

Plummeting windows were the downfall of a pioneering skyscraper.

The Eccentric Engineer

by Justin Pollard



BUILDING

THE MYSTERIOUS RAIN FROM BOSTON'S GLASS GIANT



WE'RE ALL familiar with glass skyscrapers these days. Those who ever wander around London will have noticed a new one under construction, the Shard London Bridge. This startling, mirror-glassed point will, when finished, turn a part of Southwark into something more akin to a 'Flash Gordon' cartoon. Personally, I'm all in favour of that. But building shiny glass towers did not initially get off to a very good start.

The idea of vastly tall, glittering minimalist monoliths was something of a goal for the modernist architects such as Mies van der Rohe. His Seagram building in New York, finished in 1958, was a good attempt but, due to engineering constraints, it was never the entirely smooth, glass-clad structure he had envisioned. That would have to wait until 1968, when construction began in Boston on the John Hancock Tower – officially now called 'Hancock Place'.

Designed by Henry N Cobb, the tower was to be in the form of a colossal parallelogram to emphasise the sharp corners of the building, its shorter sides broken

up by a vertical notch to further highlight its dizzying height. And at a whisker under 241m it was, and remains, the tallest building both in Boston and in the whole of New England. The entire thing was to be clad in mirrored, slightly blue-tinted glass, made of the largest panes available. These, it was hoped, would reflect a lustrous navy blue against the clear city sky.

Construction of such a novel building was not without problems. Even during the foundation digging there was trouble with the retaining steel walls of the trench buckling. This compromised the foundations of the nearby Trinity Church, one of Boston's most treasured monuments.

But such things are hardly unusual for major projects and with some shoring up and only some occasional damage to the city's vital utility lines, building went on apace.

What is unusual is what happened next. With the tower finished and about to be opened it started raining. Not the normal sort of rain, you understand – heavy rain. Rain consisting of

Competition

What are these tourists on the Hancock Tower's observation platform saying? The best caption emailed to engtechnag@theiet.org by 8 July wins a pair of books from Haynes.

230kg panes of shiny mirrored glass which, whenever the wind speed rose above 70km/h, would crash down from an extraordinary height onto the sidewalk and buildings below.

This was not really ideal, but what no-one was sure of was why it was happening. Indeed, so bemused were the engineers that a scale model of the whole of that part of Boston (the Back Bay) was built in a wind tunnel at MIT to try to work out if it was some strange conjunction of prevailing wind and topography that had caused the problem. It had been noticed that in higher winds the structure twisted, something that neither architects nor engineers envisaged.

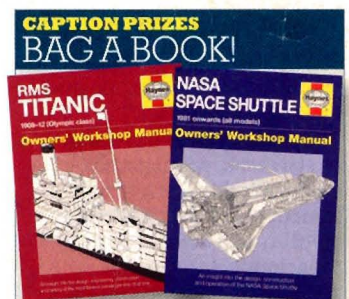
The whole building also swayed alarmingly, causing motion-sickness in people at the higher levels. In fact, motion sickness was the least of their problems as a later analysis suggested that under certain conditions the whole thing could have fallen down. Thankfully it didn't and some stiff steel cross bracing (to keep it upright) and a huge tuned mass-damper on the 58th floor (to prevent the motion sickness) brought the building under control.

None of this, however, explained the raining glass and so samples were sent across the country to independent laboratories to try to work out if there was anything wrong with the material. And there was. The panes were made of three layers – an outer glass layer, a reflective layer and an inner glass layer, bonded together in a sandwich. As the huge glass monolith heated in the daytime sun and then contracted in the cool of night, like some gigantic sundial

gnomon, so the air in between the inner and outer layers expanded and contracted – as it does in double glazing. However, in these massive and very novel panels, the bonding between the inner glass, reflective layer and outer glass had been made so stiff that the entire force of this thermal stressing was not absorbed by the gap but transmitted to the outer pane, which then, rather disconcertingly, pinged off, plummeting onto the street below.

As more panes pinged, the architects resolved that the only answer was to replace every single piece of glass – a total of 10,344 panes and at a cost that the time estimated to be around \$5-7m. While the glass was being removed, and to cover the gaps where windows had removed themselves, plywood sheeting was placed over the frames.

The modernist dream of a glass monolith was replaced by a joke that Boston was fortunate to have the tallest plywood building in the world. Not exactly what the minimalists had in mind. *



This month's competition winner will receive copies of the 'NASA Space Shuttle Owners' Workshop Manual' and the 'RMS Titanic Owners' Workshop Manual', two new titles from the ever-expanding range of Haynes Manuals (www.haynes.co.uk). Winner of our June issue competition is Vincent Li with: "Never mind sticking plasters, we'll have the Health and Safety Executive to protect us soon!"



A mere 34 acres in Wiltshire would have provided the UK government with a subterranean des res, and a refuge from war

The Eccentric Engineer

by Justin Pollard



NUCLEAR DEFENCES

ROUGH GUIDE TO BURLINGTON, THE CITY THAT NEVER WAS



THE CITY OF Burlington. A modest city. Area: 34 acres. Some 60 miles of road. Four power stations, a reservoir, offices, laundries and a hospital. Population: one. And it doesn't show up on any map.

Burlington has been known by a number of different names over the last half-century. Stockwell. Chanticleer. Turnstile. Its first name was the bland but strangely sinister '3-site'.

Military planners who had been having fun modelling the effects of an all-out nuclear war had estimated that 132 nuclear bombs falling on major British cities would cause hundreds of thousands of casualties and disable all forms of government. In 1955, when William Strath of the Central War Plans Secretariat updated this report to include hydrogen bombs, his estimate for immediate deaths had risen to 12 million, with a further four million serious injuries – around a third of the population.

Plans were considered for providing public shelters, but the costs were prohibitive so the answer was to leave the people to their own defences but hide away

a core of government officials and ministers in a new, underground city. There they could organise the massive retaliation that the doctrine of 'mutually assured destruction' required, then re-establish contact with the outside world and start explaining to the survivors what it had all been about when the radioactive dust settled.

The site chosen was the subterranean Spring Quarry, a source of fine Bath stone, near Corsham in Wiltshire and, in 1957, work began in earnest. Burlington was designed on a grid plan as a small-scale mirror of Whitehall, its streets lined with pared-down versions of peacetime ministries, complete with ministers and civil servants. This miniature government was provided with food, water and fuel to last three months, after which it was assumed it might be safe to venture outside.

Choose your area

The whole treeless city was divided into 24 areas designed to provide for outside communication and the basic

Competition

What would 1920s workers at Spring Quarry make of its later incarnation as a nuclear bunker? The best caption emailed to engtechmag@theiet.org by 9 September wins a pair of books from Haynes.

welfare of up to 6,000 people. Area 21 held the communications offices of the intelligence services that would monitor above-ground events. Here they would communicate with 12 regional bunkers which in turn would be connected to a network of 1,563 monitoring posts manned by the Royal Observer Corps who would relay details of the unfolding devastation back to base.

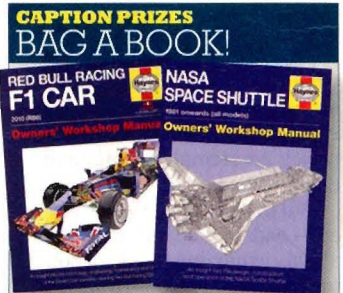
Elsewhere, Area 8 contained the second largest telephone exchange in Britain which would be manned by GPO staff. Area 16 contained the BBC studio from where the Prime Minister would update his or her remaining people on the progress of the war, and Area 12 housed the industrial ovens of the kitchens making meals from the foodstuffs stockpiled in Area 9 which also housed a fully operational hospital and dental surgery. It was a bleak and utilitarian world.

At the centre of operations was Area 17 where politicians and senior officials would live and work, centred on the 'Map Room'. Here the Prime Minister had the only en suite bedroom in the entire complex. Notably there was no provision made for the PM's, (or any other official's), family members. Indeed it was only with the declassification of the site in 2002 that many civil servants even knew they had a desk reserved for them in Burlington.

Had the warning come they would have been expected immediately to leave their families to their fate and set off for their new underground home. With the blast doors sealed and protected by the living rock of the quarry and 100ft-thick

reinforced concrete walls, it was expected that they would survive what was estimated as a two-day 'destructive phase' and the 'survival phase' of a month. The 'reconstruction phase' was rather optimistically scheduled to last just a year. Just what the inhabitants of Burlington hoped to reconstruct remains somewhat unclear.

Burlington was finished in 1961 and was put in a state of readiness. Journalists invited into the bunker after its declassification noted piles of chairs and tables still in their wrappers, thousands of toilet rolls, reams of paper and rows of 1960s telephones still in their boxes – all stockpiled for the unthinkable event. Fortunately that event never came, and when Margaret Thatcher was presented with an estimated bill of £40m for renovating the site in 1989 she deemed it unnecessary as the threat from the Soviet Bloc had disappeared. In 1992 the last few maintenance officers left and Burlington, the city that never was, never would be again. *



This month's competition winner will receive copies of the Red Bull Racing F1 Car and Nasa Space Shuttle Owners' Workshop Manuals, two new titles from the ever-expanding range of Haynes Manuals (haynes.co.uk). Winner of our July issue competition is Tim Smith: "Passengers arriving at Stansted are disappointed to discover that wings are now an optional extra on budget airline flights".



Cost-cutting was probably behind design flaws that led to a syrupy wave streaming through the streets of Boston.

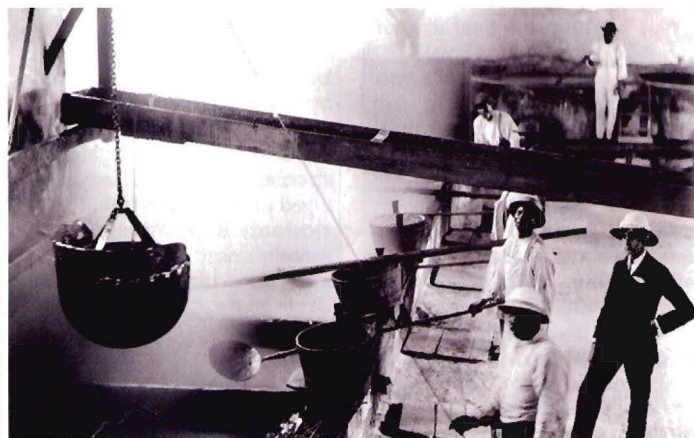
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INDUSTRIAL LESSONS

THE TERRIBLE AND PUNGENT MOLASSES FLOOD OF 1919



HAVING HOLIDAYED recently in Cornwall I can now vouch for two things. First, waves are astonishingly powerful. Secondly, middle-aged historians shouldn't try to surf. On the upside however, the subsequent period of convalescence has given me an excellent opportunity to think about waves in general, and one in particular.

Molasses is the treacherous by-product of refining sugar, and a jolly useful one at that. Not only can you cook with it and eat it, but it can be fermented and distilled to make rum and ethyl alcohol, used to remove rust, added to feedstock and even used in mortar. It is not generally used for surfing. However the terrifying power of a molasses wave has once been experienced.

In the winter of 1918 the United States Industrial Alcohol Company began filling its 15m x 27m molasses tank at 529 Commercial Street, Boston, Massachusetts. This vast container, capable of holding 8,700,000 litres, had been built in 1915 to help sate the USA's appetite for industrial alcohol, largely for use in the munitions business that booming thanks to the outbreak of the First World War in Europe. But the owners, in their haste, had made a number of mistakes.

First among these was the appointment of Arthur Jell to oversee the construction. Jell was not an engineer or architect, but the company reasoned that fabricating a big tank was hardly the same thing as building a railway or a skyscraper, so costly experts were not needed. Jell, who was unable to read blueprints, had little idea how to check if the behemoth rising before him would perform as expected and when it was finished he did not even order a simple stress test to check that it would hold up and not leak.

It did, history records, leak. Indeed there were reports of it 'weeping' molasses as soon as it was filled.

In these days of health and safety, we might have such a tank drained and resealed. However, the solution decided upon at the time was to paint the tank brown so no one would notice.

But for all its leakiness, the tank survived for the next four years, creaking and groaning, but providing locals with the occasional bonus of free molasses which they collected from the regular seepage. Then, on 12 January 1919, a molasses tanker from Puerto Rico docked at the wharf and pumped the tank full. All seemed well, until lunchtime on Wednesday

COMPETITION

What might molasses factory workers have thought of the Boston flood? The best caption emailed to engtechmag@theiet.org by 14 October wins a pair of books from Haynes.

15 January. That day had dawned unusually warm; temperatures had leapt over two days from a chilly -15.5°C to a comparatively balmy +4.4°C and the people of this densely populated neighbourhood were out and about their business. Around 12.40pm witnesses reported a "muffled roar" followed by what First World War veterans present said sounded like machine-gun fire. This was the rivets shooting out of the rupturing tank. The ground began shaking "as though a train were passing" and all hell was let loose.

If a flood of molasses doesn't sound all that terrifying it's worth looking at the statistics. In a matter of seconds nearly nine million litres were released onto Commercial Street in a wave that reached 4.5m high and was reportedly travelling at around 56km/h. Over 14,000 tonnes of syrup surged out, exerting a pressure on everything it hit of around 200kPa. Just the sickly-sweet air blast ahead of the wave threw people off their feet, and the wave itself tore the girders off the Boston Elevated Railway and lifted a train from the tracks. People, horses, trucks, carts and whole buildings were lifted onto the wave and tumbled down the street or into the dock.

Twenty-one people died. Another 150 were dragged injured from the viscous mass. It would take a further 87,000 man-hours to clear the streets and houses, and the harbour remained brown with molasses well into the summer. The smell has not, so local legend has it, gone away to this day.

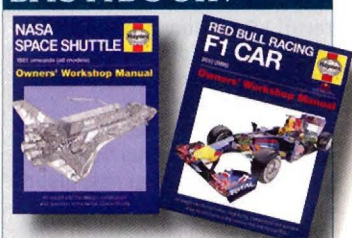
There was, of course, an inquiry. Fortunately was less of a whitewash than that into the comparable London Beer Flood of 17 October 1814 – 1,470,000 litres of beer from the Meux

Brewing Company surging down Tottenham Court Road, drowning eight people – which was declared an 'Act of God'.

The United States Industrial Alcohol Company tried valiantly to claim the molasses flood had been caused by anarchists blowing up the tank, but in the end blame was placed on the poor construction and insufficient testing of the container. In the end the company paid \$600,000 in out-of-court settlements. The damage to property was estimated at what would today be around £100 million.

The court case never did get to the bottom of exactly what had caused the tank to fail. It was certainly unusually full and some fermentation in the vessel in the rising temperatures over the previous few days may have increased the strain. One scurrilous suggestion is that the company was stocking up on molasses just before the introduction of Prohibition in the hope of making a killing on the rum market. In truth the real reason may be no more complex than the company's failure to hire a qualified engineer. *

CAPTION PRIZES BAG A BOOK!



This month's competition winner will receive copies of the Red Bull Racing F1 Car and Nasa Space Shuttle Owners' Workshop Manuals, two new titles from the ever-expanding range of Haynes Manuals (haynes.co.uk). Winner of our August issue competition is Brian Sinfield: "From here you can see the forest that supplied the wood for the plywood panels that were fitted last year".



The toilets in German wartime submarines were an engineering marvel, but perhaps too complex for their own good.

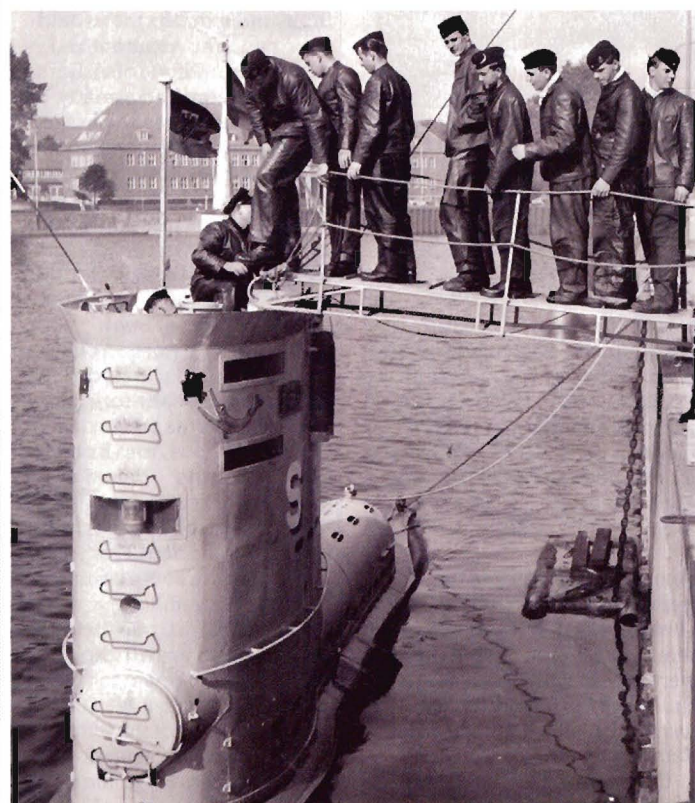
The Eccentric Engineer

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SUBMARINES

THE U-BOAT CAPTAIN WHO GAVE HIS VESSEL A SINKING FEELING



THERE'S NOTHING quite like a good piece of mechanical engineering. But there's also, sadly, nothing quite like the instruction manual that goes with it. In many cases, the fault lies with an excitable (or lazy) translation from a different language. Sometimes, however, it's simply down to the impenetrable wall that can build up between an engineer and the people who use the product.

If you were looking for a complicated manual then the Kriegsmarine Type VIIC U-boat U-1206 manual would probably make the list. A magnificent piece of engineering, 568 of this class prowled the world's oceans during the Second World War.

Not that U-1206 had brought much terror. Since her launch in December 1943, she hadn't sunk a

single ship, although it was some comfort to Captain Karl-Adolph Schlitt that neither had he lost a single crew member.

It was now April 1945 and U-1206 was some 60m beneath the North Sea, 10 miles off Peterhead, hunting for British freighters. It was now that Captain Schlitt made a decision that would change his and his crew's future forever. He decided to go to the lavatory.

On the U-1206 few things were more complicated than the loo. The problems were considerable. Whereas a sailor could go over the side, a soldier behind a tree and a pilot could wait until he landed, a submariner couldn't just nip outside. This problem did not daunt the engineers of the Kriegsmarine, however, and they came up with a complex piece of

Competition

What might this U-boat crew be saying as they board their vessel? The best caption emailed to engtechmag@theiet.org by 11 November wins a pair of books from Haynes.

equipment – the high-pressure toilet. This marvel could be flushed while underwater but required a complex series of valves to be opened and closed in exactly the right order.

Indeed, so complex was the high-pressure toilet that it came with not only a manual but also its own member of staff. On each boat, one crew member was given training so that they could instruct the crew on how to safely spend a penny, or pfennig in this case, while underwater.

What exactly happened in the moments after Captain Schlitt entered the lavatory is a matter of debate. The first version of events, put forward by the Captain himself, involved faulty equipment. The second, told by senior crew members, involved faulty captaincy.

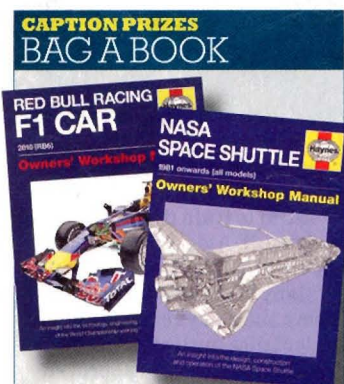
In the first rendering of events, Captain Schlitt finished his business and swiftly operated the complex series of valves which flush the bowl in the correct order. In the second, a nervous and slightly embarrassed captain forgot how to operate the mechanism but, not wishing to look stupid in front of his men, decided against calling out for help from the trained lavatory supervisor and had a go at remembering as best he could – which wasn't very well.

Either way, the result was the same. Levers were pressed, valves were opened and gallons of high-pressure water from the bottom of the North Sea shot up the u-bend, showering the captain in effluent and brine.

Being in a room with an exploding toilet would probably be enough to ruin most people's day, but Captain Schlitt and his crew had the added disadvantages of being underwater, in enemy territory and sitting on an

unfortunate piece of chemistry. Directly beneath the lavatory was the power bay where the main batteries for the vessel were kept. When the sea water began flooding this compartment, battery acid and brine formed deadly chlorine gas.

In an enclosed space rapidly filling up with poisonous gas, Captain Schlitt ordered an emergency surface. The boat shot up and the hatches were opened, just in time to see a British coastal patrol plane arc overhead. As quickly as possible, the boat was evacuated and the crew put in rubber life rafts. As the plane aborted its run, perhaps seeing the trouble the vessel was in, Captain Schlitt gave his last ever command as a U-boat captain – to open the seacocks and scuttle his boat. He, and most of his crew, scrambled ashore and were interned for the rest of the war, the victims of the only submarine to be sunk by its own lavatory. *



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The Mayan metropolis of Palenque has been a magnet for adventurers...

The Eccentric Engineer

by Justin Pollard



ARCHAEOLOGY

THE KING WHO KEPT HIS TOMB SECRET FOR 1,300 YEARS



WE HAVEN'T talked about ancient engineering for a while now, having been up to our knees in molasses and malfunctioning toilets, so this month I'd like to take you back to every child's favourite piece of engineering – the secret tomb. If you haven't ever imagined yourself as a latter-day Indiana Jones, dashing down concealed corridors and dodging ancient booby-traps to discover a priceless treasure, then you really should, not least because there's actually a grain of truth to the movie legend.

By 900AD the city of Palenque in what is today southern Mexico was a ruin, covered in forest and slipping from memory. It would be over 650 years before any outsider would see the remains, and another 250 years before the site came to the attention of archaeologists. Following the publication in 1822 of 'Descriptions of the Ruins of an Ancient City Discovered Near Palenque', interest in these mysterious Central American lost cities began to grow. In 1839 Frederick Catherwood, an architect and draughtsman, and John Lloyd Stephens, a dip'omat and

writer, glimpsed a pyramid poking through the thick undergrowth of the Chiapas foothills. Setting up camp in the ruins, Stephens and Catherwood went about recording what they soon realised was a city choked by almost impenetrable rainforest.

The temple they were camping in is known now as the Temple of the Inscriptions. Work on it began around 675AD, when Palenque was the capital of possibly the largest and most important kingdom in the Mayan world. A 23m-high stepped pyramid with a temple structure on the top, the building was decorated with the second longest inscription known from the Mayan world. Not that either Stephens or Catherwood could read the text. Instead they drew what they saw – a beautiful, empty temple in a long-abandoned city with no sign as to where the people had gone.

In fact, the inscription records 180 years of Mayan history and details the life and achievements of the man who commissioned the temple, K'inich Janaab' Pakal, known today as Pacal the Great and the man who had

Competition

What are these Mayan builders up to? The best caption emailed to engtechmag@theiet.org by 9 December wins a pair of books from Haynes.

revived the city's fortunes. What they never guessed was that he was still there. Nor had they any reason to. Since the rediscovery of Mayan civilisation it had widely been assumed that the stepped pyramids found in their cities were simply elaborate supports. There was no evidence for tombs, no evidence for any of the people who must have once lived in these places. Just empty, ruined stone buildings.

This was still the received wisdom when Mexican archaeologist Alberto Ruz Lhuillier visited the site in 1949. However, standing where Stephens and Catherwood had stood 110 years earlier, he noticed a double row of stone plugs set into one of the slabs on the sanctuary floor which he guessed marked where the stone had been lowered into position, implying there might be something beneath it.

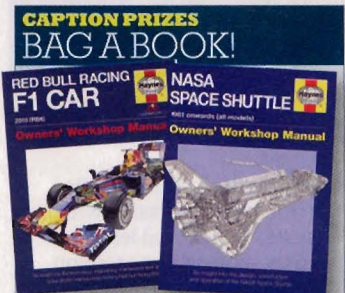
Removing the stone, he found a vaulted passage so full of rubble that it took four digging seasons to clear and it was 1952 before his team arrived at the bottom. Here they found their way blocked by a wall next to which stood a stone box full of pottery jars, shells filled with the red pigment cinnabar (mercury sulfide), beads, jade earplugs and a solitary pearl. Removing the wall, they came to a more grisly discovery – a chamber containing the skeletons of six human sacrifices, beyond which lay another large block of stone.

On the other side lay something unheard of in Mayan archaeology – a royal tomb in the heart of a pyramid. Inside a large slab covered an elaborately decorated sarcophagus, standing on six short piers, beneath which lay pottery food dishes and two life-size stucco human heads.

The lid of the sarcophagus was decorated with one of the most important scenes on any Mayan monument, a depiction of its owner, Pacal the Great, who is shown falling into the netherworld.

Beneath the lid lay the body of Pacal, sprinkled with mercury sulfide and surrounded by more than 700 jade items. He wore a jade diadem, a net skirt made up of jade pieces held together with gold wire, necklaces, pectoral decorations, rings, bracelets and ear-flares. Over his face lay a mosaic jade mask and at his feet rested two jade statuettes. He was holding a jade cube and sphere.

It was the find of the decade and one of the greatest ever Mayan discoveries. Here at last was one of the inhabitants of these lost cities, and one of their greatest – hidden for nearly 1,300 years, surrounded by his treasures. It was the sort of discovery you only find in movies and even today, with perhaps only 5 per cent of this 65 sq km city excavated, Pacal's kingdom holds on to many more secrets. *



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