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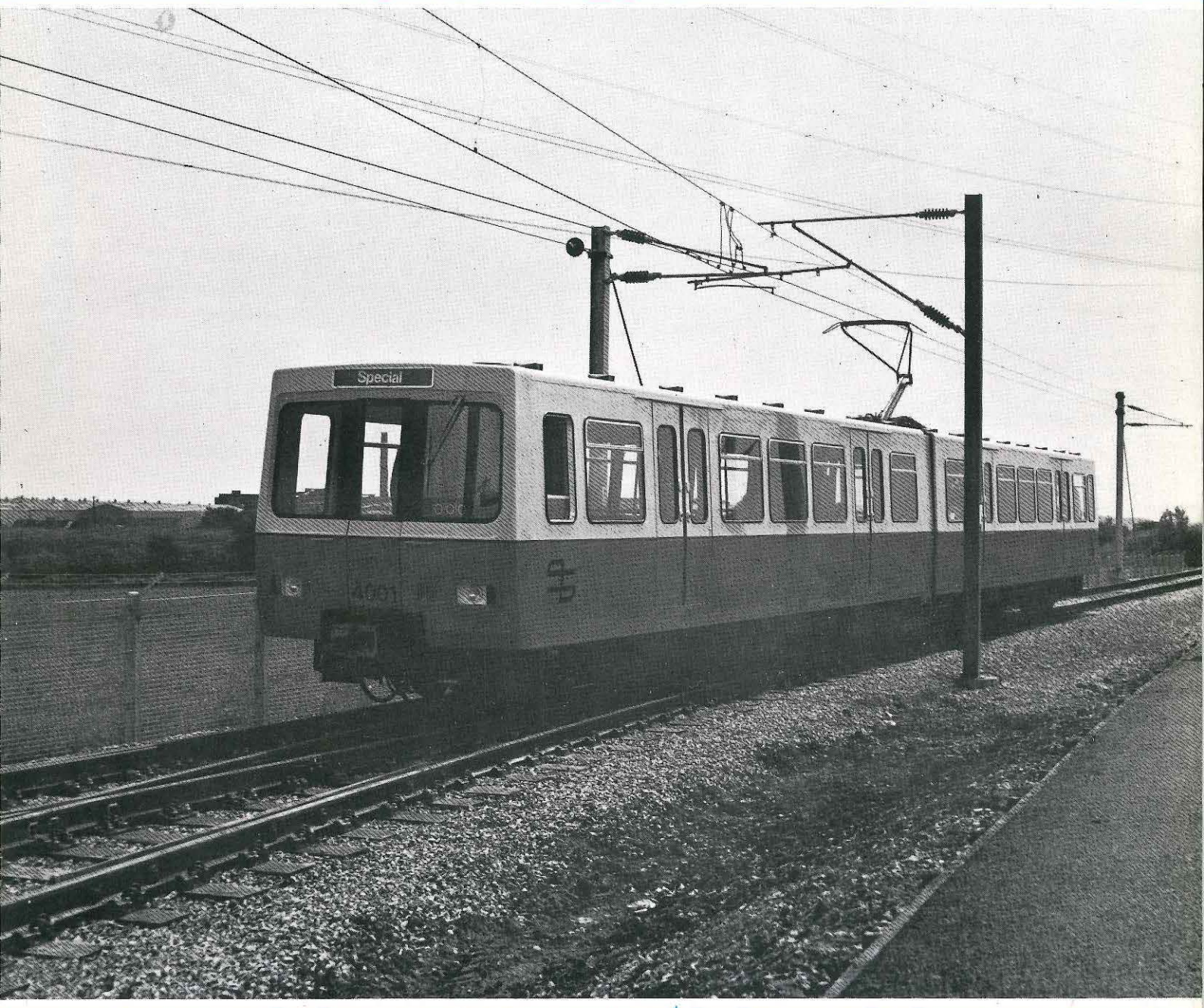

1500 volt twin-car articulated LIGHT RAPID TRANSIT trainsets for Tyne & Wear Metro

GEC Traction Limited

Light-weight twin-car articulated-sets for Tyne & Wear 1,500-V Metro

Tyne & Wear Passenger Transport Executive is now preparing facilities for the testing of two prototype articulated-cars which are at present in an advanced stage of manufacture at Metro-Cammell Limited of Birmingham. The cars will be mounted on two powered outer-bogies and a non-powered centre-bogie.

Traction current supply will be 1,500 V d.c. overhead, and a tunnel diameter of 4·6 m necessitating a maximum car height of 3,155 mm. The bogie centres are pitched at 10,400 mm and the car is designed with a wide vestibule over the centre bogie for easy access from one body to another. Platform access is by four 1,300-mm wide doorways each side fitted with twin-leaf power-operated plug-type doors.

Dynamic braking at the powered bogies is complemented by discs on the centre bogie. Powered-bogies have one disc per axle which operates when the dynamic brake is not available; each axle of the centre bogie has two discs. Disc brakes are spring-applied/air-released type controlled by Westinghouse Westcode system. All bogies carry magnetic track-brakes for use in an emergency. Service operation provides for 150-m radius curves.

The two body units are of lightweight integral-construction comprising a welded-steel underframe, bodyside elements consisting of a fabricated steel frame panelled in aluminium and a rivetted aluminium roof/cantrail assembly. The underframe is without central longitudes, adequate strength being obtained by association of deep solebars and amply-proportioned cantrail extrusions with the bodysides. The outer ends are formed by a robust assembly of collision pillars and waist-rails clad in moulded glass-reinforced plastic and incorporate a central emergency door flanked by large windows.

The driving compartment is located to the left of the end door and passenger seating extending the full length of the right wall. Cab layout is based on ergonomic studies and achieves a high standard of driver comfort. The centre end of each body unit is a box-section portal frame which, together with the articulation vestibule, provides a wide communication aisle between the two saloons. Scharfenberg centre couplers are provided and carry the wires for traction, braking and door control. Braking is self-contained in each car but the main reservoir pipe is train-lined through the coupler to cover failure of a compressor when operating in multiple.

The electrical equipment is supplied by GEC Traction Limited, and is a mixture of well-proven components. Control is based on the air/oil cam-shaft of which over 1,000 have been supplied to Denmark (in 1,500-V versions) and to British Railway's Southern Region (for 750 V duties). The traction motor is based on a standard Siemens design which is fitted to many vehicles in continental Europe equipped with Duwag mono-motor bogies and whilst the machines for the prototype vehicles will be of German manufacture, those for the production units could be manufactured by GEC Traction in the United Kingdom.

Economies obtained by 1,500-V traction

The system voltage of 1,500 V d.c. was only adopted after considerable investigation and study of the total system and comparison with alternatives of 1,000 V and 750 V d.c. A system energised at 1,500 V requires a little over half the number of sub-stations required for 750 V showing considerable savings in capital cost (particularly when taking account of the cost of land itself). The standard design of traction motor is not suitable for direct connection in parallel across 1,500 V and thus the motors are connected permanently in series during motoring but insulated at 1,500 V to ground.

At first sight the lack of series/parallel transsition would appear to be wasteful in energy but in fact this is not so because of the actual characteristic of the machine. Calculated

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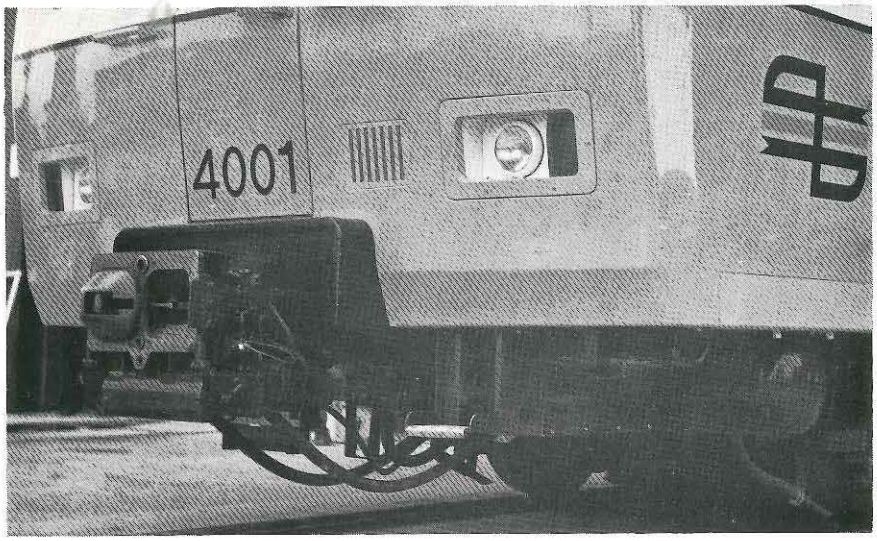
energy consumptions for the average station to station section show an energy saving of 3½ per cent when comparing 1,500- with 1,000-V systems. The electrical equipment is distributed almost equally between the two halves of the articulated car; in the case of the control equipment this is primarily to ensure heating energy for the waste heat recovery system of saloon heating is available in both halves of the saloon without an excessive number of inter-unit power connections.



Scharfenberg automatic centre coupler fitted to each end of the twin-body cars. The electric connections include the controls for releasing the plug-type passenger access doors and their closure. The other connections include the hose pipe connection for the main reservoir of the airbrake.

There is a driving position at each end of the articulated set. The combined power- and brake-controller which includes a deadman feature moves fore-and-aft for power and brake respectively which is a change from recent British practice. The driver can select four accelerating positions, viz. "Shunt", "Full-field", "Inter-field" and "Weak-field". In braking the Westcode equipment gives seven rates of service braking plus Emergency. During "Service" braking, rheostatic electric and air on the centre non-powered bogie only are used with the electric brake providing about 75 per cent of the retardation during most circumstances. In "Emergency", however, the electric brake is cut out and air brake is applied to all axles supplemented by 6 magnetic track brakes (2 per bogie). The track brakes are energised from a battery thus retaining their effectiveness even if the line supply is lost. A low speed cut-out releases the track brakes at standstill to avoid an unnecessary drain on the battery.

Operating and braking performance

Maximum service speed is 80 km/h. Initial acceleration is 1 m/sec² (up to about 40 km/h) and this acceleration is maintained by load weighing control up to the normally loaded weight. Maximum service braking produces a retardation of 1·3 m/sec² but in emergency braking when the magnetic track brakes are used this rises to 2·32 m/sec² at tare weight. There are 18 accelerating notches: 14 resistance and four with weakened field, and 15 braking notches.

The traction motors are four-pole, self-ventilated compensated machines, wound for 750-V operation but insulated for 1,500 V to ground for service on the 1,500-V system. Each motor drives both axles on its bogie through right-angle drive units and is continuously rated 185 kw at $\frac{1500V}{2}$. An iron-cored, air-gapped inductive divert is connected in series with the field-divert resistors to improve stability under voltage interruption and remake conditions.

The auxiliary-supply set is a motor-alternator set resiliently mounted under the car floor. The line-fed motor is a two-pole lap-wound machine whilst the alternator is of a four-pole brushless design rated at 10 kW. The output is 415 V, three-phase, 50 HZ so that industrial lighting units can be used. Both speed and output voltage are regulated by static controllers. The GEC type AY61 compressor motor is also line fed and is mounted as an extension of the shaft of the Westinghouse 3HC43 compressor. This integral arrangement eliminates much of the noise associated with other mechanical drives. The set runs at 900 rev/min and has an output of 43 ft³/min fad.

The air/oil cam shafts are used both during acceleration and braking with the traction motors connected in permanent series during motoring and reconnected by a changeover switch to parallel (crossfield) connection during braking. Notching-current is controlled by a static notching relay.

Electronic wheel-spin/slide protection

Wheel-slip-slide control is provided by an intergral electronic equipment which measures the speeds of each independent axle by counting the rate at which gear-teeth pass a probe. The cab-mounted speedometers are fed from the axle units. During acceleration the speed signals from the two pairs of powered axles are compared with the non-motored axle speed and if a predetermined difference is exceeded the line breakers are tripped open, the cam shaft returns to 'off' and the notching sequence starts again automatically.

In braking, this speed comparison is replaced by a 'rate-of-change of speed' detection-circuit to guard against the possibility of all wheelsets sliding together at the same speed. If slide is detected, i.e. if the maximum rate is exceeded, slide-protection is initiated which includes releasing the air brake on the half-car involved, halting progression of the cam shaft and applying sand. When adhesion is restored the cam shaft progression continues and the air brakes are reapplied.

The single-arm pantograph is a standard tramway pantograph which has been modified for multiple-unit operation. It is arranged for spring raising and air lowering with an automatic latch down. To ensure that the pantograph cannot be raised until control-air is available, the latch can only be released by that same air supply.

The envisaged operating philosophy recognises the significance of service frequency in attracting custom and is a compromise between the ideal of providing each passenger with a seat and necessity to accommodate high rush-hour traffic without excessive off-peak stock

ing troughs running the length of each saloon. Lighting is by 40 W fluorescent-tubes behind plastic diffuser panels. These operate at 240 V 50 Hz off the motor-alternator set except at the doorways where supply from the 110-V battery through inverters covers requirements for emergency illumination.

Car heating is by a waste-heat recovery system. Air from the blown traction and braking resistors under each half of the body is ducted to six seat-plinth outlets in each saloon. Discharge temperature is maintained within equable limits by cold air mixing and resistor air is dumped to the track at excessively high or low temperatures. The air circuit is reversed in summer so that air is drawn from the saloons and discharged under the car. The motor-alternator set is carried on one half of the car and the compressor on the other half, both machines being powered by 1,500-V d.c. motors.

Duwag roller-race articulation connection

The articulation is based on Duwag design in which the two halves of the body are flexibly-connected to the centre bogie through a large diameter ball-race assembly. The assembly has three rings uniting two concentric ball-races, the middle-ring being common to each and mounted to the bogie-bolster. The outer-ring is rigidly cantilevered off the headstock of one half of the body and the inner-ring carries a short intermediate-bolster with trunnion brackets pin-jointed to the other body half allowing vertical displacement of one end of the car relative to the other.

The centre-bogie bolster also carries the fabricated-steel articulation portal which forms the wide communication aisle between the two saloons. Stability is maintained by a ball-jointed link between the top of the portal and one of the body roofs and by a similar link transversely-disposed and connecting the two body halves at roof level. U-section rubber bellows between the portal and the ends of the two body sections accommodate relative movements and provide a continuous seal against draughts and airborne noise.

The floor within the articulation-vestibule is in the form of a turntable 1,748 mm diameter and side finish panels at the ends of the two saloons are extended into the portal to provide an appropriate overlap during negotiation of curves. Suitable handrails are incorporated and the area contributes to rush-hour standing-passenger capacity and conveniently accommodates bulky baggage, push-chairs, etc., during 'off-peak' conditions.

This article was prepared when the vehicles were under construction. They are now complete and in service on the test track near Tynemouth.

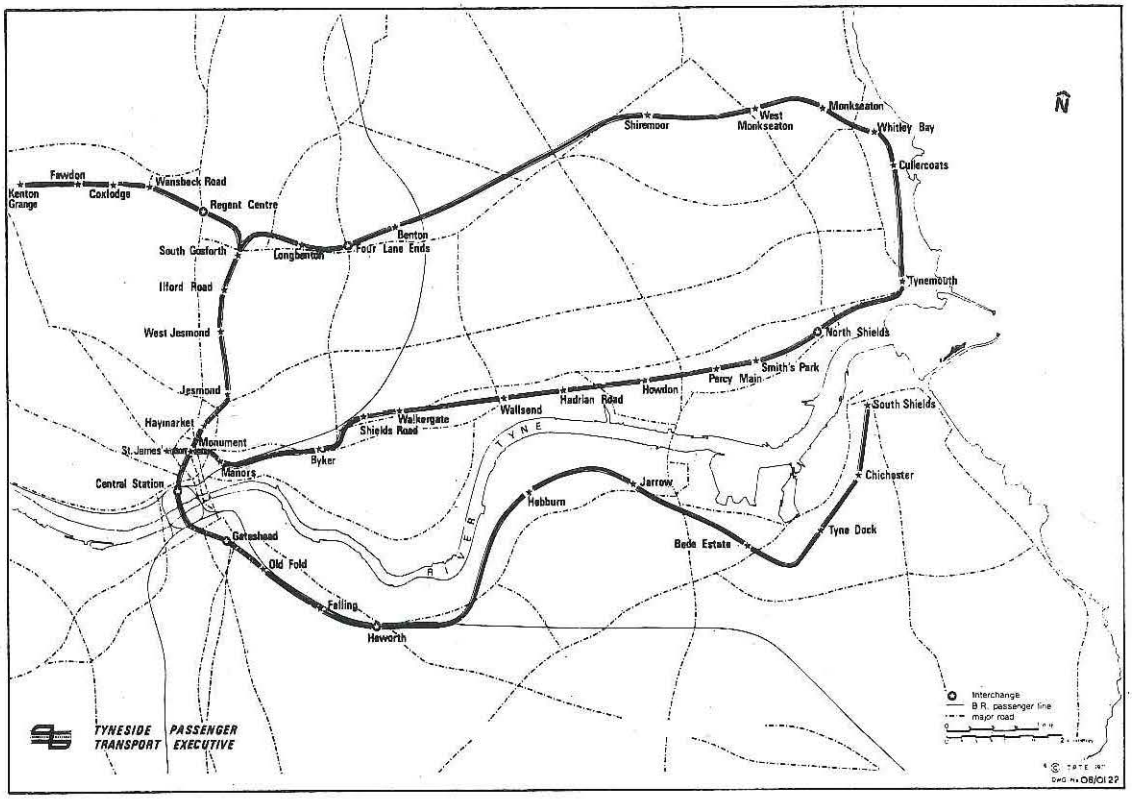
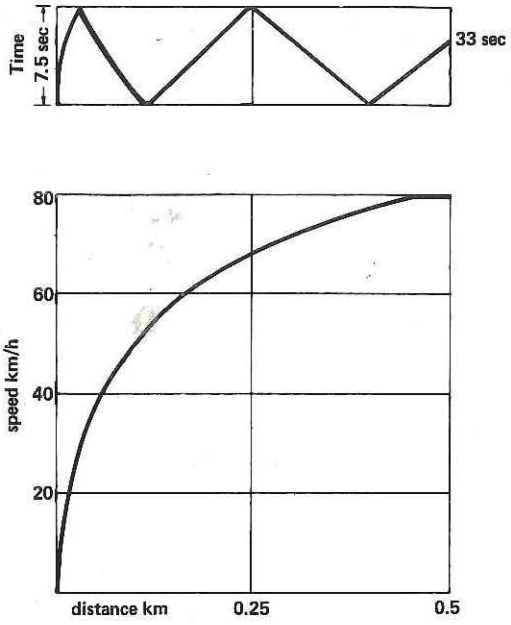
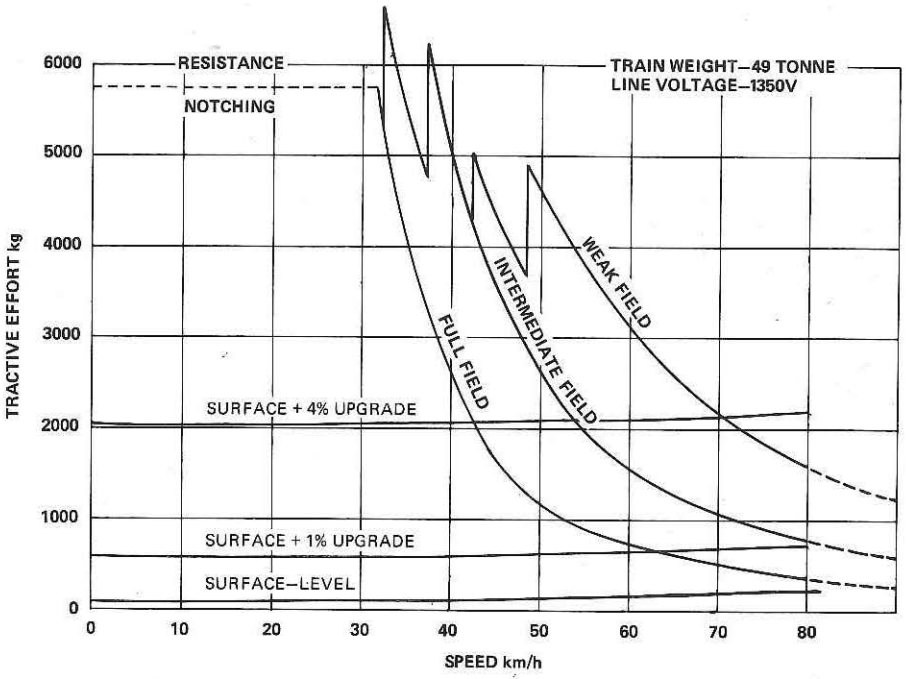


Fig. 2. *Tyne & Wear Metro 54-km (34-mile) double-track network, some 13 km of which will be new construction. The system will embrace 42 stations, 22 of which exist on the present BR network and six will be underground*

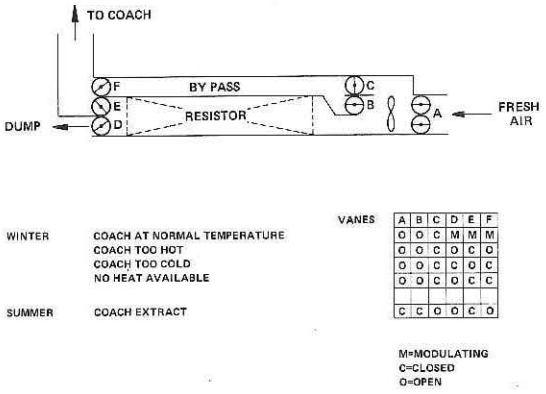


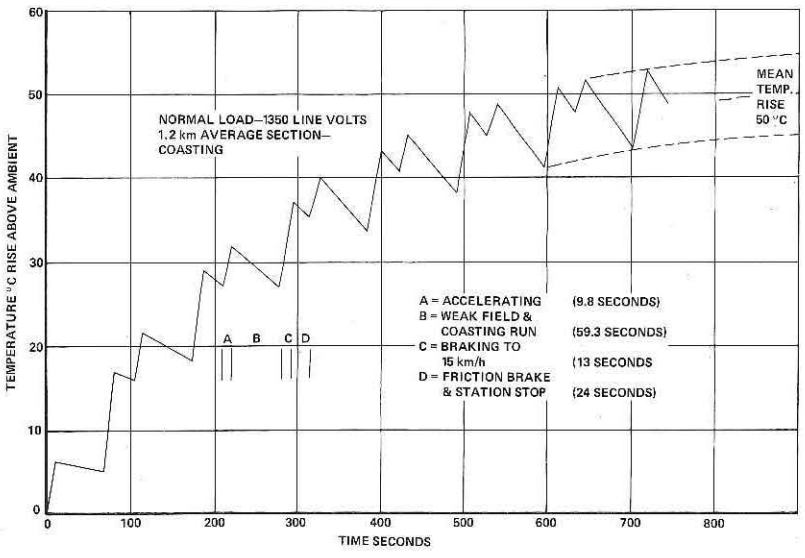
Performance showing speed and time against distance for 49 tonne two car train with the supply line voltage at the nominal figure of 1350V.



Tractive effort and speed characteristics for a two car train showing balancing speeds on various grades with 1350 line volts

WASTE HEAT RECOVERY UNIT





RESISTOR OUTLET AIR TEMPERATURE

GEC Traction Limited

Holding Company–The General Electric Company Limited
Trafford Park, Manchester, M17 1PR, England. Telephone: 061 872 2431 Telex: 667152
Telegrams: Assocelect Manchester