UNDERGROUND ITEMS FROM THE TELEVISION
AN OCCASIONAL SERIES

by Paul Creswell

BUILDING THE LONDON UNDERGROUND

Wednesday 11 July 2012. Channel 5 from 20.00 to 21.00.

Every morning, four million people descend on to the London Underground, which is the largest underground railway system in the world. A billion passengers a year use a system which was not designed to carry nearly so many. The network cannot cope with such a level of demand. Now, over sixteen billion pounds is being spent to enhance the system.

There is to be a fleet of new trains, twenty-five miles of new tunnel and thirty new stations. (Your reviewer paused to wonder whether or not Crossrail was included in some of these statistics?). A spokesman told us that the engineering involved was rather like performing open heart surgery on a tennis player (whilst playing) or a marathon runner (whilst running).

Four key inventions have allowed the adoption of underground railways around the world. The programme referred to each of these as 'Leaps', which was probably a fair description. The first 'Leap' described was concerning the progress made in tunnelling techniques since the first tube railways were constructed.

In the nineteenth century, the main line railways were not allowed to encroach into central London for fear that they would cause problems to all the historic buildings. Thus they all terminated at the edge of London, with commuters making their way on to the streets to complete their journeys. This was causing massive traffic problems.

The traditional method of constructing 'cut and cover' tunnels was demonstrated, using some remarkably good graphics. Good that is, except for the horses and carriages, which were travelling on the right hand side of the road!

James Henry Greathead, an engineer, had the idea that a railway could be 'burrowed' under the ground and thus was born the idea for the 'City and South London Railway'. The tunnels would be made by a 'Tunnelling Shield', where workers would excavate a small section of tunnel (about 60 centimetres) and the shield would then push itself forward against the already completed tunnel rings, such that further rings could be inserted in the newly-dug section. This method worked particularly well in the prevalent London clay. The work was carried out twenty-four hours a day at a rate of about three metres a day, with, of course, no disruption to road traffic – the curse of the 'cut and cover' method.

The City and South London Railway was completed in four years and carried five million passengers in its first year of operation. We were shown a section of tunnel and a close up of a tunnel ring – embossed 'GN&CR'. Relevant perhaps, but not quite the C&SLR! Shields went on to dig most of the tunnels for the London Underground and also led to its nickname – 'The Tube'.

One hundred years after the first tunnels were dug, the underground needed a big upgrade. Engineers took the idea of Greathead's machine and pushed it to the extreme. It is now called a 'Tunnel Boring Machine'. This has cutters which chew their way through the earth and rocks and drop the excavated material on to a conveyor belt, which removes it from the constructed tunnel. Mesh is placed over the tunnel surface (to stop the tunnel caving in) and quick-drying concrete is then injected, by robot arms, on to the mesh, to give solidity. The machines can complete up to forty-five metres a day, in the right conditions. Two machines were utilised on the Jubilee Line Extension.

An obstacle was encountered in the shape of Big Ben. The clock tower was built in the 1850's on a shallow raft foundation and tunnelling had to pass close to it. There were fears that the clock tower could be affected to a possibly dangerous degree. Professor John Burland, a Civil Engineer, who had previously saved the Leaning Tower of Pisa, was retained to give advice. Calculations showed that if the tower deviated by more than 35 millimetres, cracking might well occur (whether this was to the tower or to its foundation was not made clear).

Engineer Gem Stansfield (previously seen on BBC's 'Bang goes the Theory'), explained what was done by means of a model. Pipes were inserted under Big Ben and grout (a mixture of sand, cement and water) was pumped in, in strictly regulated quantities, so that any movement of the tower's support raft could be compensated for as the grout set. Automated plumb lines were installed inside the tower, giving constant readings to detect movement. Three-hundred tons of grout was used in the process. In the outcome, the tower did move some 35mm to the north, but stopped at that position.

It took six years for the Jubilee Line tunnels to reach Canary Wharf. The construction of the City and South London Railway had proved that you could project a railway without disturbing city streets.

Engineer Gem Stansfield demonstrated, with a small model steam locomotive and train, the problems encountered as you tried to add more and more carriages on the gradients involved. Of course, you could add more locomotives, but that simply added to the already dirty and unhealthy conditions.

In 1884, engineer Frank Sprague developed the electric elevator, this being easily fitted in to the ever taller skyscrapers that New York was building The size of existing steam and hydraulic powered elevators was causing serious space problems in the new (and ever taller) buildings. Some years later, Sprague thought that the 'vertical' arrangement of elevators could be placed horizontally, to provide a much more efficient and much cleaner means of powering underground trains.

The New York subway embraced Sprague's new technology in that they dismissed steam trains as being too inefficient and dirty. By providing electric motors in each carriage, trains would be better able to crest gradients and cause no pollution to passengers. Furthermore, trains could be increased in length at busy times, with the proportion of power to each carriage still broadly the same. The first line in New York, which opened in October 1904, was a resounding success and carried three-hundred thousand passengers a day into the city.

Sprague had really made the modern city a working possibility. He had inspired the means of getting from home to workplace and also the means of ascending and descending the workplace itself.

Views were shown of London tube trains under construction at Derby. We were told that they could not be made larger because of the constraints of the tunnels. However, modem technology had allowed the 'walls' to be thinner, giving space for ten more passengers in each carriage. Each train takes the power needed for some three-hundred homes.

London tube carriages being delivered by road were shown, as was the problem of getting them on to the working railway. This was perhaps a slight exaggeration, compared to almost any other delivery location. We saw the carriages being lowered into the 'hole' at Waterloo, for (we assume, as it was not stated) the Waterloo and City Line! The narrator commented that the slightest gust of wind would turn the elevated carriage into a 'wrecking ball'! Twenty-four hours had been allowed to get twenty carriages lowered to the railway, but all was completed with some hours to spare. Each carriage was expected to travel 3 million miles in its lifetime, equivalent to one hundred trips around the earth.

Once Sprague had shown the way in 1895, it was not long before 'everyone' wanted an underground station in their locality.

Paris was one example given, where 'everyone' wanted access to a system. In the late nineteenth century, it was one of the most densely populated cities on the planet. To build over one hundred stations involved a sensational 'vanishing act' by engineer Fulgence Bienvenüe.

Paris lies in a valley, through which runs the River Seine. The ground each side of the river is very waterlogged, as the river tends to project sideways into the adjacent ground. Also, in the north of the city, exist many ancient catacombs, records of which do not exist.

To build the stations at Saint-Michel and Cité (these being opposite sides of the river), Bienvenüe decided upon a unique construction method to cope with the treacherous soil conditions. The stations were first constructed on the surface. Gangs of labourers then toiled away beneath each station, excavating the soil. As the earth was removed, the station was gradually lowered, so that it effectively 'sank' into its final resting place, where it was anchored by concrete. Working conditions were terrible and five men died during the work.

To link these two stations under the river, Bienvenüe sank steel boxes into the river bed, then workers in pressurised chambers dug the boxes into the river bed and finally joined them together. One bank of the river presented a particular challenge, as there was a railway there. This would have meant tunnelling through the impossibly wet soil. Bienvenüe's solution was to sink pipes into the soil and pump coolant through them. Once again, Gem Stansfield demonstrated, using another model, how this was achieved. The coolant caused the wet soil to freeze solid. Gem described this as an ‘audacious’ plan! Once the ‘ground’ was solid, he could drill through the soil (here using a hand drill), just as Bienvenüe’s workforce would have done in real life. It took forty days to freeze the ground.

In twelve years, Bienvenüe built one-hundred and twenty stations and almost sixty miles of track.

In London’s Docklands, a massive new station is under construction for Crossrail. The station ‘box’ is as large as Canary Wharf tower laid on its side. Because the area is already fully developed, the only place for such a large structure was in one of the docks. This was described as like trying to sink a bath into water – the more you push down the harder it tries to pop back out. The process started with construction of a watertight basin, using steel piles and earth. This was then drained and a hole was dug inside it. Groundwater was continuously pumped out and concrete was poured in to form the station ‘box’. Piles were used to lock the station in place – each one longer than two double-deck buses. With so many offices in the area, noise could have been a big problem. Sinking of the 1.2 metre diameter piles was achieved by use of pressure alone, thus obviating the more usual constant pile-driving. It took a year just to drain the water before work could commence. We were shown the two levels of the station box – ticket hall and track bed. Once the box was completed, tunnel boring machines could commence work on the running tunnels.

The programme then looked at safety. We were shown footage of the King’s Cross fire of 18/11/87, a time of 7.43 p.m. being quoted. This started as a relatively small fire, five metres or so down an escalator shaft. Shortly after this, a wall of flame exploded into the ticket hall, which was engulfed in flames and smoke. Thirty-one people were killed in what was the worst (fire) disaster in the history of the London Underground.

Forensic experiments were conducted to establish exactly what turned a small fire into a ‘firestorm’. Once again Gem Stansfield had a model to demonstrate to viewers what really happened. In normal fires, the fumes rise upwards and the fire spreads, fairly slowly, sideways. In the angled escalator shaft, the fumes have to follow the shaft and the fire itself spreads up the stair treads, thus preheating the material ahead of the actual fire. This is known as the ‘Trench Effect’. Flames thus travel at a higher speed, releasing a greater volume of toxic gases. The gases themselves can ignite and this happened when they reached a high enough temperature to achieve ignition.

Fires are clearly more deadly below ground than above it. In modern stations there is practically nothing that can burn. Escalators are now metal, walls and ceilings are steel and concrete. Stations are thus so fire-proof that they do not have sprinklers, at least in the passenger areas.

Fire on a train in a tunnel is a different matter. Toxic fumes can spread down the tunnels and choke passengers on the train affected (and, one assumes, other trains). Powerful fans suck air into the tunnels, at a rate of three-hundred litres per second. This pushes the air towards the next fan shaft, thus both removing the fumes and providing a supply of fresh air at the same time. This allows passengers to escape the train concerned.

Your reviewer considered that this programme was interesting, informative and, so far as he could tell, accurate. The graphics and models used were excellent and the explanations offered were of the sort that virtually anyone could understand. One of my usual ‘moans’ about programmes that I review is the inclusion of irrelevant shots and scenes – ones having absolutely no bearing on the subject at hand or even the whole programme! This did ***not*** happen here, so congratulations to Windfall Films for a truly excellent and well researched offering! The film was dated 2012.