DUBLIN SUBURBAN
ELECTRIFICATION SCHEME

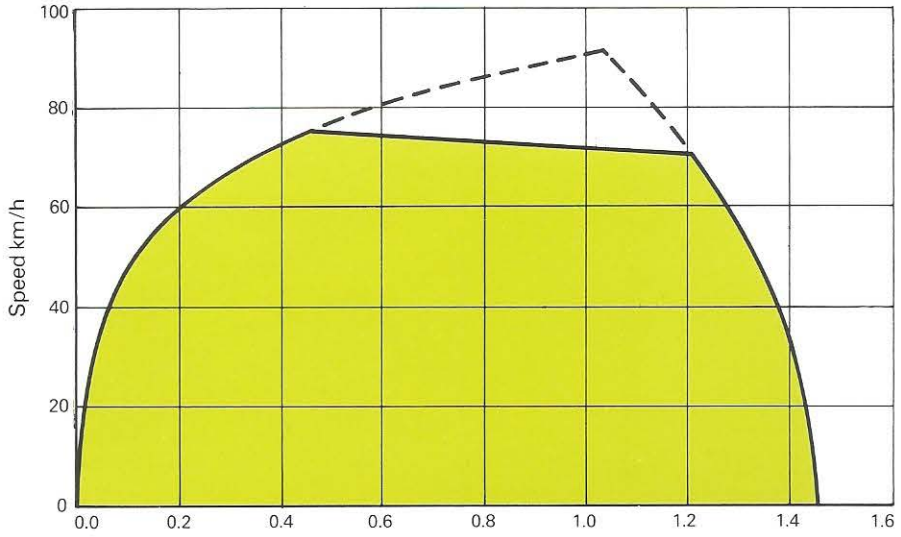
Power equipment for electric multiple unit trains

GEC
TRACTION

DATA

Nominal line voltage	1500V dc	
Maximum service speed	100 km/h	
Maximum gradient	4%	
Gauge	1.6 m	
Train weight – tare	65.3 tonne	per 2 cars
– crush laden	97.6 tonne	
Seated passengers	144 + 64 tip up seats	
Capacity when crush loaded	500	
Acceleration rate	.92 m/s^2	
Braking rate	.78 m/s^2	
Jerk limit	.9 m/s^3	
Traction motors type	G314 BY	
rating	130 kW continuous	
Motor-alternator type	G781	
output	11.5 kVA, 380V, 3 phase, 50 Hz	

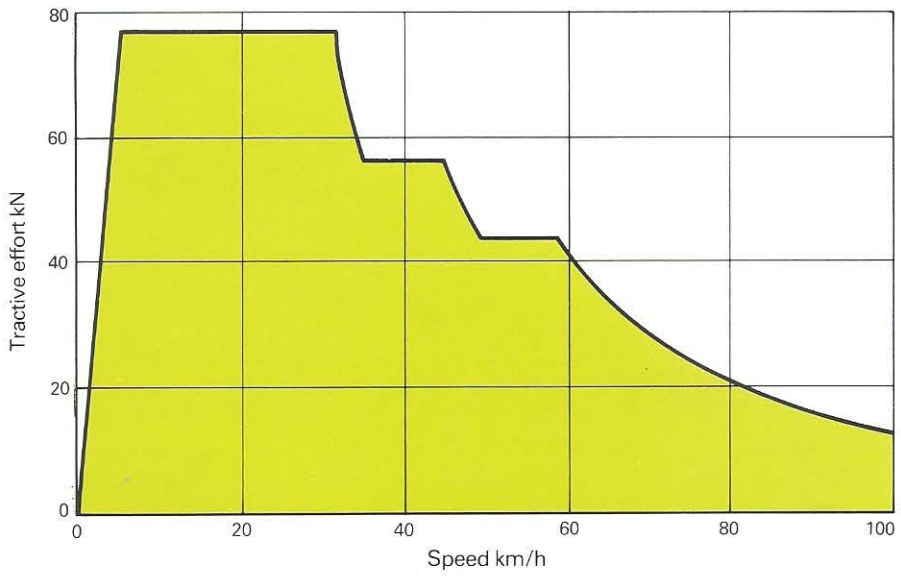
1 *Speed/distance performance for the Dublin equipment over the average station to station distance.*



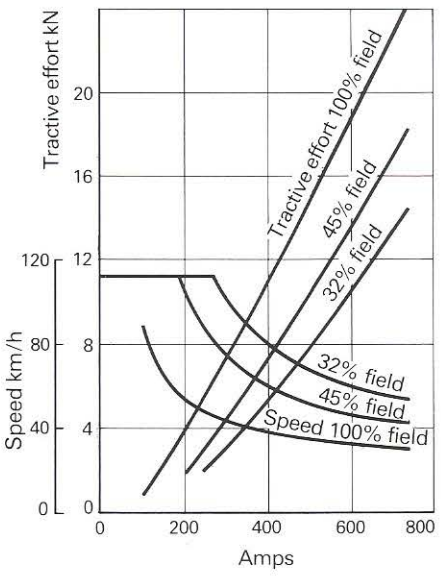
PERFORMANCE

The trains are scheduled to operate the 36 km route from Howth to Bray in 56 minutes including stops at 24 intermediate stations. The route has no severe gradients but there are several lengths where sharp curvature requires speed restrictions. Because of the relatively close station spacing the high-speed capability of the trains is rarely used although future system extensions will permit more sustained high speed running.
Performance during acceleration is limited both by the Customers' desire not to exceed 18% adhesion and by a line current limit (per 6 car train) of 2000 A.

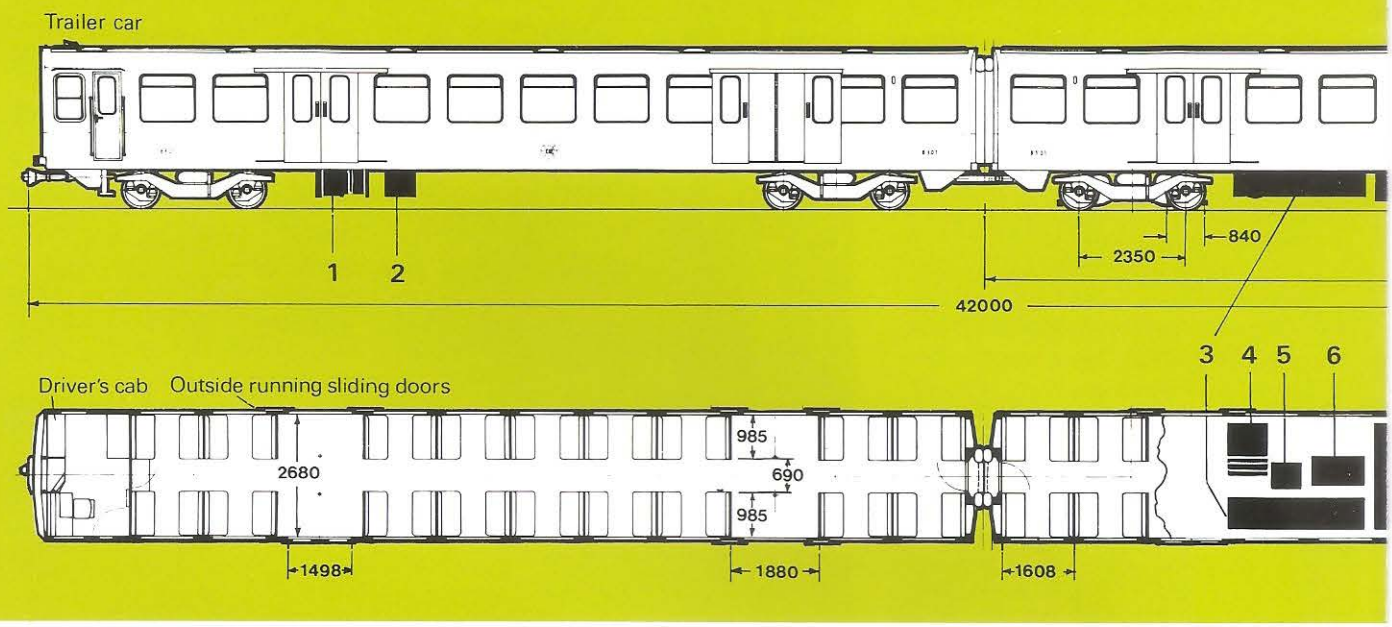
2 *Speed/tractive effort characteristic.*



3 *Characteristics of the traction motor G314.*



GENERAL ARRANGEMENT



BRAKING

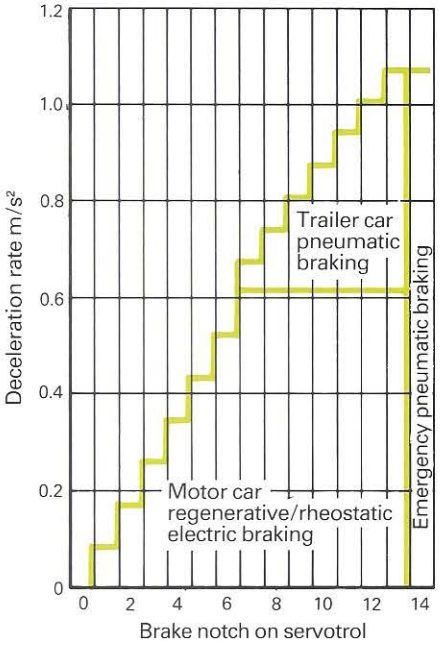
The requirements in braking were as follows:–

i) to maximise electric braking (to minimise wear on the mechanical brakes)
ii) to maximise regenerative braking (to minimise total energy consumption)
iii) to be compatible with ATO (when fitted)
iv) to have a fast response (but without exceeding the jerk limit)
v) of sufficient capacity to cope with 4% grades on future extensions.

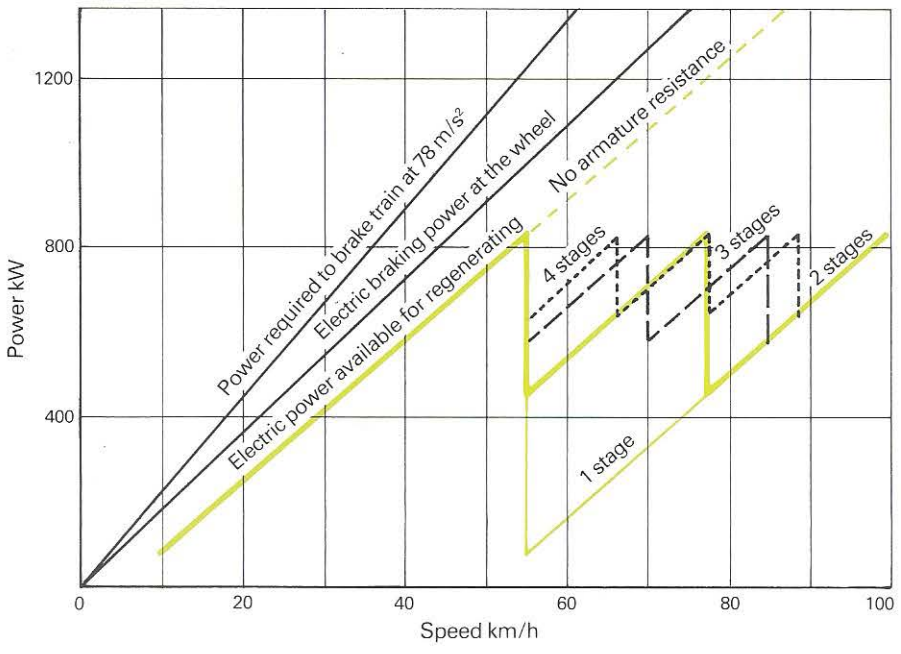
The first two requirements might appear to be similar but in fact they are contradictory. With regenarative braking the voltage across the traction motors is limited to the line voltage and thus at high speed the braking effort is limited. Alternatively full electric braking effort at high speed can be achieved by the use of a resistance in series with the armature (thus enabling the motor voltage to be increased above that of the line). In this case, however, energy is dissipated in the resistance and thus is lost as far as regeneration is concerned. The only way to achieve maximum electric braking with maximum regeneration is to have a relatively low retardation rate at high speed and this is rarely accepted by operators of high performance suburban (or transit) railways.

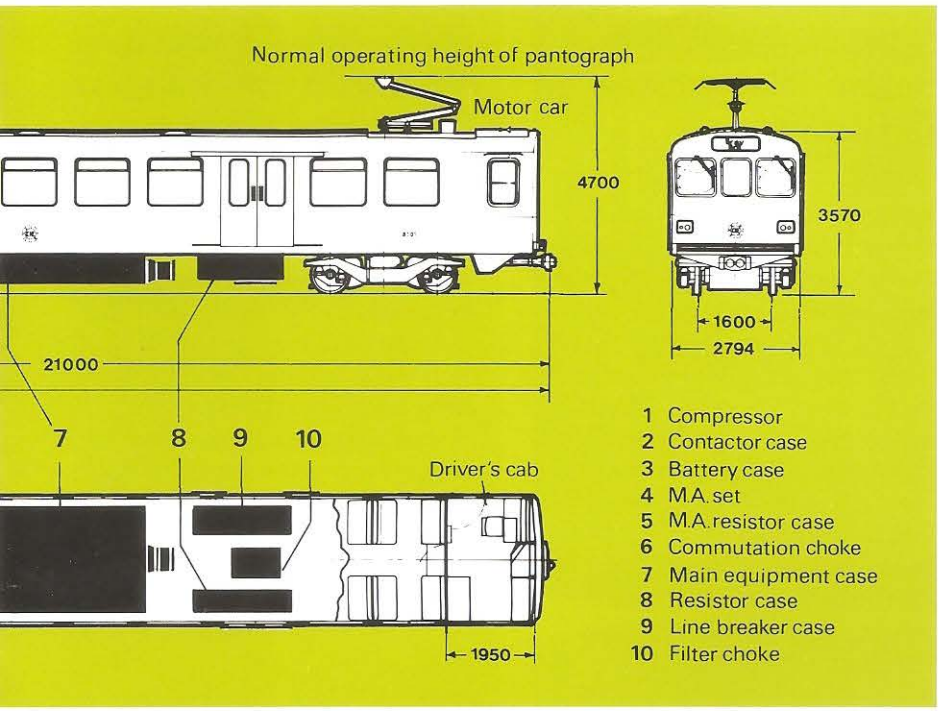
The compromise adopted for Dublin was to ensure that electric braking in the motor car always took preference over the mechanical brakes of the trailer. As much as possible of

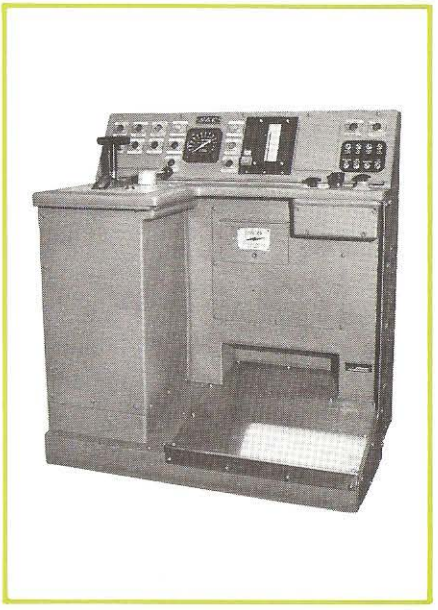
4 *Braking performance showing how the regenerative/rheostatic electric braking of the motor car always takes preference over the mechanical brake of the trailer. A total of 13 notches are available for automatic operation but when driven manually only notches 4, 7, 10 and 13 are used.*



5 *This curve shows how braking power varies with speed and also the effect of using armature resistance in braking. Two stages of armature resistance were chosen as the optimum but the curve also shows what the performance would have been with 1, 3 or 4 stages.*







7 *The prefabricated driver's desk fitted with all the essential instruments and controls.*

this electric braking effort was then offered for regeneration within the limits set by motor commutation and the line voltage. A study was undertaken to determine the optimum value (or values) of armature series resistance. The study showed that two equal "steps" were the ideal. If there had been more resistance "steps" then more energy would have been available for regeneration but the extra complexity would have had penalties in first cost, maintenance costs, weight and volume. The energy available for regeneration is some 30% of the total traction energy and rather less than 30% when other auxiliary loads are taken into account. With these proportions there is a very high chance of the line being receptive (ie being able to accept the energy offered to it) and this will be particularly important during the peak hour service at which time the maximum demand tariff is calculated.

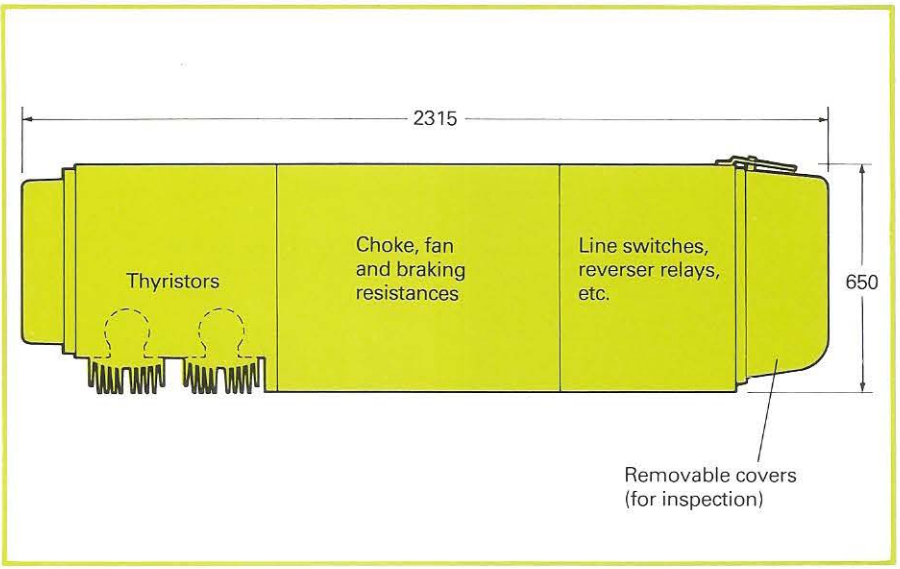
ATO

The brake equipment has 13 service brake notches plus emergency. During the initial "manual driving" phase, however, only 4 of these notches will be used.

PACKAGING
of the electrical equipment

Every effort has been made both to simplify installation of the electrical equipment and to provide for ease of maintenance in service.
The majority of the control equipment is fitted in a single case 3.5 m long and virtually the full width of the car. All the component parts in the package are pre-wired (and pre-piped) so there is the very minimum of electrical and pneumatic work on a final assembly. The equipment in the case is so arranged that items which are subject to routine, regular inspection are at the sides where they can be inspected from trackside in any running shed. Other items (such as the smoothing choke, braking resistances and their cooling fan) are in the centre of the case: they need less frequent attention such as at the longer intervals when the cars come on shed for mechanical maintenance.
The driver's desk has also been supplied pre-wired and pre-piped thus allowing the coach builder to avoid the usual problems of several specialists all wanting to be in the same small space at the same time.

6 *Cross section drawing of the equipment case which is some 3.5 m in length.*



Chopper controlled emu trains for Dublin

GEC Traction and Linke-Hofmann-Busche are jointly supplying 40 2-car multiple unit trains for the electrified suburban lines in Dublin. The railway is electrified at 1500V dc and the trains are equipped with chopper control designed to provide regenerative/rheostatic blended braking.
The first phase uses existing track along the coast from Bray (via Dun Laoghaire and Dublin city) to Howth. This section has no severe gradients (maximum 1%). Several new lines are envisaged, however, to inland suburbs and these will be joined to the existing line by new underground links below the central district. In places the gradients will be as steep as 4% and the equipment has been designed and rated with these duties in mind.
Initially the trains will be manually driven (using cab signalling) but they are designed to be compatible with ATO (automatic train operation) when that system is introduced.

Zerhackergesteuerte Elektro-Triebwagenzüge für Dublin

Die Firmen GEC Traction und Linke-Hofmann-Busche liefern gemeinsam 40 aus 2 Wagen bestehende Elektro-Triebwagenzüge für die elektrifizierten Vorortlinien in Dublin. Die Strecke ist mit 1500 V Gleichstrom elektrifiziert, und die Züge sind mit Zerhackersteuerung zur Rückstrom-/Strombremsung ausgerüstet.
In der ersten Phase wird eine bestehende Strecke an der Küste entlang von Bray (über Dun Laughaire und Dublin Stadt) nach Howth benutzt. Diese Strecke hat keine bedeutenden Steigungen (Höhststeigung 1%). Es sind jedoch mehrere neue Strecken zu Vororten im Binnenland geplant. Diese werden durch unterirdische Verbindungsstrecken unter der Stadtmitte an die bestehenden Strecken angeschlossen. An gewissen Stellen betragen die Steigungen bis zu 4%, und Züge und Leistungen wurden auf diese Einsätze ausgelegt.
Die Züge werden anfänglich von Fahrern bemannt (unter Verwendung von Führerstandssignalen), sind jedoch mit ATO (automatischem Zugbetrieb) verträglich, wenn das System eingeführt wird.

Trains emu à commande électronique pour Dublin

GEC Traction, en conjontion avec Linke-Hofmann-Busche, doit fournir 40 trains de 2 wagons à unités multiples pour le réseau suburbain électrifié de Dublin. Le réseau est électrifié à 1500V c.c. et les trains sont équipés de commandes électroniques destinées à offrir un freinage mixte rétroactif/rhéostatique.
La première phase utilise la voie existante qui longe la côte de Bray (par Dun Laughaire et la ville de Dublin) à Howth. Cette section ne présente pas de pentes prononcées (maximum 1%). Toutefois, on envisage plusieurs voies nouvelles vers la banlieue à l'intérieur des terres et celles-ci seront reliées aux voies existantes par des maillons souterrains en-dessous du district central. Par endroits, les pentes atteindront 4% et l'équipement a été conçu et réalisé en tenant compte de ces exigences.
Au départ, ces trains seront commandés manuellement (avec signalisation depuis le poste de conduite) mais leur conception les rend compatibles avec le système ATO (automatic train operation – commande automatique des trains) lorsque celui-ci sera introduit.

COMBINED TESTING

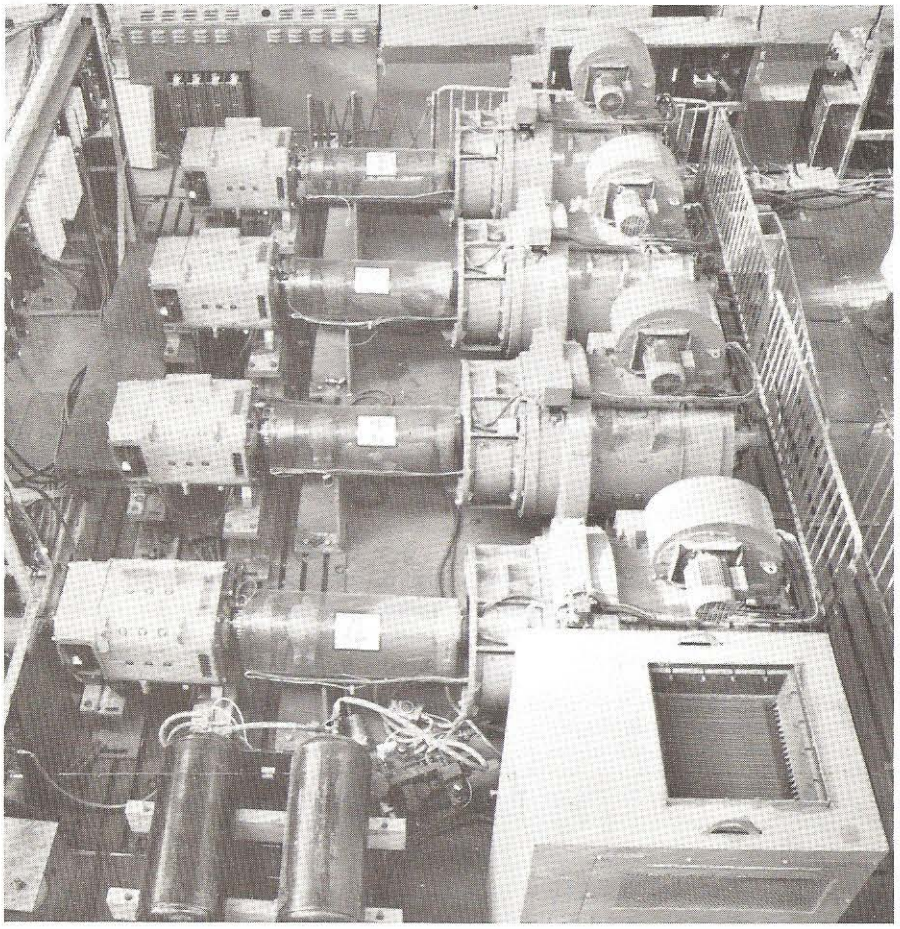
The complete electric propulsion equipment (together with auxiliary electric loads) was tested together on the combined test bed at Preston prior to despatch of the first set. Testing was carried out on full load and at full voltage.

The test-bed incorporates a simulator which can be programmed to:–

a) drive the equipment over any route profile which has been fed into it
b) vary the amount of coasting (or run all-out)
c) vary the load from tare to crush
d) vary station dwell time

Alternatively there is provision to drive the train manually, and there are additional special facilities such as simulating line transient conditions.

A VDU read-out gives continuously up-dated readings on such data as speed, distance, gradient, tractive (or braking) effort whilst waveforms can be studied on oscilloscopes. Data recording is by a 14 channel high-frequency tape recorder back-up by a 14 channel u/v recorder.



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