the ENGINEER
from the archive

160 years of innovation

Engineering milestones and curiosities from the pages of *The Engineer*

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from the archive

our opinion

Past performance

As you may have noticed, we have been celebrating a significant milestone over the past 12 months: *The Engineer*'s 160th birthday.

Earlier this summer, we published a special 160th anniversary edition of the publication in which – as well as looking at some of the great developments of the past – we gazed into the crystal ball and examined the technological trends that will shape the world of engineering in the decades to come.

But for this special supplement we've put the crystal ball away and looked firmly into the past, directing our gaze towards the dusty leather-bound tomes of our classic archive.

The stories over the following pages are just a taster of the engineering milestones and technical curiosities therein: a fascinating window on the past, and a powerful reminder of the astonishing technological progress that has taken place during *The Engineer*'s lifetime.

Alongside the big stories – we've also focused on some of the more esoteric inventions that have caught *The Engineer*'s eye over the course of the last century and a half. An innovations such as the horse tank looks ridiculous but, to *The Engineer* of the 1850s, it was a perfectly plausible vision of the future of warfare.

One wonders whether any of today's much-trumpeted innovations will provoke a similar response from future historians?

> "The stories are a powerful reminder of some astonishing technological progress that has taken place"

Or will future generations regard our current era, with its autonomous cars, new forms of power generation and dawning artificial intelligence, as a golden period of innovation every bit as world-changing as the Victorian era? History will be the judge. In the meantime, we hope you enjoy this little romp through Britain's industrial history.

Finally, we'd like to take this opportunity to wish all of our readers a very happy Christmas and a prosperous new year.

Click here for more stories, insights and classic inventions from The Engineer's archive

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Sept 1858 London’s sewer

A bill is rushed through Parliament to initiate the construction of London’s new sewer system

In the summer of 1858, the ‘Great Stink’ of London had become so overpowering that it drove members of Parliament from the chambers of the House of Commons. It’s no surprise then that a bill was rushed through Parliament in 18 days to fund the construction of a new sewer system.

The Engineer reported on the results of the Royal Commission, which was appointed to investigate the best way of dealing with London’s growing waste problem.

“To avoid the exposure of deposited matter and from the processes necessary for its manufacture into solid manure, the reservoirs are proposed to be detached lengths of large sewers,” the article said.

The design was an attempt to replace the open sewer system where waste was dumped in the Thames, resulting in cholera outbreaks and an overwhelming stench. It centred on detached embankments between Southwark and Vauxhall bridges that would act as reservoirs for waste.

The article continued: “The sewage in these reservoirs should be always deodorised and they would have no external openings in the shape of gullies for the emission of foul air, nor would offensive smells be allowed to escape from them.”

The sewage was proposed to be pumped away through pipes connecting the reservoirs to the sea. The commission estimated the total cost of the improvements to be £3.3m, adding that they would also improve transport and recreational activities.

The Metropolitan Board of Works’ chief engineer, Joseph Bazalgette, was responsible for designing and building the huge system of intercepting sewers, which is still in use today.

A few years later, in 1867, London’s sewer was up and running and *The Engineer* took an in-depth look at East London’s ornate Abbey Mills pumping station, which along with its partner south of the river at Crossness provided the power to lift the sewage so that it could be pumped into new outfalls downriver of London.

The writer lavished almost as many superlatives upon the project as there were bacteria in the water, explaining that the station’s eight pumping engines and double-acting piston pumps would lift the sewage by about 36ft into three parallel sewers, discharging into a 9.5-acre, 16.5ft-deep reservoir and thence into Barking Creek. To this day, flushing something down the loo in east London is known as ‘sending it to Barking’.

The article explains the machinery to be installed in the station in great detail, noting that the engines “will be made according to the most approved construction and design and will be perfectly balanced both in and out of action”. Even the leather for the valve seals comes in for praise, being “of the best description of hide [a quarter of an inch] thick, which will have laid in the tanpit for two years”.

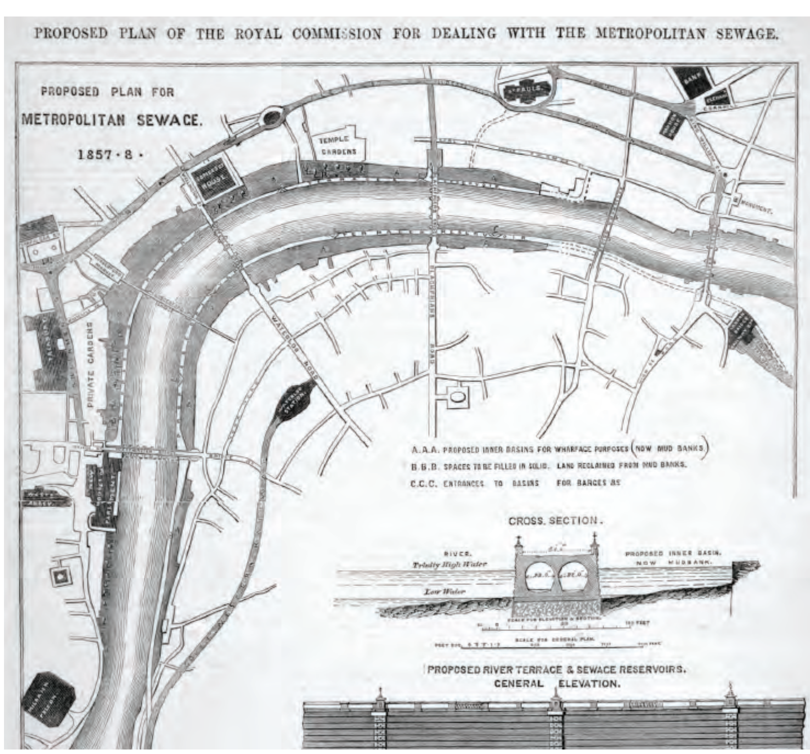
The safety margins for the engines is also described — an important part of the design of the project, with every part of the system oversized for the scale needed at the time to cope with Bazalgette’s projected rise in London’s population. “The materials, workmanship and finish of the said engines and other works will respectively be the best of their kind,” it said, “and no part of the engines will be of less strength than is equivalent to at least 10 times the maximum pressure (estimated at 35 tons) of the steam on the piston.”

> “The sewage in these reservoirs should be always deodorised and they would have no external openings for the emission of foul air”
> The Engineer

The sheer ornateness of the designs also caught the reporter’s eye. “It would not be easy to do justice to the elaborately ornate character of the design as a whole,” he said. “The design of the engine and boiler, the chimney stalk and, in fact, of every portion of the whole structure, does infinite credit to Mr Bazalgette and his staff; while we are at a loss to detect a single feature calculated to unnecessarily increase the outlay. Until we have placed our readers in full possession of the details of this dainty palace of machinery — if we may use the words — it would not be well to speak further of its merits.” It says a lot about Victorian engineering that all the fancy curlicues of cast iron weren’t seen as an unnecessary expense.

The article concludes by bemoaning the out-of-the-way location of the station, saying that it will not get the attention it deserves, and that North London will feel its effects on health much more than appreciating it as an example of “high art in engineering”. Both Bazalgette and *The Engineer*’s reporter might be pleased to know that this isn’t the case. Abbey Mills is still in service and, although the steam engines and pumps have been replaced, the amazing ironwork can still be seen today.

The 1857–58 plan to deal with the ‘Great Stink’ that was engulfing London



September 1856

The horse tank — a new concept in cavalry technology

An armoured suit for horses with a rigid adjustable frame

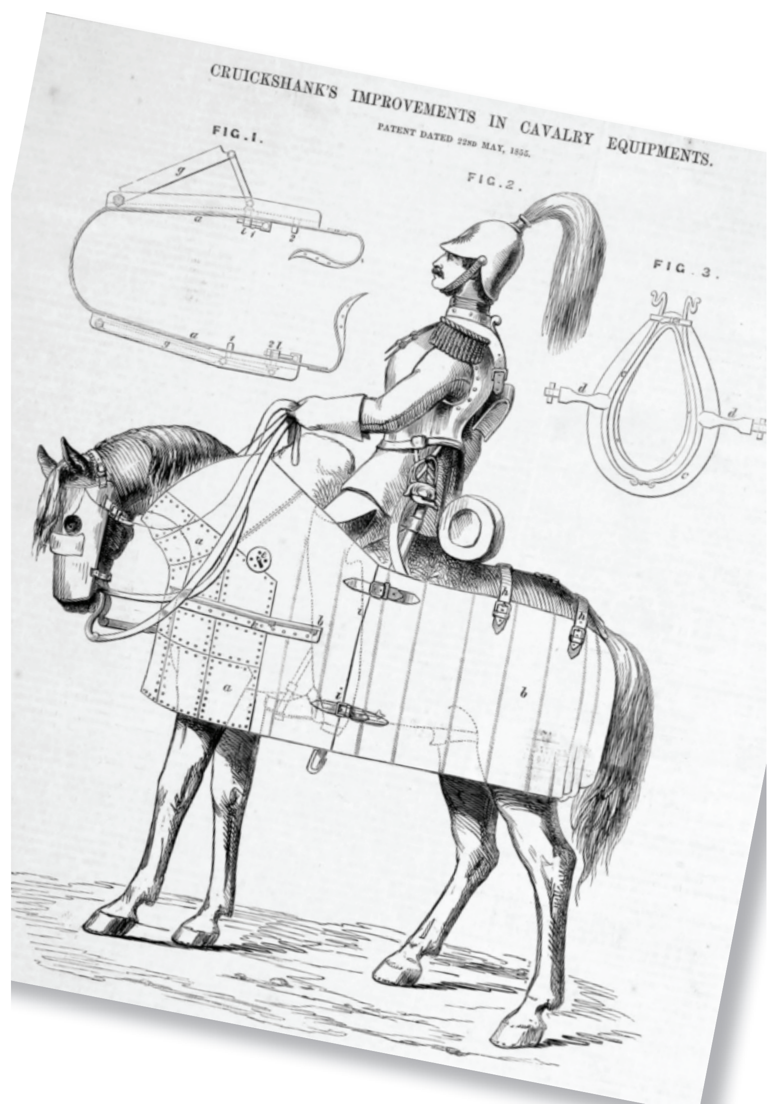
Military minds wondering how to equip the modern soldier with the means to safely travel long distances while burdened with gadgets may like to consider reviving the idea of the horse tank – a startling concept in cavalry technology described in the first-ever issue of *The Engineer*.

The article, drily entitled 'Cruickshank's improvements in cavalry equipments', described an armoured suit for horses consisting of a rigid adjustable armoured frame to protect the horse and the lower extremities of the rider.

However, any similarities to the armour-clad chargers of Arthurian folklore ended here, for attached to this frame was a series of retractable lever-operated cutting implements and weapons with which the rider could scythe his way through enemy troops. "These cutting edges are capable of being adjusted to act as offensive weapons during an attack and of being returned to an innocuous position when not required," reported *The Engineer*. It would, continued the piece, "render the attack of cavalry more formidable by providing horses with a means of destroying troops against which the attack is directed".

The armoured suit was designed to help even the most nervous war horse to enter battle, courtesy of a helmet-mounted blinker system. "When occasion shall require, such as when the horse is required to face danger, a sliding piece of blind is provided. This is fitted with rings which run on guide rods, and by means of cords passing upwards and through guides at the top of the helmet, the soldier is enabled to raise the blind."

It's not clear whether Cruickshank's invention ever made it from the sketchbook to the battlefield, but a quick scan of the history books suggests that, sadly, the horse tank may have fallen at the first hurdle.



March 1869

The Tower Subway

Going underground to cross London's River Thames

Before Tower Bridge took its place on the London skyline, people had to go underground to cross the river. *The Engineer* described the construction of the now-forgotten Tower Subway, a forerunner of the modern deep-level Tube.

An engineer named Peter Barlow proposed that a subway should be built under the river bed, as it was the only way that a river crossing could be achieved: an attempt to bridge the river had failed in 1863, because of "the great height required for the passage of ships" (a problem solved by Tower Bridge, of course, by allowing the roadway to rise).

Barlow's son, also called Peter, oversaw the work, which began with the sinking of a shaft at Tower Hill – 10ft wide and 48ft deep, and lined with brickwork and cast-iron cylinders. The subway itself was dug using a wrought-iron tunnel-boring shield, presumably similar to the one developed by Marc Brunel to dig the first Thames tunnel at Rotherhithe in 1825. "This shield, which has an outer plate, will overlap the completed work, and a smaller heading will be carried forward in front of the work, and the shield propelled by screws, and as it progresses the tunnel segments will be bolted on behind," the article said.

The subway itself was 100ft long and 7ft in diameter, lined with cast-iron segments. Running 22ft below the river bed through stiff London clay — much easier to tunnel than the soft river mud that Brunel had dug through — it was fitted with steel rails on a 2ft 6in gauge, and stationary steam engines were installed at either end, which pulled a wrought-iron carriage along from north to south. Another shaft was dug at the southern end, just off Tooley Street, and lifts installed to take passengers up and down to the subway. The tunnel was completed in 14 weeks, and opened in August 1870. Unfortunately, Barlow's system of steam engines and carriage proved unreliable, and the company running it went bust within a year.

The lifts and rails were removed and spiral stairways and gas lighting installed, and the subway reopened as a foot tunnel, and 20,000 people a week used it, paying a ha'penny toll. It was very popular with working people, although contemporary accounts make it sound rather unpleasant: Charles Dickens Jr, the novelist's son, said in a London guide that the headroom was so low that you shouldn't walk it wearing a hat "to which you attached any particular value".

The tunnel remained popular until Tower Bridge was completed; being free to cross, it caused the subway revenues to collapse.

The armoured suit was designed to help even the most nervous war horse to enter battle

1850s–1860s

Feb 1861 SS Great Eastern

Brunel's vast iron steamship provoked fierce criticism of the notion of iron-constructed navy warships

Iron-clad warships were a new development that provoked intense scepticism in the 19th century. A lengthy article from our archives for February 1861 discusses an issue of great importance to the defence of the British Empire, then at its height: whether the ships of the Royal Navy should be made primarily of wood or should be protected by a coat of iron.

Wood had, of course, been the only material used for shipping construction for centuries. It had become part of British mythology – 'Heart of Oak' is still the official march of the Royal Navy – and the need for the emblematic tree to provide the timbers for ships changed the appearance of the English countryside. The nation had fought off both the Spanish Armada and Napoleon with wooden ships. Why change now?

The reason the question was even posed was largely down to one man: Isambard Kingdom Brunel. Although he is now universally praised as a genius and an iconic figure of British engineering, that wasn't true of his own time.

Brunel was an iconoclast whose projects pushed at the edges of available technologies, and, as *The Engineer*'s obituary on him (see p9) makes clear, to his contemporaries he was a foolhardy figure more notable for his failures and the great cost of his completed projects than for his successes. However, the completion of his final project, the enormous iron steamship SS *Great Eastern*, had focused attention on the future of shipping.

By far the biggest ship ever built, SS *Great Eastern* was 692ft long (211m) and weighed 18,915 tonnes – records that would not be surpassed until 1899 and 1901 respectively. It could carry 4,000 passengers from England to Australia without refuelling. But it wasn't an unqualified success: an explosion during the maiden voyage had damaged the ship, and Brunel's death soon afterwards cast a pall.

The Engineer's article (which, in fact, does not mention Brunel at all) focuses on General Sir Howard Douglas: a veteran of the Peninsular War, expert in military strategy and authority on marine engineering. Gen Douglas, the article said, "has long been recognised as the principal literary champion of wooden ships of war", and, when anyone dared to suggest that iron could be used instead, he "uniformly exerted his influence, which is by no means inconsiderable, against the project".

Gen Douglas had issued a pamphlet stating that: "Vessels constructed wholly, or nearly so, of iron were utterly unfit for all the purposes of war, whether armed or as transports for the conveyance of troops." He even opposed the cladding of wooden ships in iron armour.

Stepping up to oppose the formidable soldier was Scott Russell, whose company had built the all-iron, double-skinned SS *Great Eastern* (and had gone bankrupt in doing so). Gen Douglas had been unimpressed by the vast ship, stating in his pamphlet that 68lb solid shot "would pass straight through the *Great Eastern* with tremendous effect, and this perforation could not be plugged up". Moreover, the ship was "an awful roller, and has never attained anything like the calculated speed", and he claimed that iron of 8in thickness would be needed to proof the hull against shells and solid shot.

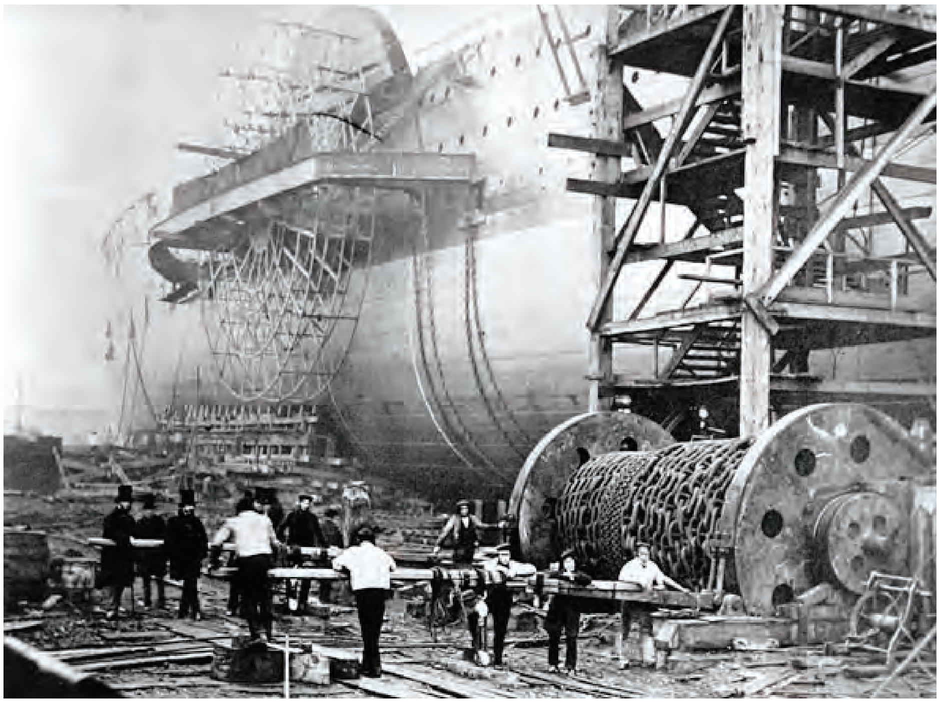
> "68lb solid shot would pass straight through the *Great Eastern* with tremendous effect, and this perforation could not be plugged up"
> General Sir Howard Douglas

Russell took umbrage. On balance, he said, iron performed better than wood; iron ships would be stronger than wooden vessels of equal weight, would be able to carry heavier loads and would not catch fire. SS *Great Eastern*, he insisted, rolled less than wooden ships and had realised a speed of 14kt on a transatlantic route.

The article points out also that iron hulls could be repaired easily and fairly cheaply; shots striking at an angle tended to glance off and did not shatter into sharp splinters, which, in wooden ships, were a cause of terrible injuries to crew.

The argument in favour of iron ships was a good one, the article concluded, with fire safety being particularly powerful. In a close engagement between two wooden ships of the line, incendiaries could destroy both ships in under five minutes.

The argument had been won, in fact, two years earlier. HMS *Victoria*, launched in 1859, was the Royal Navy's last wooden ship of the line, and the ironclads HMS *Warrior* and HMS *Black Prince*, both launched in 1860, set the scene for iron-armoured wooden vessels.



The SS *Great Eastern* iron-clad warship pictured before its launch in 1858

October 1858

The Westminster Clock, London

Considered as one of the finest mechanical clocks ever built

For almost 160 years the giant faces of the Westminster Clock (the most distinctive features of the tower popularly known as Big Ben) have gazed out across London.

And in 1856, shortly before its installation in the Westminster's iconic tower, *The Engineer* took a look at a device that's still considered by many to be one of the finest and most innovative mechanical clocks ever to be built.

Designed in the 1840s by lawyer and amateur horologist Sir Edmund Beckett Denison, the Great Westminster Clock represented a fundamental breakthrough in clock design.

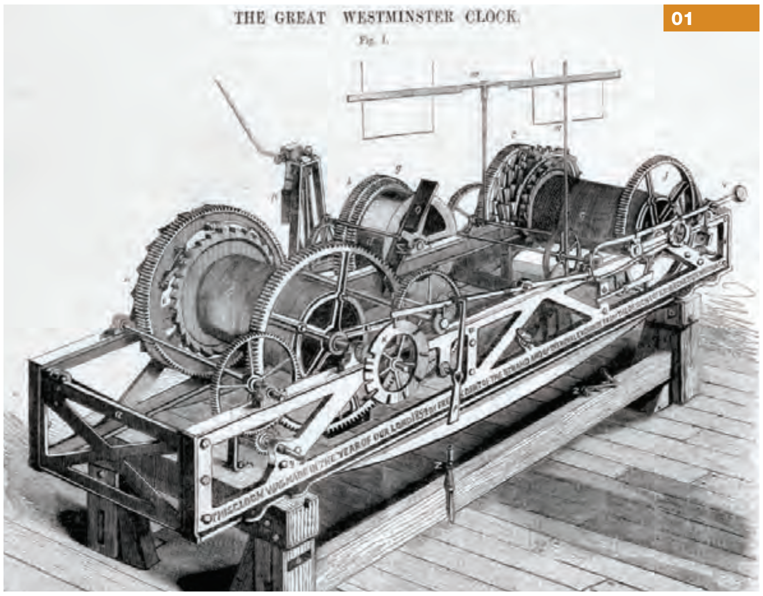
"The merit of the design of the Westminster Clock is due to Edmund Beckett Denison," reported *The Engineer*, "a gentleman who has devoted very considerable time to the study of clock and watch-making and who has at various times introduced many important improvements in their construction."

At its heart is an innovation that's been hailed as one of the most significant horological advances of the 19th century: the double three-legged gravity escapement.

An escapement is the device in a mechanical clock that transfers energy to its time-keeping element. It's driven by force from a coiled spring or weight that's transmitted through the clock's gear train. Each swing of the pendulum releases a tooth of the escapement's gear wheel – allowing the gear train to advance by a fixed amount.

Big tower clocks are particularly challenging, as the large hands often have to work against the wind. The escapement of the Westminster clock uses an ingenious arrangement of weighted 'gravity arms' to isolate the pendulum from the outside world.

"The gravity escapement is adopted because it is more independent of these peculiar causes of vibration which are found to affect clocks in such a position as the Westminster Clock will occupy," wrote *The Engineer*. Another key innovation was the clock's pendulum, which was designed to ensure that the clock is unaffected by changes in temperature. In ordinary pendulums the rod will expand and contract depending on temperature, leading to changes in the length of the pendulum swing, and inaccuracies in time keeping.



01

01 The Great Westminster Clock was a breakthrough in clock design
02 Brunel's career was described as "unfortunate" by *The Engineer*

September 1859

Brunel's obituary

A man now revered was viewed differently by contemporaries

02

More than 150 years after his death Isambard Kingdom Brunel remains one of the few engineers that most British people can name.

Revered alike by industrialists, politicians, media and the general public, he regularly tops lists of 'Great Britons'; is frequently held up as an example of the qualities missing from modern Britain; and even played a starring role in the London Olympics opening ceremony in 2012.

But as the obituary that appeared in *The Engineer* following his death in September 1859 illustrates, a man regarded by many today as the greatest engineer that ever lived was viewed very differently by at least some of his contemporaries.

Dwelling on a number of projects that it asserts were failures, the article describes Brunel's career as "unfortunate", writing that "notwithstanding the number and imposing character of his works many of them, often indeed through no fault of his own, have proved unsuccessful".

His celebrated bridge over the Thames at Maidenhead – today in the running to be considered a world heritage site – is described as "bold, but unsuccessful", while the Great Western Railway – routinely held up as one of the marvels of the Victorian age of innovation – is described as remarkable for its high cost rather than "any merits which it may possess as a work of engineering".

Brunel's efforts in the arena of shipbuilding come in for a bit more praise. On his championing of screw propulsion for the SS *Great Britain*, the magazine suggested that "Mr Brunel never allowed himself to overlook any new discovery giving promise of value in its application to engineering. Being in a position to exercise considerable influence he did not hesitate to employ it in introducing the new means of propulsion which has wrought such a marked change in the construction and working of our ocean steam marine".

The article also contains a valuable lesson for politicians and businesses, who struggle to justify investment in projects with little short-term economic pay-off. "Judged by another standard, that of the financial results of the vast sums of money the expenditure of which he controlled, Mr Brunel was almost uniformly unsuccessful."

Brunel was reportedly a friend of *The Engineer*'s founder Edward Charles Healey, so it seems unlikely that the paper would have an axe to grind. But it's hard to escape the feeling that the maverick engineer had managed to upset someone on the editorial team. "He did not seek, in proportion to his opportunities, to raise those beneath him, and comparatively few men enjoyed his confidence. He often managed to quarrel with his contractors. He had little sympathy for struggling genius, he seldom lost an opportunity for decrying against inventions and inventors not withstanding that his reputation was largely due to the applications which he had made of the ideas of others."

Mar 1876 Channel tube

Proposals to create a link between Britain and France go as far back as the time of the Napoleonic Wars

This island nation's relationship with the continental mainland has always been fraught, and conflict between the major powers has punctuated European history, from the Spanish Armada and Napoleon to the Great War and the rise of fascism.

Despite the almost ever-present tension, plans to connect the UK to mainland Europe have been around for centuries. In March 1876, *The Engineer* compiled an extensive round-up of the various means that could be employed to accomplish the task, including tunnels, tubes, and bridges.

According to that same edition of the publication, proposals to create a link between Britain and France go as far back as 1802, just as the Napoleonic Wars were getting underway.

"Ever since the commencement of the present century there has been evinced a very firmly rooted conviction that there ought to be a line of communication established between England and the Continent of Europe other than that afforded by the passage of steamships between shore and shore," our predecessors wrote in 1876.

"The first proposition to unite England and France was made in 1802, by Monsieur Mathieu, whose plans were laid before the First Napoleon, then First Consul, and were afterwards exhibited at the Luxembourg and public galleries in Paris. They have, however, long since been lost, and with them the proposed method of carrying out the work."

Another Frenchman is singled out for special praise by *The Engineer* for his lifelong dedication to the project. Known today as the 'father of the tunnel', Monsieur Thomé de Gamond died just a month prior to the 1876 article's publication. He devoted more than 40 years of his engineering career to researching a tunnel under the Straits of Dover, his "scientific attainments" and "irreproachable character" winning him "the love of many and the regard of all".

Throughout the course of his work M. de Gamond made over 1,500 experimental borings in France and England to examine the strata, as well as carrying out three dives to the bottom of the channel to examine the contents of its bed. The last of these dives saw him "attacked by conger eels or dogfish", resulting in serious injuries. Although he didn't get to witness his vision become reality, M. de Gamond did live to see his idea for a channel tunnel be "adopted by eminent engineers in both countries, and supported by financial authorities".

Those eminent engineers would include Sir John Hawkshaw and Sir James Brunlees, founders of the original Channel Tunnel Company in 1872. They proposed a tunnel of 31 miles between St Margaret's Bay in England to a point on the French coast roughly midway between Calais and Sangatte.

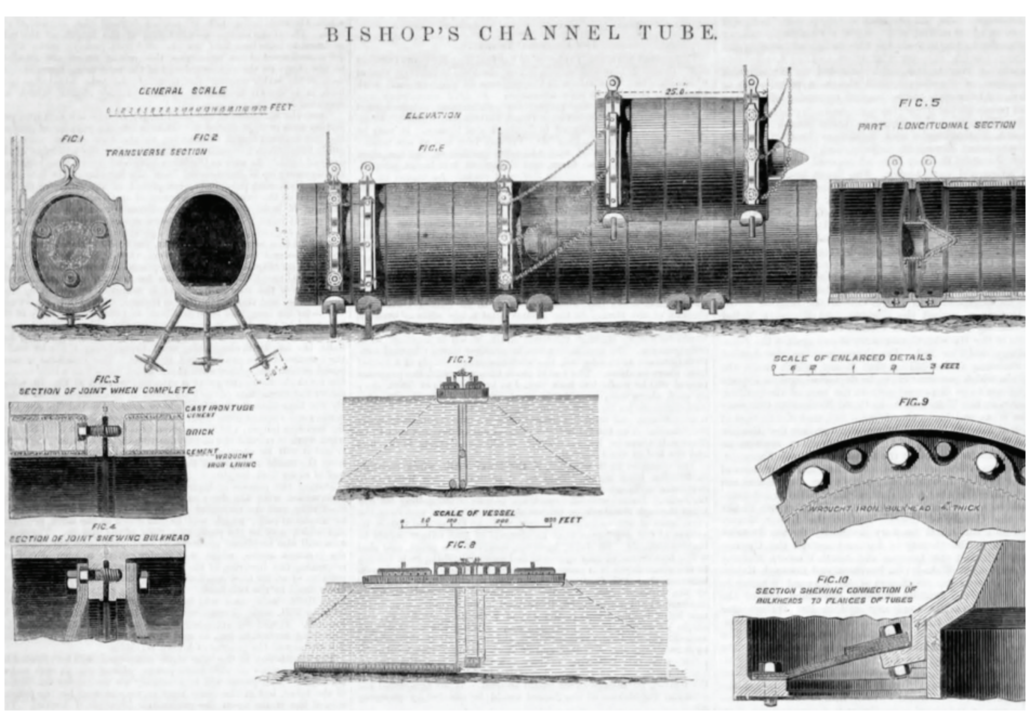
This line was chosen to take the tunnel entirely through the lower chalk, assumed at the time to be homogenous. Although undoubtedly a serious challenge, it was certainly one that was technically possible, according to *The Engineer*.

> "There is now ample means in the way of tunneling machinery and ample experience in its extensive use"
>
> The Engineer

"For the execution of the work, as far as mechanical aid is concerned, there need be no apprehension, there now being ample means in the way of tunneling machinery, and ample experience in its extensive use.

"The tunnel will be a single one of circular or of the ordinary tunnel section, the chalk boring being 36ft in diameter at the arch springing, and when lined with brickwork in cement it will have an interior diameter of 30ft."

We, of course, know now that Brunlees and Hawkshaw's particular endeavour would never be attempted, and the Channel Tunnel would not be completed until over a century later.



Looking at some of the plans for early ideas to bridge the gap between Britain and mainland Europe

Jan 1880 Electric light

A substantial dose of finely honed scorn greets the arrival of Edison's latest electric light

A certain formality is often the hallmark of articles in the Victorian editions of *The Engineer*; but in the case of the US inventor Thomas Alva Edison, that formality gives way to a finely honed scorn. Edison, along with many others, had for some years been trying to develop a practical electric light, and our predecessors were reacting to a report in *The New York Herald* that he had finally succeeded.

It's fair to say that they were not persuaded.

The article is headed "Mr Edison's latest electric light" and you can almost hear the weariness in the word "latest". It starts by recalling a Charles Dickens character, who when asked their opinion of another replies that "I don't believe there is such a person". *The Engineer* said that when it comes to the description of Edison by *The New York Herald*, it does not believe that such a person exists, and added that it is surprised that Edison allows the claims attributed to him to be published. "We refuse to believe the latter gentleman [Edison] can hold himself responsible for the sayings and doings of his prototype," it said.

The difficulty that Edison and all the other electric light pioneers had been experiencing was to find a suitable material to form the filament of an electric lamp that would glow reliably when heated by electric current but would not disintegrate. The electric lamp described in the *Herald* article, it seems, used a filament of carbon inside an evacuated glass bulb, something that had already been tried unsuccessfully. In fact, *The Engineer* quotes JW (Joseph) Swan, in later years co-credited with Edison as the inventor of incandescent electric light, who stated in *Nature* in January 1880 that he had tried a horseshoe-shaped carbon filament 15 years previously, and had failed. The *Herald* claimed that Edison had told it he had made a filament from compressed lampblack mixed with tar, which he had been rolling between his fingers while contemplating the problem. He tried this in his prototype lamp apparatus, and the result, although not completely successful, was better than he expected. This led him to try other textures of carbon that he had not previously tested, and he found that a filament made from the charred carbon remnant of a short length of cotton thread proved to be successful.

The Engineer was sceptical. "It is neither more nor less than an incandescent lamp," it said. "Such lamps have been invented and made already by the hundred, and they have failed." The length would not be able to burn continuously for at least four or five hours a night for half a year, it predicted. "It is a pretty toy and nothing more."

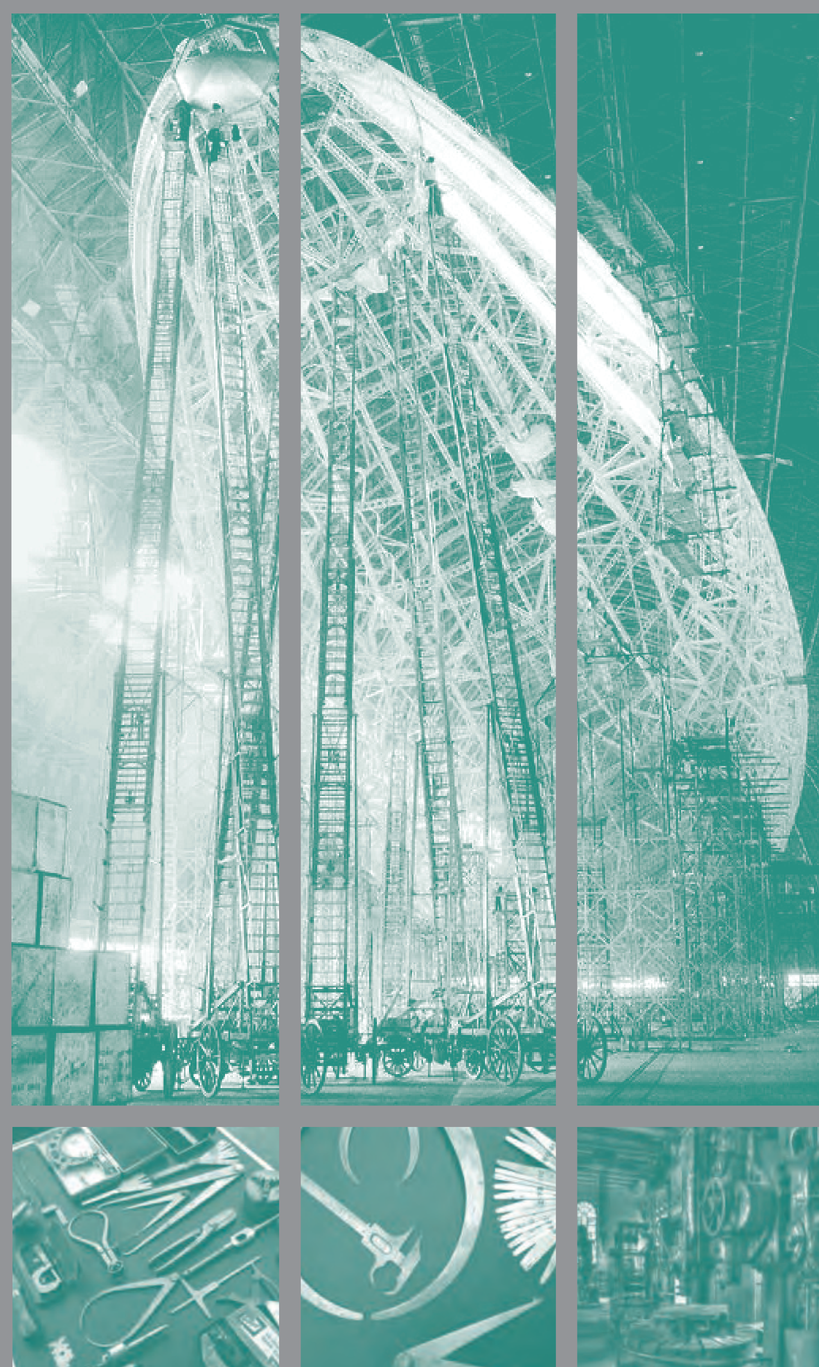
Some of the claims made for the lamp were "glaringly absurd", it added. Particular scorn is poured on the claim the lamp could be made for 25 cents, or one shilling as it was at the time in Britain. "Is it credible," it asks, "that glass globes can be exhausted of air to the millionth of an atmosphere for one shilling?" Moreover, it noted, the filament was held in place with clamps made of platinum, and no other metal would do. "How much platinum wire do the readers of *The New York Herald* imagine can be got for one shilling? And what kind of skilled labour will be required to make such a thing? The notion that such a refined mathematical instrument could be made for one shilling is simply preposterous."

With hindsight we can see that the journal was quite right to be sceptical. The version of the electric lamp described by the *Herald* was not the final article; Edison eventually settled on carbon derived from bamboo, which again he claimed to have stumbled upon, this time while examining fibres from a bamboo fishing-rod. He patented this bulb and marketed it throughout the US, while Swan retained the UK rights and it was 1,200 of his bulbs that lit the world's first public building equipped with electric light, London's Savoy Theatre.

Swan had also tried many different substances, including carbonised hairs from his beard. Later, he discovered a process for squeezing nitro-cellulose through holes to form a conducting cellulose filament. When Edison and Swan formed a joint-venture in 1883 to manufacture and market lightbulbs, it was this cellulose filament that was used. In later years, the 'Ediswan' factory at Ponders End, North London, became a centre for the manufacture of thermionic valves and cathode-ray tubes.

> "Such lamps have been invented and made already by the hundred, and they have failed. It is a pretty toy and nothing more"
> The Engineer

> Edison, along with many others, had for some years been trying to develop a practical electrical light



October 1885

The Forth rail bridge

A structure that has become shorthand for a job without end

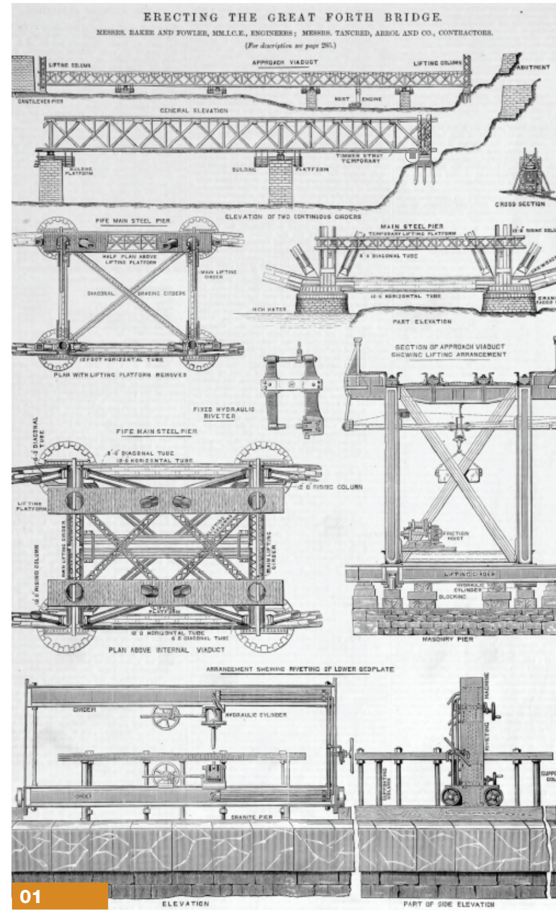
Almost 130 years after it was built it remains one of the UK's engineering marvels. Stretching just over 2km (1.5 miles) and rising 46m above the high tides of the Firth of Forth, its scale is such a headache for those charged with repainting it that it has become shorthand for any job without end. It is, of course, the Forth rail bridge.

Determined not to see a repeat of the Tay Bridge disaster of 1879, no expense was spared in the construction, which cost around £3m. It's a chastening reminder of the conditions endured by Victorian engineers that the project carried a high human cost, with more than 60 workers losing their lives. Many more became seriously ill after suffering the effects of 'Caisson disease', today known as the bends, brought on when they left the compressed atmosphere of watertight structures, called caissons, used to construct the bridge's foundations.

Reporting on the early stages of the bridge's construction, *The Engineer* barely hints at these problems, writing, with characteristic Victorian understatement: "The difficulties met with in preparing for and founding the piers of the Forth bridge have been neither few nor unimportant, and it's patent to even the uninitiated that causes for anxiety will neither disappear nor diminish until the steel superstructure has been completed."

The article, the first in a number about the design of the bridge, goes on to concern itself primarily with the installation of the first part of this superstructure: the lower bed plates. "The whole plate is bolted on a number of short iron columns in situ and is riveted up by a special hydraulic machine. Two girders are employed, one above and one below the bed plate… on each girder slides a hydraulic cylinder, one having a more effective area than the other… the result is that when water is admitted the total pressure on one is greater than on the other, thereby holding the rivet head firmly in place."

In a later article, the magazine reports on the numerous other challenges that left us with such an enduring icon of the Industrial Revolution.



01

November 1887

The writing telegraph

Taking a look at one of the early forerunners of email

01 Getting to grips with the details of the Forth rail bridge

02 The writing telegraph meant a written record of conversations could be made

A lack of written records from telephone calls led to an invention that allowed handwriting to be sent down the wires.

An early forerunner of email – or perhaps that emblematically defunct piece of office equipment, the fax machine – the 'writing telegraph' was invented as a response to a perceived problem with telephones: the lack of a written record of a conversation. The device worked by encoding the movement of a stylus at the transmitting station into electrical pulses and sending these pulses via the telegraph cable to the receiving station, where an arrangement of magnets forces a similar stylus to perform the same movements. Both styluses were in fact pens, writing onto a paper tape that moved underneath them at a steady speed – so a written message at one end would be reproduced perfectly at the other.

The inner workings of this device were in fact rather ingenious. The transmitter pen's movements were transmitted via mechanical linkages (via a float sitting in a cup of viscous glycerine, to damp out any jerkiness of the user's hands) to two series of thin carbon discs set at right angles to each other and housed in a hard rubber, and placed 'in circuit' with the telegraph wire itself. Moving the stylus caused 'pressure points' to press on the series of discs, which reduced the electrical resistance in the circuit by an amount proportional to how far the stylus had been moved.

At the other end, the receiver contained a pair of electromagnets placed in a similar configuration to the stacks of carbon discs. "When the stylus of the transmitter is pulled to the right its pressure point presses on the left and right carbon discs, the resistance in the circuits is reduced and an increased current is sent into the corresponding magnets of the receiver, which pulls the receiving rod to the right in accordance with the strength of the current," *The Engineer*'s correspondent explained.

If the movement of the receiving stylus was curved, then the up-down and left-right components of the movement are automatically picked up by the perpendicular carbon disc stacks and transmitted, resulting in a similar curved movement of the receiving rod.

02

1870s–1880s

July 1884 Panama Canal

The Engineer reports on some slow and sometimes lethal progress towards the canal's 1914 opening

Our report on the machines used to create one of the modern engineering wonders of the world included hints at some of the terrible troubles it would go on to face.

When the Panama Canal was opened in 1914, it revolutionised world trade, allowing ships for the first time to travel from the Atlantic Ocean to the Pacific without making the long and treacherous voyage around Cape Horn. Today, around 13,000 vessels use the 50-mile (80km) passage every year, serving 144 maritime routes used by ships from 160 countries and 1,700 ports worldwide.

But the canal's genesis was an incredibly slow, arduous and, for many people, lethal process that was nearly never completed. Construction began in 1881 by a French-led international company, headed by the former diplomat and developer of the Suez Canal in Egypt, Ferdinand de Lesseps. Three years later, *The Engineer* published a report on the machines being used to dig the channel that gives some indication of the scale of the challenge.

Portions of the canal works accessible by water were dug using steam dredging machines, but inland the process relied on excavators to open and then enlarge the trench, the latter type of which were essentially mechanical systems of buckets on chains. Although these appear quite primitive compared to today's excavation equipment, they included what *The Engineer* called at the time "a very ingenious arrangement" for emptying the buckets once they reached the top of the chain.

Because the machine was essentially scraping earth from the side of the trench with buckets on the underside of the conveyor arm, simply allowing it to empty as it turned over the top of the device would just have poured the rubble back into the hole. To solve this problem, the buckets were attached in such a way that once they began turning around the top cam wheel they opened at the bottom into a 'shoot' that carried the earth away.

It was estimated that 80 of these kinds of excavators could remove around 8m-9m cubic metres of earth per annum (although only 40 were operating at the time). However, despite *The Engineer*'s delight at the engineering of these machines, the report also noted that there were already rumblings of discontent with the canal's progress that hint at the problems it would face.

"There is but too much reason to fear that the works are not progressing as satisfactorily as is desirable," the report said. "M. de Lesseps states that the Panama Company will complete the work it has undertaken without the assistance of any government and that up to the present time nothing has occurred to justify the assumption that the canal will not be finished by the anticipated time, viz., 1888."

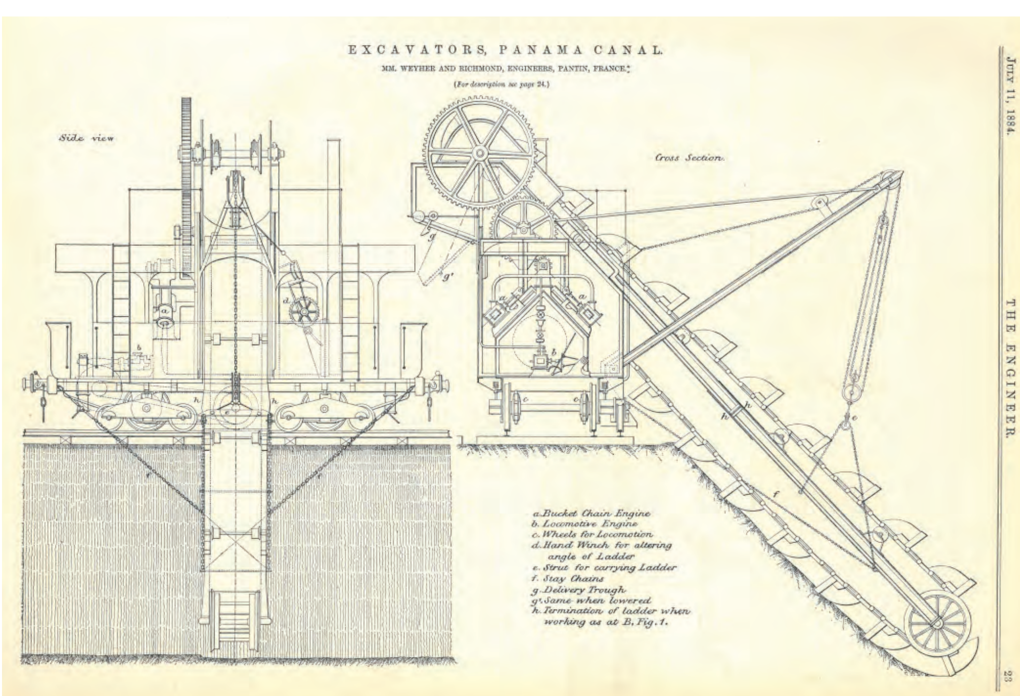
It was estimated that 80 excavators could remove around 8m-9m cubic metres of earth per annum

"There is but too much reason to fear that the canal works are not progressing as satisfactorily as is desirable"
The Engineer

The machines were described as resembling those used to dig the Suez Canal. And de Lesseps' plan was to build a sea-level channel similar to the one he had created in Egypt. However, rather than digging through a flat patch of sand in the desert, the new project involved cutting through much more difficult and varied terrain.

Landslides due to heavy rains proved to be a frequent problem and the tropical climate made progress even more difficult for the recruited labourers and engineers, not least because of the extensive impact of mosquito-borne diseases that killed thousands. Those employees that survived often didn't stick around for long.

The report also gave some hints of these difficulties in a horribly racist account of the use of black labourers: "The severe climate has prevented the employment of as many men as could be worked advantageously, and has forced the company to substitute black for white labour. Although the sanitary regulations are enforced as rigorously as possible, it is not in the power of any company to make a negro — such as are found upon the isthmus — obey rules which he will not understand, and which interfere with his present comfort."



1870s–1880s

Sept 1889

World's largest ship

The Engineer reserves some very special acclaim for RMS *Oceanic* and the provision it made for smokers

Giant ships were a staple of the late 19th century *The Engineer* but it reserved special acclaim for RMS *Oceanic*, which at 705ft long and 17,272 tons, was for a time, the largest ship in the world.

Built in Glasgow by Harland and Wolf, and designed by Thomas Ismay – founder of the White Star Line – the ship's maiden voyage saw it travel down the coast to Liverpool's Canada graving dock. *The Engineer* was there to report on its arrival.

"The presence of the *Oceanic* in the Canada graving dock – a view of which we herewith present – forms a noteworthy and unique circumstance in the annals of shipping and docks; being nothing less that the largest vessel in the world within the largest and newest graving dock in the world."

Before describing the ship, *The Engineer* marvelled briefly at the graving dock itself, which had been built to accommodate the vessel so that its vast hull could be cleaned and painted. "It is 925ft in length, has an entrance width of 94ft and its complement of 80,000 tons of water can be pumped out in one hour and 40 minutes."

The article describes the ship as "a magnificent example of shipping enterprise and acumen – a triumph of shipbuilding powers and skill, and a marvellous advance on all previous ocean, mail and passenger vessels as regards dimensions, tonnage, accommodation and outfit".

Unusually, *The Engineer* chose to focus on the interior layout of the ship rather than its design and construction (which had been covered in an earlier article) and the title's lucky reporter was clearly impressed by what he found aboard, writing that "among the first and most striking impressions obtained on going aboard is one of spaciousness and freedom of movement".

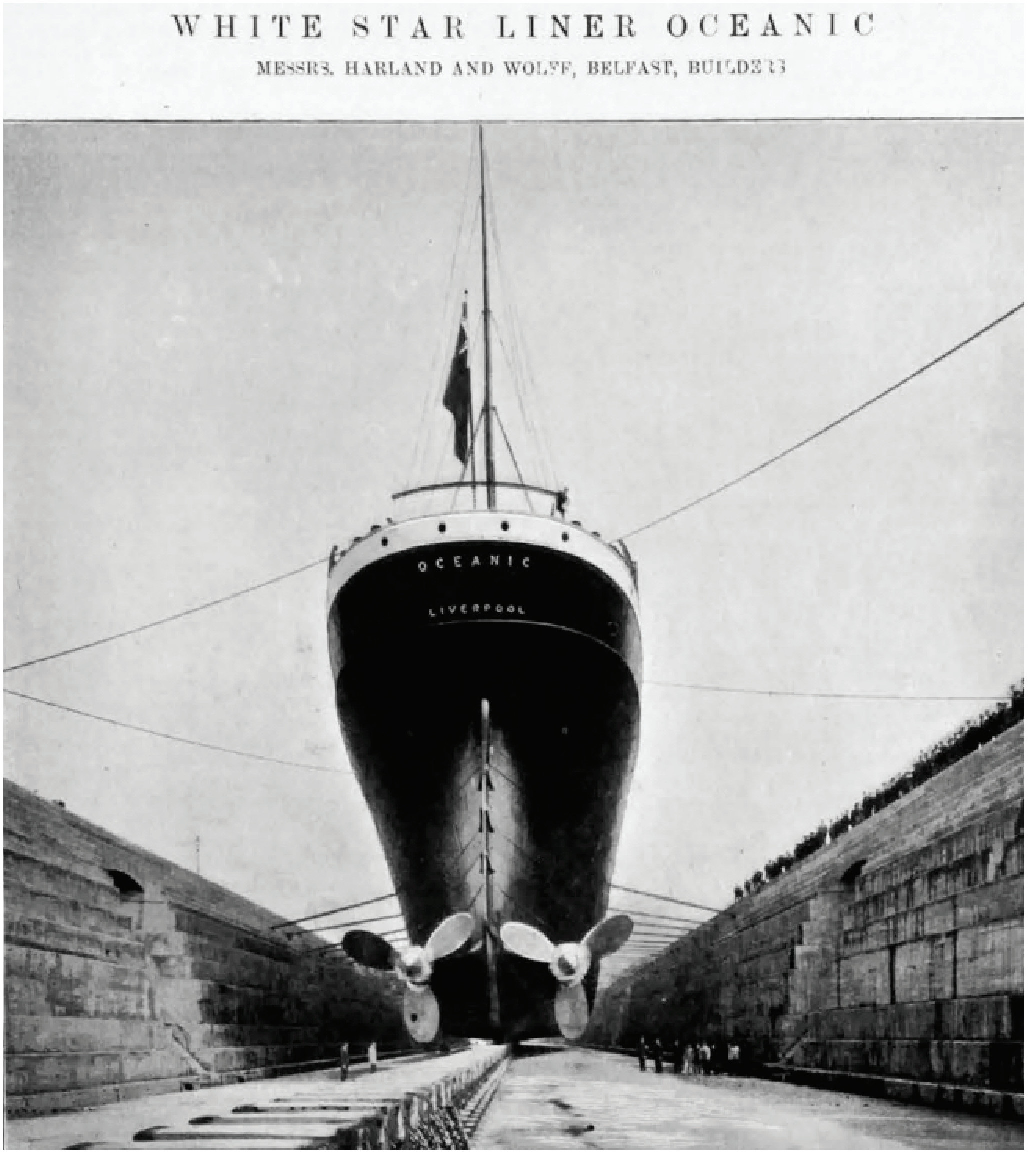
The reporter was particularly impressed by the provision made for vessel's smokers. While today's tobacco users must skulk and shiver in fenced-off outdoor areas, *Oceanic* passengers could chuff away in a dedicated suite decorated with mahogany sea-nymphs, embossed leather walls, and oil paintings representing the life of Columbus .

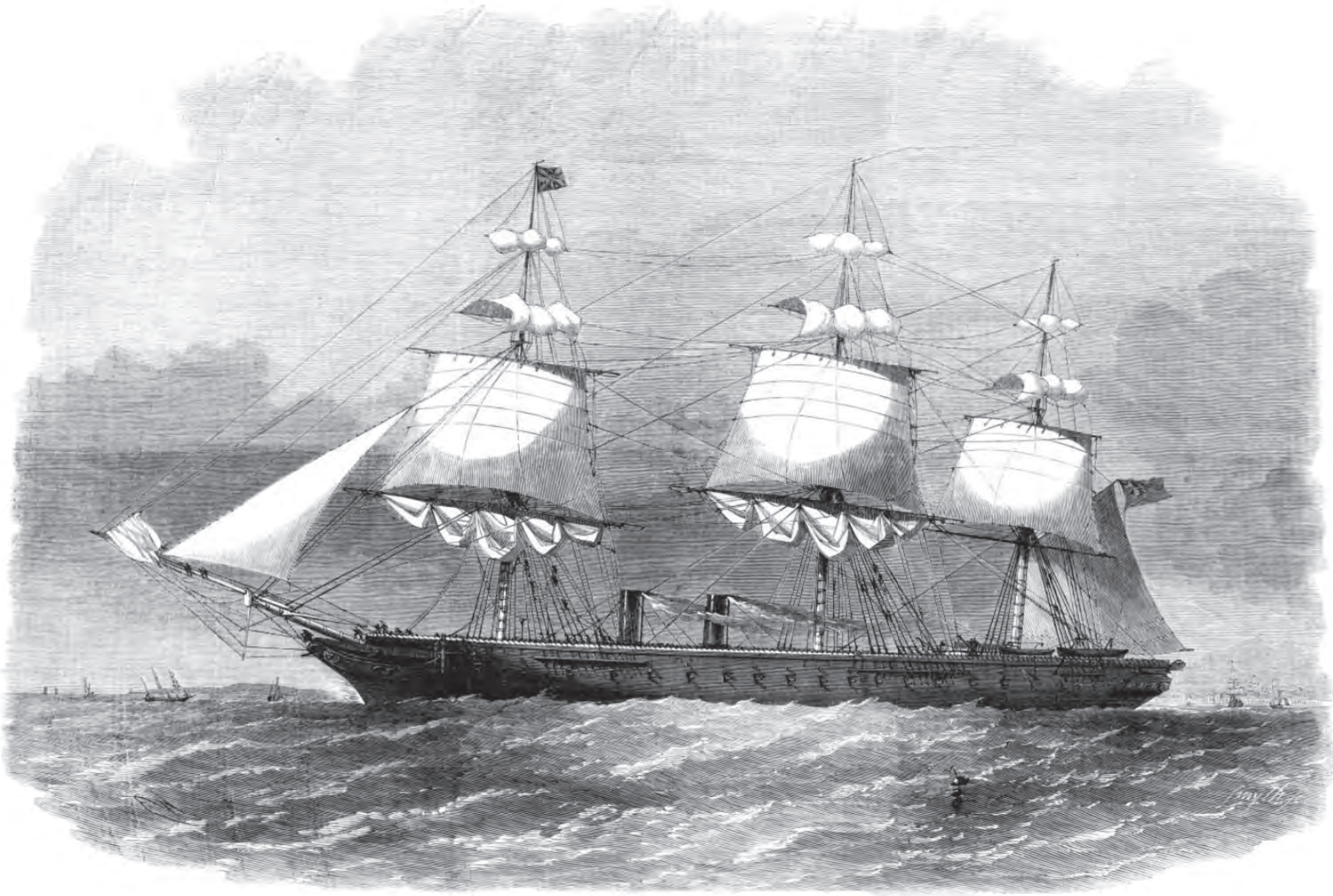
RMS *Oceanic* was commissioned into Royal Navy service as an armed merchant cruiser at the start of the First World War. Following a navigation error, the ship ran aground on the notorious Shaalds of Foula, a reef off the coast of Shetland. She was the first Allied passenger ship to be lost in the war. The last remains of the wreck were recovered in 1979.

The ship's maiden voyage saw it travel down the coast to Liverpool's graving dock

"The presence of *Oceanic* in the Canada graving dock forms a noteworthy and unique circumstance in the annals of shipping"

The Engineer





April 1902

Self-propelled war car — forerunner of the tank

Designed for defensive work on the coastal roads

One of the earliest precursors to the tank may have resembled an upturned bathtub but it impressed *The Engineer* nonetheless.

Author HG Wells had a particular reputation for predicting the future, one that was boosted by his 1903 short story 'The Land Ironclads', which anticipated the First World War by describing the use of armoured vehicles to break through fortified trenches.

But *The Engineer* featured an even earlier precursor to the tank 18 months earlier in April 1902.

The 'self-propelled war car' was designed by Frederick Richard Simms, inventor and founder of the RAC and SMMT, in 1899, and its building completed by Vickers, Sons and Maxim Limited in 1902. It was a development of Simms' earlier design for a 'motor scout', a petrol-powered quadricycle with a machine gun and front iron shield.

The war car, however, was a more robust vehicle consisting of a rectangular chassis built by the British Daimler Motor Company covered by a 28ft-long detachable metal shell that was somewhat reminiscent of an upturned bathtub. It was powered by a 16hp four-cylinder engine provided by the German Daimler company, and had a top-speed mode of nine miles an hour, although this could be increased by 25 per cent with the accelerator on.

The car was topped by two quick-firing Maxim guns and a 'pom-pom', an automatic cannon named for the sound it made when fired, and required four people to operate it, although several riflemen could also be accommodated.

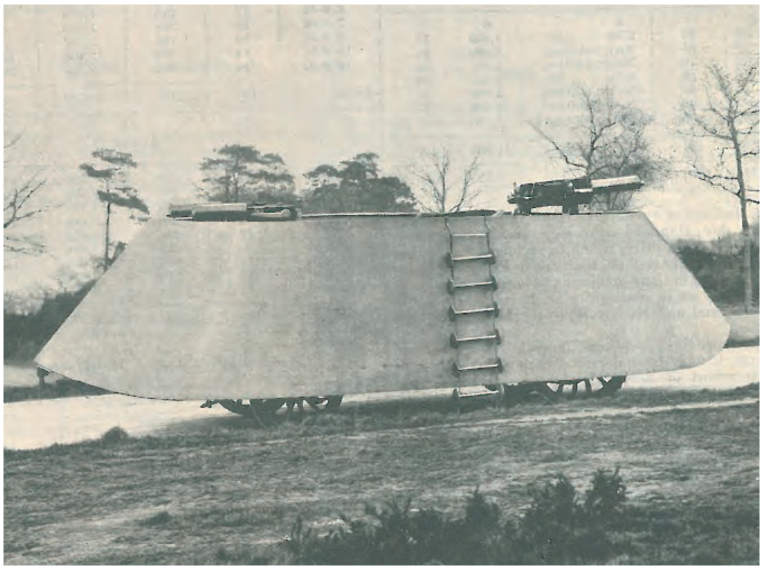
One of the innovations claimed by the car's inventors was to allow the shell a certain amount of movement on its frame when struck by projectiles, supposedly increasing its impenetrability.

The Engineer wrote that the car's principal purpose was "to act on the defensive on the coast roads of this country, but if successful in this departure there are many other obvious uses in warfare to which the car can be applied".

In what was perhaps a hint of either the more authoritarian or unstable nature of Edwardian Britain, *The Engineer* coolly added that the car might be adopted for quelling street mobs. Thankfully, it's a lot more difficult to imagine the government of today sending something that so resembled a tank out onto at least the mainland British streets to deal with rioters.

The Engineer also described the war car as "a novel appliance, the scope and utility of which may prove of far-reaching character". Unfortunately the British War Office was less enthusiastic and rejected the idea.

The war car was reminiscent of an upturned bathtub



August 1909

First passenger flight takes off from Aldershot

A flamboyant showman from the UK's early aviation history

Sometimes you have to do a little digging to discover the story behind an item in *The Engineer*. Having the benefit of hindsight, we can appreciate what an important event the world's first passenger flight was: the birth of the whole commercial aviation industry. But to our predecessors in 1909, it only merited four paragraphs, and skipped the background of possibly one of the most eccentric individuals who has ever graced our pages.

The first passenger flights — two of them — took place at Aldershot in a large biplane designed and built by Samuel Franklin Cody, an American who had been living in the UK since 1890. To call Cody an interesting chap would be an understatement. Aeronautics was his second profession: his first was Wild West showman.

Growing up in Iowa at the end of the 19th century, Cody learned to ride, shoot, train horses, use a lasso and hunt buffalo, and spent some time prospecting for gold in Alaska. He then turned to showbusiness, changed his name (he was born Franklin Cowdery) and toured the US as 'Captain Cody, King of the Cowboys', performing feats of horsemanship and sharpshooting. He later took the show to Europe, and around this time became interested in kites, competing with his adopted son to build bigger and bigger versions.

This interest eventually turned to gliders and manned aircraft, and Cody managed to convince the War Office (for whom he had worked designing Britain's first powered airship, the poetically named Nulli Secondus) to fund development of an aircraft, the Cody British Army Aeroplane No.1. This became the first heavier-than-air machine to fly in Britain, reaching 1,390ft. The aircraft was damaged on landing and, with typical foresight, the War Office decided there was no future in aeroplanes and cancelled Cody's contract, without even leaving Cody any funds to repair the flyer.

As you might expect from an ex-gold prospector and Wild West stalwart, Cody wasn't to be dissuaded and repaired the plane at his own expense. On 14 August 1909 he made two sets of flights carrying passengers, the first a Colonel JE Capper, who had worked with Cody on the airship project, and the second Cody's wife Elizabeth. *The Engineer* notes that the plane weighed almost a ton, was powered by an 80hp engine, and was prone to overheating; Cody made a few adjustments to the design over the course of the day, shifting the radiator to the back to counterbalance the weight of the passenger. The following month, Cody made the world's then longest flight, lasting an hour and three minutes.

Cody continued in the record-breaking vein, building the world's largest aeroplane, the Flying Cathedral, which finished fourth in a round-Britain air race in 1911. The end of his story is sad but probably inevitable: in 1913 he built a floatplane, and was flying it in the company of a footballer called WHB Evans when it broke up in mid-air. Both Cody and Evans were killed. Over 100,000 people turned out for Cody's funeral.

July 1909

Aviation tackles Channel crossing

Back when aircraft pilots were referred to as 'aeroplanists'

One skill that all reporters on *The Engineer* must quickly develop is an ability to understand the unique language of each engineering sector: a distinctive and often impenetrable patois of buzzwords, acronyms and confusing terminology that can render the most basic concepts incomprehensible.

But it's not always been this way. *The Engineer* archive frequently shines a light on these sectors before they had a chance to evolve their own vernacular. At the dawn of the automotive industry, before cars were cars, reporters marvelled at the 'horseless carriage'. The bicycle was – and maybe still should be – the velocipede and, as *The Engineer* article reminds us, at the very beginning of the aviation sector pilots were aeroplanists.

The article in question – from 23 July 1909 – was reporting on a recent attempt by French aviation pioneer Hubert Latham to make the first cross-channel aeroplane crossing. Latham attempted his crossing in a monoplane dubbed Antoinette IV that had been designed by French inventor Léon Levavasseur. The aircraft was equipped with a 50hp eight-cylinder petrol motor equipped with a novel cooling system that used the radiator as part of the structure of the aircraft.

"Sangatte, the French terminus of the abandoned Channel Tunnel, was chosen as the starting point, the aeroplanist intending to land at Dover," wrote *The Engineer*. "At a quarter to seven, having made all the necessary preparations, Mr Latham ascended in his machine and, after executing a wide circle round Sangatte, headed for Dover."

After travelling around eight miles, the article reports that the "machine was seen to be gradually descending in a long straight line to the surface of the water" where it eventually landed and was rescued by a torpedo boat that was following Latham's progress in the air.

Although ultimately unsuccessful, *The Engineer* wrote that "sufficient was done to demonstrate the possibility of success and the suitability of Mr Latham's type of machine for this particular purpose". What's more, Latham did at least earn the distinction of becoming the first person to land an aircraft on a body of water.

Describing the technical challenges of flying overseas, "there are, more or less always, over any large stretch of water vertical currents of air which must naturally render the condition of the problem of flight somewhat more complicated than in their absence". As for the cause of the accident, Latham put it down to the effect of salt in the air on the carburettor.

Latham made a second unsuccessful attempt a few days later, but had by then been pipped to the post by Louis Blériot, who made the first successful crossing of the channel just days after Latham's initial attempt.

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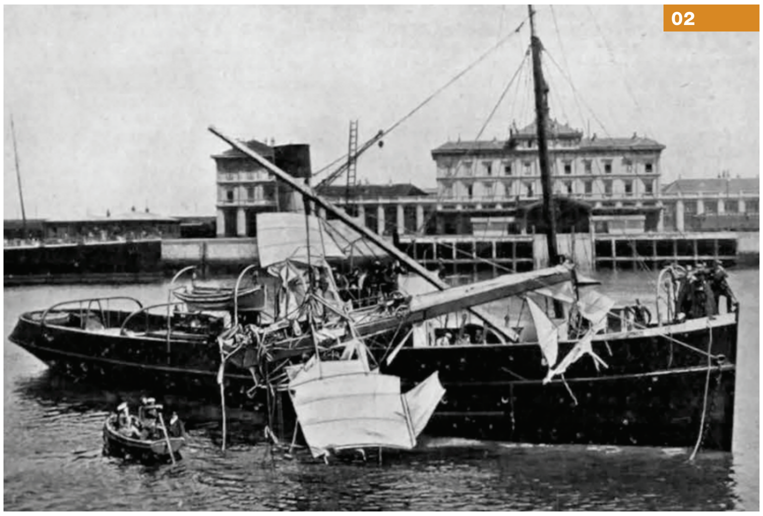

02

01 Hubert Latham takes off from Sangatte on 23 July 1909

02 The aircraft had to be fished out of the water and brought back to land

November 1895

Horseless carriage race and the birth of US motor cars

Competition gets off to shaky beginnings on the starting grid

The great horseless carriage race of 1895 set the stage for the introduction of the motor car in the US. The competition was organised by the *Times-Herald* newspaper of Chicago, it was hailed at the time as the defining race to prove the viability of mechanical transport.

But as *The Engineer* reported, the competition got off to a decidedly shaky start. It was due to run on 2 November, however, only two entries were ready to compete and a decision was taken to postpone the race until later that month.

Entrants H Mueller and CE Duryea were nevertheless determined to run on the original date and arrangements were made for the two cars to race head to head on the 92-mile road track from Chicago city to Waukegan and back.

The H Mueller entry was a four-wheel open carriage. It ran on a 3hp Benz gas engine, consuming around one pint of gasoline per hour. The rear wheels were driven from the motor shaft by a chain-and-sprocket wheel on the carriage axel.

"The Duryea motor carriage is a four-wheel buggy, seating two persons, and has ball bearings for the axles and rubber tires on the wheel," according to *The Engineer*. "The gasoline tanks carry a supply sufficient for [a 150-mile] run and can be recharged in five minutes."

H Mueller made the run in nine hours, 20 minutes, averaging a speed of 10mph, with a maximum speed of 12mph. The Duryea motor carriage, however, encountered some problems and was finally run off the road by an approaching wagon.

> "The Duryea is a four-wheel buggy"
> The Engineer

Work on a project that will stand the test of time

There is a wealth of opportunities for engineers looking for a fresh challenge across the infrastructure, aerospace, automotive, maritime and energy sectors. Here are just a few of the projects you could be working on.

INFRASTRUCTURE

Some of Europe's largest infrastructure projects are currently underway in the UK, offering a range of exciting opportunities for civil and structural engineers.

2017 is set to be a landmark year for the rail industry with significant phase 1 design and construction packages set to gather momentum for HS2. With such a large and complex project, there are a range of job opportunities available including Design Engineers, BIM/CAD Coordinators, Project Managers, Project Planners, Field Engineers, Quantity Surveyors and Commercial Managers.

The first new Crossrail passenger train services are expected to be in operation from 2017 and the project will continue to need more engineers as it reaches the final stages. Opportunities on this project include Site Managers, Quantity Surveyors, Project Managers, Field Engineers, Project Planners, Quality Assurance and HSQE.

If you'd like to find out more about working on the latest rail projects, please contact our rail team.
rail-engineer@matchtech.com

AUTOMOTIVE

The UK automotive industry is bucking the trend across Europe by achieving record growth, creating thousands of jobs and attracting major inward investment. Companies like Tesla are investing heavily to ramp up production. Recent reports estimate the firm is aiming to make as many as 1m a year by 2020. The London Taxi Company is set to launch its first electrically powered black cab in 2017, ahead of Transport for London legislation that all new taxis must be 'zero-emission capable'.

With a booming market there are many opportunities available for Electrical Leads, Design Engineers and Managers looking to drive through innovation in the industry. Whilst these opportunities are predominantly in the UK, there are also some available in other European locations such as Germany and Slovakia.

To find out more about working on the latest automotive projects, please contact our automotive team.
automotive-engineer@matchtech.com

AEROSPACE

The aviation industry is entering an exciting phase. Aircraft are being re-engineered and upgraded and the race is on to produce newer, faster, quieter and more fuel efficient aircraft. Aerospace companies across the world are looking for engineers who can drive innovation in the industry.

With such strong competition, large projects are driving a range of job opportunities across airframe, systems and interiors including Design Engineers and Manufacturing Engineers. Working on these projects, you will get the chance to shape the use of game changing materials, and design and manufacturing methods.

Contact our aerospace team to find out more about jobs within the latest aerospace projects.
aerospace-engineer@matchtech.com

MARITIME

There is a strong demand for maritime professionals, not just in the UK but around the world.

There are numerous opportunities available for people looking to work at shipyards overseas. In Canada, the National Shipbuilding Strategy has increased the demand for maritime professionals including Ship Managers and Production Supervisors to help build the country's shipbuilding future over the next two decades.

If you'd like to find out more about opportunities within the latest maritime projects, please contact our maritime team.
maritime-engineer@matchtech.com

ENERGY

Hinkley Point C is a flagship Nuclear project in the UK that is going to kick start a generation of new build nuclear energy projects. At the peak of its construction, there will be 25,000 workers on site.

As the UK has not built a nuclear power station for over 20 years, the consultancies and contractors responsible for hiring for the project will be looking to attract candidates who have worked across other sectors, to make up for a shortfall in nuclear talent. Engineers will be required to work across the complete project lifecycle and mechanical, electrical, civil and structural engineers will be particularly sought after.

If you'd like to find out more about working on an energy project like this, please contact our energy team.
energy-engineer@matchtech.com

May 1915 Gretna rail disaster

The Engineer counts the cost of one of the most devastating train crashes in the UK's history

On 22 May 1915, five separate trains were involved in a devastating crash at the Quintinshill signal box near Gretna Green in Dumfriesshire, Scotland.

The collisions and subsequent fire resulted in the loss of at least 226 lives, although a definitive number of victims has never been subsequently established.

"The Gretna disaster establishes a record in that it is the greatest railway accident since communication by rail was established," *The Engineer* wrote in the days following the disaster. "There has never been anything like it as regards numbers of casualties in this country or the United States, the total in this accident alone being as many as those killed in the United Kingdom during the last 10 years."

The Quintinshill signal box overlooked the Caledonian Main Line linking Glasgow and Carlisle, now part of the West Coast Main Line. As well as northbound and southbound tracks, passing loops for both main lines were also situated at this point. On the morning of the crash, both loops were occupied; the southbound loop with an empty coal wagon, the northbound with a goods train that had left Carlisle at 04.50.

Just before 06.30, a local train travelling north from Carlisle was shunted across to the southbound line in order to allow a London to Glasgow sleeper express to overtake it. Although not an ideal manoeuvre, this wasn't considered a dangerous thing to do so long as proper procedures were observed. Unfortunately, a personnel change at the signal box – compounded with a litany of rule breaches – led to a southbound troop train being given the all-clear to proceed, despite the section of track being occupied by the stationary local train.

The resulting crash officially claimed the lives of 215 soldiers, mainly from the Leith Battalion of the Royal Scots headed for Gallipoli: "Added to the prominence given to this disaster by the number of victims and the manner in which they were killed, there is the pathetic fact of over 200 gallant Scottish Territorials, who were on their way to fight for their King and country, in which work they were willing to lay down their lives."

With the roll-list of the regiment destroyed in the ensuing fire, the precise number of casualties could never be confirmed with confidence. It's believed that the majority of deaths occurred not from the initial collision, but when the Glasgow-bound express for which the local train had been shunted came hurtling into the wreckage just a minute later.

"The first collision must have killed many in the troop train," wrote our predecessors, "but the greater number were, we think, killed by the down (northbound) express – not only as a consequence of its running into the debris, but because those who alighted from the troop train on the 'off' side were caught like rats in a trap on the down loop."

Alongside the dead soldiers were three railway employees and at least nine passengers, including four victims believed to be children but whose bodies were never identified or claimed. The cause of the incident was found to be neglect of the rules by the two signalmen, and both were subsequently charged with manslaughter in England, then convicted of the equivalent charge of culpable homicide after trial in Scotland.

Perhaps the most damning fact to emerge from the entire incident was this: despite all the confusion of the occupied loops, the shunted train, and the shift change (which were by no means extraordinary circumstances), the signalman who gave the green light to the troop train had an unobstructed view just yards away of the stationary local train that occupied the tracks. According to this publication, simple measures could have been taken to avoid this fundamental human error.

> "In conclusion, there is a remedy against such oversight as happened in this case and that is to track-circuit the lines"
> The Engineer

"We may say, in conclusion, that there is a remedy against such oversight as happened in this case, and that is to track-circuit the lines. Had the up line been track-circuited, the signal for the troop train could not have been lowered. Such safeguards are, however, only used in places where a signalman's view is indifferent. In this case the view could not be improved."

Events at Gretna Green led to the loss of at least 226 lives

April 1923

Wembley Stadium

Setting the scene for a host of football and musical triumphs

The building of the original Wembley Stadium was a feat of – literally – military precision, including formation marching. It was also unthinkably fast by today's standards.

People have many fond memories of the old Wembley Stadium. As well as being an iconic building in and of itself, it was the scene of many football triumphs and celebrations in various cup finals down the years; and has also been the venue for many famous concerts, including an epoch-defining Live Aid concert in 1985.

The old stadium is gone now, of course; the iconic Twin Towers ground into rubble, the gents' toilets unlamented by anyone with a sense of smell. The demise of the burger concessions have probably improved the average cardiac health of the nation. But the old Wembley was also a prodigious feat of engineering, which *The Engineer* featured across a five-page feature in 1923.

What's particularly remarkable, considering the four-year duration of the construction project for the new stadium, is how fast it was. The ground for the original stadium was cleared in February 1922 – a considerable project in itself, with over 120,000 cubic yards of clay removed to level the site – and it took less than a year to complete the building of the stadium itself: the project was expedited, the feature said, so that the stadium could host the 1923 FA Cup final. (Bolton Wanderers beat West Ham 2-0, but the final is better remembered for a policeman mounted on a white horse who helped to control a 300,000-strong crowd, many of whom were standing around the perimeter of the pitch.)

The feature is particularly strong on the tests the stadium was put through. "A body of labourers… numbering, we are given to understand, 1,280, was first of all drawn up outside the building and then marched in, in companies, and led to the banks of seats immediately behind the Royal Box… It was quite obvious that the majority of these men had seen service in the war, for otherwise we do not believe it would have been possible for them to act in unison with such wonderful precision," the article said.

These workers "were put through a series of movements" by the resident architect, Captain FB Ellison (no doubt utilising his own military experience), including standing up, sitting down, swaying from side to side and backwards and forwards, marking time at the double, and jumping up and down while shouting and waving their arms. This was repeated at various places around the stadium. "Finally, gangs of the men were ordered to run up and down several flights of the steps," it said. As much a test for the builders as for the stadium, we imagine; you'd be hard-pressed to find 1,280 builders who could do that today.

The article noted that the stadium contained 1,400 tones of structural steel; half-a-million rivets; 600 tons of steel rods for reinforcing 25,000 tons of concrete; and 14 miles of concrete beams to form the terracing.

February 1924

Sydney Harbour Bridge

Iconic man-made structure gets the most cursory of welcomes

Its status as one of the world's most iconic man-made structures is undisputed, but the decision to give the green light to the North Shore Bridge, as it was known, warranted the briefest mention on the pages of *The Engineer*.

"We learn that Mr Bradfield, engineer to the state of New South Wales, has recommended the Australian government to accept the tender of Dorman, Long and Co for the construction of the North Shore Bridge at Sydney."

Opened in 1932, the steel arch bridge carried rail, vehicular and pedestrian traffic between the Sydney central business district and the North Shore. Until 1967 it was the city's tallest structure and, according to Guinness World Records, it is the world's widest long-span bridge and tallest steel arch bridge, measuring 134m from top to water level.

Designed to carry six lanes of road traffic, two railway tracks and a footpath on each side, the 48.8m-wide structure was indeed designed and built by Dorman, Long and Co. Based in Middlesbrough, this UK company apparently came up with the most attractive bid for the contract: "The total estimated cost of the bridge was approximately £6,000,000 and it is calculated that 35,000 tons of steel will be used in its construction. According to reports we have received the price tendered by Dorman, Long and Co was £4,500,000 and that of William Arrol and Co, £5,300,000."

01 Wembley Stadium starts to take shape during construction

02 Until 1967, the Sydney Harbour Bridge was the city's tallest structure

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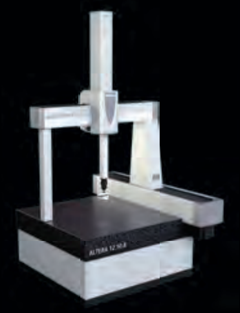

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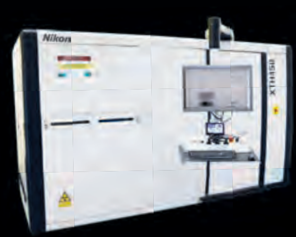

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1910s–1920s

Feb 1927 Land speed record

Scepticism was *The Engineer*'s order of the day as Blue Bird hit Pendine Sands in Wales

Bloodhound SSC, the latest attempt to break the world land speed record, is regularly featured in *The Engineer*; it's one of the highest-profile engineering projects in the UK, and its mixture of high technology and derring-do makes it fascinating for many people.

The same wasn't true in 1927, when a brief news piece marked the breaking of the land speed record by Malcolm Campbell, then a captain in the Royal Flying Corps – a parallel with current record holder and Bloodhound driver Andy Green, who is an RAF wing commander.

Campbell broke the record in the second car to bear the name Blue Bird at Pendine Sands in Wales, and broke the 150mph barrier, hitting 174.883mph on the Flying Kilometre and 174.224 on the Flying Mile.

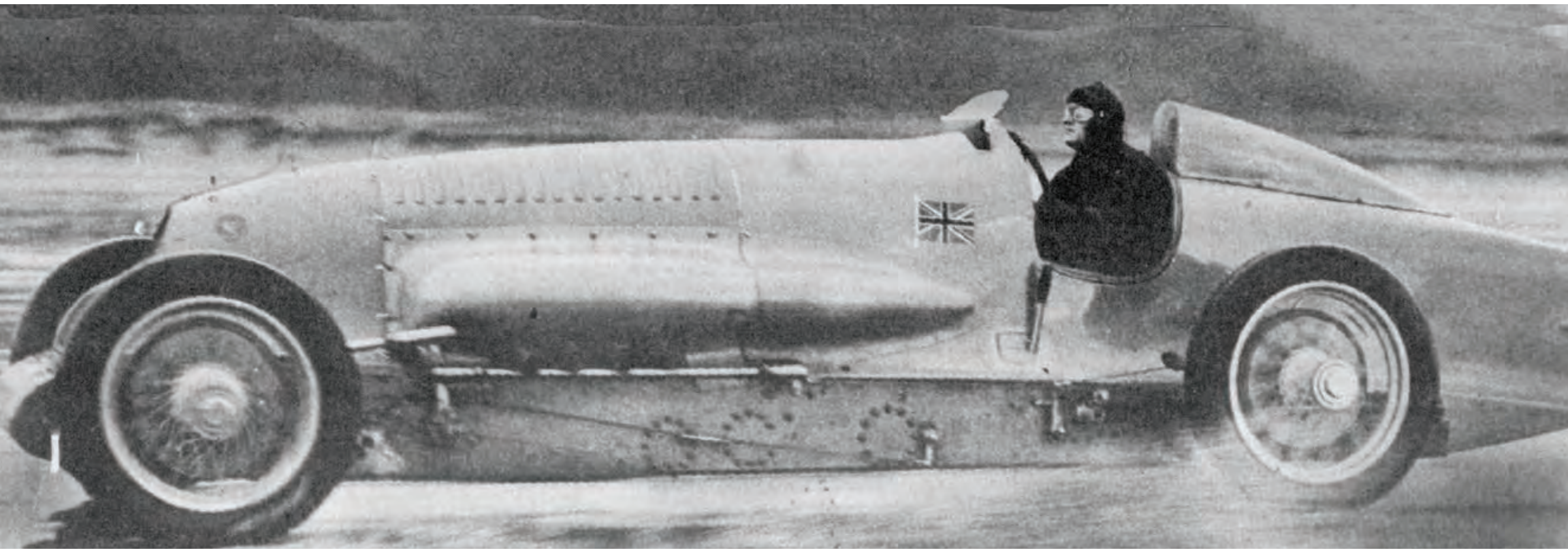
In another Bloodhound parallel, this Blue Bird was driven by an aircraft engine; in this case a Napier Lion 12-cylinder, with the cylinders arranged in three banks of four in a 'broad arrow' configuration: this produced 450bhp, which is 100hp less than the Jaguar supercharged V8 that Bloodhound is using to pump oxidiser into its hybrid rocket motor; it positively pales beside Bloodhound's aero engine, a Rolls-Royce EJ200 turbojet.

The Engineer was surprisingly sniffy about Campbell's achievement. "While we admit that the speed achieved is remarkable for a machine travelling on wheels, we are not disposed to feel undue enthusiasm for the fact that it is claimed to be a record," the journal said. The uncertainty was due to a lack of information about the timing method used. No stopwatch could measure to the accuracy claimed, *The Engineer* added: even the first decimal place was dubious, as stopwatches of the time measured to a fifth of a second, and only when the sweeping hand was exactly on a division was the time accurate. "A stopwatch capable of being read to the thousandth part of a second would require to have a balance wheel making a thousand oscillations per second" rather than the five oscillations made by the best stopwatches. "Captain Campbell's feat consists of doing the mile in 0.436 seconds faster" than the previous record holder, John Godfrey Parry-Thomas, the article said. "That figure speaks for itself, as regards both the achievement and the accuracy [that] is required."

Parry-Thomas tragically died trying to retake the record: a month after Campbell's run he tried again at Pendine, but his car, named 'Babs', crashed and caught fire. Campbell himself was a rarity among speed record specialists of the time: he died of natural causes, in 1948, after breaking land and water speed records in a succession of Bluebird vehicles. His son, Donald, was not so lucky; after a dazzling record-breaking career on water and land he perished in an attempt on the world water speed record in the jet boat Bluebird K7 on Coniston Water in 1967.

> "While we admit the speed achieved is remarkable we are not disposed to feel undue enthusiasm for the fact that it is claimed to be a record"
> The Engineer

Captain Malcolm Campbell breaks the land speed record by breaching the 150mph barrier in Blue Bird on Pendine Sands in Wales



1930s–1940s

Oct 1945 Whittle engine

Sir Frank Whittle, inventor of the jet propulsion gas turbine, presents his ideas to *The Engineer*

By the age of 21 Sir Frank Whittle had conceived a technology that would transform military and civil aviation in a way that has remained largely unchallenged for 75 years.

It should go without saying that Sir Frank invented the jet propulsion gas turbine, and, in doing so, created a market that between 2014–2023 alone will require 55,000 new engines.

Some of those engines will be on the Airbus A350-1000, an aircraft coming into service next year with power being delivered by two Rolls-Royce Trent engines that will each deliver 97,000lb of thrust.

By contrast, Sir Frank's first jet propulsion gas turbine – the W1 – delivered 1,240lb of thrust, rising to 1,600lb with the development of the W2.

A remarkable element of the jet engine's story is the fact that Sir Frank was rejected twice by the RAF; an organisation that would ultimately reward him with a commission and an education.

No less remarkable was the fact that just a few months after the end of the Second World War, Air Commodore Frank Whittle, CBE, RAF, MA, Hon. MI Mech E had set about contributing a series of articles to *The Engineer* that would candidly and eloquently explain how the jet engine came into being.

"I first started thinking about this general subject in 1928, in my fourth term as a flight cadet at the RAF. College, Cranwell," he wrote. "Each term we had to write a science thesis, and in my fourth term I chose for my subject the future development of aircraft. Among other things, I discussed the possibilities of jet propulsion and of gas turbines; but it was not until 18 months later, when on an instructors' course at the Central Flying School, Wittering, that I conceived the idea of using a gas turbine for jet propulsion. I applied for my first patent in January 1930."

The idea was submitted to the now defunct Air Ministry but turned down due to perceived difficulties surrounding a gas turbine. Similarly, Sir Frank tried and failed to attract funding from a number of different sources.

"I gave up hope of ever getting the idea to the practical stage, but continued to do paperwork at intervals, until, in May 1935, when I was at Cambridge as an engineer officer taking the Tripos course, I was approached by two ex-RAF officers (Mr RD Williams and Mr JCB Tinling), who suggested that they should try to get something started," he said. "Although I had allowed the original patent to lapse through failure to pay the renewal fee, and although I regarded them as extremely optimistic, I agreed to co-operate. I thought that there was just a bare chance that something might come of it."

With Messrs Williams and Tinling on board, Sir Frank was able to come to an arrangement with investment bankers OT Falk and Partners, leading to the formation of Power Jets in 1936.

The engine itself was to be a simple jet propulsion gas turbine having a single-stage centrifugal compressor with bilateral intakes, driven by a directly coupled single-stage turbine. Combustion was to take place in a single chamber through which the working fluid passed from the compressor to the turbine.

"We were going beyond all previous engineering experience in each of the major organs," he said.

> "I gave up hope of ever getting the idea to the practical stage but continued to do the paperwork at intervals"
> Sir Frank Whittle

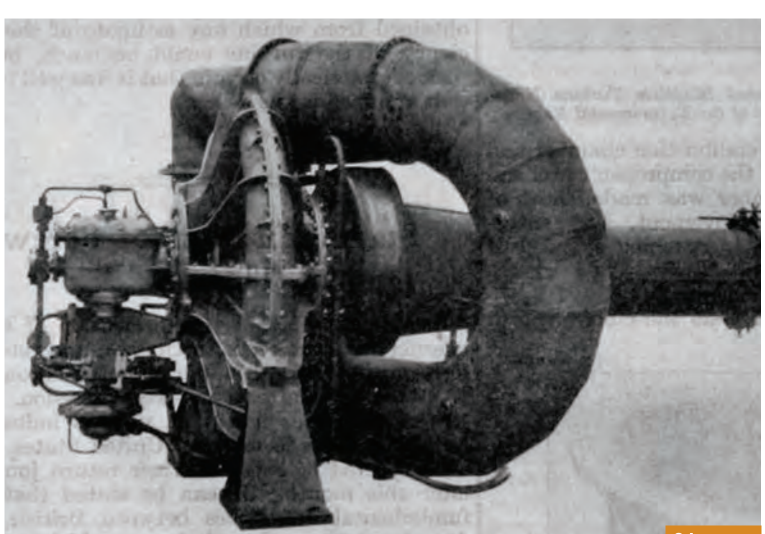
"We were aiming at a pressure ratio of about 4/1 in a single-stage centrifugal blower when at the time, so far as we knew, a ratio of 2t/1 had not been exceeded. We were aiming at a breathing capacity in proportion to size substantially greater than had previously been attempted.

"The combustion intensity we aimed to achieve was far beyond anything previously attempted. Finally, we had to get over 3,000 SHP out of a single-stage turbine wheel of about 16lin outside diameter, and to do it with high efficiency."

The engine was tested for the first time on 12 April 1937, with the initial start-up declared a success.

"But it [the engine] accelerated out of control up to about half its designed full speed," wrote Sir Frank. "This happened several times, and altogether it was a very alarming business, so much so that in the early days the individuals in the vicinity did more running than the engine."

Just shy of his 34th birthday, Sir Frank saw his invention provide power for the new Gloster E.28/39 on its maiden flight from RAF Cranwell in 1941.



01/02/03 The invention provided power for the new Gloster E.28/39 on its maiden flight

May 1937 The Hindenburg

Dramatic destruction prompts detailed coverage of this fascinating area of transportation

The destruction of the Hindenburg brought the age of the airship to a shocking close. In 1937 *The Engineer* reported on the design and construction techniques that went into making this iconic aircraft.

From the ill-fated British R101, to more recent efforts to develop large airships for military reconnaissance, *The Engineer* has long taken an interest in the engineering challenges of developing lighter-than-air vehicles.

But it is the dramatic destruction of the German Hindenburg airship in May 1937 that prompted perhaps our most detailed coverage of this fascinating area of transportation.

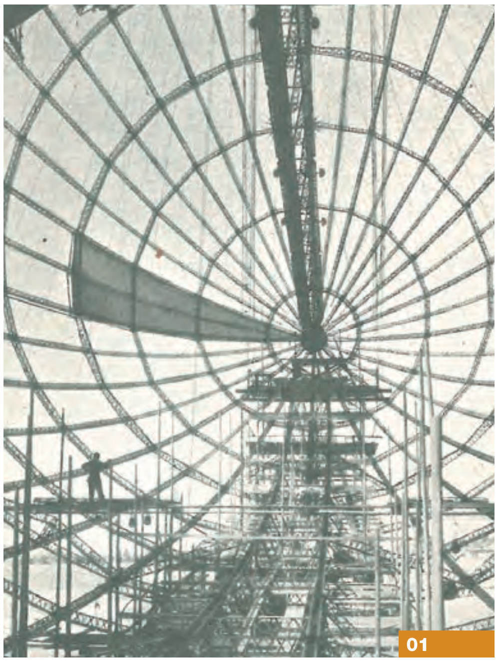
On 6 May 1937, shortly after arriving in Lakehurst, New Jersey, the Hindenburg caught fire and was destroyed while attempting to dock with its mooring mast, with 35 of 97 people on board losing their lives.

> "The loss will not stop the further perfecting of the airship design by Dr Eckener and his staff"
>
> The Engineer

There's little doubt that the accident contributed to a shattering of public confidence in airships, but *The Engineer*, which had recently returned from a trip to Germany to view the Hindenburg and its sister ship the LZ-130, clearly felt that the industry would survive one of aviation's most infamous accidents. "The loss of this fine example of lighter-than-air construction, at a time when British and American interest was again being aroused in the possibilities of a commercial North Atlantic airship service, and when the postal advantages of a two-day voyage between Frankfurt and New York were being recognised by all, will retard progress," wrote *The Engineer*, "but it will not stop the further perfecting of the design by Dr Eckener and his trained staff of workers on the building and operation of airships."

Rather than speculating on the cause of the accident (which today remains something of a mystery – different theories point to sabotage, a build-up of static electricity and a lightning strike), *The Engineer* article instead focuses on the design and construction of the huge German vessels, and is full of praise for the high engineering standards involved.

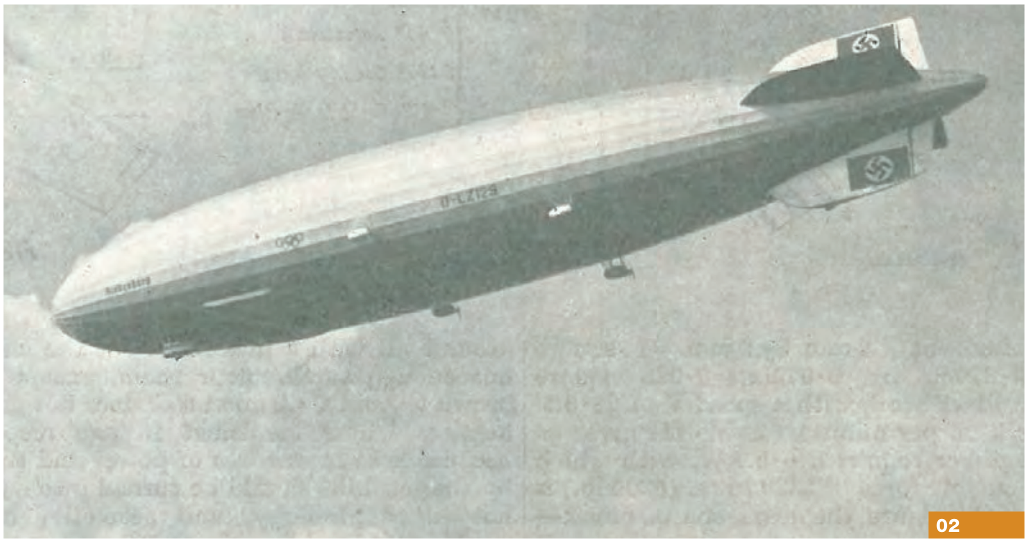
"A few weeks ago, we were afforded an opportunity of inspecting the 'LZ-130' in her shed at Friedrichshafen and also paid a visit to the Hindenburg at the Frankfurt am Main airport. We were greatly impressed by the thorough way in which the problems of design have been worked out and embodied in the construction of the new ship and the way in which the arrangement for the operation and navigation of the ships have been perfected."



01

Commenting on some detailed line drawings of the Hindenburg, *The Engineer* wrote: "As our drawings show… an outstanding feature of the new design was the separation of the control gondola, which was placed below the front of the ship, from the passenger quarters which were arranged on two decks inside the hull of the ship. By this means, more space was made available for the use of the passengers…"

In a later issue (21 May), *The Engineer* turned to the construction techniques used to build the airships, writing that "the new design incorporated the long-established Zeppelin principles of construction, which include a braced light metal girder construction, with the internal space divided by rings, forming compartments in which the cells or bags for the lifting gas are housed".



02

01/02 *The Engineer* felt that the airship would survive and prosper, despite the destruction of the Hindenburg in May 1937

August 1936

The dawn of TV broadcasting

A visit to Alexandra Palace television station in 1936

Today, London's Alexandra Palace is known around the world as the birthplace of television broadcasting – arguably one of the most disruptive innovations of the 20th century.

But, back in 1936, few could have anticipated the way in which television would come to dominate public life. And following a visit to the London television station in August of that year, *The Engineer* reported on the technology in a characteristically measured tone.

"On Sunday last we paid a visit to the Alexandra Palace," it wrote, "where a television station has been established to provide an extended trial of the systems devised by Baird Television, Ltd, and the Marconi EMI Television Company, Ltd."

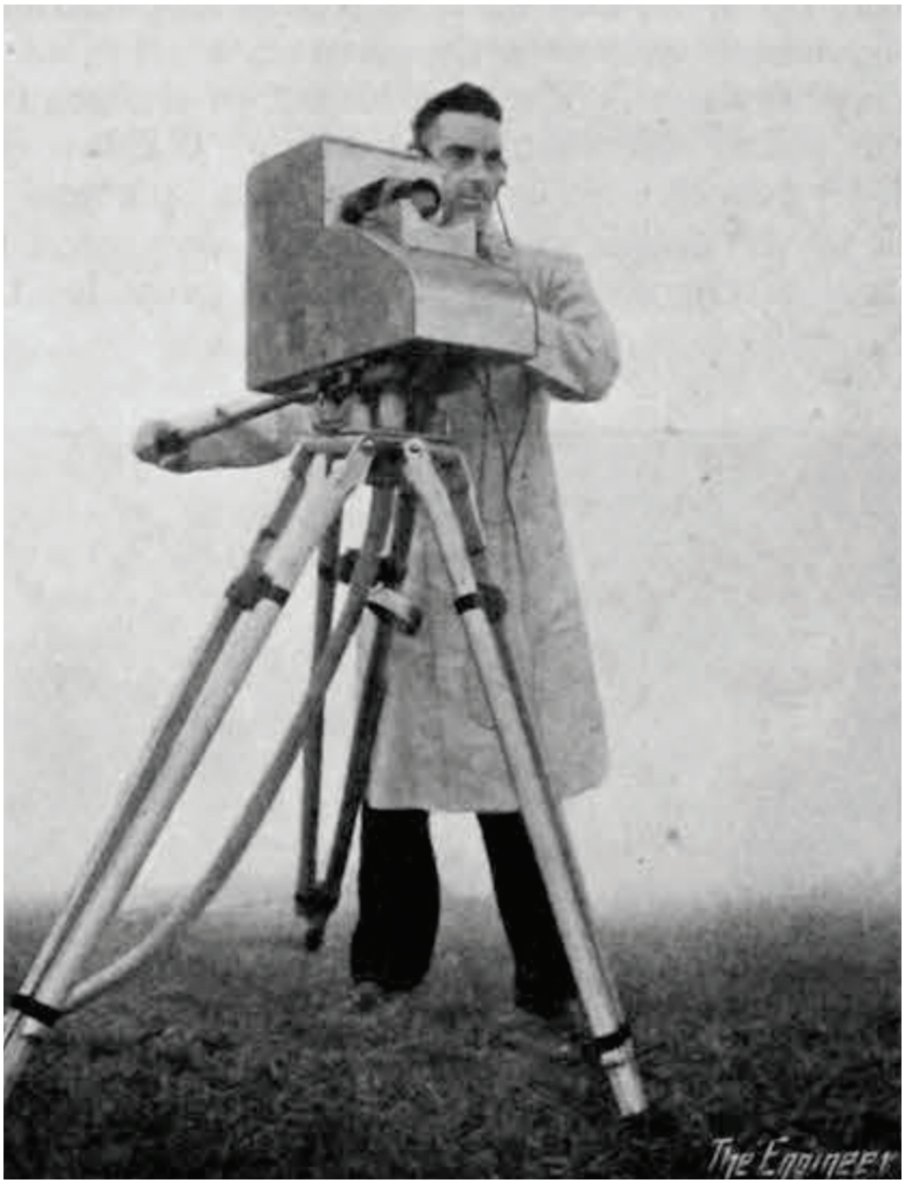
The article looks in detail at the key features of Marconi's 405-line system and John Logie Baird's 240-line system.

After a year-long trial, during which each system broadcasted on alternate weeks, Marconi-EMI's so-called "hi-definition" system was chosen. The system was suspended during the Second World War, but remained in operation in the UK until 1985.

Describing the system's operation and advantages, *The Engineer* wrote: "There are six Marconi EMI Emitron television cameras and six Emitron supply and amplification units, which feed two alternative channels to the vision transmitter. Signals from the cameras are raised from 0.002V to 2,000V. A special unit supplies to the equipment all the necessary pulses for synchronisation. The signals are first amplified in a unit built into the camera itself, and the amplified picture signals then pass by a special cable to the amplifiers in the control room."

The mast, which carried aerials for both the Marconi and Baird systems, was 300ft above the ground at its highest point.

As well as the high order of definition (405 lines), *The Engineer* report added that one of the key advantages of the Marconi system was a complete absence of flicker. "By the use of interlaced scanning, the flicker frequently is raised to 50 per second, which is well above the limit of visual perception. The vision transmitter and its associated aerial radiates a linear band width of zero cycles to 3,000,000 cycles per second, which has been made possible by the development of new methods of amplification, modulation, and aerial design."



Getting to grips with the nascent technology of television broadcasting

November 1940

The collapse of the Tacoma Narrows Bridge

An infamous engineering failure in Washington

This year marks the 75th anniversary of one of engineering's most infamous failures. The Tacoma Narrows Bridge, which briefly spanned the Puget Sound in the US state of Washington, opened in July 1940. Just five months later, the bridge was to suffer a catastrophic collapse, the iconic video footage becoming synonymous with engineering disasters.

Christened 'Galloping Gertie' by construction workers due to its vertical movement in high winds, the 1,800m-long structure had a main span of 853m. However, on 7 November, Gertie went for her final gallop. In winds of just 40mph – relatively mild for the Pacific North West – the bridge began to sway and buckle dangerously. Aerostatic fluttering caused the central span to twist and contort, with the amplitude ultimately causing the suspension cables to fail.

Although the dramatic pictures of the bridge's collapse were only to reach these shores a few weeks later, the incident still gained several column inches in *The Engineer*. One part of the report gives a definite insight into one of the underlying causes of the collapse: "The span-to-width ratio of the Tacoma Bridge at 72 may be contrasted with the comparable figure of 42 for the Golden Gate Bridge at San Francisco, itself at the time of its design considerably higher than that of any earlier bridge."

Jan 1941 Lancaster bomber

The Engineer took a detailed look at one of Britain's most iconic war planes

Like *The Engineer*, the Lancaster is celebrating a landmark, with this year marking the 75th anniversary of the aircraft's maiden flight in January 1941. The bomber would not enter active service until the following year, but by August 1942 when *The Engineer* was invited to see it in action, the Lancaster had already started to make a name for itself.

"But a few months after its completion, the 'Lancaster' has left its mark on the German landscape and its people," wrote our predecessors. "It has helped powerfully by night to batter Cologne and Essen, with bombs of the heaviest calibre. By day it carried out the epic raid led by squadron leader JD Nettleton, VC, on Augsburg, and the raids on Danzig and Flensburg.

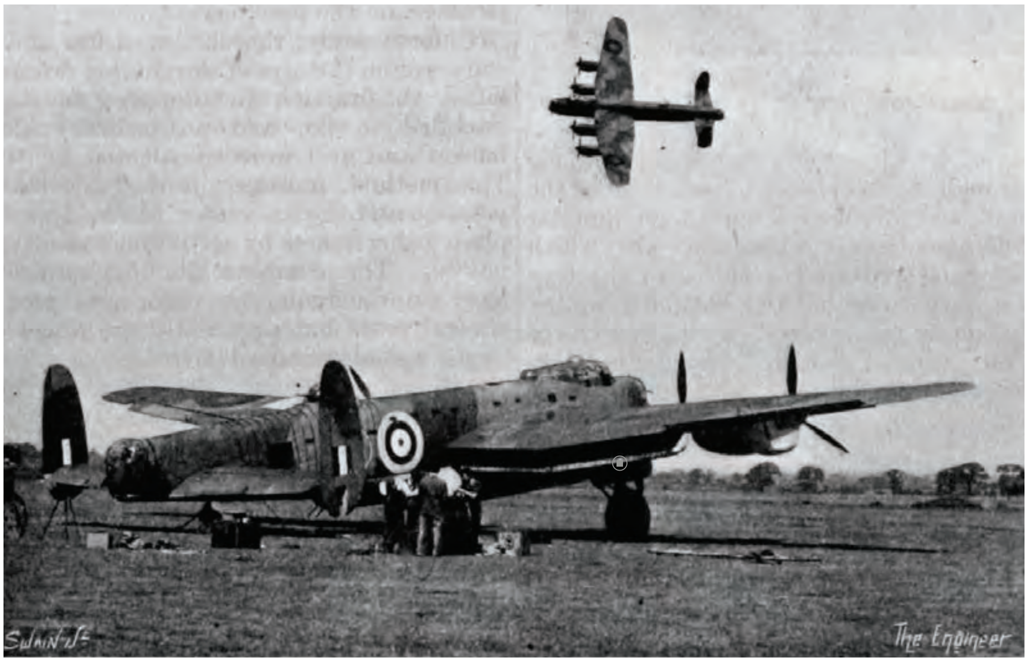
"From the initial flights and the report of the Ministry of Aircraft production testing staff, it was soon obvious that the Allied cause had now what has since been aptly styled by many pilots as a 'war winner'."

Of course, the Lancaster's most famous hour was to come in May 1943 with Operation Chastise, better known as the Dam Busters mission. Armed with Barnes Wallis's bouncing bomb, 19 of the aircraft (slightly modified) were involved in the attack on the Möhne, Edersee and Sorpe dams in Germany's Ruhr valley. The Möhne and Edersee dams were destroyed, but eight of the aircraft would not return, with 53 aircrew killed during the mission and another three taken prisoner.

While the story of the Dam Busters certainly added to the Lancaster's legend, its iconic design also won it a place in the public consciousness. Despite being "designed and built in record time" in what this magazine referred to as "a triumph of aeronautical engineering", the bomber was also noted for its "particularly graceful lines and a pleasing appearance, perhaps rarely seen in large military aircraft".

A more technical description comes later in the article: "In design it may be described as a mid-wing four-engined all-metal cantilever monoplane, with a retractable undercarriage. In general, it is powered by four Rolls-Royce 'Merlin XX' liquid-cooled engines, which have given such a good account of themselves in other bombers and fighter aircraft.

"Other engines, notably the Bristol 'Hercules,' are also being fitted to the 'Lancaster'. An outstanding feature which was demonstrated on the occasion of our visit is its great ease of control, and this, coupled with its high speed, is of great defensive value."



"It is obvious that the Allied cause has what has been aptly styled by many pilots as a 'war winner'"
The Engineer

The Lancaster proved to be the mainstay of British heavy bombers following its introduction, flying 156,000 sorties between 1942 and 1945

It is testament to the Lancaster's quality that variants of the aircraft were still in operation as late as 1963. Central to this longevity was the modular design, which in 1942 was described by *The Engineer* as enabling "ease of production, easy transport, and easy maintenance and repair".

The report added: "The design, the makers claim, lends itself to rapid and relatively cheap production as the entire machine is built up of numbers of components [that] are manufactured largely as separate and self-contained units, and are easy to transport and to assemble.

"Full 100 per cent interchangeability has been aimed at and achieved, and this, coupled with ease of construction, has contributed largely to the ease of maintenance and repair."

This flexibility, along with the aircraft's operational excellence, would prompt Air Chief Marshal Arthur 'Bomber' Harris to refer to the Lancaster as RAF Bomber Command's "shining sword". It became the mainstay of British heavy bombers following its introduction, flying 156,000 sorties between 1942 and 1945. During this period, Lancasters would drop over 600,000 tonnes of bombs, and 3,249 aircraft would be lost in action.

Manufactured primarily at Avro's factory at Chadderton near Oldham, Lancasters were also built in one of Canada's largest aircraft factories and flown by the Royal Canadian Air Force, as well as the Royal Australian Air Force. A true giant of the skies, the Lancaster is among the most fondly remembered of all British military aircraft, and one that undoubtedly played a vital role in turning the tide in favour of the Allies. *The Engineer* salutes this incredible aircraft.

December 1942

The Rolls-Royce Merlin 61 engine

One of the defining engineering achievements of the last war

In a fascinating example of how the Second World War upped the pace of technology development, *The Engineer* looked at one of the defining engineering achievements of the war: Rolls-Royce's Merlin 61 engine, which made its debut on the Mark IX Spitfire.

Designed in response to the Focke-Wulf 190, the Luftwaffe's most effective fighter, the huge performance improvements brought about by the Merlin 61 supercharged engine enabled the RAF's most iconic aircraft to claw back its aerial superiority.

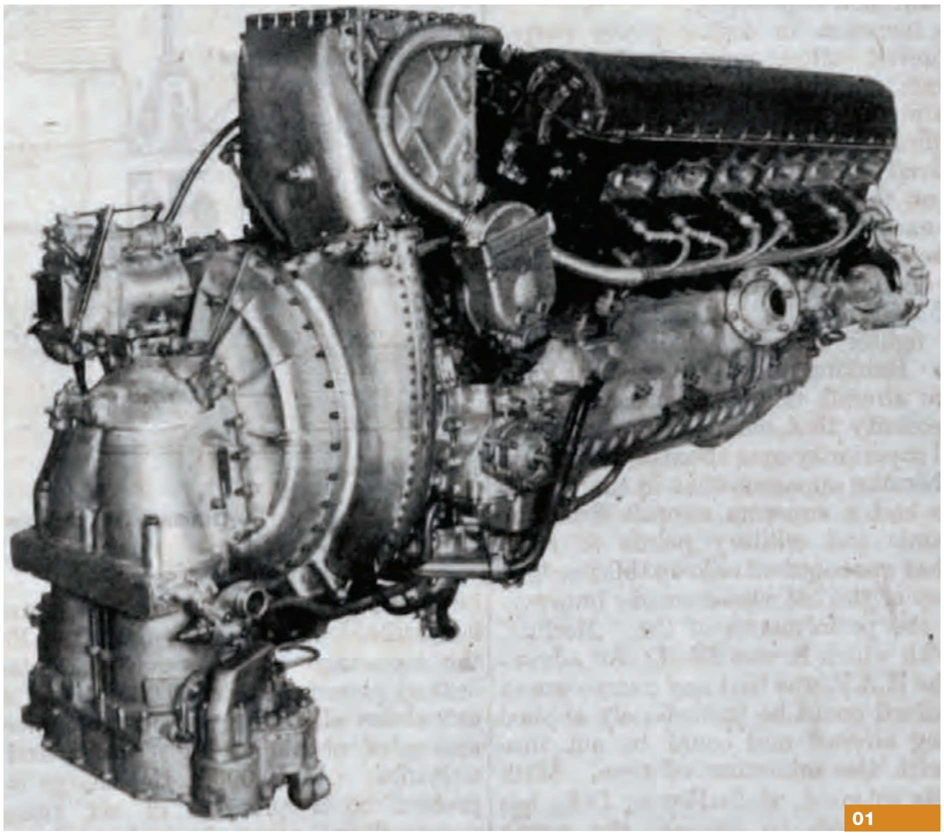
Commenting on the technical oneupmanship that characterised the battle between German and Allied engineers, *The Engineer* wrote that "the war demands that the performance of all types of aircraft, and particularly that of fighter aircraft, shall continually improve. Ranking above the need for more and more aircraft of all types is the overriding necessity that ours shall have technical superiority over those of the enemy."

01 Rolls-Royce's Merlin 61 engine

02 'Chicken' cannons have a long provenance in engineering

Describing the engine, the report claimed that "by using a double-stage supercharger with a water-cooled passage between the first and second stages of the supercharger, and a cooler between the supercharger outlet and the induction pipe to the rear cylinder, it is found possible with the new engine to develop double the power output. When operating at a height of 40,000ft, the charge of air and fuel is now raised by the supercharger to six times the pressure of the surrounding atmosphere".

This redesign, concluded the article, had the desired effect. "The results obtained from the improved Spitfire have, we learn, more than fulfilled the hopes and expectations of all who have helped in the work. The advent of the new German Focke-Wulf 190 with its 1,600hp air-cooled supercharged engine caused some uninformed persons to believe that the Germans had stolen a march on us in the high-performance fighter class of aircraft. But as enemy fighter losses continually show, the improved Spitfire with its new Merlin 61 engine was there to surpass it."



01

June 1944

The chicken cannon

Protecting windscreens from bird strikes

It is one of industry's enduring urban myths: UK engineers firing dead chickens at the windscreen of a new high-speed train were tersely advised to 'defrost the chicken' when their tests saw the feathered projectile crash through the window, smash up the driver's seat and become embedded in the wall of the cabin.

02

Whatever the provenance of this tale, protecting windscreens from bird-strikes has exercised the industry's finest minds for longer than readers might expect.

"There are many minor problems of flight about which little is heard," reported *The Engineer*. "One of them is provided by migratory birds which, when struck by a fast-moving aeroplane, may cause serious damage.

"It has been recorded in America, for instance, that a bird once not only broke through the windscreen of a passenger aeroplane, but punched a hole through the metal bulkhead behind the pilot, travelled the full length of the passenger compartment and finally came to rest… among the luggage!"

To aid the development of bird-proof windscreens, *The Engineer* reported on the development of the world's very first 'chicken cannon', designed by the Westinghouse Electric and Manufacturing company, to subject a variety of windscreen specimens to "such missiles as chickens and turkeys".

Explaining the operation of the device, the magazine wrote: "The apparatus was mounted on an undercarriage carried on rails. It consisted of a motor-drive air compressor supplying a large receiver at pressures up to 200lbs per sq in (nearly 14 bar). The receiver supplied air to the cannon's barrel – made from lengths of ordinary piping – mounted above it. Windscreen materials were mounted on a sheet steel easel."

The article said the gun enabled engineers to formulate a new bird-strike-resistant windscreen. "A construction has been developed that will withstand the impact of a 15lb bird at speeds up to 200mph. On the outside there is a layer of full tempered glass. Next, there is an air space, behind which is a sandwich of two sheets of glass separated by a thick filling of plastic."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July 1969 Apollo 11

The Engineer concentrated on technical matters, in vivid contrast to the mainstream media's output

How do you mark the most significant achievement in the history of mankind? The Apollo landings of the late 1960s and early 1970s are still seen as a high water mark of humanity and, as *The Engineer* pointed out, much of the millions of words of press coverage of the first mission to land, Apollo 11, was concerned with the human stories of the three astronauts on board. Admirably sticking to its remit, *The Engineer* decided it would be apt to focus instead upon the machinery that will be taking our first extraplanetary pioneers a quarter-of-a-million miles from the Earth's surface to the Moon's, and back again in safety.

In a special issue entitled 'The Mightiest Machine in the World', the magazine explained this decision. "Not surprisingly the stage has been dominated by the three astronauts who will land on the Moon. We join with all men of goodwill in wishing them success. But the welter of publicity focused on the astronauts casts a long shadow [that] tends to obscure the extraordinary achievements of the thousands of specialists whose technical accomplishments have made the Moon landing feasible." One notable quirk of the coverage is that, with typical British formality, the issue consistently refuses to use the name Buzz Aldrin, instead referring to him always by his given name of Edwin.

Over the subsequent pages, *The Engineer* not only went into detail about the technical specifications of the Saturn 5 launcher, Apollo Command Module, Service Module and Lunar Excursion Module, it also attempted to place the mission in the context of the US economy and of its effect on industry. The cost of the Apollo mission exceeded US$15bn, and the greatest economic significance of this was in "the growth of national industrial strength that has occurred in response to the opportunity and challenges of the space programme". For example, it noted that NASA's work on space communications systems led directly to the establishment of the Communications Satellite Corporation, and to a subsequent "many-fold increase in the ability to communicate, a major decrease in the cost of communication, and an international expansion of communications facilities". Benefits had included unprecedented televisation of the Olympic Games, but even more significant was a 25 per cent drop in the cost of a long-distance telephone call: "a permanent benefit to every citizen".

The development of precision manufacturing techniques was also credited to the rigours of space exploration, as was the development of new products and new techniques. It's now a cliché to mention non-stick pans in the context of the Apollo missions, but *The Engineer* avoided this, instead mentioning

> "A welter of publicity focused on the astronauts casts a long shadow that tends to obscure the technical accomplishments"
> The Engineer

"a 24-ounce battery-operated TV camera the size of a packet of cigarettes [not a comparison that we would use today], bearings coated with a ceramic-banded dry lubricant for use at high temperatures, and the technique for polishing metal masters to shape elliptical glass mirrors". It also mentions the transfer of successful management techniques from the industrial side of the programme to universities, government agencies and industrial corporations. The total spin-off from Apollo in economic terms have been cautiously estimated to be £1bn a year. *The Engineer* said: "Their value to a better environment may be immeasurable".

In an optimistic note, the issue even suggests (remarkably for 1969), that as astronomy had led to the harnessing of nuclear energy, space sciences were suggesting "regimes of power" that could free mankind from reliance on diminishing or expensive fuels.

The issue is lavishly illustrated with photos of Saturn 5 and the Apollo vehicles, and it details the stages in which the launcher in particular was developed. This included proving the concept of clustered rocket engines, development of the guidance system, and experience in handling liquid hydrogen fuel, which was used in preference to liquid oxygen and kerosene for the second and third states of the rocket because of the higher energetic value of oxygen and hydrogen. But, remaining consistent with the stated goal, there are absolutely no pictures of Neil Armstrong, Buzz Aldrin or Michael Collins to be seen.

The Apollo 11 landing mission contributed to a growth in national industrial strength in the US

March 1950

The De Havilland Comet airliner

The optimism surrounding this aircraft proves to be shortlived

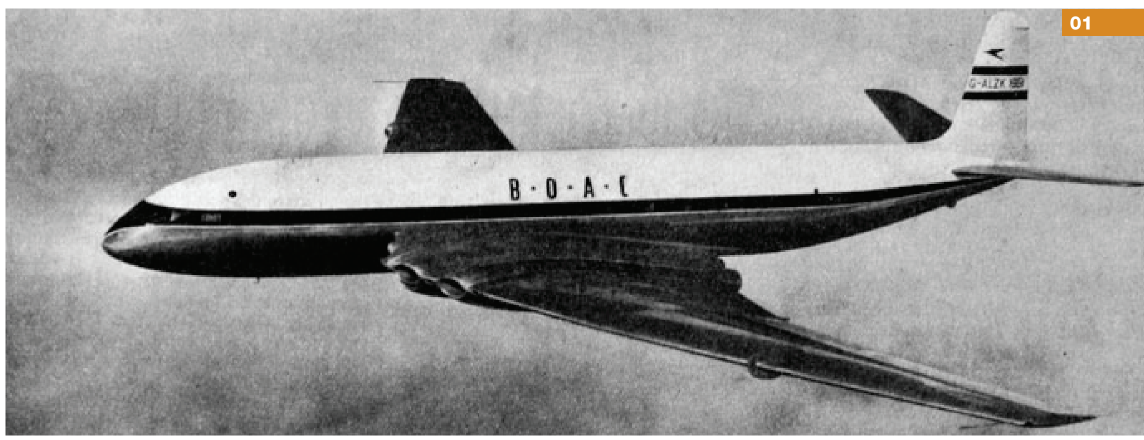
Six months after it became the first commercial jet airliner to reach production, *The Engineer* examined the performance of the De Havilland Comet.

"These figures bear out predictions made when the 'comet' formula was thought of four years ago, namely that its high speed would more than retrieve the cost of the higher fuel consumption inherent in the jet engine. It is considered that compared with the most modern liners of its class at present in world service, the 'comet' will be about 20 per cent cheaper per ton-mile of payload and will be able to fly at least 50 per cent more ton-miles in the year."

The article continued: "The first cost of the aircraft is taken at £450,000. As the SBAC formula does not as yet provide figures for the cost of maintenance of turbine engines the De Havilland company has made an assessment, which yields a cost per hour slightly less than that of piston engines in comparable aircraft."

The Engineer claimed that "more favourable figures will emerge as the developments now in hand materialise". These developments were expected to yield increases in the thrust of the 'ghost' engine for take-off and emergency climb, a decrease in specific consumption for cruising, an increase in the all-up weight of the aircraft and an increase in the internal fuel capacity.

Sadly, all the optimism was short-lived, and following early commercial success, a series of failures caused by metal fatigue led to all Comets being withdrawn. In 1958 a redesigned Comet was introduced, but by this time Boeing had gained the commercial edge with its 707 and orders for the Comet all but dried up. The Nimrod, a heavily modified version of this redesigned Comet, has been in military service since 1969.



01 The De Havilland Comet takes to the air in 1950

November 1950

The Centurion tank

Britain's heaviest tank to date rolls onto the production line

02 The Centurion tank was one tough machine – even surviving a nuclear explosion during testing

The Engineer's visit to the production line of Britain's heaviest tank to date marvelled at the process, but had no clue as to what a formidable machine it would become.

In what was clearly a big deal for our predecessors, the press were invited, for the first time since the Second World War, to tour a Royal Ordnance Factory and see the assembly of what was to become an icon of the Cold War: the Centurion Tank, which saw service in the Korean War, the 1970s Arab-Israeli conflicts, the Vietnam War and even as late as the 1991 Gulf War.

The Centurion was a remarkable vehicle. The heaviest armoured vehicle that had ever been produced in Britain, it weighed 50 tons, was built from 3.5in-thick (88mm) steel armour-plate, carried a 3.7in (94mm) calibre gun firing a 20lb (9kg) shell and housed a modified Rolls-Royce Merlin engine, which gave it a top speed of 25mph (very speedy for a tank).

The Engineer reported on the whole production process, including the ingenious welding jigs that rotated the steel-plate hull so that the joints were always presented so that the welders – all working by hand – could wield their welding electrodes downwards and vertically, which maximised the welding current that could be used and minimised the number of welding runs needed. The report also describes how the tank turret was machined out of a single 8.25-ton casting.

These efforts paid off, as the Centurion was one tough machine. In a nuclear test in 1953, a Centurion built the year after *The Engineer*'s visit was placed 500 yards from the detonation point of a 9.1kt bomb, cleared of crew but fully loaded with ammunition and with the engine running. After the test, it was found to have been pushed back about 5ft and its engine had stopped – but only because it had run out of fuel; the tank was refuelled and driven away. After repairs, it re-entered military service and stayed in action for 23 years, including 15 months in operational service with the Australian army in the Vietnam War.

July 1951

Manchester Electronic Computer

The world's first commercial general-purpose computer

Today, most of us have become fairly blasé about the computing power of even the tiniest handheld devices. But a report in *The Engineer* from 1951 on the so-called Manchester Electronic Computer is a potent reminder of how far and how fast computer technology has advanced in a relatively short space of time.

Delivered to Manchester University at the beginning of 1951 the room-sized machine, which was also known as the Ferranti Mark 1, was the world's first commercially available general-purpose computer.

Running through the machine's specifications, *The Engineer* wrote: "It can carry out arithmetical calculations with extreme rapidity, for example, it takes only two seconds to do 600 multiplications of pairs of 10-digit decimal numbers, which would require a normal day's work by a girl with a standard desk calculation machine."

The Engineer also marvelled at the machine's 'capacious memory', which enabled it to store "16,000 12-digit numbers and recall any one of them within 1/30th of a second".

The article added that the system was also able to make decisions, "that is to say, it can decide which of two or more contingencies has occurred and it can determine its future course of operations accordingly".

Paying tribute to those who laid the groundwork for the modern computer, *The Engineer* added: "It is worth recalling that Charles Babbage anticipated by more than 100 years these principles but unfortunately he could not get the necessary financial backing and lacked the facilities provided by electronic devices upon which modern electronic computers depend."

01 The room-sized machine was delivered to Manchester University at the beginning of 1951

02 Christopher Cockerell, pictured here with the SR-N1 hovercraft, was forced to sell personal possessions to fund the project

June 1959

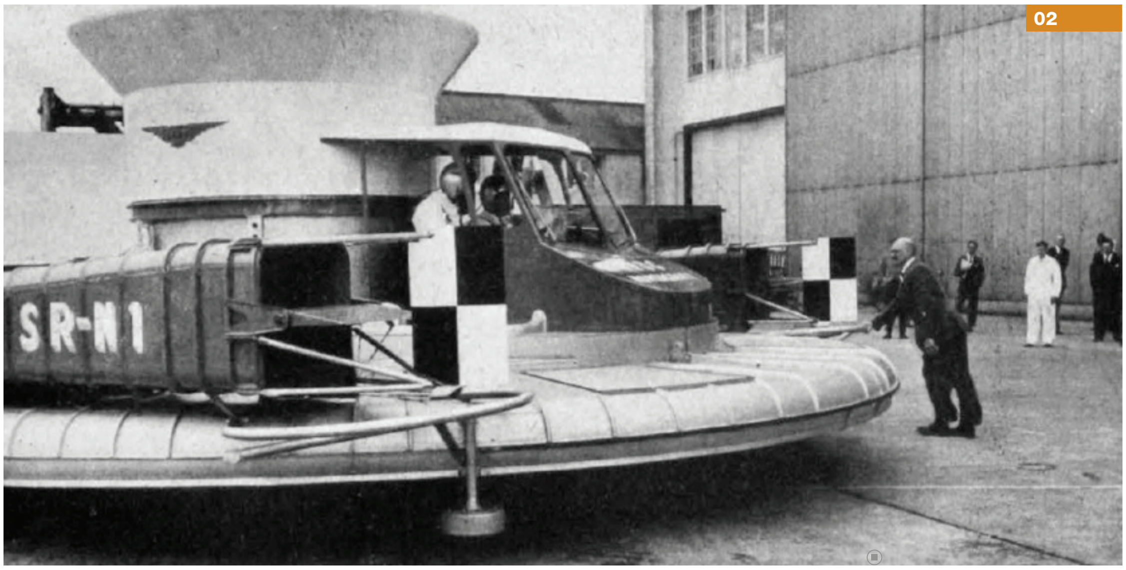
Hovercraft vehicle

A landmark event in maritime history

For three decades the hovercraft was the fastest and most thrilling way to cross the English channel.

And back in 1959 *The Engineer* was present at the birth of a vehicle so new and hard to categorise that it was described simply as a "ground-effect aircraft".

The culmination of six years of work – its inventor, Christopher Cockerell, was forced to sell his personal possessions to fund the project – the SR-N1 hovercraft research vehicle was built by Saunders-Roe on the Isle of Wight and 'flew' for the first time on 11 June 1959.



Privileged to witness this landmark event in maritime history, *The Engineer* wrote: "The principle of operation is closely related to that of the jet flap, a pressure difference being sustained by the change in momentum of the jet sheet: the product of 'cushion' pressure and hovering height has proved to be, as simple theory predicts, the change of momentum in deflecting the jet sheet into the horizontal plane."

The article continued: "[On the hovercraft] can be seen one of the four propelling nozzles with the control vanes that allow a transverse or vertical component of thrust to be developed. The yaw vanes at the rear nozzles are extended upward to give directional stability and improved yaw when flying forward."

A couple of months later, on 25 July, the prototype craft, which was capable of carrying four men at a speed of 28mph (45km/h), made a successful crossing of the channel.

In the UK, commercial cross-channel hovercraft operations ceased in 2000, although a service still operates across the Solent from Southsea to Ryde on the Isle of Wight. The vehicles are also widely used by the military.

July 1957 Lovell Telescope

Jodrell Bank's colossal moveable dish is still one of the world's most powerful radio telescopes

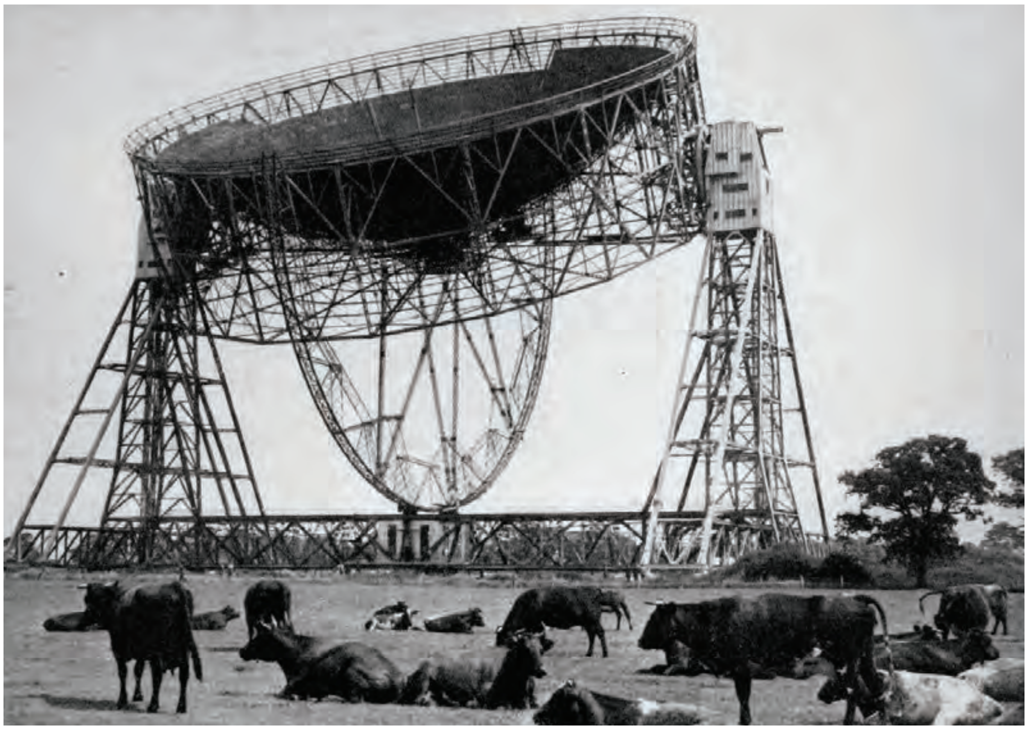
Sixty years ago this year, *The Engineer* was invited by the Department of Scientific and Industrial Research to visit the Jodrell Bank Observatory in Cheshire. The purpose of the visit was to get a behind-the-scenes look at the station's steerable dish radio telescope that at the time was the largest in the world.

Known today as the Lovell Telescope – in honour of its chief proponent, the late Sir Bernard Lovell, the construction garnered attention for several reasons. "This enormous instrument is of special interest, not only for the uniqueness and promise for the astronomer but also because of the engineering problems that had to be surmounted to design and build it," wrote *The Engineer* in 1957. "Civil, mechanical and electrical engineering techniques are all involved in the successful operation of the radio telescope, sometimes in an original manner."

With a moveable dish 76.2m (250ft) in diameter, the Lovell telescope is today still the third-largest telescope of its type, as well as a Grade I-listed building. In 2006 it won a BBC competition as the UK's greatest 'Unsung Landmark'. But what are now its storied history and place in the national consciousness was, of course, unknown to our predecessors all those years ago, whose focus was primarily the telescope's construction and operation.

The article went into detail: "The bowl… is carried on two towers by trunnion bearings; it can be turned on those bearings through 180 degrees. The towers are mounted on bogies on a circular rail track so that the whole structure can be rotated. Driving and control mechanisms are installed in such a manner that the telescope can be pointed at any given star and can be driven to follow the path of the chosen star till it disappears below the horizon."

Despite aluminium alloy initially being offered as a possible construction material, the consultants ultimately chose to build the entire telescope from steel. Steel provided the highest strength/cost ratio and had a low coefficient of expansion, meaning that reasonable accuracy of the dish's shape could be maintained. It was also judged the best material to help overcome one of the telescope's key challenges: the wind.



> "This enormous instrument is of interest because of the engineering problems that had to be surmounted"
> The Engineer

Stability in wind was a key consideration and the telescope had to be steady enough to maintain the bowl's accuracy in moderate winds of 30–40mph. The first designs of the telescope "allowed deflections of several inches – say 6in or 7in". However, the iteration that was ultimately built meant that "any deviation of the skin of the paraboloid from its true shape [was] intended to be kept down to about 1in".

The bowl itself was constructed from more than 7,000 stiffened steel plates of 3ft by 3ft, welded to purlins. The purlins were bolted together and attached to the main structure of the telescope, enabling alignment of the shape of the bowl by adjusting the bolted connections. According to *The Engineer*, detailing of the steelwork was "unusually onerous" due to both the structure's unusual shape and the high degree of accuracy required.

"An idea of the complexity of this aspect of the work may perhaps be given by referring to the purlins. There are 2,200 angle-iron purlins carrying the surface of the bowl. Each had to be curved to different diameters in two planes, so that a purlin lay truly on the surface with one side of the angle iron parallel to it."

If necessary, the bowl could be fully inverted, with the intention that the telescope could be placed in this position whenever the 62.5ft aerial mast needed to be changed.

Since 2010, the dish has been protected from pigeons' and other birds' foulings by two breeding pairs of peregrine falcons. An indication of the structure's endurance, however, is the fact that, since 1957, just two of the original 64 drive wheels that help it track stars across the night sky have needed to be replaced.

They certainly don't build 'em like they used to.

With a moveable dish 76.2m in diameter, the Lovell Telescope is today still the third-largest telescope of its type and a Grade-I listed building

April 1959

The Triumph Herald

A classic car that was loved and derided in equal measure

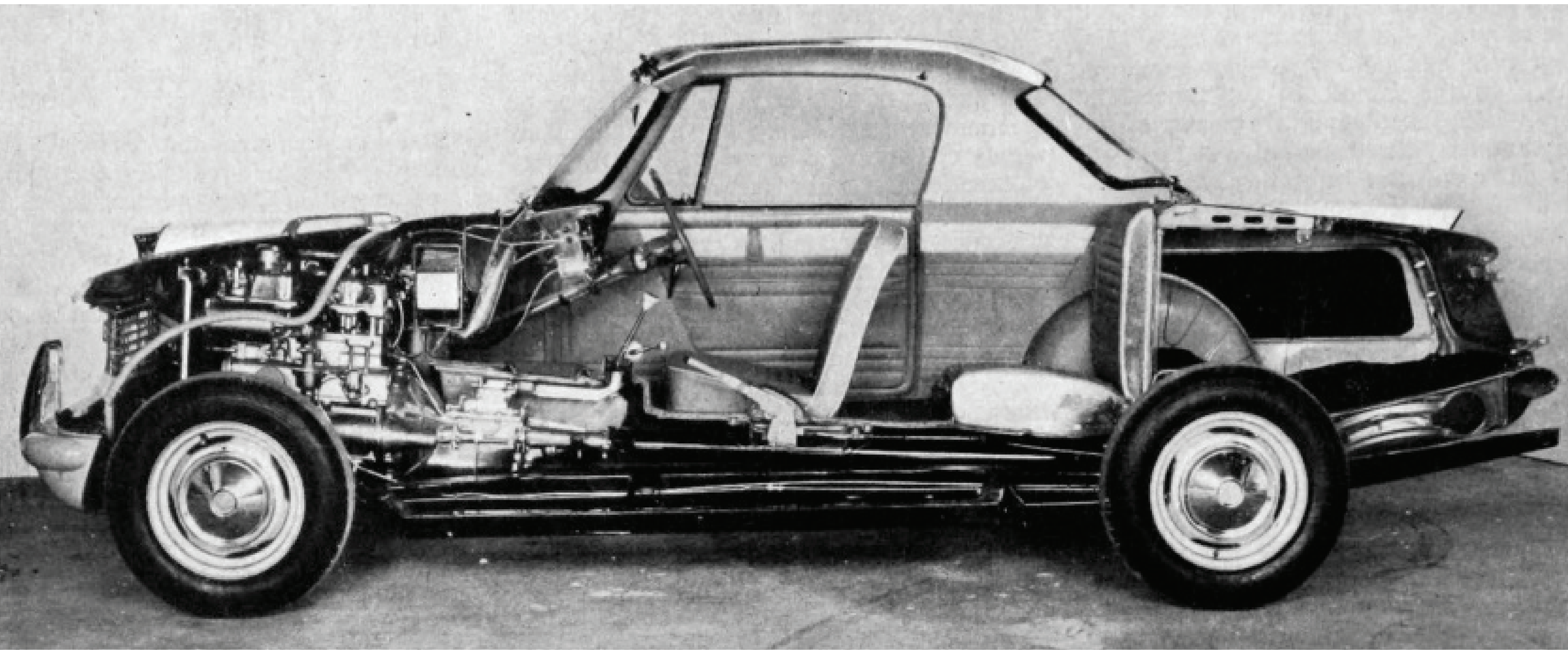
Designed by an Italian and built in Coventry by the Standard-Triumph company, the Triumph Herald is one of those classic cars that is loved and derided in equal measure. However, the number of vehicles still on the road almost 40 years after it rolled off the production line for the last time is testament to its enduring appeal, if not its design.

The Engineer wrote that one of the primary objectives in the development of the vehicle was "redressing the increase in the cost of upkeep compared to the cost of original manufacture that has occurred in recent years".

The Triumph Herald had a separate chassis as opposed to a monocoque construction. "The new car is not of integral construction but has a backbone frame onto which the sections of the body are bolted," the magazine reported. "The cost of accident repairs also should be reduced by the construction of the body in sections, which are bolted to each other and the frame: six out of seven body sections are common to both saloon and fixed-head coupé.

"In addition, those parts of the body which, in the absence of bumpers, are most likely to suffer damage, are arranged to be accessible and can if necessary be removed by drilling out the spot welds securing them."

The Herald had a separate chassis rather than monocoque construction



February 1961

The BT Tower

Set to become one of London's landmarks

The Engineer took a look at the proposed design of a structure that has become one of London's best-known landmarks: the building known today as the BT Tower.

The new tower was required for a variety of reasons, explained *The Engineer*. But its main role was to support the microwave aerials that were used to carry telecoms traffic from London to the rest of the UK. According to the article, it was designed to replace an 180ft-high steel mast on the nearby Museum Exchange building, which was being affected by London's appetite for increasingly tall structures.

Reporting on the challenges of building the tower, *The Engineer* wrote that "the design envisages a structural connection with the main building 80ft above the ground, where horizontal loads due to wind will be transmitted from the tower. The maximum horizontal reaction at this point is to be 500 tons, but vertical deformation of the tower will not be restrained".

The report added that "wind-tunnel tests are in progress at the National Physical Laboratory to ensure that no resonance phenomena will arise due to steady winds of moderate strength".

Opened by Prime Minister Harold Wilson in October 1965, the 189m-high tower enjoyed the distinction of being London's tallest building until the Natwest Tower (now known as Tower 42) was completed in 1980.

Today, the building transmits broadcasts via fibre-optic cables rather than its distinctive round dishes, and is used as a broadcast transmission centre by ITV, Channel 4, BSkyB and CNBC.

The revolving restaurant at the top of the tower has been closed since 1980.