Programme synopses

Programme 1: The Great Ship

Isambard Kingdom Brunel is played by Ron Cook

In the early 1850s, the world's most brilliant engineer, Isambard Kingdom Brunel, dreamed of creating the largest ship ever built. The *Titanic* of its day at nearly 700 feet, it would be able to sail, without stopping, to Australia and unite the two ends of the empire.

Shipwrights of the day regarded his scheme as utter madness. But Brunel was a genius who had created such spectacular wonders as the Great Western Railway, the Clifton Suspension Bridge and even the first tunnel under the Thames; there seemed no limits to his superhuman ability. Yet his "Great Ship" would destroy him, and all who were associated with it. Many believed it was cursed.

Brunel enlisted the support of brilliant naval architect John Scott Russell and bitter rows soon erupted as Brunel developed a swathe of innovations with the utter conviction that he was right. This was the most advanced technology of the day with a double hull, 10 water-tight bulkheads and vast steam engines fashioned by newly invented hammers of unprecedented scale. However, nothing proceeded as planned; workers were involved in tragic accidents, there were fires at Millwall docks and Scott Russell was financially ruined. As the great hull finally took shape, plate by plate, the ship, nicknamed "Leviathon", became the biggest tourist attraction in Europe.

Brunel had asked for perfect silence during the launch, but 10,000 people gathered in November 1857 to see the massive 12,000-ton hull shift into the water – the greatest weight mankind had ever attempted to move. Their efforts were to end in tragedy as huge chains snapped and workers were flung to their deaths. Brunel was ridiculed in the press as his massive creation would not budge.

His fate became inextricably mixed with that of his "great babe" and, by the time the SS *Great Eastern* was finally launched, months later, 52-year-old Brunel had become very ill. Moments after choosing his cabin for the maiden voyage, he suffered a severe stroke. As he lay dying at home during the first voyage, he was informed of a horrific explosion on board which burned alive several of the crew. Devastated, Britain's greatest engineer succumbed to a second stroke and died soon afterwards.

However, his ship was to become one of the crowning achievements of the Victorian age by carrying the first transatlantic telegraph cable to link Europe and America. At first, the proposal to span the Atlantic with wire was greeted with incredulity. It was soon established that the SS *Great Eastern* was the only ship to have a large enough hold for such a gigantic cargo and 2,000 miles of cable was coiled into her tanks. The cable snapped half way across the Atlantic and months were to elapse before the mission was complete. With great excitement in 1866, the first shore-to-shore telegram was tapped through the cable.

Despite this triumph, the *Great Eastern* never succeeded as a passenger ship and, in 1889, after a few years as a show boat, it was finally dismantled for scrap. In a macabre twist, it was rumoured that two skeletons were found entombed between the double hull. Many believed that a basher and his mate – a young boy – had been trapped during the construction and literally starved to death. Many said the Great Ship had, indeed, been jinxed after all.

The Great Ship is written and directed by Chris Spencer. Isambard Kingdom Brunel is played by Ron Cook.

Programme 2: Brooklyn Bridge

Washington Roebling is played by George Anton

In the mid 19th century, New York was growing faster than any city in the world. A seemingly impossible scheme was devised to unite Manhattan to Brooklyn, spanning the East River, with the longest suspension bridge ever built.

At 1,600 ft from tower to tower, it would be the longest suspension bridge ever built and the first to be made entirely of steel. The two vast gothic towers would have foundations in the East River, larger and to a greater depth than any before. Giant cables lashed between the towers – each with a breaking strength exceeding anything yet designed – would be held in place by great granite anchorages of over 60,000 tons. Yet the ambitious dream of brilliant engineer John Roebling fast turned into a nightmare – a technological feat set against greed, corruption and a double family tragedy.

In July 1869, just a few days after Roebling finally won approval for his plan, his foot was crushed in a freak accident. He developed lockjaw and died 16 days later. Before his death, he entrusted his oldest son, Washington, with the construction of the bridge, urging him to use the new technology of pneumatic caissons. Unknown to father and son, this would prove to be a death sentence.

Caissons, or gigantic diving bells, had not been used on such a grand scale in construction before. At 170 x 100 ft, they would form the base of each tower. Working inside them, men toiled away at the river bed to bury the foundations into the bedrock. Their submerged pressurised airtight chamber was described by the master mechanic Edmund Farrington as a Dante's *Inferno*; intense heat and humidity, dimly lit by gas lights. And bizarrely, the workers began to suffer from a mysterious and debilitating illness – which would later be known as the bends.

On December 1870, the first disaster struck. A fire broke out and, in the oxygen-charged, compressed air, it quickly got out of control. Roebling himself spent the entire night fighting the flames – and collapsed the next morning. Unknown to anyone, he'd been struck by his first case of the bends. Soon workers were dying of the mystery illness and Roebling himself suffered such a severe attack that he became semi-paralysed. He could only continue his father's dream by directing operations from his sick bed.

Barely able to speak or move, the only person he could rely on was his loyal wife, Emily, who liaised between Washington and his men to continue the work. Washington could only monitor progress, observing the bridge from his bedroom window through a high powered telescope.

Construction continued at breathtaking speed with great feats of engineering combined with foolhardy stunts. When the first cables connecting the two towers were swung out across the East River, the

daring Farrington was the first to "fly" across on a boatswain's chair, cheered on by crowds of New Yorkers. Yet this success was followed by the most horrifying accident to occur during the construction of the bridge. While Farrington was supervising the fixing of the wires to the anchors, one of the super loaded cables snapped and whipped through a bunch of workers, maiming two and killing two more.

The entire undertaking was dogged by gross political corruption, with the bridge's leading investor brought to trial. In a further scandal, it was discovered that substandard wire had been woven into the fabric of the bridge and the cables had to be redesigned at a frighteningly late stage.

When the bridge finally opened in 1883, some 20,000 New Yorkers crammed onto it – in the ensuing crush, 12 people died. For Roebling himself, observing the fireworks from his bedroom window, it was a moment of personal triumph. His great achievement, which had destroyed two generations of his family, was to change the New York landscape forever.

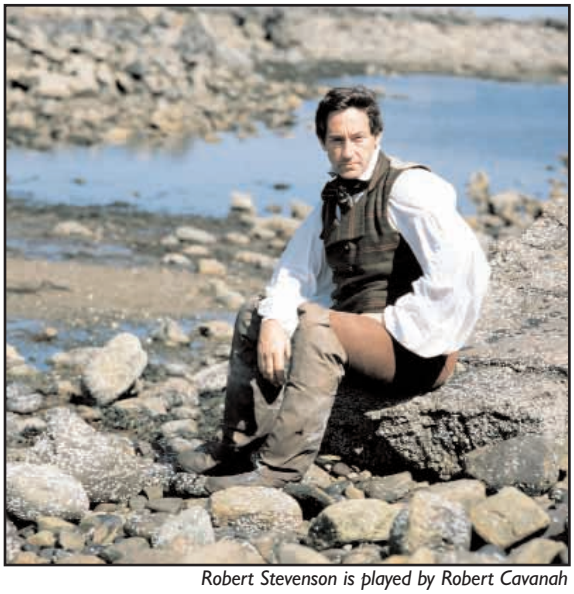
Brooklyn Bridge is written and directed by Paul Wilmshurst. John Roebling is played by Steven Berkoff, Emily Roebling by Debora Weston and Washington Roebling by George Anton.

Programme 3: Bell Rock Lighthouse

The deadly Bell Rock Reef had terrorised seamen for centuries. Eleven miles out to sea, off the coast of Scotland, this vast, treacherous rock lurked deceptively just a few feet below the surface of the water and stretched over a third of mile.

The scene of countless shipwrecks, such was the fear of the reef that, in storms, sailors would risk the rough seas rather than face certain death approaching the Firth of Forth. In one wild night in December 1799, such a violent hurricane raged that 70 ships went down.

Yet one young engineer, Robert Stevenson, dreamed of building the impossible – a lighthouse on Bell Rock Reef. His rivals ridiculed his plan which required building on a rock that was almost



Robert Stevenson is played by Robert Cavanah

constantly submerged, set 11 miles off-shore, in perpetually hazardous seas. Nothing like this had been attempted before. As they predicted, when Stevenson set off with a crew to check out his ideas, the waves and tides were so treacherous around the reef that they could not even reccy the site. Taming the seas would prove to be an extraordinary battle against the elements that was to cost both reputations and lives.

Stevenson, a lighting engineer who had worked with his father to light up Edinburgh, was certain he could win – but no one believed him. This is his story, set against the Westminster establishment, distinguished engineers, ever-greedy financiers – and, above all, the elements. During the Napoleonic Wars, as his plans were still thwarted, navy ships continued to go down with countless lives lost. The worst disaster was in 1803 when HMS *York* was shipwrecked on the reef with the loss of nearly 500 lives and 60 guns – yet still no one would listen to the lighting engineer.

Stevenson never lost faith in his plan, and after years of campaigning and researching lighthouse design – not to mention an Act of Parliament – in 1807, he finally won the backing he needed. Out at sea, he pushed his workers to the limit to create the impossible. They lived and worked moored above the dangerous reef for months on end. Men and children died as they were washed out to sea,

working against waves, storms and sea fogs. In one horrific incident, as their boats lost anchor and drifted out to sea against a fast-rising tide, the whole crew nearly drowned. Even as the lighthouse began to take shape, waves 60 feet high crashing against the walls could wash workers out to the sea to their deaths. Stevenson would not be deflected from his course, even when his own children had died back home.

Yet this was to be Stevenson's triumph. By February 1811, the lighthouse was built. In an historic moment, the first keeper, John Reid, lit the lamps which beamed out over the cold grey northern seas – lights which still shine to this day.

Bell Rock Lighthouse is directed by Chris Spencer. Robert Stevenson is played by Robert Cavanah.

Programme 4: Transcontinental Railway

The eastern United States was crowded with immigrants while the west held the tantalising promise of vast riches and gold. Between the two lay a harsh wilderness, Indians and months of wagon travel that few survived. A railway was needed.

In 1862, President Lincoln signed the Pacific Railroad Act authorising the construction of 1,800 miles of track. Two corporate giants were pitched against each other in a race to join the east and west coasts of America – "to shrink the continent and change the whole world". The Union Pacific Company was led by the corrupt Dr Thomas Durant who was intent on bleeding the railroad dry. The Central Pacific was funded by the "Big Four" Sacramento shop keepers: Crocker, Stanford, Huntington and Leland.

Competition between the two companies was ruthless and uncompromising but an even bloodier battle was fought on the ground. The surveyors who planned the route struggled through wilderness, living off buffalo, elk and antelope. Behind them followed the two workforces of labourers – each the size of Civil War armies. Indian attacks, brutal weather, floods, food shortages and even a war stood between them and success.

Dr Thomas Durant is played by Robert Young

Both companies got off to a slow start. At the Union Pacific, Dr Thomas Durant, a publicity-seeking showman, after spending $500,000, had only advanced a pitiful 40 miles. The Big Four at the Central Pacific hired slave driver Harvey Strobridge, but even he was defeated by the seemingly impassable solid granite ridges of the Sierra Nevada. A railroad at such high altitudes had never before been contemplated.

While the Central Pacific team was battling with the Sierras, Durant faced another problem in the desolate wilderness of prairies. Native Indians waged guerrilla warfare, desperate to halt progress at any cost. At the bloodthirsty massacre of Plum Creek, Nebraska, they derailed the train and burnt the tracks. The workers who weren't scalped and mutilated, were thrown onto the flames. One worker, Thompson, who miraculously survived, left a horrific account of being scalped alive.

Durant hired the toughest men he could find but this soon made matters worse. In Cheyenne,

Wyoming, murders among the workers – in the "hell on wheels" shanty towns that sprang up at the end of the line – outnumbered accidental deaths. Durant's henchmen, the Casement brothers, two legendary, gun-swinging cowboys, weren't afraid to restore order by literally shooting the workers. His railway gave birth to the Wild West.

Meanwhile, Strobridge's men at the Central Pacific were still struggling to bore the Summit Tunnel. But conditions rapidly deteriorated into one of the worst winters in history, with 44 blizzards. Reduced to emergency food rations, men were trapped as temperatures plummeted to minus 20 degrees and survivors lived in terror of the frequent avalanches which buried entire camps. To speed up progress, a chemist was hired to experiment with nitro-glycerine – an explosive which was five times more powerful and 13 times more destructive than the existing "black powder". Although tunnelling was faster, accidents were so horrific that the management was forced to abandon its tests.

Far removed, in the city boardrooms, the leading railway engineers and businessmen battled for supremacy – marshalling unprecedented resources and encouraging speed over caution in the fight for funds. Locomotives, rails and spikes were hauled through America and dragged across the plains.

Yet this was a race that both sides won. As both railways converged on Promontory in Utah, they were so hell-bent on clocking up the mileage that they overlapped by 100 miles, until forced by the Government to link up.

On 10 May 1869, 1,800 miles and 21 million hammer blows later, the tracks from east and west were about to be joined. Ironically, Durant was kidnapped on his way to the celebration by rebel workers who hadn't been paid.
When the final spike, made in gold, was driven in at Promontory Summit, it held the attention of a nation: nothing like this had been seen before. As for the railway pioneers themselves: Dr Durant became very rich – too rich – until an investigation revealed corruption and fraud. The Big Four kept their fortunes – Crocker alone was worth $40m. And the railway became the catalyst for the vast expansion that was to make America the industrial giant of the world.

Transcontinental Railway is written and directed by Paul Bryers. Dr Thomas Durant is played by Marcus D'Amico.

Programme 5: London Sewers

In the hot summer of 1858, a window was opened in the Houses of Parliament and Britain's great government suddenly ground to a halt. Disraeli and other leading MPs fled from their chambers, overwhelmed by the fearsome stench of decaying sewerage. Fleeing the "Great Stink" for the country, MPs realised that they had to deal with the horror and filth of London's sanitation which had been literally building up on their doorstep for centuries.

Despite London's rapid expansion, little had changed since the "pissing alleys" of Tudor times. The poor were worst affected as sewage seeped through the floors of their homes or ran down the walls. Some even scrounged a hopeless living from sewage: the desperate "toshers" and "mudlarks" – as they were known – who sieved through refuse searching for bits of old tin or oyster shells.

Worst of all, although no one yet knew how or why, killer diseases like cholera swept through the city in a series of epidemics – killing more than 30,000 by the mid 19th century in London alone.

Utterly at a loss, the medical profession added to the problem by supporting the idea that disease spreads through smell. This prompted the reformer, Edwin Chadwick, to call for cesspools to be drained away from houses and into the Thames.

Unwittingly, he poisoned the city's drinking water and sealed the fate of thousands.

Slowly, clues to the cause of cholera were being pieced together in a small surgery in Soho. John Snow was the first to crack the causes of cholera – but nobody believed him. It was to take two more devastating epidemics before the medical establishment was even prepared to test his theory.

This scientific detective story entwines with an epic tale of Victorian construction. As the grotesque smell from the Thames brought London to crisis point, the level-headed Joseph Bazalgette proposed an impossibly ambitious scheme: 318 million bricks would link over 1,000 miles of street sewers with 82 miles of sewerage super-highway.

His vision required extraordinary and novel engineering solutions to set the bricks into watertight tunnels and create vast steam pumping engines, installed in gothic cathedrals of engineering, designed to raise the sewage up to surface levels before it could run under gravity into the sea. London had to be redesigned to accommodate the vast scale of his plan. In 1865, with the first phase of the sewers completed, Bazalgette celebrated with the Prince of Wales in a barge trip down the Thames as Londoners cheered.

Their success was short-lived for cholera was to strike a further deadly blow. On 27 June 1866, a labourer and his wife contracted the disease and soon died. Investigators found their sewage had infected the East London Water Company and unleashed an epidemic that would kill thousands more. After an embarrassing cover-up, it was found that the Water Company was at fault, and not Bazalgette's magnificent system.

This was the last time cholera ever swept though London but, more importantly, this final epidemic provided the proof that the medical establishment needed to accept John Snow's theory. With cholera now conquered and a sewage system fit for a modern metropolis, Bazalgette was deemed to have saved more lives than any other Victorian official.

London Sewers is directed by Ed Bazalgette. Joseph Bazalgette is played by Mark McGann.

Programme 6: The Panama Canal

When French engineer Ferdinand de Lesseps returned triumphantly to Paris after completing the Suez Canal in 1869, he was hailed as a national hero. Thousands raced to invest in his next, even bolder scheme – to build a great canal across Panama.

His dream would cut a swathe across the South American continent and unite the vast oceans of the Atlantic and Pacific. Fortunes seemed assured as shipping would no longer have to face the terrors of Cape Horn to sail from one side of America to another.

In 1879, the Paris Geographical Society set up a committee to investigate how best to turn the plan into reality. De Lesseps favoured a sea-level canal which would slice through the mountains to unite the oceans. In a furious debate, his rival, Baron de Lepinay, claimed this was impossible and proposed a gigantic lake and lock canal system. Ignorant of the dangers, the committee backed the eminent de Lesseps.

On 1 January 1880, de Lesseps set out confidently to Panama with his daughter to dig the first spade of earth at the mouth of the Rio Grande. But times and tides conspired against them and they failed even to find the correct site – an omen of what was to come.

As a symbol of French national pride, thousands trekked to Panama to find themselves facing impenetrable jungle, deep swamps, poisonous snakes, torrential rains and deadly mudslides. De Lesseps put his son, Charles, in charge of daily operations but they were soon to face two more formidable enemies – malaria and yellow fever. Men literally walked off ships to their deaths and thousands succumbed to the horrific conditions of "fever coast". Nuns unwittingly made things worse by providing breeding sites for mosquitoes in the gardens of their hospital.

With 20,000 dead by the late 1880s, the "Panama Affair" was rocked by financial scandal and brought down the French government. Shares collapsed, investors lost their money and Ferdinand and Charles de Lesseps were both tried for bribery. The dream of the Panama Canal evaporated. Ruined and disgraced, Ferdinand died, shamed and quite insane, in 1894.

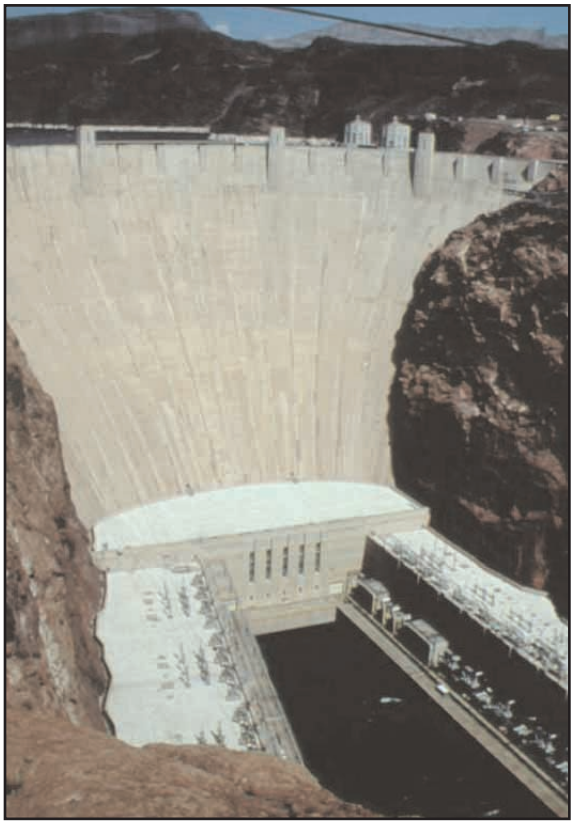
Four years later, as America headed to war with Spain, its Navy's first and only real battleship, US *Oregon*, took 67 days to get from San Francisco via Cape Horn to the Caribbean. By the time it finally reached its destination, the war was practically over. Roosevelt needed little convincing. The idea of the Panama Canal was reborn.
Roosevelt pioneered a new plan and forced the countries of South America to agree terms after a stand-off with a fleet of warships. He personally appointed experienced engineer John Stevens to direct the scheme. Stevens saw it as certain death – every killer disease known to man was endemic in the region – but against his better judgement he agreed to the President's wish. His first step was to clear the area of malaria and yellow fever. Scientists had finally established that these diseases were carried by mosquito. Through his Chief Medical Officer, William Gorgas, Stevens launched one of the largest all-out assaults on nature – fumigating houses, draining pools and digging ditches – until, by 1905, he'd completely eliminated yellow fever.

In an historic U-turn, Stevens also reverted to the original scheme proposed by de Lepinay of using a gigantic lake and locks system. His plan would see the creation of the largest artificial lake in the world, the first constructional use of a relatively new material called concrete and the excavation of the impassable Culebra Cut, or Hell's Gorge – as it became known. But just when it seemed he might win, he suddenly resigned and the military had to take over.

By 1914, the canal was finally opened – the greatest engineering feat the world had seen. And in France, De Lesseps' son, Charles, at last saw his father's name restored to honour and his own reputation cleared.

The Panama Canal is directed by Phil Smith. Ferdinand de Lesseps is played by John Walters.

Programme 7: The Hoover Dam



With its impassable canyons, dangerous rapids and severe seasonal variations that could reduce the western states of the USA to a desert, the Colorado was one of the most dangerous and unpredictable rivers in the world. But in 1902, engineer Arthur Powell-Davis dreamed of creating the largest dam ever and taming the wild river.

The scale of his ambition was matched only by the scale of his plan. At 727 feet, the dam would stand 60 stories high and would have a larger volume than the Great Pyramid at Giza. With electricity and irrigation, the deserts of the west would bloom and the face of America would change forever.

His dreams turned to nightmares as 20 years passed in legal wrangling and funding disputes and he left the project a bitter man. It took the desperate conditions of the Great Depression to revitalise the scheme, which became a symbol of hope for thousands.

Several engineers bid for the project but one man stood out: the ruthless and dedicated Frank Crowe. He had his choice from thousands of poverty-stricken workers, queuing up to labour in desert temperatures of more than 120 degrees for a few dollars.

Many lives were lost as the entire Colorado River had to be diverted to make way for construction. The workers built four mammoth tunnels through nearly a mile of rock, using innovative contraptions called drilling jumbos. These trucks, stacked tall with tiers of 24-30 drills, would back up against the rock face to bore holes for the explosive. Carbon monoxide poisoning and injuries from cave-ins were common as men struggled deep underground with power tools and dynamite.

Safety was sacrificed for speed. To his workers, Frank was both God and the Devil; they nick-named him "Hurry Up Crowe". But by 14 November 1932 – 11 months ahead of schedule – they were finally ready to re-route the raging Colorado.

Work then began on the dam itself. At its base, some of the poorest workers removed over half a million cubic yards of mud before reaching the bedrock foundation – many dying of heat exhaustion.

Most dangerous of all, in spectacular stunts, the "high-scalers" had to swing right out over the sides of the Grand Canyon to blast the canyon walls in order to create a smooth surface for the concrete. In one daring feat of heroism, it is said that Oliver Cowan managed to swing out to catch hold of a falling man, while himself dangling at a precipitous height. The rock face was a maze of live air hoses, electrical lines and other climbers, and falling objects were the most frequent cause of death. The men soon improvised the first use of hard hats by coating cloth hats with coal tar.

By June of 1933, Crowe was ready to pour the concrete. The men constructed the base, column by column; if the concrete had all been poured at once, the heat it generated would take 125 years to cool down. Crowe chose an unusually dry mix which, although stronger, gave the men little time before it started to harden. To combat this, he pioneered a new complex series of cranes, cables and buckets to guarantee speedy delivery.

For the next two years, workers poured concrete round the clock – 24 hours a day, seven days a week. Six billion kilograms later, the dam was finished. On 1 February 1935, the diversion tunnels were blocked. The Colorado resumed her natural course and the dam went into operation.

Frank Crowe, decked in glory, walked away with a $350,000 bonus. His great triumph had come at a cost. Throughout the four gruelling years, over a hundred lives had been lost. In a curious twist, shortly after Roosevelt's inaugural speech, a man called Patrick Tierney fell to his death. He was the last to die on the project and his father, 13 years earlier, had been the first.

Hoover Dam is written and directed by Mark Everest. Frank Crowe is played by Jaudon Benedict.