Moving Pavement or "Trav-o-lator" for Railway Passengers

The twin "Trav-o-lator" installation at the Bank station of the underground Waterloo and City line of British Railways introduces a new conception of short-distance, high-capacity passenger movement in Europe. It solves the problem of faster handling of passenger traffic in an unavoidably congested area, and eliminates a walk which, particularly in the uphill direction, was unpopular with the public.

NOW operated by the Southern Region of British Railways, the Waterloo and City line was opened to the public in 1898, to form a connecting link between Waterloo main line terminus and the busy commercial area of which the Bank of England is the centre. Modernised and equipped with new rolling stock in 1940, the line carries a very heavy passenger traffic over its length of 1 mile 1,012 yards. More than 40,000 passengers use the line daily, a large proportion of them travelling in the morning and evening rush periods. It was obvious even before the war that more trains were needed in the rush hours, but although augmented services were possible from a railway operating point of view, the then existing means of passenger movement to and from street level at the Bank station were inadequate.

At the Bank, which is the City terminus of the line, the rails are 59ft below street level, and passengers made their way to and from the railway along a pedestrian tunnel 340ft long and 13ft wide, with an overall gradient of 1in 7·4, the effective slope for pedestrians being reduced to 1 in 14 by five steps at 40ft intervals. Just before the war it was proposed to install a three-way escalator to eliminate the long climb up the tunnel—the "drain" as the public called it—and Parliamentary sanction for the scheme was, in fact, obtained. War-time and post-war capital restrictions prevented the scheme from materialising and when, in 1955, the matter was revived, the consulting engineers, Mott, Hay and Anderson, proposed a different solution. This was adopted, and is now in full operation. The new scheme—using twin travelling pavements or "Trav-o-lators"—offered numerous advantages over the orthodox escalator for this particular site. It carries the passengers further than escalators could, the existing subway is retained, and the construction involved far less interference with existing underground installations. In addition it was carried out with less inconvenience to the travelling public.

The "Trav-o-lators" are installed in a specially-driven tunnel 16ft 6in internal diameter running approximately parallel with the existing subway. A machinery room and substation at the upper end of the tunnel house the driving and control gear below the passenger access area. At the top end of the tunnel a new ticket office has been built and staff amenities provided. At the lower end of the tunnel the station has been modernised and access to the "Trav-o-lators" has been improved.

Tunnel Construction

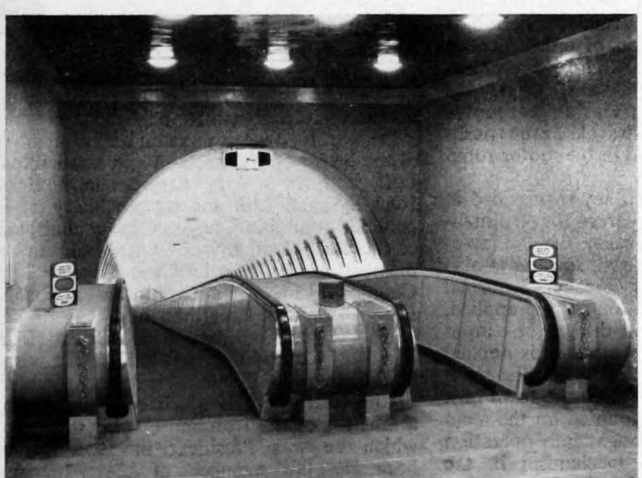
For the greater part of its length the "Trav-o-lator" tunnel is, as stated, 16ft 6in diameter, but at the lower end it opens out to 19ft 6in for a distance of 52ft to accommodate the lower landing and return machinery. Beyond this point a further enlargement of 10ft in the diameter provides a circulating area for passengers arriving at the foot of the "Trav-o-lators" and from the existing subway. Work began with the closing of two short subways at the top leading to streets, and between these two entrances the civil engineering contractors, Mitchell Brothers, Sons and Company, sank a shaft to the level of the "Trav-o-lator" tunnel. Progress was limited by the restricted access to the site, and the fact that much of the work had to be done at night, to avoid interference with road traffic. In addition, only a fairly small labour force could be employed owing to the confined space.

As soon as the shaft was sunk, a pilot tunnel, 8ft diameter, was driven down the incline. Excavation was done at night, and the spoil had to be hoisted out and removed by lorry until the line of the existing railway tunnel was reached. It then became possible to take away the spoil in rail wagons, again working at night after the passenger service on the line had ceased. Spoil wagons were hauled by one of the passenger cars to the Waterloo end of the line, where they were hoisted some 40ft to main line rail level by the 30-ton lift used for normal railway maintenance, and taken away by surface locomotive for dumping. This route was also used later for taking in the contractor's heavy materials and the main "Trav-o-lator" parts.

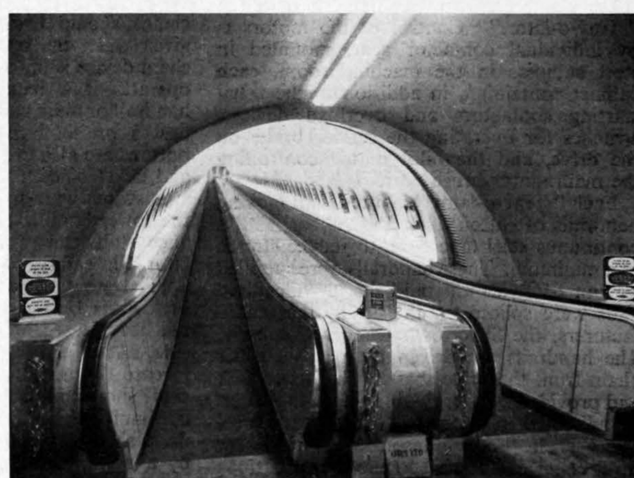
When the 8ft pilot tunnel had been driven, it was enlarged to the full 16ft 6in diameter, and cast iron segmental linings, with lead-caulked joints, were fixed in position; 800 tons of lining segments were used in all. While the tunnel was being enlarged, six new openings, each 9ft wide, were cut in the dividing walls between the station platform to facilitate the flow of passengers to and from the "Trav-o-lators."

At the upper end of the tunnel excavations were necessary for the booking hall and machinery room. This space, approximately 100ft long, 35ft wide and 30ft deep, lies beneath a public highway, and it was excavated in a series of headings to avoid undue interference with passenger movement and traffic overhead. Because it is also cut in the filling of the former channel of the river Walbrook, the chamber was floored with a reinforced concrete raft. The whole of the area of the chamber was "tanked" with $1\frac{1}{4}$in of asphalt, applied hot. Construction of the 3ft thick reinforced concrete roof slab of the chamber, which varies in depth from 3ft 6in to 1ft below the road surface, was done by open trenching in strips about 8ft wide. Road traffic during the construction period was carried on temporary steel decking, which often had to be removed at night to allow work to proceed, and made good again in time to allow traffic to move normally during the day. About 10,500 cubic yards of material were removed, and 5,000 cubic yards of concrete, plain and reinforced, placed.

Many cables and other public services had to be diverted to allow the excavation to be made, and most of this diversion work was done by trenching in the roadway. But a sewer, 5ft diameter, which crossed the booking hall site, had to be diverted by means of a new 5ft tunnel of cast iron segments lined with concrete, and with an engineering brick invert. An additional pipe subway with a new shaft had to be constructed, and power feeder cables belonging to London Transport had to be diverted.



"Trav-o-lator" seen from the booking hall



View of "Trav-o-lator" from the station platform

"Trav-o-lator" Equipment

The two Otis Elevator "Trav-o-lators," though somewhat similar to the American "speed-walks," and having some features in common with an escalator, are the first of their kind. Escalators normally work at a angle of about 30 deg., but the "Trav-o-lators" operate at a much lower angle of incline. They could, in fact, be horizontal if required, but to accommodate the necessary vertical rise of 42ft in this instance, the "Trav-o-lators" rise at an angle of 8 deg. 7 min. 48 sec. with the horizontal, giving a gradient of 1 in 7.

Each travel strip consists of 488 individual platforms, each 40in by 16in, with four ball bearing wheels of phenolic and canvas material, running on a concealed track. The platforms are closely coupled by side chains to give a virtually continuous surface. The length of each "Trav-o-lator" is just under 297ft on the incline, and the overall length, which includes horizontal portions at each end, is just under 302ft 6in. Each travel strip is 40in wide and the sides taper outwards to 48in at a point just below the handrails. The platform surfaces are of aluminium, with closely-spaced cleats so designed as to avoid a continuous gap between adjacent platforms. Combplates are fitted at the entry and exit points, and the platform cleats pass through these combs to give a comfortable and easy movement for passengers on and off the travel strips. Each of the "Trav-o-lators" is designed for intensive service, with an adequate safety-factor based on a working load of two passengers, or 300 lb, on every 4·45 square feet of the overall area available for passenger loading. The two roller chains used to propel each set of platforms are assembled in matched lengths, to ensure that they are always square with each other, and that chain stretch is kept within reasonable limits.

At the upper and lower landings, the "Trav-o-lators" flatten out to the horizontal for a short distance, and the chains, just beyond the combplates, pass over a pair of sprockets carried on shafts running in roller bearings. The shaft at the upper end takes the drive, while that at the lower end is mounted in a movable frame to regulate the chain tension. Each "Trav-o-lator" is driven by an 85 h.p. variable-speed, three-phase commutator motor of A.E.I. manufacture, coupled to a worm gearbox. The coupling between the motor and gearbox forms the drum of a spring-applied, magnetically-released brake. The output shaft of the gearbox carries the pinion for the duplex roller chain drive to the main shaft of the "Trav-o-lator." Control of the motors is by individual contactor gear, mounted in steel cabinets in the machine room, each cabinet containing, in addition to the usual starting contactors and overload devices, switches for operating the service brake on the drive, and the pilot motor controlling the main motor brush gear.

Each "Trav-o-lator" is fitted with moving handrails of cotton duck and rubber, with a continuous steel tape core, to reduce stretch to a minimum. These handrails were supplied in four 656ft lengths, and the un-vulcanised ends were spliced on the site by the manufacturers, the Silvertown Rubber Company. The handrails are driven by a single roller chain from the drive shaft at the upper end, and provided with tensioning gear at the lower.

Individual main frames of structural steel carry each "Trav-o-lator," the frames in turn being carried by concrete foundations extending the whole length of the tunnel. At both landings the steel frames extend to carry a portion of the flooring. Access to the whole of the underside of the "Trav-o-lators" is provided in the concrete foundations, where there are 50V lighting and plug points at 30ft centres. For further access purposes, the flooring of each landing is of steel, in tray form, filled with black rubber tiling and designed to be lifted out.

Operation and Safety Equipment

The "Trav-o-lators" are designed for a maximum linear speed of 180ft per minute (2·04 m.p.h.) and can be adjusted down to 90ft per minute. In addition, a crawl speed of 36ft per minute is available for inspection and maintenance purposes. At its maximum speed each "Trav-o-lator" has a theoretical carrying capacity, allowing two persons on each platform, of 16,200 passengers an hour. In practice, the machines will run at less than the maximum, at least for the present, the actual rate being decided in the light of experience. For the greater part of the day one "Trav-o-lator" will run in the up direction and one in the down, but in the morning rush period from (at present) 8.30 a.m. to 10.0 a.m., both will be operated in the up direction. At this time the few passengers travelling against the tide will use the old pedestrian subway, which has been re-decorated and re-lighted, and will also serve as an emergency exit. Rapid clearance of the station platforms will make it possible to run trains at 2½ minute intervals, instead of 3 minutes, and seventeen more trains will be run in the rush period.

For normal control, up and down push-buttons are provided on the motor starter gear, and key-operated switches for use by the station staff are flush-mounted in wall panels at the upper end and lower landings. Inching control is from a push-button on the starter. To save wear during slack periods, a light-sensitive control operates after a pre-set delay to reduce the speed to half if no passengers have crossed the light ray. An over-riding control enables the station staff to reduce the speed to half the normal or to stop the "Trav-o-lators" at any time if the station platforms should become too congested.

Very comprehensive safety devices are incorporated, all of which break the electrical circuit, cut off the drive motor and apply the brake to bring the "Trav-o-lator" quickly and smoothly to rest. Five emergency switches, of diamond shape, large and easily recognised, are fitted to the balustrade deck between the "Trav-o-lators" for public use. A centrifugal governor operates in the event of excess speed, and microswitches stop the drive if one or both of the main platform chains should break. Visual indication is given when the operation of either broken chain device is imminent. Similar equipment operates if a handrail breaks, or if the handrail or main platform tension gear moves past a pre-set limit of travel. Stop push-buttons are also provided in the motor room and ticket office.

A switch with a Castell key is provided in the lower landing chamber, so that maintenance staff can work inside the "Trav-o-lator" in safety, and Castell locking is also applied to the circuit breakers, normal braking is by means of the spring-applied, magnet-released brake on the gearbox input side, but a further safety measure is applied in case the duplex drive chain to the main shaft should part. This takes the form of a mechanical disc brake mounted on the main drive shaft, which is brought into operation by a ratchet and pawl mechanism in the event of a driving chain breakage.

The scheme was developed, and the work designed and carried out by Mott, Hay and Anderson, Iddesleigh House, Caxton Street, London, S.W.1, under the general direction of Mr. A. H. Cantnell, Chief Civil Engineer, Southern Region, British Railways. Mitchell Brothers, Sons and Co., Ltd., 167 Victoria Street, London, S.W.1, were the civil engineering contractors, and the Otis Elevator Company, Ltd., Falmouth Road, London, S.E.1., designed, built and installed the "Trav-o-lators." Associated Electrical Industries (Rugby), Ltd., Rugby, supplied the drive motors and control gear, and the distribution switchgear in the machinery room was manufactured by George Ellison, Ltd., Perry Barr, Birmingham, 22. The moving handrails were supplied by the Silvertown Rubber Company, Ltd., Vincent Square, London, S.W.1.

Obituary

SIR CHARLES BRUCE-GARDNER

We regret to have to record the death of Sir Charles Bruce-Gardner, Bt., which occurred on October 1. Charles Bruce-Gardner was born on November 6, 1887, and was educated at St. Dunstan's College and Battersea Technical College. His early studies were of mechanical engineering, both at Battersea and in the apprenticeship he served after leaving the College. In 1913 Bruce-Gardner joined the board of John Summers and Sons, Ltd., and thus started an association with the iron and steel industry which was to last all his life. A year later, in 1914, he became a member of the Sheet Trade Board, and so began his long connection with industrial committees which was to lead later on, to a distinguished membership of various Government bodies.

In 1930 he was appointed industrial adviser to the Governors of the Bank of England, relinquishing this post in 1938 to become executive chairman of the Society of British Aircraft Constructors. In 1938 he also became a member of the Air Council Committee on Supply, and of the Secretary of State for Air's Industrial Advisory Panel. When the Civil Aviation Planning Committee was set up in 1939, Bruce-Gardner was also appointed a member. His experience in the aircraft industry led to further appointments, including membership of the Joint Central Advisory Committee to the Production Executive, and in 1942 he became chairman of the Production Efficiency Board at the Ministry of Aircraft Production.

By 1944, when the question of changing over British industry from war to peacetime production was under consideration, Bruce-Gardner was appointed Chief Executive for Industrial Reconversion, being relieved of his duties at the Ministry of Aircraft Production in order to devote his time to this new work. When the task ended, in 1946, he returned to industry to resume his extensive connections in steelmaking.

He was for twelve years an active member of the board of Guest, Keen and Nettlefolds, Ltd., and for a long period chairman of John Lysaght, Ltd. and its subsidiary companies. In addition, he was deputy chairman of the Steel Company of Wales, Ltd., and a member of the board of the Consett Iron Company, Ltd., and of Crompton Parkinson, Ltd. During the later years of his life Bruce-Gardner was chairman of the British Iron and Steel Corporation and industrial adviser to the Board of Trade. He was a Member of the Institution of Mechanical Engineers, a member of the Iron and Steel Institute (of which he was President in 1955–56), an honorary life member of the American Institute of Mining and Metallurgy, and the American Society for Metals. He was knighted in 1938 and created a baronet in 1945.