The Celestial Bed made James Graham's name, but unfortunately not his fortune... or many babies.

The Eccentric Engineer

by Justin Pollard

ELECTRICAL THERAPY

James Graham: a wannabe electrical engineer and doctor

GETTY IMAGES

IN THE EARLY DAYS of any subject, it can be hard to tell science from snake-oil.

Development of a new field of engineering expertise is always likely to encourage the odd quack, but few have been as eccentric as James Graham.

Graham was born in England in 1745. The son of a saddler, he read medicine at Edinburgh University but never finished the course. Setting up in Doncaster as an apothecary, he took to calling himself 'Doctor', but business was slow and in 1770 he took the opportunity to move to the American colonies. He settled in Philadelphia, making a living performing cataract surgery and installing prosthetic eyes, and here he met Ebenezer Kinnersley.

Kinnersley was a scientist of a new type, an electrical engineer. As a friend and collaborator of Benjamin Franklin, he lectured across the young nation on 'The Newly Discovered Electrical Fire'. As a scientist and inventor, Kinnersley was only interested in proving and measuring the effects of electricity, but for Graham it seemed there was nothing these magical 'effluvia' could not do and hence no limit to the commercial possibilities.

Graham set to work on his own great electrical device but, at the first intimations of the coming Revolution, he decided to return to England and try his luck there. For Graham, electricity wasn't simply a force or phenomenon, it was a magical cure-all and he began offering treatments involving 'Effluvia, Vapours and Applications ætherial, magnetic or electric'. Horace Walpole even consulted him about curing his gout, with limited success.

Having toured Europe meeting 'fellow' electrical engineers, Graham returned to England to set up practice in Bath, where fashionable patients, including the celebrated historian Catharine Macaulay, soon began taking his cures. She was so enamoured with the practice that she married Graham's brother who was almost half her age. Graham's therapy consisted of delivering a jolt of electricity to patients through a variety of electrical crowns and thrones.

COMPETITION

What's happening in this picture? The wittiest caption emailed to engtechmag@theiet.org by 6 February 2019 wins a pair of books from Haynes.

Further travels followed, from which a new patron, Lady Spencer, emerged. She encouraged Graham to set up a 'Temple of Health' in London. He did this at the Adams Brothers' Adelphi site. Here he not only sold 'electrical Aether' and offered therapies, but put on shows featuring electricity and magnetism which he performed with the help of scantily clad young ladies, 'Goddesses of Health', who were displayed as examples of physical perfection. These demonstrations proved very popular, particularly with men.

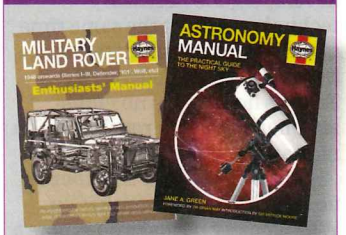
Yet Graham's *pièce de résistance* was still to come. In June 1781, he moved to Schomberg House on Pall Mall, which he christened the 'Temple of Hymen'. Here he installed his greatest engineering wonder, the 'Celestial Bed', to help couples struggling to conceive. For those of limited means, a visit to the temple cost a mere two guineas, for which they could wander through ornately furnished rooms, breathe in the perfumed air (some claimed he piped nitrous oxide into the building), listen to music or hear Graham delivering lectures on health and reproduction (which he saw as a patriotic national duty), or watch scantily clad young women pose among the statues. Among them was one Emma Lyon, who in later years would marry Sir William Hamilton and become Lord Horatio Nelson's lover.

For the staggeringly high sum of £50, a couple could spend the night in Graham's high-tech bed, which he guaranteed would solve their problems. The bed was 12ft long and 9ft wide and could be tilted to any angle 'to improve conception'. The mattress was filled with wheat or oat straw mingled with balm, rose leaves and lavender flowers, and hair from the tails of fine English stallions. Soft music played and doves fluttered under its domed canopy while huge magnets beneath apparently worked their magic. The headboard was inscribed with the words 'Be Fruitful. Multiply and Replenish the Earth' and crowned with a clockwork tableau celebrating the goddess of marriage, crackled with electricity, filling the air with 'electrical fluvia'.

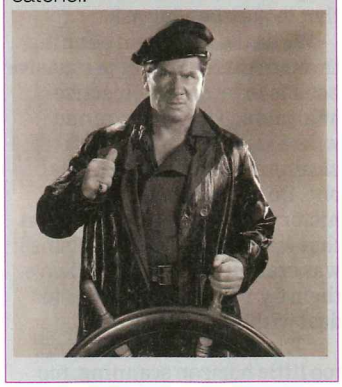
Sadly for Graham, while the Celestial Bed made his name, it failed to make his fortune. Electrical research was, by now, moving on apace and many saw through the quackery of the bed. Forced to sell off his eletro-mechanical devices, he retired to Edinburgh, where he began advocating 'mudbaths' and extended fasting. In 1794 he was arrested for walking down the street naked having given his clothes to the poor. He died shortly afterwards.

CAPTION PRIZES

BAG A BOOK



This month's competition winner will receive copies of 'Military Land Rover Manual 1948 onwards' and 'Astronomy Manual: The Practical Guide to the Night Sky', both from Haynes Manuals (haynes.co.uk). The winner of our November 2018 caption competition is Paul Fulton: "This time I've invented the amazing invisible satchel!"



This month we look at the parallel lives of the Aluminium Magnates, who set out to crack the problem of isolating the world's most abundant metallic element.

The Eccentric Engineer

by Justin Pollard

ALUMINIUM

A tale of two countries and two clever chemical engineers

ALUMINIUM is one of the most useful metallic elements for engineers, being light, strong and self-protected in its metal form by a quickly formed layer of oxide. Yet for most of human history it has been rare and precious, simply because it was enormously difficult to isolate.

By the early 19th century, metallic aluminium was more expensive than gold and platinum. The Emperor Napoleon III offered the King of Siam aluminium cutlery at dinner, while the other guests had mere gold. At the *Exposition Universelle des Produits de l'Agriculture, de l'Industrie et des Beaux-Arts de Paris* in 1855, an aluminium ingot was proudly displayed alongside the French Crown Jewels.

There were improvements in manufacture, but even so, by 1885 when a capstone was being commissioned for the Washington Monument – then the tallest structure in the world – the chosen aluminium was more expensive than silver. The 22cm-high pyramid cost $225 – the same amount a labourer on the monument received for eight months work. The finished piece was displayed in Tiffany's before being installed.

By the late 19th century, anyone who could find a cheap way of smelting aluminium was likely to earn themselves a fortune, and two men had set out to do just that. Charles Martin Hall and Paul Louis Toussaint Héroult were born on opposite sides of the Atlantic Ocean.

Hall, the son of a missionary, had attended Professor Frank Fanning Jewett's chemistry lectures at Oberlin college, the oldest coeducational liberal arts college in the USA, and had taken Jewett's challenge to heart: "If anyone should invent a process by which aluminium could be made on a commercial scale, not only would he be a benefactor to the world, but would also be able to lay up for himself a great fortune."

Oberlin's liberal atmosphere proved doubly important as Hall's sister, Julia Brainerd Hall, had also attended these classes at what was the first college in the US to admit women (in 1837).

GETTY IMAGES

COMPETITION

What is the woman pulling the cart thinking? The wittiest caption emailed to engtechmag@theiet.org by 6 March 2019 wins a pair of books from Haynes.

Together they set out to crack the problem of aluminium.

Across the Atlantic, Héroult had found his inspiration in reading Henri Sainte-Claire Deville's treatise on aluminium, when he was just 15 years old. Héroult was a very different creature from the respectable, devout and unmarried Hall. He was hardly the studious academic, preferring to spend his evenings drinking with women and playing billiards. Yet both hit upon the same idea at almost the same time.

Their process involved dissolving aluminium oxide obtained from the ore bauxite in the molten mineral cryolite (a naturally occurring sodium aluminium fluoride) and electrolysing the molten salt bath at around 950°C.

This is impressive chemistry in a lab, but Hall, aided by his sister, managed it in his summer kitchen – effectively a shed – behind his house. Many failed experiments followed in what Hall's biographer would later refer to as "the immortal woodshed". However, having used a rack of Bunsen batteries to pass a direct current through the molten solution for several hours and allowing it to then cool, he at last found – when he broke the resulting lump apart – several small buttons of shining metallic aluminium. These he preserved and today they remain as the Aluminum Company of America's 'Crown Jewels'. It was 1886 and Hall was 22 years old.

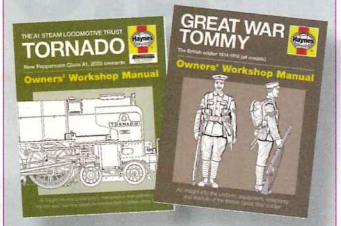
In France, Héroult had recently converted the tannery he inherited from his father into a laboratory, while his mother gave him her life savings to buy a Bréguet dynamo. After three years of similar struggle, he too produced his first buttons of aluminium in the same year.

All that remained was to patent the process and claim the rewards. Here fate took a hand. Héroult was the first to file and, as such, under European laws, had precedence. However, American patent law was different, dating the patent from the 'reduction to practise' i.e. the date at which the process was first successfully completed. Thanks to the meticulous record-keeping of Julia Hall, they could prove to the United States Patent and Trademark Office that Hall had first made aluminium on 23 February 1886 – two months before Héroult applied for his patent. So the award went to him.

Much litigation followed, but in the end the method became known as the Hall-Héroult process and the two men became friends. It was on a trip to America that fate took one final twist for Héroult. He caught typhoid and died on 9 May 1914 aged 51. Hall died just seven months later.

CAPTION PRIZES

BAG A BOOK

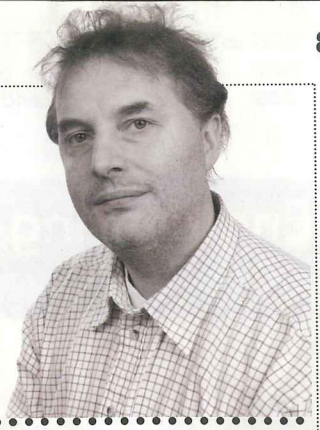


This month's competition winner will receive copies of 'Great War Tommy Manual' and 'A1 Steam Locomotive Trust Tornado Manual', both from Haynes Manuals (haynes.co.uk). The winner of our December 2018/January 2019 caption competition is Mohamed Hashim: "I wish she would stop doing this – my wife is bound to recognise me!"

The story of one inventor who foresaw the future of buildings, and another who brought the idea to birth.

The Eccentric Engineer

by Justin Pollard



BUILT ENVIRONMENT

Lift off! How the elevator shaft came before the elevator

GETTY IMAGES

NOT ALL GREAT engineering inventions come out of the blue. Sometimes it seems inevitable that a 'thing' will be invented soon and those with foresight can prepare for it. That's just what industrialist Peter Cooper was doing when he built his Cooper Union for the Advancement of Science – now one of the USA's leading engineering colleges.

The original plans for the building in New York contained something of mystery. Cooper insisted that an empty shaft run the entire height of the building, accessed at each floor by doors. This might have seemed a little reckless to many. Certainly, walking through those doors would get you to the basement quicker than the stairs – but the arrival might be your last. Cooper, though, could see the future. As buildings got taller, he was betting on the invention of the elevator.

Of course, there had been lifting devices before. Cranes and winches had been in use for millennia for lifting materials from mines, and loading and unloading ships. Archimedes invented an elevator using a man-powered capstan and pulleys in the 3rd century BC. In the 11th century, Andalusian astronomer Ali Ibn Khalaf al-Muradi included an elevator mechanism in his 'Book of Secrets in the Results of Ideas', though this was little more than a type of windlass that could already be found in medieval castles and cathedrals. However, very few of these were ever designed to carry people.

There were perhaps two main reasons why the passenger elevator had been thought of, but not built, before the mid-19th century. First, very few tall buildings existed before the 19th century – certainly not ones that required regular access to the upper floors by large numbers of people. Obviously, there were other reasons to build one. Louis XV of France had a personal elevator – his 'flying chair' – installed in Versailles so he could travel to his mistress's bedroom out of sight of the prying eyes of courtiers. Ivan Kiblin had installed a similar device in the Winter Palace in St Petersburg in Russia in 1793, involving a screw mechanism attached to a chair, enabling the aged and rather large Catherine the Great to access the upper floors of her palace.

Yet for most people the stairs were just fine, particularly when it comes to the second reason why 'flying chairs' hadn't taken off. Elevators were dangerous. Being suspended in a shaft by a single cable attached to a winch mechanism was putting a lot of faith in a small amount of technology. Winches regularly failed, the cables parted and the load plummeted to the ground. This seemed like an excellent reason to take the stairs.

Fortunately for Cooper, just as he was planning his Union, a former wagon driver and amateur engineer, Elisha Otis, was having a revolutionary thought. Life had been hard for Otis and all his business ventures had failed, usually due to factors far beyond his control. In 1851, aged 40, he got a job converting an old sawmill in New York into a bedstead factory and was faced with a huge clearing-up job. He thought about installing hoists to help clear the upper floors, but these often failed, sometimes catastrophically, so his mind turned to making them safe.

With his two sons he began designing a 'safety elevator'. His wonderfully simple device consisted of an old wagon spring attached under the roof of the hoist platform and connected to the lifting cable above. Normally the tension in the cable kept the spring closed, but were the cable to snap the spring would open, engaging saw-toothed ratchets on both sides of the lift shaft and bringing the elevator to a stop.

The 1853 World's Fair offered an ideal advertising opportunity. In the New York Crystal Palace, Otis had himself hoisted high in the air on his elevator platform. With great showmanship, he then ordered the hemp rope holding him aloft cut with an axe. The crowd gasped, but the platform only dropped a few inches before locking securely in place.

Otis's business was also secure and, from then on, orders doubled every year. As the safety elevator went on to prove itself as the safest form on transport on Earth, so the skyscrapers of New York could begin to grow.

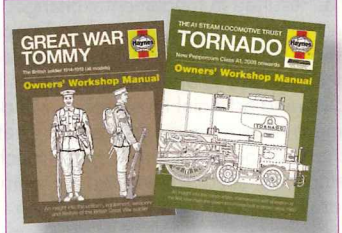
However, despite already having an elevator shaft, the Cooper Union would not be the first building to get Otis's machine. Cooper had assumed the most efficient shape for the shaft would be cylindrical and Otis's elevators were square. It would be several years before Otis had the time to design a bespoke elevator for the Cooper Union.

COMPETITION

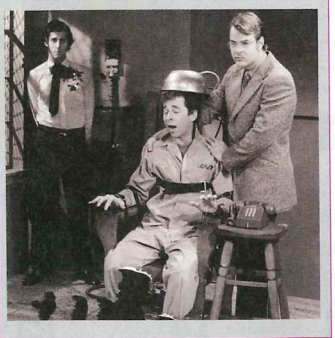
What's happening in this picture? The wittiest caption emailed to engtechmag@theiet.org by 10 April 2019 wins a pair of books from Haynes.

CAPTION PRIZES

BAG A BOOK



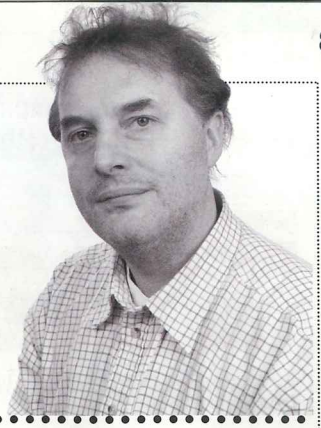
This month's competition winner will receive copies of 'Great War Tommy Manual' and 'A1 Steam Locomotive Trust Tornado Manual', both from Haynes Manuals (haynes.co.uk). The winner of our February 2019 caption competition is Robin Milward: "Steven was expecting a call from his lawyer to exonerate him, but he was not expecting a call telling him he had been mis-sold PPI."



This edition tells the story of 'Germania', and the engineers behind the infamous reminder of Hitler's Impossible City – a grand place to house the 'Master Race'.

The Eccentric Engineer

by Justin Pollard



CONSTRUCTION

The enduring relic of an imperial capital that was never built

GETTY IMAGES

IF THERE'S ONE thing that megalomaniacs tend to have in common, it's a love of grandiose statements. Hence, behind every tyrant, there's usually an ambitious architect. Behind them, a very nervous structural engineer.

Of all the megalomaniacs and all the grandiose statements, few can compete with Adolf Hitler and his plan to build a new capital city for his great German Empire – 'Germania'.

Under the supervision of Hitler's favourite architect, Albert Speer, Germania was to rise on the foundations of old Berlin, as a capital worthy of the 'Master Race'. It was to be vast, both in extent and in the scale of the buildings within it. Created along a monumental east-west axis, the city would include a great 'Volkshalle' [People's Hall], designed by Hitler and modelled on the Pantheon in Rome. However, Hitler's temple to himself would be so large that St Peter's Basilica in the Vatican would fit inside it, while Agrippa's old Pantheon would fit – just – into the oculus in the roof.

Of course, building on this scale presented several problems, the most notable being that Berlin sits on a marsh around the River Spree – not the ideal foundation for the largest structures on Earth. Of course, people had managed similar feats. Winchester Cathedral is built on a raft floating in a marsh and has stood up for over 900 years, though admittedly with a lot of interventions.

Yet Hitler's plan put most cathedrals in the shade. Speer realised that before ground could be broken, a serious experiment had to be done. The engineers of Dyckerhoff & Widmann were brought in to construct the 'Schwerbelastungskörper,' or 'heavy load-bearing body' in the borough of Templehof, where Speer planned to build Germania's Triumphal Arch.

As was typical with the plans for Germania, this arch was to be big – three times bigger than the Arc de Triomphe in Paris. Indeed, the Arc would fit under the arch of Speer's proposed gate. Therefore, it would be heavy, hence the need for the Schwerbelastungskörper – a trial weight equivalent to the pressure that one pillar of the intended arch would exert on Berlin's soft ground.

The Schwerbelastungskörper consisted of a solid concrete cylinder, 11 metres in diameter and weighing 12,650 tonnes, set on a foundation reaching over 18 metres underground which housed rooms containing stress meters and tiltmeters to measure what subsidence – if any – took place. The whole structure placed 1.24MPa of pressure on a 100-square-metre area. Speer calculated that if the sinkage was less than 6cm, work could go ahead. Otherwise, massive stabilisation would be needed before building could begin.

Assuming all went well, there would then be the problem of the Schwerbelastungskörper itself. More than 12,000 tonnes of concrete is not easy to get rid of, so the plan envisaged creating an artificial hill over the structure, upon which the arch itself would be built.

Any modern-day visitor to Berlin can see that Hitler's plans for Germania never came to fruition. Although much land was requisitioned, and many buildings demolished, construction was paused with the German invasion of Poland in 1939. Germany had first to seize an empire before building its imperial capital. Of all the main monumental structures, only Hitler's Reich Chancellery was completed.

Building briefly began again after the defeat of France, when Hitler visited Paris and the sight of the Arc de Triomphe reminded him of his own far more majestic plans. Only the invasion of Russia and necessary diversion of resources brought building to a final halt in 1943.

The 5km-long 'Avenue of Splendours,' the 350,000m² Großer Platz, the Fuhrer's Palace and Hitler's monstrous Volkshalle all remained just plans and models. Even Speer's triumphal arch never made it off the drawing board.

Yet the Schwerbelastungskörper did. Unlike the Reich's Chancellery, it has survived to this day. Plans to demolish the eyesore were mooted, but its sheer solidity meant it was unsafe to dynamite the structure in a built-up area. It remains where the engineers placed it.

It served its purpose. Measurements continued at the site up to June 1944. After the war, an analysis showed the structure had subsided by 19cm in two and a half years. Had the plans gone ahead, some poor engineer would have had to tell Speer – and perhaps even Hitler himself – that their grandiose city was doomed to sink into the marshes of the river Spree. *

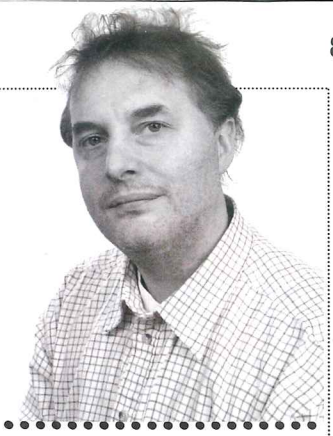
COMPETITION

What is the woman thinking? The wittiest caption emailed to engtechmag@theiet.org by 15 May 2019 wins a pair of books from Haynes.

CAPTION PRIZES

BAG A BOOK

This month's competition winner will receive copies of 'Great War Tommy Manual' and 'A1 Steam Locomotive Trust Tornado Manual', both from Haynes Manuals (haynes.co.uk). The winner of our March 2019 caption competition is Ming-Tak Shum: "Wait until I get an aluminium plating on all these gold pots – then we'll see who is rich!"



Ben Carlin persuaded his new wife that the ideal honeymoon would be crossing the Atlantic in an ex-Army amphibious vehicle.

The Eccentric Engineer

by Justin Pollard

TRAVEL

How sea sickness and near-suffocation spoiled a romantic getaway

IMAGE SOURCE

THE SEASON OF weddings and honeymoons is upon us and there can be few groups in society more romantic than engineers. So where would an engineer honeymoon? Cern? The Tacoma Narrows? Both have their positives, but few have had quite the impact of mining engineer Ben Carlin's suggestion to his new wife Elinore: "Let's spend our honeymoon crossing the Atlantic in a Jeep."

Carlin was not quite as reckless as he sounds. Having served across the globe in the Indian Army Corps of Engineers during the Second World War, he had come across a remarkable vehicle, the Ford GPA, effectively an amphibious version of the ubiquitous Army Jeep. This was designed for crossing rivers and lakes, but not oceans, and his fellow engineers had ridiculed his suggestion that he might be able to go around the world in one. Yet he remained undaunted.

In 1946, Carlin managed to buy a GPA and set about modifying it for ocean travel, increasing the fuel capacity, fitting a rudder, installing bunks and rebuilding the front to give it a seaworthy bow. Pleased as any engineer would be with his handiwork, he named his vessel 'Half-Safe' and asked Ford if they would sponsor him. They refused, claiming the vessel wasn't safe at all.

And they had a point. Carlin and his wife left Montreal in late 1947, arriving at New York in time to try the Atlantic crossing to the Azores in the summer of 1948. One newspaper describes their departure as witnessed by "crowds of sceptical waterside workers". Like Ford, the workers were right to be sceptical. They were rescued after five days, just 40 miles from New York after steering gear failure. The second attempt went the same way thanks to a cracked exhaust pipe that nearly suffocated them. A third attempt failed, mainly due this time to sea sickness, and a fourth rescue had to be made after a propeller bearing seized.

Lesser honeymooners may have given up, but engineers never surrender. Pausing to raise more money and further refine the Jeep, the fifth attempt might have been successful had it not been for the auxiliary fuel tanks being lost. Astonishingly, it was Carlin's wife who persuaded him to continue and their sixth attempt proved auspicious. Having left Halifax on 19 July 1950, they arrived in Flores in the Azores after 32 days at sea. From here they travelled to Madeira, coming ashore in Morocco, crossing the Straits of Gibraltar, driving up through Spain and France, crossing the Channel and finishing their voyage in Birmingham, England.

Hailed for their engineering feat the Carlins decided to carry on around the world, but only after spending four years recuperating in Birmingham, during which time Ben Carlin completed his seminal book 'Half Safe: Across the Atlantic by Jeep'. The money from the book allowed for repairs and improvements and the Carlins set off across Europe and the Middle East in early 1955. Having reached Calcutta, they were forced to detour to Ben's native Australia for a publicity tour as money was running short.

Patience, it seems, was also running thin and Elinore Carlin decided the honeymoon had gone on long enough and returned to her native USA. Undaunted, Ben returned to Calcutta and set off alone across the Bay of Bengal to Burma. Here he was joined by fellow Australian Barry Hanley, who continued with him across the Burmese mountains to the Irawaddy river, crossing the South China Sea to Hong Kong and Japan.

In Japan, further rest and repairs were needed both for Carlin and the Half-Safe. Hanley had also had enough and was replaced by Boyé Lafayette de Mente, a US journalist from the *Japan Times*. From Tokyo, the two bumped and scraped their way to Hokkaido, hitting a few submerged rocks and springing a leak en route. From here, the two set off across the Pacific Ocean for the Aleutian Islands. Despite being feared lost as they failed to make radio contact, the Half-Safe arrived on Shemya on 8 July. From here, they island-hopped to Alaska and then drove to Anchorage, where de Mente called it a day. The title of his book speaks volumes about the voyage: 'Once a Fool: From Tokyo to Alaska by Amphibious Jeep.'

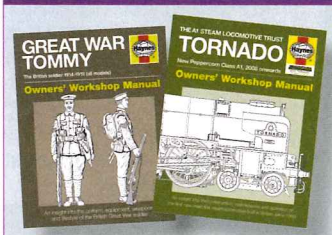
Carlin continued, driving all the way to California where he met his wife who he hadn't seen in two years. From here, he drove back to Canada, finally reaching their starting point, Montreal, on 10 May 1958. Carlin was the first and only person ever to circumnavigate the world in an amphibious vehicle. The honeymoon was over. As was his marriage. The long-suffering Elinore had divorced him three years previously in 1955. •

COMPETITION

What's is the man thinking? The wittiest caption emailed to engtechmag@theiet.org by 12 June 2019 wins a pair of books from Haynes.

CAPTION PRIZES

BAG A BOOK



This month's competition winner will receive copies of 'Great War Tommy Manual' and 'A1 Steam Locomotive Trust Tornado Manual', both from Haynes Manuals (haynes.co.uk). Our April 2019 caption competition winner is Colin Payne: "I name this lift Elle Vator. May God bless her and all who travel in her."