mounted on the sawbench, I now rarely use the fence that came with it.



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12. My narrow-gland nut pliers

Like the light cross-peen hammer, these came in the toolbox that I was given for my 21st.

It's a good-quality chrome-vanadium tool and, although quite slender, can grip very firmly. The slim jaws reach easily into smaller corners than most, where the angle seems particularly good for bending sheet metal, and they can reach in narrow places to tightly grip a nut. Unlike some others, the adjustable jaw is reliable despite having had heavy use.

13. My 300mm pry bars

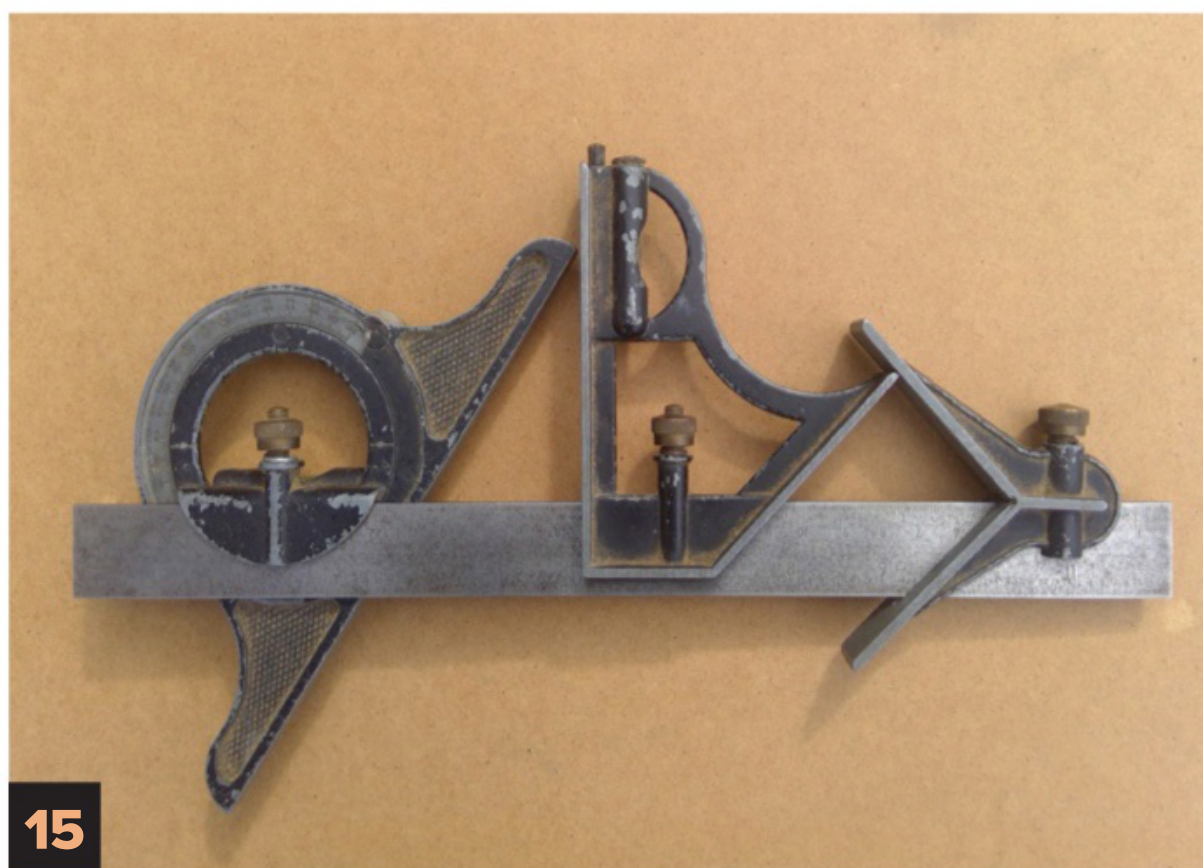
This strong tool comes in useful in very many ways, not just for levering things or removing nails.

The long end is narrow enough to open quite small tins, and sharp enough to spare chisels' inappropriate 'careful' use scraping off glue, 'gently' levering, or worse. It is useful as a wedge and for separating things (one can hammer on the other end), as well as for heavy jobs such as lifting the edge of pavers. I have two and quite often use them together or in opposition.

14. My scribing block

I should use this more often.

When you have mastered the trick of holding it firmly, watching the grain direction, and making a deep enough mark without being dragged off the line, it is often better and easier than a pencil line — particularly for marking the wavy side of a piece of wood near the edge that needs planing, for matching the thickness of one piece to another, as well as in a number of other situations.



15. My combination set square

This old tool is very useful for edge-marking, checking, and copying an angle, as well as as a set square.

The inbuilt spirit levels are occasionally very useful, as is being able to protrude the ruler behind the square, or advance it. I use the 45-degree side quite often, and marking two lines using the V-block simply and easily finds the centre of a circular piece. The various sections are easily removed (watch the inserts and springs) and

they replace, locate, and lock accurately as required.

16. My mini hacksaw

I find I choose this frequently for cutting small things quite accurately — wood as well as metal. The ends of a small, halved joint or cutting off small extras can be done with little need for filing, so it joins the list of frequently used tools.

Part of the satisfaction of not having every possible tool is that of achieving a good result without them. Our predecessors set great examples with the pyramids, etc. 





KEEPING THOSE SHED SKILLS ALIVE

As people live longer and more baby boomers hit retirement age, the number of people choosing to live in retirement or rest homes and take it easy is also rising.

This older generation has a massive collection of diverse skills, acquired from the days when people fixed things themselves, when men got together to build a house, add a room, make hay on farms, or lay a concrete pad or driveway.

A time when do-it-yourself dated back to pioneering days and many people acquired and passed down skills through the generations. If you didn't have the skills, then someone you knew could plaster up your Gib board, rewire

THE CHANGING FACE OF RETIREMENT VILLAGES

By Ray Cleaver

Photographs: Rob Tucker

your car, change a head gasket, or had a concrete mixer in their shed — maybe one turned by hand, but it did the trick.

There's a wealth of skills with these older guys — such as joinery skills, construction skills, mechanical, painting, and electrical-work abilities — from the

days when you didn't call a tradie in, you did the job yourself or got friends and relatives in to help.

Some of these guys have slowed down a bit but skills acquired and used over many, many years don't just go away.

No rest for the wicked sheddie

Retirement villages and rest homes once were places where you went to put your feet up, maybe get some care, and maybe share some company. Folk today live longer and are more active, and some retirement homes are now offering sheds, where residents can tinker, make things, or pass on skills.

Right: Sharing knowledge and keeping out of trouble

Below: Graham Steele with one of the Christmas trees the boys put together



Left: The boys, one with their feet up on a newly restored garden seat, and two with one of the Christmas trees they have made. From left, Denis Whiting, Owen Davies, Noel Titchener, Graham Steele, and on the seat Neil Spedding

Right: Neil Spedding and one of the notice boards / art stands that the residents have made in their shed



Below: Owen Davies with a book of past projects



When men got together to build a house, add a room, make hay on farms, or lay a concrete pad or driveway

One such place is Summerset Mountain View in New Plymouth where the shed and benches are provided, and residents provide the tools to make what they want.

Summerset, with 240 residents, provides a bar, pool, library, and bowling green, but for a group of the guys the shed is a good place to hang out and make things.

Their shed even has a bar and lounge with TV attached to the workshop.

"It's our man cave," says resident Neil Spedding with a grin. "Women are welcome ... They can call in as long as they bring pikelets and scones."

"They give us stick about our shed but they have their hair salon, which is no use to us — we don't have much on top these days."

They worked out of a container for the first few years and this year the new workshop was built. ►



Planning the next project in the retirement-village workshop

Boys in the shed havin' fun

The day *The Shed* visits, there are three retired farmers, a retired electrician, and an ex-procurement officer for the oil industry. They obviously enjoy having a laugh.

In the past, they have made 32 wooden Christmas trees from pallets, and these, complete with flashing lights, are placed around the village in the festive season.

They found a garden seat on nearby land that was leased by a pony club and, as it was in a bad shape, they got together and rebuilt it.

They have made jigsaw boards for residents and wooden stands for residents' art works.

The village now wants some planter boxes made and the boys have got the job.

"When we finish a job it's good to put our feet up in the lounge and have a few beers, or put the kettle on," says resident Graham Steele, who they call 'Bob the Builder'.

"We don't have to do maintenance on our own homes, so it's good to use our accumulated skills," he says.

Some other residents just come along and help out by doing some painting.

"Actually we've got pretty good at

scrounging wood and paint," Graham tells us.

The guys agreed that one thing they would really love to have is a wood lathe to work on, and teach others.

All the residents have a door key to the facility and for safety's sake the power tools are locked in a cupboard.

Village manager Wayne Mackay says that all the new Summerset villages now provide a shed. "It's a good opportunity

for the guys to share their skills and experience. They enjoy working together on projects too," he says.

*"Women are welcome ...
They can call in as long
as they bring pikelets
and scones"*



The shed even has a bar



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The Rhino Cart Mobile Fixturing Station is a turnkey table and clamping system for welding and fabrication. The reversible, flat, 1200mm x 750mm tabletop is CNC machined with 16mm holes for easy jigging, accuracy, and repeatability in set-ups. The nitrided finish protects against weld spatter and rust. The Rhino Cart® package includes the mobile welding cart — which also has built-in storage — leveling feet, and a 66-piece fixturing kit. Kit content may differ from the image. Extended special now until the end of August 2019 for \$5405 from participating retailers nationwide. For more information, email sales@isl.nz.

NEXT-GENERATION CUTTING

Tusk MCO cutting wheels and grinding discs are the latest generation of high-performance, angle grinder cutting discs designed for fast, burr-free cutting or stock removal of hard ferrous sheet metal or stainless steel. They are made from high-density single-crystal aluminium oxide, which is twice as tough as standard aluminium oxide, and feature an abrasive grain that is continuously exposed during use to maintain an aggressive cutting edge. The result is low heat build-up and a dramatically longer tool life.

In testing, the cutoff wheel cut a continuous clean 800mm channel through 10mm steel twice the length of its competitors in the same time. 1mm cutting wheels and 6mm grinding wheels are available in 105, 115, 125, 180 and 230mm diameters.



A PLACE FOR EVERYTHING

Simple to put together without the need for tools, the Hafco RSS-4WS Industrial Racking Steel Shelving (Order Code: S014) is 1955mm tall, 610mm deep and 1830mm wide and weighs 56kg. The feet can be bolted down and the whole unit is powder-coated. The vertical posts are of a 64 x 38 x 1.6mm heavy-duty C-stud section design, braced with 40x18x1.4mm C section strengthening supports. Each of the four reinforced wire mesh shelves have a 364kg load capacity. The shelf rails are secured into position with a locking wedge system. You can double the storage with an optional racking extension (Order Code: S014A). RRP is \$342.70. Visit machineryhouse.co.nz/S014 for more information.

THE ART OF MAKING CHESTS AND BOXES

By Coen Smit

Photographs: Coen Smit

MAKE THE EFFORT TO CRAFT A USEFUL ADDITION TO THE HOME THAT WILL ALSO BECOME AN HEIRLOOM

A nicely made chest can be a handsome addition to the furniture of any home and it is the sort of project that most sheddies will tackle sooner or later. A well-made and evocative chest can easily become an heirloom passed down from one generation to the next while quietly and unobtrusively fulfilling its primary function of being a storage receptacle. I can still recall in detail the chests and trunks that my parents had of which my siblings are now the custodians.

A job worth doing well

When you embark on your own journey to make one, remind yourself that you are laying down memories for your children and descendants yet unborn. Chests have a myriad of uses around the home, housing blankets, clothes,

*If I make the effort
to build something I
would like it to
outlive me*

camping gear, toys, shoes, socks, and even books, to name but a few. A chest is a boon when it comes to a quick tidy up, and if made with a bit of flair, is nice to have around as well. They also make great gifts and act as a constant reminder of you because of the care and effort that you invested in making them. For these reasons, making a chest or box is a job worth doing well.

The boxes I have built have one thing

in common. They are all made of real timber. If you want a box that does justice to the effort you have to put in to construct it, you simply cannot go past using natural timber. If you use processed timber such as MDF, particle board, or even plywood, you end up with a product that has none of the character or longevity that you can achieve with real wood.

If I make the effort to build something I would like it to outlive me. Therefore, for me there is no real choice but real timber. I have found that a mixture of recycled and newly purchased timber is probably the most effective way to build affordable boxes and chests. Recycled timber also adds a certain patina to the finished article and avoids that perfect, mass-produced, machine-made look. Of course this approach influences the ►



Above: An art-deco-style box using a combination of brass, copper, and timber to accentuate its features

Left: A simple box, used to hold paperwork, made from Tasmanian oak and myrtle. The top was cut out using a scroll saw

Right: A small box made from Huon pine using a bandsaw

Below: A mid-sized box in the style that sailors on whalers may have used, decorated with the animal life of the Arctic Circle





This and the facing page: The construction stages of the steamer trunk and (right) its final incarnation — the perfect place to keep my *Shed* magazines for easy reference!

size of the finished article to a degree, as you have to work within the constraints of the recycled materials used.

What to build?

To inspire you with the possibilities available, a Google image search offers a wealth of boxes and chests with features that you may want to incorporate in your own design, so before you plunge in, check out what the competition has built. Having said that, I personally build with a flexible, let's-see-where-it-takes-us approach, rather than a prescriptive image of what I want the finished item to look like. This may not suit your way of working however, so if you prefer, sketch a design before commencing, or copy one that you like.

An important constraint to bear in mind is that your satisfaction in making this item is likely to be in proportion to how closely it matches the dimensions of 'the golden ratio'.

That mathematical ratio of 1:1.618, which suggests that if side A = 1 then the closer that side B comes to being 1.618 times the size of side A, the more pleasing it will be to the human eye. Of course it is not essential that it conforms exactly; you may well be influenced by factors such as the eventual use the box is to be put to, or where it is to be situated. Just bear in mind that if the finished article is not pleasing to the eye, you are unlikely to enjoy having it around in the long run.

If you follow these simple guidelines you will end up with a piece of interesting and useful furniture that lends itself to many applications and will easily achieve heirloom status in your family.



Your build tools

The tools you will need depends largely on the types of chests and boxes you decide to make. If, for example, you would like to make a traditional Viking chest, you are not going to want to use a cut-off saw, routers, drills, or a thicknesser. If, on the other hand, you would like to build a modern interpretation of a Viking chest, these tools will be very handy. Similarly, a bandsaw and a scroll saw are very useful if you want to make smaller, intricate boxes or if you want to incorporate

decorations in the finished article but are not essential for larger chests.

Larger chests may require you to join timber lengths, in which case you will need access to clamps, a biscuiter, and a thicknesser. If you want to use dovetail or finger joints, a router will greatly simplify the process. As a minimum I would recommend using an accurate bench-mounted drop saw capable of cutting at various angles — this will help speed up the process and enable you to make more exotic corner joints. ►



“Chests have a myriad of uses around the home, housing blankets, clothes, camping gear, toys, shoes, socks, and even books, to name but a few”





“Take the opportunity to hide the fact that despite your best efforts the chest isn't perfectly square”

Above: A sizeable toy chest for my grandson incorporating wooden hinges and handles as well as his birth sign on the lid and some copper strips as accents

Below left: A small jewellery box made from black-hearted sassafras and myrtle incorporating an old belt buckle

Below right: The jewellery box was made as a single piece then the lid was cut from the finished box on a bench saw to ensure that the lid perfectly matched the base of the box





A Viking-style chest showing the dowels that hide the screws, the simple plank construction, and timber hinges in keeping with the era. Viking-style drawings have been routed in the sides and another glued to the lid from myrtle offcuts"

The box's hardware

Hardware for boxes and chests extends mainly to hinges, handles, and closure mechanisms. I think it is important to select these items to suit the style of the chest or box. For example, a piano hinge on a chest that evokes the Viking era would look out of place as much as a rawhide leather hinge would on an art-deco jewellery box. Of course you need to draw a line between what is required to make it look the part and how functional the finished item will be. On a couple of occasions I have made the hinges and handles myself and, in my opinion, they added to the overall character of the finished chest.

For those of you embarking on the construction of your first box or chest I recommend that you start with a larger unit. Going down this route you will minimize the small finicky aspects of these projects as you build your competence. A chest approximately 800x500x300mm is more forgiving in terms of installing hinges, squaring the corners, and incorporating all the detail finishes, than a jewellery box 120x80x40mm when precision suddenly becomes paramount.

Getting the right look

Regardless of what size and shape box or chest you decide to make, ensuring that the corners are square is essential, or if it is more or less than four sided, that it is symmetrical. Nothing ruins the look of one of these items more than asymmetry!

To ensure that this does not happen measure and cut the timber precisely.



When assembling, measure across the diagonals of the box and adjust the clamping of the box sides until they are equal before gluing and screwing them together. Another good method is to accurately cut out the base to fit inside the sides of the chest as this will help to square the sides during assembly. You should still measure the diagonals to ensure that the top of the chest is also square because even a small inaccuracy in the base, or introduced when attaching the sides, will show up in the opening at the top. If you are building a smaller box or chest, a good way to ensure that the lid will be a perfect fit to the sides is to construct the lid as one with the sides. In effect you have a closed-up box. When the whole unit is glued and finished you can then cut the lid from the sides on a table saw. This method saves a lot of time in separately constructing the lid and is ideal if you want a raised lid.

The finishing touches

Having constructed the basic chest it's time to incorporate any embellishments to give the finished item added appeal. This is also a great way to hide any slight imperfections and misalignments that may have crept into the project. Using a contrasting timber you may want to emphasize the corners of the chest and take the opportunity to hide the fact that despite your best efforts the chest isn't perfectly square or doesn't sit flat on the floor. The accompanying photos show some embellishments I have resorted to in building my boxes and chests. Some have been purely decorative; others have allowed me to use up timber offcuts or have hidden small imperfections.

Small detail features can also hide modern construction techniques in boxes meant to convey the impression that they were built using traditional methods. For example, the Viking-inspired chest uses simple butt joints, which I glued and ►

“Every little extra detail you put into the job is a reflection of the pride and thought you put into your creation”

screwed making for a much easier build and a stronger overall result. To hide my handiwork and to maintain the correct look, I sunk the screws and then glued short lengths of dowel over them to give the impression that the chest was put together with dowels similar to what the Vikings themselves probably resorted to.

I also like combining different materials in a chest or box to act as highlight points. For example, copper or brass can be used to reinforce corners and edges. Using contrasting species of timber is another good way to draw the eye to details such as the hinges and handles. I have also found that we often refer to a chest either by its use or a distinguishing feature, therefore it's nice to add those small visual clues that help define it.

More than just a simple box

Despite the fairly simple look of a finished chest it is remarkable how much time it actually takes to make one that is more than just a simple box. The amount of attention to detail and the finish you achieve will ultimately determine the satisfaction you will feel with the finished article. A carefully crafted, decorated chest will not fulfil its purpose of storing stuff any better than a plain utilitarian version, but it will tell the story of its construction and evoke memories of the considerations and decisions you made when you built it every time you look at it.

Its plain counterpart won't evoke those feelings; after all, it is just a chest or box, whereas every little extra detail you put into the job is a reflection of the pride and thought you put into your creation during the building process. These small embellishments



A smaller box I made in the Viking style from slab timber

will individualize the box and act as signatures of your craftsmanship, both of which will help secure it as an heirloom in your family.

There is no better illustration of this phenomenon than the small box that my father made for my mother while he was a prisoner of the Japanese working on the Burma Railway.

It's a simple little box made of some

unknown tropical timber and some discarded aluminium for an inlay, yet it evokes so much about the man, the love he had for my mother, the privations he must have suffered, and yet, with the few tools at his disposal, he still made this small box not even knowing whether he would ever see her alive after the war. Without question, this little box has earned its place in my family. 📖



The small box that my father made while a prisoner on the Burma Railway, undoubtedly the most significant one in my collection

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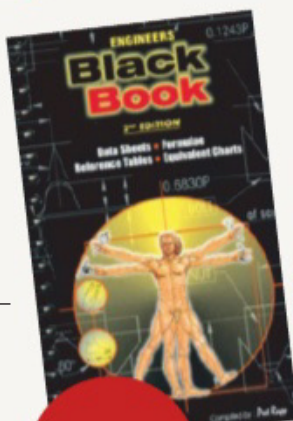
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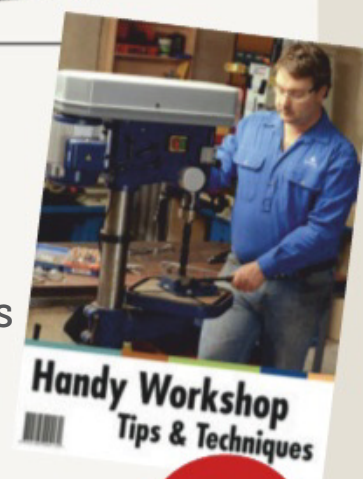
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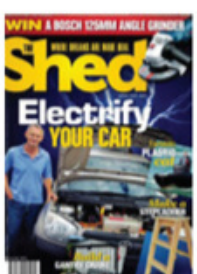
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GETTING SHARPER

By Jude Woodside

Once a year I collect all the knives from the kitchen and spend a day getting all of them sharp. Whenever I do this procedure, I am reminded of my friend Pete 'The Knife' Caulfield's motto: "Everything sharpened except wit."

As a callow youth I spent time in the freezing works where I learnt the importance of having a sharp knife. If you cut yourself on the chain you went to get your wound dressed but you were not permitted back on the floor until you had sharpened your knives. The theory was that a blunt knife meant you exerted more effort and were more likely to do yourself an injury. It's a very good rule. It also taught me how to sharpen a knife properly and how to use a steel. I still have one of the old steels from my time in the works. Unlike many I have seen this one does not have heavy striations down its length. It was common to grind the steels smooth. The steel is not for sharpening; it's for refining the edge and removing the burr. It can dress an edge to some degree but it won't sharpen your knife. There is a point where you simply have to resharpen the blade, thereafter you can maintain the edge for some time with a steel.

It is a pleasure to prepare food with really sharp knives; it feels effortless. It's no different in the shed of course — using blunt chisels is a recipe for disaster but the joy of being able to pare wood like cutting cheese is incomparable. So I usually sharpen all my chisels at the same time.

I have a sharpening device in the kitchen but it is no real replacement for having the knife properly ground. I use a wet grinding stone and then finish on water stones of 1000 and 6000 grit.

There are degrees of sharpness: arm-hair sharp (impressive), slicing-newsprint-cleanly sharp (respectable), whittling-hair sharp (scary). Scary sharp is what I'm aiming for. But the real test of a good kitchen knife has to be how thin you can slice a tomato. Only don't try it with a chisel.

I usually start sharpening with a knife that I'm not too fussed about because my technique always takes a bit of practice to get back in tune. The first one often tends to get rounded rather than sharpened, especially on the water stones where the angle you hold the blade is critical. With chisels it's not so much an issue since they

have a well-defined bevel.

Knives have to be one of the earliest tools and that might explain the curious attachment that people have for them. At a recent event at Gameco in Masterton I saw not just a fine array of the knife maker's art but a selection of swords. Not perhaps as utilitarian as they once may have been but objects of beauty nonetheless and, by the attention they garnered, also objects of desire. With their cast and engraved hilts, engraved blades, and beautifully finished scabbards, they were certainly collectors' pieces. I'm not quite so sure that the work that goes into making one can ever be fully realized — after all, we don't live in Westeros.

The old samurai swordsmiths, facing the demise of their profession with the banning of the samurai, moved to making saws and chisels using many of the same techniques that they used to make some of the finest swords. So, me in my shed sharpening my Japanese chisels links me directly back to the ancient swordsmiths of Japan.

I wonder how thinly I could slice a tomato with a sword?



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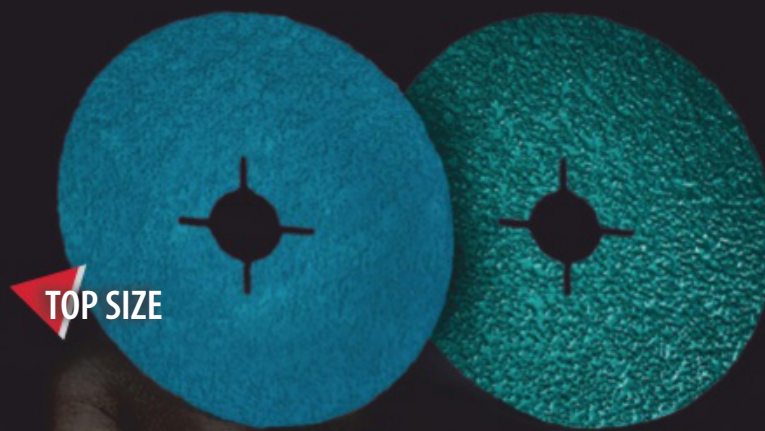
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