

Justin Pollard on the importance of perseverance in engineering

the eccentric engineer



PICTURE THE SCENE – you stand outside the boardroom of a major company, the patent for your invention clutched firmly in your hands. You know it’s a great idea, the patent examiner knew it was a great idea, but what will the sharp suits on the other side of the door think? The time has come, you walk in and for the next 20 minutes you give yourself body and soul to explaining why this will change the world. You’re met with a surly indifference from ranks of executives too set in their ways to ever contemplate anything so radical for fear it might affect their share options.

So what went wrong? Well, in the first place, you can comfort yourself with the thought that, historically, this is a very familiar scene. Perhaps the answer lies in giving a little demonstration. Consider Charles Parsons.

Charles Parsons shouldn’t have had trouble getting support from the establishment. He was the sixth son of the third Earl of Rosse, some time proud possessor of the world’s largest telescope. He had also received a thorough scientific education thanks to his father who had employed the astronomer Royal as his tutor. So the adult Charles Parsons that emerged should have found every door open to him (even allowing for the regrettable incident when Lady Bangor fell off his home-made steam car and was killed).

A great engineer, however, must fight for recognition – even

if he is the mathematically talented son of an earl. The young Parsons undertook a string of apprenticeships to learn the practical elements of engineering before settling down in 1884 to solve the problem of electricity generation as a partner in a Gateshead firm. The problem was simple – the dynamos used to generate electricity were powered by low-velocity reciprocating engines attached to a belt drive running at around 1000 revolutions per minute, leading to very low efficiencies and very low generating pressure. Parsons’ idea was to do away with nearly all the machinery and, rather than condense and evaporate the steam through pistons and chambers, just let the steam race directly, in a series of controlled stages, through a disk of vanes, around a central spindle which was also the drive shaft of the dynamo. And so the steam turbine was born.

His 18,000 revolutions per minute turbo-dynamo was an instant hit, particularly aboard ships where small and efficient generators were needed for lighting. But Parsons realised that his turbine was more than just a neat way of generating electricity – it was a whole new way of delivering power – and ships seemed to him to be the ideal way of exploiting this. His idea, patented in 1884, was to power not just the lighting but

the drive shaft of the main screw using a turbine instead of a traditional steam engine. Increased mechanical efficiency would mean a reduction in fuel consumptions, and increased revolutions per minute would translate as faster speeds on the water. Surely the admiralty would jump at this? And so Charles Parsons found himself

standing outside the door clutching a patent. He explained to the admiralty his wonderful idea and showed them the drawings, and they no doubt muttered amongst themselves about what the son of an aristocratic astronomer was doing trying to tell them their business. In short, they completely ignored him. Why did the British navy need steam turbines when they already had destroyers capable of the dizzying speed of 28 knots?

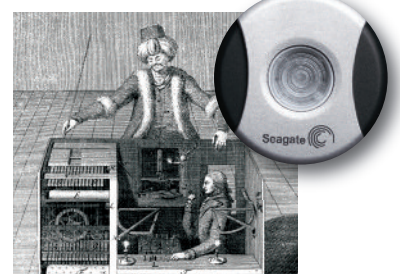
A lesser man may have been disheartened, but Charles Parsons was not one to give up, so he decided upon a little demonstration. The year 1897 was to be the Diamond Jubilee of Queen Victoria – a momentous occasion to be marked by a full naval review at Spithead at which the Queen could gaze on with satisfaction at the huge state-of-the-art fleet which ensured that Britannia ruled the waves. And Parsons intended to be there, uninvited. And he would not come alone. As the 26 June dawned, and as dignitaries began arriving and the warships began forming up in lines off Spithead, another much smaller ship was creeping out of harbour unannounced. She was Parsons’ new vessel – a 100ft, 44t craft powered by three screws running off three turbines and called, appropriately, ‘Turbinia’. She had had a hard birth. Running ship’s propellers at high speed off turbines had created such cavitation that the project was nearly scuppered before it could get started, but Parsons had spent months redesigning the

propellers, their housings and the hull as well as studying models to see how the bow wave and wake of a high-speed ship would affect its performance. Now he was ready – 165 ships lay at anchor off the shore and the Prince of Wales (representing Queen Victoria who was too frail to attend), Prince Henry of Prussia and the whole Admiralty board climbed the specially built stage to watch proceedings.

Then, as the national anthem struck up and the assembled dignitaries rose to their feet, Parsons hoisted a bright red pennant on Turbinia, opened the throttle and out she shot, pelting along at 34 knots between two lines of lumbering British warships, right past the Royal party and just narrowly avoiding a French yacht. The admiralty was furious at being upstaged and signals were quickly sent to intercept the interloper. Patrol boats swung into action and the chase was on. But it was an unfair match. Turbinia easily outran the slow, steam-powered navy vessels – she was, after all, the fastest boat in the world.

By that evening the assembled naval dignitaries from across the world were not celebrating Britain’s steam-powered fleet, but the death of that technology and the birth of a new one. Within 15 years all new British warships and Atlantic liners were turbine powered. Thanks to one audacious demonstration, a new age of steam had been born.

■ Winner of September’s caption competition is Paul Curtis who receives a 6GB USB pocket hard drive courtesy of Seagate. “Are you sure people will buy into this iPod Classic? It’s not exactly what you’d call portable.”



win!

What’s the pilot of Turbinia saying as the vessel hits top speed? A stylish LArobe laptop case from Be-ez is available for the best suggestion. Send your entries to fvitaliev@theiet.org by 29 October.

A Bristol baker's perseverance made life a little more bearable for 19th century sailors

The Eccentric Engineer

by Justin Pollard



FOOD INNOVATION

A LIVELY REMEDY FOR HARD TIMES ON THE HIGH SEAS



IT'S NOT always been easy being in the Navy. In 1797 naval ratings got their first pay rise in 139 years and even then the money was, frankly, disappointing. Then there was the savage corporal (and sometimes capital) punishment doled out by the officers. Then, assuming you shrugged off the penury and beatings, there was the food.

Sailors in the 19th century didn't even get their 'daily bread'. Bread was simple enough to prepare but it did require a slightly unusual ingredient – live yeast. Unlike Her Majesty's jolly tars, yeast wasn't fond of long sea voyages and, when press-ganged, had a habit of dying, just to annoy the baker. So the answer for most on board was the truly grueling hard tack biscuit.

Hard tack was an even simpler

food, made from flour and water and, if you were lucky, a bit of salt. This glutinous paste was shaped into rounds or squares and baked hard. Then it was baked hard again. This was how poorer landlubbers came across it, but for sailors it was considerably worse. Ships are damp places and damp food tends to go off so it was essential that the hard tack was bone dry when it went into the hold. The navy baked their tack four times, creating a snack with many of the physical properties of cement. They also liked to bake early, often preparing the biscuits a full six months before a ship set sail. In this time the only creature more tenacious than the British sailor made its own heroic inroads into the stock – the biscuit weevil.

Competition

What did this sailor make of Henry James Jones's invention? The best caption emailed to engtechmag@theiet.org by 12 May wins a pair of books from Haynes.

Clearly a change was needed and fortunately, in 1845, Henry James Jones came on the scene. Jones, a Bristol baker, had been puzzling over the problem of how to make bread without yeast. It was the need to keep yeast alive that prevented anyone from making their own bread and, after much experimentation, he had come up with a method of combining ordinary flour with tartaric acid, bicarbonate of soda, a dash of sugar and a pinch of salt. Here was a flour that could be mixed with just water to make a bread dough that would rise like a yeast dough. And so the rest should have been history.

In fact the new 'self-raising flour' was a hit at home and Jones was a great promoter of his flour, which he sold in 'signed' yellow bags with blue lettering. Patents were granted and the judicious mailing of samples to the great and good soon brought a Royal warrant along with hearty recommendations from the *Lancet* and even Florence Nightingale. Naval men also sent their compliments, including the captain of the *SS Great Britain*.

But one door remained firmly closed – the Admiralty's. Their Lordships were not known for taking hasty decisions. Ten years passed without an Admiralty decision on the patent flour in which time Jones tried everything to persuade them. In 1846 he invented a bread machine designed to bake his self-raising bread. The Admirals dithered for a year before demanding the machine be sent to Woolwich for trials. When no word came back Jones wrote again, receiving a curt reply telling him his machine had been sent for scrap. A legal case followed before Jones recouped any of his costs.

The following year the report into the testing of the machine emerged and was wholly positive. This spurred the Admiralty into action and six days later they sent Jones a letter saying they were rejecting both his flour and his machine. Six more years passed before Jones tried again. In one last bid he gathered together all his correspondence with the Admiralty along with all the recommendations he had received. These he published in a pamphlet, which he sent to every member of Parliament, with a note saying "that a grave responsibility would rest upon himself" if he did not make this attempt.

Their Lordships, suddenly finding themselves in the uncomfortable glare of adverse publicity, saw the light. Within a month, Jones' self-raising flour was on the provisioning lists of every ship in the Royal Navy. However, just in case the sailors thought all their birthdays had come at once, its use was restricted to Sundays. *

A design for a circular battleship championed by Tsar Alexander II failed to live up to its promise.

The Eccentric Engineer

by Justin Pollard



MARINE ENGINEERING

CIRCULAR BOAT THAT LEFT RUSSIAN SAILORS IN A SPIN



Circular boats have proved excellent for sea-sickness, though not, sadly, for preventing it

THERE HAVE been enough ludicrous weapons over the years to fill many a book on engineering folly. Perhaps one day I'll tell you about the world's first stealth bomber, the German Linke-Hoffman R1. It was a 1916 leviathan covered in transparent cellulose, which glistened so delightfully in the sun that it was perhaps the most visible plane of the whole war – or would have been if it had ever managed to get off the ground. I will however be confining myself to Russia, or at least hovering off its coast.

It is well known that some of the very earliest boats were round – coracles being a good example. It is also the case, however, that naval engineers rapidly began making boats that were longer than they were wide, with keels and more pointy at the front, to help them handle the sea. And so ships, particularly fast warships, became pointier and longer right up until 1873.

In that year, radical Russian vice admiral Andrei Alexandrovich Popov decided to go back to basics. He already had a formidable reputation as a naval architect, being the man

behind the turret-ship *Piotr Veliky*, one of the most advanced battleships of the age, but now he decided to take a great leap backwards.

Popov's ships couldn't carry guns as large as he would like and couldn't get near enough inshore. His answer was to make his new battleships circular. After all, a ship that was round would need less armour plate and hence could be either faster or more heavily protected, as well as being more manoeuvrable (not having a keel) and more stable.

The Russian Tsar Alexander II also liked the idea. In 1873, work began in the Galerniy dockyards in St Petersburg on the first of two round, flat-bottomed iron-clads. The ships were driven by six engines, each powering one propeller, while the firepower came from a pair of 11 in rifled, breech-loading guns. The first monstrous vessel was the 2,490t *Novgorod*. Three years later the *Kiev* was laid down at Nicolaiev, although her name was soon changed to the *Rear Admiral Popov* in honour of her inventor.

By now you may be wracking your brain trying to remember

Competition

What would the pilot of this simpler and more successful circular vessel make of Popov's version? The best caption emailed to engtechmag@theiet.org by 17 February wins a pair of books from Haynes.

the last time you saw a circular ship in anyone's navy. The truth is that the idea was a disaster. These 'popovkas', as the Tsar affectionately called them, had numerous problems. Their bulbous shape meant that even with six engines they were only capable of around 6-7 knots, less than the current on the River Dneiper where they were tested and promptly swept out to sea. Being flat-bottomed they were also remarkably difficult to keep steady and as they were swept away they spun round repeatedly, making the crew seasick.

Then there were the guns. They were designed to be fired independently, but when one was unleashed, the recoil imparted an off-centre force to the ship, making the whole thing spin like a merry-go-round. This made it tricky to aim properly, although it did make them amusing targets in themselves. Twelve bilge keels were added to improve the situation but, frankly, didn't.

When the sailors onboard weren't being spun round like salads, they could boil instead. In the Ukrainian summer these shallow silver dishes, which presented a huge surface area to the sun, heated up like ovens.

Unbelievably, the two Popovkas did see combat in the Russo-Turkish War of 1877-78, although the main action involved the crews being sick as the ships pitched intolerably in even the slightest seas. Retired to serve as permanently moored batteries, they were finally decommissioned in 1903 and served as store ships until they were broken up in 1912.

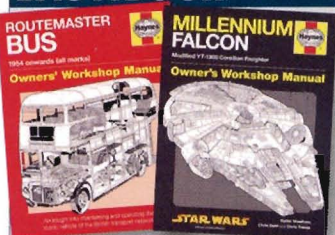
But that isn't the end of the story. You remember that Tsar Alexander II though the Popovkas were a good idea.

So good in fact that he commissioned a new Royal yacht, the *Livadia*, based on the same design and built by John Elder & Co in Clydebank. The Tsar confidently predicted that this novel layout would finally cure the Empress Maria Alexandrovna of her sea-sickness.

Of course the *Livadia* had every modern convenience and was the most luxurious private vessel of its day. It even boasted a flower garden and a fountain. But it was not a cure for sea-sickness. It took two months to deliver the lumbering, wallowing vessel from Glasgow to southern Spain and the entire crew of seasoned sailors were continuously sick for the whole voyage – even during the subsequent calm passage from Spain to Istanbul.

Fortunately Tsar Alexander II would not have to face his wife's wrath. Just days after the ship was delivered at Sevastopol in 1881, he was assassinated by an anarchist's bomb. *

CAPTION PRIZES BAG A BOOK!



This month's competition winner will receive copies of the 'Star Wars Millennium Falcon Owners' Workshop Manual' and the 'Routemaster Bus Enthusiasts' Manual', two new titles from the ever-expanding range of Haynes Manuals (haynes.co.uk). Winner of our December 2011 issue competition is Dale Haines with: "It's the same thing every year. The wife goes to the Chelsea Flower Show and I have to find somewhere to put yet another garden ornament!"



This edition of Eccentric Engineer tells the story of the BBC Time Signal, and how, over the years, it has just got more complicated.

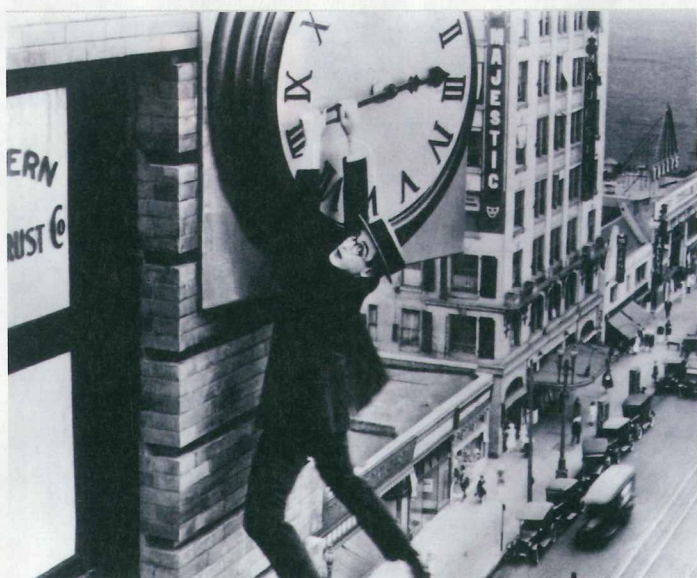
The Eccentric Engineer

Justin Pollard



BROADCASTING

A tale of six pips – how the BBC became the national arbiter of time



EVERY ENGINEER needs to know the time, if only so as to not miss lunch. Since 1924 many Britons have been checking their watches against the BBC time signal, known affectionately as 'the pips'.

The history of the 'pips' is almost as long as the history of the BBC itself. The first transmissions from what was then the British Broadcasting Company began in late 1922, and soon afterwards there were suggestions of broadcasting a time signal under the control of the Royal Observatory at Greenwich – then the arbiter of time in the UK.

No one seems to have seen a need for this degree of precision, but early broadcasts did use their own ad hoc 'pips', marking the 8pm and 9pm news programmes with a time signal consisting of the announcer playing the Westminster chimes on a piano, and later a set of tubular bells.

This proved rather popular with listeners, who could now adjust their clocks and watches daily, so the BBC decided to invest in some more high-tech clocks from

the Synchronome Company. These provided audible 'ticks', which the announcer then simply counted down.

The idea for the actual pips probably came from amateur horologist and radio enthusiast Frank Hope-Jones, who ended a particularly well-timed radio lecture by counting down the last five seconds to 10pm. After this, he suggested that the BBC might broadcast an audible time signal.

John Reith, managing director of the BBC, decided to contact the Astronomer Royal, Frank Watson Dyson, to discuss the idea. Dyson agreed to modify two clocks at Greenwich, so their escapement wheels controlled a switch on a 1kHz oscillator, which sent this signal down a telephone line to the BBC to produce a time signal every half-hour. To help people set their watches it was decided to broadcast six tones from the oscillator starting at five seconds to the hour and ending on the hour, the start of the last tone being the hour itself. The 'pips' were first transmitted at 9.30pm on 5 February 1924,

COMPETITION

What's the man thinking?

The wittiest caption emailed to engtechmag@theiet.org by 11 March 2020 wins a pair of books from Haynes.

introduced by Dyson himself.

For 13 years the system worked well, until the Royal Navy, which controlled Greenwich Observatory, realised the BBC had never paid for the service and sent them a bill. In return, the BBC reminded the Navy that they had never billed them for the shipping forecast and the matter of fees was quietly dropped.

When the Royal Observatory moved to Herstmonceux Castle in Sussex in 1958 the 'pips' had to move too. Here two electric clocks generated the signal, which was sent down two phone lines (one for redundancy) to the BBC in London. To confirm that the lines were working the clocks sent a continuous tone all the time, the 'pips' being short silences. This signal was turned into 1kHz 'pips' by the BBC.

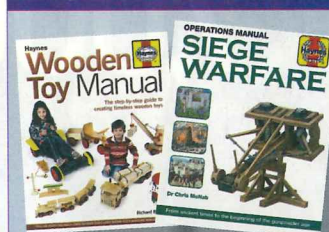
With the occasional spurious pip, the time signal survived largely unchanged until 1971, when an international agreement brought all time signals on to International Atomic Time (IAT). While this hardly bothered those setting their watches before the news, it bothered the timekeepers. IAT is relentlessly accurate whereas the Earth itself is not, running slightly slow. It was decided that local time, such as GMT, would have to occasionally be adjusted by adding a 'leap second'. Yet this proved problematic for the 'pips'. Obviously, a seventh 'pip' could be added, but how would the audience know which was the last pip? The answer was to alter the length of the last pip from 0.1s to 0.5s and so the familiar sounding last 'pip' was born.

From 1990, the BBC took over creating the signal itself, always aiming at higher accuracy and even adjusting for the time it takes the signal to travel to the transmitter and then to the receivers, even though these

fractions of seconds are far less than the time lost in the sound getting from the radio to the listeners' ears. Of course, occasionally things went wrong. At 8am on 17 September 2008, seven 'pips' were broadcast six seconds late. To this day, no one knows why, but the machine was reset by switching it off and on again and has worked well ever since.

Being a story of scientific endeavour, one might expect that from here on in, it just gets more accurate – but you'd be wrong. With the advent of digital radio and internet, the time signal has become, ironically, far less accurate. Digital signals need to be encoded and decoded, and for digital radio this can take 1.5 seconds. For the BBC website, it can be as long as 10 seconds. The digital age may herald the end of the 'pips' as we know them. Time to dust off those tubular bells. *

CAPTION PRIZES BAG A BOOK



This month's competition winner will receive copies of 'Siege Warfare Operations Manual' and 'Wooden Toy Manual', both from Haynes Manuals (haynes.co.uk). The winner of our December 2019 caption competition is Caroline Levison: "Dad must be taking the Mickey if this is what he thought I meant when I asked for a wireless mouse for Christmas."



By Justin Pollard

Published Friday, August 20, 2021

What is the best shape for a ship's hull? Oddly enough, this is a trickier question than it first appears and it would take a 19th-century railway engineer with a love of curves to answer it.

William Froude did not intend to be a naval engineer. The son of a Devon archdeacon, he took a first in mathematics before becoming a surveyor for the South Eastern Railway in 1833. This was the great age of railway expansion and Britain suddenly found itself with a pressing need for practical engineers who could find elegant and inexpensive solutions to carving the great railway routes through the country.

Froude was just such a man and in 1837 Isambard Kingdom Brunel, the biggest engineering name of the age, took him on to manage the construction of the last section of the Bristol to Exeter line. Froude applied his mathematical genius to the practical problems of railway building. He devised 'spiral easements' to transition between straight and curved track in such a way that the carriages didn't fly off the rails, as well as drawing up plans for a new type of skew arch.

With a small private income, Froude retired from full-time engineering aged only 36, to look after his ill father. To fill his time, he took on voluntary roles as a magistrate and harbour commissioner as well as applying himself to improving the water supply in Torquay. It was this that first gave Froude the idea of studying friction in water, which in turn perhaps inspired Brunel to hire him to work on another of his great projects – improving ocean travel.

Brunel's question was simple – how do you find the optimum hull shape to ensure the stability and economy of a ship in seaway? The answer was far from easy. Yet after five years' work, Froude presented a paper to the Institution of Naval Architects, outlining the first correct theory for the behaviour of a ship in a seaway.

Until this point, ship design had been somewhat haphazard. Ship lines were derived by eye and only tested when the final vessel was launched. Naval architects worked by trial and error, not mathematical planning. Not that the maths was easy – indeed, it took another decade for Froude to perfect his ideas, using modelling where mathematics proved simply too complex, and it was this idea that brought about his next breakthrough.

It was one thing to build a ship by trial and error, another to plan it mathematically, but the actual building of ships required something in between, and Froude realised that was modelling. At the time the idea was considered outlandish. Surely the only way to see how a ship behaved was to build it and sail it? A model would behave differently.

Or would it? Now a Fellow of the Royal Society and a partner in business with Brunel's son Henry, Froude was asked to join a committee of the British Association charged with creating methods to estimate the power required to drive a ship. Of course, the power was dependent on the shape of the hull and speed of the vessel, and the committee decided the best way to study this would be to build several full-size ships and test them.

Froude disagreed and instead went away and built three models at different scales of each of two radically different hull shapes – the Raven and the Swan.

These were both extensively tested and Froude reported back two astonishing discoveries. First, contrary to centuries of naval understanding, there was no optimum hull shape. Raven sailed better at low speeds, but Swan was better at high speeds. Second, he demonstrated that when tested at corresponding speeds, the resistance per

unit immersed volume of his models was the same at all scales; hence, testing a hull model would be just as effective as building a whole ship. This is known today as Froude's Law.

Of course, engineers of the Royal Navy and the British Association still needed convincing, so in 1871 HMS Greyhound was fitted out as a full-size test vessel, being towed at several speeds and her resistance measured. Much to his delight, this triumphantly proved Froude right.

With the navy now onboard, Froude persuaded them to build the world's first test tank, near his home in Torquay. At 270 feet (82m) long and with a constant-speed steam pulley system, it allowed the resistance of paraffin wax hull forms to be tested through the water and measured with Froude's own-design dynamometers. The machine remained in service until 1938.

Now the toast of the Admiralty, Froude was offered a holiday voyage to South Africa as a guest of the Royal Navy to help him recover from the death of his wife. However, he contracted dysentery onboard and died at Admiralty House, Simonstown in 1879. He was buried with full naval honours.