PDHonline Course C658 (5 PDH)

UNDERGROUND: How The TUBE Shaped London

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How *The TUBE* Shaped London

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The earliest thoughts of underground railways in *London* go back to the mid-1830s. However, the first proposal with any serious sort of backing was put forward in 1851. The *Great Northern Railway* (GNR) had just been opened using a temporary station north of the present site of *King's Cross* station. The plan was for an underground line of eight tracks from the temporary GNR station heading southeast, under a newly built road, to a large station complex at more or less the present site of *Farringdon* station. The idea was to attract a substantial "through-running" traffic of GNR trains and also *Great Western Railway* (GWR) trains after a suitable link was built. Two of the tracks were to use the GWR's broad gauge of 2141mm (7'-0.25"). The *City Terminus Company* (CTC) was thus formed to achieve this goal.

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In 1851, *Charles Pearson*, solicitor to the *City of London*, devised the plan to build an "Arcade Railway" beneath *Farringdon Road* to connect the GNR at *King's Cross* with *Farringdon*, in the City of London, thereby reducing traffic on the capital's congested streets. The idea of an underground system had originated with Pearson who persuaded the *City Corporation* to put up most of the money for fear that the congestion was adversely affecting business. The GNR, recognizing advantages for its own passengers, agreed to subscribe £170K, a substantial proportion of the capital required. Unfortunately, one of its officers misappropriated the money. The culprit; *Leopold Redpath*, was one of the last criminals to be transported to the penal colony in *Australia*. Charles Pearson died in 1862, just a few months before his vision was realized.

Left: Charles Pearson

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The North Metropolitan Railway

7

In the meantime, another proposal was being formed; the *Bayswater, Paddington & Holborn Bridge* (BP&HB). This line would run west from *King's Cross* to a terminus under *Sussex Gardens*, under what was then called the *New Road* (now *Euston Road*). Back in 1829, this route formed part of the first horse-drawn bus service in *London* which was highly profitable. The *Paddington Vestry* objected to the Sussex Gardens terminus thus, BP&HB cut back their proposed route to terminate in the area of the present *Edgware Road* station. The company was renamed the *North Metropolitan Railway* (NMR) and received its *Act of Parliament* in 1853 ("North" was later dropped from the name). Rather than building the line as authorized, the NMR arranged a merger with the CTC, allowing an end-to-end route to be considered. The NMR owners were mostly interested in local traffic and they dropped the proposals for extra tracks and a major terminus. This also helped reduce opposition to the plan since some people wanted the main-line railways to advance no further south into the city (none ever did). Instead, a terminus under the *General Post Office* at *St. Martin's-le-Grand* was proposed (this would have allowed for the convenient carriage of mail). Meanwhile, at the western-end, the line would be extended along *Praed Street* to in front of *Paddington* station and there would be a link to the main-line as well. In return, the GWR agreed to invest in the railway which would be built with mixed gauge track; partly the standard-gauge (used by most railways) and partly the broad-gauge used by the GWR.

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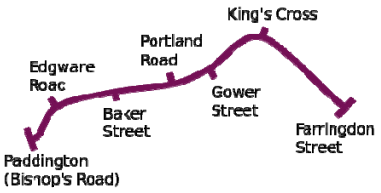

The resulting merged company was renamed "Metropolitan Railway" and received its first *Act of Parliament* in 1853. Both endpoints were changed yet again before the line was actually constructed. In the east, it was cut short to *Farringdon* while in the west, the *Paddington* station was moved from the front to the north side of the GWR station, where it did not need to be underground. Furthermore, by diverting the main route on to what would have been the link to the GWR, it was possible to eliminate about 500m (0.3 miles) of tunnel to the original station.

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"…The directors are rapidly possessing themselves of the land, and there is every reason to hope that the commencement of the year 1862 will find the line open and in active work. The company obtained their first Act in 1853, but the breaking out of the Crimean war, and the disturbances of the monetary system resulting there from, rendered it impossible to obtain the capital necessary for carrying out the undertaking. After many unsuccessful efforts in various directions the directors succeeded in obtaining the necessary assistance from the Corporation of London, who became shareholders to the extent of £200,000. The capital of the company consists of £850,000, in shares of £10 each: of this amount £200,000 is held by the Corporation, £175,000 by the Great Western Railway Company, and the remainder by the general public. The contractors are Messrs. Smith and Knight, and Mr. Jay, both firms being well known in connection with works of this description. Messrs. Smith and Knight are constructing the western portion of the line from Paddington to Euston-square, and Mr. Jay the eastern portion from Euston-square to Farringdon-street…"
The Illustrated London News

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"…Utopian and one which, even if it could be accomplished, would certainly never pay…the whole idea has been gradually associated with the plans for flying machines, warfare by balloons, tunnels under the Channel and other bold but hazardous propositions of the same kind…"
The London Times
RE: the *Metropolitan Railway* would connect *Paddington*, *Euston* and *King's Cross* to the *Farringdon* terminus. Most of the capital required was contributed by engineering firms who hoped, thereby, to gain contracts to build the proposed railway. They included the firms owned by *Thomas Brassey* (who had built railways throughout the world and who had also constructed London's main drainage system) and by *Sir Samuel Morton Peto*.

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"…The need of railways communication between the City and the great series of railways on the north of the Thames, both for passengers and goods, had been long grievously felt, but the difficulties in the way of carrying a railway into the City appeared to be almost insuperable. To have a railway, after the American fashion, passing through a densely-populous district, and crossing on the level our overcrowded streets and thoroughfares, was utterly out of the question; and scarcely less so to carry an unsightly viaduct through the heart of the Metropolis. The only alternative was that adopted by the Metropolitan Company - namely, that of an underground communication, by which the most densely-crowded districts could be traversed without the slightest annoyance or obstruction to the existing traffic…"
The Illustrated London News

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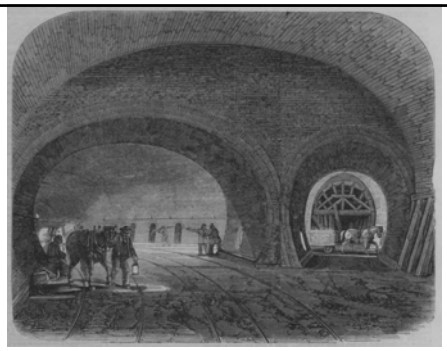

Above: caption: "Junction of the Great Northern Railway at King's Cross with the Metropolitan Railway." In addition to the link with the GWR, there were three junction curves linking the *Metropolitan Railway* to the GNR at *King's Cross*.

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"…the railway starts from opposite the Great Western Railway Hotel at Paddington, with a fork up the South Wharf-road to join the Great Western Railway on the level, near the site of the old passenger station. The line then crosses the Edgware-road, and enters the New-road, which it follows to King's-cross, it being one of the peculiarities of this railway that it occupies, throughout the greater part of its course, the under surface of the existing roadways, thus avoiding the enormous expenditure which would otherwise have been necessary for the purchase of valuable house property. From King's-cross, the line, avoiding the House of Correction at Coldbath-fields, and passing for some distance under the Bagnigge Wells-road, takes an almost straight course to Farringdon-street; and this part of the railway, except when passing under roadway, will be in open cutting. In addition to the principle terminal stations at Paddington and Holborn-hill, commodious passenger stations will be erected at the Edgware-road, Baker-street, in the triangular plot of ground opposite Trinity Church, Regent's-park, Hampstead-road, Euston-square and King's-cross. The terminal stations, and the Edgware-road, Regent's-park, and King's-cross stations, will be open, or covered with a glass roof; the others, as that at Baker-street, will be commodious, airy, and well lighted with gas. The ascent and decent to the underground stations, will be no greater than at the Great Western station at Paddington and other metropolitan lines…The main tunnel will be 20.5 feet broad by 16.5 feet high. The stations, which will not be in the tunnel but in open cuttings, will be at the following places - Paddington, Edgware-road, Baker-street, Portland-road, Gower-street, King's-cross, and Victoria-street. There will be branch lines from the North-Western and Great-Western Railways…branch railways will consist of single lines, running through tunnels of 13 feet 8 inches broad and 15 feet high…"
The Illustrated London News

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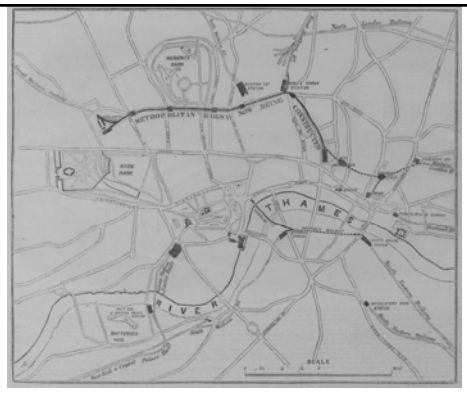
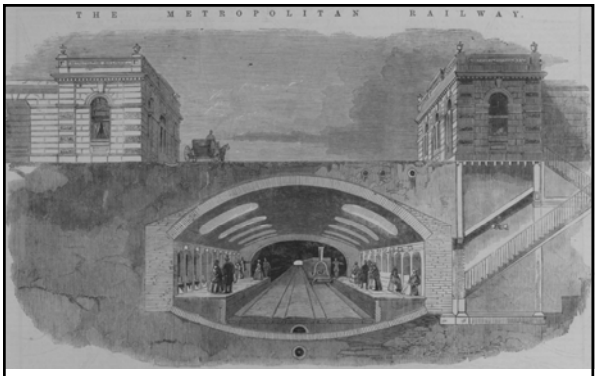


Above: caption: "Map of the Metropolitan Railway"

15



Above: caption: "Proposed Station a Baker Street"

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Fowler's Ghost

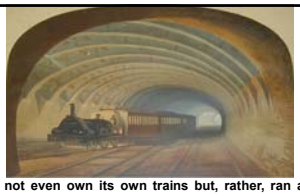
17

"…The traffic is to be worked by locomotive engines of a novel and ingenuous contraction. In order to obviate the annoyance in a tunnel arising from smoke and the products of combustion, the locomotive will have no firebox, but will be charged with hot water and steam at a certain pressure to be supplied by fixed boilers at the termini, and will be furnished with a large heater to assist in maintaining the temperature. It is estimated that each locomotive will thus carry with it sufficient power to enable it to effect the double journey. In order to test the efficiency of locomotives constructed on this principle the directors have instructed Messrs. Stephenson and Co. to build a broad-gauge engine, which will be employed in the construction of the works..."
The Illustrated London News
Left: "condensing" locomotive. This engine remained in service until the 1960s.
Right: one of six "K-Class 2-6-4" steam locomotives introduced to the *Metropolitan Railway* in 1925 to haul freight trains

18

An additional concern was motive power. Steam locomotives were the only practical possibility, but main-line experience showed how slowly smoke and steam would dissipate from tunnels. Furthermore, unlike typical railways of the day, the Metropolitan would have a frequent service with many closely-spaced stations in the tunnels. The first proposal was for fireless steam locomotives whose boiler would be filled with sufficient pressurized steam (presumably fed from a fixed installation) at each end of the journey. But these had not yet been successfully developed and what was actually built was a locomotive with a mass of brick inserted around the firebox. The fire would burn intensely in the open-air sections of the line, then be damped down for the tunnel sections, allowing the hot bricks to heat water into steam for propulsion. However, the prototype was such a failure (it was hardly able to move itself) that it gained the nickname "Fowler's Ghost." The Met's chief engineer was *John Fowler*, the leading railway engineer of the day, who would go on to create the *Firth of Forth* railway bridge in *Scotland* (his salary of £137,700 would be worth about £10 million today). Instead, the actual service was operated from opening right up to electrification with "condensing" locomotives whereby the exhaust steam was diverted into water tanks. As the steam would heat the tank water to boiling, it had to be drained and replaced with cold water at the termini. This became impractical on completion of the *Circle Line* in 1884, and thereafter the drivers would sometimes have to release steam into the tunnels to keep the train from stalling. Despite the existence of ventilation shafts in the tunnels, the smoke and fumes remained a problem. However, such discomfort did not dissuade the public from using the underground railway.

19



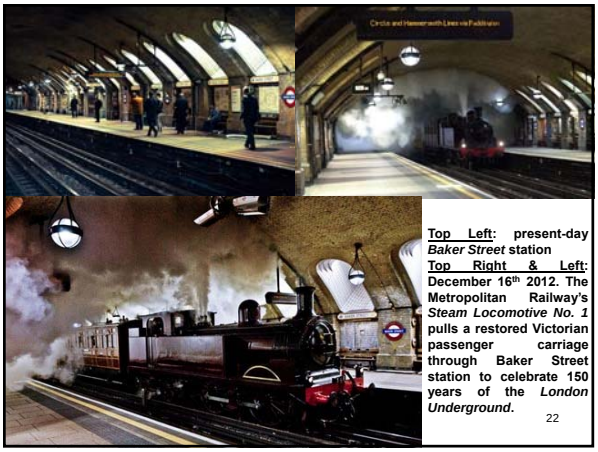
Originally, the Met did not even own its own trains but, rather, ran a service with broad-gauge GWR rolling stock. No services were run from other railways and the *King's Cross* links went unused. When it was decided to add services from the GNR, the GWR realized that the eastern-end of the line would be at capacity and unable to accept the new services they were planning, resulting in a dispute over who would operate many of the trains. Thus, the GWR set a short deadline after which it would withdraw the use of its stock. Instead of capitulating, the Met put into place a stock-building program and in the meantime, borrowed replacements from GNR. This required the GNR to hurriedly convert some engines to condense their exhaust steam via a flexible pipe into the tender. The GNR stock did the job until the Met introduced its own standard-gauge engines in 1864; eighteen 4-4-0 tank locomotives manufactured by *Beyer, Peacock & Company.* The locomotives' condensing apparatus (intended to direct steam into cold water tanks on the engine) was not very efficient and the atmosphere in the underground stations was often foul. After only a few months of running their trains along the new line, the GWR withdrew and all Met trains ran on standard-gauge rails thereafter.

Above: a lithograph of a GWR broad-gauge steam locomotive on the *Metropolitan Railway* line near *Paddington* station

20

Above: lithograph of steam locomotive approaching *Baker Street* station on the *Metropolitan Railway*

21



Top Left: present-day *Baker Street* station

Top Right & Left: December 16th 2012. The Metropolitan Railway's *Steam Locomotive No. 1* pulls a restored Victorian passenger carriage through Baker Street station to celebrate 150 years of the *London Underground*.

22

23

"…It is intended to run light trains at short intervals, and calling at perhaps alternate stations, and all risk of collision will be avoided by telegraphing the arrival and departure of each train from station to station, so that there will always be an interval of at least one station between the trains…"

The Illustrated London News

Above: early 1860s view of *King's Cross* Underground station in the 1860s. Illustrations from the time invariably depict middle-class passengers using the Underground, despite the disproportionately high number of workmen's fares and third-class tickets sold by the Met. In fact, in May 1864, the Met became the first railway in *London* to introduce discounted workmen's fares.

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Cut and Cover

25

"…the mode of construction is to open the ground, construct the archway, and then replace the surface. In this manner the whole of the New-road will be taken up and re-laid in sections. This is not only a much cheaper process than of tunneling, but it admits of the work being finished in a much more complete style, and rendered perfectly watertight. The works have been commenced at the Great Western Station and at the Great Northern station to secure a ready outlet for the immense mass of excavated earth, gravel, etc.; and a large portion of the preliminary work of the reconstruction of the sewers has been already accomplished…"

The Illustrated London News

RE: to build the *Metropolitan Railway*, streets along the route were dug up, tracks laid in a trench, covered with a brick-lined tunnel and the road surface replaced. Known as the "cut and cover" method, it was quick and effective but created as many problems as it was designed to solve. The congestion caused during construction led to its abandonment towards the end of the *19th Century*. Work on the world's first underground railway began in March 1860 when the Metropolitan Railway began building a tunnel more than three-miles long from *Paddington* to *Farringdon Street*.

26

The chosen route ran beneath existing main roads to minimize the expense and inconvenience of demolishing buildings. Originally scheduled to be completed in twenty-one months, construction took three years. The line was built just below street level using the cut and cover technique. A trench about ten-meters wide and six-meters deep was dug and the sides temporarily shored up with timber bracing. Brick walls were then constructed, and the cutting roofed over with a brick arch. A two-meter deep layer of topsoil was laid on top and the road above was rebuilt. Where there was insufficient depth for a brick arch, iron girders were used to support the road.

Above: caption: "Early cut and cover techniques were extremely disruptive as buildings were flattened and utilities ripped up"

27

Left: caption: "Construction of the Metropolitan Railway close to King's Cross station in 1861. The general above-ground view of the cutting at King's-cross shows the site of what will be the King's-cross station of the Metropolitan Railway near the junction of the New-road, Old St. Pancras-road, Maiden-lane, Gray's-inn-road, Bagnigge-wells-road, and the Pentonville-road "

Right: caption: "Construction of the Tunnel at King's Cross. The mode of construction is shown by the Sketch of works as actually in progress at King's-cross."

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A deep trench was excavated along what are now the *Marylebone Road* and the *Euston Road* (turning south-east beside *Farringdon Road*). Brick walls were built along the sides, the railway tracks were laid at the bottom and then the trench was roofed over with brick arches and the roads were placed back on top, though the last stretch to *Farringdon* was left in an open, brick-lined cut. Stations lit by gas were created at *Paddington, Edgware Road, Baker Street, Great Portland Street, Euston Road* and *King's Cross* on the way to *Farringdon*, which was at ground level (on the former site of the City cattle market).

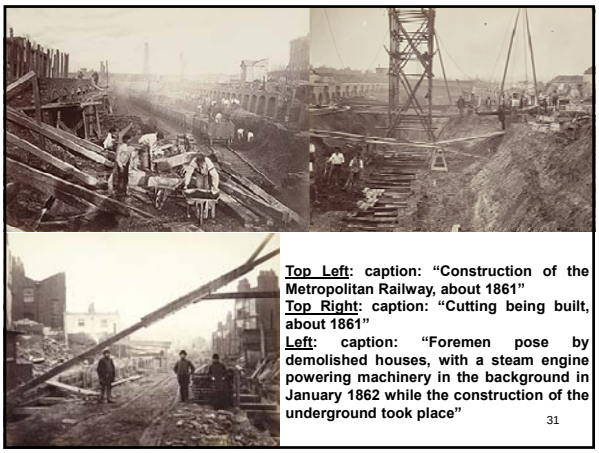
29

"…a great difficulty had to be overcome in the construction of the branch tunnel to the Great Northern, and that was the Fleet River. This stream of sewage has been successfully enclosed in a huge iron tube, which crosses through the upper part of the tunnel. It will be readily understood that the enclosing of this stream, which in wet seasons is very full and rapid, was no light undertaking. It has however, been safely completed, and the trains will run actually under the Fleet River…"

The Illustrated London News

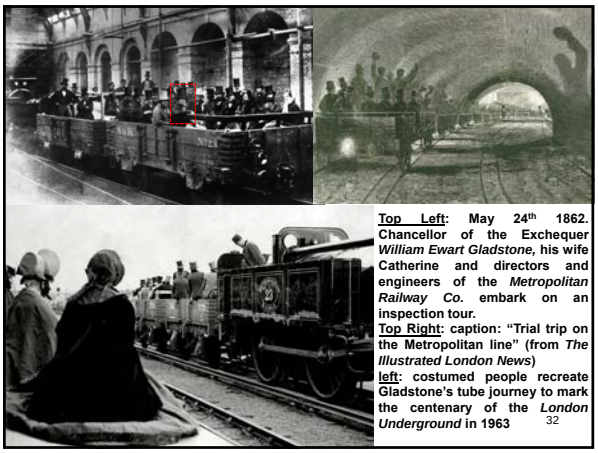
Above: caption: "The Metropolitan Railway's cutting at Farringdon following the flooding from the Fleet sewer in June 1862." Built around-the-clock by shifts of *navvies*, the line had to avoid numerous water and gas pipes, drains and sewers. There was a problem when the noxious *Fleet Ditch* sewer flooded the works at *Farringdon Road*.

30



Top Left: caption: "Construction of the Metropolitan Railway, about 1861"
Top Right: caption: "Cutting being built, about 1861"
Left: caption: "Foremen pose by demolished houses, with a steam engine powering machinery in the background in January 1862 while the construction of the underground took place"

31



Top Left: May 24th 1862. Chancellor of the Exchequer *William Ewart Gladstone*, his wife Catherine and directors and engineers of the *Metropolitan Railway Co.* embark on an inspection tour.
Top Right: caption: "Trial trip on the Metropolitan line" (from *The Illustrated London News*)
left: costumed people recreate Gladstone's tube journey to mark the centenary of the *London Underground* in 1963

32

The Great Engineering Triumph of the Day

33

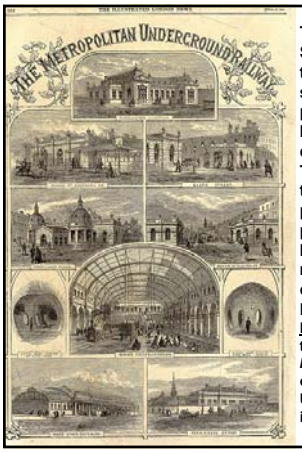
METROPOLITAN RAILWAY.

The inauguration ceremonial of the Metropolitan Railway took place yesterday. A train, consisting of five new Great Western carriages, started at six minutes past one from the Bishop's-road station, Paddington. Among the passengers were the Lord Mayor, Mr. W. A. Wilkinson, Mr. H. Love, Mr. Western Wood, M.P., Mr. Alderman Challis, Mr. Fenton, manager, and Mr. Johnson, resident engineer. Each carriage contained 70 passengers, so that in the five carriages there were 350 persons. The Edgeware-road station, though the pace was very moderate, seemed to be reached in no time. The name was called out and the station inspected for about ten minutes. By this time the gas-lights in the carriages, owing to some defect in the apparatus, had gone out. The remaining stations were successively inspected with great interest. At 28 minutes past two the train was at King's-cross, and the station there was inspected at considerable length. The train then completed its course to Farringdon-street, where a banquet awaited the passengers. The travelling was considered smooth and easy, but the tunnels are cold and render warm clothing necessary.

34

On January 9th 1863, the line's completion was celebrated at a gathering of railway executives, members of *Parliament* and the City elite including the *Lord Mayor*. The prime minister; *Lord Palmerston*, declined his invitation stating that at age 79 he wanted to stay above ground as long as possible. Starting from *Paddington*, some six-hundred guests were carried in two trains along the line to *Farringdon Street* station where a banquet was held, speeches made and due tribute paid to the memory of *Charles Pearson*. Music was provided by the *Metropolitan Police* band.
Above: the banquet at Farringdon Street station to mark the opening of the *Metropolitan Railway* (from *The Illustrated London News)*

35

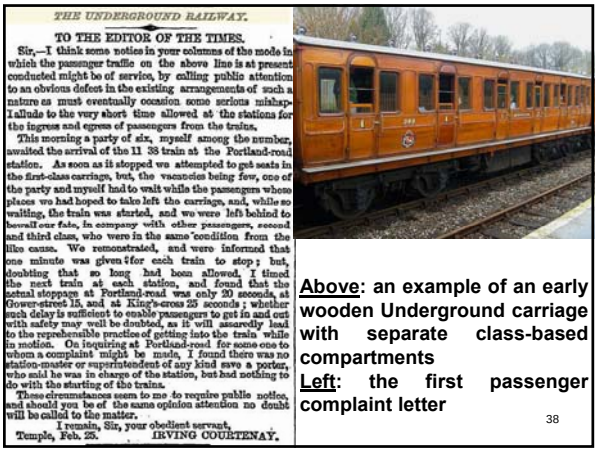


The line was opened to the public on Saturday, January 10th 1863. More than 30K passengers crowded the stations and pushed their way into packed trains. The underground had been mocked in the music halls and derisively nicknamed "The Drain." There were predictions that the tunnel's roof would give way and people would fall into it while passengers would be asphyxiated by the fumes. An evangelical minister had denounced the railway company for trying to: "break into Hell."
Left: a contemporary illustration from the December 27th 1862 edition of *The Illustrated London News* depicting the original seven Metropolitan Railway Underground stations, including the interior of *King's Cross* station.

36

The Times hailed the underground railway as: "The great engineering triumph of the day." It was the world's first subway system and it was an immediate success. This despite six derailments on the first day of operation due to the fact that the standard-gauge rail had not been aligned properly (the line had been laid with three rails throughout, but only the outer two had been used up to that time). Transporting 40K people the first day it was open to the public, 29K passengers used it each day in the first three weeks of operation. Within a few months, it was carrying over 26K passengers per day (9.5 million the first year) in gas-lit first-class, second-class and third-class carriages drawn by steam locomotives that belched out choking quantities of smoke. The fact that the passengers were, at first, forbidden to smoke in the carriages was not much help. These early Underground cars weren't like modern tube cars. Rather, they were wooden carriages divided into compartments that were pulled by steam engines; literally underground trains. The maximum permitted speed was 25 mph and trains took eighteen minutes to complete the 3.75-mile journey. To dispel any fears Victorian passengers might have had about traveling underground, stations were designed to make use of natural light and carriages were brightly lit with gas lamps (the gas was stored in rubber bags on the carriage roofs). As far as the *City of London* was concerned, the corporation was able to sell its shares in the *Metropolitan Railway* at a profit and the Underground did ease congestion for a time. A more lasting consequence was to make commuting far easier and so cause *London* to sprawl out even more from its center, while the number of people actually living in the City itself declined sharply.

37



THE UNDERGROUND RAILWAY.

TO THE EDITOR OF THE TIMES.

Sir,—I think some notice in your columns of the mode in which the passenger traffic on the above line is at present conducted might be of service, by calling public attention to an obvious defect in the existing arrangements of such a nature as must eventually occasion some serious mishap. I allude to the very short time allowed at the stations for the ingress and egress of passengers from the trains.

This morning a party of six, myself among the number, awaited the arrival of the 11 38 train at the Portland-road station. As soon as it stopped we attempted to get seats in the first-class carriage, but, the vacancies being few, one of the party and myself had to wait while the passengers whose places we had hoped to take left the carriage, and, while so waiting, the train was started, and we were left behind to bewail our fate, in company with other passengers, second and third class, who were in the same condition from the like cause. We remonstrated, and were informed that one minute was given for each train to stop; but, doubting that so long had been allowed, I timed the next train at each station, and found that the actual stoppage at Portland-road was only 20 seconds, at Gower-street 15, and at King's-cross 25 seconds; whether such delay is sufficient to enable passengers to get in and out with safety may well be doubted, as it will assuredly lead to the reprehensible practice of getting into the train while in motion. On inquiring at Portland-road for some one to whom a complaint might be made, I found there was no station-master or superintendent of any kind save a porter, who said he was in charge of the station, but had nothing to do with the starting of the trains.

These circumstances seem to me to require public notice, and should you be of the same opinion attention no doubt will be called to the matter.

I remain, Sir, your obedient servant,

Temple, Feb. 25. IRVING COURTENAY.

Above: an example of an early wooden Underground carriage with separate class-based compartments

Left: the first passenger complaint letter

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Part 2

Atmospheric & Pneumatic

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Atmospheric

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There are, in effect, two types of air-driven railways; a *Pneumatic Railway* and an *Atmospheric Railway*. The latter used conventional carriages and a conventional train track, but running between the tracks was a metal tube inside of which would be a large "bullet." A steam engine at the end of the railway (or at intervals along it) would suck the air out of the tube thus drawing the bullet along the tube. The bullet was itself attached to the train carriages by a stiff metal bar and as the bullet was sucked along the tube the carriages would follow. The top of the tube had a slot, sealed with leather flaps and, as the bullet raced along the tube, it pushed the flaps open to let the connecting bar pass and they then shut behind the passing bar. Removing the steam locomotive had the huge advantage of the train carriages being propelled through towns without any of the steam and soot that plagued Victorian cities. However, no matter what design was chosen for the flaps, it was impossible to maintain a sufficiently strong vacuum to drag the carriages along and the flaps also tended to be rather unreliable and jam open at times, ruining the suction effect. Although famously associated with *Isambard Kingdom Brunel*, the system of flaps was, in fact, developed by the marine engineers *Jacob* and *Joseph Samuda.*

41

There were a number of trials of the *Atmospheric Railway*, but the two most famous uses of the system were the line between *London Bridge* and *Croydon* and another railway in *South Devon*. Neither lasted more than a year, switching to conventional steam locomotives. Both routes are still in use today using electric train service.

Above: Atmospheric Railway with iron tube running between tracks

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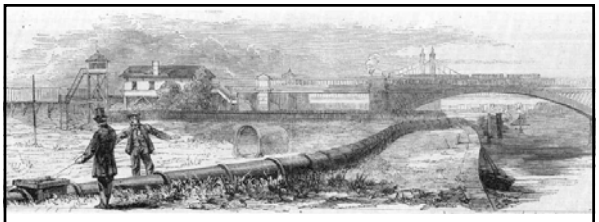
Pneumatic

43

A *Pneumatic Railway* also used a tube with a steam engine at one end to suck air out, but in this system the tube surrounds the railway entirely and the carriage itself became the "bullet" that is either blown or sucked down the tube. This sort of railway had a number of precedents before being enlarged to passenger service. *Thomas Webster Rammell* originated the idea for the Pneumatic Railway and his greatest success was the *London Pneumatic Dispatch Company* – a predecessor of the more famous *Post Office Railway* that still exists under *London*.

44



To test the system, in 1861 *Thomas Rammell* and *Josiah Clark* set up a length of tube just over 450-yards in length in *Battersea Park* and ran small capsules through it, powered by blowing air down the tube from a 30-HP steam engine. The tube also negotiated several steep slopes, including one which was said to be as steep as the notorious slopes at *Holborn Hill*, near *Fleet Street*. During the experiments, two carriages; each of one-ton in weight, were said to have traversed the tunnel in less than thirty seconds. Although the trial was for cargo services, several people had squeezed into the capsules and ridden through the tunnel and declared that aside from the size of the capsule, traveling without the noise and soot of the steam locomotive was quite pleasant. Therefore, the next logical step was to scale-up the pneumatic tube to carry passengers.

Above: the Battersea Park trials

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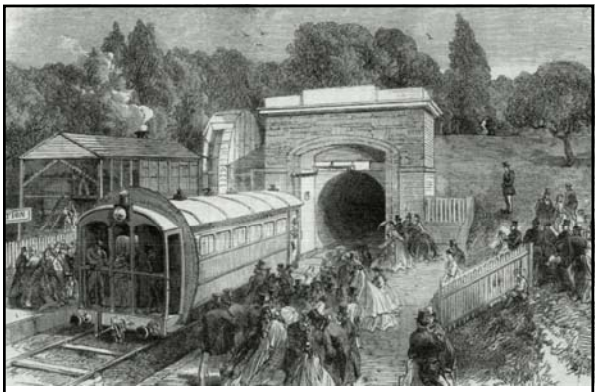
The Crystal Palace

46

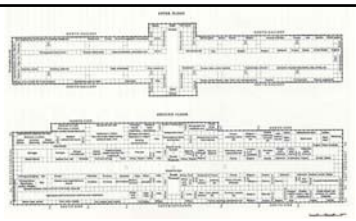
Perhaps the most famous example of a *Pneumatic Railway* was conceived for London's *Crystal Palace*. The *Crystal Palace Pneumatic Railway* (CPPR) was a full size railway built in 1864 running along the lower (eastern) end of *Crystal Palace Park*. It ran for about 600-yards in a ten-foot high by nine-foot wide brick tunnel between the *Sydenham* and *Penge Gate/s* to the park. It was constructed above ground (covered with earth) and had a gradient of one in fifteen, with a sharp curve. A single coach with sliding glass doors at each end (described as an "elongated omnibus") could seat thirty to thirty-five passengers. A bristle-laden collar kept the tunnel airtight while at one end a steam engine coupled to a fan blew or sucked air through propelling the carriage at about 25 mph. The trip from one end to the other took about fifty seconds. When the carriage began its journey, it would slide down to the mouth of the tunnel where it passed over an iron grill in the floor and iron doors closed behind it. From the grill came the atmospheric pressure generated by the pumping station that would then blow the carriage down the tunnel. Another grill (in the roof) acted to suck air out on return trips.

47



Above: the *Pneumatic Railway* in *Crystal Palace Park*

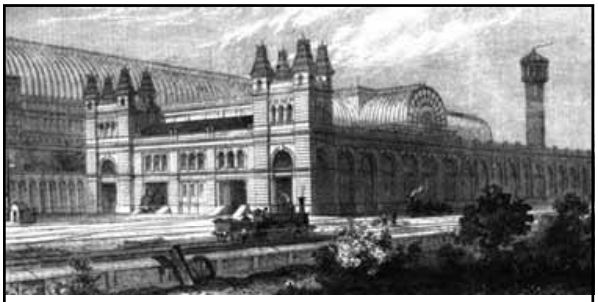
48



The great exhibition held in *Hyde Park* attracted just over six million visitors to the *Crystal Palace* between May and October 1851. After closing, the structure was dismantled and, in August 1852, the rebuilding began on a site at *Sydenham Hill*. The intention was to create a winter park and garden. The reconstructed iron and glass structure was opened by *Queen Victoria* in June 1854. To cater to the expected large number of visitors, the *London Brighton & South Coast Railway* (LB&SCR) opened a station serving the area on June 10th 1854, but the station was not ideally sited and involved visitors walking along a 720-foot glass covered colonnade.

49

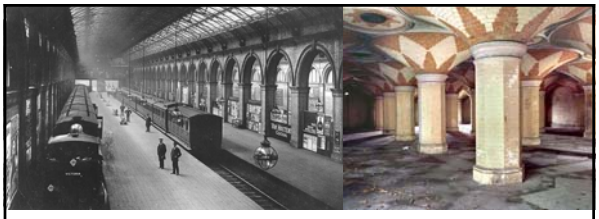
Above: floor plan/s of the Crystal Palace



On July 7th 1862, the *Crystal Palace & South London Junction Railway* (CP&SLJR) was authorized to build a line from *Peckham Rye* to a large covered terminus alongside the *Crystal Palace* with a "subway" (pedestrian arcade) from one end of the station under the road into the grounds. It was opened on August 1st 1865 from *Peckham Rye* to a terminus called *Crystal Palace High Level.*

Above: an engraving from *The Illustrated London News* showing the newly opened Crystal Palace High Level station (adjacent to the palace).

50



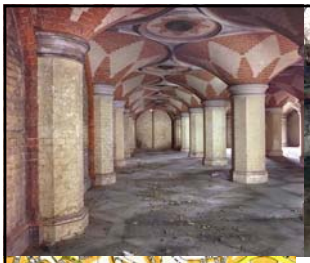
The impressive terminus was designed by *Edward Middleton Barry* and cost £100K to build. The station was an outstanding example of Victorian architecture with high red and terra cotta brick side and end walls and a glass and iron trainshed roof (left). The station was divided longitudinally by a series of brick arches with a passenger concourse above the tracks at each end of the station incorporating a booking (ticket) office, refreshment rooms and waiting rooms. The subway linked the station directly with the Palace. It consisted of a wide vaulted and tiled chamber resembling a *Byzantine* crypt and was designed and built by cathedral craftsmen from *Italy* (right). The subway was used as an air-raid shelter during WWII.

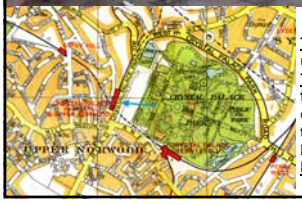
51

Despite the terminus being conveniently sited, the branch came too late as the *Crystal Palace* failed to attract the expected number of visitors. Despite electrification after WWI, traffic on the branch remained disappointing. On November 30th 1936, the Crystal Palace was destroyed by fire. After the fire, visitor traffic dropped to practically zero and when the service was reduced as a war-time measure in 1940, the few remaining passengers began to drift away. Beginning on January 6th 1941, the branch was worked as a shuttle to and from *Nunhead,* but due to wartime manpower shortages the line was closed on May 21st 1944. After the war, the station was in a run-down condition, much of the glass trainshed roof having been shattered during "The Blitz" with no attempt made to repair it thus allowing rain to pour into the station. As a result, the timber platforms were soon covered by vegetation with scurrying rats beneath the platforms far outnumbering the passengers

52

Above: caption: "Crystal Palace High Level Station in the late 1950s"





Top Left: caption: "The vaulted subway under Crystal Palace Parade"
Top Right: caption: "Steps led down from the main floor of the Palace to this courtyard with passengers walking through the arched subway into the high level station"
Left: map of *Crystal Palace Park*

53

After its closure in September 1954, the crumbling structure survived until 1961 when the station was demolished leaving only the high retaining wall on the west-side of *Crystal Palace Parade*, the vaulted subway beneath the road and the roofless concourse at the east-end of the subway.

Above: the last train to leave *Crystal Palace* was a special excursion on September 19th 1954, the day after the last passenger train ran

54

Waterloo & Whitehall

55

The *Crystal Palace Pneumatic Railway* opened to the public on August 30th 1864 and although it was advertised in local newspapers as a visitor attraction, it was supposed to be just a technical trial to be open for only a few months. Nonetheless, in just a few short years the idea of the *Pneumatic Railway* had gone from a small tube at *Battersea Park* to a full sized passenger railway at the *Crystal Palace*. The way was set for someone to take it to the next stage and build a commercial railway that would be no mere attraction, but a vital part of the transport infrastructure of the metropolis. On May 15th 1865, a prospectus for such a railway was published in the national press for a Pneumatic Railway running from just outside *Waterloo Railway* station to a new station which would be built in *Great Scotland Yard* next to *Whitehall*. The "Waterloo & Whitehall Pneumatic Railway" was thus born. The W&WPR prospectus sought to raise £135K from investors in shares of £10 each.

56

The first *Waterloo* station was built in 1848, but passengers needing to get across the river either had to pay a toll of a halfpenny to use the *Hungerford* pedestrian bridge (leading to today's *Charing Cross*) or walk down to *Westminster Bridge*. Thus, a short railway carrying passengers from Waterloo to *Whitehall* seemed to make a lot of sense. The problem was that it had to pass under the *Thames* and the only other tunnel to do that had been Marc Brunel's *Thames Tunnel* at *Rotherhithe*, which took eighteen years and cost a fortune to build due to is vast size (it was originally built for horse and carriage traffic). A *Pneumatic Railway* had the great advantage of being much smaller; just a tube very slightly larger than the carriage itself.

57

"in its present form the pneumatic system is simply an adaptation of the process of sailing to railway; the wind being produced by steam power and confined within the limits of a tube."

RE: excerpt from the W&WPR prospectus. The Crystal Palace's pneumatic system (CPPR) required a pressure of from 120 to 160 ounces per square inch to move the carriage whereas the new W&WPR system would need a pressure of just three or four ounces per square inch, largely due to the fact that it would run down a slope towards the river thus, gravity would provide much of the initial acceleration.

58

"__First__. The pneumatic tube being smaller than the ordinary railway tunnel, the lines will occasion less interference with property and displacement of dwellings, and be constructed more expeditiously and at far less cost; while being noiseless and free from vibration in operation, they may be introduced where a locomotive line would not be tolerated.

__Secondly__. The dead weight of the locomotive being got rid of, the service will be more prompt, and therefore better suited for the working of a short local traffic, while however frequent the dispatches, there is no danger of collision, since two trains can never meet within the tube.

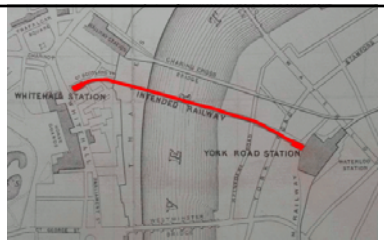
__Thirdly__. Steep inclines and sharp curves are readily and safely worked on the pneumatic system. The line at Sydenham was purposely constructed with an incline of 1 in 15 (somewhat steeper than the worst part of Holborn-Hill), and with curves of eight chains radius, it was traversed with ease and regularity.

__Fourthly__. From the absence of smoke, steam, and other objectionable accompaniments of the locomotive, and the complete ventilation of the tunnel by the continuous draught of air through it, the working is attended with perfect comfort to the passengers.

__Lastly__. The working expenses and the cost of maintenance are less the power being stationary; and the wear and tear of rolling stock reduced to a minimum."

RE: excerpt from the W&WPR prospectus

59



Having outlined the benefits of the railway, the W&WPR prospectus went on to describe the route, which would start at an underground station in *Great Scotland Yard* and be continued in brickwork under the *Thames Embankment* to the river across which it would be carried in a watertight iron tube encased in cement concrete laid and fixed in a channel dredged out of the bed of the river. From the river, the line was to be continued in brickwork under *College Street* and *Vine Street* to a station convenient for the traffic of the *York Road* and the *Waterloo Terminus* of the *South-Western Railway.*

__Above__: W&WPR route map (from the prospectus)

60

The prospectus also predicted that the trains would be able to depart at intervals of from three to four minutes from each end; a frequency of dispatch that was unheard of heretofore. To gain that level of service using only one tube, each station would have two platforms. As a carriage was disembarking passengers, the carriage on the other platform would be slid into position for the return trip. W&WPR expected to be able to run the service with just three alternating carriages. The prospectus made the assumption that, on average, there would be for each train at least five first-class passengers, at two-pence each and twenty second-class passengers, at one-penny each. Upon that assumption, the total receipts per train, multiplied by the number of trains per day (fifteen each way every hour from 7am to 12pm) gave a total gross annual revenue of £23,268 which was considered sufficient to generate a return of ten percent for the investors.

61

The prospectus boldly stated that: *"…the cost of the undertaking has been calculated with unusual care..."* and concluded by noting that the railway could be constructed in just one year once Parliamentary approval had been granted. The *Samuda Brothers* were given the contract to construct the four cast-iron tubes (to be laid in the *Thames*) at their ship building yards on the *Isle of Dogs.* The pumping station at *Waterloo* was described as containing a 22-foot wide "spinning wheel" contained within an iron case capable of spinning at varying speeds for blowing or suction (the system would use the recently invented electric telegraph to signal which option to use at the engine). It was claimed that the air pressure could reach 14psi to propel the carriage down the tunnel. Iron doors at each end of the tunnel/s would help to contain the air pressure and prevent air from blowing into the stations. *Brassey & Company* were awarded the contract for the extensive riverbed works.

62

Turn Up and Go

63

An architects drawing of the *Whitehall Station* (side elevation above) shows a fairly large building (there was a lower level for the train platforms). It's interesting to note that, at the time, it wasn't fully understood how short railway services would be used so the new station included a ladies waiting room. Similar designs were adopted on parts of the early *London Underground* elsewhere until it was eventually realized that no one used them on what was termed a "turn up and go" service.

64

The railway itself was formed from three sections; the tubes within the river, then two cut and cover brick tunnels on either side of the river. The construction method within the river itself required that a channel be dug along the riverbed in which four cast-iron tubes would be laid. By driving down iron caissons into the riverbed (about 270-feet apart) and digging down by hand, three concrete piers would thus be formed providing support foundations in the river for the iron tubes. Lined with brick, the piers were built up until they were about twenty-feet under the level of the riverbed, then the rest of the riverbed was dredged to the required depth. The tubes themselves were to have an internal diameter of twelve-feet and an external diameter of 15'-3" (each section was 250-feet long). The wall of the tubes was constructed from 0.75-inch boiler plate surrounded by four rings of brickwork. Each tube weighed about 1K-tons.

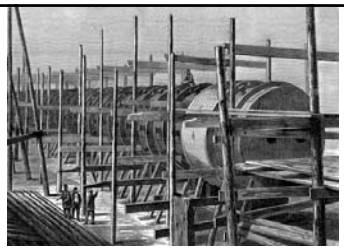
65

The Banker's Banker

66

The Parliamentary bill for the W&WPR was passed on July 5th 1865 and construction started a few months later; on October 25th 1865. Initially, steam powered machines were used to dredge the river and the land at *Scotland Yard* was swiftly enclosed with wooden walls in preparation for clearing the site. Despite having reviewed the plans in great detail and determining there were no hidden costs to dismay investors, it wasn't long before unforeseen problems started to pop-up. A sewer in *Whitehall* could not be avoided thus it was suggested that the railway adjust its cut and cover tunnel to run under the *Duke of Northumberland's* garden and, also, under the *Rising Sun* pub next door. The pub was paid a compensation of £475, and the Duke got £750 for his garden. In June of 1866, *Overend, Gurney & Co.*, a bank so respected and important that it was known as "The Banker's Banker," collapsed triggering a financial panic in the City. The bank was a particularly heavy lender to railway companies thus when it collapsed, so did many railway investments. During the crisis, approximately two-hundred companies, including several banks, were forced to close. Despite the setbacks, as of November 1866, the W&WPR was sufficiently interesting to attract the attention of American investors.

67



The first of the four iron tubes was ready at the Samuda works on the *Isle of Dogs* by November 1866. It was still intended, at the time, that the ends of the tube/s would be made watertight by sealing their ends and floating them downriver to *Whitehall*, where they would be sunk onto the foundations previously prepared in the riverbed.

Above: caption: "Thames River, London. Pneumatic Dispatch Tube" (from *Scientific American* magazine, March 1867)

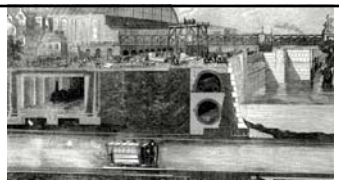
68

Six months after the banking crisis hit the country, a W&WPR board meeting held in December 1866 discussed the worsening financial situation. Two bills were being presented to *Parliament*; one to extend the company's authority to build the railway and the other to shut-down the entire project. The chairman explained that to abandon the railway would be to lose all the money invested with nothing to show for it, but that thanks to the banking crisis, it was felt that the future did not look promising. In fact, other railways such as the *London Chatham & Dover* (LC&D) had suspended payments to their shareholders for want of funds caused by the banking crisis. That the company needed more money than was originally expected was a matter of considerable annoyance to many shareholders. One shareholder argued strongly that the project had been driven by engineers rather than by businessmen and had it been the latter situation, they wouldn't be in this predicament. Although the W&WPR was funded by the sale of shares thus not itself directly dependent on bank loans, those shares were sold with a deposit first and the rest of the funds were due at a later date. With the banks in crisis, shareholders were no longer able to meet their obligations and the firm was forced to seek outside assistance. The directors approached the *South Western Railway* (SWR), owner of *Waterloo* station, to see if they could/would provide the £115K needed to complete the project. In the meantime, all construction work was stopped, the site sealed and the workers laid off.

69

The Thames Embankment

70



During this time, an alternative for the railway was considered; build the tunnel but scrap the railway entirely opening it as a pedestrian tunnel with a nominal toll. This was, in fact, quite a sensible proposal since the *Hungerford Bridge* was, at the time, a toll bridge so a tunnel offering a link to *Whitehall* would probably be very popular. The delay to the construction of the railway tunnel was also holding up the construction of another great endeavor of *Victorian London* – the *Thames Embankment*. The two projects had an agreement to work together at the point where the railway would pass under the embankment, but the stoppage of the railway works was holding up the embankment work above the tunnel. By January 1867, the only works at the embankment carried out by the railway was to prepare an iron box for fitting onto the river-end of the line.

Above: drawing from *The Illustrated London News* showing the relationship between the W&WPR, the Thames Embankment and its *Bazalgette Sewers* and what are today known as the *Circle/District Line* railways

71

In February 1867, another W&WPR board meeting was convened to discuss the ongoing financial problems. An attempt to raise an additional £30K by issuing new shares had been a failure with just £8,770 being received. Having been blocked by *Parliament* in their attempts to raise money from the *London & South Western Railway* (L&SWR) directly, they agreed to try and appeal to the shareholders of that railway to invest directly in W&WPR arguing that their investment in the overland railway would be a significant beneficiary of the convenience of the underground link to *Whitehall*. Such was the impact of the banking crisis and the general recession that a newspaper report on the state of the shipbuilding yards along the *Thames* in September 1867 found just one project under construction; the iron tubes for the W&WPR. At a February 13th 1868 board meeting, it was proposed that for just £150K, a rail link between *Waterloo* station and what is today the *Embankment* station could be created. They planned to seek assistance from the L&SWR to secure the completion of the underground railway.

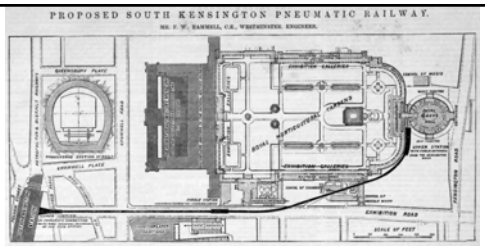
72

Warrant of Abandonment

73

Despite the L&SWR initiative, the works were still abandoned in *Whitehall*, with nothing started at *Waterloo*. The unsightly piling in the river was causing an obstruction to river traffic during the suspension of construction and the matter was raised in the *House of Commons* to determine how swiftly they could be removed; not very quickly came the answer. In July 1869, the W&WPR Directors finally bowed to the inevitable and sent a letter to the *Board of Trade* seeking Parliamentary approval to abandon the railway. At the time of the abandonment, the records showed that the company had successfully constructed the tunnel from *Scotland Yard* to the embankment and the construction of part of one of the junction chambers by the station. They had dredged a portion of the riverbed, and one single length of iron tube had been completed in the *Isle of Dogs* shipyard. A second tube was assembled, but the brick linings had not been applied and the iron for the other two lengths of tube were cast, but not assembled. The letter approving the request to close the railway project was signed on September 6th 1870. The company was also ordered to remove the troublesome wooden piles in the river before the *Warrant of Abandonment* was signed (they had been due to be removed in early August 1869), but it seems likely that they were still there a year later since the final warrant was not signed until February 10th 1871. The W&WPR was no more.

74



The W&WPR was now just a failed memory, but the notion of the *Pneumatic Railway* itself did not die with it. In fact, there were several more proposals for such railways in *London*, but none of them got any further than the occasional newspaper article. One of the more notable proposals was by the undaunted *Thomas W. Rammell* who came back with the *South Kensington Pneumatic Railway* (SKPR) of 1877, which would have been a short branch line running from *South Kensington* railway station up to the *Royal Albert Hall*. Despite a warm reception in the press and support from the Met, the scheme vanished leaving barely a trace of its existence save for drawings occasionally sold as curios by antique map dealers.

75

Above: proposed railway between *South Kensington* and the *Royal Albert Hall*

Alfred Ely Beach

76

Alfred Ely Beach (1826-1896) was the editor of the popular and respected publication *Scientific American* magazine and the inventor of, among other things, a successful typewriter and was well known and respected in technical circles. He was not a civil engineer, but was concerned about New York City's chronic traffic problems and as a solution, developed plans for a rapid-transit subway to extend the length of *Broadway*. His subway plan had been first introduced at the 1867 fair of the *American Institute* in the form of a short plywood tube through which a small, close-fitting car was blown by a fan (the car carried twelve passengers). Sensing opposition to the subway scheme from *Tammany Hall*, in 1868 Beach obtained a charter to place a small tube beneath Broadway for transporting mail and small packages pneumatically, a plan he advocated independently of the passenger subway. Work on the Beach tunnel began in 1869. Under this thin pretense of legal authorization, the subterranean excavation began from the basement of a clothing store on *Warren Street* near Broadway. The eight-foot-diameter tunnel ran eastward a short distance, made a ninety-degree turn and thence southward under Broadway to stop a block away under the south-side of *Murray Street*. The total distance was about 312-feet. Work was carried on at night in total secrecy, the actual tunneling taking fifty-eight nights. At the Warren Street terminal, a waiting room was excavated and a large blower installed for propulsion of the single passenger car.

77

Beach's plan was similar to that used for the fair working model in 1867. The cylindrical car fit tightly into a circular tunnel with only slight circumferential clearance. The blower created a plenum within the waiting room and tunnel area behind the car of about 0.25 pounds per square inch, resulting in a thrust on the car of almost one-ton (not accounting for "Blowby"). The car was thus blown along its course and was returned by reversing the blower's suction and discharge ducts to produce an equivalent vacuum within the tunnel. The system opened in February of 1870 and remained in operation for about a year.

Above: caption: "Interior of Beach Subway showing iron lining on curved section and the pneumatically powered passenger car. View from waiting room" (from *Scientific American*, March 5th 1870)

78

Aftermath

79

The site of the *Whitehall* station became the police headquarters (*Scotland Yard*). There was a suggestion that the abandoned cut and cover tunnel by Whitehall be reused by the proposed *Charing Cross & Waterloo Electric Railway* (CC&WER) of 1883, but that plan was never realized. An attempt to build a *Pneumatic Railway* in *Mersey* got as far as constructing the tunnel, but they later chose an alternative form of locomotion. The grandest proposal came in 1869, suggesting the use of the pneumatic principle for a tunnel under the *English Channel*. In *New York*, the *Beach Pneumatic Transit Company* (BPTC), opened in 1870, was ultimately undone by the hostile influences of *Boss Tweed* and *Tammany Hall.* The project was completely abandoned in 1871.

80

MailRail

81

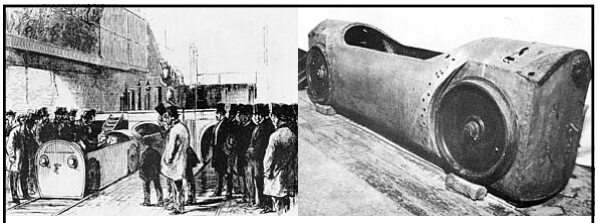
The first proposal for a tube line to carry the mail ("Post Office Railway" or "MailRail") was put forward by *Sir Rowland Hill* in 1855. He suggested a line from the Post Office at *St. Martins-le-Grand* to *Little Queen Street* in *Holborn*. The initial proposal was for an atmospheric railway designed by *Thomas Rammell.* A smaller version of this system was later developed as the "Lamson Tube" for message handling in large department stores, government offices etc. (some Lamson Tube networks are still in use today). Rammell devised plans for a number of lines in *London* to carry goods and the *Royal Mail*, setting up the *London Pneumatic Despatch Company* (LPDC) on June 30th 1859. Lines were proposed from *Camden* and *Euston* stations. The Post Office was initially skeptical about the scheme, though they agreed to try it out.

82

The first two-foot gauge line was built in a shallow cut and cover tunnel from the *Arrival Parcels Office* at *Euston* to the Post Office's *North Western District Office* in *Crowndale Road*, a distance of 600-yards. The first train ran on January 15th 1863. After an inspection by Post Office Secretary *Sir Rowland Hill*, the new service was approved and a permanent service introduced with seventy trains a day making the seventy-second journey. With the undoubted success of this first line, a longer (3' - 8.5") gauge line was proposed running from Euston to *245 Holborn* and then on to the *General Post Office* at *St. Martins-le-Grand* and Pickford's depot in *Gresham Street*. The section from *Euston* to Holborn was opened on October 10th 1865, but the extension to St. Martin le Grand proved problematic with a limited service finally opening on December 1st 1873, the extension to Gresham Street was later dropped.

83

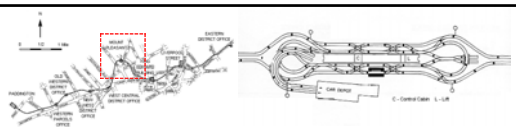
Above: map of the LPDC's London railways



Ultimately, the Post Office was not satisfied with the new pneumatic service since it only reduced by four minutes the time taken to carry the mail by road rendering the pneumatic service non cost-effective. In 1874, they announced that they would not be using the new line and it was quickly abandoned with the dissolution of the LPDC a result. In 1895, there was a proposal to reopen the tunnel with electric traction and a new company: *London Despatch Company* (LDC) was formed. Some work was done on upgrading the line and tunnels but the Post Office remained skeptical about its worth and work on the new project ceased in 1902 (the LDC was dissolved in 1905). The Post Office finally bought the tunnel in 1921 for the use of telephone cables.

Left: opening day of the *Holborn* to *Euston* line (from *The Illustrated London News*)
Right: two-foot gauge LPDC car

84

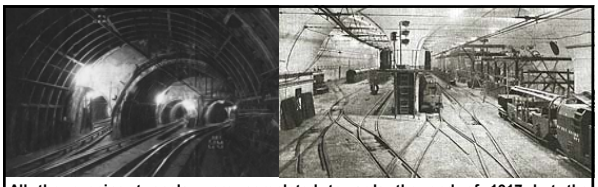


With the demise of the pneumatic line, electric railways seemed a more versatile means of transport for the mail and numerous proposals were made for new underground electric lines even before the pneumatic railway had closed. In 1909, a committee was formed to consider all the schemes. Eventually, they recommended a two-foot gauge twin electric line in a seventy-foot deep tunnel running from the *Paddington District Office* to the *Eastern District Office* on *Whitechapel Road* with intermediate stations along the route; a total length of six miles. The recommendation was approved and a bill was put before *Parliament* on August 15th 1913. An experimental length of line was built in 1914 and in 1915 a contract to build the new line was let. Tests on the first completed section (between *Paddington* and the *West Central District Office*) began on January 24th 1927 and the first letter traffic was carried by the completed railway on February 13th 1929. The total length of track (including sidings and loops) was twenty-three miles. Each station would have a wide island platform with sufficient room for loading and unloading and a loop line to leave the main line clear for through running. The suggested line capacity was 40 trains/hour in each direction.

Left: map of the *Post Office Railway* (*Mount Pleasant* station highlighted)

Right: Mount Pleasant station track diagram

85



All the running tunnels were completed towards the end of 1917 but the contractors were ordered to suspend work on the stations because of problems with labor and materials during WWI. With the danger of *Zeppelin* air raids, the completed tunnels were considered a suitable place for the storage of art treasures. Thus, in January 1918 much of the collection from the *Tate Gallery, National Portrait Gallery* and the *Public Record Office* were stored in the station tunnel at the *King Edward Building*. The King's pictures and the *Wallace Collection* were stored in the tunnel at *Paddington Station*. With the threat of war looming in the late 1930s, it was decided to use the stations as staff shelters. They were brought into use in 1939 with hinged bunks that lowered onto the platforms and track. The stations were last used as an air raid shelter in 1944, but the dormitories remained in use until September 1945. The railway suffered little damage during the war save for a direct hit at *Mount Pleasant* flooding the station.

Left: view of the tunnels from the eastern-end of the Mount Pleasant platform

Right: the depot at Mount Pleasant

86

The main line runs in a single tube, nine-feet in diameter, diverging at each station into two parallel tunnels, seven-feet in diameter, widening out at the stations to twenty-five feet. For most of its length, the line runs at seventy-feet below ground with a one in twenty rise and fall at each station (which helps to slow the trains down as they approach a station and aids acceleration away from a station).

Left: train at the western-end of the east-bound platform at *Mount Pleasant* station

Right: "Battery" electric locomotive

87

Part 3

Expansion

88

Left: *Gustave Dore's* famous 1872 depiction of congestion at *Ludgate Circus* in the heart of the *City of London*, published nearly ten years after the Underground was opened with the intention of eliminating such scenes. Among the vehicles are horse buses, *Hackney* cabs, wagons and a flock of sheep being driven to market. The only solution was expansion of the Underground to reduce, but not eliminate entirely, the above-ground traffic jams.

89

The City Widened Lines

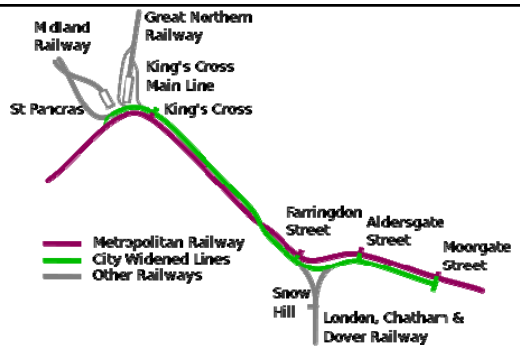
90

With connections to the GWR and GNR under construction and connections to the *Midland Railway* (MR) and *London, Chatham & Dover Railway* (LC&DR) being planned, the Met obtained permission in 1861 and 1864 for a four-track eastward extension to a new terminus at *Moorgate* and two additional tracks from *King's Cross* to *Farringdon Street*. The Met used two tracks for its services (the other two tracks were used by other railway companies). These became known as the "Widened Lines" or "City Widened Lines." A pair of single track tunnels at *King's Cross* connecting the GNR to the Met came into passenger use on October 1st 1863 when the main line company began running services. By September 1864, the Met had sufficient carriages and locomotives to run its own trains and increase the service frequency to six trains per hour. On January 1st 1866, LC&DR and GNR joint services from *Blackfriars Bridge* began operating via the *Snow Hill Tunnel* under *Smithfield Market* to *Farringdon* and northwards on to the GNR. The extension to *Aldersgate Street* and *Moorgate Street* (now *Barbican* and *Moorgate*) had opened on December 23rd 1865 and all four tracks were open on March 1st 1866. The *Midland Railway Junction* opened on July 13th 1868 when services ran into Moorgate Street before the main-line *St. Pancras* station opened. The line left the MR main-line at *St. Paul's Road Junction* before entering a tunnel and joining the Widened Lines at *Midland Junction.*

91

Above: *Blackfriars Bridge* Underground station (with *St. Paul's Cathedral* in the background)

92



Above: the *City Widened Lines* between *King's Cross* and *Moorgate Street* and their connections. The east curve south to the LC&DR opened in 1871, the station at *Snow Hill* was opened in 1874.

93

Hammersmith & City Railway

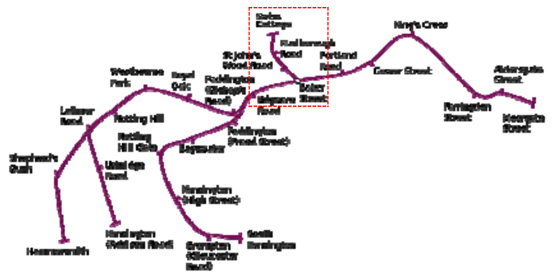
94

In November 1860, a bill was presented to *Parliament*, supported by the Met and the GWR, for a railway to run from the GWR's main-line one mile west of *Paddington* station to the developing suburbs of *Shepherd's Bush* and *Hammersmith* with a connection to the *West London Railway* (WLR) at *Latimer Road*. Authorized on July 22nd 1861 as the *Hammersmith & City Railway* (H&CR) as a subsidiary of the GWR, the 3.9km line, constructed on a twenty-foot high viaduct (largely across open fields), opened on June 13th 1864 with a broad gauge GWR service running from *Farringdon Street* with stations at *Notting Hill* (now *Ladbroke Grove*), Shepherd's Bush (replaced by the current *Shepherd's Bush Market* in 1914) and *Hammersmith*. The link to the WLR opened on July 1st 1864, served by a carriage that was attached or detached at Notting Hill for *Kensington* (*Addison Road*). Following an agreement between the Met and the GWR, starting in 1865 the Met ran a standard-gauge service to Hammersmith and the GWR a broad-gauge service to Kensington. In 1867, the H&CR became jointly owned by the two companies. The GWR began running standard-gauge trains on the route and the broad-gauge rail was removed from both the H&CR and the Met in 1869. In 1871, two additional tracks parallel to the GWR (between *Westbourne Park* and *Paddington*) were brought into use for the H&CR and in 1878 the flat crossing at *Westbourne Park* was replaced by a "Flyunder." In August 1872, the GWR Addison Road service was extended over the *District Railway* to *Earl's Court* and onto *Mansion House*. This became known as the *Middle Circle* and ran until January 1905. Additional stations were opened on the H&CR at Westbourne Park (1866), *Latimer Road* (1868), *Royal Oak* (1871), *Wood Lane* (1908) and *Goldhawk Road* (1914).

95

Near its midpoint the H&CR crossed over the WLR, a line connecting *Willesden Junction* to *Clapham Junction* (via *Kensington*). Part of the WLR's route was opened in 1840 and used for an experimental pneumatic traction system. Passenger service started in 1844, but was so unsuccessful it lasted only a few months. From 1845 onwards, the WLR was operated (and later owned) by a consortium of main lines and did not have any trains of its own. Until 1862 it was purely a freight branch line. The attraction of serving *Kensington* meant that a connection from *Latimer Road* to the WLR was part of the original design and it opened a couple of weeks after the H&CR route. From then on, trains from *London* divided at Latimer Road, one portion running to *Hammersmith* and the other to Kensington.

96



Expansion to the northwest of *London* began in April 1868 when the *Metropolitan & St. John's Wood Railway* (fully absorbed by the Met in 1882) began operating from *Baker Street* to *Swiss Cottage*, via *St. John's Wood Road* (highlighted). Services were extended to *West Hampstead* in June 1879, to *Willesden Green* in November 1879, to *Harrow-on-the-Hill* in 1880 and to *Pinner* in 1885.

Above: the *Metropolitan Railway* in 1873, ten years after opening

97

The Inner Circle

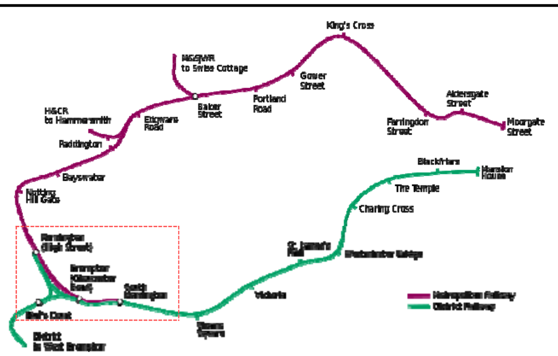
98

A flurry of interest in the underground railways followed the opening of the Met in 1863. Two-hundred and fifty different schemes for *London* were presented to the 1864 session of *Parliament.* The *Metropolitan District Railway Company* (MDRC), headed by *John Fowler*, was granted approval to work with the Met to form an "Inner Circle" linking the capital's mainline railway termini. The first section of the "District Railway" (DR) opened in 1868, but the Inner Circle was not completed until 1884. The Met quickly extended its services across London. The first extension, from *Farringdon* to *Moorgate Street*, opened in December 1865. This was followed by *Paddington* to *South Kensington*, opened in 1868; *Moorgate* to *Liverpool Street* to *Bishops Gate*, opened 1875; and *Bishops Gate* to *Aldgate*, opened 1876. An agreement between the DR and the Met led to the extension of both lines between *Aldgate* and *Mansion House*. This completed the route encircling central London known as the "Inner Circle" (service began in October 1884). The Met generally ran its trains in a clockwise direction on the outer rail. The complete thirteen-mile trip took seventy minutes.

99


Left: one of a series of photographs by *Henry Flather* showing the construction, undertaken between 1866 and 1870, of the *Metropolitan District Railway's* underground lines between *Farringdon* and *Paddington* and on to *Kensington*. It now forms part of the existing *District* and *Circle Line/s* on the *London Underground*. The construction work, utilizing the cut and cover technique, caused a lot of disruption to *London* neighborhoods. *Praed Street* station (now known as Paddington), is hidden from view by the beer house in the center of the picture.
Right: another photo by Henry Flather shows the construction (1866-1870), of the MDR's underground lines which included the destruction of many houses

100



Above: in 1871 the *Inner Circle* services began, starting from *Mansion House* and traveling to *Moorgate Street* via *South Kensington* and *Paddington*. The two companies had their own pairs of track between *Kensington High Street* and *South Kensington* (highlighted).

101



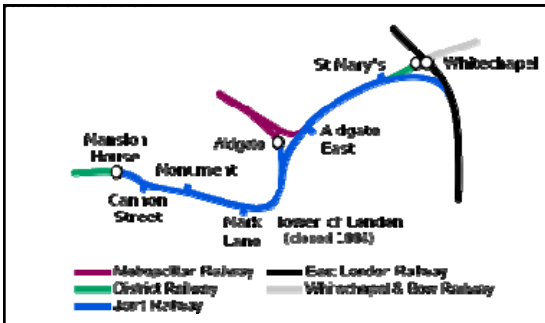
Top Left: caption: "In 1867, construction of the Metropolitan District railway, as it was called back then, was undertaken"
Top Right: caption: "Workers continue to establish more lines on the London Underground in order to provide a rail connection for travelers between London's main railway terminals situated around the city in 1869"
Left: caption: "Here, a trench is erected during the construction in 1868"

102

Friction between the two companies arose when the DR introduced its own trains in 1871 to escape its financial responsibilities to the Met. The election of bitter rivals *James Staats Forbes* and *Sir Edward Watkin* as chairmen of the two companies made this corporate animosity even worse, as the two men had very different management styles and visions. Watkin saw the Met as a mainline railway and made no secret of his ambitions which included building a link to *France* through a Channel tunnel. Forbes favored shorter extensions largely constructed in partnership with other companies such as the L&SWR. Rivalry and legal action continued between the two companies throughout the 1870s and 1880s. In fact, the *Inner Circle* was only completed largely as a result of government pressure.

Left: construction of the *Metropolitan District Railway* (ca. 1867)

103

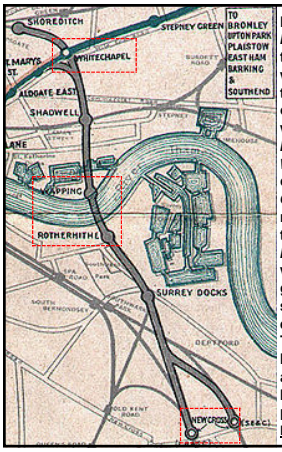


Above: the "Joint Line" (shown in blue) that completed the *Inner Circle* in 1884 and gave the Met and DR access to the *East London Railway*. The Met's station at the *Tower of London* was closed soon after the line was opened. DR services were extended east of *Whitechapel* over the *Whitechapel & Bow Railway* (W&BR) in 1902.

104

East London Railway

105



Despite great difficulties, the engineer *Marc Brunel* had proved that tunneling through the soft, blue clay that lies beneath *London* was possible. Originally intended for road traffic, the *Thames Tunnel* eventually opened for pedestrians-only in 1843 and was converted in 1869 to carry the *East London Railway* (ELR) between *Whitechapel* and *New Cross*. The ELR was created by the *East London Railway Company* (ELRC), a consortium of six railway companies. The ELR reused the Thames Tunnel (built by Marc and *I.K. Brunel* between 1825 and 1843). The tunnel was built for horse-drawn carriages with generous headroom and two carriageways separated by arches. It connected *Wapping* on the north bank of the Thames with *Rotherhithe* on the south bank. A triumph of civil engineering, it was a commercial failure and by the 1860s had become an unpleasant and disreputable place.

106

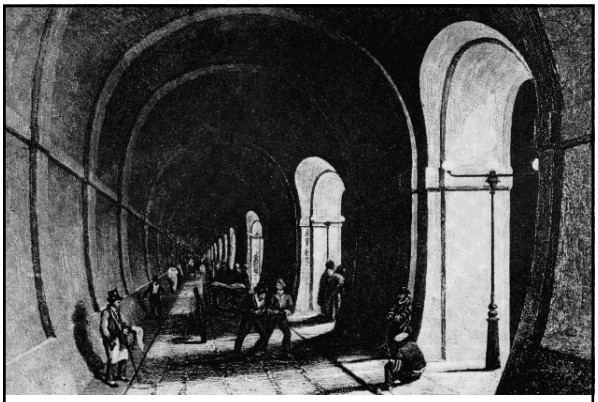
Left: map of the East London Railway (ca. 1915)

The *Thames Tunnel*; from *Wapping* to *Rotherhithe*, was the world's first underwater tunnel, begun in 1825 by *Marc Brunel* but not completed until 1843, under the supervision of his son *Isambard Kingdom Brunel*. With a lavish opening ceremony in March 1843, the Thames Tunnel became an important sight for any visitor to *London*, with *Queen Victoria* herself making a visit in July 1843. Throughout the 1850s and 1860s it was host to traders during the day and also the site of several spectacular fairs, beginning in 1852. On a day-to-day basis, traders lined the tunnel and mainly sold souvenirs to the passing tourists.

Left: caption: "Fair in the Thames Tunnel" (from *The Illustrated London News*, 1855)

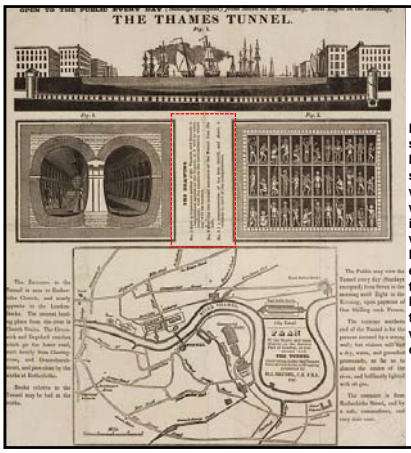
Right: caption: "Thames Tunnel Watchpaper, ca. 1840s." Watchpapers were small printed round paper inserts placed in pocket watches to protect their inner workings from rust.

107



Above: caption: "Interior of the Thames Tunnel shortly after completion in 1843"

108



THE DRAWING.

Fig. 1 shows a transverse section of the Thames, and beneath it a longitudinal section of the Tunnel, as it will be when completed; with the ascents in the inclinations in which they will be finished.

Fig. 2 shows the two arched entrances of the Tunnel from the shaft.

Fig. 3 is a representation of the iron shield, and shows a workman in each of the compartments.

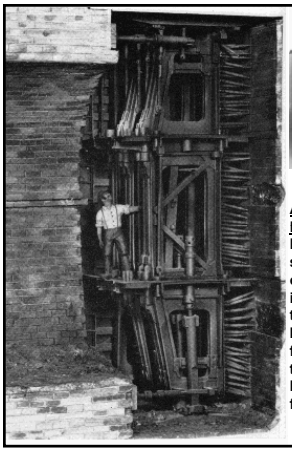
109

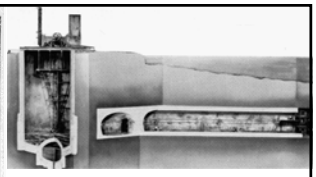
The Great Bore

110

The first tunnel under the *Thames* was proposed in 1798, but nothing came of it. However, four years later the *Thames Archway Company* was formed to build a tunnel from *Rotherhithe* to *Limehouse* in the docklands area of *London* and construction started in 1805. After initial problems, *Richard Trevithick* was appointed as engineer and by the start of 1808 the initial drift; 1.5 m (5-feet) high and 0.9 m (3-feet) wide, reached from the southern shaft all the way to the low-tide mark on the northern shore; only 60m (200-feet) or so short of its target. However, on January 26th 1808 a breach in the tunnel roof flooded the works and the project was abandoned. Ten years later, in 1818, *Marc Brunel* patented the first version of the tunneling shield. Five years thereafter, one of the Archway company's promoters learned of this and backers were found for a new tunnel (about a kilometer west of the previous site) joining *Rotherhithe* to *Wapping*. Construction began on March 2nd 1825. The tunnel was intended to be used by road traffic, with 12m (40-foot) wide spiral ramps coming down from the surface, but the first stage of the project was to dig the southern vertical access shaft and drive under the river, using a shield, to eventually meet the northern shaft (which was dug sometime later). Test bores in the riverbed seemed to show a good solid layer of clay a little below it, so Brunel decided to stay in the clay by placing the tunnel roof just 4.3 m (14-feet) below the riverbed. In fact, the clay was riddled with faults allowing water to leak into the tunnel and several times breakthroughs of the river above flooded the works. The first breakthrough turned out to be at a point where dredging of the riverbed for gravel had brought it even closer to the tunnel. Due to these and other problems, the project ran through a succession of engineers in charge, including *I.K. Brunel* (at 20yo). The company's capital was exhausted and work had to stop completely several times (during one of these hiatuses the tunnel gained the nickname of "The Great Bore"). During the final stages of the work, a driftway was dug from the northern shaft to the almost complete tunnel and when they met, Isambard Brunel's three-year-old son was handed through to become the first person ever to make the complete crossing under the Thames. Marc Brunel was knighted in 1841 for his contributions to the tunnel's creation.

111

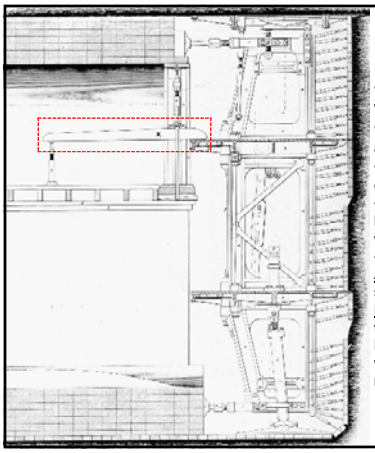




Above: scale model of the *Thames Tunnel*

Left: caption: "Enlarged detail of Marc Brunel's tunneling shield (vertical section). The first two and part of the third of the twelve frames are shown. To the left is the tunnel's completed brick lining and to the right, the individual breasting boards and screws for supporting the face. The propelling screws are seen at top and bottom, bearing against the lining. Three miners worked in each frame, one above the other."

112



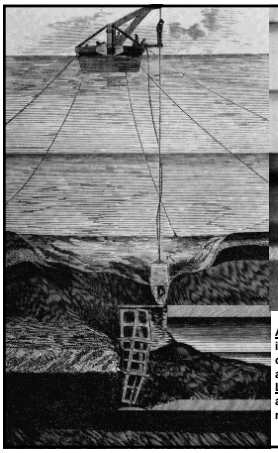
THAMES TUNNEL

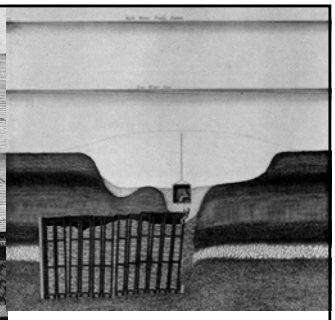
- **Brickwork lining, 38-feet wide by 22.5-feet high;**
- **120-ton cast-iron shield, accommodating 36 miners;**
- **Workings filled by irruption of river five times;**
- **Eighteen years elapsed between start and finish of work;**
- **Cost: $3 million**

Above: *Thames Tunnel* statistics

Left: caption: "Vertical section through Brunel's shield. The long lever, x, supported the wood centering for turning the masonry arches of the lining."

113

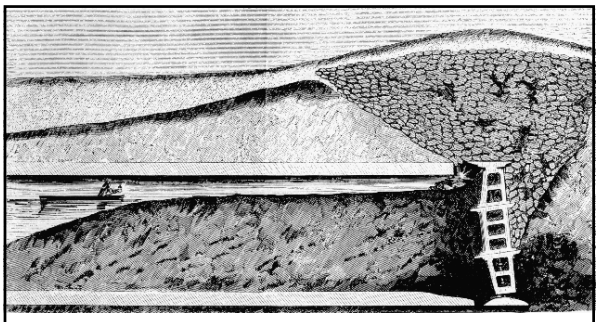




Above: caption: "Transverse section through shield, after inundation. Such disasters, as well as the inconsistency of the riverbed's composition, seriously disturbed the alignment of the shield's individual sections."

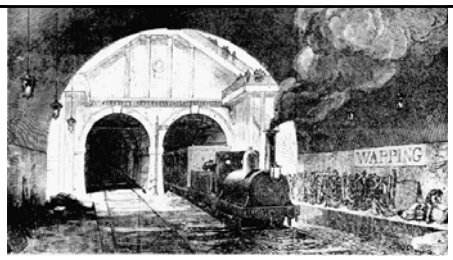
Left: caption: "Thames Tunnel. Section through riverbed and tunnel following one of the breakthroughs of the river. Inspection with a diving bell."

114



Above: caption: "Longitudinal section through Thames Tunnel after sandbagging to close a break in the riverbed. The tunnel is filled with silt and water."

115



The tunnel was the most easterly land connection between the north and south banks of the *Thames*. It was close to London's docks on both banks of the river and was not far from main-line railways at either end. Converting the tunnel to a railway thus offered an ideal means of providing a cross-*Thames* rail link without having to go to the great expense of boring a new tunnel. On September 25th 1865, the ELR took ownership of the *Thames Tunnel* at a cost of £800K. Over the next four years, the company built a railway line running through the tunnel to connect with existing railway lines.

Above: caption: "Thames Tunnel in use by London Underground railway" (from *The Illustrated London News*,1869)

116

In 1933, the ELR came under the control of the *London Passenger Transport Board* (LPTC). Although the infrastructure was still privately owned, passenger services along the line were operated under the auspices of the "East London Branch" (ELB) of the *Metropolitan Line*. In 1948, the railways were nationalized and became part of the newly created *British Transport Commission* (along with the *London Underground*). The identity of the "East London Line" (ELL) changed considerably during the London Underground era. On tube maps between 1933 and 1968, it was depicted in the same color as the Metropolitan Line. In 1970, it was renamed the "Metropolitan Line - East London Section" (in Metropolitan Line purple with a white stripe down the middle). In the 1980s, it was renamed as a line in its own right (though it was still grouped operationally with the Metropolitan Line) and from 1990, the color on the map changed to orange. Engineering work on the *East London Line Extension* (ELLX) started in 2005 and the existing underground service ended in December 2007. The ELLX project was a *British Rail* engineering project in *London*, managed by *Transport for London*. The project involves extending the ELL and making it part of the mainline *London Overground* network.

117

Left: one-half of the *Thames Tunnel* today – part of the *London Underground* network

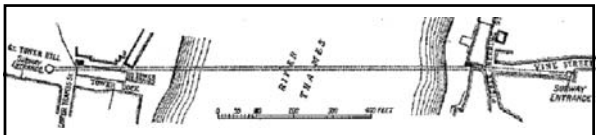
118

The Tower Subway

119

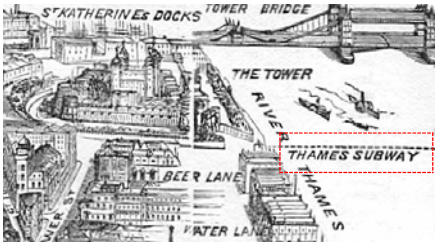
Advances in deep-level tunnel design came rapidly in the latter part of the *19th Century*. Tunneling shields and segmented tunnel linings allowed stable tunnels to be constructed deep underground. The world's first underground tube railway: the *Tower Subway* (beneath the *River Thames*, running from *Tower Hill* to *Tooley Street*) at first operated with cylindrical cars that nearly filled the seven-foot bore (the cars were drawn by cables powered by small steam engines in the shafts). This mode of power had previously been used in passenger service only on the *Greenwich Street* elevated railway in *New York City*. Although the construction was successful, the problem of how to power a railway to run through the subway led to its financial failure. A steam locomotive was out of the question in such a confined space and the only other solution at the time was to haul the carriages with cable traction. This proved unreliable and the railway closed in November 1870 after only a few months of operation. Later the cars were abandoned and the tunnel turned into a footway. However, this small tunnel was the forerunner of the modern sub-aqueous tunnel. In it, two of the three elements essential to such work thereafter were first applied; the one-piece movable shield of circular cross-section and the segmental cast-iron lining.

120



"The tunnel commences at Tower Hill, where a hoarding encloses a small square of ground, not larger than an ordinary sitting-room…In the centre of this is a little circular shaft, about fourteen feet diameter and sixty feet deep, and at the end of this, facing south, a clean, bright, vaulted chamber, which serves as a waiting-room. At the end of this chamber is the tunnel, a tube of iron not unlike the adit of a mine, which, in its darkness and silence, heightened by the knowledge that this grim-looking road runs down deeply below the bed of the river, gives it at first sight anything but an inviting appearance. The length of the whole tunnel is about 1,340 feet, or as nearly as possible about a quarter of a mile. From Tower Hill it runs in a south-west direction, and, passing under Barclay's brewery, opens under a shaft similar to that at entering, but only fifty feet deep, and out of this the passengers emerge within a few yards of Tooley Street, close to the railway station."
RE: excerpt from "Old and New London" (1897)

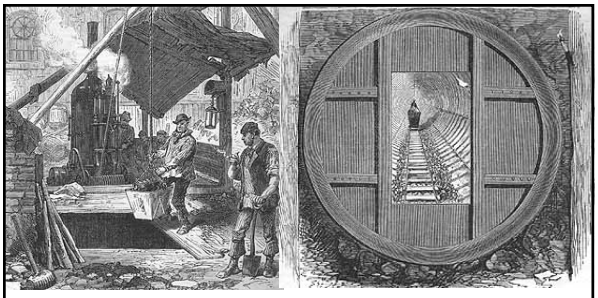
121



122

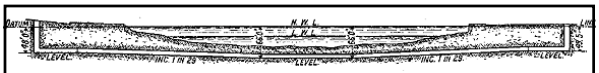
"A tunnel, crossing beneath the river from Tower Hill to Tooley Street, near the London Bridge railway station, has been constructed in the present year (1869). It is not a brick archway, but a circular iron tube, 7 ft. in diameter, laid deep in the clay of the river bed. The engineer is Mr. Barlow, Jnr., son of the Mr. Barlow who constructed the Lambeth Suspension Bridge. The contractor is Mr. Greathead; and the cost, it is said, will scarcely exceed £16,000. The works may be approached from Tower Hill by going down a circular iron shaft, 10 ft. in diameter and 60 ft. deep. The upper part of the shaft is lined with powerful rings of cast iron, the lower part with ordinary brickwork, which will be coated with glazed tiles. There the visitor sees before him an iron tube 7 ft. in diameter, and lined closely along the inside with iron: flanges, or rims, nearly 2 in. deep. This tube has much the appearance of one of the large clean main drainage sewers, except that it is built of iron and has a greater incline and curve. Candles, few and far between, twinkle in the distance and just make darkness visible. The whole length of the tube is 1320 ft…"
***The Illustrated London News*, October 30th 1869**

123



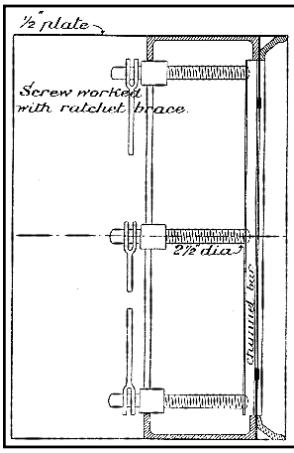
Left: caption: "The shaft at Tower Hill"
Right: caption: "The tunnel from the heading"

124



"…A rather steep incline of 1 in 40, curving from north-east to south-west that is to say, from Tower Hill to near Tooley Street, soon leads the visitor from the London clay beneath the land to the London clay beneath the water, and a difference of temperature between the two is at once perceptible. It is so dry throughout that every drop of water wanted for the works has had to be sent down in buckets. The tunnel, from the north to the south shores, makes a dip to pass under the water and its line of curve is rather deep. At its nearest point to the river water it has a thickness of not less than 22 feet of London clay between the bed of the river and the top of the tube, while at its furthest point it has a thickness of 32 feet. Sounds from above are distinctly heard in the tunnel…"
***The Illustrated London News*, October 30th 1869**
Above: longitudinal tunnel cross-section

125



The *Tower Subway* was constructed by the engineer *Peter Barlow*. He had patented a cylindrical iron tunneling shield which was an improved version of I.K. Brunel's original rectangular shield. He contracted a former pupil; *James Greathead*, to carry out the work. The tunneling shield Greathead used was seven-feet in diameter and closed at one end. In the center of the closed end was a small watertight door behind which two miners could remove the soil by hand. The entire shield was forced forward into the space by means of huge screw jacks. The newly dug section of tunnel was then lined with cast-iron segments to form a cylinder, or "tube."
Left: vertical section through the Greathead shield. It was the first one-piece shield of circular section

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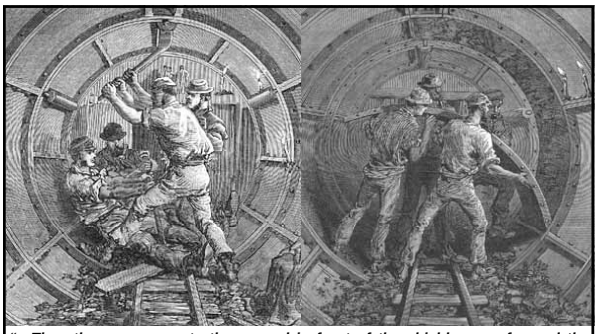
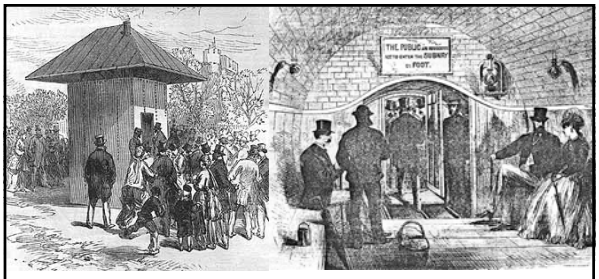
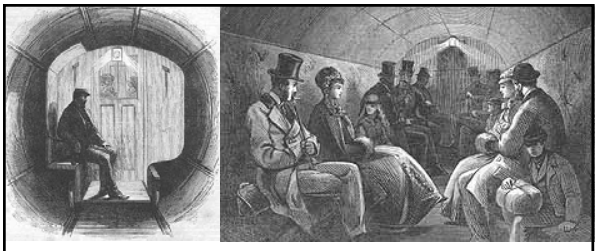
"The shield which is advanced to cover the driving of the tunnel is a light circular piece of mixed cast and wrought iron, weighing 2 1/2 tons, and having an outer diameter of 7 ft. 3 in. The tube of the tunnel itself is built by means of three segments of a circle of cast iron, each of great strength and weighing 4 cwt., with a centre key-piece at the top weighing 1 cwt. Each segment or ring when bolted together is only 18 in. long, but no fewer than six of these rings are bolted on in every twenty four hours, so the tunnel is advancing at the rate of 9 ft. a day. As the cap or shield is pushed on for a length of 18 in. it leaves within its tube or rim a space 1 in. greater all round than that occupied by its own tube on the outside. This, therefore, leaves ample room to fit in the segments of the tunnel-tube easily. It is done very rapidly. The bottom segment is laid in its place, and the two side segments above it, and between these at the top the key-piece is slid in. Between the long horizontal flanges a layer of white pine is placed before they are screwed close up, and it is to be regretted that some such indestructible material as gutta-percha was not chosen for this work. The spaces between the circular flanges of each segment are regularly caulked in with tow and cement. Still, the shield or cap is 1 in. wider all round than the diameter of the tunnel-tube within it, which comes afterwards to occupy it, leaving an opening of that space between the clay and the iron. This interstice, when the segment-ring is fixed, is closed by pumping in blue lias cement, which, as it quickly sets, forms a ring of stonework, not only impervious to the water, for that, indeed, the tube itself is, but impervious to the action of water on the iron tube itself, which is a very important matter. It takes some time to explain all these details, but in practice they are very quickly done."
The Illustrated London News, October 30th 1869
127



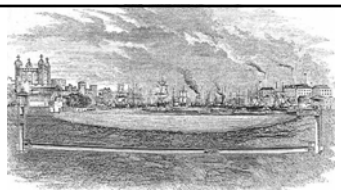
"…Thus the men excavate the ground in front of the shield, move forward the shield and fill in another segment behind it every four hours and as the work is continued day and night in three relay gangs working eight hours each spell, it follows that the tube advances 9 ft. every twenty four hours…"
The Illustrated London News, October 30th 1869
Left: caption: "Advancing the Shield"
Right: caption: "Fitting the Castings"
128



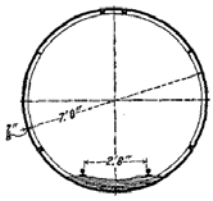
"…The arrangements visible from above are very simple. The upper opening of each shaft is covered by a small square building, at the door of which passengers take their tickets, then enter and descend in the lift. On reaching the bottom they find a space of a few feet between the shaft and the buffers fitted up with benches, as a waiting room. When the omnibus arrives and has discharged 'its load', those who are waiting step in and start off for the other end…"
The Illustrated London News (ca. 1870)
Top Left: caption: "Entrance to the tunnel"
Top Right: caption: "Waiting room, showing how passengers entered the 'omnibus'"
129



"…This circular tunnel is not intended for foot passenger traffic; it is meant for a tramway of 2ft. 6 in. gauge, on which is to run a light iron omnibus of 10 1/2 ft. long, 5 ft. 3 in. wide and 5 ft. 11 in. high. This will accommodate fourteen people with the most perfect ease. Ordinary lifts will take them down and up the shafts at each end, and at the end of the shaft the 'bus' will be waiting. For the first hundred feet or so the omnibus will be pulled by a rope fixed to a stationary engine; after that it will descend by its own velocity down the incline and up the incline on the other side to the foot of the shaft. The whole transit, including time for descent and ascent, is not to exceed three minutes…"
The Illustrated London News, October 30th 1869
Above: caption: "Interior views of the Omnibus Carriage"
130



"…The tube is about a quarter of a mile in length and sinks from both ends towards the centre with a gradient of about 1 in 30; the omnibus is of iron; light, but very strong, and runs upon eight wheels. It is connected with a rope of steel wire by means of a gripe that can be tightened or relaxed at will. At each end of the tunnel this wire runs over a drum, worked by a stationary engine. The declivity of the tunnel is such that, when once the omnibus is started, it requires only a small amount of traction, and the momentum acquired during its descent will carry it a long way up the opposite slope. It is said that the strain on the rope will never exceed 2 cwt. The omnibus is provided with brakes, so that its motion is completely under the control of the man in charge. At each end of the tunnel it is received by buffers, or catches, which are connected with very strong springs of vulcanized India rubber…"
The Illustrated London News
131



"The Tower Subway consists of an iron tube, 7 feet in diameter and about 1,235 feet in length, laid some 18 feet below the bed of the Thames. It runs between Great Tower Hill on the north side of the river, and Tooley Street on the south. It belongs to a Limited Liability Company, and was opened for tramway traffic on the twelfth of April, 1870. Being a losing speculation, the tram cars ceased to run on 7 December, 1870; but it was opened for foot-passengers (toll, one halfpenny) on the 24th of that month, and the Company have successfully continued it only as such. It is reached at each end by a spiral staircase of 96 steps. The Subway is well lighted up with gas, the average heat by the thermometer being 65 degrees Fahr. Those, however, who are afflicted with chest complaints should not attempt to make use of it, owing to the extreme closeness of the atmosphere and the limited space in the tube, which renders stooping necessary. It is open from 5.30 AM. till midnight."
RE: excerpt from "Collins' Guide to London and Neighbourhood"
Left: caption: "This shows the tunnel once it was used by people on foot. The rails are still in place"
Right: cross-section of sub-aqueous tunnel "tube"
132

Although the press launch of the subway was held in April 1870, problems involving the difficulty of signaling between the engine drivers in the shafts and the conductor aboard the omnibus took time to be resolved (public service did not commence until August 1870). In any event, the scheme was not successful as conceived and operated for barely three months before the lift and omnibus service were abandoned (after a number of mechanical failures and minor accidents). The company went into receivership in November 1870 and from then on, passengers walked up and down wooden spiral stairs and made their own way through the gas-lit tunnel. A new entrance on *Tower Hill* was opened in 1871. In its heyday, however, the subway carried a million foot passengers a year. Even so, this trimmed-down operation came to an end once *Tower Bridge* opened nearby in 1894. Given the opportunity to cross the river for nothing in the open-air by bridge, people deserted the toll tunnel and soon after the *Tower Subway* closed to the public for good.

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In 1897, the *Tower Subway* was sold to the *London Hydraulic Power Company* (LHPC) which used it to link its high-pressure mains on either side of the *Thames*. These mains delivered power to shops, factories, theatres and even car showrooms for powering lifts and other machinery. The hydraulic main through the subway was laid in 1903, from the *Rotherhithe Pumping Station* and was used as a feeder main for supply to the City. The *Metropolitan Water Board* leased space in the subway for two water mains as well (laid in 1898 and 1925). Electric lighting was installed and vertical iron ladders replaced the wooden spiral staircases in 1926. A near-miss by a German bomb in 1940 caused significant damage to the subway tube. Emergency repairs were made enlarging the diameter of the repaired section to 10-feet. One of the two entrance kiosks, (the north one, on *Tower Hill*) still exists. It is not the original structure but, rather, a round brick structure erected by the LHPC in 1926. The southern entrance was demolished in the 1990s. Use of the LHPC's services declined after WWII and the company eventually ceased operations in 1977. In 1981, a group of investors bought the 150 miles of pipes, ducts and conduits and in 1985 it was sold to *Mercury Communications Ltd*. In recent years, optical fiber cables were laid through the subway.

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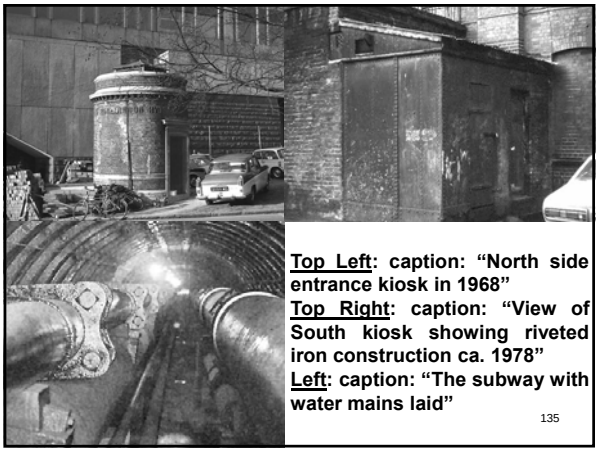

Top Left: caption: "North side entrance kiosk in 1968"
Top Right: caption: "View of South kiosk showing riveted iron construction ca. 1978"
Left: caption: "The subway with water mains laid"

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The Sardine Box

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By the 1880s, electricity offered a clean and efficient way of powering the railway. It was the development of a reliable electric motor and a means of transferring the power from the generator to a moving train which made possible the construction of the world's first deep-level electric railway; *City & South London Railway* (C&SLR). The line was designed by *James Greathead* for cable traction, but electricity was finally chosen for motive power. The method of construction was similar to that used for the *Tower Subway*, although Greathead improved Barlow's tunneling shield and made the tunnels larger (10-foot diameter). The C&SLR opened in 1890 and ran from *King William Street* in the City to *Stockwell*. Hydraulic lifts were installed at the stations to transfer passengers between street and platform. Trains were made up of three carriages and hauled by electric locomotives. The carriages were narrow and furnished with tiny windows just below the roof (it was thought that passengers would not want to look out at the tunnel walls). Guards at the end of each carriage called out the names of stations and opened and closed the gates for passengers. The railway was extremely busy during the rush hours prompting *Punch* magazine to christen it the "Sardine Box Railway." The line was not without its problems. These problems were mainly caused by cramped tunnels, under-powered locomotives and a power supply that had difficulty in coping with the volume of traffic.

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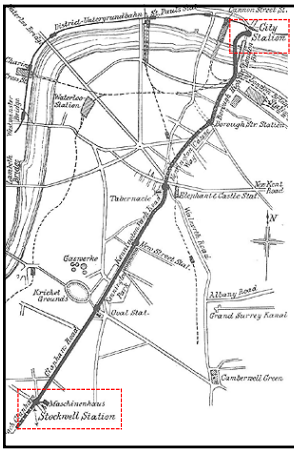

The line was inaugurated on November 4th 1890, from *King William Street* to *Stockwell*. The *Prince of Wales* (later *King Edward VII*) performed the opening ceremony on December 18th 1890; the day the line was opened to the public. The old City terminus (King William Street) was awkwardly placed facing almost due west and curved sharply to the left under *Swan Pier* (crossing the river under the up-stream side of *London Bridge*). The line southward from King William Street involved a sharp curve and a gradient of one in thirty upon leaving the station, while the northward line from *Stockwell* station was still steeper; one in fourteen. The line was originally called a "subway" (most likely to avoid the negative connotations of the smoke-ridden atmosphere of Underground lines then worked by steam locomotives). The name caught on in *America* and stuck.

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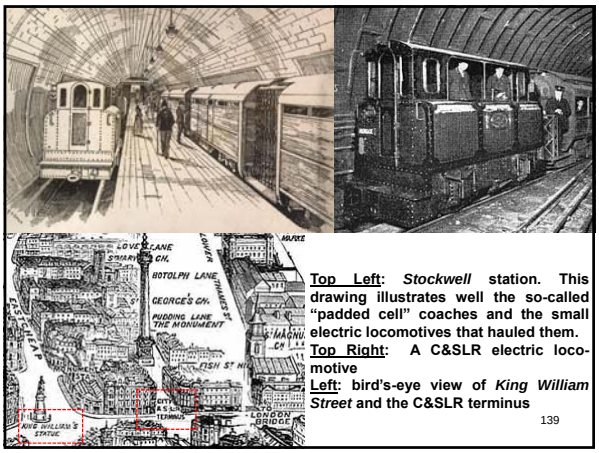


Top Left: *Stockwell* station. This drawing illustrates well the so-called "padded cell" coaches and the small electric locomotives that hauled them.
Top Right: A C&SLR electric locomotive
Left: bird's-eye view of *King William Street* and the C&SLR terminus

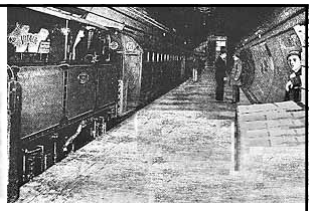
The new line was heavily used from the opening day and the station layout quickly proved unsatisfactory. To overcome this, a bill was introduced into *Parliament* in 1882 to construct a new line from *Borough* to *Moorgate Street* and abandon the unsuitable *King William Street* terminus. The Bill received *Royal Ascent* in 1883 but this was for a long term solution. To alleviate the congestion problems in the short term, surface facilities were improved by taking a lease on an existing building in *Arthur Street East* for a ladies room, parcels room and lost luggage office. A plan to install a third lift was dropped due to cost. With 15K passengers using the terminus daily, improvements were also urgently required at platform level so the single line was replaced by twin lines running into an island platform which was completed in December 1895. A scissor-crossing was added at the south-end allowing trains to use either line but this required a shortening of the platform which could now only be used by three-car trains. Today the C&SLR forms part of the *Northern Line* of the *London Underground*, with the exception of the bypassed *King William Street* terminus and the empty tunnels leading to the abandoned station.

Left: the pair of tunnels at the end of *King William Street* station were at slightly different levels. By the time the tunnels reached *Swan Lane,* the two tunnels were above each other. Tunneling was not allowed directly beneath buildings so the tunnels had to follow the path of roads on the surface. Where the road was narrow, the tunnels would have to be built one atop the other.
Right: beyond the *Thames* bulkheads, the two running tunnels ran above each other. The ladder in this picture leads to the other (upper) tunnel.

Above: caption: "THE CITY AND SOUTH LONDON SUBWAY. An underground railway from King William-street, City, passing beneath the Thames to Southwark, and thence to Newington-butts and to Clapham, is now being constructed. One tunnel has been completed from King William-street to St. George's church in Southwark, the first station south of the Thames. The second tunnel is almost completed for the same distance, with the exception of about 100 yards. Both tunnels are being pushed forward towards the Elephant and Castle, and the works for the station there, and the stations at King William-street and Great Dover-street, are in hand. At the terminal station at Stockwell sinking operations will also very shortly commence. The means of access for passengers, between the level of the underground railway and the level of the streets, will be hydraulic lifts, two of which, each to take fifty persons, will be at work at each station. There will also be steps at the stations. As the carriages are to be drawn by wire ropes, working from a stationary engine, the atmosphere should be much fresher than in the tunnels of the Metropolitan Railways north of the Thames. It is hoped that the first section of the line will be opened for traffic in the summer of this year."
The Illustrated London News, March 3rd 1888

King William Street Station

The entrance to *King William Street* station was incorporated into an existing building at the corner of King William Street and *Arthur Street East* (now *Monument Street*) with the company's offices in the upper floor and the booking hall in the ground floor. The station was 75-feet below ground and was accessed by two hydraulic lifts within a single shaft; there was also an emergency spiral staircase.

Initially, the station was provided with a single track and two side platforms (one for arrivals and the other for departures). This unusual arrangement prevailed because the original proposal to use cable haulage required a simplified track layout. By the time the 10-foot, 2-inch diameter tunnels reached *King William Street,* they were side-by-side and opened into a single 20-foot high by 26-foot wide bore, which had a 3-foot lining of brick, and was finished in white glazed tiling.

Left: period drawing illustrating the original layout of the station, with one track and two platforms (for departing passengers on the left and arrivals on the right). This was altered to two tracks and a single island platform in December 1895.
Right: view of the island platform in use

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Work on the extension to *Moorgate Street* started in 1896 and *King William Street* station closed with the inauguration of the new service beginning February 25th 1900. The station and the tunnels running under the *Thames* to *Borough* were abandoned. Initially, no use was found for the tunnels but as early as 1901 it was suggested they could be used for cultivating mushrooms or as a bonded store. The favored solution was to use the tunnels to carry telephone or electric cables, but no user could be found. The track remained in place and was used to store empty stock. At the outbreak of war in August 1914, there were fears that the tunnels might be used by enemy agents and a thorough search was undertaken before the track was removed and the tunnels sealed up. In 1923, the King William Street station was offered for sale or lease. In 1930, the *London Underground* took steps to dispose of the old station building at King William Street and shortly after, the old station and office buildings were demolished to make way for a new block known as *Regis House*. Regis House retained the quarter-round profile of the original structure.
Left: Regis House (ca. 1990s)

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Gimme Shelter

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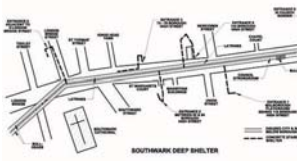

"I slept many times in the former King William Street station under Regis House, where my father worked. I was there the night the bomb fell on the Bank station and the tunnel really rocked…The two running tunnels at the end were toilets apparently running all the way to Borough. One male and one female. The air conditioner made such a noise that when it switched off at about 5 a.m. the sudden silence woke you up! That part that I slept in was north of the Thames, and the only access of which I have any knowledge was from the basement of Regis House (corner of Monument Street) via the standard spiral tube station staircase. This comes out into a double track sized tube tunnel which was much larger in diameter than a normal tube station and then a large office and full of desks and filing cabinets, between which we used to put up camp beds…"
Alan Gilderslev

RE: on November 11th 1939, it was reported in the *Evening Star* that work would start to convert the running tunnels, but not the station itself, into a deep level public air raid shelter. The work, which was expected to last three months, would include the construction of eight entrances, air conditioning plant, seats and first-aid posts. The *Minister of Home Security* had approved Southwark Council's proposal in principle and a rent of £100 per year was agreed-to with the LPTB. Work then began (in January 1940) on conversion of the tunnels into "Southwark Deep Shelter" for 8K people.
Above: plan of Southwark Deep Shelter

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Top Left: the *Southwark Deep Shelter* nearing completion in 1940
Top Right: female toilet cubicles in the northbound tunnel
Left: the original emergency (spiral) stairs

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Although the C&SLR was a technical success, it did not make a profit at first. Consequently, whilst many proposals to build more "tube" railways followed, it proved very difficult for companies to raise the money to build them. It was not until 1898 that the *Waterloo & City Railway* (W&CR) opened (it would be incorporated into the *London Underground* in 1994). Then, in 1900, the *Central London Railway* (CLR) began operations using new electric locomotives (now the *Central Line*). It was very successful and soon after new railways and extensions were added to the growing tube network. By 1907, the heart of London's modern Underground system was in place.

Left: a typical London Underground platform (ca. 1900)

Right: platform view at *Victoria* Underground station (November 1896). The ubiquitous railway news stall was a convenient dispenser of literature about the Underground as well as the place for the commuter to buy the daily newspaper.

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The Drain

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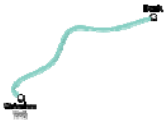

Operated by the *London & South Western Railway* (L&SWR), the *Waterloo & City Railway* (also known as "The Drain") is a short underground railway line in *London*, opened on July 11th 1898. It has only two stations, *Waterloo* and *Bank* (the latter formerly called "City" since it is within the *City of London*) and as such is the least used line on the *London Underground* network with about 15 million passengers annually. The line passes under the *River Thames* and was originally built with a central power rail, level with the running rails, at about 520 Volts. Unlike the other two independent tubes, which started with locomotives, the W&CR from the outset used trains with motors in passenger carriages and no locomotive. This was not "multiple-unit" working where only low-voltage control signals are sent from the driving cab to each car. Rather, power ran directly from the driver's controller to all the motors using rooftop wires to reach the other motored car. Later, an outside rail at 600 Volts became the standard third-rail system. The W&CR was closed for several months following a bomb hit in 1940. It exists almost exclusively to serve commuters to the City traveling from the *South of England* via the *Waterloo Mainline Station*. It's believed that the term: *The Drain,* originally applied to the sloping subway with stairs that led to the surface at Bank, but over time it transferred to the line as a whole. The shortest line on the London Underground at 2.37 km (1.47 miles), it takes only four minutes to travel from one end to the other. It was the second electric tube railway to open in *London*, after the C&SLR.

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The Twopenny Tube

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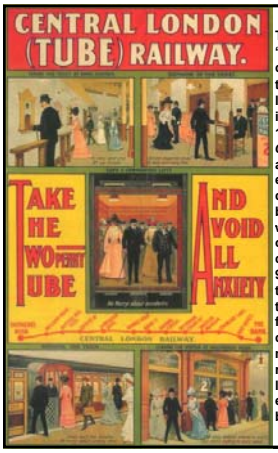

The *Central London Railway* (CLR), also known as "The Twopenny Tube" (the company initially charged a flat-fare of two pennys between any two stations whatever the distance) was a deep-level, underground "tube" railway that opened in *London* in 1900. The CLR was incorporated in 1891 as a line between *Shepherd's Bush* and *Cornhill*, but a further act in 1892 authorized an alternative terminus at *Bank* with a later extension to *Liverpool Street*. The time for completion had to be extended twice; first to 1894 but with work not starting until April 1896, this was further extended to 1899. When the line opened, the CLR served thirteen stations and ran completely underground in a pair of tunnels for 9.14 kilometers (5.68 miles) between its western terminus at Sheperd's Bush and its eastern terminus at the *Bank of England*. The CLR was formally opened by the *Prince of Wales* with a ceremony at Bank station on June 27th 1900; a month before public traffic began to use the railway on July 30th 1900. The line used electric locomotives for a short time, but problems with excessive vibration caused them to be replaced by multiple-unit stock

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To design the railway, the CLR employed engineers *James Henry Greathead*, *Sir John Fowler* and *Sir Benjamin Baker*. Greathead had been the engineer for the *Tower Subway* and the C&SLR and had developed the tunneling shield used to excavate those companies' tunnels under the *River Thames*. Fowler had been the engineer on the *Metropolitan Railway* and Baker had worked on *New York City's* elevated railways and on the *Firth of Forth* railway bridge with Fowler. Greathead died shortly after work began and was replaced by *Basil Mott*, his assistant during the construction of the C&SLR. The tunnels were to be 11-feet, 8.25-inches in diameter (a planned concrete lining to the cast iron tunnel rings was not installed) constructed with a tunneling shield and lined with cast iron segments. The tubes were not well aligned and in practice, trains had to be significantly smaller than would be expected for this size tunnel (the very first CLR locomotive didn't fit into the tube until the rails had been replaced by shallower ones). This meant that stock from other lines could not be used on the CLR. At stations, the tunnel diameter would be 22-feet or 29-feet, depending on layout. A depot and power station were to be constructed on a 1.5-acre site on the west-side of *Queen's Road*. Hydraulic lifts from the street to the platforms were to be provided at each station. In the late 1930s, the tubes were expanded and realigned and the stations lengthened from 325-feet to 427-feet. The line had been built with a central positive rail 1.5-inches above the running rails and energized at 550 Volts, with return through the running rails. In 1940, this was replaced with the standard *London Underground* four-rail power system. Greathead had originally planned for the trains to be hauled by a pair of small electric locomotives (one at each end of a train) but the *Board of Trade* rejected this proposal and a larger locomotive was designed by the *General Electric Company* which was able to pull up to seven carriages on its own. Passengers boarded and left the trains through folding lattice gates at each end of the carriages; these gates were operated by guards who rode on an outside platform. The CLR had originally intended to have two classes of travel, but dropped the plan before opening (although its carriages were built with different qualities of interior fittings for this purpose).

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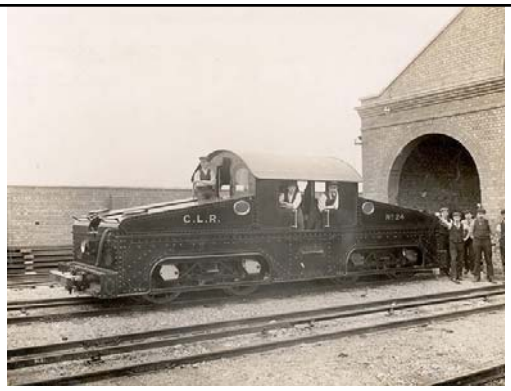

Above: an early underground electric train of the CLR. This engine could be driven in both directions.

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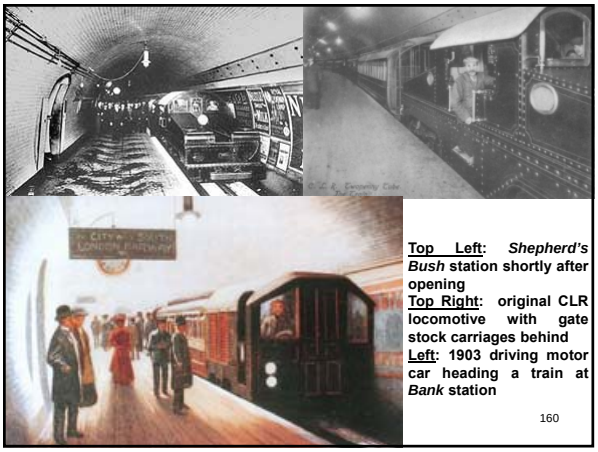

Top Left: *Shepherd's Bush* station shortly after opening
Top Right: original CLR locomotive with gate stock carriages behind
Left: 1903 driving motor car heading a train at *Bank* station

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Soon after the CLR opened, complaints about vibrations from passing trains began to be made by occupants of buildings along the route. The vibrations were caused by the heavy, largely un-sprung locomotives which weighed 44-tons. The *Board of Trade* set up a committee to investigate the problem and the CLR experimented with two solutions. For the first solution, three locomotives were modified to use lighter motors and were provided with improved suspension, so the weight was reduced to 31-tons (more of which was sprung to reduce vibrations). For the second solution, two six-carriage trains were formed that had the two end carriages converted and provided with driver's cabs and their own motors so they could run as multiple units without a separate locomotive. The lighter locomotives did reduce the vibrations felt at the surface, but the multiple units removed it almost completely thus the CLR chose to adopt that solution. The committee's report (published in 1902) also found that the CLR's choice of 100 lbs./yard "bridge rail" for its tracks rather than a stiffer "bullhead rail" (on cross sleepers) contributed to the vibration. Following the report, the CLR purchased sixty-four driving motor carriages for use with the existing stock. Together, these were formed into six or seven-carriage trains. The change to multiple unit operation was completed by June 1903 and all but two of the locomotives were scrapped. Those two were retained for use in the depot.

Left: experimental passenger train that ran for six months in 1900
Right: Passengers boarding a CLR multiple unit train (ca.1920)

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Apart from the station at *Bank*, which was completely below ground, all stations had buildings designed by *Harry Bell Measures*. They were single-storey structures to allow for future commercial development above and had elevations faced in beige terra cotta. Each station had lifts manufactured by the *Sprague Electric Company of New York*. The lifts were provided in a variety of sizes and configurations to suit the passenger flow at each station. Generally they operated in sets of two or three in a shared shaft. Station tunnel walls were finished in plain white ceramic tiles and lit by electric arc lamps. The electricity to run the trains and the stations was supplied from the power station at *Wood Lane* at 5K Volts AC which was converted at sub-stations along the route to 550 Volts DC to power the trains via a third rail system.

Left: *Oxford Circus* station. A fine example of the Harry Bell Measures designs used for the CLR's stations
Right: CLR fare ticket

162

Entente Cordiale

163

In 1905 the *French Chamber of Commerce* proposed holding a *Franco-British Exhibition* in *London* to promote the industrial achievements of both countries and in celebration of the "Entente Cordiale" which was signed by *France* and *Great Britain* in 1904. It was to be a very opulent affair housed in a spectacular setting, built on 140 acres of former farmland on the west-side of *Wood Lane*. The plan got the royal seal of approval and work started in January 1907 with contractors working around the clock to complete the exhibition site within a year. The majority of exhibition buildings were constructed on an impressive scale and set amongst specially laid-out gardens and waterways. Most of the buildings featured highly ornamented plaster ("staph") exteriors which were weather-proofed with white paint and the site quickly became known locally as the "White City." The exhibition area also included a large stadium to accommodate 150K spectators and was built to host the *1908 Olympic Games*.

Left: The White City (postcard)

Right: *White City Stadium* (during the 1908 Olympics)

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The closest existing station/s to the exhibition site were *Shepherd's Bush* (on the CLR) and the adjacent *Uxbridge Road* station (on the *West London Line*). Both stations fronted onto Uxbridge Road and were nearly half-a-mile away from the exhibition site by road. To overcome this, an exhibition entrance was built between the two stations from where a raised arcaded walkway incorporating exhibition halls was built thirty-feet above railway owned land linking the two stations with the exhibition site. However, it was soon clear that the walkway would be inadequate.

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Above: the entrance to the arcaded walkway ca. 1999 (shortly before demolition)

The location of the exhibition site was across *Wood Lane* from the CLR's depot. To exploit the opportunity to carry visitors to the exhibition, the CLR announced a bill in November 1906 seeking to create a loop from *Shepherd's Bush* station and back on which a new *Wood Lane* station, close to the exhibition's entrance, would be built. The new work was approved on July 26th 1907. The station was to be sited on a single-track loop in the northwest corner of their depot. Westbound trains would continue north from Shepherd's Bush using the steeply inclined depot line, coming to the surface alongside the depot. A loop-line was built through the new station and back into a tunnel for the return journey to Shepherd's Bush. Changes were made to the depot layout to accommodate the new station and the new loop operations. The station was on the surface between the two tunnel openings and was a basic design by *Harry Bell Measures*. Although the station was only on a single-track loop, it had platforms on both sides of the curving track (No. 1 on the inside of the curve for alighting passengers and No. 2 for boarding passengers).

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Above: Wood Lane station ca. 1935. Platform 1 (for alighting passengers) is in the foreground and Platform 2 (for boarding passengers) is on the other side of the track

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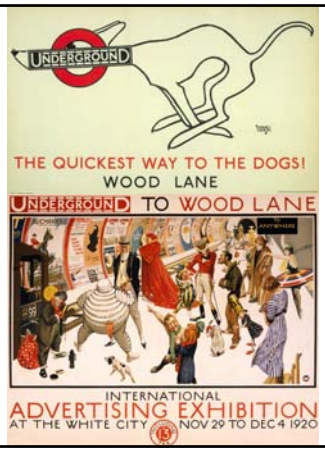
The station entrance was on the east-side of *Wood Lane* with passengers entering the station at the north-end of the building and leaving at the south-end. The station was provided with a large concourse from where a staircase took passengers up to the raised walkway which was carried on a bridge over Wood Lane and into the exhibition. At the back of the concourse there was a porter's room. The booking office was in a direct line with the entrance and was equipped with eight ticket windows. The *Franco-British Exhibition* was a complete success and by the time it closed on October 31st 1908, a total of 8.4 million people passed through the turnstiles. The *White City* continued to host annual large exhibitions until the outbreak of war in 1914 when it was handed over to the government which used it for a variety of functions including army training and aircraft construction. It was finally vacated by the military in the early 1920s and put up for auction in 1922. In 1936, some of the buildings on the fifty-acre site were demolished (to make way for housing estates) while other buildings were again used by the government during WWII. The remainder of the site was cleared in the late 1950s to make way for the construction of the *BBC Television Center* which was built in 1960. The stadium fell into disuse after the 1908 *Olympic Games* but was eventually taken over by the *Greyhound Association* in 1927. It closed in 1984 and was demolished in 1985.

168

Above: Wood Lane booking office (ca. 1927)



169

After a rejected proposal to turn the line into a loop in 1902, it was extended at the western end to *Wood Lane* in 1908 and at the eastern end to *Liverpool Street* station in 1912. After initially making good returns for investors, the CLR suffered a decline in passenger numbers due to increased competition from other underground railway lines and new motorized buses. In 1913, it was taken over by the *Underground Electric Railways Company of London* (UERL); operator of the majority of London's underground railways. In 1920, it was extended along a GWR line to *Ealing* to serve a total distance of 17.57 kilometers (10.92-miles). In 1933 the CLR was taken into public ownership along with the UERL. The *New Works Programme of 1935-40* included a vast modernization program for the former CLR. It was to be extended at both ends beginning August 28th 1937. In anticipation of the extensions taking its services far beyond the boundaries of the *County of London*, "London" was dropped from the name (on August 23rd 1937) and thereafter it was simply known as "The Central Line." Today the CLR's original tunnels form the core of the Central Line's 72.17-kilometer (44.84-mile) route.

Left: rejected loop route (1902)
Right: route map of the CLR (1900-1933)

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Straphanging

171

Above: one of a series of comic cards (ca. 1905) set on the *District Railway* which was up and running by the autumn of 1905, carrying electric trains between *East Ham* in one direction and to *Wimbledon, Richmond, Hounslow, Ealing* and *South Harrow* in the other direction. With the District line, the underground's reputation for slowness, filth and unreliability was swept away (although commuters had to learn the skill of "straphanging" during rush hours).

172

Above: a crowded platform at *Piccadilly Circus* Underground station (ca. 1922). A parliamentary select committee set up in 1919 to investigate congestion, overcrowding and fare increases on the tube said the problem had become "a public scandal" but because London's public transport system remained in the hands of various private companies, a coordinated solution was impossible.

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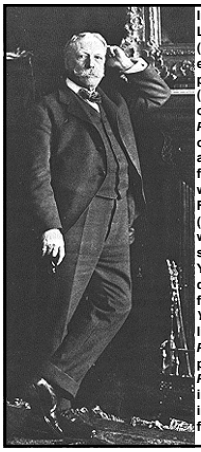
Part 4

Creators of London Transport

175

Yerkes

176



In 1902, the *Underground Electric Railways of London* (UERL) Ltd., a holding company known as "The Underground Group" (UG) was formed. The UG built *Lots Road* power station, electrified the *District Railway* and completed three new tube projects in just five years. Headed by *Charles Tyson Yerkes* (left), he was to be the powerhouse behind the electrification of the *District Line* and construction of the *Bakerloo, Piccadilly* and *Northern Lines* in *London* that formed the core of the modern Underground network. Yerkes made a fortune as a dealer in bonds as a young man but his luck turned following the great *Chicago* fire of 1871 (he lost all his money when insurance companies all over *America* defaulted). Following this, Yerkes was imprisoned for a few months (reputedly for embezzlement). In 1882 he moved to Chicago where he developed the tramway and suburban railway systems, through astute and convoluted business tactics. Yerkes' ruthless business methods became increasingly disreputable and he was forced to leave Chicago, having failed to renew franchises on his railways. He made for *New York*, taking with him his fortune of $15 million. It was while living the high life in New York that he was contacted by *R.W. Perks*, the ex-solicitor for the *Metropolitan Railway*, who persuaded him to finance the electrification of the *District Railway* in London. By 1898, Yerkes had bought a large interest in the District Railway which was in bad condition and in urgent need of renewal. Yerkes believed electrification would substantially improve the line's performance.

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Yerkes was also interested in the as yet un-built deep-level tube; the *Charing Cross, Euston & Hampstead Railway Company* (CCE&HR), now part of the *Northern Line*. He obtained parliamentary authorization to build the line and in September 1900, he paid £100K to the company. He became its chairman and *R.W. Perks* a director. Yerkes saw an opportunity in extending the line to *Golders Green* which was in open country and ideal for suburban development. By March 1901, Yerkes had control of the *District Line* and formed the *Metropolitan District Electric Traction Company* (MDET). In July 1901, Yerkes raised £1 million to invest in the company, most of this capital originating in *America* (*London* financiers still did not trust the returns on investments in electric underground railways). The MDET acquired control of the *Brompton* and *Piccadilly* tube as well as the CCE&HR in September 1901. In order to buy the *Piccadilly Line*, Yerkes used his ruthless dealing skills to outmaneuver *J.P. Morgan*, another American industrialist trying to make a fortune constructing the *London Underground* system. The third tube line Yerkes had in his sights was the half-finished *Baker Street & Waterloo Line* (now known as "The Bakerloo"). It was acquired by the MDET in March 1902. To raise more capital, a syndicate backed by financier *Sir Edgar Speyer* was formed to deal in shares for a new company (the UERL/UG). In 1902, the UG acquired *London United Tramways*. This new company - just like its owner, Yerkes, was treated with suspicion in London's close-knit financial circles.

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"To take a system which has not been thoroughly tested is a species of business recklessness which I do not wish to try"
Charles Tyson Yerkes

RE: still needing to convince his financial backers that his method of electrification was the way forward, Yerkes wrote letters to *The Times* questioning the adoption of a rival system. Eventually, he won the debate. On March 28th 1905, the first successful trial run of an electric train took place from *Mill Hill Park* along the southern section of the *Inner Circle*. The electrification of the line was completed on July 1st 1905. Yerkes died in 1905 in *New York City*, his fortune in disarray. Although he was financially ruined, his legacy was great. The UG became the *London Underground*, taking over the *Central London* and the *City & South London Railway/s* as well as the *London General Omnibus Company* (the main bus company). This in turn became the core of *London Transport* (LT).

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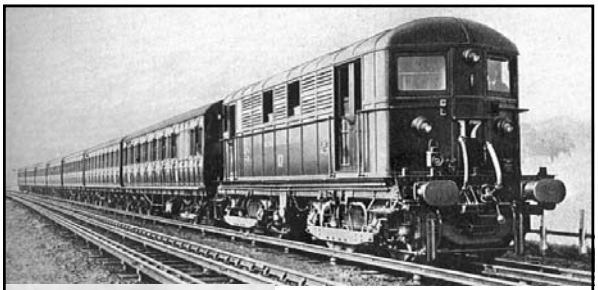

Above: an electric locomotive and train on the *Metropolitan Railway* in the 1920s
Left: a "T-Stock" multiple electric unit

180

Stanley

181

Albert Henry Knattriess **(later *Lord Ashfield*) was born near *Derby* in 1874. His family emigrated to the *United States* when he was a child and changed their surname to "Stanley." Educated in *America*, he was determined to become an engineer. It was arranged for him to start working with the *Detroit Citizens' Street Railway Company* (a horse tram operator) when he was fourteen years old. In the meantime, he attended courses at a technical college. His abilities and ambition helped him progress rapidly and he was made general superintendent by the time he was 28yo. *Albert Stanley* joined the *Street Railway Department* of the *Public Service Corporation of New Jersey* as Assistant General Manager in 1903. By 1907, he had been appointed General Manager and had built a reputation as one of the leading managers of urban transit in the U.S. He was approached by the American managers of the UG and appointed General Manager in 1907 and Managing Director in 1910.** 182

Stanley's management style focused on public relations and publicity. One of his first moves was to encourage use of a common recognizable symbol. He used the word "UNDERGROUND" (written with a large "U" and "D" at beginning and end, respectively) as part of an illuminated sign. This symbol (a.k.a. "Roundelle") was officially adopted in February 1908. 183

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Albert Stanley **was knighted in 1914 for services to London's passenger transport system. During WWI, he was appointed Director General of mechanical transport at the *War Office*. He resigned from the UERL in 1916 and successfully campaigned for *Parliament*. As MP for *Ashton-under-Lyne*, he was made president of the *Board of Trade*. Stanley left the government in May 1919, returning to the UG. He became chairman in February 1921. In the following years, Stanley negotiated with the *London County Council* which ran the trams in central *London*. Although his attempts to forge cooperative arrangements failed, Stanley remained committed to a non-competitive system of London-wide public transport. Stanley was made *Baron Ashfield of Southwell* in 1920. He played a major part in the negotiations that led to the formation of the *London Passenger Transport Board* (LPTB) in 1933. He became Chairman, a position he held until his retirement in 1947. During WWII, he was Chairman of the *London Aircraft Production Group*. When the *British Transport Commission* (BTC) took over *London Transport* in 1948, Stanley was appointed a founding member. He died later that same year. His memorial at *55 Broadway*, the Underground headquarters, has the simple inscription: "Creator of London Transport."** 185

Above: ***Lord Ashfield*** **(left) hands over a train key at the opening of the *Northern Line* in 1926**

Pick

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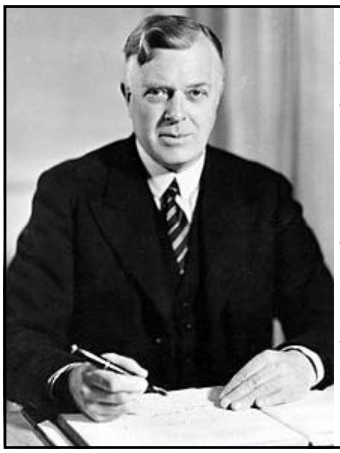


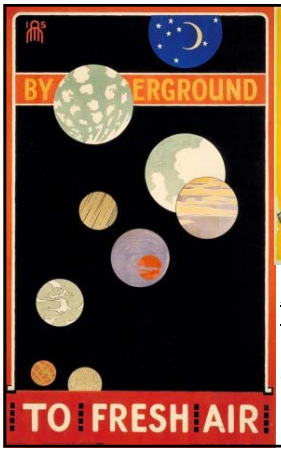
When *Albert Stanley* first arrived in *London*, the UG was facing bankruptcy. Stanley had a forceful personality and adopted a tough leadership style which allowed him to persuade banks to lend UERL money and effectively eliminate competition over the next few years by bringing most of it into the fold. Stanley recognized the potential of an integrated transport system combining trains, buses and trams and supported its development by his very able deputy *Frank Pick* (left).

187

Frank Pick was born on November 23rd 1878 in Lincolnshire, into a devout Quaker family. After leaving *St. Peter's School* in 1897, he worked for a *York* solicitor. In 1902 he earned an honors degree in Law from the *University of London*. However, that same year he decided on a dramatic career change by joining the *Traffic Statistics Office* of the *North Eastern Railway Company* (NERC) under general manager *Sir George Gibb*. When Gibb moved to *London* in 1906 as chairman of the UG, he took Pick with him. In 1907, Pick was put in charge of publicity by *Albert Stanley*. Pick effectively created this job for himself since, at that time, separate publicity and design departments did not exist. It was in this role that his talents became evident. He changed the look of the new underground system. Pick eliminated the clutter from stations where, until then, commercial advertising could be displayed anywhere. He designated far larger areas for UG essential signage, including route maps and station names. In fact, it was Pick who developed the *Roundelle*.

Left: "The Way For All" by *Alfred France* (1911). This poster came at a time when the underground saw an increase in the number of female passengers.

188



Above: "Trooping the Colour" (1935)
Left: "By Underground To Fresh Air" by *Maxwell Ashby Armfield*, 1915. Pick's commissions tended to emphasize the journey's destination, rather than the idea of simply being underground.

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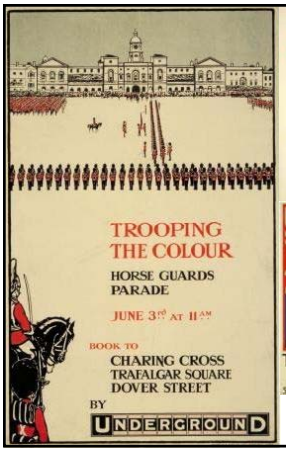

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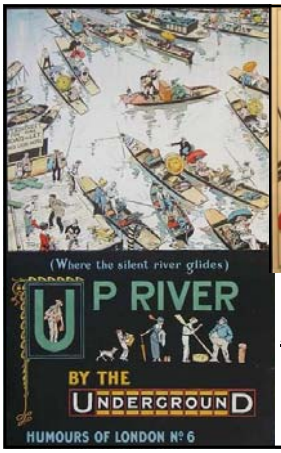
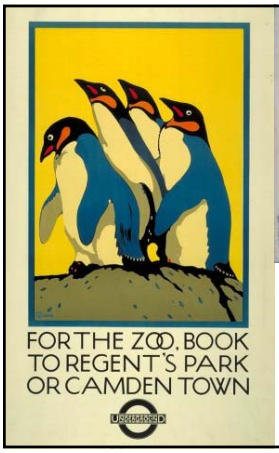


Above: "Lord Mayor's Show"
Left: "Up River" by *Tony Sarg*, 1913

191



Above: "The Zoo by floodlight" by *Tom Eckersley* and *Eric Lombers*, 1935. Eckersley and Lombers (commissioned after graduating from art school) chose to focus on the appeal of *London Zoo* at night.
Left: "For The Zoo, Book to Regent's Park Or Camden Town" by *Charles Paine*, 1921. This poster featured in the first major exhibition of *London Underground* posters in 1928.

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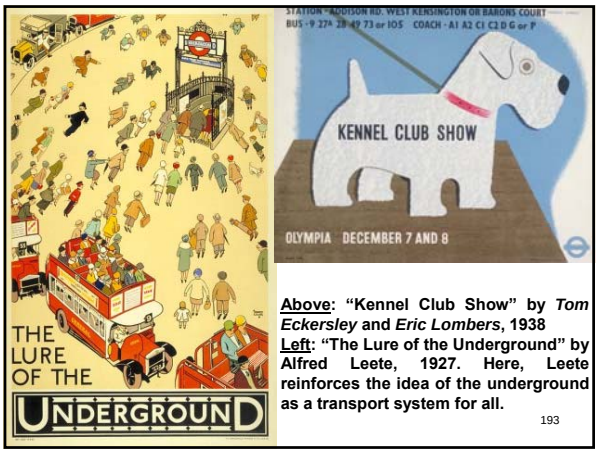

Above: "Kennel Club Show" by *Tom Eckersley* and *Eric Lombers*, 1938
Left: "The Lure of the Underground" by Alfred Leete, 1927. Here, Leete reinforces the idea of the underground as a transport system for all.

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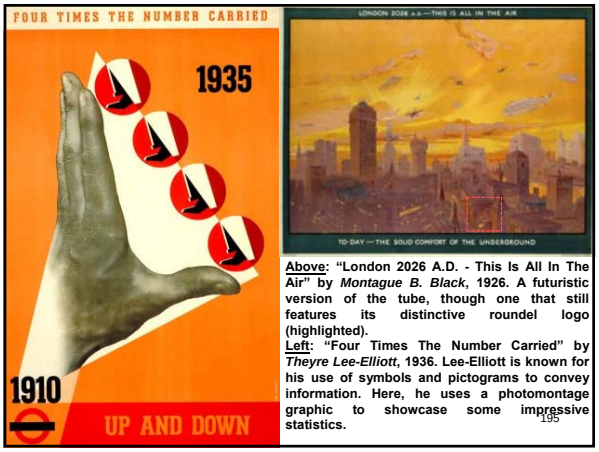
Above: "Boat Race"
Left: "Winter Sales are best reached by Underground" by *Edward McKnight Kauffer*, 1921. Kauffer's Japanese wood-block-style design reminds customers that if you want to avoid London's famous downpours, the tube is your safest mode of transportation.

194



Above: "London 2026 A.D. - This Is All In The Air" by *Montague B. Black*, 1926. A futuristic version of the tube, though one that still features its distinctive roundel logo (highlighted).
Left: "Four Times The Number Carried" by *Theyre Lee-Elliott*, 1936. Lee-Elliott is known for his use of symbols and pictograms to convey information. Here, he uses a photomontage graphic to showcase some impressive statistics.

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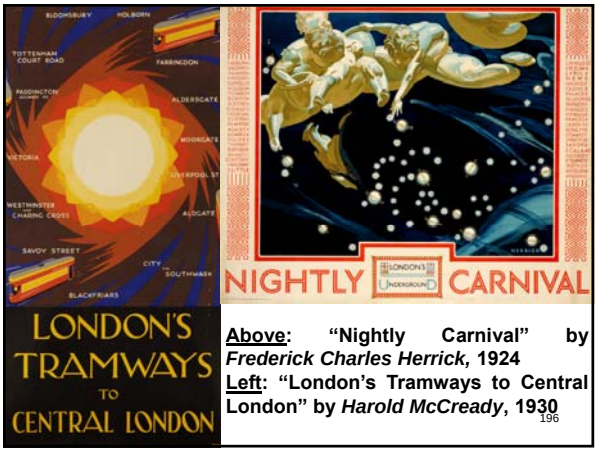

Above: "Nightly Carnival" by *Frederick Charles Herrick*, 1924
Left: "London's Tramways to Central London" by *Harold McCready*, 1930

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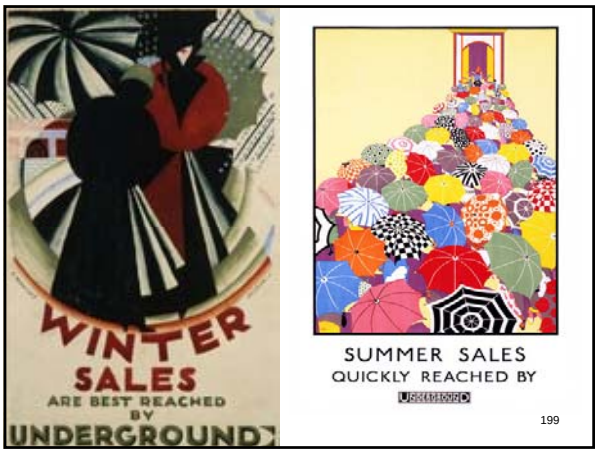

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Above: the joint "London UNDERGROUND Railways" map (published in 1908). The original *Metropolitan Railway* is shown in red. The Underground network expanded considerably during the 1890s and 1900s when the deep tube railways were built. Many of the lines were operated by different railway companies who each produced their own map/s. This became increasingly confusing for the public as the system grew. In 1908, the UG produced a single standard map that included all lines. This was part of promoting the UG as a "system" and of cooperation between private companies that were still independent operations.

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Left: caption (cartoon): "Londoner (proud of the Tube system, to friends from the country). 'There's the whole thing, you see! Absolutely simple!'"

206

By the early 1930s, the *London Underground* network had expanded considerably. draftsman *Fred Stingemore* was finding it increasingly difficult to squeeze all the new lines and stations into a geographical map. Passengers complained that the result was confusing and hard to read, especially in the center where stations were concentrated. The network had become too big to be coherently represented geographically. In 1931 *Harry Beck*, who worked for the Underground as an engineering draftsman, proposed a radical solution. Taking his inspiration from electrical circuit diagrams, he designed a schematic map that did not rely on the street plan. This meant that the central area of *London* with the most stations could be enlarged, and the outlying areas with fewer stations could be compressed. Each line had a different color and routes were drawn only horizontally, vertically or at 45-degrees. Stations were represented as dots and interchanges as circles and diamonds. The Underground's publicity department initially rejected Beck's idea thinking it too radical. However, he resubmitted his designs after making a series of modifications and a trial pocket map was published in 1933. It was an instant success with the traveling public. Beck continued to refine and update his map until 1960. His revolutionary diagram remains the basis of London's Underground map and has become internationally recognized as a design classic. Urban transport systems all over the world, including *New York, St. Petersburg* and *Sydney* have applied Beck's theory to maps of their own systems and similar diagrammatic maps are now used for over-ground railway networks and airline systems.

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Above: Harry Beck's tube map of 1933

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209

Fitness for Purpose

210

Architect *Charles Holden* was one of of Pick's appointments. He was first commissioned in the 1920s to design new Underground stations on the southern extension of the *Northern Line* and the northern extension of the *Piccadilly Line*. Holden also designed *55 Broadway*, the headquarters of the UERL near *St. James's Park* station. The building was completed in 1929 and won that year's *Royal Institute of British Architects* prize for architecture. All these functional yet stylish designs avoided ornamentation and showed "fitness for purpose" (Pick's motto) and a modernist ideal.

Left: a 1929 rendering of the new London Underground headquarters at 55 Broadway, drawn while it was still being built. The underground's rapid expansion in the 1920s brought the need for a company headquarters that could both accommodate the growing staff and make a statement about the its importance. When completed, it was London's tallest building.

211

Above: "Stabler" ceramic tile showing *55 Broadway*, representing *London Transport*, (ca. 1938). The commission for LT's headquarters was based on Holden's previous work for the UG. Both Pick and Holden shared the same philosophy in architecture, mainly that it should be well designed and easy to use. The building is *Portland Granite* over a steel structure. Holden's response to the site, which was an awkward diamond shape, was an inspired cruciform plan. Open plan offices radiate in four wings from a central tower. Large expanses of glass made the most of the direct natural sunlight (there are no internal light wells as was common in buildings of this size/era). The offices were partitioned with *Muranese Glass* that let in light but could be moved as necessary. This plan followed contemporary American office design, but was considered an innovation in *London*. Holden also designed the furniture in the senior executives' offices.

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Above: panel poster (ca. 1933) advertising architect Charles Holden's new *Piccadilly Line* stations as an attraction in and of themselves.

Left: night view of the new booking hall interior at *Sudbury Town* (ca. 1932). Spacious, uncluttered and beautifully lit, this was a revolution in station design. It replaced the District Railway's cheap shack station building of 1903.

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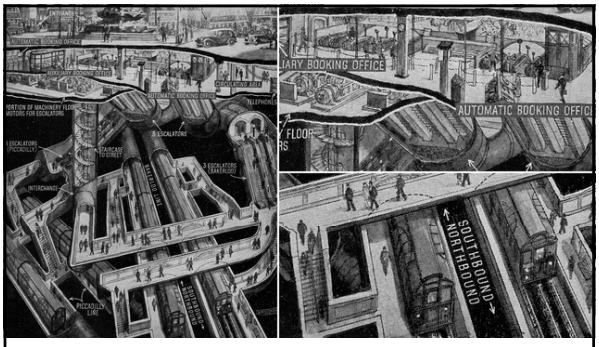
Above: the so-called "Moscow Concourse" at *Gants Hill* station (ca. 1947) designed by *Charles Holden* and inspired by the original station designs of the *Moscow Metro*, which the *London Underground* had influenced in the 1930s. Gants Hill opened to passengers on December 14th 1947 as part of the *Central Line Extension* program.

214



Above: caption: "The crazy maze that is the *Piccadilly Circus* tube station, ca. 1930"

215

216

Patient Progress

217

In 1912, *Frank Pick* was made Commercial Manager and began planning the integration and joint promotion of the bus and underground services when the UG took over the *London General Omnibus Company*. He often walked miles researching improvements to bus routes. Pick's design interests soon extended beyond publicity and encompassed every aspect of the company. He hired people who made great and lasting contributions to the overall design of London's Underground. *Edward Johnston* was commissioned in 1916 to create a new, easily legible typeface combining the best of the classic typefaces with an unmistakably *20th Century*-style. The result was the iconic *Johnston Sans* typeface (left), which is still used (with minor modifications) by *London Transport*. This font is the basis for *Verdana* - one of the most popular modern fonts.

218

By 1928, Pick had risen to the position of managing director of the UG. In 1933, he became Vice Chairman and Chief Executive of the newly formed *London Passenger Transport Board* (LPTB) under *Lord Ashfield*. This was soon known as *London Transport* (LT), the largest city transport authority in the world responsible for all the capital's bus, tram and underground services. Pick's interests were broad, both within and beyond LT. He campaigned vigorously for better design education and passionately believed in design's civilizing nature and its ability to affect people's lives for the better. His skills lead to a number of appointments. He became President of the *Design and Industries Association* in 1932, Chairman of the *Council for Art and Industry* in 1934 and an *Honorary Associate* of the *Royal Institute of British Architects*. He was involved in designing new rolling stock for the *Northern Line* that had light-shades and armrests to add to the passengers' comfort. His role also included developing designs for equipment and buildings, ranging from signal cabins to substations. Pick's attention to detail was legendary. Though he was demanding and sometimes difficult to work for, he managed to get the best out of people.

219

Above: interior shot of an all-steel *London Underground* train (ca. 1920)
Left: interior of an Underground train carriage (ca.1930)

220

Top Left: the comfortable interior of a 1938 Stock car. These cars, which entered service in 1937/8, were a great improvement over their predecessors, boasting deep-cushioned seats covered in *Woollen Moquette*, slatted hardwood floors and art deco-style lampshades. They were hardwearing and still in good condition when this photograph was taken in the 1960s.
Top Right: the tube trains got a makeover with more seating, better lighting and ventilation and a more streamlined shape. Here, tube travelers test out their new accommodations.

221

Top Left: a new underground stock car being transported on wheels through the streets of London (ca. 1937)
Top Right: woman in a "new design" tube train, August 1937
Left: cut-away view of a new (1938) stock car

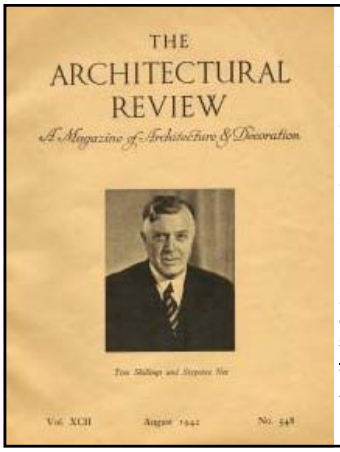
222

Top Left: a female traveler buys an Underground season ticket from a vending machine at *Highgate* station (ca. 1932)
Top Right: a man writing on a *London Underground* complaints poster (ca. 1922). Apparently, not everyone was satisfied with the service (even then).

223

He Served His Fellow Men

224



Frank Pick* left *London Transport* in 1940. After a brief (and unhappy) stint at the *Ministry of Information*, where he was Director General, he retired to his home in *Hampstead Garden Suburb*. Having not been well for several years, he died in 1941. In 1952, a plaque was unveiled in his old school, *St. Peter's of York*, which read: *"He served his fellow men, made transport an art and sought beauty and good design in all things."
Left: "Patient Progress: The Life Work of Frank Pick." From *The Architectural Review*, August 1942

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Part 5

Second Century

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Metro-Land

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Unlike other railway companies which were required to dispose of surplus land, the Met was in a privileged position with clauses in its acts allowing it to retain such land that it believed was necessary for future railway use. Initially, the surplus land was managed by the *Surplus Lands Committee*, made up of Met Directors. In the 1880s, at the same time as the railway was extending beyond *Swiss Cottage* and building a workers' estate at *Neasden*, roads and sewers were built at *Willesden Park Estate* and the land was sold to developers. In 1912 the Met's General Manager *Robert Selbie* thought that some professionalism was needed and suggested a company be formed to take over from the Surplus Lands Committee to develop housing estates near the railway. However, WWI delayed these plans. Thus, it wasn't until in 1919 (with the expectation of a post-war housing boom) that the *Metropolitan Railway Country Estates Ltd.* (MRCE) was formed. Concerned that *Parliament* might reconsider the unique position the Met held, the railway company sought legal advice. The legal opinion given was that, although the Met had authority to hold land, it had none to develop it. As such, an independent company was created (all but one of its Directors were also Directors of the Met). The MRCE went on to develop estates at *Kingsbury Garden Village* (near Neasden), *Wembley Park*, *Cecil Park* and *Grange Estate* (at *Pinner*), the *Cedars Estate* (at *Rickmansworth)* and *Harrow Garden Village.*

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The term "Metro-Land" was coined by the Met's marketing department in 1915 when the *Guide to the Extension Line* became the *Metro-Land Guide* (left). This promoted the land served by the Met for the walker, visitor and later the house-hunter. Published annually until 1932 (the last full year of independence for the Met), the guide extolled the benefits of: *"The good air of the Chilterns"* using language such as: *"Each lover of Metro-Land may well have his own favourite wood beech and coppice - all tremulous green loveliness in Spring and russet and gold in October."* The dream promoted was of a modern home in beautiful countryside with a fast railway service to *Central London.*

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The *Great Northern & Strand Railway* (GN&SR) and the *Brompton & Piccadilly Circus Railway* (B&PCR) merged to form the *Great Northern, Piccadilly & Brompton Railway* (GNP&BR) opening in 1906 (now the *Piccadilly Line*). The *Baker Street & Waterloo Railway* (BS&WR) opened in 1906 (now the *Bakerloo Line*) and the *Charing Cross, Euston & Hampstead Railway* (CCE&HR) opened in 1907 (now part of the *Northern Line*). To improve service, new electric locomotives with a top speed of 65 mph were introduced in 1922/23. The generating capacity of the power station at *Neasden* was increased to approximately 35 MW and on January 5th 1925, electric service reached as far as *Rickmansworth* (in 1925 a branch opened from Rickmansworth to *Watford*).

Above: London's famous *Eros Monument* is dismantled to make way for construction work on the *London Underground* (ca. 1925)

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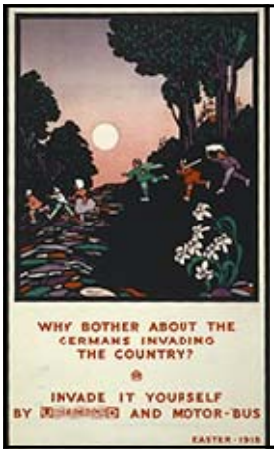
Top Left: workmen removing a concrete wall during construction of the *Central Line Extension* to *Bank* (ca. 1912)
Top Right: workers building the *Piccadilly Line Extension* at *Turnpike Lane* (ca. 1930)
Left: Underground workers' canteen (ca. 1935)

231

The Great War

232



On July 28th 1914, war broke out in *Europe* and on August 5th 1914, the underground rail network was made subject to government control in the form of the *Railway Executive Committee* (REC). The railway lost significant numbers of staff who volunteered for military service. Beginning in 1915, women were employed as booking clerks and ticket collectors. The *City Widened Lines* (CWL) assumed major strategic importance as a link between the channel ports and the main-lines to the north and were used for troop movements and freight haulage. During the four years of the war, the CWL handled 26,047 military trains which carried 254K-tons of materials. However, the lines' sharp curves prevented ambulance trains returning with the wounded from using this route. Government control was not relinquished until August 15th 1921.

Left: WWI era Underground poster

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British Empire Exhibition

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In 1924 and 1925, the *British Empire Exhibition* was held on the *Wembley Park Estate* and the adjacent *Wembley Park* station was rebuilt with a new island platform (a covered bridge linked it to the exhibition). The Met had its own stand in 1924 exhibiting an electric multiple unit car and in 1925 this car (together with electric locomotive No. 15) was subsequently named "Wembley 1924." *Wembly Stadium, a* national sports arena, was built on the site with a capacity of 125K. It was first used for the *FA Cup Final* on April 28th 1923 where the match was preceded by chaotic scenes as crowds in excess of its official capacity surged into the stadium. In the 1926 *Metro-Land* edition, the Met boasted that they had carried 152K passengers to Wembley Park that day.

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The Railways Act of 1921, which became law on August 19th 1921, did not list any of London's underground railways among the companies that were to be grouped together. The *London Passenger Transport Bill* was aimed, primarily, at better coordinating the small independent bus services and was published on March 13th 1931. The bill survived a change in government in 1931 and on July 1st 1933, the *London Passenger Transport Board* (LPTB) was thus created as a public corporation. It soon became commonly known by its shortened title: "London Transport" (LT). Underground railways, tramway companies and bus operators would be amalgamated under the LPTB. LT set in motion a scheme for the expansion of the network; the 1935-1940 *New Works Programme*. A number of extension schemes were in progress on the *Northern* and *Central Line/s* at the outbreak of WWII in September 1939, which led to their interruption or abandonment.

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The New Works Programme

237

The "New Works Programme, 1935-1940" was the major investment program delivered by the LPTB which had been created in 1933 to coordinate underground train, tram, trolleybus and bus services in the capital and its surrounding areas. The program was to develop many aspects of the public transport services run by the LPTB and the suburban rail services of the *Great Western Railway* (GWR) and *London & North Eastern Railway* (L&NER). The investment was largely backed by government assistance as well as by the issuing of bonds and was estimated to cost £42,286,000 in 1936. The Program featured major reconstruction of many central area *London Underground* stations, with escalators being installed to replace lifts as well as extensions of several tube lines and connection to and electrification of several suburban lines. Underground lines affected included the *Metropolitan, Bakerloo, Northern* and *Central Line/s*. Also included under the program was the design and construction of a new fleet of trains (the "1938 Stock") to operate on the *Central* and *Northern Line/s Extension/s*. Also planned were improvements to the power supply system from *Lots Road Power Station.*

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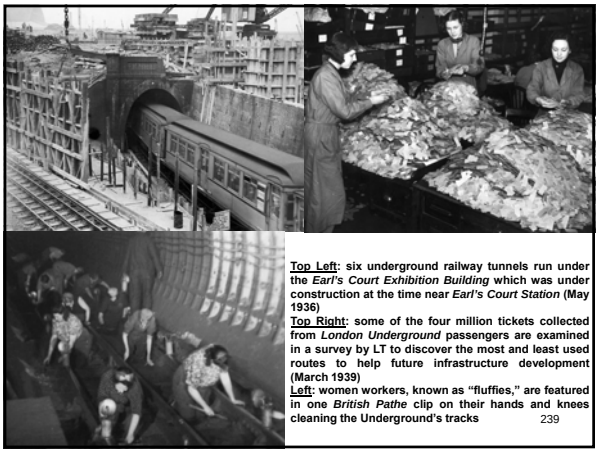

Top Left: six underground railway tunnels run under the *Earl's Court Exhibition Building* which was under construction at the time near *Earl's Court Station* (May 1936)
Top Right: some of the four million tickets collected from *London Underground* passengers are examined in a survey by LT to discover the most and least used routes to help future infrastructure development (March 1939)
Left: women workers, known as "fluffies," are featured in one *British Pathe* clip on their hands and knees cleaning the Underground's tracks

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Substantial and rapid progress was made on the underground network across the capital before the advent of WWII delayed, then prevented its completion. The *Central Line* tunnel relining works were completed in 1938 and the replacement of the line's power supply was completed in 1940. The *Bakerloo Line* service to *Stanmore* started on November 20th 1939. The *1938 Stock* came into operation as intended although the extensions they were built for were not all completed. Progress on the *Northern Line* works enabled the extension from *Archway* to come into service as far as *East Finchley* on July 3rd 1939. Works on the extension beyond *Edgware* were stopped, although the construction of the new depot at *Aldenham* was completed and the buildings were used to construct *Halifax* bomber aircraft for the RAF. Other parts of the land purchased for the *Bushey Heath Extension* were farmed during the war to provide food for LT canteens. On the *Central Line*, works on the eastern extension had progressed furthest with tunnels constructed to *Leyton* and from *Leytonstone* to *Newbury Park*. These were put into service as air-raid shelters (with disastrous results at *Bethnal Green*) and as underground factories operated by *Plessey*.

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Plessey Underground Factory

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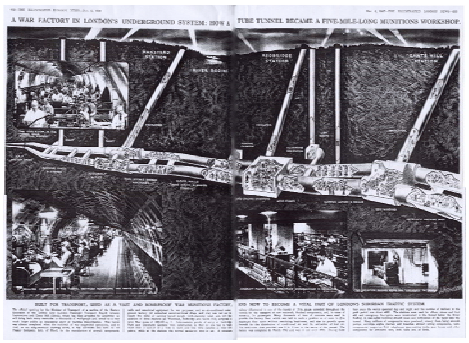
"The official opening by the Minister of Transport of a section of the Eastern Extension of the Central Line (London Transport Passenger Board) between Leytonstone and Gants Hill (Ilford), which has been arranged for December 12, will bring back many memories to thousands of workpeople and reveal to a much larger public an interesting story of wartime improvisation. This tunnel was almost complete when the outbreak of war suspended operations and in 1942, it was converted and used by the Plessey Company, Ltd., of Ilford, for the manufacture of aircraft components, radio and associated equipment for war purposes; and an air-conditioned under-ground factory (of somewhat unconventional shape and site) was laid out in nearly five miles of running tunnel (single 12-ft-diameter tube), and, with the addition of three stations (at Wanstead, Redbridge and Gants Hill), comprised a total floor space of 300,000 sq. ft. Intermediate points of entry at Cambridge park and Danehurst Gardens were constructed, so that no one had to walk more than a quarter of a mile to work and lifts were installed at these two points, while at the stations the normal escalators were in use. A miniature railway of 18-in. gauge extended throughout the tunnels for the transport of raw materials, finished components, and, in cases of necessity, for passengers. Many thousands of tons of concrete were used to provide the factory floor, which was laid in such a position as at once to give maximum floor space without restricting head-room, and also to provide space beneath for the distribution of conditioned air and the extraction of foul air. The factory was completed in March 1942 and was in use until 1946. During these four years the works operated day and night and the number of workers at the peak period was about 4,000. The stations were used for offices, stores and first aid, and emergency flood-gates were constructed in the tunnel below the River Roding, in case aerial bombing should cause any infiltration of the water into the tunnel. Many millions of components were produced, among them being aircraft pumps, cartridge engine starters and breeches, aircraft wiring components, radio components, magnetos, field telephones, gear-cutting tools, gear levers, components for armoured cars, shell fuses, etc."
The Illustrated London News, December 6th 1947

242



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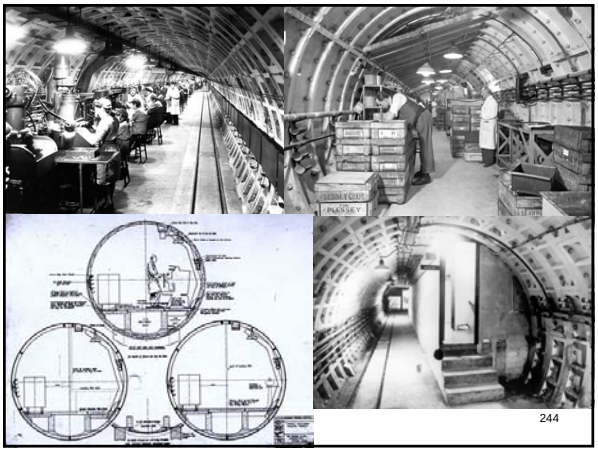

244

Top Left: *Gants Hill* **station**
Top Right: *Redbridge* **station**
Left: *Wanstead* **station**

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Finest Hour

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Great Britain declared war on *Germany* on September 3rd 1939. Preparations for war had been in progress for some time and the government expected air attacks on all of Britain's cities, particularly the capital: *London*. Mass evacuation from London began on the same day that war was declared. During August and September 1939, about 600K children, mothers and expectant mothers were moved into the relative safety of *Kent*, *Sussex*, *Wales*, *Devon* and *Cornwall*. London was not attacked early in the war and many evacuees had returned.

Left: east-end children being evacuating via a LT bus at the start of WWII

Right: evacuees at an Underground station begin the journey to their new homes

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Women joined the workforce in jobs left vacant by enlisted men. They became firefighters, bus conductors, munitions workers and truck drivers; jobs previously dominated by men.

Above: *Women War Workers* (WWW) enter and leave an underground aircraft parts factory which occupied an incomplete section of the *London Underground* network 60-feet below street level (August 1943)

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Throughout the war, the government encouraged the impression that in *London* there was "business as usual." The *Ministry of Information* reported that, despite the devastation of the Blitz, *"London, heart of the British Empire, still beats strongly and undismayed."* This propaganda contained an element of truth. Despite the attacks, Londoners still turned up for work and carried on with their lives as best they could. It truly was the great city's "Finest Hour."

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The Blitz

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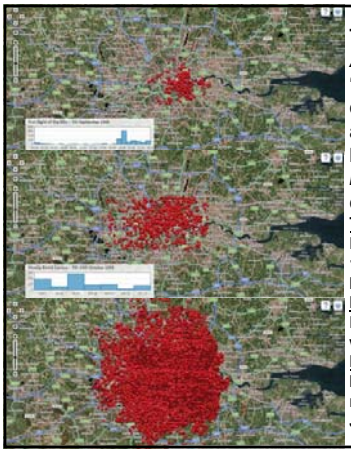


The UK's *National Archives* has compiled "Bomb Census Maps" detailing the locations and dates of all the bombs that fell on *London* and its environs during "The Blitz."

Top: the bombs that fell on London on September 7th 1940, the first night of bombing

Middle: the bombs that fell on London during the second week of October 1940

Bottom: here are the total bombs that fell on London at night from October 1940 to June 1941

251

The Blitz occurred between October 7th 1940 and June 6th 1941. In its aftermath, 20K civilians were dead and more than a million homes were destroyed.

Left: January 12th 1941. Soldiers help to clear the debris of *Bank* Underground station, the morning after it received a direct hit. Over one-hundred civilians were killed.

252

Top Left: during WWII, Underground stations were used as shelters during bombing raids. This December 1940 image shows residents sheltering from air raids at *Bounds Green* Underground station
Top Right: a woman dispensing water from a watering can as Londoners take shelter in the *London Underground* during *The Blitz*
Left: members of the public are entertained in *Aldwych* Underground station 253

Top Left: people sleeping at *Piccadilly* station
Top Right: Londoners sleeping on tube platform (ca. 1941)
Left: an air raid warden checks on children sleeping on hammocks strung between the train tracks in an Underground station during *The Blitz* (ca. 1940) 254

Above: British soldiers returning home via the *London Underground* at the end of WWII (ca. 1945) 255

Nationalization

256

After the war, a prioritization of the limited resources available to *London Transport* saw the *Central Line Extensions* progressed with the first new section in the east opening to *Stratford* in 1946 and the services to *West Ruislip* and *Epping* starting in 1948 and 1949. Initially, plans were put in place to complete the *Northern Heights* project during 1947 and 1948 and the plans for the extension to *Bushey Heath* were revised. Parliamentary powers were renewed in 1947 for most of the outstanding *New Works Programme*. The introduction of the *Town & Country Planning Act* in 1947 led to the creation of *Metropolitan Green Belt* around the capital including areas of land through which the new lines were planned and which had been intended for development as housing. As such, the *Northern Line Extension* to Bushey Heath and the continuation of the Central Line Extension beyond West Ruislip to *Denham* were adversely affected. LT was nationalized on January 1st 1948 and renamed the *London Transport Executive* (LTE). It was placed under the authority of the *British Transport Commission* (BTC) which oversaw the completion of the electrification of the network. By 1948, most of the system was run using electric trains. In 1963, the *Ministry of Transport* created a separate board to run LT. This period saw the construction of the carefully planned *Victoria Line* on a northeast-southwest alignment. It was the first underground line to use *Automatic Train Operation* (ATO) on the entire route. 257

Top Left: when the *District Line* needed additional trains after WWII steel was in short supply so designers turned to aluminum. The resultant trains were called "R49 Stock." In the photograph (ca. 1951), a partially painted prototype arrives at the *Festival of Britain* site on the *South Bank* (the *Dome of Discovery* and *Skylon* can be seen in the background). The unpainted trains were put into service in 1953.
Top Right: *Sir John Elliott*, Chairman of LTE, shakes hands with the driver of the new prototype "silver" tube train at *Northfields* station on the *Piccadilly Line* (August 1957) 258

Top Left: a brand new tube train makes one of its first journeys on the *London Underground* (ca. 1960)
Top Right: the "new-look" Underground station, with its long sprawling escalators (ca. 1960s)
Left: photographer *George Freston* poses as a commuter on the tube, reading a copy of D.H. Lawrence's novel *Lady Chatterley's Lover*, on the day the book went on general sale. A jury at the *Old Bailey* decided that the book was not obscene, after a 33-year old-ban (November 1960). 259

Above: *Harry Weatheley*, responsible for keeping the ventilator shafts clean, surfaces from a vent at *Piccadilly Circus* Underground station (ca. 1959) 260

The Victoria Line

261

The *Victoria Line* (left) has always been tied up with plans to relieve the passenger burden on the *Charing Cross* branch of the *Northern Line* and to provide a route from the *Lea Valley* area of northeast *London* to the *West End*. The first plan which was a recognizable precursor of the *Victoria Line* appeared in 1937. A new express tube line would run from *Victoria* to *Finsbury Park*. In 1939, this plan was expanded into plans for an express tube that would be built in three stages. After WWII, a 1946 plan for *London* envisaged providing a completely separate express route under the Northern Line, allowing the Victoria and Finsbury Park route to serve new markets. In 1949 the two plans were merged under the name "Route C." Parliamentary powers were finally sought in 1954 for a line that would run from *Walthamstow* to *Victoria* initially (southward extensions were planned). The name "Victoria Line" was chosen in honor of Victoria station (and the late Queen). Attempts to repeat the success of "Bakerloo" (a combination of "Baker" and "Waterloo") produced only the rather awkward sounding "Walvic Line" and (better) "Viking Line" ("Victoria" and "King," from *King's Cross*). 262

Constructed in the 1960s, the *Victoria Line* was the first entirely new tube line in *London* for fifty years and was designed to relieve congestion on other lines, in particular the *Piccadilly Line*. Construction began in 1962 on the initial *Walthamstow-Victoria* section, opening *Walthamstow-Highbury* on September 1st 1968. The full *Walthamstow-Brixton* Line was completed in 1972. A test tunnel from *Tottenham* to *Manor House* (under *Seven Sisters Road*) had been bored in 1959 and was later incorporated into the running tunnels. The line is equipped for *Automatic Train Operation* (ATO) and trains are normally driven in this mode, with the motorman's work being limited to starting the train at each station and operating the doors. The line's tunnels were the first constructed with the new increased diameters chosen to reduce air resistance. Depending on the type of lining (concrete, bolted iron or flexible iron) the actual diameter varies between 3.71m (12'- 2") and 3.86m (12'- 8").
Above: work-in-progress on the Victoria Line (ca. 1960s). Unlike most other lines on the Underground, it runs entirely below ground (with the exception of the connection between *Seven Sisters* and the line's depot at *Northumberland Park*) 263

Under *Automatic Train Operation* (ATO), the on-train computer instructs the train operator what to do. The underlying protection system is called *Transmission-Based Train Control* (TBTC). The computer does everything except opening and closing the doors and/or starting the train at every station. If ATO fails but TBTC is still operational, the trains can still be manually driven at line speed. If TBTC fails on an individual train then it would be put into *Restricted Manual Mode*, which means that the train operator can drive the train at 5 to 10 mph to the next station, where the train would be taken out of service until the fault is repaired by trained technicians.

264

Above: mock-up at the "Victoria Line Exhibition" at the *Design Centre, London*, of the interior of a new type of carriage that would be used on the new *Victoria Line*, August 20th 1968. The new carriages featured lengthwise seating to allow more room for standing passengers, two-level arm rests (which could be shared by adjacent passengers) and internal speakers for driver announcements.
Left: interior of a 1970s-era *London Underground* carriage 265

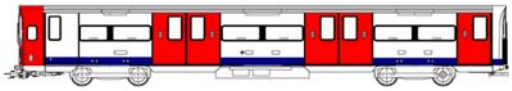
The official opening ceremony took place at *Victoria* station on March 7th 1969 when *Queen Elizabeth II* unveiled a commemorative plaque on the station concourse. After a short ceremony, *Her Majesty* bought a 5d ticket and traveled to *Green Park*. The line was deliberately designed to interconnect with existing lines thus it has an unusually high proportion of interchanges. Nearly every station is either served by *British Rail* or another Underground line. The *Victoria Line* was dug under *Central London* and, unlike the earlier Underground tubes, the tunnels did not follow the roads above.
Top L&R: the Queen's visit underground in 1969 was her second time experiencing the Tube. Her first trip came as a 13-year-old in 1939 with *Princess Margaret* and her governess *Marion Crawford*. 266

267

The Jubilee Line

268

In 1979 another new Tube; the *Jubilee Line*, named in honor of *Queen Elizabeth II's Silver Jubilee,* opened. It was built in two major sections; initially to *Charing Cross* station (in *Central London*) then expanded in 1999 (with the *Jubilee Line Extension*) to *Stratford* station in the docklands section of *East London,* areas once poorly connected to the Underground. The Jubilee line of 1979 was to be the first of four phases of the project, but lack of funds meant that no further progress was made until the late 1990s. An alternate plan was devised in the 1970s to extend the Jubilee Line parallel to the *River Thames*. However, the "River Line" (as this extension was called) was deemed too expensive and construction of the extension never proceeded. Changes in land use, particularly the urban renewal of the *Docklands* area, caused the project to change considerably in the 1970s, '80s and '90s. The Jubilee Line Extension (JLE), as the eventual project became known, opened in three stages in 1999. Compared to the *Victoria Line*, the preceding cross-*London* line, the JLE stations have been criticized for poorly planned connection facilities with other Underground lines. 269



1996 Tube Stock Driving Car

1996 Tube Stock Trailer Car

The *Jubilee Line* was initially operated using "1996 Tube Stock" running in seven-car trains (a four-car and a three-car unit coupled together; single units have only one cab and may only run alone within depots). With the construction of the JLE, the opportunity was taken to introduce the new trains which have an exterior similar to the 1995 Stock used on the *Northern Line.* The 1996 Stock has internal displays and automated announcements to provide passengers with information on the train's route. 270

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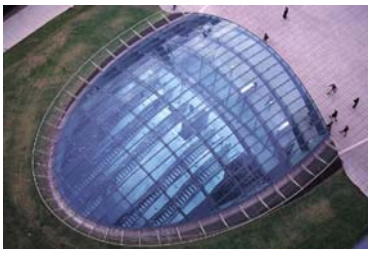
Top Left: exterior view from plaza of entry to *Canary Wharf* tube station
Top Right: The concourse at Canary Wharf station on the *Jubilee Line Extension*, designed by architect *Norman Foster*. First proposed in 1973, the JLE opened in 1999 but by then had become a byword for cost overruns and delay.
Left: overhead view of entry to Canary Wharf station

272



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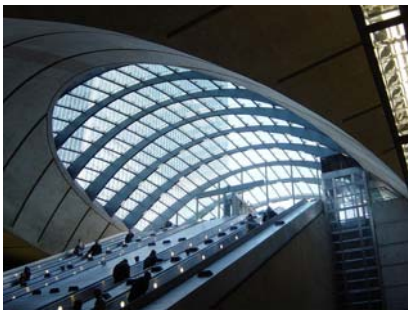

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Left: train stopped at *Canary Wharf* Underground station. The platform-edge doors (outlined) were primarily introduced to prevent drafts underground and to assist in air flow. They also prevent people from falling or jumping onto the track.
Right: part of the new *Jubilee Line Extension* is seen at *Westminster* station, with platform edge doors (at right)

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The Changing Times

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Left & Above: In 1978, *Hannah Dadds*, became the Underground's first woman driver after 115 years of network operation.

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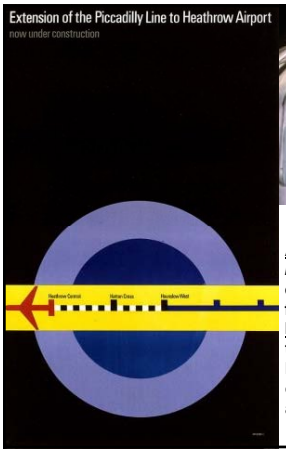
Above: graffiti being removed from a train at *Neasden* depot (ca. 1986). The growth of graffiti, inherited from the *New York City* subway, led to a change in the look of the network from the 1990s forward. The unfinished aluminum surfaces, perfect for spray paint, were replaced with today's red, white and blue trains using baked-on, tri-pack paint.
Left: "Weekly Travelcard" promotion from 1986. Travelcards were first introduced in 1983

281



Above: *Prince Charles* and *Princess Diana* arrive at Heathrow's *Terminal 4* on the new *London Underground* link from *Hatton* (April 1st 1986)
Left: "Extension of the Piccadilly line to Heathrow" by *Tom Eckersley*, 1971. Eckersley's poster informs customers of the link from London to *Heathrow* airport, completed in 1977.

282

Top Left: 1975: faces blackened, passengers are helped out of *Moorgate* station after a train ran into the buffers, killing forty-three people
Top Right: November 1987: burnt-out escalators are seen at *King's Cross* station after a fire broke out, killing thirty-one people. Investigators determined that the fire was started when a lit match was dropped onto a wooden escalator. Smoking was banned in all *London Underground* stations five days after the fire and wooden treads removed.
Left: known for crowded and cramped conditions, travelers still flock to ride the tube everyday. Here, a group of commuters ride the escalators at *Tottenham Court Road* station in January 1996.

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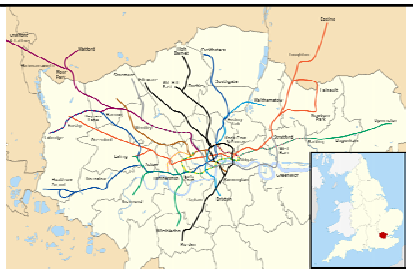
Transport for London

284

Transport for London (TfL) was created in the year 2000 as the integrated body responsible for London's transport system. It replaced *London Regional Transport* and assumed control of *London Underground Limited* in July 2003. TfL is part of the *Greater London Authority* (GLA) and is constituted as a statutory corporation regulated under local government finance rules. The TfL Board is appointed by the *Mayor of London* who also sets the structure and level of public transport fares in *London*. However, the day-to-day running of the corporation is left to the *Commissioner of Transport* for London. The Mayor is responsible for producing an integrated transport strategy for London and is also responsible for setting TfL's budget. The GLA is consulted on the Mayor's transport strategy and inspects and approves the Mayor's budget. It is able to summon the Mayor and senior staff to account for TfL's performance. *London TravelWatch*, a body appointed by and reporting to the Assembly, deals with complaints about transport in London.

285



The *London Underground* currently includes eleven lines, with 270 stations (fourteen Underground stations are outside *Greater London*). There are two types of lines; services that run on the sub-surface network (just below the surface and use larger trains) and/or the deep-tube lines that are for the most part self-contained and use smaller trains. Most of the lines emerge onto the surface outside *Central London*. Fifty-five per cent of the system runs on the surface and there is 20 miles (32 km) of cut and cover tunnel and 93 miles (150 km) of tube tunnel. The total length of railway is 250 miles (402 km) and the longest distance between two stations is 3.9 miles. Trains generally run on the left hand track, although in some places tunnels are above each other. Seven of the thirty-two *London Boroughs* are not served by the Underground. The lines are electrified with a four-rail DC system: a conductor rail between the rails is energized at −210 Volts and a rail outside the running rails at +420 Volts, giving a potential difference of 630 Volts.

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Above: geographic London Underground map, showing the extent of the network (2013)

Hampstead is the deepest station below the surface, at 58.5-meters (192-feet), as its surface building is near the top of a hill and the *Jubilee Line* platforms at *Westminster* are the deepest platforms below sea-level at 32-meters (105-feet). The highest station is *Amersham* (on the *Metropolitan Line*) at 147-meters (482-feet) above sea-level and the highest point above ground is the *Dollis Brook Viaduct* over *Dollis Road* (between *Finchley Central* and *Mill Hill East* on the *Northern Line*), 18-meters (59-feet) above the ground. There are 164 lifts (elevators) in use with more planned to increase system accessibility.

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The first escalator on the *London Underground* was at Earl's Court in 1911, between the *District* and *Piccadilly* platforms. It was advertised by a signs and a porter shouting: *"This way to the moving staircase – the only one in London – now running."* Beginning in 1912, all new deep-level stations were provided with escalators instead of lifts. The *Otis-Seeberger* design of escalator, with a diagonal shunt at the top landing requiring a sideways step off, was used until 1924 when the first "comb" type was installed at *Clapham Common*. In 1921, a recorded voice instructed passengers to stand on the right and signs followed during WWII. It is thought that people were standing on the right as the diagonal shunts at the top of the escalators made it easier to step off with the right foot. In the 1920s and 30s, many lifts were replaced by escalators. Before WWII, an escalator installed at *Sloane Square* was the first connecting *Circle Line* platforms to the street, but it was destroyed when the station was hit by a bomb in 1940. Due to wartime conditions, no escalators were provided when *Highgate* station on the *Northern Line Extension* opened in 1941, these were finally installed in 1957. There are 426 escalators on the London Underground system. The longest is at 60-meters (200-feet) and the shortest gives a vertical rise of 4.1 meters (13-feet).

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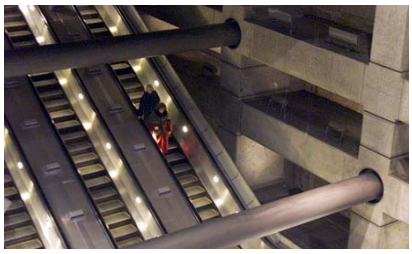

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London Underground **trains come in two sizes, larger sub-surface trains and smaller deep-tube trains. Since the early 1960s all passenger trains have been electric multiple units with sliding doors. All lines use fixed length trains with between six and eight cars, except for the *Waterloo & City Line* that uses four cars. New trains are designed for the maximum number of standing passengers, for speed of access to the cars and have regenerative braking and public address systems. Since 1999, all new stock has had to comply with accessibility regulations that require such things as access and room for wheelchairs and the size and/or location of door controls. All underground trains are required to comply with the *The Rail Vehicle Accessibility* (*Non Interoperable Rail System*) *Regulations 2010* (RVAR 2010) by the year 2020. Stock on sub-surface lines is identified by a letter (i.e. "S Stock" as used on the *Metropolitan Line*), while tube stock is identified by the year of intended introduction (i.e. "1996 Stock" as used on the *Jubilee Line*).**

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Above: a *Northern Line* deep-tube train leaves a tunnel mouth just north of *Hendon Central* station

Above: March 29th 2001: *Piccadilly Line* trains are parked outside the depot at *Northfields*, *West London*. A strike by *London Underground* staff crippled the capital, causing chaos among commuters. The strike brought *London* to a virtual standstill, with fewer than thirty trains running during the rush hour, compared to a normal service of five-hundred.

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Top Left: a crowded carriage during morning rush hour, 2012
Top Right: passengers using mobile technology, June 2012
Left: March 2004: a poster warns passengers to be on their guard against possible attacks on the network, in the wake of the bomb blasts on Spanish trains

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Above & Left: May 31st 2008: revellers enjoy one last drink on the *London Underground*. A ban on drinking alcohol on the Tube was introduced to be effective June 1st 2008 by *Boris Johnson*, the mayor of *London*.

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Crossrail

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Crossrail **is a railway, 118 km (73 miles) in length that will link *Berkshire* and *Buckinghamshire* via *Greater London* to *Essex* with 42 km (26 miles) of new tunnels. Ten-car trains will run at frequencies of up to twenty-four trains per hour in each direction through the central tunnel section. *Cross London Rail Links* (CLRL) (now *Crossrail Ltd.*) was formed in 2001 to deliver the scheme. The project was approved in October 2007 and the *Crossrail Act* received *Royal Assent* in July 2008. Crossrail will be operated as a *London Rail* concession of TfL, in a similar manner to the *London Overground.***

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Left: in 2012, *London* mayor *Boris Johnson* and transport secretary *Justine Greening* at *Westbourne Park*, unveiling the tunnel-boring machines that began work on the *Crossrail* project which will create a new line linking *Maidenhead* in the west with *Abbey Wood* in the east. The first machine was named "Phyllis" after *Phyllis Pearsall*, the woman who mapped the original "London A-Z" in 1935.

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"The arrival of the Tube was truly revolutionary and today it is still admired around the world. It annihilates distance, liquidates traffic and is the throbbing cardiovascular system of the greatest city on earth."
London **mayor *Boris Johnson***
RE: the 150th birthday of the *London Underground*

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Above: Google's doodle from January 9th 2013, celebrating 150 years of the *London Underground*

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