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CONTENTS

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MAY 2015 VOL 13, NO 10 | | BE THE FIRST TO KNOW

How Your World Works

Technology

Tested

Features

Wheels

Skills

Monthly

Cover caption: All aboard for a far-reaching revamp of our national rail network. The sleek metro train featured on our cover may be down the line, but in the here and now we have a homegrown new locomotive and big, big plans. This page: Lego's amazingly detailed Death Star set has everything a battle station needs – from Death Star control room to rotating turbolaser turrets, advanced hangar bay with TIE Advanced star-fighter and tractor beam controls. See pages 22 and 52.


71


28


12

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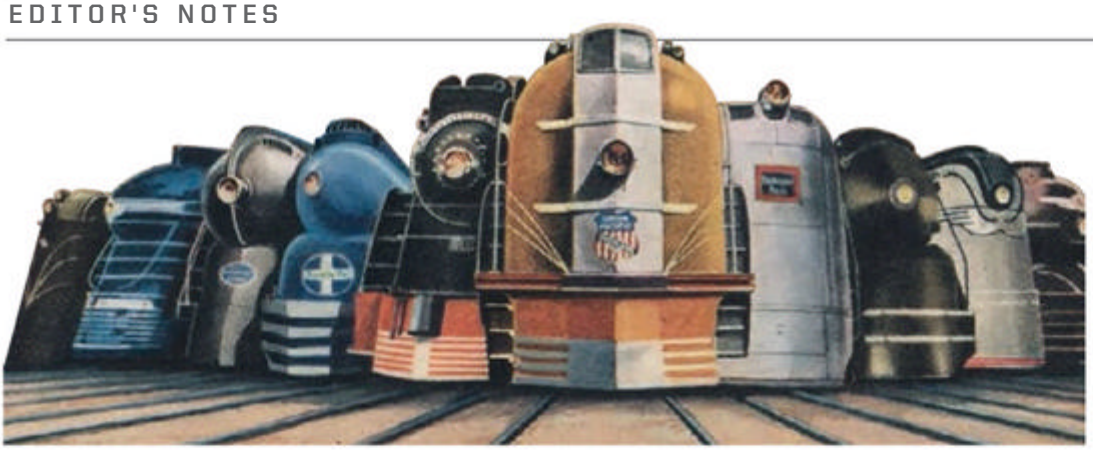


It's 2015, and trains are big news. But trains were even bigger in October 1941, when PM featured these state-of-the-art streamliners in "Science rides the rails".

RIDING THE RAILS

ANYBODY WHO HAS EVER BEEN trapped sweatily between stations during a midsummer rush hour – cable theft *again*! – is unlikely to feel anything but ugly thoughts when talk turns to the romance of railroads. Ditto anyone who has traipsed through a dusty, smelly, coalspecked railyard.

Still… there's something undeniably evocative about the keening wail of the passing long-distance express cruising through the night, the gentle rocking motion as the wheel flanges kiss the rails in a long sweeping bend, even the urgent clatter of the metro commuter as it criss-crosses multiple points.

But never mind romance, there's something undeniably practical about rail. It's a vital part of the nation's transport infrastructure. It can move massive loads – freight, people, *everything*. After all, South Africa can boast the biggest and best rail network on the continent.

That's why, this month, POPULAR MECHANICS brings you the story of what's shaping up to be a revolution in train travel in this country. It starts with a new-era homegrown locomotive and, if all goes according to plan, continues with a revitalising of rolling stock and network, from stations to the rails our trains run on.

The reality: rail isn't what it used to be. As roads have improved and alternatives – car, bus and plane – have developed, so passenger use of the rail network, particularly the long-distance kind, has dropped off. Metro areas are looking to alternatives such as bus rapid transit. Deregulation diverted freight to our roads, too. It's the opposite to what has happened in more developed areas such as Europe, where the convenience of rail has in some cases forced the closure of air routes.

Here's the thing: South Africa has 20 000 kilometres of track. That's a priceless asset. Sadly, only half of it is in regular use. Nearly a third of the total sees little or no use and many's the sad, derelict stations and train stop where the only activity is sighing winds and scuttling beetles. It's not quite the vision of the man ironically, much in the news for other reasons lately, Cecil John Rhodes: "A railway from Cape to Cairo".

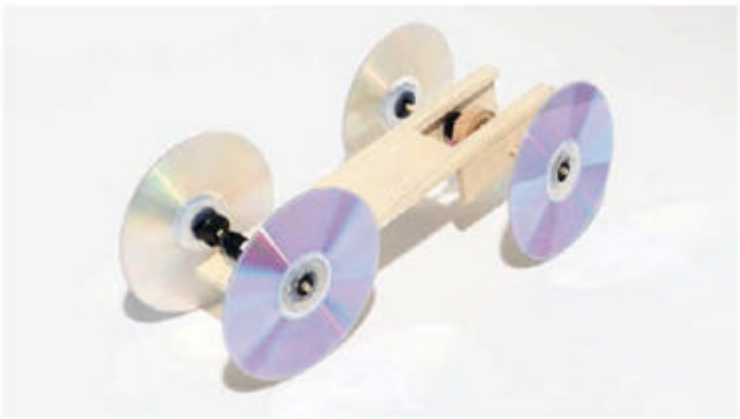
But we're due for a change.

Clickety click. Clickety clack. There's a rail revolution coming your way.

● Planning has started on the 2015 edition of POPULAR MECHANICS **FutureTech**. At this stage, the intention is to present **FutureTech** at this year's Johannesburg International Motor Show. In the lead-up to that, PM will be looking to host smaller "warm-up" events showcasing cutting-edge science and tech. Keep an eye on *popularmechanics.co.za* as well as our social media platforms – including Facebook and Twitter – for updates on what is sure to be once again a must-see event for sci-tech fans.

● Finally, our apologies for not being able to bring you our in-depth investigation into the whys and hows of fire disasters that was promised last month. The wheels of investigative justice grind slow and exceedingly small, it seems.

anthony@ramsaymedia.co.za



A gentle reminder to those of you who consider yourselves handymen: Round 2 of our DIY Challenge is drawing to a close. The challenge: devise a project suitable for tackling by a team of adult and child, along the lines of the Wind-Up Dragster featured in this issue on page 77. And may the best man/woman/child combo win!

COMPETITION WINNERS...
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WINNING LETTER

GOING OFF-GRID MAKES FINANCIAL SENSE

Off-grid power systems, from what I have read, are simply too expensive to seriously consider at between R250 000 and R400 000 for a normal household. I decided to rather focus my efforts on reducing electricity consumption.

I started by converting to solar hot water. That system has paid for itself 10 times over. I then installed a prepaid meter to take control of my consumption. Next, I replaced my hob with a gas unit, followed by LED lighting in all the important spots. I also covered my pool so that the pool motor is permanently switched off.

I then bought an energy monitor to find out where the remaining 10 units a day was going. The big shocker was the fridge and freezer, which between them consumed 6 units a day! I replaced them with a combination unit that consumes less than 1 unit of power a day. It has an A++ rating.

All of that dropped my consumption to the current 1–3 units a day. Now the question: is it still worth going off-grid? Is this not already a very sustainable solution? No matter how I do the maths I cannot financially justify a photovoltaic system, unless I leave the kitchen (excluding the fridge/freezer unit) on the grid because all my "big" appliances (kettle, washing machine, dishwasher, tumble dryer, which are mostly seldom used) are situated in the kitchen. That would leave me with at most, one unit of power to buy from the municipality per day. The rest I can supply through a small PV system of about 350 watts. This should not cost me more than about R5 000. (Our household is only two people, but the savings are scalable.)

It would cost about R42 500 to get to this point, still a tidy amount and out of reach of many South Africans. So why not borrow from your bank and pay them back from the saving? The saving in my case would be about 45 units a day – that comes to R28 000 a year or R2 333 a month. I worked on the expected average price of R1,75 per KWh over the next two years, because that's the period over which I want to pay it off.

If I pay my bank R2 333 a month and borrow at 9%, I can service the capital amount of R42 500 in just 20 months. After that I will enjoy the full R2 333 saving every month.

So my solution: first reduce your power consumption as far as possible, then look at a small PV system for most of your remaining requirements and leave the really big appliances (which are often seldom used) on the grid.

JOHAN JORDAAN
PRETORIA

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Send your letter to: Popular Mechanics, PO Box 180, Howard Place 7450, or e-mail popularmechanics@ramsaymedia.co.za Please keep it short and to the point. Regrettably, prizes can be awarded only to South African residents.

MAKE FAIR COMPARISONS

In response to the "Barroom rant" in favour of pushrod engines (Wheels, March 2015), I must point out some half-truths about the Chrysler Hellcat engine mentioned. Firstly, multivalve engines create more valve area so that less cam duration, less lift, and less overlap are needed to allow the same amount of airflow, yet with smoother running at low revs.

Furthermore it is not pushrods that make an engine shake. It is "overduration" combined with the massive overlap of the cam at low revs in conjunction with the very large inlet ports causing a low gas speed when idling. This low-end inefficiency is what causes 'the shake'.

And, by the way, the Hellcat is most definitely computerised: it runs one coil per cylinder and the ECU controls both timing and fuelling.

Regarding the issue of two valves vs multivalves, just because Top Fuel dragsters mostly use two large valves per cylinder with pushrods, don't be fooled. It is their nitromethane fuel that makes them powerful, not their efficiency. In the mid-1980s, Top Fuelers' power output was at best 435 kW per litre, or 3 360 kW (4 500 hp) from an 8-litre engine. Yet a turbocharged multivalve engine in this era, running on high-octane fuel – not nitromethane – cranked out around 700 kW per litre.

A better way to equate apples with apples or, in this case, of clearing up a "barroom rant on pushrods" and comparing Amstels with Heinekens, take the 2015 Hemi Hellcat. This engine makes 85 kW per litre of engine capacity with a supercharger. Compare it with the Honda S2000 engine, designed pre-1995, which pushed out 90 kW per litre without a supercharger or turbocharger.

ANGUS MOODIE
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WHO IS REALLY UNDER THREAT?

"The Threat Report" (March 2015) is disappointing in several ways.

Firstly, it is a thinly veiled propaganda piece for a pro-Western narrative, utilising the giant and dwarf propaganda technique, portraying Russia as the evil giant and NATO as the small and innocent dwarf. Secondly it underestimates the intelligence of its readers.

The reported threats by Russia do not even come near the illegal international actions of NATO members. In the past, America and its NATO allies have destroyed governments unilaterally, in total disregard of international law and the sovereignty of nations.

The countries I refer to include Namibia, South Africa, Cuba, Vietnam, Nicaragua, Iran, Afghanistan, Egypt, Iraq, Libya and Syria. NATO has bombed countries ranging from China to Yemen. Senior US military officers admitted in remarks published in *The Washington Post* that the US war against Iraq was intended to murder large numbers

of Iraqi civilians and destroy the ability of Iraq to sustain itself as a functioning nation. The continuing United Nations sanctions and embargo against Iraq have the same purpose.

The actions of America and its illegal band of NATO terrorists are clearly on a road of global rampage, plunder and destruction, against which the "threats" of Russia pale into oblivion. Perhaps POPULAR MECHANICS can become even more popular by publishing the truth, written by someone with a greater understanding of war, strategic thinking that is unbiased in his writing, rather than publishing the writings of someone that is voicing the narrative of rationalisation provided by the current international terrorists destroying our planet, nations and resources on the basis of being Western, and therefore automatically right.

PIETER OOSTHUIZEN
BY EMAIL (*SHORTENED.*)

TINKER, TAILOR

I've been in the repair business most of my life and although taking something apart out of curiosity is a certain way of learning, this is not where it should stop. Putting it back together again is the real accomplishment.

Repairmen more than often come across devices, not knowing what they are supposed to do at first, let alone what is wrong with it. The challenge then lies in the routine of establishing how it is supposed to work in the first place and then what is wrong with it.

One of the best sources for that info is the operator. If a repairman falls into the ego trap of: "I know better than thou", this could make things difficult for him.

About 35 years ago my neighbour, a typewriter repairman, amazed me when he took apart my old Remington electric (on the dining room table) into millions of pieces, to reach a specific spot needing attention. After that he not only effortlessly put it back together again, but also set it up to perfection in a matter of hours.

Over the years I met some excellent self-taught craftsmen, including furniture (cabinet) makers and mechanics. In each case it was easy to see that they did not go through the basic mill of apprenticeship training for basic hand tools. This was easily noted when watching them use hand tools such as the hacksaw, wood chisels, files and thread taps, among others. I wisely did not interfere.

Repairing something has and will remain among one of the most fulfilling accomplishments one can hope to experience.

PIETER BLIGNAUT
BY EMAIL

NOT SO FAST...

Ahem... perhaps I am missing something, but on the issue of the speed of the Earth's rotation (Great Unknowns, March 2015), you're moving at 1 670 km/h – but only at the Equator.

The further you move from the Equator towards either the True North Pole or True South Pole, your "speed" progressively decreases by the cosine of your latitude. At a latitude of 45 degrees (north or south), for example, cos(45) = 0,707, so your speed is merely 0,707 x 1 670 and you're rushing along at "only" 1 180 km/h. At 53 degrees north or south it's "only" 1 000 km/h.

Now maybe this explains something... Johannesburg, 26 degrees south, speed of rotation (cos[26]) = 0,899 = 1 500 km/h. Cape Town, 33 degrees south (cos[33]) = 0,839 = 1 400 km/h. Talk about the hare and the tortoise! No wonder people in Joburg always bang on about things being slower in Cape Town.

Ultimately, however, when you stand right on either of the true Poles, your "speed" is 0 km/h and all you're doing is turning through 360 degrees per day... fortunately not fast enough to make you dizzy.

But irrespective of where you are on the Earth, you're still moving... around the Sun at 108 000 km/h (again, due to the Earth's rotation, this actual speed will fluctuate, according to your latitude, slowing by 1 670 km/h if you're on the Equator and then speeding up by same amount depending on where you are in the Earth's rotation.

But all that pales in comparison with the Sun's orbital speed around the Galaxy. That is around 720 000 km/h – and we're all being dragged along for the ride.

ROD BAKER
FISH HOEK

MASTERPIECES OF THEIR TIME

The article on watches was very interesting and informative. But the article overlooked two major developments in the history of watches.

The original Bulova Accutron. This was introduced in 1960 and remained in production until 1977. It was the world's first watch with an electronic movement. It used a 360 Hz one-transistor oscillator to drive a tiny tuning fork on which a prong was mounted; this drove the timing mechanism and swept the second-hand smoothly round the dial. It was guaranteed to be accurate to one minute a month.

WIKIPEDIA

The Seiko Kinetic. This was introduced in 1986 (and still is) an electronic watch that has no battery. An offset weight, similar to that used in self-winding mechanical watches, drives a tiny DC generator; this charges a capacitor that powers the electronic circuitry to drive a tiny stepper motor, which clicks once per second to drive the actual watch mechanism. So one has the superior accuracy of the electronic timepiece, without the hassle of ever having to replace batteries. (Our picture shows the prototype.)

I'm sure there are other noteworthy timepieces that I've overlooked. It doesn't qualify as a watch, but the Atmos clock, devised by Jaeger-leCoultre is an example. Though – unlike the two mentioned above – they did not actually invent the method of operation, they were the first to produce a commercial version. This mechanism used the small daily variations in air temperature and pressure to wind the mainspring of a fairly conventional clock mechanism, though it ran at the rate of only 2 "ticks" per minute.

CHRIS GRAHAM
RANDBURG **PM**

1958 A Michigan inventor, PM reported in 1910, predicted that the interpreting telephone would come to pass. By 1958 (above), we had progressed to the Google Translate of his day, an East-bloc refugee and physics teacher who spoke eight languages and used a Datatron computer to translate four languages automatically – having preloaded the computer with condensed dictionaries.

1947 Safe from the danger of flying fragments and the disappointment of mangled meats, users of this ingenious device took advantage of a lever and ratchet mechanism to liberate nuts from their shells. Clearly ahead of its time, though, it survives today only as a curiosity among antique nuts. Er, aficionados.

1960 TOP: Skimak was a prototype of what was expected to be a new family hobby vehicle. Airscrew-driven, it was said to be capable of 100 miles per hour on snow and, using a conversion kit, was able to travel on water. Sadly, two things doomed it: the snowmobile and the jetski.
ABOVE: Cars that fly and boats that drive are familiar elements in fantasies about shapeshifting multi-mode personal transport. Surprisingly, motorcycles that float – well, partly – don't seem to have had quite the same impact. This novel idea started out as a boat that doubled as a sidecar. **PM**

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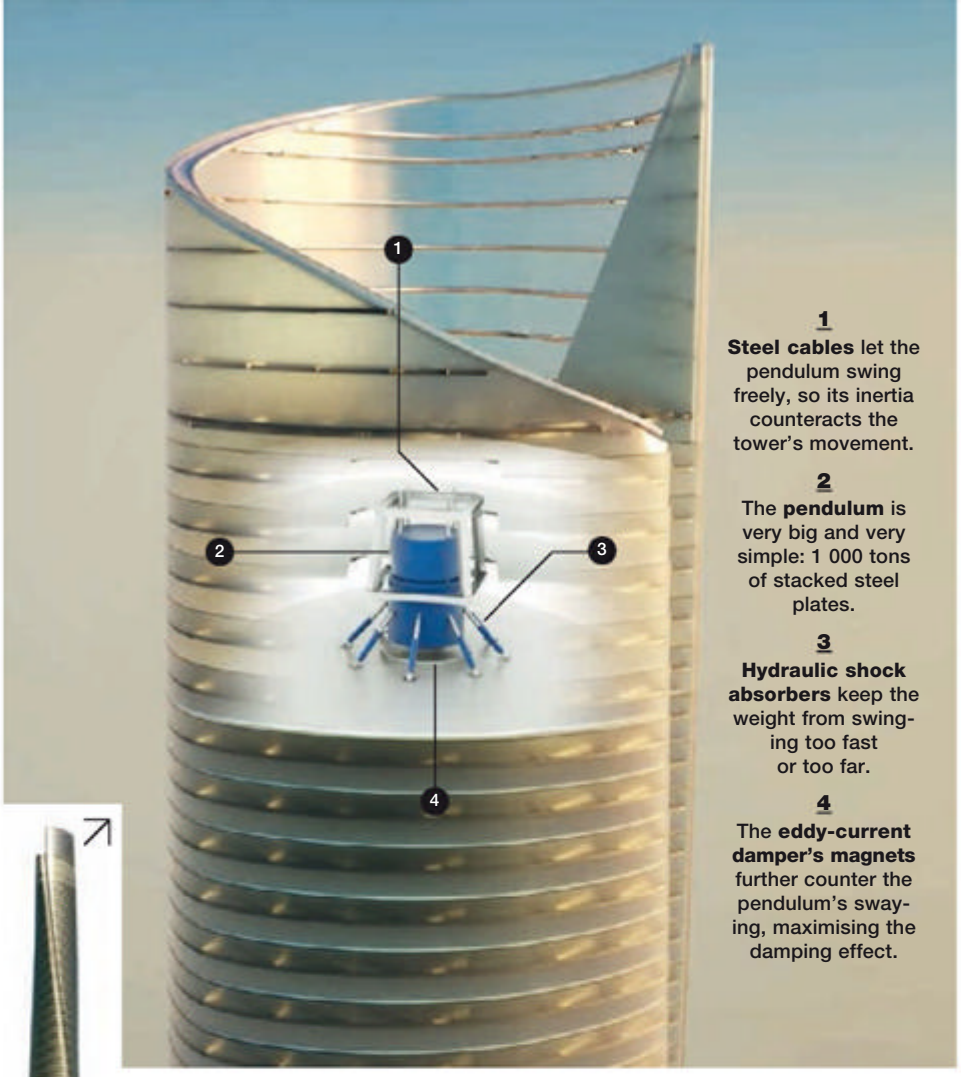
THE 121-STOREY TOWER THAT NEVER SWAYS

Okay, it sways, but thanks to a damping system being used in skyscrapers for the first time, no one will feel it.

BY TIM HEFFERNAN

PHOTOGRAPH BY NOAH SHELDON



1
Steel cables let the pendulum swing freely, so its inertia counteracts the tower's movement.

2
The **pendulum** is very big and very simple: 1 000 tons of stacked steel plates.

3
Hydraulic shock absorbers keep the weight from swinging too fast or too far.

4
The **eddy-current damper's magnets** further counter the pendulum's swaying, maximising the damping effect.

IMAGINE HOLDING A PLASTIC RULER AT one end. When you flex your wrist even the tiniest bit, the far end of the ruler whips back and forth. But if you hang a small weight on a spring at that far end, the weight's inertia absorbs some of the kinetic energy and the whipping drops to a gentle sway.

Scale that up, a lot, and you have a mass damper, the system that's used to control movement in skyscrapers by reducing both the speed at which the building oscillates and the distance those oscillations cover. Mass dampers consist of large pendulums – usually steel plates bolted together to form a solid chunk – suspended from cables near the top of the building. When the building sways in a gust, the weight's inertia acts as a counterweight, pulling it in the opposite direction.

But a traditional damper wasn't good enough for the new Shanghai Tower. At 632 m it's the second tallest building in the world, after Dubai's indulgent Burj Khalifa. On the upper floors, where the flex is greatest, the oscillations would have been fast and wide enough to cause airsickness (not to mention paralysing fear). So the building's architects and engineers came up with a solution. They installed a huge, tuned mass damper, the heaviest-ever flex-reducing weight in a building and paired it with a magnetic system to create the first eddy-current damper used in a skyscraper.

The "tuned" in tuned mass damper refers to an additional element: a control system to limit the weight's own motion, for maximum damping effect. In many buildings this is accomplished by passive damping control, but that has a couple of drawbacks: maintenance costs and the necessity for manual adjustments when vibration frequencies change. So Gensler, the architects of the Shanghai Tower, created the eddy-current damper, a masterpiece of simplicity. It consists of a 100-square-metre copper plate covered with 125 powerful magnets, mounted beneath the suspended mass damper. When the building sways, the 1 000-ton iron weight (360 tons heavier than in the previous largest damper) swings over the magnets, inducing an electrical current in the plate that, in turn, creates an opposing magnetic field, automatically counteracting the weight's motion and further amplifying its damping effect. No active control or outside power source is necessary. The magnetic flip occurs because of a version of Newton's third law called Lenz's law.

The result is not just elegant engineering, but measurable benefit. According to Benedict Tranel, one of the architects of the Shanghai Tower, most people will never feel the building sway, not even in summer, when the typhoons roar in.

HOW IT WORKS

The Shanghai Tower's enormous tuned mass damper sits just below the roof and is five stories tall.

DAMPERS CAN GO IN CARS TOO! SEE PAGE 66.

ILLUSTRATION BY SINELAB

DRYING OUT THE NEW WHITNEY

By the time the new Whitney Museum of American Art opens in New York City on 1 May, having moved from the 1966 building that housed it for forty-eight years, its galleries will have been sitting, complete but empty, for almost four months. The issue: contaminants such as sulphur dioxide, ozone, acetic acid, and chlorides, which are all by-products of standard construction materials – and which can all cause fine art to deteriorate. To remove these gases and airborne particles, the museum's HVAC system is running specific airflow and filtering sequences for 120 days. Once particulate levels are low enough, the Whitney will bring in its permanent collection, including works by Jasper Johns, Cindy Sherman and Mark Rothko.

BLACKBERRY'S LAST HOPE

The three letters that could save a dying phonemaker – and turn it into a company that has nothing to do with phones at all. BY ANDREW DEL-COLLE

WHETHER YOU BLAME CORPORATE buffoonery or the success of Apple and Android, over the last five years BlackBerry has become essentially irrelevant to the smartphone market. But the company does have one great asset: an operating system. Although it currently contributes only minimally to BlackBerry's bottom line, this technology drives two growing markets that are about to become huge. As they do, this small asset just might become big enough to give the company a future.

Back in 2010, when it was called Research in Motion, BlackBerry bought an embedded operating system called QNX (pronounced cue-nix). Most people wouldn't know it, but QNX is all around us. It runs the computers that are used to manage railroads, all sorts of hospital equipment, huge HVAC systems, and control programs for nuclear plants. Until recently it powered the yellow first-down line you see every time you watch an American football game on TV.

But where you'll really notice QNX is in your car. Modern cars are basically giant rolling computers, and on-board software and cloud services are becoming as common as extra cup holders. QNX dominates the automotive market, with clients including Volkswagen, General Motors, and Hyundai. Altogether, more than forty carmakers use the operating system to run their infotainment screens, navigation, digital instrument clusters, and even the electronic safety systems that will allow cars to operate without drivers.

The appeal has to do with QNX's diagnostic services and flexible architecture. It's a microkernel-based operating system, which QNX compares to a string of Christmas lights that have been set up in a parallel circuit rather than in series. Unlike traditional OSes (and Christmas lights), if one piece of code fails, the entire system doesn't crash. This makes finding and fixing software errors much more simple and allows QNX to more efficiently handle the staggering number of processing duties in a modern vehicle. It's more effective than the standard (and monolithic) kernel operating system, such as Microsoft's automotive platform, which is why Ford announced last year it would be ending its eight-year relationship with Microsoft and switching to QNX. Another big QNX advantage: it works with both Apple and Google's in-car systems, CarPlay and Android Auto.

If in-vehicle success were not enough, BlackBerry recently announced BlackBerry IoT, its own cloud-based network for the Internet of Things – a nascent and prosperous potential market. With QNX's history and BlackBerry's reputation for security, it could be another huge opportunity. But first, BlackBerry has to leave its phones behind. Most people already have.

A TROUBLING OBSERVATION: PEAK DVR IS UPON US

South Africans are way behind the PVR curve. DStv's current state-of-the-art Explora has a 2TB hard drive – just one-twelfth of the size of North America's equivalent, the TiVo Mega DVR. Is bigger necessarily better? Well, it's certainly more expensive: the TiVo costs R55 000 vs the Explora's R2 000 or so, but then it does hold 26 000 hours of standard-definition TV (4 000 hours in HD).

A LESSON IN DURATION

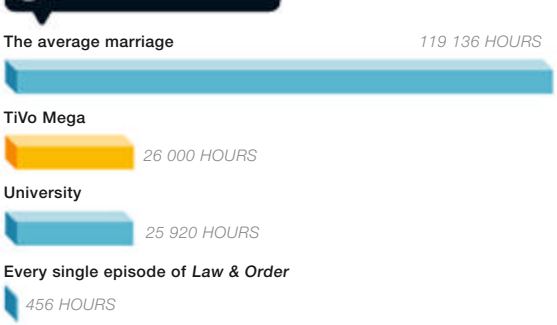


PHOTO ILLUSTRATION BY TIM VIENCKOWSKI

HMS Dragon is dramatic in its ruthlessness.

IN DEFENCE OF THE REALM

Warship HMS *Dragon* features world-first electric propulsion, a formidable armoury – and 1 000 eyes. BY SEAN WOODS

SOUTH AFRICANS GOT A RARE OPPORTUNITY to visit one of the most sophisticated warships in the world in March when the Royal Navy's HMS *Dragon* took a break from its seven-month standing patrol of the southern Atlantic to stop off in Cape Town. The *Dragon* is a Type 45 Air Defence Destroyer. That means it is primarily designed to defend the fleet against fifth-generation fighter aircraft and drones as well as highly manoeuvrable sea skimming anti-ship missiles travelling at supersonic speeds. In short, it can pack one hell of an accurate punch in a fight.

And it's future-proof, too. Commanding Officer Captain Rex Cox explains: "Technology is forever evolving. Should our Ministry of Defence opt for laser weapons in the future, HMS *Dragon* will be more than ready." With a twinkle in his eye, Cox continues: "As far as the fortunes of war go, one must never forget the element of surprise. That said, I'd say we're definitely holding our own at the moment."

Lighting up the sea

The Type 45 is the world's first fully integrated, all-electric-propulsion front-line warship. Its power plant is capable of generating 47 megawatts, or enough power for 125 000 homes. This city-sized generation capacity also means more modern weapons systems can be fitted at a later date.

KEEPING TRACK

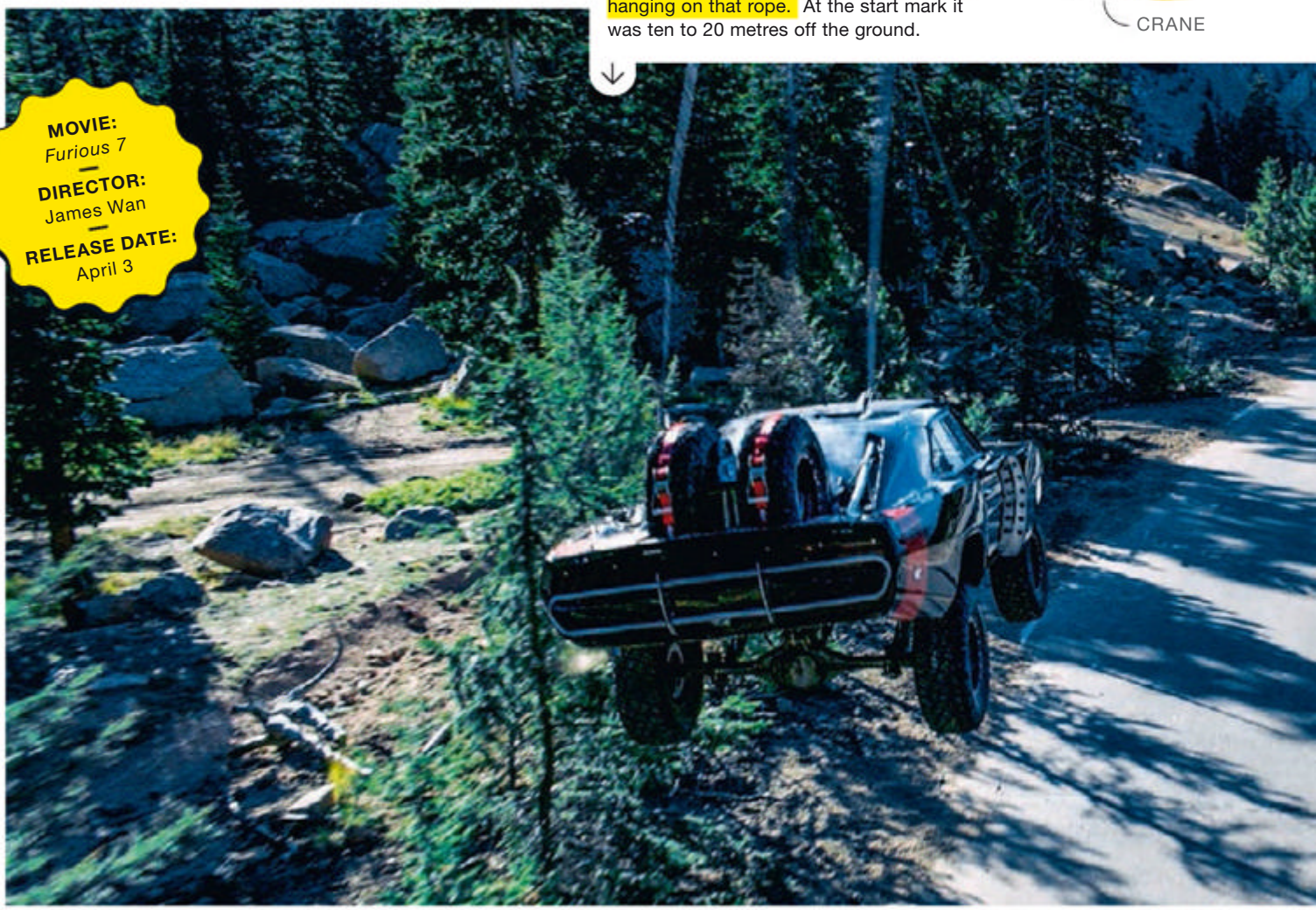
Equipped with the sophisticated Sea Viper (PAAMS) air-defence system – utilising the SAMPSON active electronically scanned array multi-function radar and S1850M long-range radar – HMS *Dragon* is said to be capable of simultaneously tracking 1 000 objects the size of cricket balls, travelling at three times the speed of sound (Mach 3). Once specific threats have been identified, it can launch multiple Aster 15 and Aster 30 "hit-to-kill" anti-missile missiles capable of intercepting all types of high-performance air threats at a maximum range of 120 km. Both missile types are guided autonomously and equipped with active RF seekers, enabling them to cope with "saturated attacks". The vessel's current weapons set-up involves a 48-cell A50 Sylver Vertical Launching System, allowing for a mix of up to 48 Aster 13 and Aster 30 missiles.

HOW'D THEY GET THAT SHOT?

MOVIE:
Furious 7

DIRECTOR:
James Wan

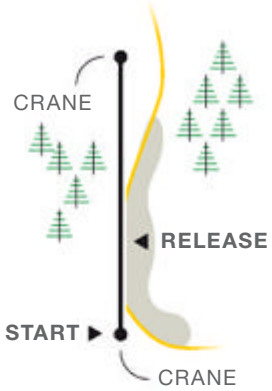
RELEASE DATE:
April 3



We asked two of the people most responsible for the action in the seventh installment of the *Fast & Furious* franchise – second unit director Spiro Razatos and second unit stunt coordinator Andy Gill – to walk us through a particularly tough but amazing shot.

WIRING

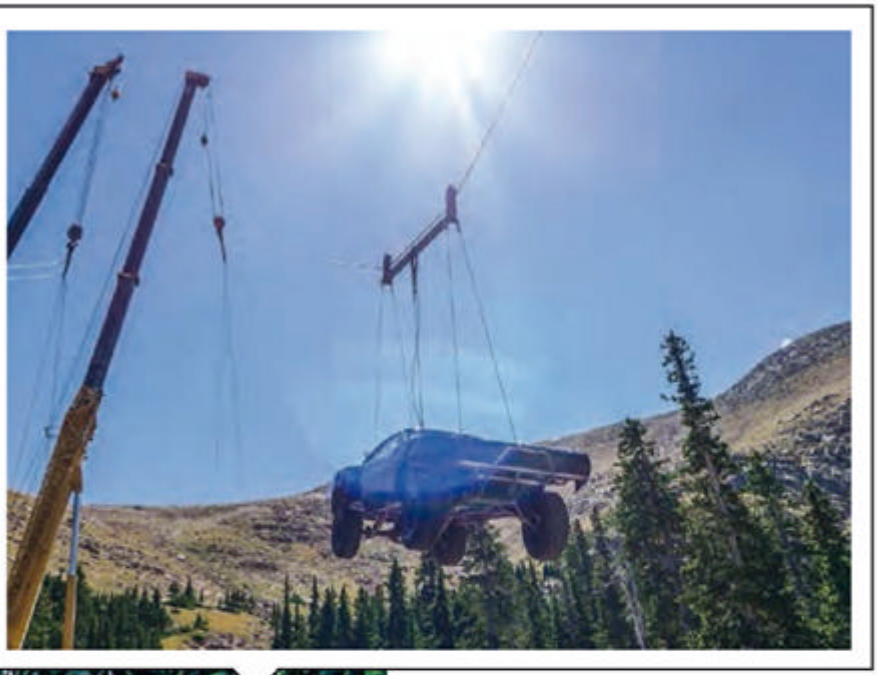
In this scene Vin Diesel and his crew of affable criminal grease monkeys are chasing a bus with valuable cargo. The bus is racing down a secluded road, so they've just parachuted their cars out of a plane to catch up to it. (Obviously.) To get forward movement in the car, we brought in two 300-ton cranes, one at the top of the road and the other at the bottom. They had 25 mm rope strung between them. The car is on a skate and hanging on that rope. At the start mark it was ten to 20 metres off the ground.



ALTITUDE

The high altitude at Colorado's Pikes Peak – the summit is 4 302 m, and this scene was shot at 3 600 m – was tough on the crew in terms of breathing, but also tough on the cars. At 3 000 m you lose 30 per cent of your power and it keeps dropping from there. The lack of oxygen interferes with the combustion process.

THE CAR
This 1970 Dodge Charger is hand-built. The only stock parts are the roof and the tops of the quarter-panels, and even those are fabricated a bit, adjusted to fit. It has a tube-framed chassis similar to an off-road rally car's, King coil-over and bypass shocks and an independent front suspension. The 390 kW LS3 engine was moved back to shift the center of gravity to handle the jumps.



ENVIRONMENT
The right side of the road was a dirt lane and a culvert, so the crew brought in their own rocks, along with trees up to 8 metres high mounted on a steel pallet.

SPEED
The parachuted car fell at 40 km/h. Once it reached that speed on the rope, the car was dropped from 2,5 m up – as high as possible without causing damage.

DROP POINT
The parachute lines are actually CGI to cover the cables suspending the car. They're attached by steel pick points welded into the roll cage. The driver hits a release inside the car to trigger explosive cable cutters.

THE DROP
With the car suspended on the cable, the driver would give a thumbs-up and start the engine. We'd count down: "3-2-1-drop." He would start out in neutral and as he got close he'd put the car in gear, then throttle up a little. When he got to his mark, he'd hit the release button and hammer the gas pedal so the car would peel out when it hit the road. It was actually less of a peel-out than we'd hoped for.

LOCATION
The road is a section of Pikes Peak Highway, which we were allowed to close down for eight days. The rest of the time we filmed in fifteen- to twenty-minute increments while a line of traffic formed behind us. Some of the people waiting – especially the cyclists – made it clear they were unhappy with the delay.

DIGITAL EFFECTS
We didn't want to do these scenes in CGI. We wanted them real. (We even dropped real cars from the airplane to set up this shot.) The only CGI was painting out the overhead and pullback wires and adding in a parachute.

PLANET WATCH

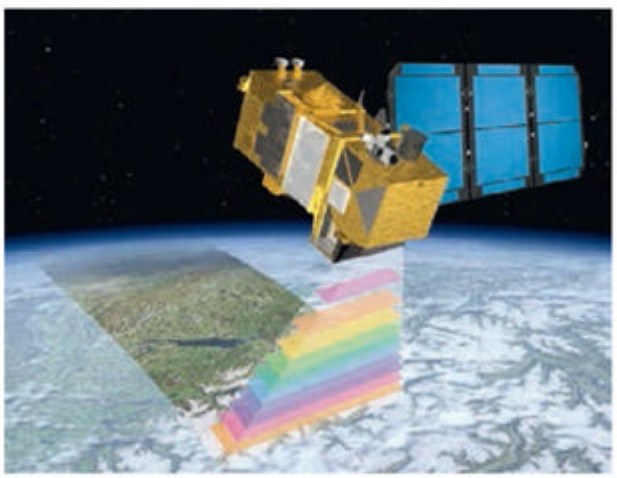
Environmental and humanitarian needs stand to benefit from ESA's new satellites. BY SEAN WOODS

BY NEXT YEAR, TWIN SENTINEL SATELLITES orbiting the Earth every 100 minutes will be able to capture images of our planet's entire land surface in less than five days. This will help policymakers and public authorities to develop environmental legislation and policies or make critical decisions in the event of an emergency such as a natural disaster or humanitarian crisis.

The first of the two Sentinel-2 satellites, developed and built by Airbus Defence and Space for the European Space Agency (ESA), is being readied for its mission in space after six months of intensive testing. The second, identical in design, is planned for launch mid-2016.

Sentinel-2A will be the second satellite of the Copernicus programme to be launched when it rockets to the skies in June. Once in orbit, it will deliver optical images from the visible to short-wave infrared range of the electromagnetic spectrum from an altitude of 786 kilometres, using 13 spectral bands with a resolution of 10, 20 or 60 metres and a swathe width of 290 km. The data will then be used for studying land use, soil sealing, land management, agriculture, forestry, natural disasters (floods, forest fires, landslides and erosion) and to assist humanitarian aid missions. Environmental observation in coastal areas likewise forms part of these activities, as does glacier, ice and snow monitoring.

"Sentinel 2 is the next important milestone to deploy Europe's Copernicus programme for which Airbus Defence and Space is a key contributor. In particular, we are the prime contractor for five



of the seven Sentinel missions, and have built state-of-the-art instruments and components for the others, such as the radar of Sentinel-1A that is working perfectly in orbit," said François Auque, head of Space Systems.

In IABG's facilities in Ottobrunn (near Munich, Germany) Airbus Defence and Space engineers put Sentinel-2A through a rigorous test campaign that included acoustic testing to simulate the huge noise generated at launch; vibration and separation shock testing to simulate mechanical launch loads; and thermal vacuum testing to simulate the environment in space. The 1,1-ton satellite was shipped to the European spaceport in Kourou, French Guiana, in April and was scheduled for launch by VEGA in June.

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Do you have unusual questions about the world and how it works and why stuff happens? This is the place to ask them. Don't be afraid. Nobody will laugh at you here. Email *popularmechanics@ramsaymedia.co.za* Questions will be selected based on quality or at our whim.

HOW HIGH UP CAN I GET WITH A LAWN CHAIR AND BALLOONS?

A You refer, of course, to the endeavour known formally as cluster ballooning, in which some yahoo (or, these days, maybe actually a trained pilot) slips the surly bonds of Earth in a manner pioneered by the storied aviator Curious George. As that good little monkey and his followers have discovered, grab hold of enough helium balloons and it's up, up, and away. How far up? A couple of folks have topped 6 000 metres, a full-on airliner altitude requiring both Civil Aviation Administration permission and the use of supplemental oxygen.

Some argue that the modern practice of cluster ballooning traces its roots not to Curious George but to "Lawn Chair Larry" Walters, a California truck driver who, one day in 1982, outfitted a standard-issue patio chair with a few dozen helium-filled weather balloons. What happened was he zoomed up to 4 900 metres, drifted into controlled airspace and, after taking out a few balloons with a pellet gun, ultimately crashed into some power lines, causing a blackout in Long Beach. So in other words, big success.

The "sport" has come a long way since. The two marquee names in cluster ballooning these days are John Ninomiya and Jonathan Trappe. Ninomiya has more than twenty years' experience flying conventional hot-air balloons, and the licence and certification to back it up. Trappe, too, is a certified pilot with a specific rating for ballooning. Typically they operate with full ground crews, who help inflate between fifty and 150 beefy, oversized helium balloons, spot for the pilot while he's airborne and position themselves to assist in a safe landing. These legit pilots know the rules and how to control their improvised aircraft –and they do not take flight in or on patio loungers, La-Z-Boys, futons, ottomans, gout stools, chaise longues, fainting couches, davenports, Eames chairs, or other household furnishings.

Would an ant be able to survive a fall from the top of a tall building?

Yes, ants could survive falls from tall buildings. They could also safely plunge from soaring Barcaloungers, making them perfect pets for cluster balloonists.

When anything – an ant, a bowling ball, a truck driver – falls from a decent height, two opposing forces act upon it. Gravity pulls the object towards the ground. Air resistance, meanwhile, pushes in the opposite direction. As something begins to fall, it picks up speed, but as speed increases, so does air resistance. Eventually the two forces reach a stalemate in which the object stops accelerating and falls at a steady rate, known as terminal velocity.

The key is that the pull of gravity is based on mass, while air resistance is based on surface area (think of a parachute). Therefore, if the relationship of these two factors is sufficiently favourable, as it would be with a very light object such as an ant, the terminal velocity will be quite modest, meaning the ant won't hit the sidewalk hard enough to injure itself.

Is it true that dogs are colourblind? How do we know what something looks like to an animal?

It is true that dogs make terrible interior decorators, but, contrary to popular belief, that's not because they're colourblind. In fact, dogs can see colours, just not as many as we can. Humans have three types of colour-sensing cone cells in their eyes; dogs have only two. The result is similar to red-green colour-blindness in humans, not a world in stark black and white. Fact is, colour isn't especially important to dogs, who rely far more on their sense of smell to discern the difference between fresh dog food and that old dead mouse in the basement immediately prior to enthusiastically eating them both.

How do we know what animals see? Brave scientists have volunteered to surgically swap eyeballs with a variety of… actually, it's much simpler than that. There are two questions researchers must answer: first, what is the animal physiologically capable of seeing? Second, how does the animal perceive it? The former question is settled by DNA analysis, which detects genes related to colour sensing, combined with the use of an instrument that measures the wavelengths an animal's eye absorbs. The latter issue is attacked by means of behavioural testing: a dog may be trained to respond to certain colours by rewarding it with treats. Of course, a dog could likely be trained to operate a locomotive if enough treats were at stake.

As animal vision goes, dogs are fairly dull. Bees, for instance, use the polarisation of light in the sky to navigate. And don't get us started on the mantis shrimp, the most common of which has at least sixteen types of photoreceptors in its visual system, making it the most complex known, and meaning that when the inevitable oceanic uprising comes, there will be no hiding from the unremitting onslaught of the mantis shrimp. You have been warned. **PM**

ILLUSTRATION BY GRAHAM ROUMIEU

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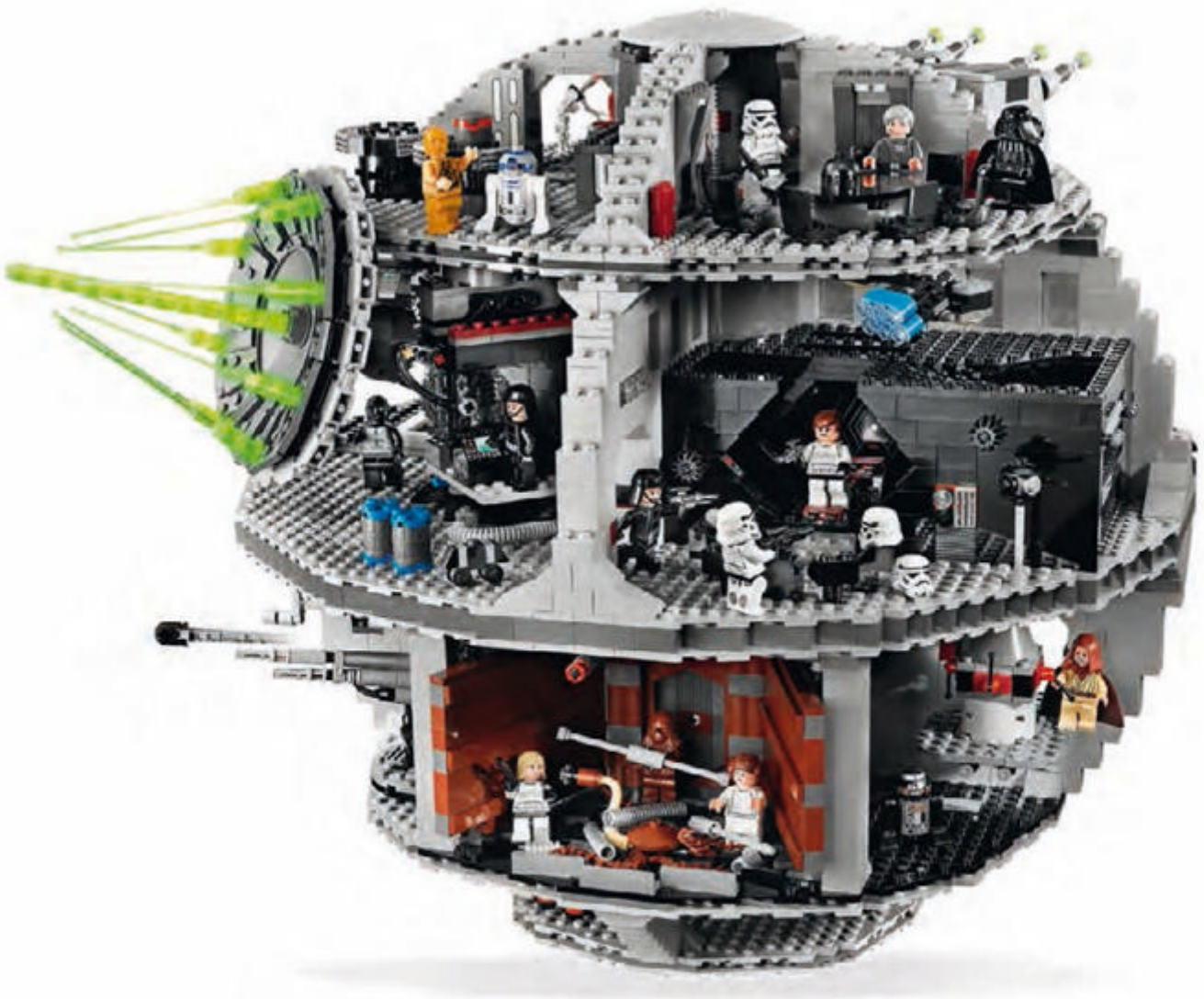

LEGO DEATH STAR

Feel the force

Want your little 'uns to get up to speed on the *Star Wars* saga before the new movie hits our big screens? If so, then Lego's Death Star Play Set is the answer. But be warned, there's a chance you'll have so much fun reliving episodes V and VI that your child stands a chance of never getting to play – unless he or she embraces The Force, that is.

This amazingly detailed battle station features a wonderful array of mini figure-scale scenes, moving parts, characters and accessories on its multiple decks – including the Death Star control room, rotating turbolaser turrets, advanced hangar bay with TIE Advanced star-fighter and tractor beam controls. You also get the Emperor's throne room, detention block and droid maintenance facility. It includes 24 mini figures and droids, as well as all the usual suspects – Darth Vader, Emperor Palpatine, Luke Skywalker, Han Solo and gang. Price: about R6 000. Contact Yuppie Gadgets on 021-593 0000 or visit *www.yuppiegadgets.com*

Editor's choice

MICRO START XP5 PERSONAL POWER SUPPLY

Crank it up

For something that's barely as big as a chunky smartphone, Antigravity's Micro Start XP5 personal power supply packs a formidable punch. It's capable of kick-starting virtually any petrol-powered vehicle, from motorcycles to V6 bakkies. Its 6 000 mAh lithium-ion battery provides an impressive 150- to 300-amp peak jump-starting ability and can hold a charge for up to six months.

Phones, tablets, Bluetooth devices, cameras and more can be recharged by the USB power port rated at 2,1 amps. Included in the XP5 carry case are detachable mini jumper clamps, a universal USB cable (with the four most common tips) and adaptors for mains and 12 V DC. Other features include built-in over-charge and over-discharge protection, lighted battery capacity indicator and automatic power-off function. Price: about R1 500. Contact Power Distributors on 021-531 2648 or visit *www.powerdistributors.co.za*

CAR POWER INVERTER ▲

Juice up on the road

A universal power socket and safety features that protect battery, user and the device being charged (low vehicle battery auto-shutdown, as well as overload and short-circuit protection) set the Car Power Inverter apart from the rest. Rated at 150 W, this device is capable of delivering 220 V and charging virtually every small gadget under the Sun, including camera batteries, via your vehicle's 12 V socket. Price: about R400. Contact Mantality on 011-462 5482 or visit *www.mantality.co.za*

SANDISK 200 GB ULTRA MICROSDXC CARD ▲

Just stash 'n go

We shouldn't really be surprised any longer at how much you can cram on these miniature marvels, but 200 GB on something this size is insane. The Ultra microSDXC card combines mind-boggling capacity and blazingly fast transfer of up to 90 MB/s. You can move up to 1 200 photos per minute and store about 20 hours of Full HD video. Price: about R4 600 (depending on the exchange rate). Visit *www.sandisk.com*

LEATHERMAN LEAP MULTI-TOOL

For can-do kids

In today's pampered world we're inclined to try to protect younger handypersons from possible harm. That's not the case with Leatherman's new Leap multi-tool. Designed for the younger DIYer, it's big on safety. Special features include safety locks, a two-hand opening 420 HC knife blade and ergo grip handles designed to ensure the blade is operated away from the user. Reassuringly, it can also be used without the knife blade – allowing you to determine when your youngster is mature enough to handle a sharp edge before inserting it using the included blade guard.

Other than that, it's a Leatherman and comes with many of the standard tools you'd expect. You'll find 12 tools, including needlenose and regular pliers, saw, wire cutter, spring-action scissors, screwdrivers, ruler and tweezers. Price: about R950. Contact distributors Awesome Tools on 021-981 6672 or visit *www.awesometools.co.za*

MIELE SCOUT RX1 ROBOVAC

Robotic dust buster

"I like work: it fascinates me. I can sit and look at it for hours," wrote Jerome K Jerome in *Three Men In a Boat*. Well, if he were around today he'd be doing just that with Miele's first robotic vacuum cleaner, the Scout Rx1 Robovac.

This little sucker may not be the first to market, but it has some nifty features that steal a march on the competition. A systematic navigation system allows it to clean in parallel tracks instead of randomly criss-crossing the room. Incorporated into the system is a gyro sensor (to register rotation and changes in direction) and a ceiling-scanning digital camera (for additional precision).

Seven front infrared sensors scan the area ahead to avoid collisions with furniture and three sensors underneath help prevent it from tumbling down stairs. Two long rotating side brushes target difficult areas along walls and furniture, sweeping dirt towards the centre of the unit. Once there, a removable beater bar picks up the coarser particles.

Areas up to 150 m^2 can be cleaned on a single charge; when the Scout RX1 detects a low battery, it simply takes itself back to its charging station. Once recharged, it starts up again where it left off. Price: about R10 000. Visit *www.miele.co.za*

ADAPT BLUETOOTH HEADPHONE ADAPTOR

Go wireless

The Adapt Bluetooth headphone Adaptor adds wireless audio, microphone and control to any wired product you own – plug in your headset, connect the adaptor to your smartphone or computer via Bluetooth, and you're good to go. It reconnects automatically to previously paired devices. The microphone features noise suppression, echo elimination and duplex sound for crystal clear calls. Its built-in Li-Polymer rechargeable battery is good for 5 to 6 hours of play time. Price: about R600. Contact Action Gear on 011-781 1323 or visit *www.actiongear.co.za*

ZARTEK 50 W LED WORKLIGHT ▲

Monster light

Sometimes, a piddly little headlamp just won't cut it. Zartek's 50-watt LED Worklight pushes out an eyeball-searing yet uniform 4 000 lumen flood beam with a 120-degree spread. An aluminium housing and powder-coated steel casing form a robust protective shield while not being excessively heavy at 2,5 kg. Expect 4 hours of operation from the Li-ion 6 600 mAh battery, which recharges in about 8 hours (mains and 12-V chargers are included). Price: about R2 000. Contact Zartek on 011-640 2460 or visit *www.zartek.co.za*

GRILL RIGHT BLUETOOTH BBQ ▲ THERMOMETER

Braai like a pro

If your braai speciality is charred meat, then we suggest you get your hands on Oregon Scientific's Grill Right Bluetooth BBQ Thermometer. Once you've inserted the probe (it comes with just one, but can accommodate two), you simply key in, on the unit or the associated smartphone app, what meat you're preparing and then sit back to await an alert when it's grilled to perfection. Price: about R800; *www.oregonscientific.co.za*

LINKQAGE PIR MOTION VIDEO RECORDER ▲

Watch your stuff

Worried about who rummages through your drawers when you're not around? Linkqage's Passive Infrared Ray (PIR) Motion Video Recorder has an 800 mAh lithium battery supports up to 29 days in standby mode and around five hours of continuous video recording. Boasting a 6-metre PIR range and 10 metres using night vision, it also features a high-sensitivity microphone – so you can always get the dirt, whether it went down day or night. You can review captured footage by connecting it to your PC via its USB port. Storage can be expanded up to 32 GB (it comes with an 8 GB SD card). Included in the box are a glass mount bracket and desktop base. Price: about R1 500. Contact Linqage on 021-514 4808 or visit *www.linqage.co.za*

WAVEBOX 12 V DC MICROWAVE ▲

Nuke it – in the bush

Most kitchens without a microwave would be considered under-equipped, so what makes you think you can get by in the bush without this modern necessity? Robust and portable, the Wave-Box 12 V DC Microwave provides tech-loving overlanders with the culinary convenience of home. Unlike other systems that use a vehicle's accessory socket or rely on an inverter, it connects directly to the battery via heavy-duty cables and a patented heavy-duty mated plug with receptacle (sold separately). In short, it's impossible to plug it in incorrectly and damage your electrical system.

Utilising a microcrystalline material plate, it pumps 660 W of power into cooking or reheating food evenly without needing a turntable. Three pre-set timer buttons make using it quick and easy and, for special needs, cooking times of up to 20 minutes can be set manually. A reinforced ABS casing keeps it looking good for longer. Price: about R2 300 for the WaveBox and around R430 for the PNP power port. Contact Safari Centre on 021-593 3910 or visit *www.safaricentre.co.za*

OPUS FOLDING CAMPER △

Hit the bush in style

For those who find pitching a tent a little too close to Nature, but find towing a caravan a drag, there's the decidedly upmarket Opus Folding Camper. Reminiscent of those pop-up camping trailers of the '70s – only much better – it truly allows your family to enjoy the great outdoors in style. Ultra-lightweight and extremely easy to tow, even with a small car, it has a low profile that allows for good all-round visibility. It's also rugged, featuring two reinforced lids. Thanks to a universal racking system it can carry boats, kayaks, bikes and even motorcycles.

Once you've reached your destination, it really comes into its own by opening up to provide two comfortable double beds plus seating. There's also a stainless steel sink with running water, kitchenette with a gas hob and refrigerator, heating, lighting, plug sockets and more. It's hard to believe that all this takes just a quarter of an hour to assemble and disassemble. Price: about R227 000 for the base version. Contact Opus on 012-998 9340 or visit *www.opuscamper.co.za* **PM**

KINGJAMES 33219

There's a time to be bold. And a time to be cautious.

With 51 of his 63 wins coming from knockouts, Jack Dempsey's bold boxing style had made him the most feared man in the sport. But when an outright underdog took his title by forcing him to go the full ten rounds, he learnt a valuable lesson. You can't always rely on a bold approach to lead you to victory. Which is why, when it comes to investing, we never take anything as a given, and always utilise the power of restraint. Because knowing when to be bold, and when to be cautious, makes all the difference. And that's what makes us Wealthsmiths™.

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SUPERTRAINS

Coming down the main LINE

Like death, taxes and Monday morning delays at Gillooly's interchange, late trains are just another inevitability of life in South Africa. The Passenger Rail Agency of SA (Prasa) will, however, have us believe that there is a bright light at the end of the poor service delivery tunnel. From the latest jewel in the passenger rail crown to the new commuter stock being built in Brazil, here's the tale of metro fails and and afro victories.

> BY LINDSEY SCHUTTERS

LET'S GET ONE THING STRAIGHT: we don't send much freight via railway because the country's extensive rail network is too narrow. While Europe and the USA – through its European origins – installed 1 435 mm standard gauge at the turn of the 20th century, the Natal Railway Company and Cape Government Railways decided in the 1860s to save costs by installing cheaper Cape gauge (1 067 mm) railway. The economics of the decision were sound at the time because of the many mountains that dot our landscape. But, in 2015, it seems a bit shortsighted.

With Cape gauge being seen as too narrow and too light to handle freight – and the subsequent stations being built with narrower clearances than in Europe anyway – Transnet won't be able to offer a viable service to compete with the truck

Afro 4000 is the first in the new line of modern locomotives customised for South African railways.

The air-conditioned cabins will make life better for the drivers and help reduce incidents due to driver error. Above, six Afro 4000 locomotives have been delivered to date.

industry. A trend towards larger shipping containers doesn't help the cause, either.

But there are positives. Plans are in place for a new rapid rail line between Johannesburg and Durban that should, like the Gautrain, be built with standard gauge. A likely consequence of this new line will be a drop in truck traffic on the N3, the national road between the two cities. In addition to that, an order of 232 Rolls Royce MTU Series 4000 engines have been placed by Chinese locomotive manufacturer CNR Dalia for use in fulfilling a Transnet locomotive order. Delivery is expected between 2015 and 2017.

SPEAKING TO THE PASSENGER RAIL AGENCY gives little insight into the dealings of Transnet, since Prasa deals with passenger rail only. Among the insights it does provide, though, is why we don't have public high-speed rail: partly because of our track gauge, yes, but the added danger of railways interacting with roadways makes this kind of transport almost impossible (there are no level crossings on Gautrain routes).

The upside about the business of passenger rail is that, while motorists are bemoaning the weak Rand/Dollar exchange and its effect on fuel costs, the rail business is booming. But a boom is the last thing Prasa needs right now.

To put it bluntly, Prasa desperately needs an overhaul. "During its formation in 2009, Prasa inherited old and outdated infrastructure and technology. That rendered our service delivery unreliable," says the organisation's head of engineering, Dr Daniel Mthimkhulu. "The modernisation programme that began in 2010 has culminated in the many areas of development that would address shortages in the current locomotive fleet, old and obsolete technology – all of which are a recipe for poor performance of the fleet and losses in passenger rail's market share."

It seems there is, finally, reason for some chest-thumping, then. And why not, given the recent launch of Prasa's latest toy, the Afro 4000?

Based on Spanish locomotive manufacturer Vossloh's hugely popular six-axle Euro 4000, the Prasa spec comes in both diesel and diesel-electric and is modified to fit the narrower Cape gauge. The original order was adjusted down to just 70 units, which will now cost the company only R46 million. That's a good thing, because this locomotive is earmarked for service in the long-distance fleet. The same long-distance business unit that, according to Transport Minister Dipuo Peters, lost R700 million in the 2013/14 financial year due to dwindling passenger numbers (currently below one million per annum) and a halving of operational trains (6 000 to 3 000).

If the financials are accurate, which we have no reason to doubt, Prasa is a firmly believer in the *Field of Dreams* mantra of delivering a fantastic product and the masses, as a result, flocking to it. Dr Mthimkhulu and the Stellenbosch University students who assisted him in developing the Afro 4000 have nonetheless made a significant contribution to the modernisation of South African railways.

IN ELECTRIC SPEC, the Euro 4000's 4 300 horsepower (3 288 kilowatts) is too great for Cape gauge with DC traction, requiring a downgrade or an AC

inverter. The machine's physical dimensions also needed significant reduction to conform to our country's 3 965 mm high and 3 050 mm wide maximum loading gauge, but without verification it wouldn't be too far a stretch of the imagination to presume that Prasa stuck to the Euro 4000 dimensions and will simply run it on narrow-gauge bogies.

The off-the-shelf nature of Afro 4000 shouldn't diminish the significance of Prasa now owning a fleet of locomotives that aren't sourced from Transnet. Yes, it's a shame that the locomotive is wholly manufactured in Spain, but the maintenance and couplings are all done on SA soil.

"Afro's role will be to haul the passenger long-distance and regional service, which is a new initiative. Unlike previous locomotives, Prasa Engineering embarked on a research and development exercise that resulted in the design of a modern passenger locomotive capable of hauling 58 coaches, as opposed to the current 21 coaches," says Dr Mthimkhulu.

"The Afro 4000 locomotive is a proudly South African design, with manufacturing done in Spain by Vossloh," he continues. "It is light and fuel-efficient, with a 16-cylinder engine to eliminate mechanical failures during travel." Afro 4000 is strictly a diesel locomotive; 20 will be manufactured and delivered.

The regional service he is referring to is a rejuvenation project focused on previously abandoned lines. Re-establishing the Johannesburg to Mafikeng route will be first priority. Then, 10 locomotives will be stationed in the Eastern Cape to rival the rural taxi and bus services linking ancestral homes to metropolises. We're not entirely sure what class designation will be given to the diesel-electric hybrids – of which 50 were ordered – but the 16-cylinder engine that drives the Afro 4000 is built by Electro-Motive Diesel on the 710 platform. With the design first debuting in 1985, the 11,6-litre, turbocharged 45-degree V, two-stroke has proven reliable, but still receives regular updates and refinements. The Afros run a 3 800 kW spec that can spin at a maximum 900 r/min.

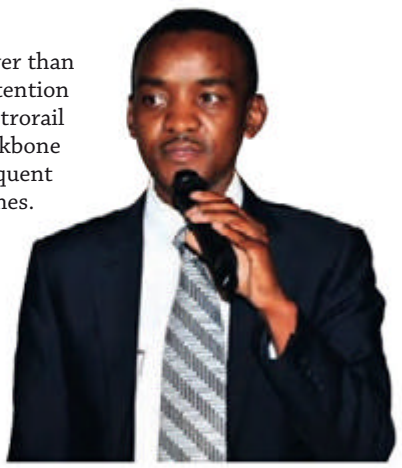
"Prasa Engineering Services has also designed an electrical passenger locomotive able to travel along either on 3 kV or 25 kV electricity lines. [This will eliminate] the need to change locomotives three times during a journey to accommodate diesel lines, locomotives for the 3 kV line and the 25 kV lines," explains Dr Mthimkhulu. "The electric locomotive(s), known as hybrids, will travel along electrified lines for both long-distance and urban travel. A total of 50 hybrids brings the number of new locomotives to 70."

WITH THE MAIN LINE MARKET of fewer than one million adequately catered for, attention now turns to the two million daily Metrorail users. This is where South Africa's backbone gets trodden on every morning by frequent delays, overcrowding and unsafe coaches. Prasa has a plan – and a new fleet of passenger trains currently on the way to help out our most vulnerable and important demographic.

At Prasa's 2014 annual meeting Minister Peters was happy to announce the agreement between Prasa and Gibela to supply 600

Below: Dr Daniel Mthimkhulu, Prasa Head of Engineering, designed the modifications for Afro 4000.

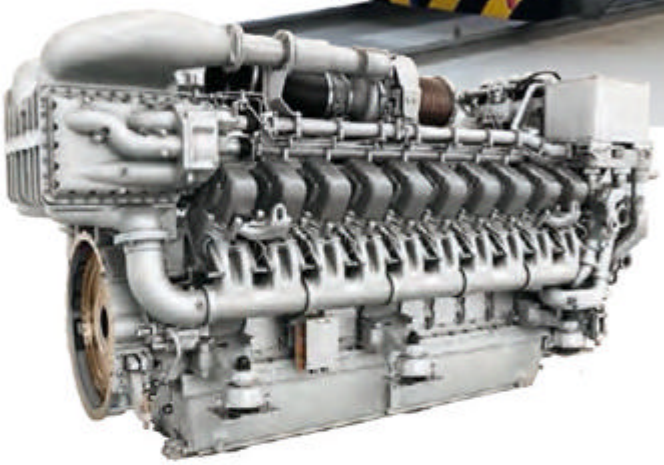
Bottom: Afro 4000 comes equiped with an air braking system, a significant upgrade to the widely used vacuum system.



AFRO 4000

ENGINE MODEL:	16-710 G3C-U2
CYLINDERS:	16
MAX POWER:	3 800 kW
MAX ENGINE SPEED:	900 r/min
WEIGHT:	126 tons
LENGTH:	23 020 mm
AXLE LOAD:	21,0 tons
FUEL CAPACITY:	6 000 litres
STARTING TRACTIVE EFFORT:	325 kN
MAX SPEED:	160 km/h

Right: Only half of SA's 20 000 km rail network is currently used, hence Transnet's investment in freight to try and monetise the network.



Above: The Type 20V 4000 R63L engine is a variant of the Series 4000 R43/R53, uprated to 3 300 kW, making it the most powerful MTU locomotive.

commuter trains. The first 20 new trains will be manufactured in Lapa, Brazil, with a South African contingent embedded in the process to gain some valuable on-the-job experience. The project will then emigrate to a newly built factory at Dunnottar on Johannesburg's East Rand.

"As part of its modernisation programme, Prasa embarked on its fleet renewal... to extend the life of its current fleet and improve reliability at a cost of approximately R5,2 million," says Dr Mthimkhulu. Upgrades to current trains include:

- New traction systems to improve reliability;
- An interior coating to improve the look and feel;
- An improved bogie system to minimise vibration and noise level when the train is in motion.

French engineering company Alstom, which leads the Gibela joint venture, will helm the project and provide parts and maintenance from its facilities at Ornans, Tarbes, Villeurbanne and Saint-Ouen. To put that into perspective, Alstom Chairman and CEO Patrick Kron described the 2014 agreement as the largest rolling stock contract in the company's history.

The new trainsets are called X'Trapolis Mega. And they really are a leap up from anything South Africans have been exposed to on home soil. These supertrains are designed to run up to 120 km/h on Cape gauge, but can be upgraded to 160 km/h. Prasa can choose to operate a mix of four- or six-car stainless steel single deck trainsets, which can carry a maximum of 1 300 passengers. The electrical multiple units (EMU) are all air-conditioned, with ergonomic seats and access to on-board Wi-Fi and real-time information systems. Special attention was given to improving the door systems and providing full-width gangways to give better accessibility to passengers and offer more freedom of movement.

Gibela's Ekurhuleni plant starts production this year and will create 1 500 direct jobs and an estimated 33 000 indirect jobs through support and linked services within the first 10 years. In all, Prasa's renewal programme will result in 7 224 new vehicles reaching our rails, costing the company an estimated R123 billion, with a modest target of 65 per cent local production.

OF COURSE, SPANKING NEW TRAINS deserve stations to match. Alongside the new rolling stock plans, Arup SA has been drafted in to re-imagine SA's stations and surrounds. "The idea is to integrate the station's activities with those of the city – to draw in pedestrians, taxi commuters, long-distance bus passengers and commuters – and create a transport hub, not just a railway station," says Nico Venter,

MTU Series 4000

ENGINE MODEL	20V 4000 P63
CYLINDERS	20
RATED POWER MAX	2 600 kW
SPEED MAX	1 500 r/min
DIMENSIONS (mm)	
LENGTH	3 647
WIDTH	1 511
HEIGHT	2 060
MASS	10 750 kg
BORE/STROKE	170/210 mm
CYLINDER DISPLACEMENT	4,77 litres
TOTAL DISPLACEMENT	95,4 litres

Prasa's new passenger trains have an emphasis on passenger comfort and freedom of movement. There should also be a reduction in commuters moving between carriages.

leader of Integrated Urbanism at Arup SA. "From this, urban regeneration can flow outwards into the city and unlock development." The project intends to bring a more holistic approach to station design, seeing the improvements as an investment and feeding into city regeneration projects.

While Prasa is in the business of cutting ties with Transnet and rolling on its own steam, the granddaddy of SA rail is bolstering its freight chops to try to compete with road and sea solutions. The freight operator updated its March 2014 agreements recently and announced a R13 billion financing package with General Electric and Bombardier Transportation to deliver new locomotives. These will work alongside the 232 Rolls Royce-powered locomotives from CNR.

GE have completed the design of 233 ES40ACi locomotives and Bombadier have green lighted 240 Traxx Africa locomotives; all will be built at the Koedoespoort plant.

The lofty ideas will be funded in two agreements. The first of the financing agreements covers 293 GE locomotives, including some being supplied under a separate order and is supported by a R6 billion US Ex-Im Bank guarantee announced in 2014. Funding of R2,25 billion is to come from Barclays/Absa, R2,25 billion from Standard Bank and R1,5 billion from Old Mutual. The 14-year facility is to be drawn down over a three-year period in line with the delivery schedule for the locomotives.

The second agreement is a R6,99 billion 13-year loan facility for the funding of the Bombardier locomotives, with R5,24 billion coming from Canadian trade finance agency Export Development Canada and R1,75 billion from Investec. A target of 60 per cent local has been set for this ambitious project, which intends to dramatically improve the reliability and availability of locomotives in SA.

WORLD-CLASS TRAINS WITH CLASS-LEADING

specifications is something the South African public has never been exposed to because of our narrow rails and need to focus on other areas. You could argue that the Blue Train won a few awards, but that symbol of upmarket rail travel caters to a microscopic segment of the population – which is the kind of thinking that got us in this pickle to begin with. The only concern, outside of perceived overspending, is that there is little talk of infrastructure renewal, as in the cables and rails that the new trains will run on.

But this is a work in progress. Re-signalling is a priority because, Dr Mthimkhulu tells us, "most of our (service) failures are due to old signalling systems". Another example of Prasa's efforts at improving the root cause of commuter delays: rail replacement to 120 km/h to improve network speed.

Overcoming the constraints of obsolete technology will take massive commitment. Not even commitment, though, will be sufficient to overcome the crippling effects of unreliable electric power caused by Eskom's supply problems. What's needed there is the kind of innovative thinking and practical alternatives that produced the Afro 4000. That's why, Mthimkhulu says, Prasa is looking to energy regeneration "(using) energy from the trains to give energy to the grid or wayside equipment from the braking capability of the current modernised coaches and new trains".

With new infrastructure on the boil and a possible unified card system in the pipeline that will be used across Metrorail, Gautrain and urban transport modes such as Cape Town's MyCiti bus system, public transport is getting a much-needed refresh across the board. Prasa is betting the house on Afro 4000. We pray that it pays off. **PM**

COMPILED BY THE EDITORS > *popularmechanics@ramsaymedia.co.za*

PM TESTED

ASUS TRANSFORMER BOOK T90 CHI

POCKET ROCKET

✔ Lightweight, performance, picture quality
✖ Fiddly sockets, switches, cramped keyboard

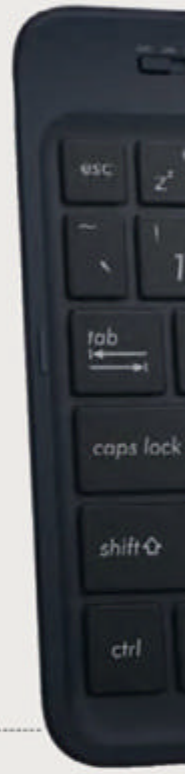
THE FIRST TABLETS were convenient, but not powerful enough to do much more than consume content. The rise of devices that can do both power *and* convenience suggests that this is a sweet spot that could very well keep on getting bigger and bigger. But hey, this sounds like a story we've heard before...

The svelte, diminutive 9-inch (22 cm) T90 is the smallest member of the Transformer Book range. Slotted into its magnetic docking sleeve and folded shut, it's an anorexic 7,5 mm thick and weighs 750 g (a little under half that is the keyboard alone). Despite that, it feels surprisingly sturdy. The price you pay for that sleek look, though, is a certain fiddliness when operating the tiny switchgear and accessing the ports (microSD, headphone jack and microUSB). The same misgiving relates to the cramped keyboard, though on the plus side the rubberised base stops the whole thing from sliding around while you hunt and peck. Incidentally, although the clip-in dock locks magnetically, it actually connects by Bluetooth.

As a mobile device, the T90 ticks the boxes. Camera quality is good, even from the 2 MP front. Perhaps the colour balance is a biased towards cold, but the display is crisp. Video is rendered with no noticeable nasty artefacts and sound quality via the headset exhibits good weight and bass extension.

All this convenience doesn't count for much if you are reduced to seeking out a real computer when you want to do real work. Fortunately, the T90 apparently differs from its bigger 10-inch stablemate only in having a lower, 1280 x 800 display, while using the same Bay Trail processor. It quite happily runs the Windows 8.1 supplied as standard.

CONCLUSION: Style points, convenience and decent computing power at what seems a well-considered price point.



SAMSUNG GALAXY A3

THE NEW MINI

Imagine being the biggest consumer tech seller in the world and then the market turns against your claim to fame. The backlash against Samsung's trademark cost-reducing plastic build has sent the Koreans into a tailspin, but that's a good thing. Finally we're getting more perceived value for money, with luxurious metal-framed masterpieces. The A3 is the cheapest and smallest, but the 4,5-inch screen isn't really that small. LTE capability, quad-core processing from Qualcomm (Snapdragon 410), 1GB RAM, and Android 4.4 handle all the "smart" and "phone" bits with aplomb. On picture snapping duty is the company's tried-and-tested 8MP sensor (first released on the Galaxy SII). The front gains a 5MP camera for high quality selfies. Meet the new king in the midrange and a hopeful end to the "Mini" Galaxies. Just don't expect flagship performance.

The essentials

PROCESSOR	Quad Core 64-bit Intel Atom Z3775, 1,46 GHz
RAM	2 GB
STORAGE	32 or 64 GB
OS	Windows 8.1
CAMERA	5 MP main, 2 MP front
PRICE	about R7 000

www.asus.com/za

COUGAR 700M

CUSTOM FITTED

You'll never make full use of the eight programmable buttons in MS Word, but the one millisecond response time and 1 000Hz polling rate will let you sketch amazing things in Paint. The braided cable and gaming grade scroll wheel means that your R1 000 purchase will last a long time, too. What you'll find most pleasing, though, is the aluminium framing structure, adjustable palm rest and custom-isable weighting. That's because you'll feel the superior heft and control when compared with your IT-issued, plasticky waste. But if you're a gamer, then all of these specs will make sense and you can make full use of the 45-degree sniper button, which eliminates mouse movement when making a headshot.

PRICE: R999, *www.cougargaming.com* **PM**

42 THINGS YOU SHOULD KNOW HOW TO DO

An age-by-age manual to a lifetime of competence.

Unless you count Nobel Prizes, no one is handing out merit badges for a life well lived. There's no handbook given to first graders that explains when you'll need to ride a bike, roast a chicken, jump-start a car, or nail a backflip off a rope swing – and how to do it. The real world is much more haphazard than that. In the crush of school and work and love and responsibility, it's easy to miss a few skills and not realise it until the time comes to use them. Though most of us have made it pretty far on our own, we could all benefit from an authoritative, well-researched guide to the most important abilities in life.

This is it.

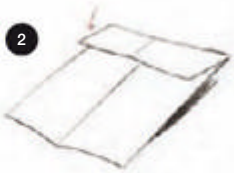
PHOTOGRAPHS BY DYLAN COULTER
ILLUSTRATIONS BY PETER OUMANSKI

MAKE A GREAT PAPER AEROPLANE

1

Fold a 215 x 275-mm sheet of paper in half lengthwise, then lay it flat on one side.

2



Fold the top 50 mm of the paper down towards you.

3

Fold that in half, then in half again.

4

Flip the paper over and fold both top corners towards the centre.

5

Fold the plane in half lengthwise so that the front comes to a point.

6

Fold the wings up 5 to 10 mm at the ends.

AGE 1

THROUGH

AGE 11

HOW TO PITCH A TENT

PARKER LIAUTAUD, *polar adventurer*

When four-time polar explorer Parker Liautaud embarked on his first trip to the North Pole, at 15, he'd never pitched a tent before. "I only learnt to set up the tent when I saw it for the first time, which was when I got to Norway," he says. Liautaud, now 20, has learnt a lot since then. Every tent is different, so the biggest thing, he says, is to practise. You should be completely familiar with all of your equipment before you ever use it in a real situation.

1. Choose your ground wisely. Of course, you don't want to sleep on lava rock, but even little bumps can make your tent floor uncomfortable. If your tent is long, position it so that the narrowest part faces the wind. Otherwise the broad side will act like a sail, which could lead to a collapse.

2. When you take the tent out of its pack, don't lose or ignore any piece. Even a lost clip could mean a less structurally secure lodging. When you place the spikes, make sure the ground is solid. Placing them at a slight angle also helps keep the rope or tent holes from slipping off.

HOW TO

TIE YOUR SHOES

Can't get the standard knot? Try this one. It's simpler, and bunnies make learning to tie your shoes fun.

1. Cross one shoelace over the other, push it underneath, pull it through, and pull tight.

2. Now make two bunny ears.

3. Tie the same knot with the bunny ears.

HOW TO

RIDE A BIKE

WHEN OUR SON TURNED 6, MY WIFE AND I BOUGHT HIM an Electra RatRod with twenty-inch wheels and orange and red flames on the black frame. For the next month Vaughn walked it around the backyard and gazed upon it as an art admirer might a Matisse. The only thing he didn't love about the bike was the idea of riding it. I tried on successive Saturdays to get him pedalling at the high school parking area, but each time he managed only a few shaky revolutions before braking or toppling over. Characteristically, he became reluctant about the whole enterprise. He is an ebullient kid, but cautious. We try to nudge him along in life, towards the nicks and welts but also the joy that might follow.

One Saturday he mounted the bike and swivelled his head, red hair poking through the helmet. "Don't let go," he said.

"But you can do this," I said. "Once you start, just keep pedalling."

He sighed, but I thought I saw a hint of resolve somewhere in there. He began to churn his feet and I jogged behind him, gripping the saddle.

Riding a bicycle isn't just a physical activity or a competitive sport or a pastime. It's also a kind of freedom. It's a way to move through the world under your own power, maybe for the first time. Vaughn is 10 now, and he pedals to school and to see friends. None of us thinks much about this except occasionally, when I recall the day he learnt to ride.

As he gained speed, I slowly lifted my hands off the seat. The bike pulled forward, smoothly this time. "That's it!" I yelled. "Go go go!" His feet blurred and he squeezed the handlebars and his face was intense, but incandescent. I ran alongside him for 20 more strides, cheering and shouting at him to keep going, until I realised I didn't have to tell him anymore, and he started to glide away. – DAVID HOWARD

SHOOT A BB GUN

1. Learn about gun safety. Never point a gun at someone else.
2. Arrange a target about five metres away. Soda cans, say.
3. Lie on the ground in a prone position, or prop the BB gun up on a ledge or wall.
4. Using your dominant eye, align the rear sight with the front sight.
5. Don't yank or pull the trigger. Squeeze it.

HAMMER A NAIL

Jack was a weatherbeaten framing carpenter on the first crew I worked on, almost 40 years ago. I've forgotten his last name, but I haven't forgotten his instructions, which were these: lose your fear of hitting your fingers. You will. It's going to hurt. Get over it.

If you're right-handed, place your left foot slightly in front of your right. Spread your feet shoulder-width apart. Bend your knees. When you need to swing with more force, grip the handle as close to the end as possible. For less force, choke up on the handle.

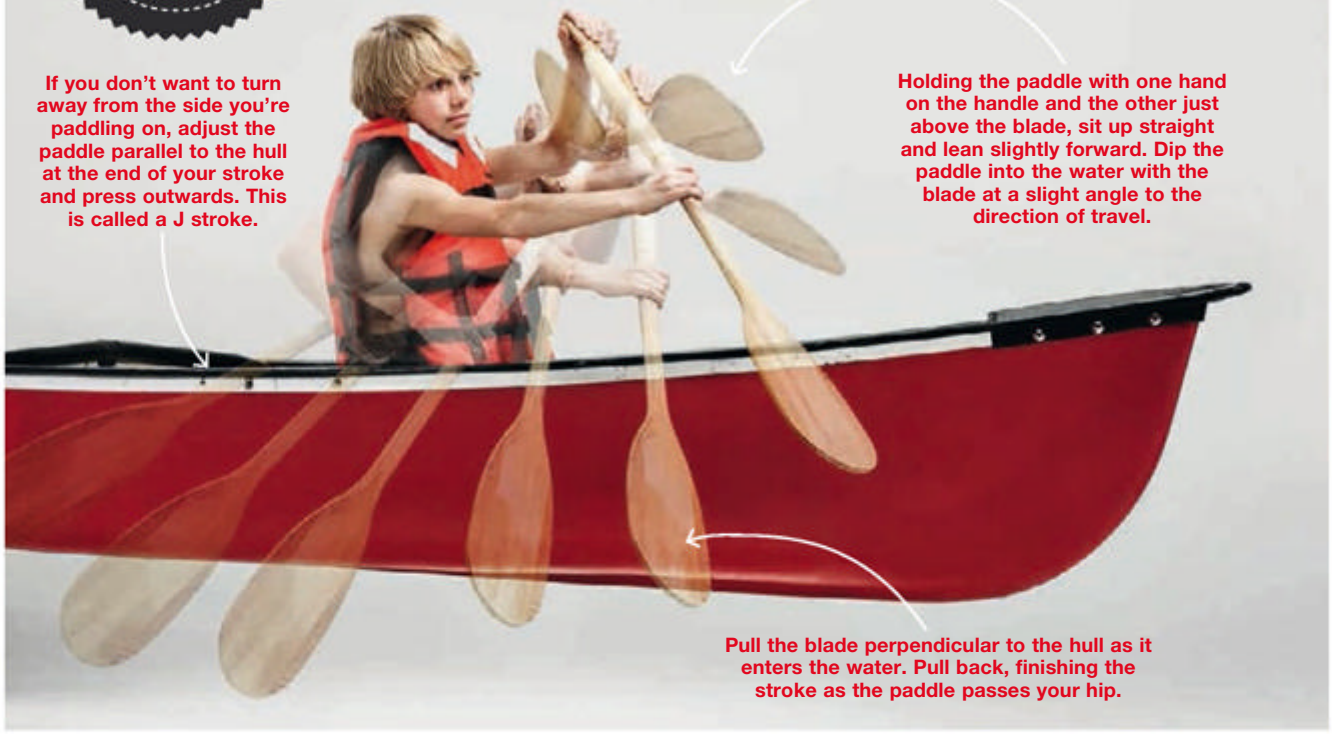
Don't use more force to drive a nail than you have to. You're trying to drive the nail, not kill it. And establish a rhythm. Rhythm is what makes the work happen. If you bend a nail, start another one nearby and keep going. Later, go back and pull the one you bent. It's less disheartening to fix a mistake when you can look at all the work you've done well. – ROY BERENDSOHN

PORTRAIT ILLUSTRATIONS BY HAISAM HUSSEIN

HOW TO

PADDLE A CANOE

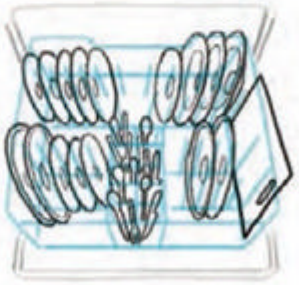
According to Alex Comb, who started building wood-and-canvas canoes in early adulthood, the first step in paddling a canoe is selecting a properly sized paddle. With your hands above your head in the surrender position, the distance between the pinkie edges of the palms should be just shy of the distance from the top of the paddle to the blade.



HOW TO LOAD A DISHWASHER

By soon-to-be-married PETER MARTIN and MERYL ROTHSTEIN, who do not agree.

PETER'S METHOD



If you can use a parking lot, you can load a dishwasher. Those tines, like parking spaces, are not suggestions. They're guidance. Silverware is easy. Evenly distribute it among the baskets and vary the contents so that similar utensils don't stick together. Everything should be pointed down, but if the baskets get crowded, you can flip the spoons over. Glasses go up top, each in the row that leaves the smallest gap between its edges and the tines. Bowls also go up there. Light things, like Tupperware, need to go on top, too, with lids pinned between two bowls to anchor them. The lower rack is obviously reserved for flat things, like plates. Cutting boards or large bowls are fine, but only if there are no more plates. And everything should be facing the centre, but that's just because it looks nice.

VS.

MERYL'S METHOD

I've been told there's a right way to load the dishwasher. Bowls, glasses, and other curved things on top, plates on the bottom. Apparently there's a way to avoid blocking jets with an errant bowl, though I haven't found it yet. Loading the dishwasher when my caring and kind and really-anal-about-loading-the-dishwasher partner is home reminds me of twelfth-grade calculus: an opportunity to demonstrate how little I understand the formula. I'd say my approach is more CliffsNotes. It lacks sophistication, sure, but it gets the job done. No room left for that plate? Why not try it at an angle and see what happens? You won't know if you don't try. Sure, Peter's method is more efficient, but is it worth the effort? I've got better things to do than treat an appliance like a Rubik's Cube.

SWING FROM A ROPE SWING Pull the rope back so it makes a 45-degree angle with the branch. Wrap your legs around the knot

HOW TO

DRIVE AN AUTOMATIC TRANSMISSION

South African drivers, in the main, have been brought up on the clutch pedal and the gear lever. Driving an automatic, by comparison, is easy: the transmission does the shifting and all the driver does is accelerate, brake and steer. But there are some things that aren't immediately apparent. For instance, automatics won't start unless the car is in Park (which should be used only when stationary) and your foot is on the brake pedal.

For normal driving, selecting D (Drive) is fine: the transmission then determines what gear ratio to use, depending on factors such as accelerator pedal position, road speed and load on the engine. When you stop, there's no need to engage Neutral, as long as you keep your foot on the brake. By design, automatics "creep" forward without any pressure being applied to the accelerator pedal. That creep helps in low-speed manoeuvring such as in a parking area.

When you need to accelerate, flooring the accelerator will not only blast more air/fuel mix into the engine, but will cause the transmission to "kick down" into a lower gear. You can also select a lower gear when going down a steep hill, which slows down the car by means of engine braking. Similarly, you may want to select, say, 3rd gear, when you are on a mountain pass or twisty road and want to avoid the car shifting into a higher gear, so you can maintain decent acceleration.

Modern cars with electronic shift management won't allow the transmission to shift unless it's safe (so there's no risk of engaging Reverse accidentally).

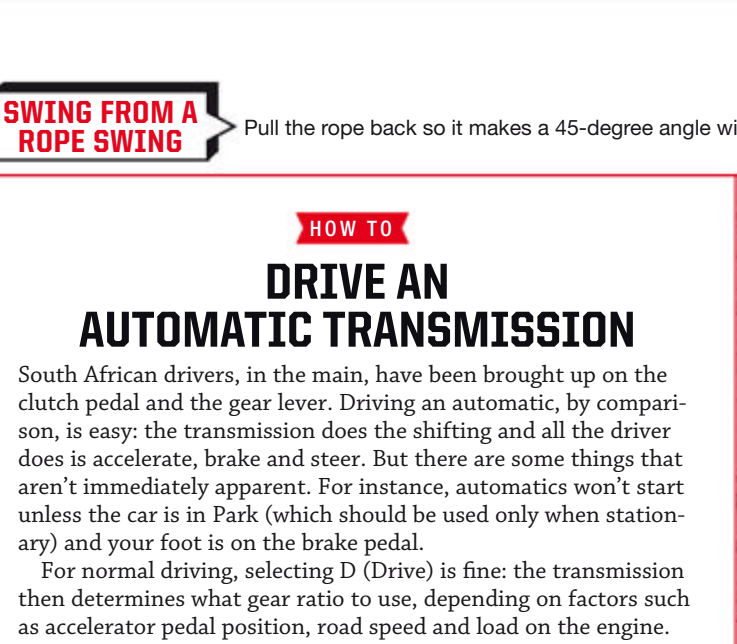
If you pass your driving test in an automatic car, you cannot legally drive a manual car. – ANTHONY DOMAN

SURVIVE ALONE IN THE WOODS

JIM CANTORE,
meteorologist

When I was a kid, we moved from the city to the countryside. Suddenly the people I went to school with had farms, they were working kids, and I'm just this little Catholic school boy thrown among the wolves. We never did any of that let's-go-out-and-sleep-in-the-woods-tonight stuff in my family. I didn't really know much in terms of life skills up there.

My high school football coach was the one who recommended Outward Bound to me. It was three weeks out in the woods in the middle of winter, trudging through the snow and building fires out in Addison County, Vermont. You spend 24 hours out there alone, dig your own snow pit, and survive. You find yourself. It makes you realise that some things take discipline. You can't just show up.



LOCATE YOURSELF ON A MAP

TRACY ROSS,
former backcountry ranger

I didn't learn to read a map until I was in my thirties, and for this I blame Denali National Park in Alaska, where I used to work. Oh, we had maps, and we were supposed to use them. But Denali has distinct landmarks, including 6 194-metre Mt McKinley, and most of the terrain is treeless tundra. You could almost always look to the mountains or the rivers and orient yourself.

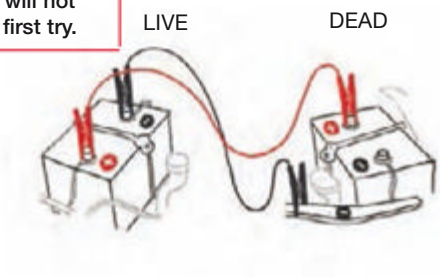
When I moved elsewhere, I learnt to locate myself on a map. To do this, point a compass's direction-of-travel arrow at a real-life landmark, then turn the circular dial until the red end of the magnetic needle is in the red orienting arrow. Place the compass on the map, aligning the dial's orienting lines with the map's north-south meridian lines. Keeping the needle in the orienting arrow, arrange the compass so the top right corner of the baseplate touches your landmark. Draw a line from the landmark down the edge of your compass. Repeat this process with two more real-life pieces of terrain. You're standing where the lines intersect.

HOW TO

WHISTLE WITH TWO FINGERS

1. Make a circle with your thumb and index finger.
2. Curl your lips back tight over your teeth.
3. Fold the tip of your tongue over itself and place fingers on top.
4. Tightly seal your lips around your fingers.
5. Breathe deep and blow forcefully.
6. Adjust to find the right angle and depth. Unless you are some kind of whistling prodigy, you will not get it on the first try.

HOW TO JUMP-START A CAR



Position the running car so that its battery is close to the battery of the dead car. Turn off the running car and get out jumper cables. Connect one end of the positive cable (the red one) to the positive terminal on the dead battery. Connect the other end to the positive terminal on the live battery. Connect the negative cable (black) to the negative battery terminal on the live car. Connect the other end of the negative cable to an unpainted metal surface on the dead car's engine. Start the live car and let it run for a few minutes. Now start the dead car, disconnect the cables in reverse order, and drive for at least a quarter of an hour to let the alternator recharge the battery.

and push off. You will achieve maximum air when the rope reaches a 45-degree angle with the branch on the other side, over the water. Do a flip.

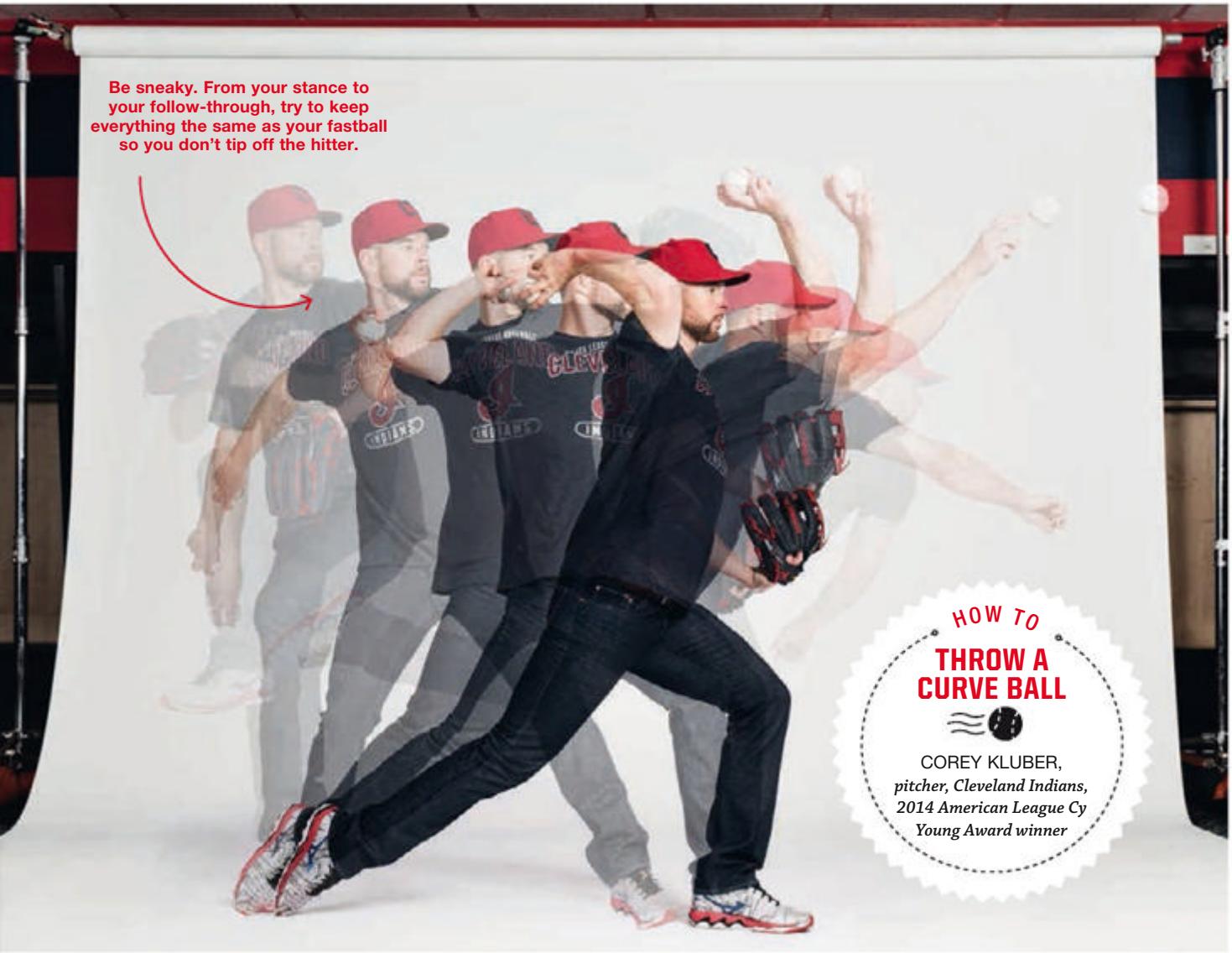
HOW TO GET DOWN A SNOWY MOUNTAIN

TODD RICHARDS,
1998 US Olympic snowboarder

The main benefit of learning to ski or snowboard when you're young is that you don't know what it's like to get hurt yet. As you get older, your brain becomes clouded with other stuff. At 45 years old, when I'm trying to make quick decisions, not only am I thinking, turn this way and lean that way, I'm also thinking about potential consequences: If you do this, that could happen and then you won't be able to work.

Get yourself a good lesson to start off.

No offence to parents, but it's easier to take correction from someone who isn't related to you. Once you have the basics down, you can chase the sport in any direction you want. You can go to the X Games, the Dew Tour, the Olympics. You can be a crazy mountaineering snowboarder. It all comes down to being able to make very fast decisions using the two steel edges of your snowboard. If you learn how to do that right in the beginning, then you're all set.



HOW TO

THROW A CURVE BALL

COREY KLUBER,
pitcher, Cleveland Indians, 2014 American League Cy Young Award winner

I hold my curveball almost the exact same way that I hold my fastball – with my index and middle fingers just along the narrow part of the seam. It's just a matter of manipulating my hand into a slightly different position during the release.

With my fastball, I'm trying to keep my two fingers behind the ball as long as I can to pull down on it and create as much backspin as possible. With the curve, instead of trying to stay behind, it's almost the opposite. At the very end of the release, you try to get your hand in front of the ball to create that topspin, which makes it break. You're rolling your hand forward and down off the side of the ball as you snap your wrist.

AGE 18 — THROUGH — AGE 22

HOW TO FELL A TREE

A tree comes down in three cuts.
CUT ONE: At a 45-degree angle downwards.
CUT TWO: At a 45-degree angle upwards, to intersect with the first cut.
CUT THREE: Into the opposite side of the tree, parallel to the ground. It should be slightly above or equal to the point of the notch formed by cuts one and two. Stop when there is a hinge left that's about 10 per cent of the width of the tree. Pound a felling wedge into the cut and the tree should fall away from you.

HOW TO THROW A PUNCH

Stand with your non-dominant foot forward, with 30 per cent of your weight on your front foot and 70 per cent on your back. Make sure your fist is tight with your thumb outside your fingers. Pivot on the ball of your rear foot and twist your waist in towards your target, carrying the energy up your back and down your arm. Drive your dominant arm forward and connect with the knuckles of your index finger, middle finger and ring finger. For maximum effectiveness, imagine you are punching through your opponent. Walls are ill-advised opponents.

MOVE OUT INTO THE REAL WORLD

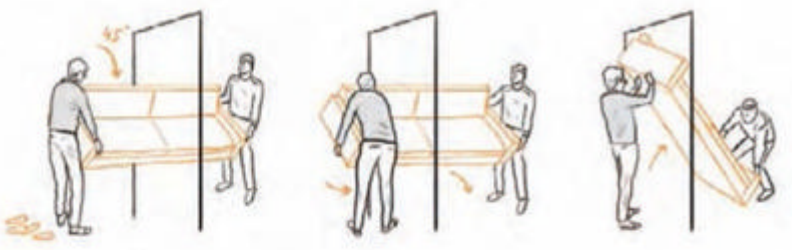
Heading off to university or your first job? Wake-up call: knowing how to put together a Mai Tai blindfolded does not equip you adequately for life on your own.

1

Laundry. The blindingly obvious (not): sort clothes into colours (white/colours/dark) before chucking into the machine.

HOW TO FIT A COUCH THROUGH A DOOR

URIAH DEAN, *moving and storage company estimator*



Take the feet off the couch, if possible. Tilt it forward at a 45-degree angle so the back faces up and the knee area faces down. Once you're most of the way through the door, turn the couch so that it's heading towards the open space. The person who's coming through the door last should shift his body so he doesn't get stuck between the couch and the doorway. If the area inside the door is narrow, the first person through should begin lowering the couch as the rear mover raises it to stand the couch up on its end once it's through.

HOW TO

PLAN THE PERFECT ROAD TRIP

HERE'S THE SECRET TO A GREAT ROAD TRIP: don't try to plan everything. Lay out the structure, then let it happen to you. If you want a story you can tell for the rest of your life, you need conflict to drive it along.

Failures of every kind are what make the road trip I took out of Las Vegas in my twenties my personal best. A blizzard in the Northeast cancelled our discount flight five days before Christmas, so my boyfriend and I, too broke to get on another airline, rented a convertible and drove to Dallas. It seemed like a better choice: four days, 2 100 kilometres, home just in time for the holidays. The first night the Sun set over a panorama of scrubland so wild and barren a herd of buffalo might have charged across it at any moment.

But then we took a detour to the Grand Canyon, because I had never been and were pulled over by a cop on the way for driving a convertible in a whiteout like a couple of idiots. When we got to the edge, the whirling mass of fog and snow was so thick that you couldn't see your hand in front of your face. It was like opening your eyes in a glass of milk. We stood at the edge of the USA's most prodigious maw and saw nothing.

I remember this trip in washed-out colours, like an old French film: the pastels of the gift shops on Route 66, the galaxy of Albuquerque reeling by in the night. At one of the motels in Texas, I made my boyfriend kick open the door to our room because it reminded me of the places Cormac McCarthy's hit-man psychopath stayed in *No Country for Old Men*. The trip was young adulthood in an itinerary: all the freedom of being over 18 with none of the responsibility. Living the way people say you should – for the story, rather than the outcome.

For those few days we planned to stay in that half-life forever. We didn't, of course. – JACQUELINE DETWILER

2

Iron a shirt. Check the temperature setting, select Steam, start with collars and cuffs, then sleeves, back and finally the front.

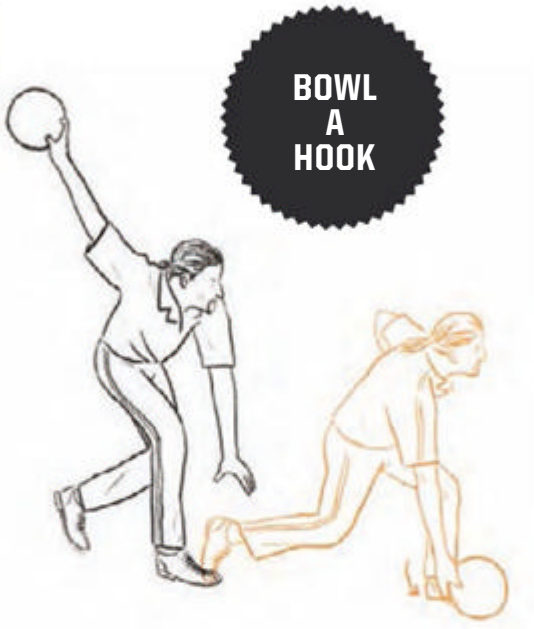
3

Basic cooking. Before you leave home, learn how to brown mince and boil water to cook noodles. And when you drain boiling water, do it away from your body.

SAFELY LIGHT FIREWORKS

1. Choose a hard, flat location with a clear radius of at least 10 metres in every direction.
2. Fill a 25-litre bucket two-thirds full with water.
3. Arrange the fireworks with all fuses facing the same direction. Make sure none of the fireworks is pointed at people.
4. Using the longest fire stick you have, light one firework at a time, at the very end of the fuse.
5. Run! (Until you are outside the 10-metre radius.)

BOWL A HOOK



Tossing the bowling ball straight down the lane may have worked for most of your life, but you're an adult now. It's time for a new challenge. Between the first and second row of pins is a six-degree pocket that almost guarantees a strike, but the only way to hit this window is with a proper hook. Here, Mike Fagan, most recent winner of the Professional Bowlers' Association World Championship, explains how.

1. Start your swing, letting the weight of the ball carry your arm backward. Don't rush.
2. Use the momentary pause at the top of your backswing to make sure your hand is positioned underneath and to the inside of the ball as much as possible. This allows for maximum rotation.
3. As you release the ball, you want to rotate your wrist, not your elbow, to create spin. Your hand should follow all the way through the outside of the ball and be almost vertical on the follow-through.
4. Practise. As you get better, you can try rotating your wrist faster, which increases revolutions and, consequently, power.

AGE 23 — THROUGH — AGE 30

HOW TO MAKE A BATCHED COCKTAIL

DAVE ARNOLD,
cocktail bar owner

INGREDIENTS
50 ml rum
40 ml water
12,5 ml simple syrup
12,5 ml lime juice
25 ml grapefruit juice
Pinch of salt

1. The ingredients above make one modified daiquiri. Multiply them to make as many as you think you'll need.

2. Mix all the ingredients and pour them into one or more litre-size Ziploc bags. One bag holds enough for four to eight drinks.

3. Place the bag(s) in the freezer overnight.

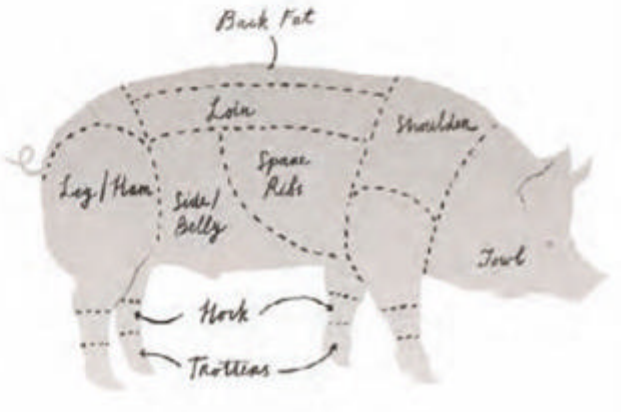
4. When you're ready to serve, remove the bag(s) and blend the drinks until smooth.

HOW TO PLANE A DOOR

Put a floor lamp or worklight on one side of the door. Stand on the other and nearly close the door. The light will reflect off the doorframe to illuminate the edge of the door itself. The part of the edge that is not illuminated is the part that's sticking. Make a pencil mark where the gleam of light tapers off, then make a small X on the dark side of the line. This is where you'll remove wood. Take the door off its hinges and stand it on its edge, supported by a pair of sawhorses. Use a hand or power plane to remove wood from your mark in the direction of the X, concentrating on the door's end. Remove just enough to get the door to close.

BUTCHER A PIG

CAMAS DAVIS, *meat collective founder*

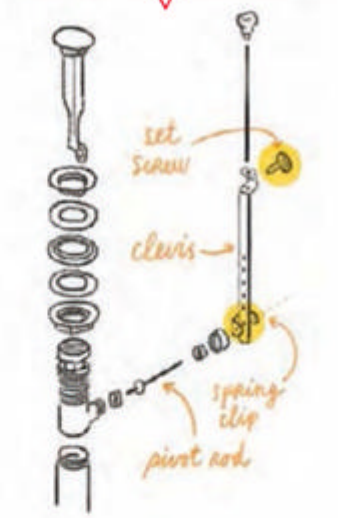


You can do most of the work with a 125-to 150-mm semi-flexible boning knife. To work on bones, you'll need a saw with bigger teeth, or a cleaver. Remove the head, trotters, hocks and tenderloin, then separate the pig into "primals". This means separating the back leg (the ham) and the front leg (the shoulder) from the middle section and splitting the middle section into loin (chops) and belly (bacon).

Next, turn the primals into subprimals. On the shoulder, for instance, this means separating the picnic roast from the Boston butt. From there, trim, sculpt and debone the meat into the cuts you see at the meat counter. Remember: if you screw up, you can always make sausage.

AGE 23 — THROUGH — AGE 30

FIX A BASIN DRAIN



It's not unusual to pull too hard on the lift rod of a bathroom basin – the thing that pulls down the drain plug – and find yourself holding it in your hand, plug stuck down for good. As an adult, you should be embarrassed if you have to call a plumber to fix this. In most basins, the lift rod is connected to the drain plug by a mechanical complex that includes a clevis and a pivot rod (see diagram). In some cases the lift rod has been pulled off the set screw, which connects it to the clevis. To fix this, just put the rod back on the screw and tighten.

In other cases, the clevis has slipped off the pivot rod. If you can find the spring clip, slide it onto the pivot rod, wrap it around the clevis, and then slide the other end on to the pivot rod to secure.

MAKE A ROUX

A roux is not a mystery. According to chef Brian Landry, it's just equal parts flour and fat, stirred like a risotto until it browns. You can add it to soups or stews to add thickness and flavor, and impress the heck out of your friends by making dishes like lobster bisque and Cajun duck gumbo. Learning to make a roux is easy. It's the half-hour of stirring that's hard.

USE A CIRCULAR SAW

Mark a line across a piece of wood. Set the saw's cutting depth to about a centimetre deeper than the timber is thick, then align the cut mark on the saw's shoe with the line you drew. Make sure the saw's blade is on the waste side of the line. Press the trigger. Once the blade reaches full speed, move the saw across. As you near the wood's far edge, push a little harder and faster so the saw clears the cut just as the waste piece drops free.

To make a plunge cut, as you might when producing a square hole, set the saw to cut about a centimetre deeper than the wood's thickness. Rest the front of the saw's shoe on the wood and pivot the blade guard back by moving the thumb latch fully forward. This sounds dangerous, but it's not.

Now squeeze the trigger and pivot the saw slowly into the cut. Don't push. the saw will lower on its own as it makes contact.

HOW TO DO A DONUT

If your car is a powerful rear-wheel drive, this is easy: turn off your traction control, crank the wheel, and floor it. If you've got a gutless rear-wheel-drive car, you might need to brake torque it to get the rear wheels spinning. Hold your left foot lightly on the brake while applying full throttle. Once the rear tyres break loose, pop your foot off the brake and crank the wheel. All-wheel-drive cars can be trickier, but the same basic rules apply. Got a front-wheel drive? Put it in reverse. Now it's a rear-wheel drive. – EZRA DYER

HOW TO

GOLF FOREVER

ONE DAY IN 1991, WHEN I WAS 36, I WENT FROM HARDLY ever thinking about golf to hardly ever thinking about anything else. A friend invited me to play nine holes and, even though I didn't hit one good shot, something changed in my brain. Since that moment, golf has been my No 1 preoccupation. Most of my friends today are golf friends, most of the trips I take are golf trips, most of my remaining ambitions involve my swing.

When I began playing, I often wished I'd started in childhood, as my younger brother did. Within a few years, though, I realised that, in most ways, starting late had been an advantage. Unlike middle-aged guys who played in high school and college, I'm not haunted by how good I was when I was young. And, unlike my brother, I didn't have to put golf on hiatus during my prime playing years because of work and kids. My wife gave me a hard time at first ("I didn't marry a golfer") but that changed a few years later, when she, at 40, took up competitive sport. And because we came to our obsessions late, both of us – at 60 and almost 60 – are still improving.

Among numerous other benefits, golf keeps its addicts interested in staying alive. I drive my car more slowly than I used to, because I worry that even a minor accident might be golf-threatening. When I walk, swim, or ride my bike, I do it because I believe that off-course exercise will help my game. And when I take up yoga – as I'm planning to do any day now – it will be because I know that increased flexibility will eventually enable me to extract a few more years, months, weeks, days, or hours for my swing. – DAVID OWEN

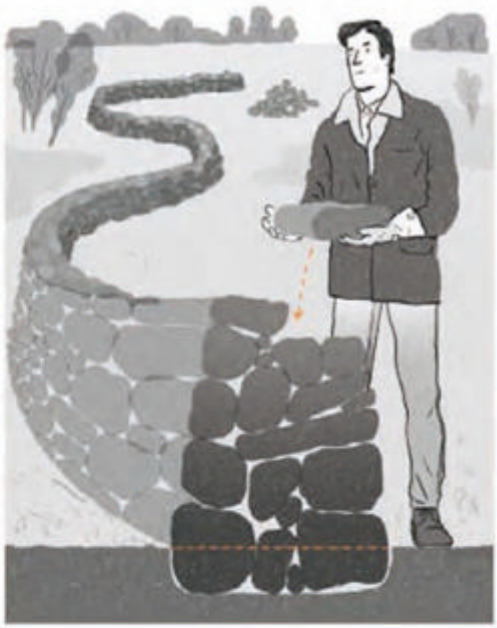
CHANGE A NAPPY

1. Set up your station: lay down a towel. Ready a clean nappy. Place ample wipes within easy reach.
2. Open the old nappy. Tuck the front half under the baby's bottom, clean front side of the baby.
3. Holding both ankles together in one hand, lift the legs and wipe. As many times as it takes.
4. Swap the dirty nappy for a clean one. Apply anti-nappy-rash agents and fasten.

PLAY POKER FOR REAL MONEY

MIKIYO AOKI,
high-stakes poker player

It's a pretty common poker saying: to live, you have to be willing to die. If you're worried about losing your money, your hesitation will show in your body language. One trick I use is to convince myself that I'm holding a certain hand. If I present myself like I'm holding pocket aces – and I believe it even if I'm holding two terrible cards – I will project confidence. I will be harder to read. After a while, I learnt to sense fear in an opponent. Maybe it's a tiny movement, a tightening in their face. You don't want to be that person. Create your own world, where you feel calm and in control. Playing for high stakes requires it.



BUILD A STONE WALL

A dry-laid wall adds gravitas to a property, a sense of acreage and potential horses. It looks like it should be an easy task to build one. It is not. First you'll need three piles of material: small, medium and large.

Use stakes and mason's line to lay out an outline of the wall's direction and width. Dig a footing trench between the lines, about 8 to 15 centimetres deep. Make the bottom of the trench smooth and level. Lay the largest and heaviest stones at the base of the wall, stacking them so they slant towards the wall's centre.

Use the two-over-one, one-over-two rule to ensure that you're not stacking stones of the same size directly over each other. Instead, lay them in an overlapping pattern, like bricks. Use progressively smaller rocks as you move up, and to fill in irregular holes.

HOW TO

TEACH SOMEONE SOMETHING

THE WHITMAN COIN FOLDER WAS BLUE AND LEATHERY AND FOLDED in thirds, with rows of circular pouches that sagged unless they were pressed full of Lincoln pennies. My grandfather gave it to me when I was at one of those restless ages – 8 or 9 – when I was annoying the whole household by banging around complaining of boredom. He was an engineer, a man of order. He had a kingdom in the garage that included a coin collection I was not supposed to touch. To still my fitfulness, he showed it to me. Inside an old chest were dozens of books like the empty one he had given me, each containing copper Indian heads or silvery buffalo in rows like a college class portrait. He had square florins from Aruba and yen with a hole in the middle. As I touched the coins, he told stories of old military campaigns. Restaurants that served fish eyes.

It was only once I had already fallen for the idea of collecting treasure that my grandfather got to the details that might have seemed tedious before. That a "D" or "S" under a penny's date was a mark from a mint in Denver or San Francisco. That a fine penny still had the designer's initials under Lincoln's right shoulder. He taught the guidelines one at a time, seeding my piles of change with extraordinary coins for me to discover. It was like he could see inside the mind of a 9-year-old, to the fantasies of international intrigue I careened around the house entertaining. He turned coin collecting into Nancy Drew and the secret of the steel pennies. He was almost 60. I was 9. But he knew. – JACQUELINE DETWILER

DRIVE 200 KM/H OR FASTER

We'll assume you're somewhere that this is legal, like the autobahn or the Bonneville Salt Flats. The most important thing about these speeds, the rule above all rules, is to keep your eyes up. Look as far ahead as you can. Don't focus on the area immediately in front of you: if anything were there, you'd hit it before you could react. Slow down your input to the steering and, especially, the brakes. Remember that nearly all street cars generate aerodynamic lift, which means that at 250 km/h the car has less grip than it does at 80 km/h. So don't ask the car to corner or brake as hard as it could under normal circumstances. And resist the urge to stare at the speedometer. A fleeting glance is all you need to prove to yourself that you did it.

HOW TO IDENTIFY PLANTS

THREE YOU CAN EAT

AROENA

WHERE: Namibia, Namaqualand
CONSUME: Stems, as a vegetable.

OUKOSSIE

WHERE: Little Karoo
CONSUME: Flowers, cooked in stews

CARPET GERANIUM

WHERE: Widely distributed
CONSUME: Flowers, in salad

HOW TO

SAIL

STEVE WHITE, *boatyard owner*

Sailing is a lot like riding a bicycle: you don't really unlearn. You can do it on holiday every year. The best way to start is to go out with somebody who already knows how and just watch. Then the experienced sailor will have you take the helm or the tiller of the boat and aim for a buoy or something. After that is when you start with theory: you can't sail directly into the wind. You can only sail at so close an angle, otherwise your sails will flap and luff and the boat won't go where you want it to. This can be frustrating at first, but in the end it's what creates the joy of sailing. Once someone understands that, the best thing to do is to just leave him alone to make his own mistakes.

If you're sailing in the direction of the wind, you'll need to "tack", or change direction to take a zigzagged path.

HOW TO

READ A RIVER

KEVIN FEDARKO, **author of** *The Emerald Mile: The Epic Story of the Fastest Ride in History Through the Heart of the Grand Canyon*

I SPENT SIX SUMMERS IN THE GRAND CANYON pursuing the dream of becoming a Colorado River dory guide. I started out in the baggage pool of a commercial river company, and spent my time rowing a bulbous inflatable raft behind the elegant wooden dories that carried the clients. But the river, like most rivers, is challenging to navigate, for reasons having to do with the complex and intricate dance of water churning through narrow spaces with enormous violence.

As I struggled with these powerful forces, an old river guide shared a secret. If you really want to fathom how white water works, he told me, then sit next to a rapid and study it under a full Moon. Moonbeams reverse the patterns of light and shadow, etching the water's surface in a milky-white glow and illuminating each ripple and wave. Mysteries that are inscrutable at noon reveal themselves at night, enabling an oarsman not only to see the current, but also to understand it: where it's going, where it wants to go (which isn't always the same thing) and where your boat needs to be to go where you want.

Armed with this knowledge – as much nuance, feel and poetry as mechanics of river hydrology – I gradually gained competence. I never graduated to dory guide, but I became adept at handling a one-and-a-half-ton garbage barge that follows the passenger boats through the canyon's Class V white water. This is no mean feat – it's the only boat that actually gets heavier the farther you go downriver. But once I learnt to read a river, that boat never turned upside down.

THREE TO AVOID

AMARANTHUS

WHERE: Widely distributed
WHY TO AVOID: Leaves normally cooked as morogo, but accumulate oxalates if grown on nutrient-rich soils.

ANACARDIACEAE

(MANGO/CASHEW NUT FAMILY)

WHERE: Warmer areas
WHY TO AVOID: Sap causes severe allergic reaction.

AFRICAN POISON IVY

(SMODINGIUM)

WHERE: Mpumalanga, KZN Midlands, Transkei
WHY TO AVOID: Sap causes itchy skin, blisters.

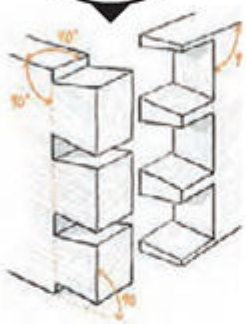
WIKIPEDIA

AGE

60+

HOW TO

MAKE HAND-CUT DOVETAILS



The first time I tried cutting dovetails by hand, as an apprentice cabinetmaker, I failed so miserably that my boss told me to cut the ends off the practice joint I'd made and throw them out. "You're not ready for dovetails," he said. He was right. Hand-cut dovetails – classic woodworking joints that use precise cuts rather than fasteners to join wood – are not the beginning but the culmination of a long string of fundamentals: you're not ready to make them until you can consistently mark a geometrically correct shape and then accurately cut it out using a dovetail saw and chisel.

Learning to hand-cut dovetails is a slow, meticulous process, but it's a rewarding one. A dovetail joint is a thing of beauty. A person who can make one well is a woodworker of consequence. – ROY BERENDSOHN

HOW TO

FLY FISH

Young men start out wanting to catch a fish. Then they want to catch more fish. Bigger fish. A trophy fish. Old men just want to relax. They navigate a patch of water slowly – they have to. So they can study the tough casting situations. Old men discern rhythms of nature they previously would have blown right by.

So says Joe Humphreys, a retired fly-fishing instructor who caught his first trout at 6 and turned 86 a few months ago. He says it all starts with the basics: casting and line control. With the pole straight in front of you, lift the rod in a counterclockwise motion, accelerating until the rod is vertical. Now pause (Humphreys: "Say 'one hundred'."). This unspools the line behind you. To send the fly to the water, flick your wrist forward like you're hammering a nail.

As for learning where to cast and what fly to use, that will take time. But that's the biggest advantage you have. – KEVIN DUPZYK

A SKILL FOR A LIFETIME
FISHING

Not every hobby can be learnt in a month, a year, or even a decade. Some are the blueprints to every skill a man ever learns. – BY C J CHIVERS

SOME TASKS ARE SO RICH IN THEIR DEMANDS that the hope of mastering them leads to the pursuit of others, and then to others, and so on for life.

When pursued with intensity, fishing works like that. Find someone who catches a variety of fish, season after season, year after year, in varied weather, habitats and conditions, and you have almost certainly found someone who possesses a range of disparate, but interlocking, abilities. Being an expert caster, while a handsome competency, is nowhere near enough. Just as cats are not predators solely by claw, people who master fishing's main goal – consistently harvesting fish – draw from a fuller set of skills. They can handle and work on boats. They read weather, currents and tides. They easily tie a multiplicity of knots – in ropes, wire or line. They understand food webs. And they typically can put to use any number of tools – a cast net, a fillet knife and its sharpening stone, a mitre saw when a dock or boat repair is required. They have forced their abilities to cohere.

This is why, in our house, fishing lies near the centre of what my wife and I consider our children's living classroom.

This is not to understate the obvious: at heart, old-school fishing remains about catching and eating fish. The waters near our home provide us a large fraction of our annual protein, beginning with yellow perch caught through ice in winter, continuing with the spring squid run on a nearby oceanic shoal, and then plunging full-bore into successive finfish harvests deep into fall, as various salt-water species migrate near New England's shores.

But as our children learn to harvest the bounties that swim within reach, they are developing and honing many other skills, from simple carpentry to animal husbandry to cooking, brining and pickling. We allow the possibilities to expand. Our gardens and fruit trees are fuelled by fish frames – the bones and heads of fish with meat removed – buried in compost piles. The trellises and beds the kids helped build provide all manner of food (garlic, potatoes, onions, leeks, beans, squash and tomatoes) that we serve with the fish. The turkeys and chickens the kids raise eat with delight any excess bait.

AS OUR CHILDREN LEARN TO HARVEST THE BOUNTIES THAT SWIM WITHIN REACH, THEY ARE DEVELOPING MANY OTHER SKILLS, FROM CARPENTRY TO ANIMAL HUSBANDRY TO COOKING, BRINING AND PICKLING.

And always it is back to the sea, where each trip helps the children develop a sense of self-reliance and achievement. One week night last summer we were about 25 kilometres out, tending the bottom in a rocky rip on a tide that had been dumping against a stiff wind. An ocean swell had been pounding across it all, creating a confused washtub sea. Once we had fish in the cooler, the crossing back to the mainland was black, and it bisected a shipping lane that required attention at the helm. (The boys, 12 and 14, pointed out the navigation lights on a tug towing a barge, determined its relative direction, and called out "all clear" on the course we had chosen.) Then, as we approached land, a blackout knocked out shoreline power, leaving little to navigate by as the hull covered the last stretch.

The boys hardly noticed. They spotted the seawall opening by scanning along a compass heading, then readied lines as we puttered up the channel past darkened docks before scooting cross-tide into the last tight passage. There they sprung from the gunwale to the dock to tie the boat off. I cut the engines, and listened as they continued the work.

The next morning the two of them carried the heavy cooler from the pickup to the cleaning table, retrieved fish from ice, and broke out the knives. An hour or so later they had filleted the catch and buried the frames in compost beside the strawberry beds. Mick, who likes to cook, was talking recipes. Jack helped me think through the design and placement of a new block and tackle.

Everything about the rhythm we had fallen into showed that the old saw – give a man a fish and he will eat for a day, but teach him to fish and he will eat for a lifetime – only brushes the truth.

Teach your daughter to fish and she may become a biologist, a mechanic, a deckhand, a carpenter and an artist, all on her spare time. You may find that you have a child who can free-dive with a spear, or build you a meticulously shingled storage shed with a classically pitched roof for your gear and lobster pots. And you will have fish, plenty to eat and plenty to share – an abundance of the food that propelled you all into motion in the first place, but required that you learn many other skills to succeed. **PM**

POLICE IN THE PANOPTIC AGE

A technological revolution is changing the way American police fight crime. Digital cameras log their every move, and those of civilians. PM dispatched an acclaimed photographer to three pioneering precincts – including a recent current flashpoint, Ferguson, Missouri – to create portraits of everyday cops wearing the controversial equipment.

Worryingly, in South Africa there seems to be less inclination to shine a light on police activities. Reports of members of the media having been harassed, assaulted and forced to delete images related to police activity – images apparently taken legitimately – continue to make the headlines.

IN 2010, THE OAKLAND, CALIFORNIA POLICE DEPARTMENT BECAME THE FIRST LARGE POLICE FORCE IN THE USA TO WEAR BODY CAMERAS THAT RECORD EVERYTHING THE OFFICERS SEE, SAY, AND DO. **CHIEF SEAN WHENT** DESCRIBES THE TRANSITION.

"There was some skepticism at first, but the officers have been won over. They really see the value in it. The cameras show that they are hardworking and do the right thing consistently. There are other factors to attribute this to as well, but over the last two years we're looking at a more than 50 per cent reduction in complaints. Those complaints that do come in, we're able to resolve them a lot faster. And although occasionally we'll catch somebody doing something they shouldn't be, the video evidence used in complaints overwhelmingly supports the police – more than 90 per cent support the officer.

"It used to be that you turn on the camera when you get out of the car to walk up to the car you've pulled over. We realised that works great for your routine car stop, but it does not work if it becomes a pursuit. So now, before you even attempt to make a car stop, you turn on the camera.

"The cameras are not perfect. They show a frontal view from the direction the officer's chest is facing, but that doesn't necessarily mean the officer is looking in that direction or that he isn't talking to somebody at his side. Also, night-time video is not great. The technology may improve, but you don't want better vision than the officer is capable of seeing either, because then there's no way to know what the officer actually saw.

"One of our major goals as a police department over the last few years has been to work on trust within the community. This is the way of the future. Law enforcement going forward has to be dedicated to some level of transparency. The public demands that, and rightfully so."

THE FOOTAGE IS RIGHT THERE, WITH ALL THE TRUTH BEHIND IT, SO THERE'S NO SIDESTEPPING WHAT TOOK PLACE. IT'S BENEFICIAL FOR EVERYONE INVOLVED.

PHOTOGRAPHS BY CHRISTOPHER GRIFFITH

ABOUT THE CAMERAS

TWO COMPANIES DOMINATE THE WEARABLE CAMERA MARKET FOR LAW ENFORCEMENT: VIEVU AND TASER. THE OFFICERS PICTURED WEAR ONE OF THE FOLLOWING NEW MODELS AT OR NEAR THE CENTRE OF THEIR CHEST.

Taser Axon Body

(used in East Haven and Ferguson)

Best known for electroshock weapons, Taser also makes this 100-gram camera with 130-degree field of view to capture peripheral action. The Axon Body records only in enhanced definition (between SD and HD), and its eight gigabytes of flash memory can store up to 13 hours of footage. Taser was due to introduce Signal technology, which uses Bluetooth to automatically activate any nearby body camera whenever an officer's conducted electrical weapon (CEW, or taser) is turned on.

Vievu LE3

(used in Oakland)

This waterproof 76-gram camera has a five-hour battery life and 16 gigabytes of internal memory – enough to hold six hours of HD footage or 12 hours of standard-definition. According to Vievu, the 68-degree field of view limits image distortion and provides a closer and larger picture. In Oakland, unless it is being used in an active case, footage is currently stored for two years. **PM**

Forget the instructions! With Lego bricks we can build anything we can imagine. Sean Kenney, a maker in Queens, New York, imagines a 1,2-metre duck.

PHOTOGRAPH BY LANDON NORDEMAN

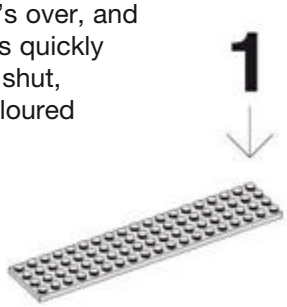
LEGO IS THE COOLEST COMPANY IN THE WORLD RIGHT NOW. BETWEEN THE HIT MOVIE, LICENSING TIE-INS, RETAIL STORES, AND ITS CONSTANT QUEST TO INNOVATE, THE BUSINESS KEEPS FINDING WAYS TO STAY RELEVANT AND PROFITABLE. BUT IT ALL COMES DOWN TO THE MAGIC THAT HAPPENS WHEN A CHILD SNAPS TWO BRICKS TOGETHER.

BY MICHAEL PATERNITI

TYPOGRAPHY BY
ISTVÁN SZUGYICZKY

WHEN HE DISAPPEARS, he disappears behind the walnut door to his room – the door, it seems, must always be closed to seal him in his private capsule – and then there's the sound of banging and rummaging in the closet, the padding of feet, and the sudden jangly spill of Lego bricks. And that's it. We won't see him for two, three, four hours. He doesn't eat, he doesn't drink. We'll crack the door to make sure he's alive and there in that slim line of light we can see the crown of his head bowed in concentration. His hands read the pieces off the floor like Braille, without his eyes having to see, and a flying machine suddenly materialises, or the minifigures amass for battle or celebration. Often he is making it up as he goes, talking to this world in low, sweet tones. Until the enemy arrives, or the monsters. Then his voice gets growly and a war ensues with the shattering of brick, one of the dangerous costs of believing in the permanence of your own self-made utopia. He is teaching himself a great deal about this world of ours, things we can't teach him ourselves. So – we retreat. He builds more. Dinner now, we call five times. And again. When he emerges, he's spent but smiling, half here. He pushes a pea around his plate, eats nothing. When it's over, and he's cleared his dishes, he pads quickly back upstairs, the door bumps shut, another jangle of sound, the coloured bricks, and he's gone again.

But where?



SO LET THIS BE A STORY about trying to find my son, and a whole lot of other kids, young and old, wherever they go, behind the walnut door. And let it begin in a storage cupboard in the Long Island City neighbourhood of Queens, New York, with a massive yellow duck. It's a mini monster, this duck, almost exactly like Ernie's rubber ducky from *Sesame Street*, but made out of nearly 25 000 Lego bricks – and the size of a Shetland pony. When I first saw it, when I came face to face with its peaceable expression of innocent no thought and its adorable citrine bill, I couldn't help myself: I blurted out a laugh. More like an inadvertent snort, then laughter. Who would ever think to make such a thing? The answer was Sean Kenney, a youthful 38-year-old maker with reddish hair and blue eyes. In fact, up until the duck moment, I'd been having a somewhat serious conversation with Kenney about his lifelong obsession with Lego bricks and, more specifically, about how, in his work as a Lego artist and entrepreneur, his medium – these bricks – seemed so primitive and regressive, well... so childlike.

But underneath, of course, I was also wondering: Why? Why was this nearly middle-aged man still playing – or getting to play – with Lego bricks?

Kenney didn't disagree with the bricks being childlike. He wouldn't even call himself an artist, as he feels he's still playing after thirtysomething years. When asked at what age he first began messing around with Lego bricks, there was no hesitation. His earliest memory of life itself was at 2 in a New Jersey suburb, surrounded by a loving family (his dad a rabid DIYer), on the floor with them: the rainbow colours, the feel, the satisfying interlocking click. He was like a bionic person half made of Lego bricks. Or his psyche was. On his Web site he calls himself a professional kid. What was that? And where might the rest of us sign up?

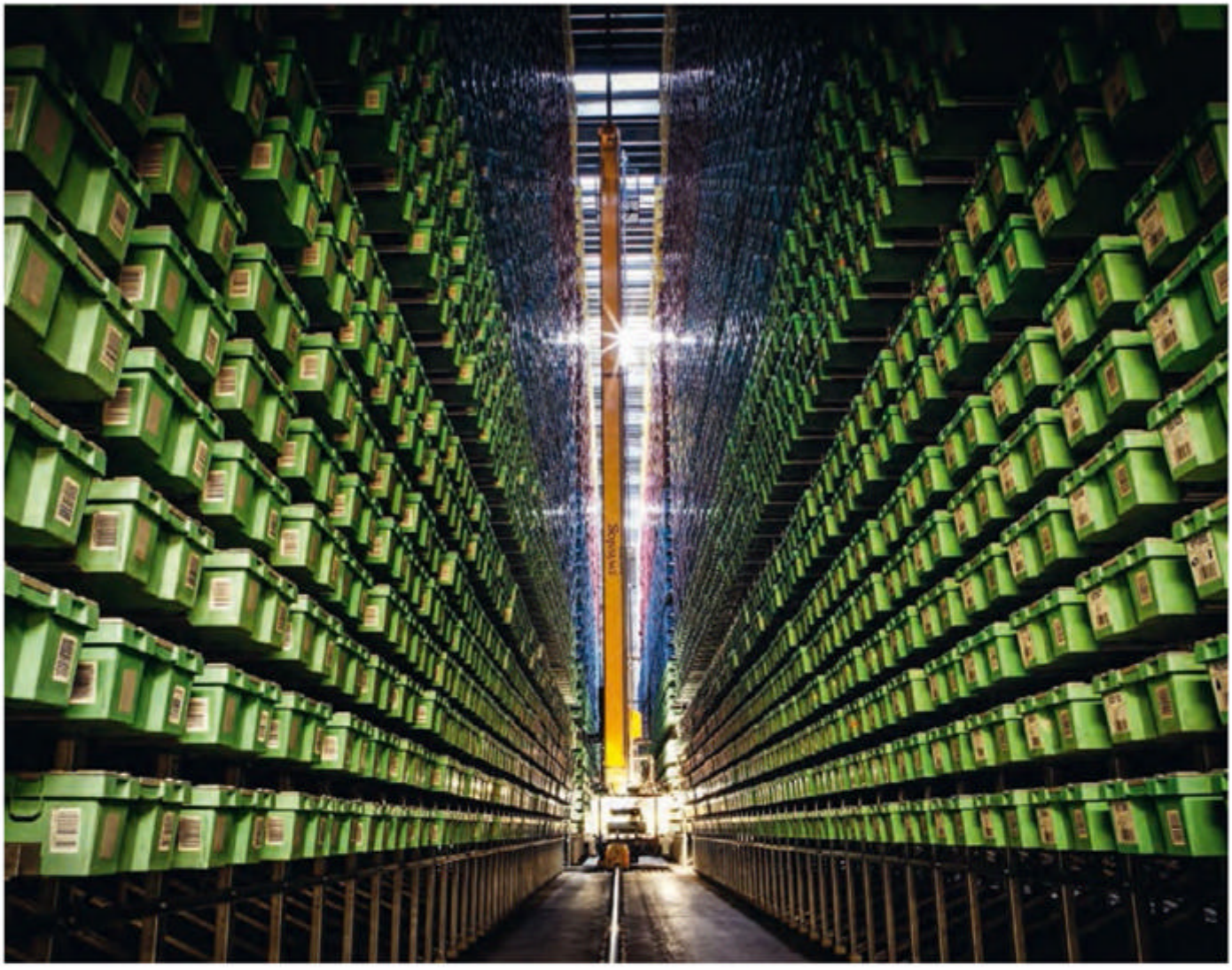
And yet right here before my eyes was visible proof that Kenney wasn't some sort of Pee-wee Herman: this gargantuan rubber ducky, retailing for a staggering R479 000. "I compare it to getting your car fixed," Kenney said. "It's never the parts that cost that much; it's the labour."

What Kenney was so good at describing, besides this world he'd created for himself, the one in which he spends every hour of the workday behind the door of his studio assembling huge Lego models (2,4-metre hummingbirds and life-size polar bears, or making little Lego lamps with the help of 11 hired assistants), what so few can put into words when it comes to the iconic building toy, is the strange thing that happens with the accrual of rectangular bricks (yellow rubber duckies! 2,4-metre hummingbirds!) and how evidence of these strange things can be found everywhere in plain sight when you begin to really pay attention.

"I think a lot of us makers are just trying to do something that's never been seen before," Kenney said. "Sometimes we're doing it just for each other, to inspire each other. It's like a conversation. How far can you push it? Can you surprise even yourself?"

I knew something about surprise, for in pursuing this story, I'd already bumped into a 1,8-metre simulacrum of Mark Twain made out of Lego bricks in Hartford, Connecticut,

ILLUSTRATIONS BY JASON LEE



The Lego factory in Billund produces about 20 billion individual pieces a year – about 38 000 per minute.

and a life-size Queen Elizabeth II (in snowy palette) and Prince William (in regal red and royal blue) built from the same in London. I had met a young guy – another maker – who kept building bigger and bigger robotic models, just for fun, until he was hired by various companies at the age of 24 to model factories out of Lego bricks before the companies went ahead and built them for real. And I'd bedded down in a Lego-themed hotel at Legoland in Billund, Denmark, where in the lobby there was a massive, Smaug-like Lego dragon, a Darth Vader, and Stormtroopers, and where at breakfast there was such a happy crush of rampaging runtlings, all ricocheting around with primitive Lego creations in hand, you could scarcely reach the pastry table.

Along the way, too, my son – the one who'd spent his boyhood behind that walnut door building with Legos, but who was now 14 and seemingly outgrowing the toy – came with me to Billund, where the bricks were first manufactured in 1949, and for the better part of a week he forwent his increasingly exciting social life and constructed stuff out of Lego bricks again. After returning home, while sifting through some old boxes, I came upon a lost photo of my son with a Lego skyscraper he'd made when he was 9, a simple tower nearly 2 metres tall, him beaming just as he had when he'd shown me a spacecraft he'd built with wings and a control room a few days earlier, in our pirate-themed room in Legoland.

The same expression, the same boy.

PERHAPS IT TAKES A PLACE as orderly as Denmark and a rather sleepy town like Billund, in the interior of the Jutland peninsula, to have given birth to the Lego legend. You can actually hear your own thoughts here among the salmon streams and beech trees. And without much else to do, the imagination has room to take its powerful precedence, too.

In the case of Ole Kirk Christiansen, master carpenter and joiner, there seems to have been a lot to think about, and imagine as well. His story's been told before, and certainly burnished, but it bears repeating. According to company lore, having

PHOTOGRAPH BY ALEX HOWE

When they first created minifigures, Lego officials decided the faces should have only one colour – yellow – and wear a neutral expression. Now the characters come in countless guises and moods.

bought a modest furniture factory in 1916, Ole Kirk built a dairy and church for the town. And with wooden scraps from the factory, he began to make toys, formalising the operation in 1934 with the name Lego, adapted from the Danish *leg godt*, which means play well. Making toys was less an act of whimsy than of priority and business proposition – and his vision, it would seem, was communal from the start. With the death of his wife, Ole Kirk was left with four young sons to educate and entertain. At first the toys were simple: a painted duck with wheels, a truck. And yet his restless mind led him to a manufacturing fair in England after World War II, where he was introduced to a device known as the Windsor SH Plastic Moulding Machine. He became the first to buy and bring one back to Denmark.

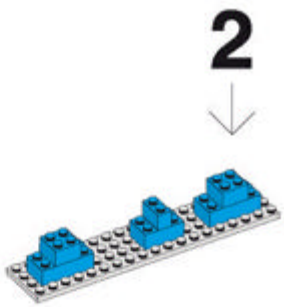
It had all the makings of a folly or a fairy tale: the widowed toymaker living in a house in the middle of town with his four boys, spending his money and time on a machine that might spit out these plastic bricks he had in mind. But by then the boys were grown and the toy company had close to 50 employees. Already Lego was playing with the idea of exporting its wooden toys, as well as diversifying – that is, making toys in plastic. Ole Kirk called his new product Automatic Binding Bricks, which were cribbed in part from the British Kiddicraft Self Locking Building Bricks. Like the Kiddicraft bricks, Ole Kirk's were at first hollow plastic rectangles. He sold them in four colours, only in Denmark, without the interior tubes that would soon revolutionise everything.

Today the company is still family owned, primarily by Ole Kirk's grandson Kjeld Kirk Kristiansen, who, according to Forbes, has a personal fortune of about R120 billion. (Even in the recession of 2008, as the toy industry died on the vine, Lego profits were up 31,5 per cent. Last year, as further evidence of the brand's enduring popularity, *The Lego Movie* grossed nearly R5 billion worldwide.) In the centre of town, the toymaker's original house is now a quaint museum called the Idea House, and one exhibit shows Ole Kirk's mind working on the initial problem of building a better brick. A patent application itemises at least 12 designs with which the company was experimenting, or perhaps claiming as its own to block future competition.

What emerged from this cogitation was the simple, if multifarious, Lego brick as we know it, with its familiar, almost primitive interior tubes and studded surface, which, when attached to another brick, creates instant stability and what the Lego people call clutch power. In other words, small hands can attach and unattach the bricks with this "stud and tube coupling system", while the bricks are strong enough to build with, sometimes elaborately.

From the start, the toy exploded in the marketplace. By 1958, the year that the stud and tube coupling system was patented (and the year Ole Kirk died, passing final control of the company to his son Godtfred, who was already developing a unified "system of play" for the company by creating a standard brick that could be used in every set made

PHOTOGRAPH BY ALEX HOWE



thereafter), Lego had 140 employees. Two years later the company abandoned wooden toys altogether, when it had 450 employees in Billund alone and eight foreign satellites. By the early sixties one employee could work two plastic moulding machines at once, and production continued to expand with play kits and minifigures (born in 1978), as well as an array of new pieces, products, and eventual movie tie-ins. Today Lego employs nearly 14 000 people, is sold in 130 countries, and has roughly 30 product lines (from *Lord of the Rings* kits to Lego Mindstorms, from which one can build motorised robots). Having opened new factories in China, the Czech Republic, and Mexico, the company now makes more than 55 billion Lego elements a year out of 4 200 tons of ABS, a thermoplastic polymer. It's said there are about a hundred bricks per person on Earth.

"People will tell you they have their own path to playing with Legos," said Michael McNally, a company spokesman. "Everybody has different sets. I began with Legoland, the town, and I love Lego Architecture. Someone else loves *Star Wars*. Or Mindstorms. People like to talk about the infinite with this system, but it's also very limited because [the brick] is a rigid geometric form. So the idea that you can look at something finite and see infinite possibilities in it and believe you can make something round out of it even though it's square, is very hard to explain. I think in other cultures we might have rounded the edges because someone wanted them round, but I think there's something to this idea of discipline and restraint that almost liberates these forms. Lego bricks can be anything you imagine them to be. That's really their appeal."

This not knowing the mystery, as well as the creative act of bending the material, or reshaping its shape to match the one in mind, may partially lie at the heart of Lego's greater addictive appeal, too. And perhaps it's a Danish diffidence, an under-assumption about what the company is really meant to do for its customers (after some dangerous years of over-assuming, years that nearly led to bankruptcy during the early 2000s), that leaves an open space for us, the makers.

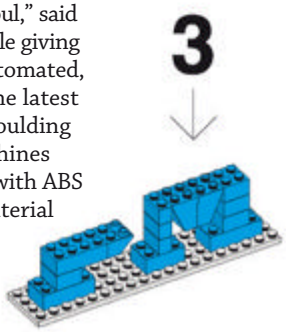
During my visit to world headquarters, in Billund, I repeatedly met with people – make that employees who've made Lego bricks their life work – who also struggle to understand the exact algorithm for the brick's ubiquity. Headquarters here are modest-looking, low-slung buildings made mostly of yellowish brick, and because the town is so sleepy, many of the employees commute up to an hour each way from bigger towns. The company culture is decidedly unpretentious – and employees really do seem to subscribe to the 11 Paradoxes of Management listed on a placard hung in every Lego manager's office, these three, among others, calling for individuals "to be a visionary – and to keep both feet firmly on the ground. To be self-confident – and humble. To take the lead – and to recede into the background."

Lego clearly isn't an oblivious collective of elves making a magic toy. "This is our heart and soul," said Roar Rude Trangbæk, Lego press officer, while giving me a tour of the factory, a fully modern, automated, 6-hectare warehouse replete with 750 of the latest versions of that old Windsor SH Plastic Moulding Machine. Working off computers, the machines purred in a low hum, fed by pipes teeming with ABS pellets. When heated and liquefied, the material fills a mould, cools to its particular shape, and then is ejected in that jangle of colour, cheap jewels filling bins until they're swept away by robots, destined for whatever particular set will excite its clamouring fans or offer complete satiation on Christmas morning. But even in its unceasing production, the Lego brick is animated by ten tenets, first codified by Godtfred in 1963. It seems a lot to put on a piece of plastic, but in boiled-down corporate bites these are:

It was the MIT Media Lab that devised the programmable brick, which contained an embedded computer capable of controlling a Lego model.

1. Unlimited play potential
2. For girls and for boys
3. Fun for every age
4. Year round play
5. Healthy, quiet play
6. Long hours of play
7. Development, imagination, creativity
8. The more Lego, the greater the value
9. Extra sets available
10. Quality in every detail

In the conversations that ensued at world headquarters, I noticed some recurring themes: most employees claimed an early love for playing with Lego bricks (that they, too, were the boy or girl behind the walnut door); evoked their bosses, the Kristiansen family, with glowing, if slightly cultish, praise; emphasised the low-key, inclusive company philosophy that continues to highlight the educational rewards of playing with Lego bricks; and spoke to the need for corporate secrecy regarding future plans and ongoing research ("We don't necessarily feel we're competing with other toys or games," said one employee, but he clamped shut when asked with whom



or what Lego was competing, then); and ended each conversation somewhere between the 23rd and 30th minute with a somewhat brusque insistence on how busy they were. At a company in forward motion, and with pressure to produce during the relatively sane number of hours in the Danish workday, there seemed little time for floaty reflection or declarative me statements here. The folks at world headquarters are happy to leave that up to others.

Meanwhile everything's on an egg timer, and you can almost hear the sucking sound of an incredibly lucrative enterprise needing their attention to maximise profit. If there was a disappointment, at least for me, it was that, except for the designers, none of the adults here seem to have any real time to play.

At one point, back at the Idea House, I was led into what the Lego people call the Archive, but it might best pass as the Stacks of Past Memory. These are huge, hand-cranked bookshelves, more or less divvied up by decade, containing almost every Lego set ever made. It's an astonishing thing, really, and some of the most obscure kits were bought on eBay. Found down here are the first Lego Mursten (or Building Bricks), and the Big Town set from 1961, and the automated Lego train and Lego Space from the 1970s. The stacks from the eighties and nineties bring an assortment of Duplo products (the bigger Lego brick) and Lego Mindstorms, while the 2000s lean more heavily on the action figures and movie tie-ins, from the Vikings sets to the *Harry Potter* set scenes. And let there be no doubt, somewhere in this plastic cornucopia is the game or set that once belonged to you too.

It's said that people get lost in the Archive for hours. In fact, afterwards, several Lego employees asked me if I'd cried on my visit there. (I hadn't, but when my son came upon the Millennium Falcon in the 2000s stack, the first big Lego kit he ever completed on his own, he gave a little yelp of joy.) They asked because either they themselves had – or they'd heard the many poignant stories of others who, when confronted with the Lego set of their youth, had had a sort of *Wild Strawberries* moment, powerfully recollecting the hours spent lost in the pure pleasure of this particular kit or remembering the person by whose hand they'd been given the gift... and then they'd found themselves absolutely overcome by this wave of strange joy/sadness, or grief/elation, or whatever it was that only a simple, infinite plastic brick could mysteriously evoke in a person reaching backwards in time for something there/not there, namely his childhood.

A FEW WEEKS LATER, back on the North American side of the ocean, I took a New England road trip. At each stop – at MIT's Media Lab to meet with renowned educator Mitchel Resnick, at the bustling Lego Model Shop in Enfield, Connecticut, and in New York City, hive of Lego makers – I was met with a blast of effusion. Though I was talking to grownups, it felt over and over again as if I were entering through the door of some geeked-out kid's room, one towering with Lego inventions and scattered bricks everywhere and the breathless monomania of perpetual youth. There was something in the primitivism of it all, the clicking bricks and blocky figures, the sophistication and simplicity, the splendour and rusticity that links the present and the past, that created some deeper disturbance of comfort.

Situated near the Charles River in Cambridge, Massachusetts, MIT's Media Lab is a glass and metal building where Resnick, perched on the fourth floor, resides in a world of inquiry meant to lead today's kids to new, sticky learning experiences. Among other things, he and his team have developed a computer program called Scratch, which enables children to make their own video games, animation, and interactive art. "We're always about kids creating, building, designing and inventing," Resnick said. Dating back to 1985 – when Lego first struck up a partnership with MIT – the Media Lab has made the Lego brick one of its primary focuses. In fact it was Resnick and his research group who came up with the idea of the programmable brick, which contained an embedded computer capable of controlling a Lego model. They created bricks with chips. The result of their work, in turn, led to the first iteration of the Lego Mindstorms line.

(The agreement between the corporation and the university appears clear cut: Lego donates an unspecified amount of money each year – beyond the R60 million it earmarked in 1999 for Resnick's connected Lego Learning Lab – while having access to the research that comes as a result of its investment. That is, beyond Lego's donation, MIT doesn't benefit from any applications it develops for, or with, Lego bricks, though Lego supports the lab's research into, among other things, smart materials, embedded computing, and attempts to understand how and what children learn through play and develop

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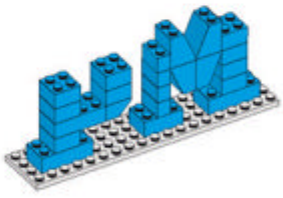


"Instead of panicking that the tactile toy will never survive, we realise that kids want the tactile and digital to work together. It's not discrete, it's complementary."

MICHAEL MCNALLY | LEGO SPOKESMAN

LEGO BROUGHT TO LIFE

A GALLERY OF PROJECTS BY THE KIDS OF PM READERS

Lila and Jack J
PARK CITY, UTAH
A megarobot named Avalugg

Jake B
RIVER VALE, N.J.
A ship with a rescue crane

Aidan O
BROOKLYN, N.Y.
A wing jet and a Batman glider

Fletcher G
LOS ANGELES
Benny's ship from *The Lego Movie*

Jake S
SHORT HILLS, N.J.
The Power Plant 6000

Jackson B
CLAWSON, MICH.
A spaceship

Bradley R
RALEIGH, N.C.
A bust of Homer Simpson

Wyeth and Auden L
NORTH SALEM, N.Y.
A tropical island getaway, an old-fashioned plane

new ways to make their playtime more expansive. The company also provided seed money for the Playful Invention Company, founded by Resnick's colleagues, to test more ideas in the marketplace.)

As part of the partnership, Resnick finds himself in Billund four or five times a year – and guides his own research by the Lego mantra of "Joy of building. Pride of creation". "What I think is special about Lego," he said, "is this idea of structure plus freedom. You can have fun with modelling clay, but Lego provides structure. The material itself – a 2 x 4 brick – is freedom and structure. It's not absolute freedom: Here are the bricks, build anything. And it's not: Here are the instructions, you can build to the specifications only. That's not great either. We want kids to imagine new worlds, but have some structure to build them."

Resnick continued, "One of the things I like about *The Lego Movie* is the core message: Don't just follow the instructions. Be creative. The best learning experiences will come when the kids are the designers, when kids aren't just watching and listening but creating. Of course we always learn from watching, too. If a movie is inspiring kids to become builders, creators, designers, I think there's a great role for it. One thing I worry about with new technology – computers and gaming – is that people talk about interactivity, but if interactivity is just moving a joystick and pushing buttons to control a character on the screen, that's not joy of building or pride of creation."

If we are headed towards a future in which increasingly complex digital–physical integration will become the norm in play, Lego officials seem unphased. "The way we look at it is simple," said Lego spokesman Michael McNally, picking up two bricks and sticking them together: "This is the same as this." He pretended to swipe his finger over a glass screen. "The user is still a kid and a creator. We have a more profound understanding of the digital than we did ten years ago. Instead of panicking that the tactile toy will never survive, we realise that kids want the tactile and digital to work together. It's not discrete, it's complementary."

Nowhere is this symbiosis of digital and tactile clearer than when one scrapes the maker subculture that barnacles the hull of the Lego enterprise. In some ways it's the most exaggerated actualisation of Resnick's clarion call for active players – and refutes the notion that Lego bricks lose their primacy when kids develop typical teenage interests, or that there's some predictable demographic for enthusiasts. If anything, Lego makers are fully grown adults and the culture thrives both inside the company and out at conventions and online fan sites and in places like the Lego Group's US headquarters in Enfield, where up to two dozen model builders work to fill company requests from around the world. Among the deadlines of the moment when I visited was a massive Lego model of the Capitol in Washington, DC, that will be more than eight metres long and will be displayed as part of the travelling Lego Americana Roadshow, which will also include a five-metre Washington Monument and a sprawling White House with both East and West wings.

The master builders, as they're called, are of a kind: happy to bounce between working at the computer, where they design and "concept", and building with the bricks themselves. And

The Archive, at Lego world headquarters in Denmark, contains 6 141 sets, some dating to the 1950s.

way more than happy to dedicate several months of their time perfecting, say, a life-size Buzz Lightyear or rakish Jack Sparrow.

"I get to be a rock star without the hassle of people knowing who I am," said Pete Donner, the design manager here, with a playful smile. His computer screen showed a koala bear that will attach to a nine-metre Lego Christmas tree to be sent to Australia as part of a holiday show, then in what Donner called "low poly phase". He began his Lego life being into "giant gorillas, dinosaurs, and all that sci-fi stuff like robots and spaceships". Seventeen years ago, in 1997, he heard they needed extra hands at the workshop.

At that time, everything was analogue. "People would grab a bunch of bricks and just start building," he said. By 2001, however, the switch to digital brought the use of 2D and 3D images to help the modellers. "It suddenly became more like sculpting with clay," said Donner. After 11 years of building, he was elevated to designer as well, a job he claims to be the best in the world, something you hear often among those who make their living working among Lego bricks.

"I go to Disneyland and see people – parents and kids – who are really excited about what we've built," he said. "And I get to spend my life chasing the creative urge. I used to go out on the road a lot, and, inevitably, a kid would come up to me at this or that show with the same ten bricks that sit in front of me every day, and I'd be like, 'How did you know those could go like that?'"

The infinite again. (Or at least the multimillionite, as it's been calculated that there are more than 900 million possible combinations for six eight-stud bricks.) "I marvel every day at how much can be done with something relatively simple," Donner said. "But you also have thousands of elements that all work together. It has transcended being a toy into something else, which is anything you want it to be."

And this is exactly what lies at the heart of what Sean Kenney – he of yellow rubber ducky – said is the maker's drive "to create something that's never been created before, just because it's a cool thing to make". Forget the cost of the sets or the corporate billions made, all the numbers and studies and thinking on it, all the people at headquarters working the spreadsheets and future plans and origin stories. This is what it always boils down to: mind, fingers, bricks. A lightning storm in the left lobe. A compulsion to build and express.

In the end it's the bricks that speak.

Kenney remembers a time when he was 20, when his mother was cleaning out his childhood bedroom. He took all of his Lego bricks back to university, and in his dorm room, with two other roommates, began building an elaborate city, mostly like the one across the river: New York. "They made fun of me for about two days," he said. He started giving himself all sorts of rules. A building couldn't be wider than it was tall, for instance. "Then when I'd return from class, I'd see they'd been playing too. There were alien invasions. Or I'd find the heads of all the minifigures in a pile, and just crack up."

Kenney's obsession carried through, even when he was working a high-paying office job. "I gave myself a (R2 000) a month budget to spend on Legos. I made a deal with myself that I'd spend it all or lose it." If he had R300 at the end of the month, he'd just buy "a bunch of doors and windows and see what I could do with them".

What he found was that there was a not-so-under-

PHOTOGRAPHS BY ALEX HOWE

This is what it always boils down to: mind, fingers, bricks. A lightning storm in the left lobe. A compulsion to build and express.

ground community of others exactly like him, posting their creations to the Internet, people who blew him away. One guy named Mike Doyle was building a mystical world called Odan, with a master plan calling for 200 000 Lego pieces. To fund part of it, he raised almost R100 000 on Kickstarter. "He's created some unbelievably beautiful things you've never seen before," Kenney said. "It's inspiring. Some of them are like oil paintings." That, he said, is a large part of the maker movement, throwing stuff out there in hopes of moving people somehow "with the purity of interlocking bricks".

And when you delve a little, all kinds of people, it seems, are on their own interesting Lego trip. The White Stripes have a music video for "Fell in Love With a Girl", all in Lego stop motion animation, and one of *The Guardian* Web site's most popular sections is called "Brick by brick", in which sports highlights, mostly soccer related, are recreated by stop action Lego figures.

Another maker, David Pagano, has created his own acclaimed animated franchise of "brickfilms", called *Little Guys*!; Brendan Powell Smith has authored a book called *Assassination*! with the subtitle *The Brick Chronicle of Attempts on the Lives of Twelve US Presidents*. (Its high/low point is a scene-by-scene recreation of the Kennedy assassination, ending with Lego Kennedy grasping for a red blotch at his neck while Lego Jackie clambers to help.) On YouTube there are Lego reimaginings of everything from World War II battles (one D-Day video has more than 10 million views) to cool skateboard crashes (nearly 5 million views).

So why does Lego, the name and the brick itself, lurk in the imagination, and in our lives, long after toys like the Yo Yo Ball and Micro Machines Zbots have faded? And in an age of Xbox and PS4, in the Time of Our Digital Panoply, why are those simple bricks more popular now than ever before, racking up more than R10 billion in profits for the Lego Group in 2013?

I wonder too: does the answer partly lie in the work of a German artist named Jan Vormann, whom one can find online, roaming the world, spackling holes in crumbling city walls with rainbow Lego brick constructions? Is that the reason that Legos resonate for us – because we need rainbow patching, too? Is it that life isn't this precise Pixar rendition, but blocky and striving and shape shifting, and in the simplicity of the Lego brick we find a certain physical, intellectual, and spiritual release?

Kenney, for his part, seems to believe there is something cosmic at work. "For some of us, it's hard to imagine anything but this," he says. He holds up two Lego bricks in yellow and blue. "These are puzzle pieces and this is how everything connects. It's like this little atomic block of the universe. Sometimes I think, what if I couldn't do this anymore? What if Lego has a CEO years from now who says we have to stop, who says we're infringing on the company's copyright? I don't know what I'd do. This has been my whole life. Would I go back and make toys? Or real houses? I don't know." Kenney grows pensive, glances at the floor to ceiling shelves containing his world, thousands of Lego bricks, some from his own childhood.

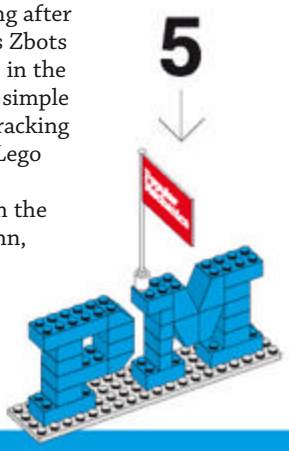
"I love slogging through all the creative problems," he says, lighting up again. "We were doing a hummingbird recently, and we were, like, three weeks behind, and I was up on a ladder building, in the thick of it again, something was squirking out here, and over here we had to lift and support and shim things.

"It seems weird to say, but I was in heaven."

SO, WHERE IS HE? Right here, it turns out, behind the walnut door again, where he's always been. The time is right now, today, and my son just turned 15. Fifteen! He will soon have his driver's licence. He's interested in many things besides Lego. And yet here he is, making a Lego forest, enacting a chase scene.

When I knock, he allows me in. He's happy to share what he's made, tolerates me fiddling with a few bricks as he adds to the forest. Besides the mechanical exercise of attaching brick to brick ("the interlocking principle", as Lego has it) and the unknowingness of what will happen (the thrill of discovery and invention), something else comes out of this exercise and these seemingly fugitive hours on a Saturday afternoon: I'm moved by memory and engagement into a timeless space, a place where thousands, nay, millions of other ghostly Lego brick players already play and where that sort of invisible interconnectedness lends its own meaning to the lopsided pterodactyl spaceship I make, the one that evokes laughter from my son and takes its place in the same world with his forest and Lego Mark Twain, with big Lego rubber ducky and Darth Vader.

But for the moment it's pretty simple. We're just playing. And the thing is this: We have no idea what might happen next. We're building a secret that we ourselves don't know yet. There are bricks in our hands, a universe. We keep building it into being. **PM**



WHEELS

Compiled by
ANTHONY DOMAN
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VOLVO XC90

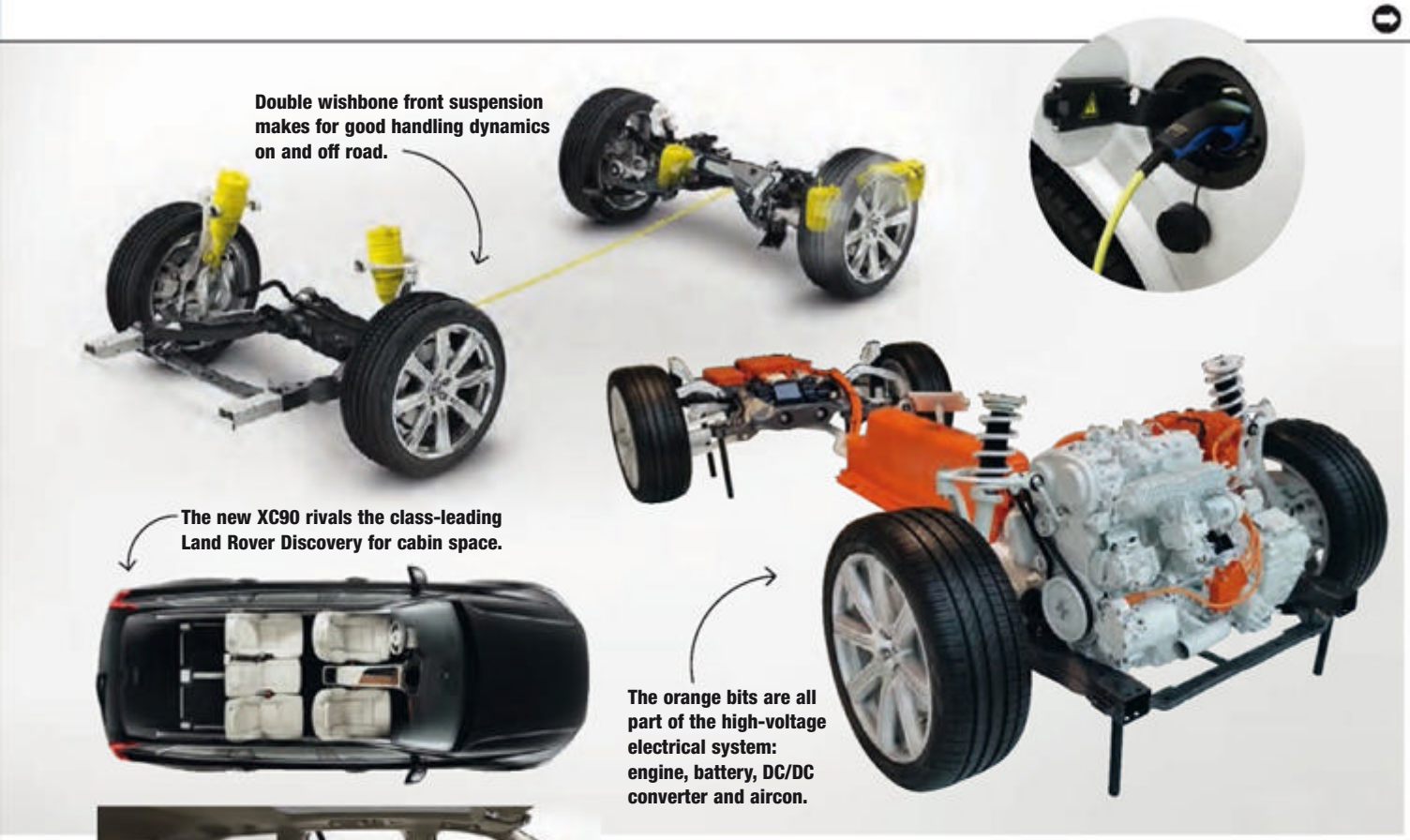
A NEW HOPE

Change is coming in Swedish motoring. After being sold to Ford at the turn of the century, Volvo was involved in many joint platform ventures with the parent company and other members of the Premier Automotive Group. A turbocharged variant of Volvo's five-cylinder B5254 engine famously powered the second-generation Ford Focus ST, and the second-generation S40 and C30 coupé share suspension, subframes, steering, braking systems and numerous electric components with the Focus. That was, kind of, the problem after the Ford sale: Volvo was sharing technology to bring down platform development costs and lending its own inventions to larger volume selling brands. All that is gone now after the unexpectedly fortuitous Geely buyout where the Chinese leave the Swedes alone.

The all-new XC90 is a statement car that combines the best of Volvo from nearly nine decades of high manufacturing standards. You wonder why Swedish car makers keep going under? Because they're too honest and spend a lot of money policing their suppliers to ensure honesty. The new car is actually a throwback. Four-cylinder motors pay homage to the original OV4, the double wishbone front suspension is from the 144, and the rear transverse leaf spring is 960-inspired.

Powertrains come in three guises: T6 two-litre petrol, D5 two-litre diesel and T8 twin engine plug-in hybrid. All models come in all-wheel drive with the Swedish-designed Haldex coupling, another technology shared with Land Rover (Freelander 2) in the Ford days, governing power delivery in the non-hybrids. Volvo's popular Drive-E engine delivers traditional driving force and forms the petrol part of the T8 twin engine with its dual turbo and supercharger intake system, which guarantees even power delivery from very low revs.

The previous XC90, launched in 2002, was a landmark car for Volvo, allowing the company to bring roll-over protection to the premium SUV market. It



Double wishbone front suspension makes for good handling dynamics on and off road.

The new XC90 rivals the class-leading Land Rover Discovery for cabin space.

The orange bits are all part of the high-voltage electrical system: engine, battery, DC/DC converter and aircon.

hasn't aged well in terms of styling, but 636 000 worldwide sales say that it was loved. The new model was first released in an online sale limited production run of 1 927 "First Edition" cars. Volvo sold out in 47 hours; 14 units are making their way to SA. With a customer list stretching from Zlatan Ibrahimovic to Lucas Radebe, Audi and BMW should be scared.

Industry firsts is something Volvo prides itself on. The first plug-in hybrid in the premium SUV segment will further enhance its reputation for early adoption. The technology at work in the T8 twin engine variant is brain-bending. A 60 kW, 240 N.m electric motor drives the rear axle, powered by a high-voltage 65 kW battery that's mounted in the centre tunnel to help with weight distribution and lower the centre of gravity. Up front is the two-litre Drive-E petrol with a 34 kW crankshaft-mounted starter generator to handle the seamless transition between driving modes as well as boost output by 34 kW and 150 N.m.

In all, you can recruit 295 kW and 630 N.m of torque, which will translate to 100 km/h coming up from a standing start in 5,9 seconds. But what Volvo really wanted to achieve here was, we found, impossible to replicate: really, really low fuel economy and carbon emissions figures. We set the car to hybrid mode, drove gingerly through the Catalan countryside and returned a best real-time

CITY SAFETY

Once the name of the automatic braking function that would stop the car from hitting a pedestrian at speeds slower than 30km/h "City Safety" has now evolved into the umbrella moniker for all Volvo cars' auto brake functions and incorporates camera and radar systems to detect pedestrians, cyclists and other vehicles. This includes a handy new cross-traffic detection system when reversing out of a parking space.

figure of 6,4 litres/100 km, a far cry from the manufacturer-quoted 2,5 litres/100 km. Bear in mind, though, that this is a 2 300 kg SUV.

Off-tar performance has always been one of the XC90's hidden talents and there's more of the same in the new generation. A fifth-generation Haldex coupling governs the torque distribution among the four wheels and the electronically controlled air suspension adjusts ride height. Things are a bit different in the hybrid T8 with the separate engines driving the front and rear axles. It should be noted that the batteries charges better from a wall plug than from regenerative driving; if the batteries go flat, it defaults to front-wheel drive only, limiting off-road performance.

On test we managed to deplete the energy stocks with some spirited driving in power, hybrid and pure electric modes well within the estimated 40 km range and didn't manage to recharge the battery sufficiently while driving. Although Volvo has assured us that this was a problem unique to the test models, we sincerely hope that the issue is addressed when owners take delivery from August.

The XC90 reminds you of its premium market placement by bathing you in light and swaddling you in comfortable leather. All models come in seven-seat configuration. Cargo space rivals that of the Land Rover Discovery when the third row is in use. Doing the sit-behind test in all three rows highlighted the good use of space and clever seat adjustments. At the helm you can tailor your seat down to the length of the seat cushion and width of the side bolsters.

Overall, the XC90 is well matched against its Bavarian rivals; Volvo should easily reach its five per cent market share goals. The new car is also a debut for Volvo's new platform and XC90 should be the oldest car on the dealer floor in four years' time. This also feeds back neatly into the company's 2020 vision of no-one being injured or killed while driving a new Volvo car, keeping Sweden with the times indeed. – *Lindsey Schutters*

AT YOUR COMMAND

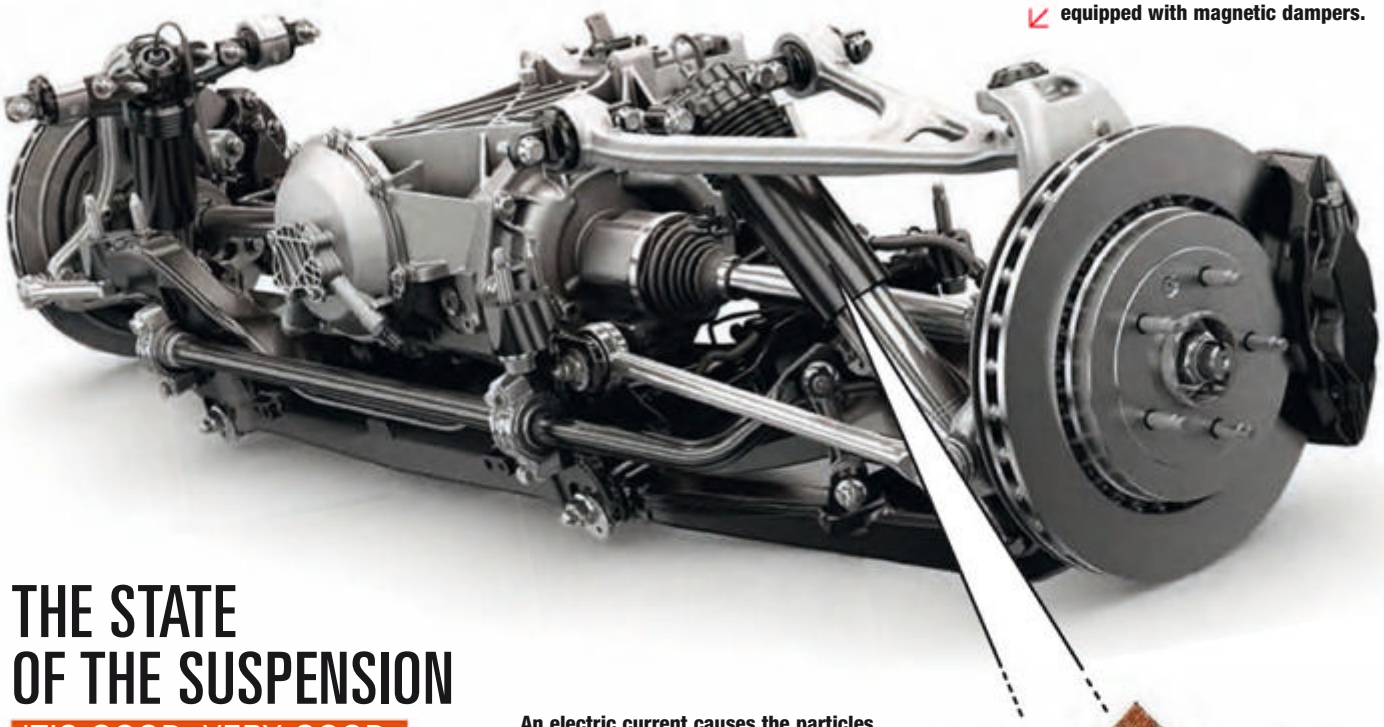
If you were hoping to haul out the old CD collection you'll be greeted with a non-compliant touchscreen. Meet Sensus, Volvo's new user interface that controls everything in the car. You can customise your driving mode and all the related throttle response and ride height adjustments here. You connect your phone to it. It does your navigation (currently via Here maps). You set your car functions through it and, in the near future, you can access Apple's Carplay and Google's Android Auto through it. Info gets fed to your eyeballs through the head-up display, instrument cluster or the touchscreen and Sensus communicates through the superb Bowers & Wilkins speaker system that'll even mimic the acoustics of the Gothenburg concert hall if you want (not recommended for pop music).

PM DRIVE

KIA SOUL 2.0 SMART

BOXING CLEVER

Glowing door speakers and funky, polarising body styling do not a high-volume seller make, but when you compare the value offering of the all-new (we'll get back to that later) Soul to its segment competitors, you wonder why this doesn't fly out of the dealers. While the outgoing model was unique in shape, it was a bit demure. The new model isn't a car for shrinking violets and the spirited performance of the rev-happy engine and over-enthusiatic autobox will try its best to lure you out of your shell. Extroverted, spacious, practical and fully loaded with tech toys, Kia's Soul is the spirit of the company in the metal. There's a radical Soul-based all-electric 4x4 concept that we hope Kia will put into production, you can salivate over the video at *popularmechanics.co.za*
– Lindsey Schutters

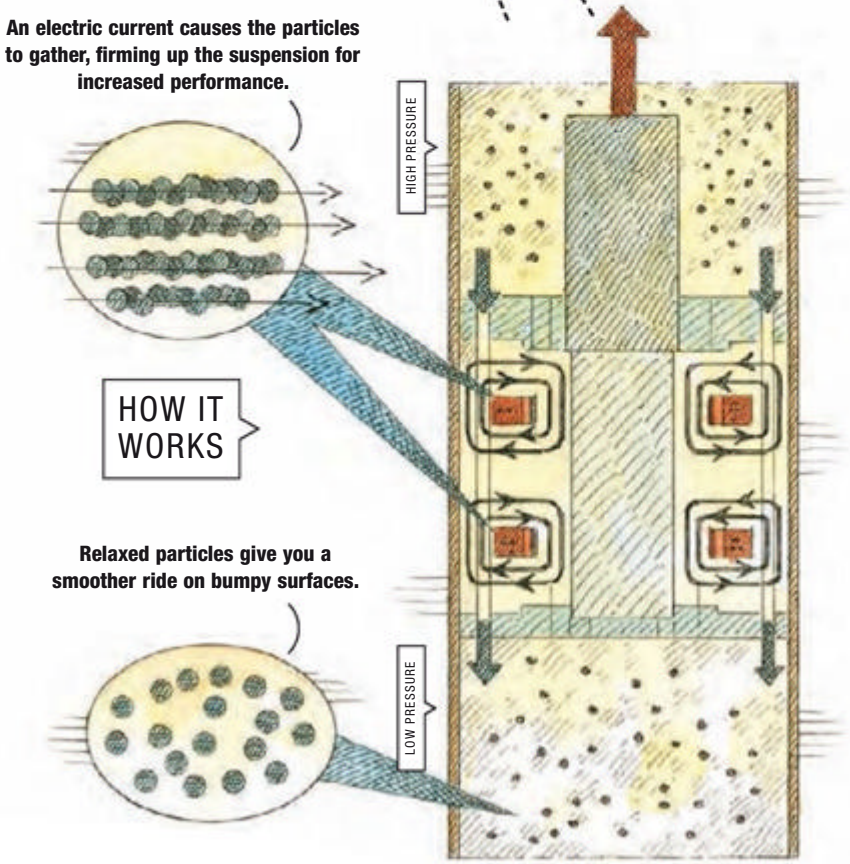


A Chevrolet Corvette Stingray suspension equipped with magnetic dampers.

THE STATE OF THE SUSPENSION

IT'S GOOD. VERY GOOD.

Suspension systems don't tend to get much publicity, but they're probably the most crucial factor in the day-to-day enjoyment of your car. Automakers are always tweaking and refining their designs in search of that elusive ideal: a perfect ride coupled with race-worthy handling. We haven't quite gotten there yet, but the latest systems are better than ever at reconciling the competing goals of comfort and performance. Here are three recent innovations to tide us over until Bose reinvents suspension entirely.



ILLUSTRATIONS BY JOHN BURGOYNE

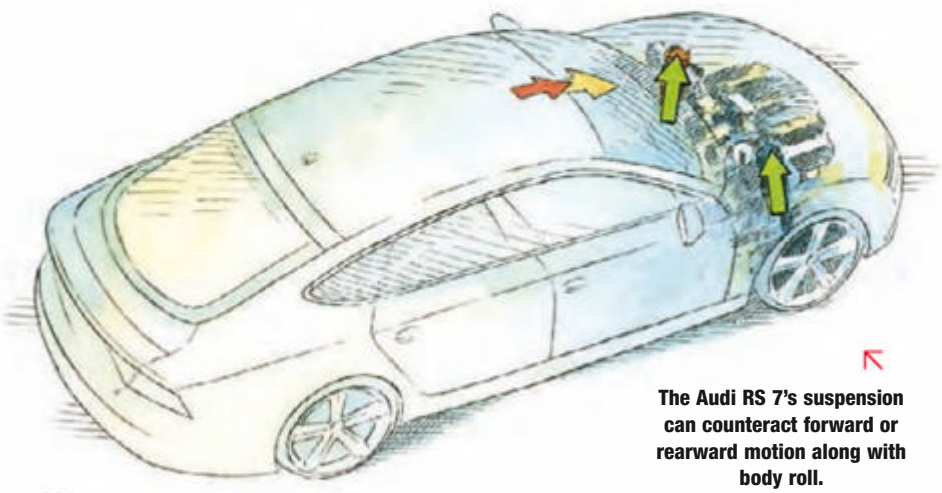
1 MAGNETIC DAMPERS

If you enjoy the magnetic dampers on your Ferrari FF or Audi R8, you can thank General Motors for developing the technology. By varying electric current through a ferrous fluid, Magnetic Ride Control dampers can adjust their stiffness in response to driving conditions. And while the system is licensed to other companies, GM, as the originator, is still out front. Its third-generation Magnetic Ride Control (as seen in select performance cars such as the Chevrolet Corvette Stingray) improves on prior designs by adding a second wire. Now the fluid can be actively switched from firm to compliant, whereas before there was a lag as the particles naturally returned to their relaxed state. The implication? At 100 km/h the Stingray can adjust for each inch of road.

Leaning into a corner reduces g-forces on the body.

2 ACTIVE CURVE TILTING

Motorcyclists can tell you that leaning into a corner feels natural – too bad cars can't do that. Well, now one can: the 2015 Mercedes-Benz S65 AMG coupé. Using a lateral-acceleration sensor paired to a forward-looking camera, the S65 perceives corners and then uses its air suspension to tilt the body in towards the apex. The goal isn't higher performance but, rather, increased comfort as the passengers experience lower lateral loads at a given speed. Basically, if the road doesn't have a nicely banked corner, the car simulates one for its occupants. Proving, yet again, that it's nice to be rich.



The Audi RS 7's suspension can counteract forward or rearward motion along with body roll.

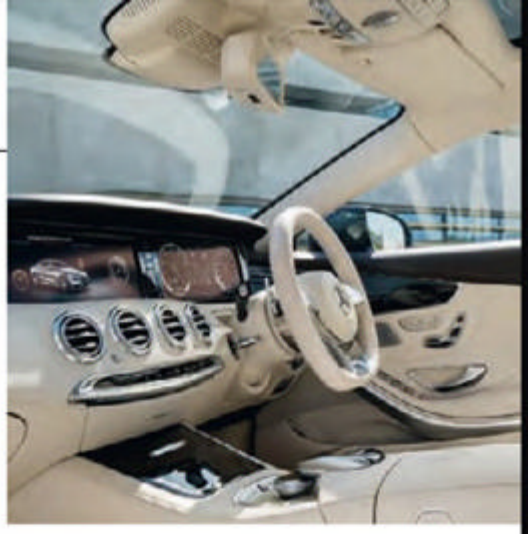
3 HYDRAULIC ROLL CONTROL

The 2015 Audi RS 7 is the latest car to gain a hydraulic cross-linked suspension, which Audi dubs Dynamic Ride Control. While conventional suspensions use steel antiroll bars to counteract body roll, hydraulic systems send fluid to the opposite side of the car. When you're not pulling major g's, the system stays out of the way, allowing unimpeded wheel travel and a smooth ride. It's like having huge antiroll bars and no antiroll bars at all, depending on the situation. The vehicles with the best compromise between performance and handling all use some version of this approach. Hydraulic cross-linking isn't perfect, but it's the closest thing right now to a full active suspension.
– EZRA DYER

WHAT HAPPENED TO THE BOSE SUSPENSION?

Back in 2004, Bose revealed that it had been secretly working on an active suspension system since 1980. By using powerful electromagnetic struts, the Bose system could instantly extend or retract any one wheel, with all four corners working in concert to keep the car's body level. Bose demonstrated the system on a Lexus LS400 outside its headquarters in Framingham, Massachusetts, speeding the car over all manner of obstacles while the body remained completely serene – as a finale, the Lexus gracefully leaped over a piece of lumber in its path. It seemed like the dawn of a new era, and the company predicted that within a few years the system would be available in production cars. More than a decade later, where's our active suspension?

So far, only in big-rig truck seats, where the Bose Ride mounting system actively nulls shock and vibration before it reaches the driver. But cars are still the main prize, so we asked whether the system could be ready in five years if a car manufacturer committed today. A company spokesman replied, "Yes. Of course, we'd have to work with a car manufacturer on development and customisation, but it's technically feasible. And when the right car customer is ready, we'll be ready." So there's your answer. Now who wants in on the suspension revolution?



PM DRIVE

MERCEDES-BENZ S65 AMG COUPÉ

KING OF THE ROAD

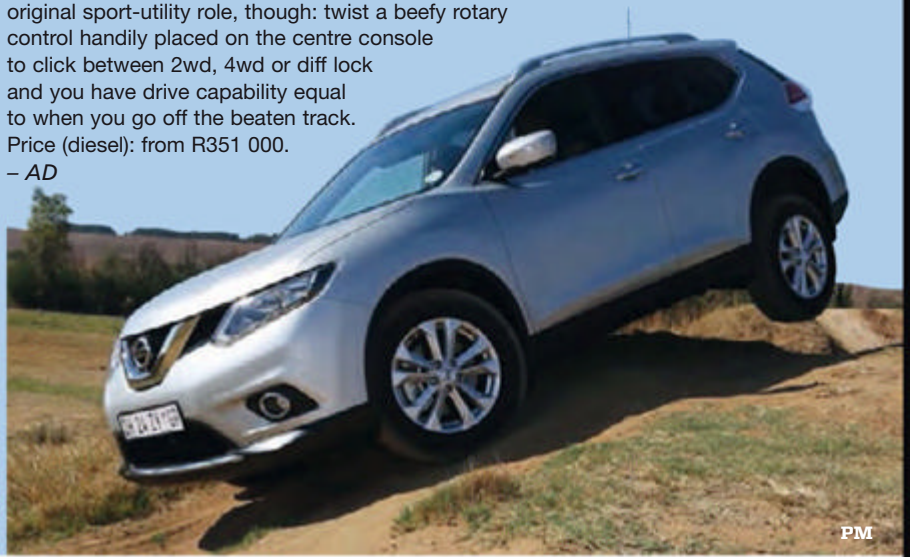
Fellow road users who may not have noticed the urgent exhaust note certainly raise an eyebrow or two when they draw alongside at the lights and spot the V12 Biturbo legend on the flanks. The S65 is road royalty, both in terms of its undisputed performance potential, its premium appointments and its lofty price tag. Combining the ability to embarrass supercars and to coddle plutocrats, this R3-million chariot of the gods simply redefines what a high-performance flagship coupé should be. If at first it seems impossibly bulky to qualify as a sports car, give yourself a few winding mountain passes (we did) and you'll quickly change your mind. The handbuilt AMG 6,0-litre V12 biturbo engine, with an output of 463 kW and 1 000 N.m, is said to be unique in its segment. Quoted acceleration from 0-100 is 4,1 seconds and top speed is, as always, governed to 250 km/h. (The speedometer reads to 320. Just sayin'.) Listing all the S65's features would take up most of the new few issues of PM, so we'll confine ourselves to reminding you that the S65 features the aptly named Magic Body Control. This scans the road ahead to smooth your progress (really!) via the air suspension and also has a curve tilting function that leans the body into the bend to counter those pesky centripetal forces up to 180 km/h. For comfort, of course. For those moments when you prefer to lose yourself in the music rather than in the twists and turns, the S Class Coupés, like products of some other manufacturers who have paired with high-end audio companies, features a bespoke sound system. Created by German hi-fi legends Burmester, it's an audio tour de force. On a less dynamic note, other options include LED high-performance headlights, each of which incorporates 47 Swarovski crystals. Some might call it excessive. Nah, it's probably just envy. Price: a smidgeon over R3 million. – *AD*

PM DRIVE

NISSAN X-TRAIL

REFINEMENT, ON- AND OFF-ROAD

The boxy original X-Trail seems worlds away from today's curvy version. Externally, this latest-generation model wears the marque's family styling cues, notably the face. On the inside, the wraparound dashboard and premium-look finishes say "car" more than "SUV". It all adds up to a driving experience that's a whole lot more refined than before, albeit that the new 1,6 diesel still growls away lustily like its predecessors did. Speaking of the powertrain, pulling away swiftly needs some care and a little experience to accomplish smoothly. There's a discernable lag that might catch out those accustomed to non-turbo petrol-engined vehicles; perhaps an automatic transmission might be a better match for the turbodiesel. Once the turbo comes on song, though, acceleration is bracing, which is exactly what you need for the urban jungle where the X-Trail will likely spend most of its time. Not to say that it isn't capable of fulfilling its original sport-utility role, though: twist a beefy rotary control handily placed on the centre console to click between 2wd, 4wd or diff lock and you have drive capability equal to when you go off the beaten track. Price (diesel): from R351 000. – *AD*



PM

Part 3 of our 10-part series Motorsport Technology Down the Ages

Absolute power

Since the dawn of F1 racing, different approaches to high performance meant that a balance had to be found to ensure that different engines could compete fairly against each other. Distilling the rules to their essentials, it comes down to two broad restrictions: minimum weight and maximum power.

At the outset, engine capacity seemed a likely solution. A normally aspirated 4,5-litre was deemed equivalent to a supercharged 1,5. Given the fairly primitive running gear and tyres of the time, the total outputs of around 425 horsepower (317 kilowatts) needed both skill and daring.

By the mid-1960s, allowable engine capacities were down to 1,5 litres and outputs were no better than a decade earlier. Yet, ironically, lap times were tumbling. What was going on? The move to mid-engined layouts, for one thing. Tyre technology, for another.

The next big breakthrough was the arrival of one of the sport's landmark engines. The V8 Cosworth DFV became the go-to power unit for those manufacturers who didn't have their own engine development capacity. It would utterly dominate the sport for the next decade. It would even soldier on into the turbo era.

Ah, turbos. Talk about gamechangers. With double the power of normally aspirated equivalents (*three times* the power in qualifying trim) the likes of the Renault-Gordini V6 Turbo had reduced proceedings to a no-contest. Neck-snapping acceleration made up for the drawbacks of prodigious thirst and yawning turbo lag. These were truly banzai racers.

What's more, these small-capacity screamers were beginning to explore new territory internally. As technology advanced, engine rev limits crept upwards from the 9 000 r/min or so regarded as standard. With more revs came more power.

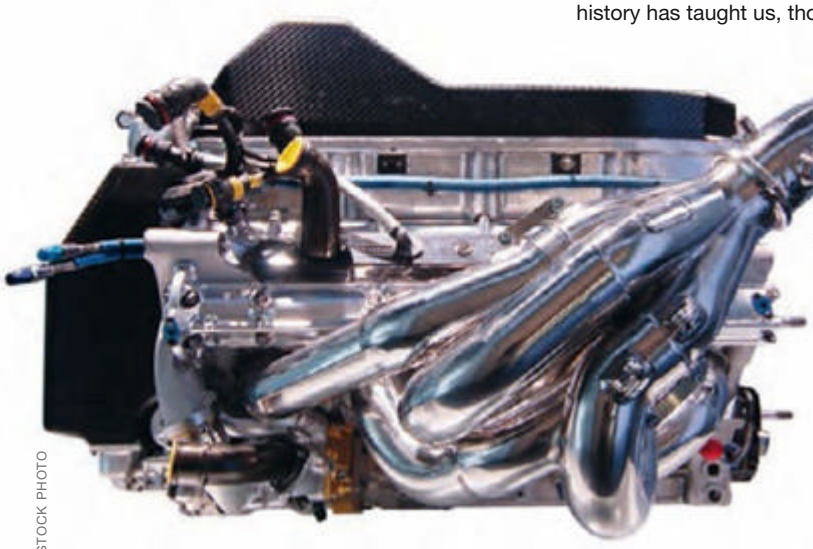
The power wars ratcheted up in the 1980s: the main combatants were BMW and Honda. By now, peak revs were around 12 000 and outputs well over 1 000 horsepower. In a bid to maintain the balance, the rules were frantically changed and changed again. Boost was limited to 2,5 bar. Total fuel allowed for turbos was cut to 195 litres, then 150, for an entire race (normally aspirated engines were allowed unlimited fuel). But still the turbos dominated on sheer performance. The phenomenon reached its peak in the Benetton-BMW, the most powerful of them all.

It couldn't last.

As the 1980s drew to a close, the rulemakers finally ended the turbo era. Power outputs returned to relative normality… but not for long. In their quest for more output, the engineers returned to the simple formula of making their engines turn faster and faster. Into the new millennium, the standard was 3-litre engines with peak outputs touching on 1 000 kW and V10 a popular cylinder layout. The BMW P82 screamed past 19 000 r/min.

Having failed to stop the relentless march of engine progress – and cost – by means of restrictions on capacity and fuelling, the legislators now began targeting reliability. It seemed to help as, within a decade, engines and gearboxes were required to last several races. And as more electronics entered the game, the authorities began specifying control units from a single supplier. Rev limits were imposed, too.

Not surprisingly, the current regulations lean heavily on sustainability. Turbocharged small-capacity (1,6-litre, six-cylinder) engines form the basis of Formula One's hybrid powertrains, which incorporate an "energy recovery system" and are limited to just 750 hp. Some say it's a step in the right direction. Others disagree. There's one thing history has taught us, though: it won't end there.



ISTOCK PHOTO

From 1950s 12-cylinders to the 1 500-horsepower turbo brutes, the gleaming 2014 example pictured left and today's super-efficient hybrids, F1 engines have been all about pushing the performance envelope.

How can you make creativity love efficiency?

Man's goals are sometimes at odds with nature. It is something we can work on though, which is why we are celebrating our 150th anniversary by co-creating solutions that will benefit both the world and all the people who live in it.

Join the conversation at creator-space.basf.com

150 years

BASF

We create chemistry

SKILLS

HOW TO DRIVE ANYTHING

Found a dangerous piece of heavy machinery with the keys in the ignition? Here's what to do next.

BY ALEXANDER GEORGE

YOU GET THE FEELING WHEN YOU WALK BY A CONSTRUCTION SITE. What would it be like to hop up in the chair and drive the digger loader, move around some gravel? All those levers. What do they do? Maybe you're momentarily imagining saving the day, and that empty tower crane would be the perfect tool for rescuing a busload of orphans. But you don't know how to drive a crane!

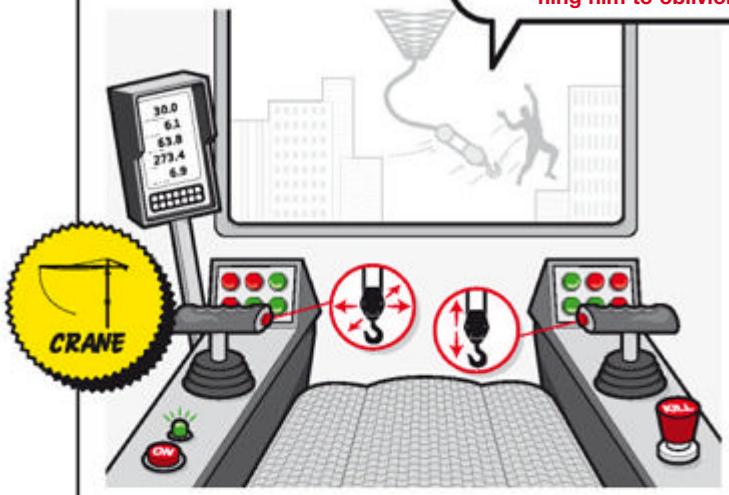
You could read the instruction manual, but the orphans don't have that kind of time. That's why we pulled together these instructions. They're not enough for a certification and the professionals would probably call the authorities if you tried any of this without permission, but when you have ten minutes to foil the plans of nefarious evildoers (or, you know, to move some pallets around the backyard), you'll be glad you know what to do.

SKILLS

VEHICLES

ACTION HERO BONUS!

Most cranes max out at about 0,6 revolutions per minute, but at that speed a bad guy at the end of the boom will be moving at over 50 kilometres per hour, which should be enough to fling him to oblivion.



Liebherr 316 EC-H Litronic Tower Crane

1. Turn the red rotary switch on the back wall to start the power. Now find the control-on button on the panel. Press it and a green indicator light will start flashing. The joysticks have induction sensors and will work only when they're in your hands.

2. The right handle controls the hook's vertical movement. Move it forward to lower the cable holding the hook. Pull it backward to raise it. Press the thumb button to raise the cable at an extremely slow speed. If the crane is on tracks, moving the stick right or left will drive the whole rig.

3. The handle on the left-hand side moves the hook towards or away from you along the boom. Tilt the stick forward to push the hook away, pull it towards you to bring it back. Tilt the same stick to the left to swing the whole crane left and vice versa.

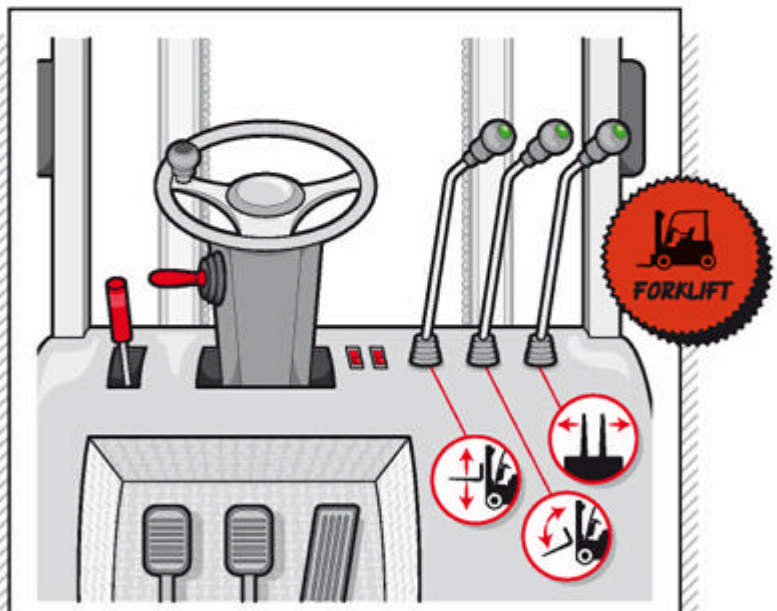
Toyota 8-Series Internal Combustion

1. The controls are like a car's: the right pedal is the throttle, or accelerator, and the middle pedal is the brake. Depress the far left pedal and the accelerator to make the forklift creep forward slowly. The lever to the left is the emergency brake. Whenever you leave the seat, pull the brake towards you to engage it.

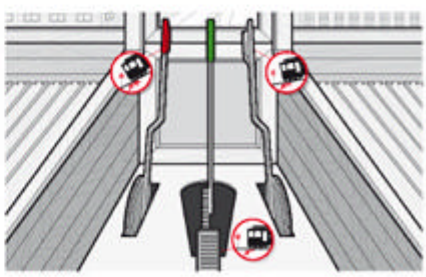
2. Fasten your seatbelt. Forklifts can tip, so the rear is usually weighted down with cast iron for balance. Forklifts are heavier than they look.

3. The direction-selector stalk is on the left side of the steering column. Push it forward to go forward, to the middle to put it into neutral, and towards you for reverse.

4. On your right, the lever closest to you controls the forks. Pull back to raise them, push forward to lower. The next lever adjusts the tilt of the forks so you can get underneath loads. If your forklift has a third lever, it will adjust the width of the forks for different loads. To lift a standard pallet, position the forks about 3 centimetres off the ground, level or at a slightly forward tilt.



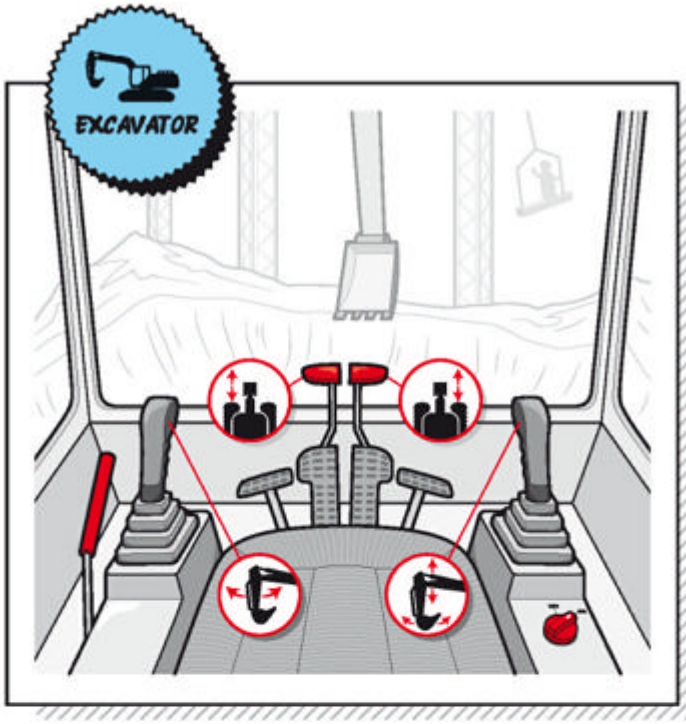
CABLE CAR
Double-ended California model



1. These cars move by gripping a cable under the street that is travelling at 15 kilometres per hour. The lever in the middle of the operator's area engages the grip, which tightens around the cable and drags the car along.

2. Before the grip operator does anything, someone has to step out into the street and pull the lever for the "gypsy", which lifts the cable to the surface so the grip can reach it. Now pull the grip lever towards the rear of the car. To accelerate

ILLUSTRATIONS BY BROWN BIRD DESIGN



John Deere 210G LC

1. On the right armrest is the ignition knob. Turn it all the way to the right and hold it to start the engine. Look for a lever with a red tip to the left of the seat. When that's raised, nothing works, so lower it when you're ready.

2. The pedals and the levers attached to them control the tracks that move the excavator. Push the left handle/pedal forward to move the left track forward or pull it back to reverse it. Same with the right. Push forward on the outside track's pedal to turn. Use the handles when you need to be precise, like when driving on to a trailer.

3. If the excavator were an arm, the right stick controls what would be its biceps, the boom. Pull it towards you and the boom goes up. Push it forward, it goes down. Push the same stick to the left to make the bucket (the hand) curl in. Push it to the right and it will empty its contents.

4. The left stick works the forearm of the excavator. Pull the stick towards you and the arm swings towards you. Push it away and the arm moves away. Push this stick left or right to rotate the cab on top of the tracks.

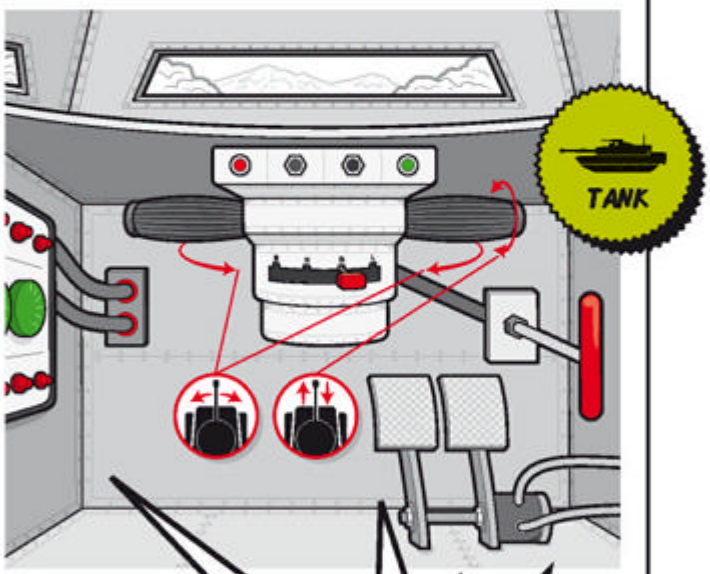
M1A1 Abrams

1. Enter through the circular hatch and move into the seat deep in the hull. Press the master power switch, then hold the starting switch for several seconds to start the engine. Both are clearly labelled. The left panel is the dashboard with revolutions per minute and fluid levels.

2. Press the left pedal to engage the brakes, then pull the chest-level lever on your right side to release the emergency brake.

3. The knob in the centre of the T-bar in front of you selects the gear for the automatic transmission. Slide this knob to D to put the tank in drive. To move, twist either handle on the bar towards you, as you would on a motorcycle. Twist it more to go faster, but be careful: the throttle is sensitive.

4. To steer, pull the left handle towards you to turn left and the right handle towards you to go right. The inputs are sensitive, so be prepared to turn hard.



smoothly, do this slowly while releasing the brake pedal.

3. To halt the car, gently release the main grip lever and apply the foot-pedal brakes, which are regular steel brake shoes that grip the wheels, or the track brake, which is the tallest lever on the right. The track brake is a set of arms made of pine or fir beams that presses against the track and stops the car with friction. A third option is to apply the slot brake, which is the red lever to the left. It sends a 40-centimetre steel wedge down to the cable slot. It's single-use, so pull the leftmost lever only if the other brakes fail.

ACTION HERO BONUS!

The top speed is a governed 67 kilometres per hour. Tanks are not good for fast getaways.

THIS IS WHAT ROCK AND ROLL LOOKS LIKE

A Fender '65 Princeton Reverb tube amp, deconstructed.

A GUITAR AMPLIFIER IS AN ELECTRONIC DEVICE that transforms a board and six strings into a furious agent of cultural change. The amps most coveted by guitarists do this with vacuum tubes (also known as valves). These archaic bits of technology heat electrodes in evacuated glass chambers, amplifying an electric guitar's signal while also introducing much-desired distortion. Give a vacuum tube too much power and the sound it produces starts to break apart. The sunny hum of a plucked string becomes a raspy howl. This is the essence of rock and roll. When the invention of semiconductors made it possible to use more durable parts to amplify sound cheaply, guitarists wanted none of it. They stood by their tubes.

To show you where all that classic sound comes from, we got our hands on Fender's '65 Princeton Reverb amp. Like rock stars, we smashed it. Then we got Chicago Amp Works technician Patrick McKeever, who counts Wilco and Red Hot Chili Peppers as clients, to explain the parts. – *KEVIN DUPZYK*

1. **CABINET:** The box that holds everything. This one is made of pine.
2. **MAIN CIRCUIT BOARD:** Connects all the amp's components, including the vibrato circuit, which varies the current in the power tubes to temporarily lower the power and create "vibrato". (Technically this is "tremolo", but Fender confused the terms in the 1950s and it stuck).
3. **SKIRTED KNOBS:** Sadly, these go only to 10.
4. **5AR4 RECTIFIER TUBE:** Converts AC electricity from the power transformer to DC. Rectifier tubes lose power when subjected to a lot of current — which tends to happen when a guitar is played hard and loud. This sag causes audio to break up, a trademark of the tube-amp sound.
5. **6V6GT POWER TUBES:** The last section the signal passes through before the speaker, these crank up the audio signal.
6. **PREAMP TUBES:** Increase the amplitude of the audio signal from the guitar and send it to circuits that introduce effects such as reverb and tremolo.
7. **POWER TRANSFORMER:** Converts the 220 volts of power from the wall socket to a higher AC voltage and sends it to the rectifier tubes.
8. **250 mm (10-INCH) JENSEN C10R SPEAKER:** The transducer that converts the electric audio signal into airborne vibrations.
9. **FOOT SWITCH:** Because a guitarist generally has both hands occupied, this is used to trigger the reverb or tremolo effects.
10. **REVERB TANK:** A metal box containing four springs. As the audio signal enters, it is converted into mechanical action on the springs. Differences in the springs' length and stiffness cause sound to exit the tank at different times, creating reverb.
11. **ISOLATION BAG:** A sheath for the reverb tank that protects the springs from vibrations that don't come from the guitar.

A GLOSSARY OF CLASSIC ROCK

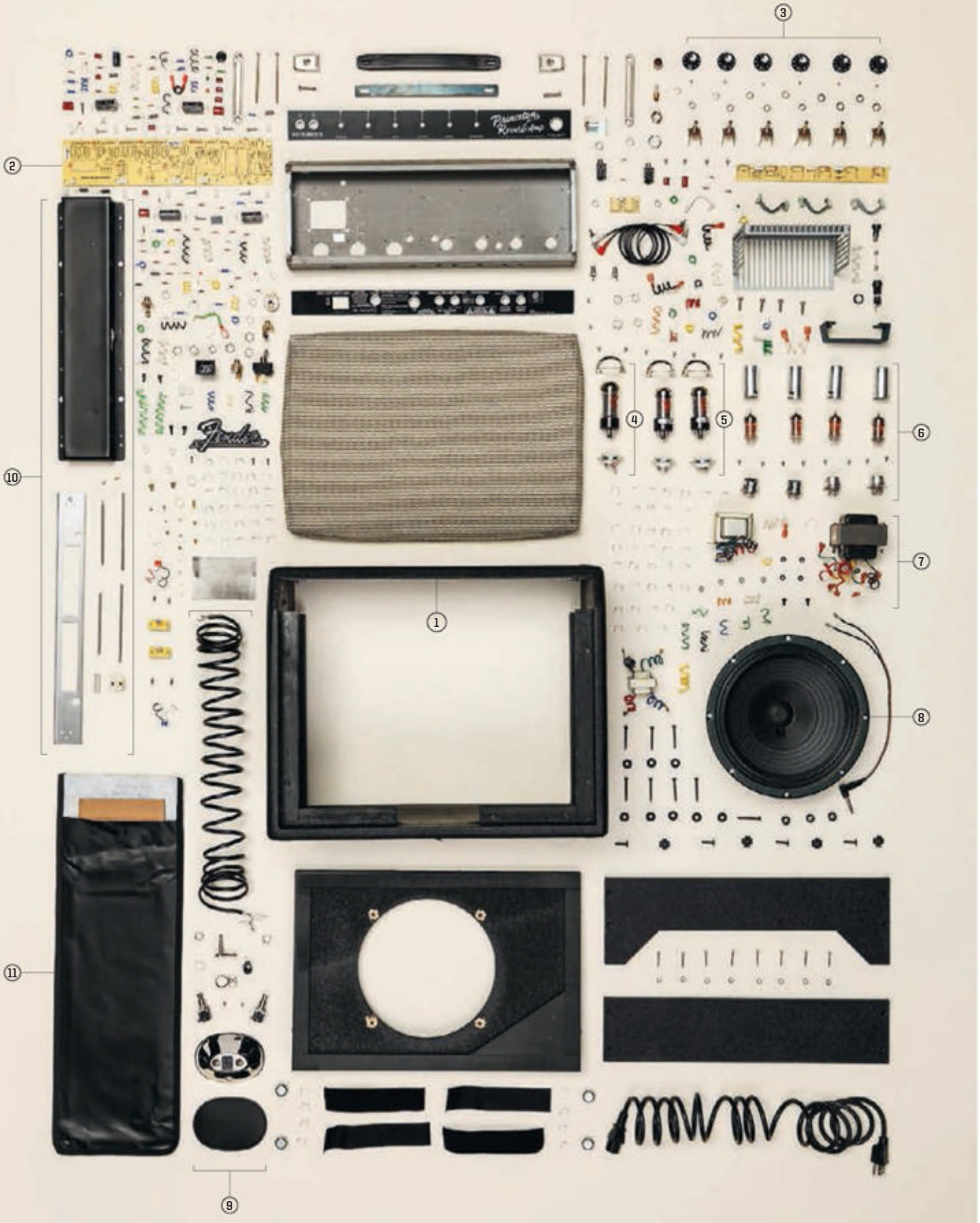
You can hear the Fender amp's bright sound best on songs like *Not Fade Away* by the Crickets. Here's where you'll find a few of the other effects we mention.

DISTORTION
Maybellene
by Chuck Berry

REVERB
Rumble
by Link Wray and His Ray Men

TREMOLO
Gimme Shelter
by the Rolling Stones

* Photographer Todd McLellan is the author of the book *Things Come Apart*. He's also really good at destroying perfectly good appliances.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Freedom student Nate Thompson demonstrates how to spray primer on the 1981 Chevrolet Camaro Z28.

THE KIDS IN THE GARAGE

How to strip, repair, repaint and rewire an old car — with help from an after-school car club. Part three of a six-month series.

EVERY AUTOMOTIVE CLASS AT FREEDOM HIGH SCHOOL in Freedom, Wisconsin,starts the same. While some students pull out tools, others manoeuvre the programme's project vehicles – up to 12 of them sometimes – around the garage. At the halfway point in our six-part series, the two cars the students are working on are ready for primer. This is the first time most of the students will have used a spray gun, so Jay Abitz, the school's automotive instructor, is encouraging them to focus on technique. "It's only going to get harder when they start spraying paint and clear coat," he says.

The proper technique: hold the gun 10 to 15 cm away from the panel and spray a continuous line from one edge to the other. On the return stroke, move down to an unpainted area, but overlap the previous sweep by 50 to 70 per cent. "If you go too slow you'll cause runs, and if you're too fast or too far away, not everything gets covered," says junior Nate Thompson. Thompson admits he has room to improve, but he has plenty of time: he plans to work on cars for the rest of his life.

PHOTOGRAPH BY ERICH SCHROEDER

HOW TO **PRIME A DENT**

Tips from the Freedom High School Automotive Programme.

CHOOSING A PRIMER

If you're restoring a panel or a whole car, you'll want to use a first layer of epoxy-based primer and a second layer of thick, urethane-based primer. Apply both with a gun designed for priming, such as a 3M Accu-spray 07 series. If you are working on a smaller repair, such as repainting the dent you learnt how to fill in our last instalment, you can get by with a can of Sherwin-Williams P30, a primer–sealer. P30 adheres to bare metal and body filler, and you can spray it on or apply it with a standard paint roller.

APPLYING AND LEVELLING

After prepping the area with a cleaning solvent, apply one coat of P30 over the body filler using a paint roller. When the primer has dried, use a high-grit sandpaper — 600 to 800 (the label on the paint should recommend a specific grit) — to smooth the primer and create feather edging around the sides. Deep scratches will show through paint, so keep it soft for a smooth finish.

→ THE CASE FOR BUYING A QUALITY SPRAY GUN

by JAY ABITZ, automotive instructor, Freedom High School

I'm not a tool snob. I'm totally not. But there is a huge difference between a good spray gun and a cheap one. At the adult night-school class I help teach in the Freedom garage, plenty of guys have their own nice guns.

But some bring cheap guns and I'm like, don't even get that out of your truck, dude. You can use mine. Older guns don't atomise paint and primer the way the new high-velocity, low-pressure guns do. And when I've tried to take them apart for cleaning after just one use, I end up throwing them away instead. Cheaper guns just don't hold up.

The 3M Accuspray 07 series is designed to atomise base coat.

→ NEXT MONTH

PLASTIC AND DASH REPAIR

WIN! with our home workshop challenge

AND ANNOUNCING:

Workshop Challenge No. 2

Accept the PM Home Workshop Challenge and a top-of-the-range cordless drill driver kit, valued at R6 794, could be yours.

CONTEST NO. 2

THE CHALLENGE: devise a joint project for a father and son. Or a mother and daughter. Guardian and ward, for that matter. We want to see something that can transcend the generation gap, perhaps even put that gap to good use. To get an idea of what we're after, see our "Wind-up dragster" project on page 84.

PRIZE:

The winner will receive a **Makita DHP458ZK Cordless 18V Lithium-Ion Impact Driver Drill Kit,** valued at **R6 794.** This top-of-the-range Makita 13 mm impact driver drill features a battery indicator that displays the remaining battery charge; twin LED lights that illuminate when the trigger is pressed and 3 functions – drilling, hammer action and screw driving. The DHP458ZK provides plenty of power for those demanding tasks, with 21 torque settings to choose from, giving you perfect control and maximum torque of up to 91 N.m. It is extremely compact, with a two-speed metal gearbox and steel keyless chuck. It features a rubberised grip, an extended side handle for greater control, a reversible belt clip for both left- and right-handed operation and a twin bit holder.

The prize includes: **1 x Makita DHP458ZK impact driver drill** (supplied in a handy carry case) with **2 x 4,0 Ah Makita Li-ion batteries** (BL1840), which recharge in 36 minutes, and a **Makita compact fast charger** (DC18RC).

For further information, visit *www.makita.co.za*, like Makita on Facebook **Makita-PowerToolsSA** or call 011 878 2600.

Your project will appear in a future issue of Popular Mechanics.

Email your plans and a picture of the results to *popular mechanics@ramsaymedia.co.za* by 24 April, 2015.

Official rules can be found at *popularmechanics.co.za*

Makita Popular Mechanics

LAZLO'S LORE

The daily ritual that separates the men from the boys needn't be a pain. Here's how you can make it more of a pleasure while being kinder to your face. And legs, too, if that's your thing.

FOURTH-GENERATION BARBER Lazlo Venter wields a mean cut-throat razor in KwaZulu-Natal, where he combines olde-worlde skills with showmanship. Lazlo epitomises how the fine art of barbering has moved beyond the conventional haircut-and-a-shave to embrace razzmatazz (wedding parties, flaming removal of ear-fuzz), while retaining the luxurious feel of a tradition that's been handed down through the ages. Here are his recommendations.

(And yes, his old man was a Viktor Lazlo fan.)

5 steps to a perfect shave

Heat and moisture. Standard barber method is to use a hot towel that leaves the entire face covered for about a minute. An alternative is to do it immediately after a shower. The idea is to soften the bristles. "Think of it as cutting spaghetti. Easier to do it with cooked spaghetti than uncooked."

Preparation. Use a good pre-shave oil. (You can buy it premixed from him.) 'This is not something you would be able to buy at a supermarket or your nearest Dischem, but you can mix it yourself. The base would be almond oil, with essential oils added according to your preference."

Single-blade razor. "The multiple blade jobs pull the hair beyond where it's supposed to be positioned in the skin."

Shave with the grain.

Finish with a good after-shave. "What you want is a good steriliser. I prefer the traditional alcohol-based type because it cauterises and generally gives a better effect on the skin than the modern alcohol-free ones."

3 things to avoid

Don't:
Shave dry.

Store your razor wet. This leaves a residue, dulls the blade and causes imperfections in the blade.

Rinse in hot water. Temperature fluctuations warp the blade.

ASK ROY

Popular Mechanics' senior home editor solves your most pressing problems.

BY ROY BERENDSOHN

My townhouse shares a wall with the unit next door, and I can hear everything. Any advice on soundproofing? (The wall is drywall.)

Hate to tell you this, but soundproofing is best handled while a structure is being designed and built, not after the fact. Given that this is a common wall with another condominium, you'll have to find out what the local building department has to say about how to proceed. Unless you're an accomplished handy person, your best bet is to hire a contractor to carry out the modifications.

The most radical fix is to remove the drywall, insulate the wall cavity with glass fibre, and then install a noise-proof wall assembly with a dense, rubbery surface material known as high-mass vinyl and multiple layers of 16 mm drywall.

A less invasive solution, but one that is still effective, is to fasten a second layer of 16 mm drywall to your shared wall using a rubbery adhesive called Green Glue. You or a contractor should apply this stuff in thick, intersecting lines on the back of the drywall before tilting it into place. When the glue cures, it forms a noise-damping layer. Finally, seal the edges between each sheet of drywall, the spaces where the sheets meet the floor and ceiling, and any gaps around electrical boxes with a noise-damping material like Quiet Putty.

My house sits at the edge of a steep rock ledge. I want to build a deck and cantilever it out over the ledge. The view is going to be awesome, but I want to make sure it's safe. Advice?

The view will be awesome. So will the risk. There's no question: hire an architect or a structural engineer to design the deck. It's important that this person be licensed. You will need the professional to certify a set of plans to get a building permit.

Couldn't you skip the permit and overbuild the deck to be sure it's strong enough? Sure, but it's illegal. Second, that's not design – it's guessing. An engineer or architect will calculate the loads that are likely to act on the deck and design accordingly.

If all this sounds excessive, think of the alternative. You guess about the deck's design and you get it wrong. The deck sags or, worse, tears loose and takes you, your guests, the grill, and the dog on a sleigh ride you'll never forget.

PHOTOGRAPH BY PHILIP FRIEDMAN

WHAT'S IN ROY'S GARAGE?

Our columnist on his favourite new tool.

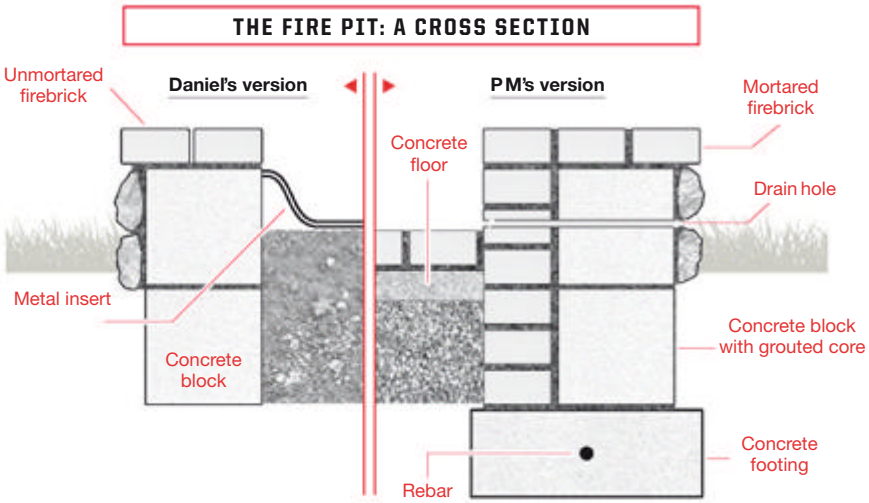
Aside from a hammer, pliers are the most frequently used tools in your kit. They lead a hard life, so they have to be well made. That's why I was glad to try out Irwin Tools' Vise-Grip Max Leverage Diagonal Cutting Pliers. They're equipped with a compound-action hinge that, the company says, doubles your cutting force. The pliers can easily chop through stranded and solid copper wire, heavy-gauge cable, steel nails and small machine screws — hardware that's usually reserved for small bolt cutters or big lineman pliers. This makes the Vise-Grip particularly useful for working in old houses, where you need to chop away junk before wiring in your new fixture or outlet. They're on the expensive side, but they're extremely sturdy. My bet is they'll last a while.

THE NEVER-ENDING FIRE PIT

Five years into a build that should have taken a few weekends, a DIYer could use some help.

BY DANIEL PAUL SIMMONS

PICTURE BY JESSE LENZ



When a group of friends sit around a table playing cards or drinking beer, not one of them will spend hours gazing into the table itself, thinking about cowboys and friendship and human prehistory. A table does not have this power. A fire, with its meandering sparks and flame animals and depthless colours, does. An outdoor fire adds ancestral depth to a weekend in the country. In the case of the table, you have a pretty good time. In the case of the fire, you wear the same shirt to work on Monday so you can still smell the wood smoke.

My point here is that, when I built a weekend cottage in 2009, I wanted a fire pit. I wanted to have a place where I could spend the evening sitting under the stars actually enjoying the setting in which I was paying to own a home. I also wanted more space for visiting friends, who tend to come in groups, overwhelming my small house. I imagined I could construct a fire pit in a couple of weekends. In a way, I was right: within a month we were all sitting around my new pit, watching the fire lick the sky. But then everything fell apart.

Like most weekend do-it-yourselfers, I began my research online. I looked at scores of designs, finally settling on a classic square. I also learnt the first rule of fire-pit safety: choose a spot three to ten metres from your house, with level ground, away from overhanging trees or power lines. I picked a location about six metres from my patio and the same distance from the trees. With a friend's help, I excavated a hole for the foundation. The soil on my property is as much rock as soil, but we eventually chipped out a 1,2 x 1,2-metre hole, about 30 cm deep. Daunted by the prospect of pouring concrete, I used sixteen standard concrete blocks to build the foundation.

It was completely submerged. Friends teased that I'd built the world's smallest swimming pool.

After levelling and tamping down the soil in the hole, we arranged eight blocks in a square, which we joined with general-purpose (type N) mortar. We laid a second level of blocks on top, mortaring as we went, then topped the foundation with 30-centimetre-square pavers, four per side.

Over the next few weekends I applied faux stone veneer to the exterior of the blocks where they stuck up above the ground, using stone veneer mortar. The veneer I used was left over from construction of the cottage, but most large hardware stores sell it. When the mortar was dry, I backfilled earth around the outside walls, leaving between 15 and 25 centimetres of wall above grade.

Building the pit

Inside the square, I laid down a 5- to 8-centimetre-thick layer of multipurpose sand, then covered that with a similar layer of small rocks. Heat can deteriorate concrete blocks, so I found a local supply yard that sold firebricks. I carted a couple of dozen home, but ran out of motivation to mortar them, so I temporarily stacked them against the inner walls.

The problems begin

My pride in a job well done was tempered by the next heavy rain. I had failed to take into account my yard's water absorbency, and the pit's sand-and-stone floor became completely submerged, as did the heavy octagonal grate I'd bought online. Friends teased that I'd built the world's smallest swimming pool.

After a trip to buy more rocks to raise the floor, the pit was operational. But raising the grate brought the fire high enough to send sparks into my guests' faces. I decided I needed a mesh cover to place over the fire when it was lit. At an end-of-season sale, I discovered a premade fire pit with a black metal stand, square steel insert, and square screen cover just the right size. The cover went on the pit, and the rest of the set went into storage.

These refinements got me through that first summer.

But then I read anecdotal reports of overheated pavers in fire pits exploding. So the next spring, out came the crowbar and off came the pavers. For the rest of year two my fire pit sat unfinished, the open-topped concrete blocks filling up with rain.

ILLUSTRATION BY HAISAM HUSSEIN

During year three I bought more firebricks, experimenting with configurations to cover the tops of the blocks, but never committing to any of them. Friends often kicked the bricks out of alignment (or into the fire), but I still resisted the necessary mortaring.

This past summer, year four, I removed all the firebricks from the interior of the pit, and retrieved that square metal insert I had purchased with the lid from storage. In a rare spot of luck, the insert fitted the opening perfectly. I drilled several drainage holes through the metal, used high-heat rust-proofing spray paint to protect the holes, then made a makeshift rim of unmortared firebricks around the top.

The cavalry arrives

Nick Blohowiak, the regional manager of a bulk mortar operation, agreed to review my project and give me suggestions for a rescue mission. Blohowiak comes from generations of masons and has worked in masonry himself since he was 10 years old. The first problem he noted was drainage. "I'd say you've been really lucky," he said. "Water's the most destructive force in Nature and it works against masonry when it's in contact with the ground." In particularly harsh climates, eventually the water sitting in the pit and in the blocks is going to freeze, thaw, pop — and then it'll fall apart.

Blohowiak recommended filling in the blocks with masonry grout to solidify the structure, then using a core saw or large masonry bit to drill several holes, 3 to 5 centimetres wide, through at least two of the side walls. He said I'd probably have to hire the tools to do it. "What you're doing is allowing the water to escape," he said, "but you're also allowing cold air to roll in from the bottom — so your fires burn better." Next, he said, pour a concrete floor inside the pit, coming up to the outside ground level, but below the drainage holes. And for the lining? "The right way to do this would be to use those firebricks to line the inside and the floor using a refractory mortar," Blohowiak said. "Eventually you're going to have problems with the foundation, but this'll probably help you save this thing for quite a while."

Now that it's spring, I can begin my work again. I intend to take the master mason's advice.

How to do it right, from the beginning

BY ROY BERENDSOHN

Daniel's fire pit turned out all right, but if I were to take on this project, I'd build a concrete foundation or footing from the start. To do this, you want to dig a footing hole and compact the soil the way Daniel did, then nail or screw together footing forms from 50 x 150 beams. For this project I would have recommended a square-doughnut-shaped footing. This would require two square forms, one to fit inside the other.

To fasten the form timber, use duplex-head nails (a nail with a head that makes it easy to remove), or use an impact driver and Spax screws, which don't require a pilot hole. Place the footing form in the hole, and stake it in position so that its corners are square and it is level across its width and length.

Simmons enjoys his fire pit and deck, which he also built.

Next I'd cut 10-mm rebar to fit into the form. The trick to using this reinforcing metal is to support it off the ground so that the concrete forms all around it. You don't want to set rebar on the ground and place concrete on top of it. You want it in the middle. Masonry supply houses and home centres sell supports called rebar chairs for exactly this purpose. You place the chair-supported rebar into the form and then shovel concrete into the form, making sure that you consolidate the concrete well in the corners and around the rebar. In fact, overfill the forms slightly and slide a long piece of wood back and forth over the form to remove the excess. This is known as screeding. The completed footing should consist of concrete that's smooth and level with the top of the form, but it should have a slightly rough texture that will help it hold the mortar for the first row of concrete block.

Let the concrete cure, at least overnight, then remove the footing forms.

Now you can take Blohowiak's advice. Build up a square of eight concrete blocks on the footing, filling them with masonry grout and joining them with general-purpose mortar. Do the same with another level of blocks. Affix stone veneer to the exterior, where it rises above the ground. Lay down a 7,5-centimetre layer of crushed stone inside the pit, and then pour a 9-centimetre-thick concrete floor. Line the inside and floor with firebricks and refractory mortar, then drill a drain hole through the side (see diagram, page 81) using a core saw or masonry bit. Finally, mortar firebricks along the top. Keep the masonry moist with a plastic tarpaulin or piece of wet hessian for at least a week before lighting a fire.

PHOTOGRAPH BY ZACH DESART

The bakery's hot smoker (at right) reaches temperatures of 150 degrees. Its cold smoker sibling (at left and below) used to be a dishwasher.

THE JUNKYARD COLD SMOKER

How a bistro chef transformed an old dishwasher into the ultimate kitchen machine. BY JOLYON HELTERMAN

THE COMMERCIAL DISHWASHER outside Pain D'Avignon bakery on Cape Cod, Massachusetts, is belching out plumes of blue-tinged smoke, which is exactly what Matthew Tropeano, executive chef of the bakery's on-premises bistro, wants. The dishwasher is a cold smoker, a machine that imbues food with smoky flavour without fully cooking it. Tropeano had been hoping to add the technique to the kitchen's capabilities for some time. "We were already doing a lot of hot smoking... sides of bacon, whole chickens, tomatoes, you name it," Tropeano says. "But all the excess smoke was going nowhere. All we needed was to capture it."

Tropeano approached Richard Leboeuf, the bakery's maintenance supervisor, for help finding a vessel he could use to piggyback on to his hot smoker, a Landmann Smoky Mountain series. Leboeuf immediately thought of a broken Jackson Warewashing Systems Avenger HT dishwasher he had sitting around in a warehouse. Leboeuf gutted the thing, removing the electrical wiring, the drain-line hose, the pressure-regulator valve, even the "built-in stainless steel booster heater with exclusive Sani-Sure technology". Then he added 110-mm-diameter galvanised stove piping to funnel in the smoke from the hot smoker's vent.

The only remaining challenge was temperature control: the smoke that was exiting the Landmann was 150 degrees, far too hot for cold smoking, which works best at 27 to 32 degrees. By fiddling with pipe length, Leboeuf landed on the optimal distance (1,5 metres) for the smoke to travel to drop the requisite 90-plus degrees by the time it enters the dishwasher. Thus cooled, it can smoke delicate ingredients such as fish and house-made duck sausage. "We recently stuffed an entire brie cheese with black truffles and threw that in there," Tropeano says.

A year later the repurposed dishwasher remains a workhorse, despite near-constant use. It turns out a commercial-grade washer – designed to keep hot water from spewing out all over the kitchen floor – is an ideal machine for containing cool smoke. So solid is its construction, in fact, that the chef expects he'll be replacing the hot smoker long before its cooler sibling needs any attention.

Just in case, he's been eyeballing a backup: a hot water tank the bakery just threw out.

TRY THIS AT HOME **If you don't have a dishwasher lying around, you can buy a handheld cold smoker called The Smoking Gun. Place your food in a covered bowl, insert wood chips into the gun, and use the gun's rubber tube to infuse smoke into the bowl.**

THINGS YOU MIGHT ENCOUNTER AT THE BAR

REFRACTOMETER

He doesn't use it as often as a jigger, but Chad Solomon, co-owner of Dallas bar Midnight Rambler, often reaches for his Extech refractometer to make certain that the bar's cocktails are balanced.

The device, which resembles a small telescope, registers the amount of sugar in a liquid by measuring the refraction of light travelling through that liquid. Solomon uses his to make complex ingredients in-house, such as falernum, a spiced-rum base mixed with additional spices and lime oleo-saccharum, an essential oil from citrus and sugar. The refractometer ensures that Solomon can duplicate any ingredient within a 1 per cent margin of error every time. It's like a measuring cup with a laser on it.

— ALIA AKKAM

A project to build with your children.

DESIGNED BY ROY BERENDSOHN

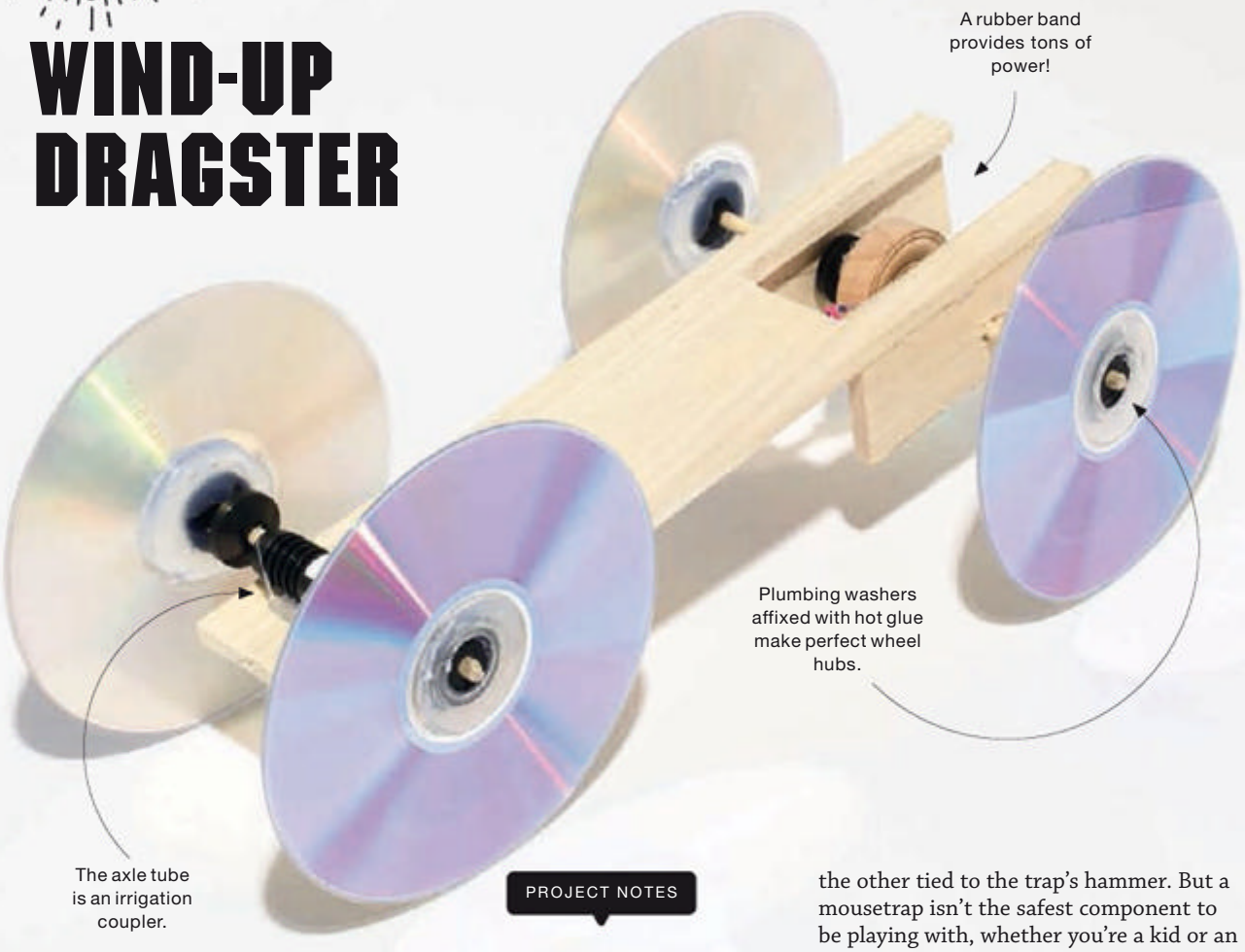
EASY | REASONABLE | HARD

Difficulty:

Time: 2.5 hours

Ages: 6+

WIND-UP DRAGSTER



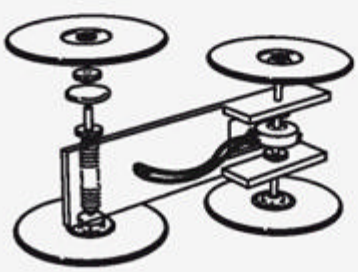
PROJECT NOTES

We built the first prototypes of this rubber band powered dragster using wood glue and Super Glue, but they took too long to dry, and the bonds weren't solid enough. A kid's toy needs to be durable, so we decided to use hot glue. You don't have to wait for it to dry, and it's superstrong.

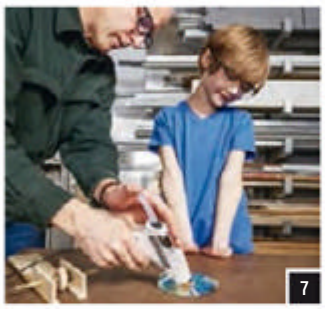
To make the wheels even stronger, we added a step to the process: a generous glob of hot glue over the washer/wheel hub. That should keep the hub from popping off in most situations, but if you really want tough construction, try making the axle out of a bolt, washer and nuts.

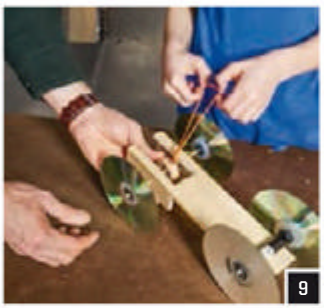
Our initial thought for powering the racer was to use a mousetrap, with one end of the string looped around the driveshaft and the other tied to the trap's hammer. But a mousetrap isn't the safest component to be playing with, whether you're a kid or an adult, so we switched to a rubber band. In early tests the rubber band was affixed to both ends of the system — the cup hook and the wheel. It took only one test run to learn that you want the rubber band to drop off as soon as its tension is completely released, otherwise it stops the car from going forward. Depending on the size of your rubber band, you'll want to adjust the position of the cup hook accordingly.

And finally, we learnt that with any project with kids — especially one involving drilling and cutting — you want an expendable work surface. Even laying a piece of plywood or masonite over your existing workbench would work great. You won't mind when it's cut into or drilled through, and you can focus on the actual construction.



PHOTOGRAPH BY DEVON JARVIS



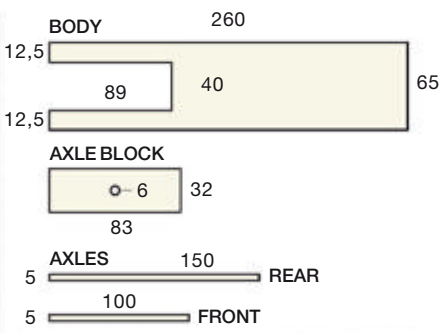


Materials

QTY.	DESCRIPTION
1	6 x 63 x 600-mm block of wood
1	Package 1/2L bevelled washers
1	40 mm diameter wooden tread wheel
1	Package (two pieces) 12 mm brass cup hooks
1	12 mm plastic barbed irrigation fitting
1	5 mm x 1,2 metre dowel
3	Sticks of hot-melt glue
1	250 mm rubber band
4	Old compact discs
1	Jumbo paper clip

Instructions

- **1.** Mark the outline of the car body (see right) on the wooden block. Using a 10 mm bit, drill two holes at the interior corners of the U-shaped rear axle cutout. Use a jigsaw to make a parallel cut to each hole. Cut between the holes to form the U.
- **2.** Rip and crosscut the two blocks that will support the rear axle. Make diagonal marks on one of the blocks to find the centre, then clamp both to the workbench and bore a 6-mm hole through the centre mark.
- **3.** Cut two dowel rods to length with cutting pliers. Clamp the wooden wheel and drill two small holes in its side with a 1-mm bit. Chop the end off a paper clip with pliers, then insert the remaining U-shaped piece into the holes and secure with hot glue.
- **4.** Twist the cup hook into the bottom of the car body, 60 mm back from the front. On the opposite side, 25 mm back from the front edge, affix the irrigation tube to the body with hot glue.
- **5.** Attach the rear axle blocks to the body with hot glue. Push the axle through one block, then slide on a bevelled washer, the wooden wheel, and another washer. Push the axle out through the opposite block, centre the wheel, and affix it with hot glue.
- **6.** Slide the front axle through the axle tube and add bevelled washers to either side.
- **7.** Affix the flat side of a bevelled washer to each CD wheel with hot glue, then reinforce the seal by covering it with a dome of glue, being careful not to block the axle hole.



- **8.** After the glue cools, press the wheels on to the axles.
- **9.** Loop one end of the rubber band through the paper clip winder on the wooden wheel and place the other over the cup hook. Rotate the wheels backwards to wind the rubber band, place the racer on the floor, and let it go. **PM**

● parent only ● kid only ● parent and kid

PHOTOGRAPHS BY DEVON JARVIS

COMPANY:
Grillworks

OWNER:
Ben Eisendrath

LOCATION:
Ann Arbor, Michigan

A BEAUTIFUL THING

The Grillworks Dual 54 CRE

PHOTOGRAPHS BY JOSH SCOTT

The grill's superstructure is made of high-finish 304 stainless steel.

IN THE SHOP

Often a single master welder works on a grill from start to finish. The craftsmanship comes at a cost. Residential grills start at R30 000 and go up to R160k.

SOUTH AFRICANS who think that this country has elevated the braai to an art form clearly haven't encountered the Grillworks Dual 54 CRE. Charles Eisendrath was a correspondent for *Time* magazine in the early 1970s, based in Buenos Aires and covering a nascent coup in Chile. While there, he developed a taste for Argentinian open-fire grilling and the light smoky flavour you can get only from cooking over a burning log. When he returned to the United States in 1974 and started working at the University of Michigan as a professor of journalism, he spent his summer breaks in the backyard developing a grill that he thought could outdo what the Argentines had perfected ages ago. Through fourteen different prototypes (turns out aluminium doesn't hold up well under fire), Eisendrath created the gleaming stainless-steel structure that would become the foundation of his company. He outfitted it with details such as V-shaped grates tilted downward at a 4-degree angle to collect runoff juice and fat, preventing flare-ups and providing a reserve of liquid for basting. But it was Eisendrath's signature innovation, a flywheel system, that made open-fire grilling feasible. The wheel raises and lowers the grates over the fire, the temperature varying from 90 to 425 degrees with a few cranks.

The operation clipped along as a family hobby that also happened to be a business for about twenty years, with his wife taking orders over the home phone. By the end of the nineties, though, the company, Grillworks, lay dormant. For Eisendrath, making the grills and trying to keep up with his university work became too much, and his day job won.

Then, in 2007, his son Ben got Grillworks going again. Ben, who'd hammered the serial numbers into the first grills as a kid, expanded the line beyond the original Grillery. Today they make large-format models like this behemoth along with custom installations for restaurateurs. The company may be out of his father's hands, but Ben has found a way to honour Charles and his invention. The "CRE" on the Dual 54 CRE, the biggest consumer grill they make, are his dad's initials.

The business is now split about half-and-half between home grills and collaborating with chefs and restaurants. No matter for whom, though, each grill is still made to order. The company relies on the local expertise of high-finish welders, who learnt their trade in Michigan's automotive industry, to assemble each grill. Dozens of man-hours from a single welder go into the smaller grills, hundreds for the big ones. Because the work is so specialised and the talent for it so rare, Ben has recruited apprentices from metalworking schools. That allegiance to local craftsmen, the long-ago reporting stint in South America, a love of American backyard cooking – these are the details that make up Charles Eisendrath's life and that shaped Ben's. The grill is proof that the best ideas come from a life of such character. – *MATT GOULET*

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WINNING TIP

CLEAN-UP MINUS THE MESS

Rollers make painting go quickly, but cleaning them can be a messy business. My method, for water-soluble paints, uses any large PVC pipe, with a slot cut in it to fit the handle of the paint roller and position the roller in the middle of the PVC pipe.

Using a copper pipe and fittings, fabricate the water jet (see photo). Block the copper pipe at the bottom.

Now drill 1 mm holes 10 mm apart in the copper pipe, the length of the roller. Clamp the copper pipe in place by means of cable ties or wire, threaded through two pairs of holes drilled into the PVC pipe alongside the top and bottom of the pipe. This allows the copper pipe to swivel and move up and down.

Operation: Place the contraption over a drain and insert the paint roller inside at the slot, with the handle outside. Connect a hosepipe to the copper pipe connector. With the water squirting out the many 1 mm holes and holding the paint roller handle and the copper pipe, adjust the angle of delivery to get the roller spinning. In two ticks it is clean – no mess.

JOHANN VILJOEN
FLORAUNA

LOADSHEDDING LORE

To run the basics during the typical Eskom loadshedding period of two to four hours, I use an old meths-burning fondue pot for tea, coffee or soup. For my DStv decoder, Plasma TV, PC and a light, I went to China Town at the Hillfox, Joburg and bought a 600 W inverter for R350. I did NOT buy a battery or generator. I simply use the cigarette lighter plug from my 90 amp-hour BMW battery, which still starts easily after 5 hours of loadshedding.

ROBBIN LEHMAN
NORTHCLIFF

EASY DOES IT

In the Ask Roy section of your January 2015 issue, he mentioned buying a fan blade balancing kit at a home centre. I asked around and couldn't find any, though. But my father-in-law has an easier way. He sticks a small ball of Prestik on the tip of one of the blades (depending on which blade is throwing out the balance), and then adjusts the size of his stick-on weight to get to the perfect balance. This takes him about 20 min to get perfect, but it always works. (As Roy said, check if the fan is properly installed and fixed to the ceiling.)

RENE KRUGER
KRUGERSDORP

CARRY THAT LOAD

Ever had to transport long lengths of wood, conduit or PVC pipe using only a sedan without a roof rack? Try this: use a couple of PVC gutter brackets, which are held in place by winding up the car window.

A slight modification to the bracket is required. Pop rivet an L-shape bracket to the gutter bracket as illustrated in the photo. (I used a portion of square PVC downpipe support bracket, cut to size). Cable ties can be used to secure the material to the brackets.

Don't forget to fix a red rag to the end of protruding pieces.

DAVE CROW
AMANZIMTOTI **PM**

SEND US YOUR HINT – AND SCORE!

WIN

Send us your best home, garage workshop and general DIY hints – and win! This month's best tip wins a **Makita DHP453RYEX 13 mm lightweight 18 V cordless Impact Driver Drill kit** worth **R5 394**. Powered by a 1,5 Ah Li-ion battery, this variable-speed model delivers up to 19 500 impacts per minute. It features an electric brake, drill mode and 16 torque settings with a maximum fastening torque of 42 N.m Hard and 27 N.m Soft. Supplied in an aluminium carry case with two 1,5 Ah BL1815N batteries, it comes with a fast charger DC18RC and a drawer filled with handy accessories. The 1,5 Ah battery recharges in about a quarter of an hour. The "Big Brothers" – 3,0 Ah and 4,0 Ah batteries – will fit this model and can be purchased separately.

To find out more about Makita Power Tools, visit *www.makita.co.za* or *www.facebook.com/MakitaPowerToolsSA*.

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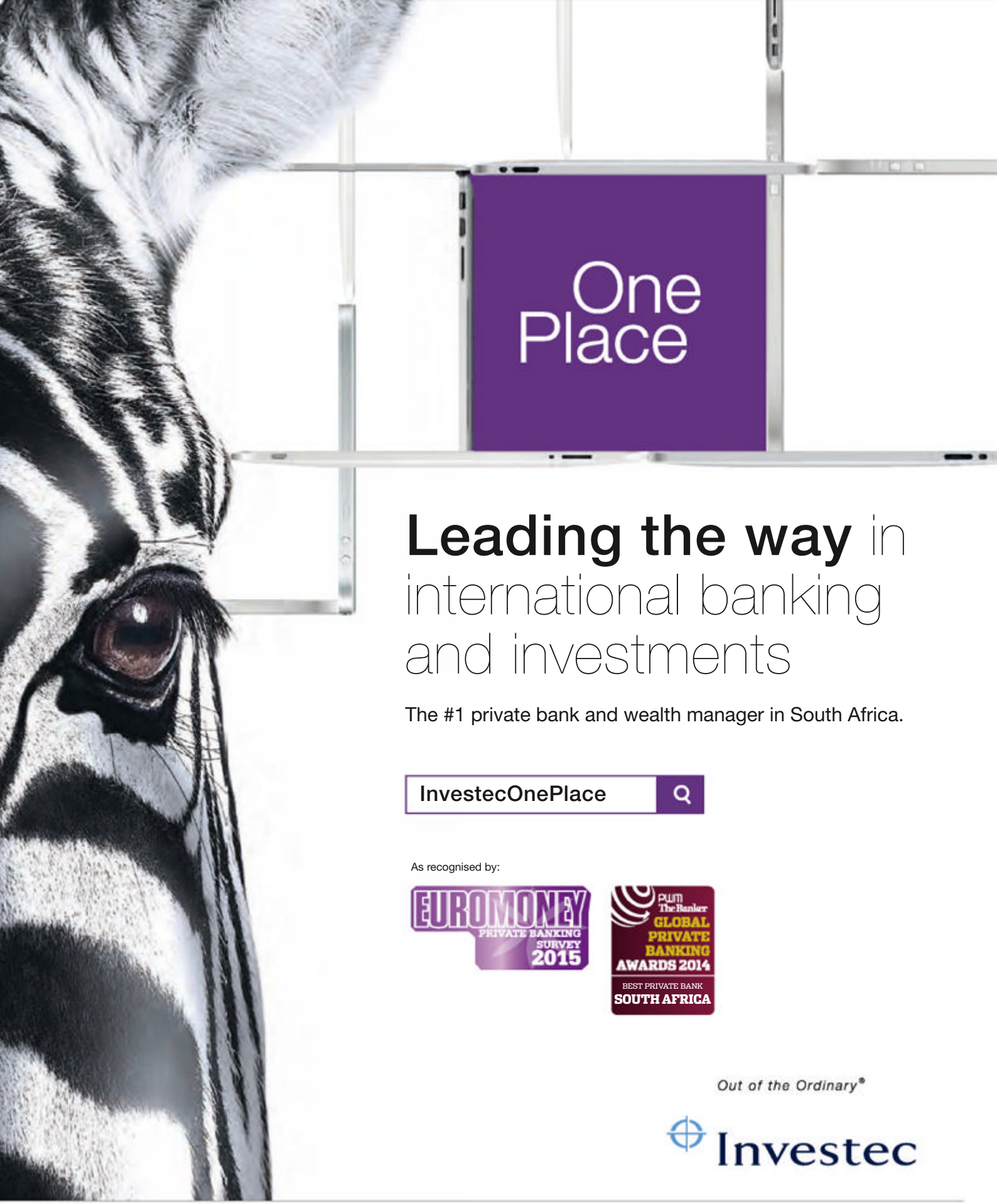
PM Do It Your Way, Box 180, Howard Place 7450, or e-mail *popularmechanics@ramsaymedia.co.za*. Please include your name, address and contact number. Regrettably, only South African residents are eligible for the prize. Prizes not claimed within 60 days will be forfeited.



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