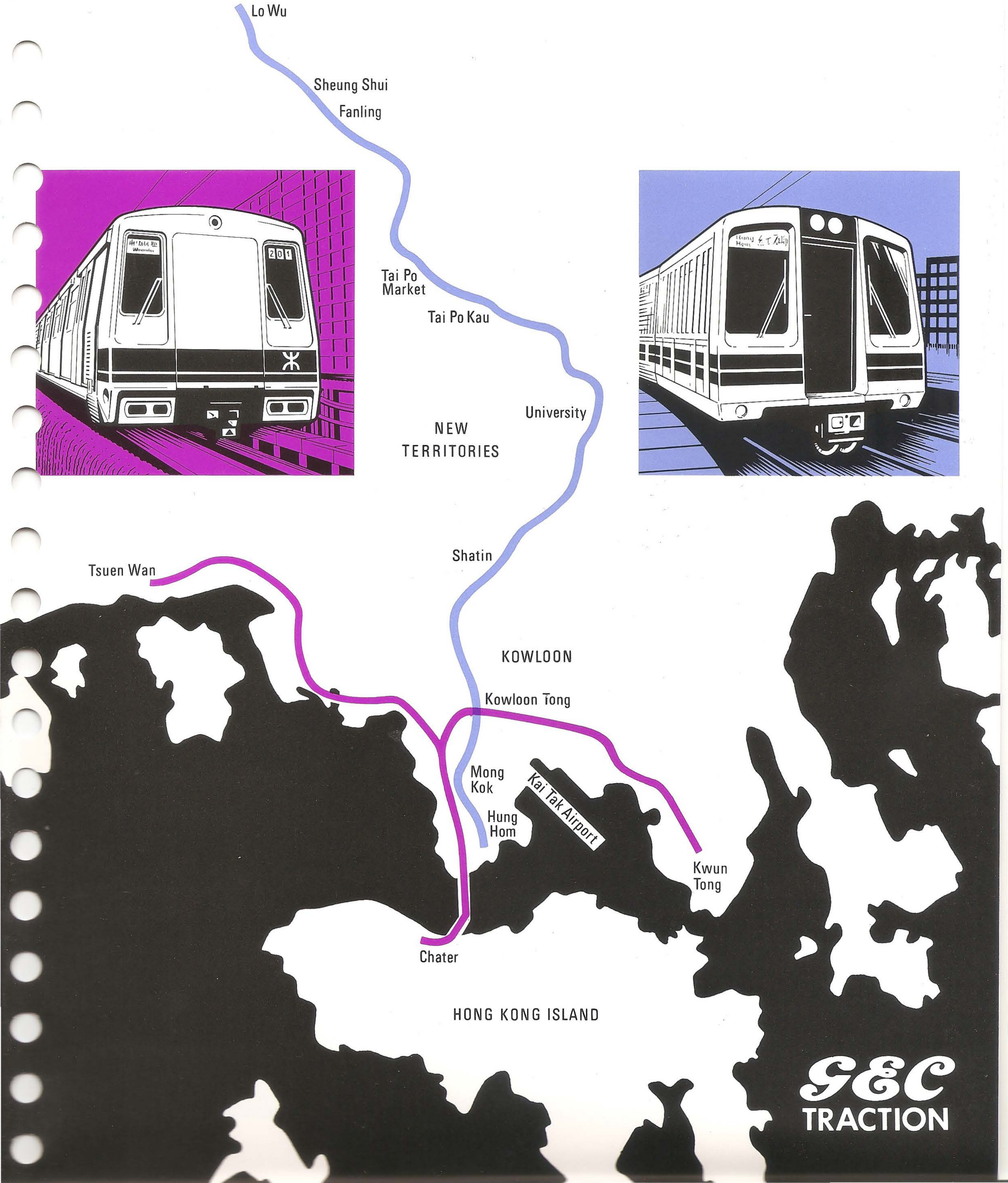
GEC TRACTION IN HONG KONG



GEC TRACTION

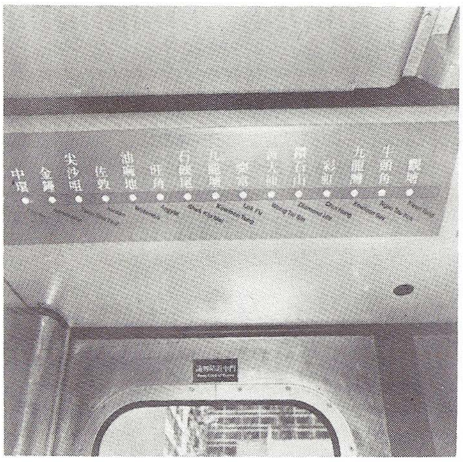
GEC Traction in Hong Kong. GEC Traction has been deeply involved in the creation and equipping of Hong Kong's new Mass Transit Railway as well as providing propulsion equipment for the electrification of the Kowloon - Canton Railway.

For the Mass Transit Railway Corporation (MTRC) the Company provided the complete propulsion equipment package for the trains on the first line to be completed (known as the Modified Initial System or MIS), to be soon followed by further trains for that line and then very similar equipments for the second line known as the Tsuen Wan Extension (TWE). The three contracts totalled 360 cars. In addition the Company provided valuable behind-the-scenes assistance regarding the design of the electrical power system and the effect of that system on interference in telecommunications and related circuits.

In the case of the Kowloon - Canton Railway (KCR), the British Section of the line runs from near the waterfront by Hong Kong harbour to the border with the People's Republic of China at Lo Wu. GEC Traction is providing complete propulsion packages for all 45 of the new trains both for the inner suburban and the outer suburban services.

Superficially there are many similarities between the rolling stock on the two railways but technically there are significant differences and it is the purpose of this brochure to discuss both the similarities and the differences particularly insofar as they effect the propulsion equipment.

The railways and their trains



1 Route diagram located above each door of the cars allocated to the MIS Mass Transit line.

2 Route map of the Mass Transit Railway system.

The Kowloon - Canton Railway is an existing railway with relatively infrequent passenger trains hauled by diesel locomotives. In parallel with electrification the track is being up-graded, doubled for much of its length and resignalled. It runs partly through densely populated urban and business areas and partly through rural areas.

The Mass Transit railway is totally new. The two lines provide links between the Central District of Hong Kong Island and the business and residential areas of Kowloon. Much of the route is underground as are most of the stations.

Both railways are standard gauge and have overhead electrification, the mass transit railway at 1500V dc and the KCR at 25kV 50Hz. The loading gauges of both railways are very generous and this has permitted the use of large rolling stock with very high capacity, all supplied by Metro-Cammell.

The MTRC cars are believed to have the highest capacity of any Metro car in the world. Most cars are 22 m in length and 3 m wide. There are five pairs of doors per side in each car to speed passenger flow and a single row of transverse seats along each side providing seating for 48 passengers. Most of the floor area, therefore, is available for standing passengers - up to 330 standees per car under maximum load conditions! Most transit systems do not carry their full rated load because of uneven passenger distribution first on the platforms and hence in the trains themselves. This is overcome in Hong Kong by providing wide vestibules between cars so that passengers can move between cars even while the train is moving. In view of design features such as these it is expected that 8 car trains will carry 3000 passengers each during peak travelling periods.

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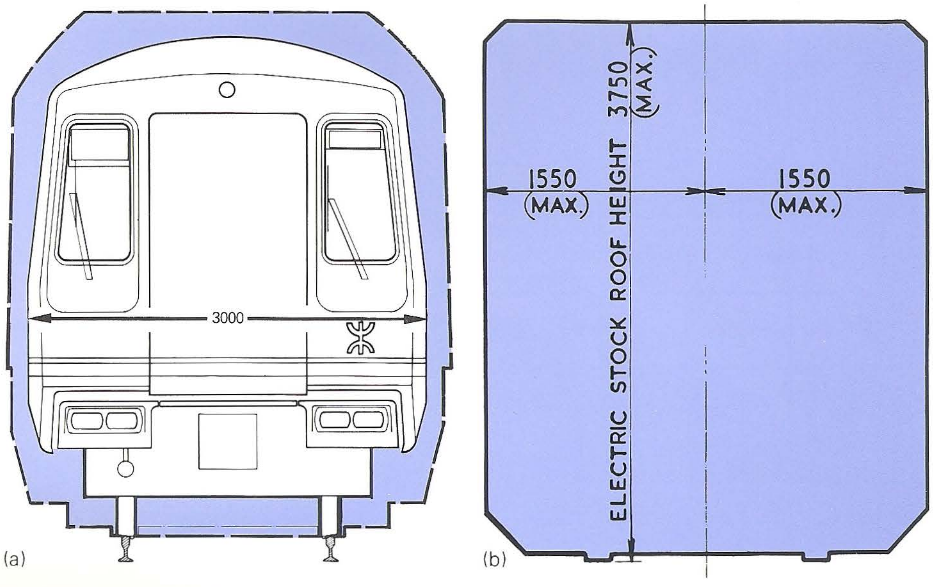
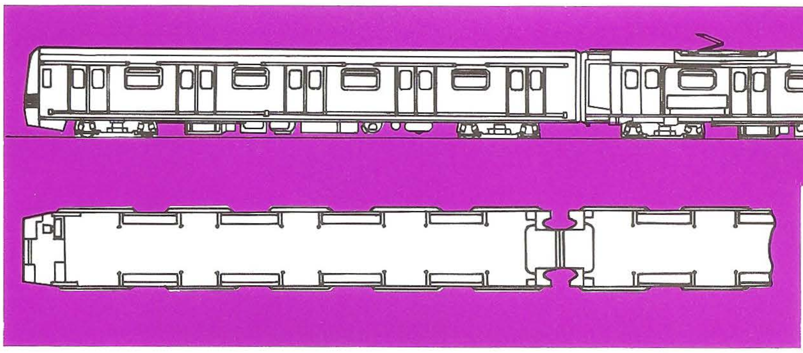
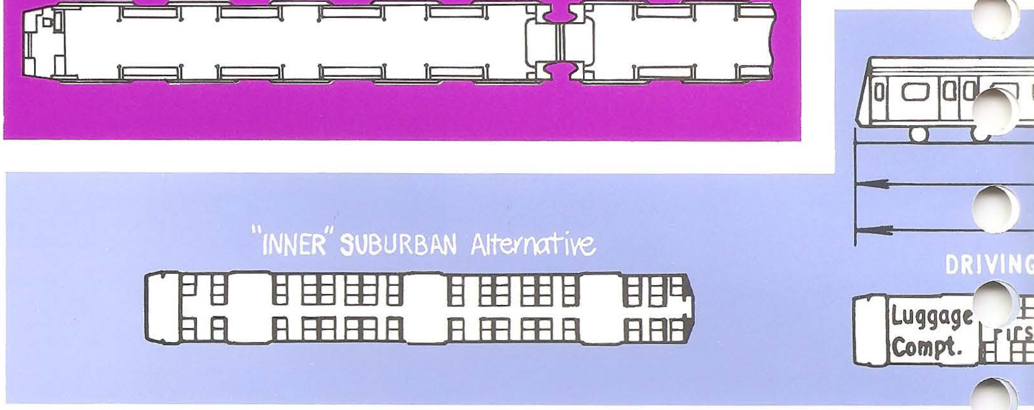


3 Simplified loading gauges for the Mass Transit Railway (a) and the Kowloon-Canton Railway (b).

4 Arrangement of part of a 6 car mass transit train showing the large number of wide doors, the wide vestibules and the minimum number of cabs.



5 Arrangement of an outer suburban 3 car KCR train-set showing the baggage compartment, first class accommodation and toilets. The inner suburban sets (left) have second class accommodation instead of these features.



The KCR trains are designed for longer journeys and therefore have a higher proportion of seats. There are two types of train, the "inner suburban" in which all the accommodation is second class and the "outer suburban" which have toilets and a luggage compartment as well as some first class seats. Even with these constraints the outer suburban units are designed to carry 884 passengers in a 3 car set and the inner suburban sets 961 passengers!

In off-peak periods the KCR trains will sometimes operate as trains of only 3-cars and thus each 3-car unit is self-contained with full-width cabs at each end although trains of up to 12 cars will be used in busy periods. The mass transit trains, however, only have cabs at the outer ends of the train in order to maximise passenger accommodation and, furthermore, the cabs are very narrow in order to leave a wide gangway for use as an emergency exit in the tunnel.

There are three types of transit cars but they operate, in traffic, in non-divisible pairs because of equipment shared between them. Power is taken in at the 'C' type cars which have pantographs and which are coupled to either 'A' type which have cabs or 'B' type which do not. Initially 4 car trains were ordered (viz. AC-CA), later increased to 6 car (AC-BC-CA) and later still a further BC unit will be added to produce an 8-car train.

Electrification

The mass transit railway is electrified at 1500V dc with the supply taken from an overhead wire. At one time it was intended to use a 3rd rail supply but it was felt that safety margins would be inadequate even with a shrouded contact rail.

A supply voltage of 25kV at industrial frequency (50Hz) was chosen for the KCR line partly because the line is above ground (and so there were no problems with clearances in tunnels, etc) and also to give compatibility with any future extension of the electrification across the border into the People's Republic of China.

Performance

The performance requirements for transit trains and suburban are very different. The mass transit railway is designed to carry trains at 2 minute intervals during peak periods and this is only possible if the trains accelerate very quickly away from the stations and brake at correspondingly high rates. The MTRC trains have all their axles motored to give a nominal acceleration rate of 1.3 m/sec² (3 mile/h/sec) but this is increased in practise by the "hump" layout of many stations. The average station spacing is little over 1 km, the average speed (including steps) is some 34 km/h and the maximum permitted speed 80 km/h.

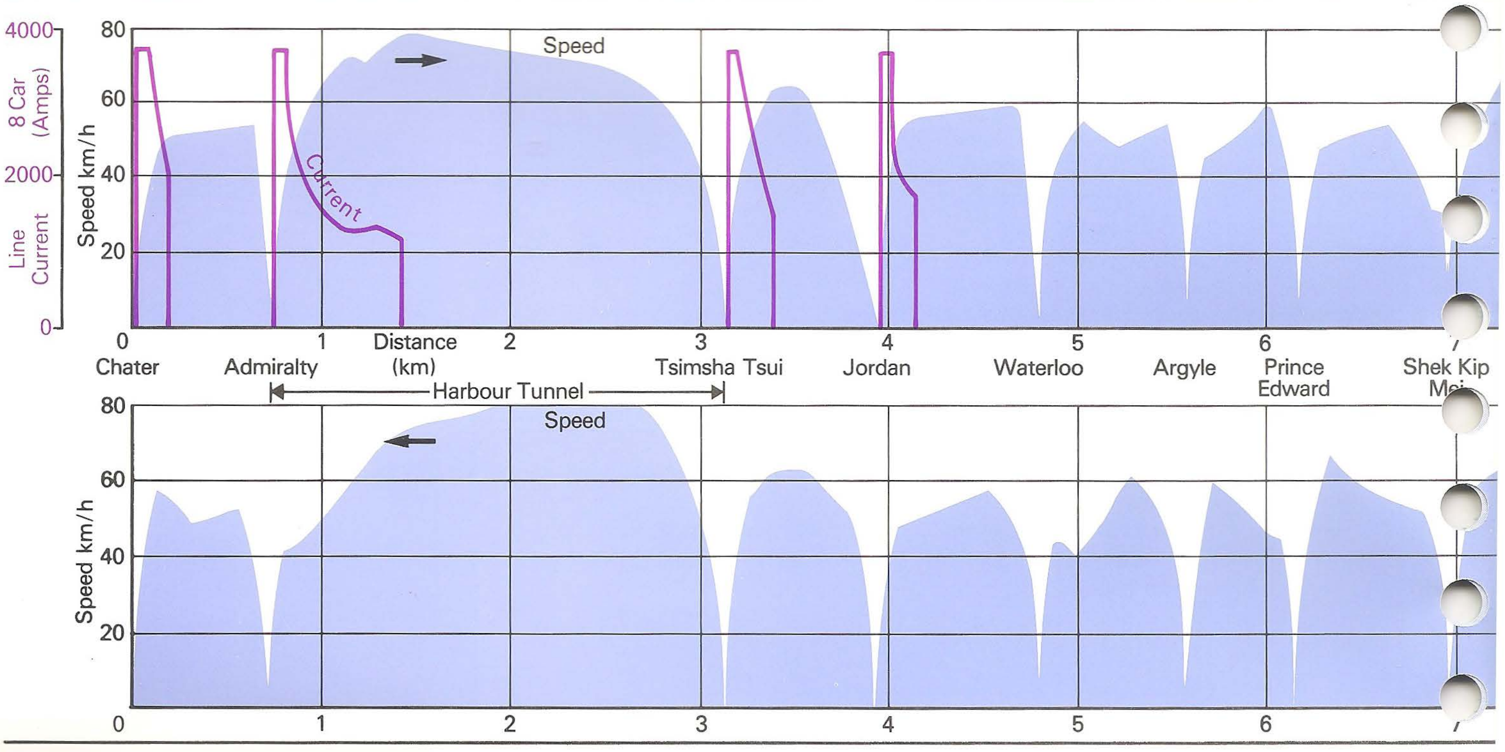
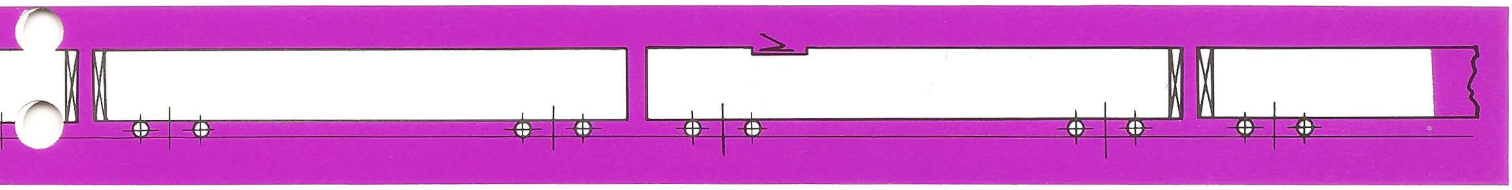
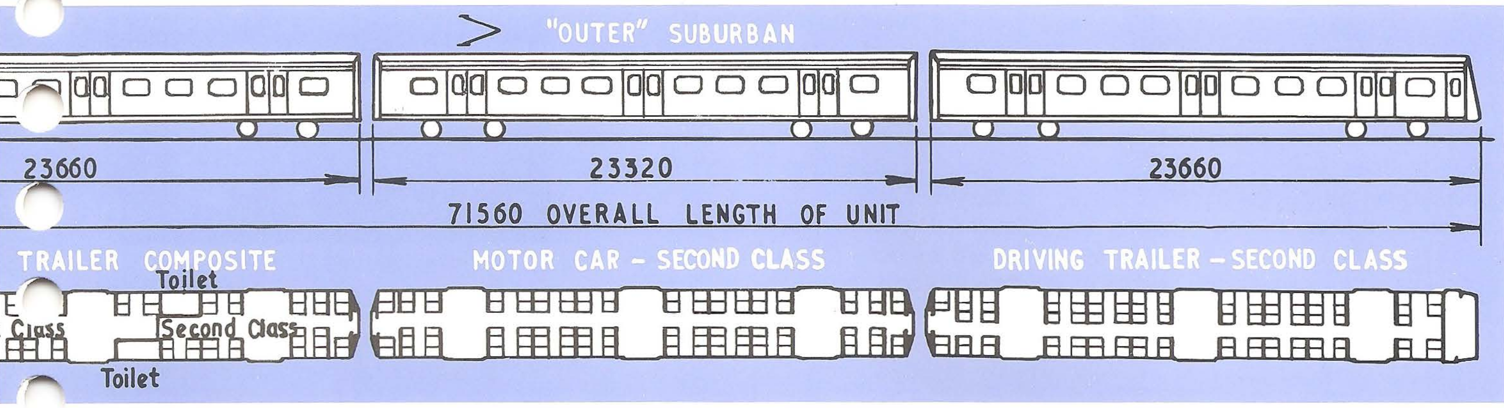
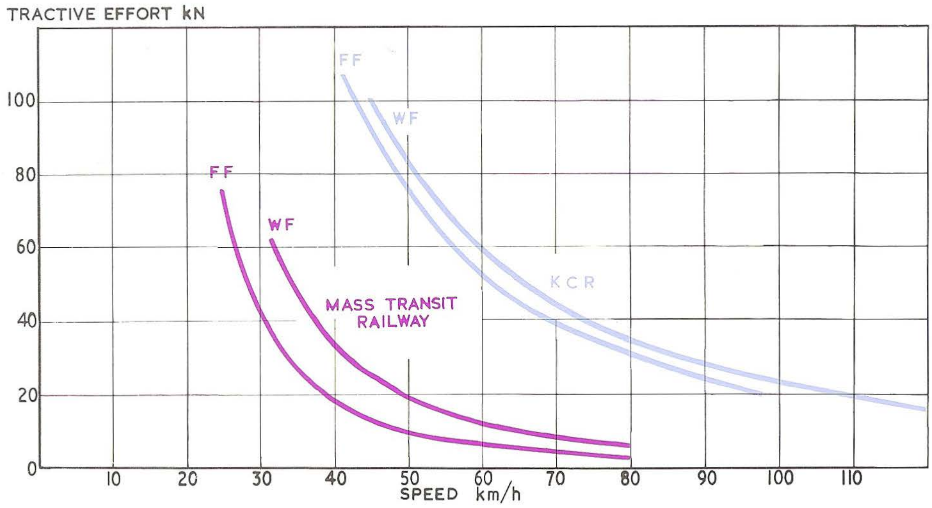


Fig. 6





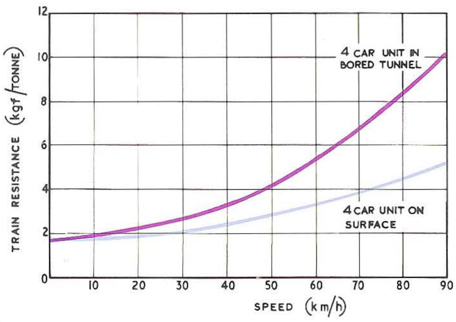
By contrast the KCR station spacing is more than 3 km, the system speed limit is 120 km/h and the average service speed (including stops) will be close to 60 km/h. For such a duty high rates of acceleration are not so important and so the KCR trains only have ⅓ of their axles motored. The ruling gradient is 2.2% but this is very short in length and most of the route has very gentle gradients.

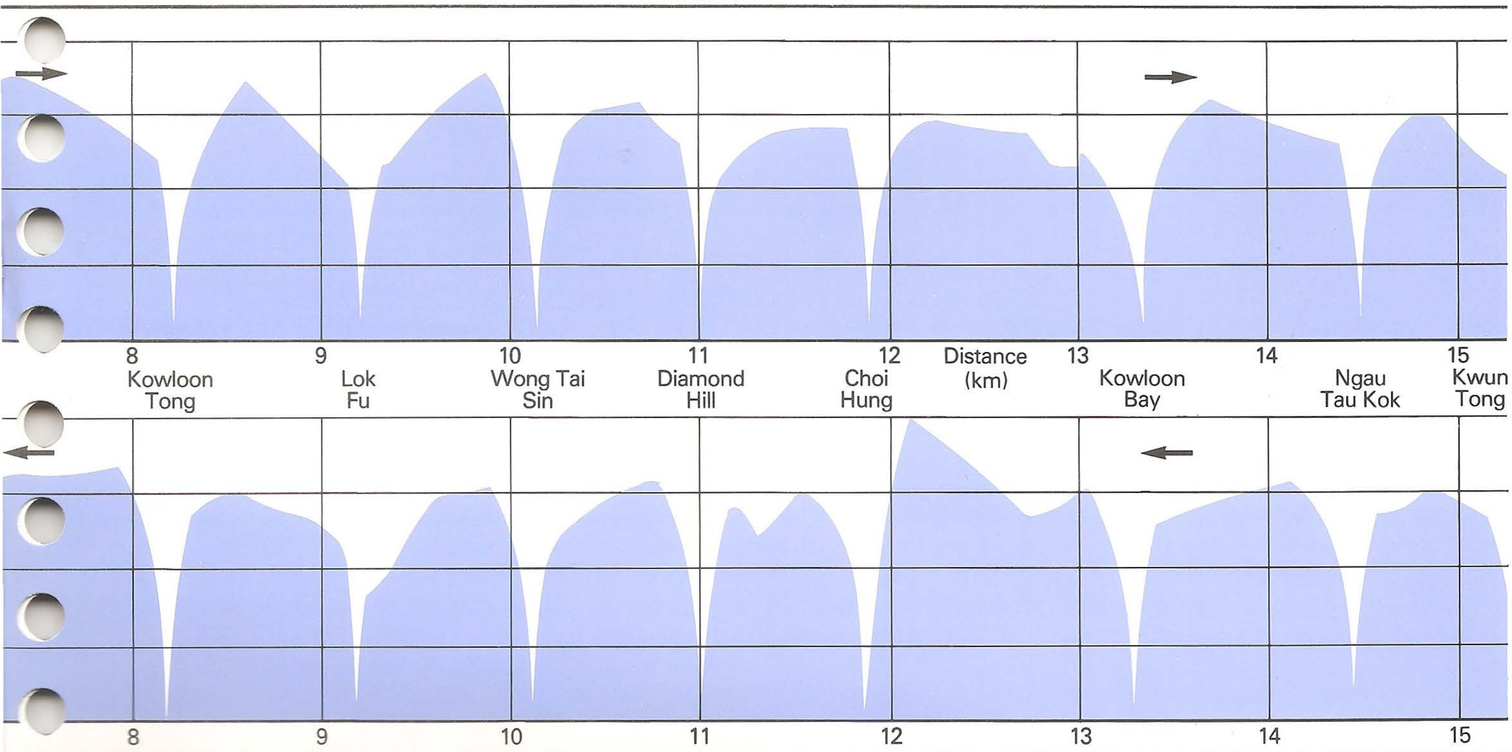


6 *(bottom of page)* Speed/distance performance curves for (part of) the first mass transit line from Chater under the harbour to Kwun Tong.

7 *(left)* Performance curves (tractive effort/speed) for (a) the mass transit trains and (b) the KCR trains.

8 *(below)* Train resistance curves for mass transit trains on the surface and in tunnel.

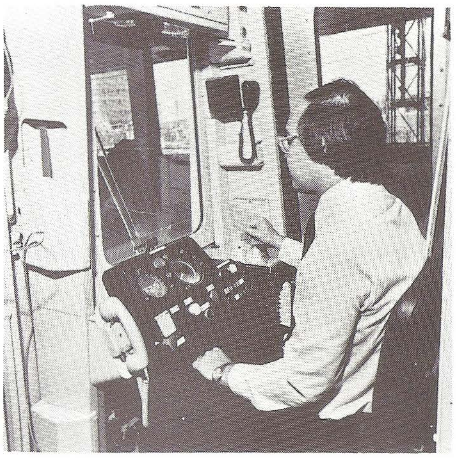




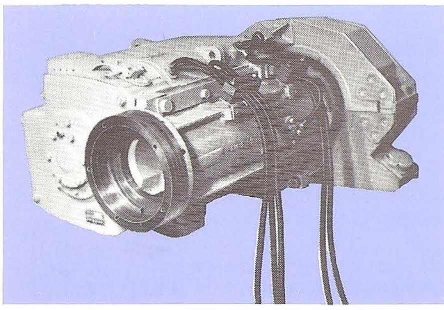
Propulsion equipments

The propulsion equipment chosen for the mass transit cars was based on the 1500V camshaft control equipment which GEC Traction has been supplying to Denmark for many years. The Hong Kong transit requirement, however, demanded very high acceleration (and braking) rates which could only be achieved if all axles were motored and so it was decided to use a variation of the new "standard" traction motor currently being introduced for high-performance emu trains in Britain. Chopper control was contemplated or the transit trains but as the prime reason for considering the adoption of choppers is their ability to regenerate into the line during braking and as Hong Kong had designed its stations on the *hump* principle (steep rising grade on approach, falling on leaving) even this advantage disappeared.

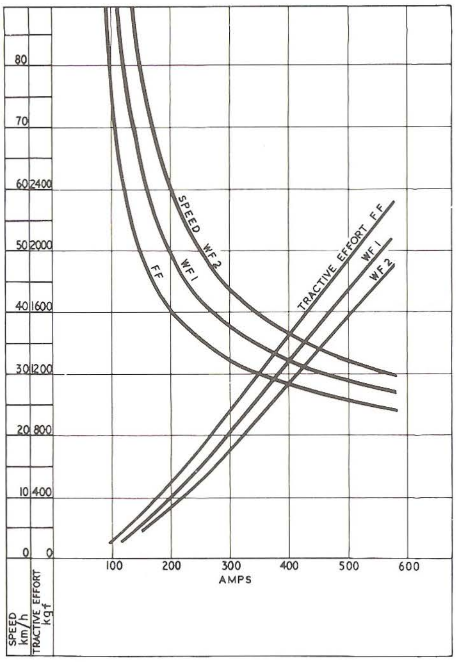
The KCR equipment was almost entirely derived from that supplied to British Rail - the transformer and control equipment from the existing 310/312 fleets and the traction motors from the new class 317 stock (for the St. Pancras - Bedford electrification). The class 310 fleet of 50 trains entered service in the mid-1960's and during its first 15 years accumulated no less than 100 million km in service. During that time the "minimal maintenance" aspects of the design were much appreciated by the operators and this undoubtedly played a part in choosing similar equipment for KCR.

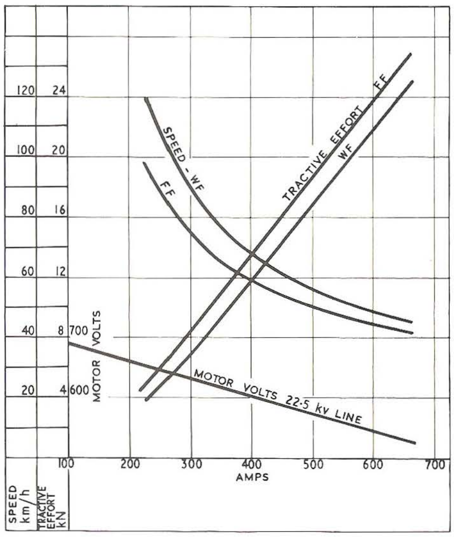


9 The neat layout of the MTRC controls is evident from this view. There are additional hostler cabs throughout the trains.

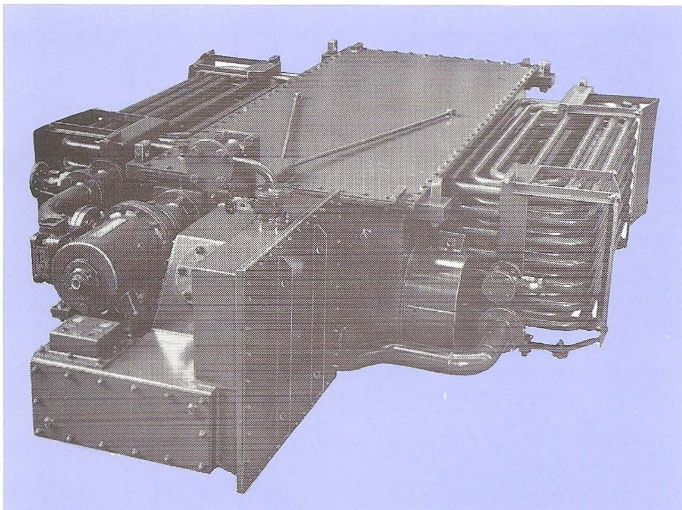


10 Traction motors of the type installed on the mass transit trains.

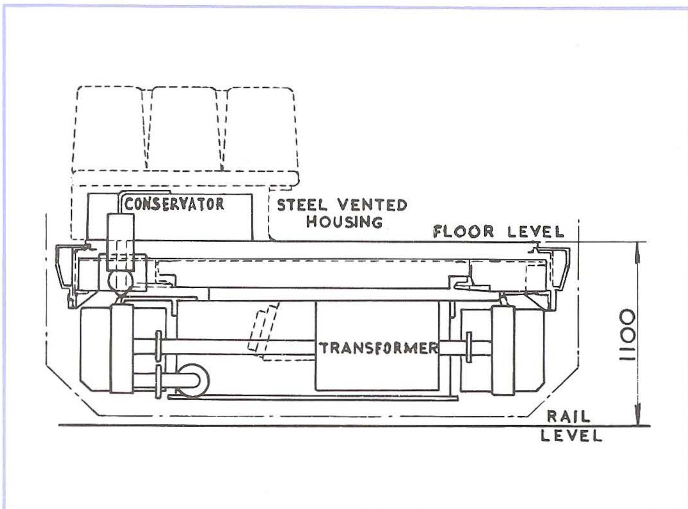




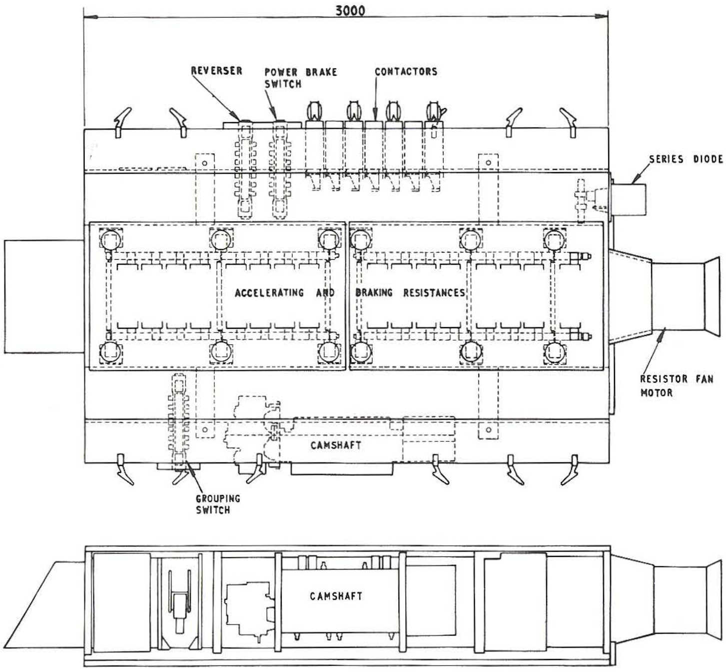
11 Traction motor characteristics:-
(Left) G313 for mass transit trains
(Above) G315 for the KCR trains

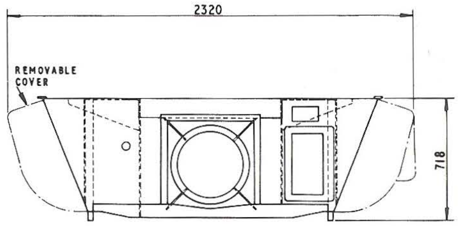


12 Transformers, such as this for British Rail's Class 312 trains, will be fitted to the KCR trains.

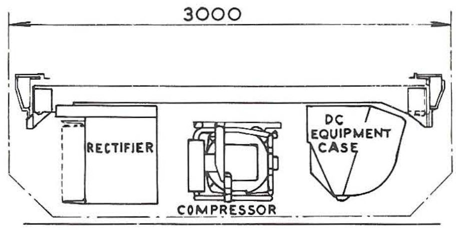


13 Cross-section of the KCR power car showing the disposition of the transformer and its auxiliaries.

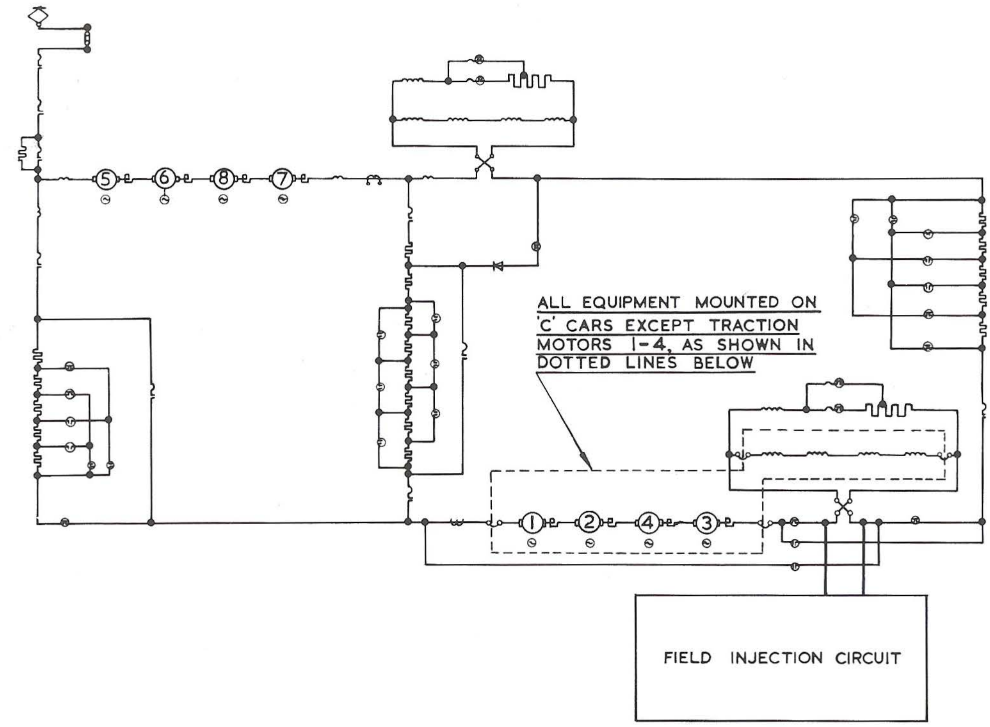




14 Three views of the main equipment case fitted to the TWE transit cars showing the full-width pannier arrangement.



15 The KCR equipment layout, however, uses half-width pannier cases.



16 The original mass transit cars were fitted with a camshaft on each car whilst on the TWE contract (and as part of the weight saving exercise) there is only a single camshaft controlling all 8 traction motors on a pair of cars. The TWE power scheme is shown here.

The climate and the need for air conditioning

The climate in Hong Kong is onerous. Temperatures vary between freezing point and almost 40°C, whilst 100% humidity is frequently recorded and typhoon-strength winds gust up to 130 km/h. Salt-laden spray is frequently blown at the vehicles where the track runs close to the sea and in places the cars may have to run through flood water.

The combination of high temperatures and high relative humidity poses special problems for the passengers particularly in the underground sections of MTRC. The nominal summer tunnel temperature can be 35°C and the heat liberated by the passengers alone travelling in an 8 car train can exceed 300kW whilst the total heat rejection from such a train could exceed 1000kW. To put these figures in perspective, the air at the back of *each* train will be 8°C hotter than that at the front and it will be apparent that forced cooling (refrigeration) of the underground stations is required as well as air-conditioning in the cars themselves. To cater for emergency conditions when a train might be stopped in the tunnel, the fans which circulate the saloon air were designed to operate from the batteries (which are of larger than normal capacity in order to cope) for sufficient time to enable all the passengers to be evacuated.

The KCR trains also have the high ambient conditions to contend with and a similar density of passengers in the peak conditions but in addition there is a high solar heat gain resulting from operating in direct sunlight for much of the time. The air-conditioning units on these trains, however operate from the main power supply because loss-of-power is not critical in the open where, in emergency, the doors could be opened to provide ventilation.

The E11 co-ordination contract for MTRC

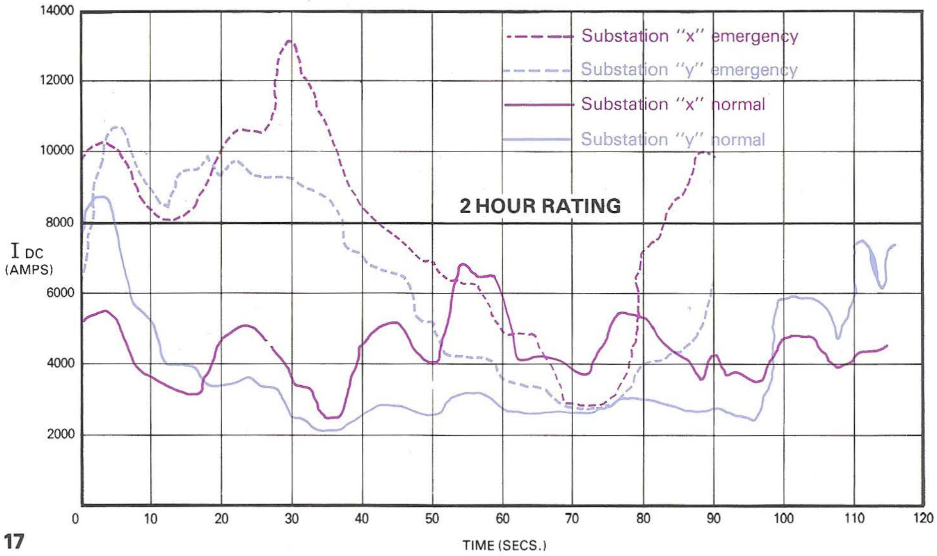
The multi-contract arrangement for the construction of the mass transit railway demanded close co-ordination both of the supply and the installation of all electrical and mechanical equipment. Of perhaps greater importance was the need to check the adequacy of the inter-related electrical systems and their mutual compatibility both under normal and abnormal (emergency) conditions. The principal electrical hardware contracts involved were:-

E1 the emu trains themselves
E2 signalling and control systems
E3 telecommunications
E4 power supply fixed equipment
E5 escalators and lifts
E6 automatic fare collection equipment
E7 environmental control systems
E8 station and tunnel auxiliary equipment
E9 Kowloon Bay depot equipment

The E11 Contract was between three parties, the Mass Transit Corporation as Customer, GEC Traction who carried out both a Power System Study and an Interference Study, and Metro-Cammell who co-ordinated the installation work. GEC Traction's work under this contract was carried out completely separately from that as sub-contractor for the propulsion equipment on the trains, but the fact that they had the capability and the expertise to do the studies undoubtedly helped secure the contract. The initial co-ordination contract covered the MIS line but it was later extended to cover the Tsuen Wan extension.

The power system study was primarily concerned with checking the ratings of the distribution systems and sub-stations, checking adequacy of cables and the settings of circuit breakers. It covered both high voltage and medium voltage networks, traction and auxiliary, ac and dc. Particular attention was paid to abnormal conditions (such as trains running on very close headways, sub-stations out of service) and procedures were discussed for the introduction of standby equipment during emergency conditions. Harmonic levels were investigated and the earthing methods proposed for the various contracts - this latter point was particularly important in view of the wide variety of earth conditions to be found on the routes of the metro lines.

Having established power flow levels in the various systems during normal and abnormal conditions the Company then checked their effects on other systems.



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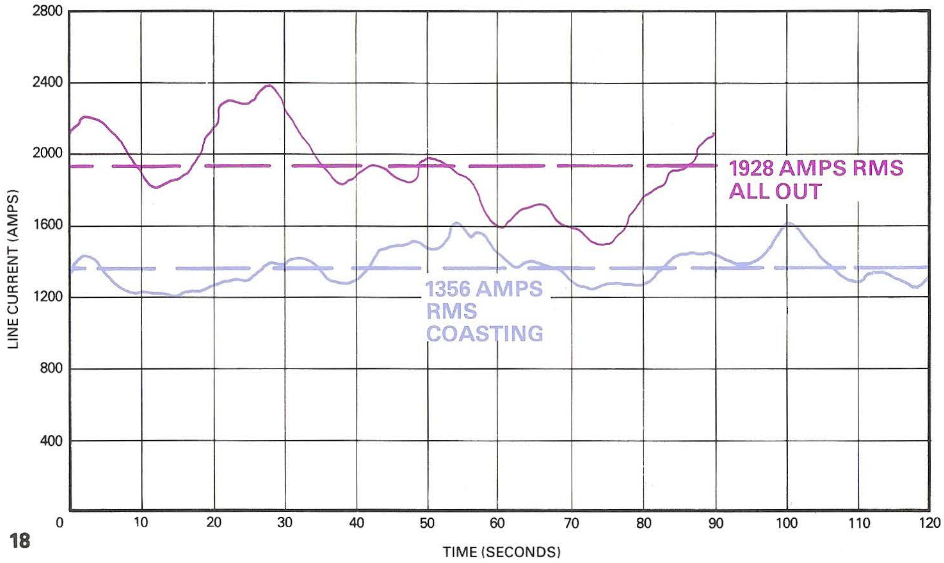
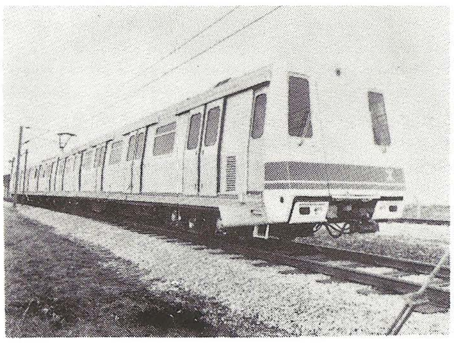


18

17 Shows load-currents at two rectifier sub-stations whilst **18** shows current in a 33kV feeder.
In both cases they were computed over a full operating cycle:-
(a) for schedule speed operation (including make-up time) and 2 minute headway.
(b) for emergency operation with all-out running (no coasting) and 90 second headway.

Particular attention was paid to signal cables and equipment because of the vital need to protect the integrity of the signalling system. Of only slightly less importance, however, were the telecommunications sub-systems such as telephones, telemetry, selective call public address equipment, and radio, because with such an intensively worked underground railway good communications are vital at all times.

The validity of the theoretical calculations was verified by live testing and for this purpose the test track of the tyne and Wear Metro near Newcastle in the UK was invaluable. The first cars to be produced for the mass transit railway were sent to the test track to take part in these and other tests.



19 The prototype mass transit train on the Tyne & Wear Metro's test track.

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