

Diamond Jubilee of the Waterloo & City Railway

By T. S. LASCELLES



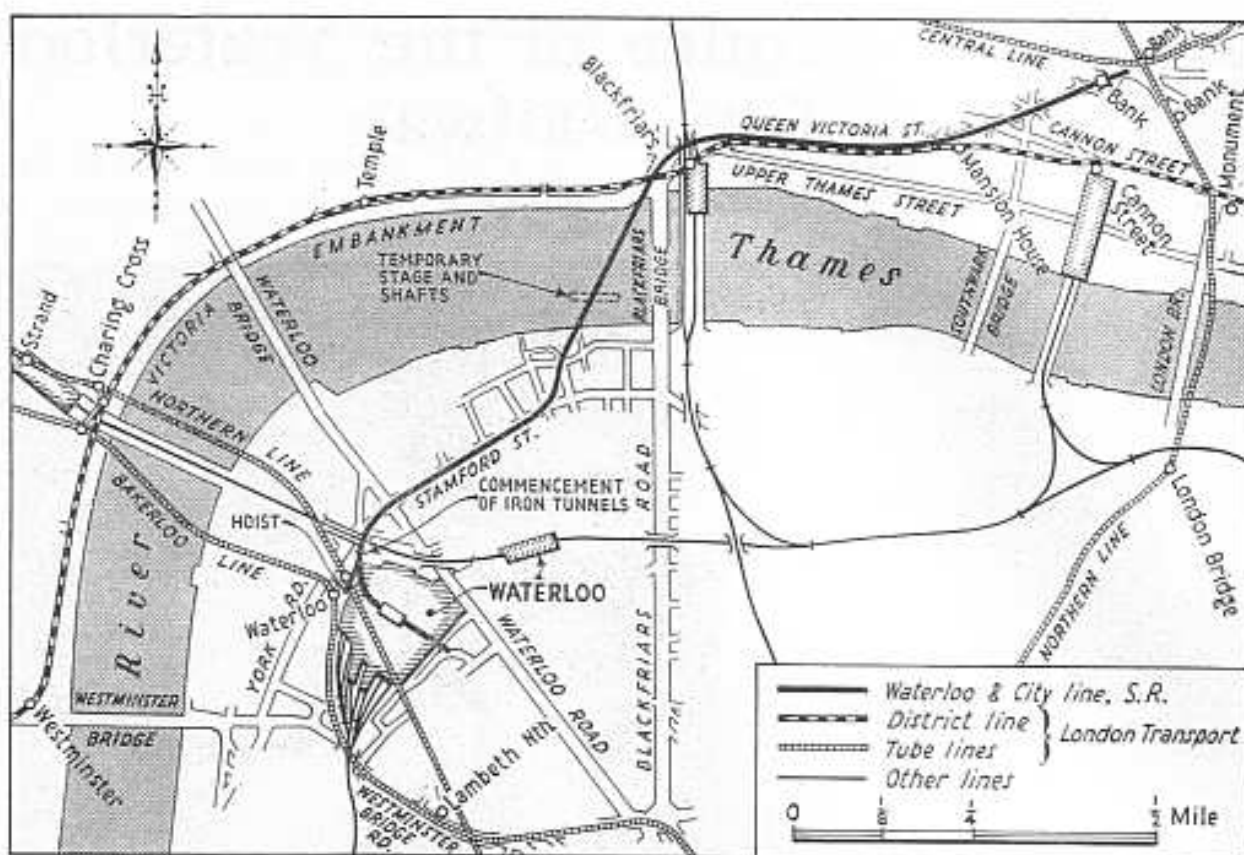
Recent view at Bank Station showing a train of the all-steel stock which replaced the original equipment in October, 1940

THE London & South Western Railway early recognised the desirability of having a terminus in, or close to, the City of London. In 1846, it obtained powers to extend to London Bridge, but the great cost involved, and a financial crisis in 1848, caused the project to be abandoned. The extension in the sixties of the South Eastern Railway to Cannon Street and Charing Cross, with a station at Waterloo close to that of the L.S.W.R., and a simple through connecting line, improved the position, but want of more direct communication with the City continued to be felt. Several schemes for meeting it were elaborated without result until the success of the City & South London Railway, opened in 1890, pointed the way to a solution likely to be commercially successful.

Plans were prepared under the auspices of the L.S.W.R. by W. R. Galbraith and R. F. Church, with J. H. Greathead

in consultation, for a deep-level electric line on the tube principle, $1\frac{1}{2}$ miles long, from a point under the main-line terminus at Waterloo to the eastern end of Queen Victoria Street, close to the Mansion House, passing below the Thames just west of Blackfriars Bridge. Application was made to Parliament, and the Act received the Royal Assent on July 27, 1893. Under this, a Waterloo & City Railway Company was incorporated with a capital of £540,000 in £10 shares and borrowing powers up to £180,000. The L.S.W.R. was prepared to guarantee a minimum 3 per cent. interest, and, when a prospectus was issued on March 17, 1894, the capital was oversubscribed. The shares were allotted among 476 holders.

The first directors were W. S. Portal, Chairman (Chairman, L.S.W.R.); Lt.-Colonel the Hon. H. W. Campbell (Deputy Chairman, L.S.W.R.); A. F. Govett and A. E. Guest (directors of



The Waterloo & City line in relation to present topographical features

that line); P. Mortimer; Major-General Taylor du Plat; the Rt. Hon. Sir Algernon West; and Charles Scotter (General Manager, L.S.W.R.). The first ordinary general meeting, held on February 1, 1894, was followed by an extraordinary one to confirm an agreement with the L.S.W.R. to work the line for not more than 55 per cent. of the gross receipts.

As was the case with the City & South London, powers were taken to sink shafts from temporary staging in the river, about 240 ft. from the south bank, from which to begin boring the tunnels, and the first pile for the staging was driven on June 18, 1894. The contractors for the whole of the section from Cross Street, Waterloo, to the City (including that station) were John Mowlem & Company, of Millbank, and Perry & Company, of Bow, for the Waterloo terminus and approach, and the yard which terminated at Lower Marsh. Mr. (later Sir) Harley Dalrymple-Hay was appointed resident engineer, and introduced the so-called hooded shield to accelerate operations.

A diameter of 12 ft. 1 3/4 in. was selected for the tunnels, increased to 12 ft. 9 in. on curves, of which there were a number

of 5 ch. and 9 ch. radius. However, Mowlem & Company elected to use the larger diameter for the entire route south of the river shafts, to avoid the complication of changing shields several times. North of the shafts, both lines followed the same changes of gradient, but south of them did not. The up line left Waterloo on gradients of 1 in 60, and 1 in 30, but the down track approached that station at 1 in 60, the steepest incline against the load.

The City Station (renamed Bank on October 28, 1940) was built in the form that became so familiar in London, with two 23 ft. dia. platform tunnels, connected by cross passages, giving in effect an island platform, and scissors crossing outside. The up line was prolonged to form a siding tunnel able to hold one train. The corresponding tunnel on the down side was at first intended to form part of a subway to the platforms of the Central London Railway, but eventually also became a siding. At Queen Victoria Street, the tubes were laid under the Metropolitan District Railway for a quarter of a mile. In the early days of the company, an intermediate station at Blackfriars was contemplated, but the idea was finally abandoned in May,

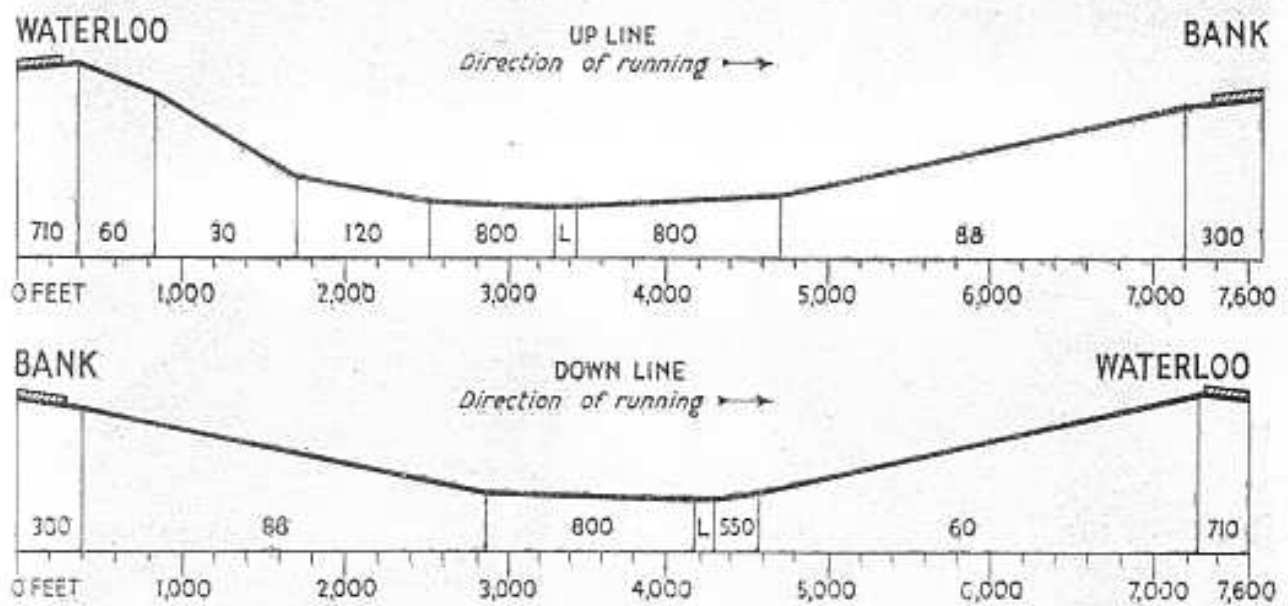
1895, because it was considered to be too great an obstacle to the intended "switch-back" method of working the line.

A short section of the tubes at Blackfriars had to be driven under compressed air, to meet the wishes of the Metropolitan District Railway. Compressed air also was used on the south side under Stamford Street, by the S.E.R.'s Charing Cross line viaduct, the abutments of which were underpinned to the level of the bottom of the tubes. The tube tunnels did not continue quite to the Waterloo terminus, but were succeeded by short lengths of covered way, which were included in Perry & Company's contract.

This terminus involved some very

it at Waterloo, as it could serve later, if required, to light the main-line station. A short way out on the up line was a siding tunnel connection leading to a lift communicating with another siding at main-line level by which rolling stock and coal wagons could be transferred to and from the new railway.

The stairs, passages, and long walks necessary at Waterloo, where there were six approaches, were far from convenient, but this became lessened in 1919 when an escalator from the concourse in the rebuilt main-line terminus was opened. The situation was little better at the City, where also there were no lifts, although they had been intended here



Gradient sections of each line between Waterloo and Bank

heavy engineering operations. The foundations of the arches carrying the main-line station were not deep enough to allow the new line to be connected to it by slopes and passages, and had to be underpinned to platform level, about 17 ft. below ground level, and joined by heavy brick and concrete inverts. The electric line ran at right angles to the arches, and to allow space for a reversing siding beyond the platforms, a length of 22 ft.-radius all-over arch was built, allowing one pier to be removed, leaving the inner abutments of the old arches resting on its keystone.

The line terminated in carriage and coal sidings, between retaining walls, with the power house adjoining. The original intention was to have the power house on the south river bank, but the consulting engineers recommended placing

originally, as the platforms are 59 ft. below the street. A subway inclined at 1 in 9 led to two rather awkward entrances with steps, in Walbrook and at the corner of Poultry, but when the Central London's subways and underground booking hall were completed the position was somewhat improved. The long slope proved trying to elderly passengers, and an attempt was made to improve matters by providing shallow steps at intervals and flattening the slopes between.

Some years ago, powers to instal escalators were obtained, but the second world war caused the work to be postponed. In May, 1957, it was decided to use a moving pathway device, on the belt conveyor principle, called the "Travolator." Preliminary work was begun, but the scheme has been suspended under the present economy measures.

The entrances in Walbrook and Poultry were closed on September 3, 1957, in connection with this work.

The tunnels were lined smooth with concrete to reduce noise, and provided with lights at 60 ft. intervals, for some years kept always burning. The track consisted of L.S.W.R. standard 87-lb. bullhead rails; 90-lb. rails were later substituted. The chairs rested on longitudinal sleepers bedded on concrete, except in the stations, at the City crossover, and in Waterloo yard, where cross sleepers and ballast were used.

Dr. (later Sir) Alexander Kennedy to fill the vacancy and deal with the provision of the electrical equipment. (Dr. Kennedy later became adviser to the London County Council for the electrification of its tramways.) Power was supplied to the trains at 500 volts by a central channel-section third rail of $4\frac{1}{2}$ sq. in. cross section, resting on oil cup insulators. (The use of oil was found to be unnecessary.) The conductor rail was level with the running rails, and wooden inclines were used to lift the train shoes up slightly at points and crossings. Later



Escalator between Waterloo main-line station and the Waterloo & City booking hall level as opened on April 9, 1919

Check rails were provided on the 9 and 5 ch. curves. Wear on these curves was at first very severe, but became less when the rigidity of the train bogie frames was improved. The accompanying diagram shows the gradients on each track; only a short length under the river was level. At the lowest point, a short length of tunnel was driven alongside the up line, with a cross passage, to serve as a sump and pump house for dealing with any accumulation of water.

Construction was well advanced when on October 21, 1896, Greathead died at Streatham. The company then appointed

the third rail was carried further forward and sloped up to effect this.

The power house contained five Davey, Paxman boilers feeding six high-speed Belliss & Morcom engines, each driving a Siemens 200 kW generator. The sets were very closely governed, and the lighting of the trains and stations was little affected by traffic movements. A rather elaborate system of feeder cables, both traction and lighting, with frequent link switches, was provided in each tunnel. The running rails were cross-bonded every 100 ft., and also between tracks at the ten tunnel cross passages.

For 1,100 yd. from Waterloo a return re-inforcing cable was laid in each tunnel. The original rail bonds were too rigid and broke frequently, and flexible ones were substituted. The whole of the electrical equipment was supplied by Siemens Brothers & Co. Ltd., of London.

Locomotives had been used on the City & South London but for the Waterloo & City the "locomotive-car" system, used on the Liverpool Overhead line, was adopted with the support of Sir William Preece of the Post Office. Each train consisted of four cars permanently coupled with two 60-h.p. (maximum) gearless motors on the front and rear bogies, with rather involved direct control arrangements enabling all four motors to be connected in series at starting and combined in various ways up to full parallel. No fewer than eleven cables were carried over the car roofs besides the Westinghouse reservoir and train pipes. The controllers in heavy square boxes, and operated by a hand wheel, had eleven stages, three of which were not marked on the pointer dial and were intended to be passed rapidly; these stages were later reduced to eight. There were no brake pumps, but sufficient storage of air was provided to cover four hours' running without re-charging.

The motor cars seated 46, and the trailers 56. As no English builder could promise delivery in the stipulated time because of disputes in the industry, the vehicles, which had roller bearings, were ordered in America from Jackson & Sharp, and assembled by the L.S.W.R. at Eastleigh. However, the wheels and axles were made in England. Although at first devoid of upholstery they had a comparatively agreeable look—one enthusiastic writer said they were "not unlike the third class dining cars which run on the long journeys of the northerly lines"—and were appreciably roomier than those running on the pioneer tube where the tunnels were smaller. The use of gearless motors eliminated at least one source of noise.

The car platforms were closed by sliding lattice gates worked by the guards and the motor cars had an extra side door near the front, locked from the outside and operated by the platform staffs. Four trains were delivered for the opening of the line, and two more were on order. It had at first been intended

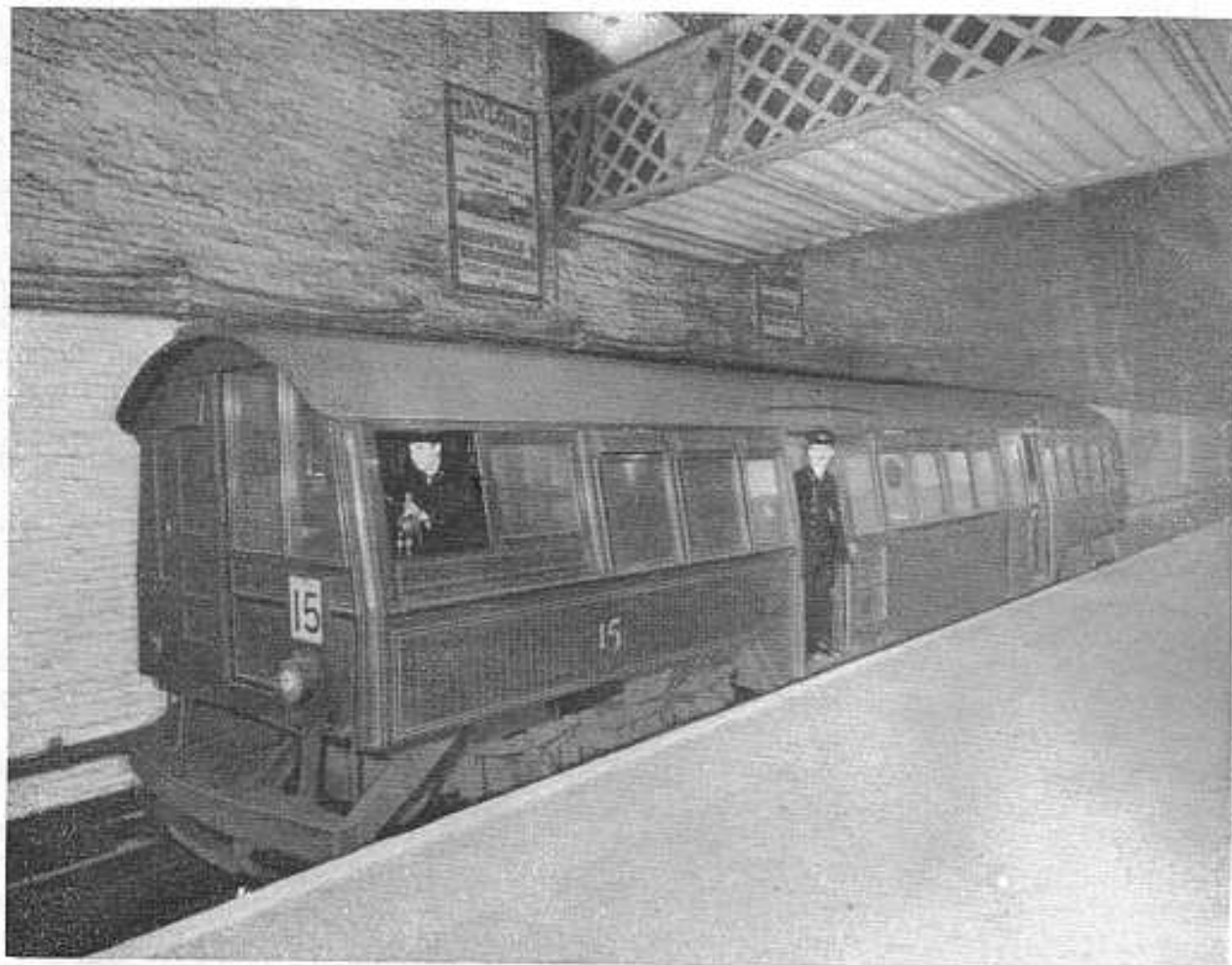
to have five-car trains; not until 1921 or so were additional trailers built to permit this.

To handle the coal trucks to and from the power house, and perform other shunting, Siemens supplied a small four-wheel locomotive with gearless motors, which is still in use. In later years, a small Bo-Bo geared engine was obtained as a standby; eventually this was transferred to Durnsford Road depot.

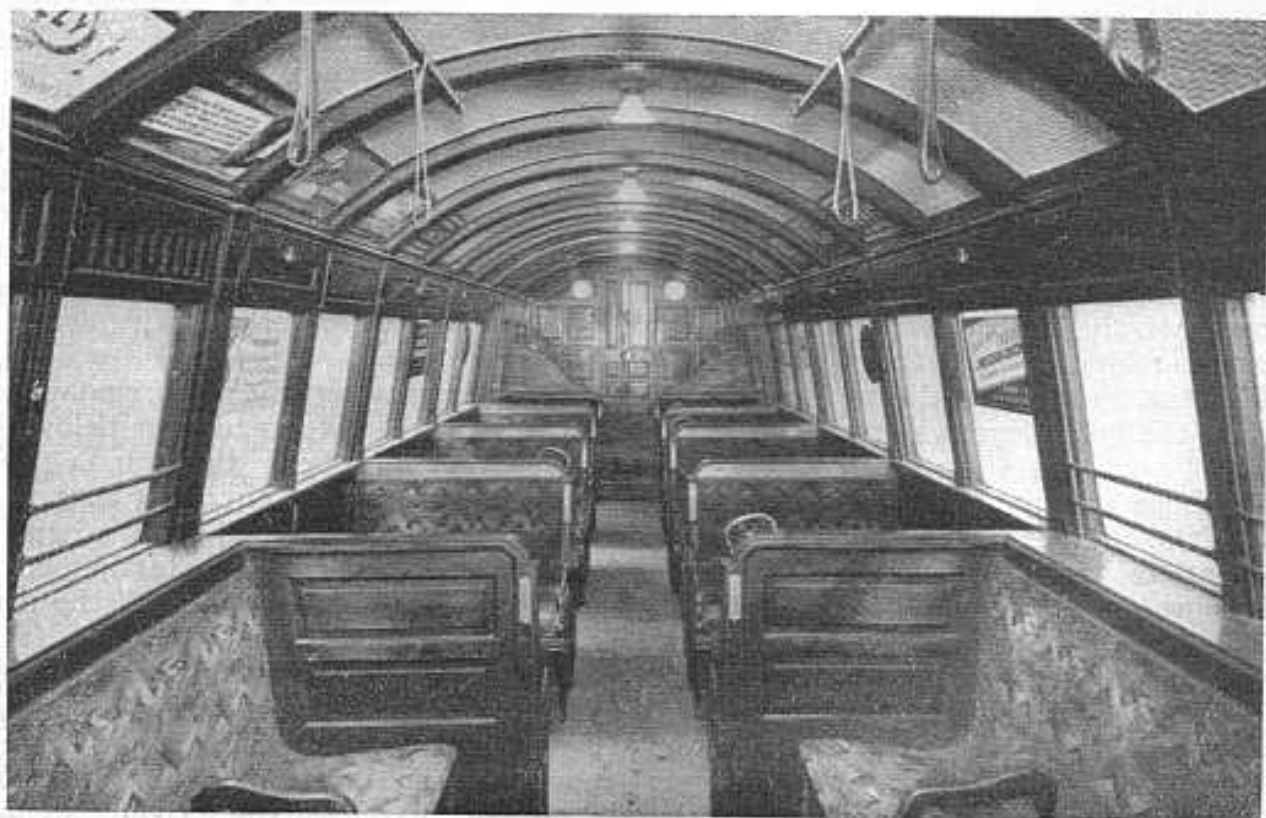
The signalling was designed by J. P. Annett, son of the inventor of the Annett key lock, and Signal Superintendent of the L.S.W.R., and W. R. Sykes, the well-known inventor, whose business at Clapham was formed into a company in 1899. The signals were worked from boxes at Waterloo and the City fitted with mechanical type frames and Sykes lock-and-block, the only instance of its use on a tube line. On the City & South London, each station had an outer home, and immediately a train had been protected by it, another could leave the station in rear. This was considered unsuitable for the new railway, because if a train was stopped at such a signal, it would have to re-start on a heavy gradient.

It was, therefore, decided to divide the line in each direction by advanced starting signals, called the "river" signals, operated, with the distant signals under them, electrically. The mechanism designed by Sykes comprised a Z-armature electro-magnet actuating a spectacle frame carrying coloured glasses between electric lamps and a lens in the front of the case, on the principle of the search-light signal of today. The home signals in the tunnel, and certain ground signals, were of the L.S.W.R.'s flap target, or Stevens, type.

The starting signals were semaphores, each with a draw-ahead arm below, one lever working them through a Sykes electric selector so circuited that if the "river" signal was "off" when the lever was pulled the starting signal would fall but if it was "on" the draw-ahead would be lowered. A driver, therefore, knew on leaving a terminus whether the "river" signal was already clear for him or not. A signalman had to clear his home signal before he could "plunge" to release the "river" signal in rear, and thus a lowered main starting signal meant that the line was clear into



Platform view at Waterloo, with one of the five Dick, Kerr double-ended motor coaches built in 1899. These were used as single units during non-peak periods



Interior of rolling stock in use until 1940, with austere upholstery added in later years to the original wooden seats

the other terminus. This arrangement had been based on running the trains at a much higher speed than proved practicable.

All signals had duplicate lamps fed on independent circuits. Facing points had electric detectors, with Sykes electric fouling bars in the platforms and sidings. The fouling bars also served, in pairs, as "treadles" to release the block. These release circuits were in duplicate, and were used on alternate days. In rear of each running signal, and at the approach to dead-end roads, were short lengths of insulated rail outside the track called "slipper bars," connected to return when the signal was "on." A sliding contact piece on the train picked up the current which discharged the main cut-out switch, a simple form of a.t.c. (The first movement each day was required to test this equipment.) The mechanical parts of this signalling were supplied by the Railway Signal Co. Ltd., of Liverpool; with small modifications, it gave satisfactory service for over 40 years.

The line was formally opened by the Duke of Cambridge, then nearly 80 years old, on July 11, 1898, the 50th anniversary of the opening of the original main-line terminus at Waterloo. It already had been inspected by Colonel Sir Francis Marindin for the Board of Trade, assisted by its electrical adviser, Major P. Cardew. About 200 guests were invited and entertained to lunch in the so-called booking hall at Waterloo; the contractors, Spiers & Pond Limited, were much praised for organising the repast, with attendant cloak room facilities, so well in such unfavourable surroundings. Opening to the public was delayed until August 8 by a fire in the arches close to the line. Passengers paid the 2d. single fare at turnstiles but for 3d. could obtain a return ticket. Through season and ordinary tickets from L.S.W.R. stations were issued; the latter had to be nipped at Vauxhall before presentation at the tube entrance.

Sir Francis Marindin imposed a limit of 10 m.p.h. on the 5 ch. curves; this was raised later to 12, then 15, and finally, in 1912, to 20. The speed restriction prevented the service, which at first ran from 8 a.m. to 10 p.m., from being worked in the manner envisaged by the designers of the electrical equipment, and the last three steps on the

controllers were practically useless. This increased the journey time, and the signalling had to be altered to permit the "river" signal to be again released as soon as a train had arrived at the terminus ahead, without having to clear the home signal first. The draw-ahead arms under the starting signals were then found to be unnecessary, and were abolished. This enabled a better peak-hour service to be run. The midday traffic did not justify running four-car trains, and in 1899 Dick, Kerr & Co. Ltd. supplied five double-ended motor coaches which ran singly during slack hours. No assistant motorman was carried on them, the guard travelling in the driving compartment instead.

The turnstile system was abolished in 1900, and the issue of tickets transferred to the guards; this lasted until the rehabilitation of the line in 1940. The guard on the single cars was required to proceed to the cab immediately all fares had been collected. The second man on the four-car trains was eliminated by fitting a deadman's attachment requiring the handwheel to be kept pulled towards the driver when running. Fairly complete fire-fighting equipment was provided, and gradually considerably augmented. Its location in the tunnel passages was indicated by purple lights. At first, the trains carried green headlights, but in a short while red lamps were substituted, a feature of the line to the present day.

The original company lasted until December 31, 1906, when it became absorbed into the L.S.W.R. under the provisions of that Company's Act of July 20 of that year. In 1908, that company spent nearly £10,500 in renovating and rewiring the original trains. In due course other improvements were made, but generally speaking the line continued to be operated as before, with some improvement in journey time, frequency of service, and earlier first departures. In 1915, concurrent with the L.S.W.R. electrification, power was supplied from the Waterloo sub-station, and the old equipment held in reserve. Some generator sets were removed, and motor generators installed for standby lighting and other services.

In 1913, a 600-volt accumulator battery was installed, sufficient to enable all trains to work clear of the tunnels if power failed entirely; this also fed the

pumps, lights, and so on, when the traction supply was cut off. The line enjoyed a good traffic, which continued to increase, and fully justified its purpose. Except for a time in the second world war, no Sunday service has been given. Then, to facilitate military leave traffic, a Sunday evening service (from 5 p.m.) was begun on March 7, 1943, and lasted until February 23, 1947.

In 1938, it was decided to rehabilitate the line entirely, and this was proceeded

being needed. At Waterloo, however, the mechanical frame was retained, and fitted to work the new controls. Extensive alterations also were made in power supply and feeder arrangements.

The English Electric Co. Ltd. supplied 12 all-steel motor coaches and 16 trailers, to form 5 five-car trains, carrying about 600 passengers in peak hours. Five motor coaches running singly provided the off-peak service. The vehicles had roller bearings, electro-pneumatic control, auto-



Interior of new all-steel stock with which the Southern Railway replaced in 1940 the original trains of 1898

with, despite the outbreak of war in the following year. A new 100 lb. conductor rail was laid outside the track, and a walkway provided by filling the invert with ballast and adding a drainage duct. Running rails were welded into 315 ft. lengths. Improved tunnel lighting, emergency telephone wires, and other facilities were installed, with a.c. track circuiting, new light signals throughout, and electro-pneumatic train stops. Point mechanisms were installed at Bank, and the whole working of that station made normally entirely automatic, with panel control for emergencies, no signalman

matic acceleration, and air doors, and were much welcomed by the public. The line was closed during October 25, 26 and 27, 1940, and reopened with the new trains on the morning of Monday, October 28. It continued functioning during air raids, when other cross-river lines had to be closed. At present the service begins at 6.46 a.m. from Waterloo, and 6.54 a.m. from Bank; the last train leaves the latter terminus at 10 p.m. No train accident calling for a formal inquiry has ever occurred in the sixty years' existence of this very useful link in London's underground railways.