GEC

EXPRESS ELECTRIC TRAINS

British Rail Southern Region

Bournemouth Brighton Kent Coast Portsmouth

GEC Traction Limited

ENGLISH ELECTRIC | AEI

A 4 REP (Bournemouth tractor) unit propelling two 4 TC trailer units near Winchester.

(J.H. Cooper-Smith)

An express leaving London (Waterloo) for Portsmouth consisting of 4 BIG and 4 CIG units.

A class 74 electro-diesel locomotive at speed

Frontispiece

A Bournemouth express train with the tractor unit propelling.

BOURNEMOUTH ELECTRIFICATION

The electrification of British Rail's Southern Region line to Southampton and Bournemouth was completed in July 1967 involving third rail 750v dc electrification of some 136 km (85 miles) from Brookwood on the Southampton main line.

The journey time for the 173km (108 miles) express service from London (Waterloo) to Bournemouth was reduced to 100 minutes giving an average speed of 104 km/h (65 mile/h) inclusive of a station stop at Southampton. The line speed limit is at present restricted to 144 km/h (90 mile/h) but the rolling stock is geared for 160 km/h (100 mile/h) and in practice this latter speed is often achieved in service.

Push-pull operation

The electrification terminates at present at Bournemouth but express passenger services work through to Weymouth hauled by diesel locomotives. In order to minimise both operating costs and time the push-pull principle has been applied to trains in both the electric and diesel operated sections, trailer car sets being marshalled at the "country" end of the train and propelled from London. On arrival at Bournemouth the trailer coaches are detached from the tractor unit and one of the Southern Region's diesel-electric locomotives is attached to the head of the train to haul the front coaches to Weymouth. At Weymouth the diesel locomotive remains in the same position and is then used to propel the trailer coaches from Weymouth back to Bournemouth with the driver controlling the diesel locomotive from the leading cab of the trailer coach. To achieve this there is a push-button on each driving desk in the new units which initiates the starting cycle of the diesel engine of any diesel-electric locomotive connected to the unit. At Bournemouth, the coaches are coupled again to the electric tractor unit and the diesel locomotive detached. The express then proceeds to London with the tractor unit pulling the trailer coaches.

This was the first time that push-pull operation had been carried out on trains with a service speed of 144 km/h (90 mile/h) and extensive tests were carried out by the Southern Region engineers before this mode of operation was finally decided upon.

Original electric rolling stock

Power for the rolling stock for the express services was originally provided by 11 tractor units each with a nominal 1 hour rating of 3200 hp. These are designated type 4REP. These four-car units consist of two driving motor coaches, one at each end of the tractor unit, with a buffet car and a trailer car incorporating a guard's compartment, situated between.

In addition there were 28 four-car trailer units type 4TC and 3 three-car trailer units type 3TC. These are non-powered units but the end coaches have driving cabs so that any of the powered units coupled with the trailer units can be controlled from the leading cab of a trailer unit.

For the semi-fast services a total of 20 four-car units were introduced. These are designated type 4VEP and similar units are also in service between London - Portsmouth, and London - Brighton. Although they are described as semi-fast trains in fact they are geared for a maximum service speed of 160 km/h (100 mile/h) i.e. the same as the express units.

Additional rolling stock

Increased traffic necessitated the purchase of 4 further 4REP tractor units in 1974 and by that date the total number of semi-fast 4VEP units allocated to the Bournemouth service was 40.

Service experience with original rolling stock

By 1974 the power cars on the express tractor units alone had accumulated some 40 million km (25 million miles) in service, much of it running at the maximum line speed of 144 km/h (90 mile/h). The individual annual distances covered per power unit were some 250,000 km for the express units and 175,000 kms for the semi fast units.

Interrunning of rolling stock

A unique feature of the service is that all the various types of rolling stock can be coupled together and controlled from any driving position. This applies to electric, electro-diesel and diesel electric locomotives as well as electric and diesel electric express and suburban multiple unit power cars and trailers.

Original 4REP Units - Nos. 3001 - 3011

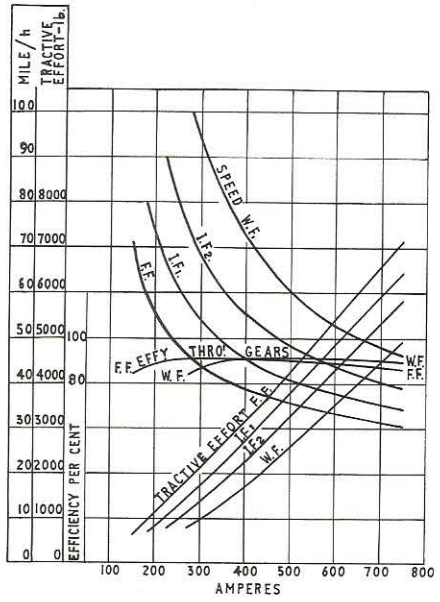
The 4REP tractor units which have a nominal rating of 3,200 hp, fulfil the Region's requirement of operating a 12-car train between London and Southampton in 70 minutes and to Bournemouth in 100 minutes. Each motor coach of the tractor unit has four GEC Traction Type EE546/B self-ventilated traction motors, arranged in permanent parallel pairs. Conventional series and parallel groupings are used with bridge transition, together with three stages of field weakening which utilise an inductive reactor across each field. Air/oil engine driven camshafts control the resistance and weak field notching, sixteen series and seven parallel notches being used.

Each motor bogie carries four radial arm current collector shoes, making a total of sixteen on the tractor unit. These are paralleled between the two motor coaches by two power bus lines running between them, In order to force current sharing by the shoes and prevent one shoe carrying the majority of the current, as may happen with ice on the conductor rail, the shoes and traction circuits are divided.

Traction Motors

The continuous rating of each type EE546/B traction motor is 385A, 675 V, and 320 hp at Class B temperature rise.

It is a four-pole series wound motor, suspended from the axle on roller bearings with cooling air drawn from underneath the coach by a fan on the armature shaft. The armature is insulated to Class H standard with the slot portion finally taped with glass tape treated with Epoxy Resin which gives excellent abrasion resistance. The coil overhangs are sealed completely against dust with self-bonding silicon Elastomer tape, and held in position at the pinion end with glass tape. The field coils are insulated with integrated mica, fully impregnated with Epoxy Resin and finally bonded to the pole pieces, thus eliminating relative movement. This construction gives a strong water-proofed coil with good heat transfer properties.



The commutator vee-ring is of Epoxy glass - resulting in improved mechanical stability of the commutator bars. Split rubber-topped brushes are used to give improved commutation and better riding of brushes on the commutator.

The traction motor field is diverted and not tapped, there being an inductive reactor in series with steps of resistances, all being connected in parallel across the field. Field weakening is achieved by progressively eliminating the steps of resistance. This method was chosen since it affords enhanced protection for the traction motors when gaps in the conductor rail are encountered while the traction motors are in weak field.

Control Gear

Although the tractor unit motor coach is the most powerful of its type in service on Southern Region, a large measure of standardisation with existing control equipment has been achieved. The contact elements on the resistance camshaft are the same as those used for weak field control on the 1600/600 hp electro-diesel locomotives whilst the weak field camshaft is similar to that employed on the 4VEP units for resistance notching. Both camshafts are driven by the air/oil engine used on all the Region's multiple unit stock since 1957. The starting resistances are of the edge wound strip type mounted on ceramic insulators and are naturally ventilated. All the power equipment is housed in under-car cases fabricated from sheet steel with reinforced glass-fibre covers. This system was standardised, since it enables one fitter to remove or replace any cover and since these are of insulating material affords protection against accidental shocks when covers are being removed in close proximity to the live third rail.

One interesting feature of this equipment is the use of a cable duct which is situated above the undercar cases and which contains inter-case wiring. This simplifies the wiring procedure when the coaches are being assembled since many conduits are eliminated.

Driver's Desk

In order to simplify further the coach builders' work GEC Traction supply a complete prefabricated driver's desk which houses all the necessary equipment and which has merely to be lowered into place and then connected to the coach air pipes and control cables. All the driving cabs in the new stock are identical and house all the necessary controls for the direct or remote operation of straight electric equipment or a diesel-electric locomotive. The knee-hole driver's desk is made in polyester reinforced glass fibre and incorporates all the driver's controls. It is air-piped and electrically wired with suitable unions for convenient connection after fixing the desk into the correct position in the cab ends. The cab floor was designed with a space of approximately four inches between the top and the bottom panelling to facilitate the passage of conduits and air pipes, around which glass fibre is packed to insulate the floor against cold and eliminate draughts. The driver's foot rest incorporates an electric heater, this being of the same type as is used for de-icing the leading edges of aeroplane wings. In addition, two other electric heaters are mounted on the back wall of the cab below the driver's seat. There is also an electric heater below the learner driver's seat on the offside of the cab end.

Braking Equipment

Electro-pneumatic and automatic air brake equipment is identical to that previously used in the Brighton replacement units (4BIG and 4CIG types) and is fully compatible with all existing vehicles. The latest three-position type of driver's brake controller has been fitted in which the same working sector of the handle is used to control either e.p. or automatic brake applications. When using the e.p. brake, the automatic brake is locked out of action by the magnet valve. Any loss of supply to the e.p. brake during braking causes the magnet valve to become de-energised; an automatic brake application of comparable value to the previous e.p. application is then made without any action by the driver. The brake controller is self-lapping in both e.p. and automatic brake modes of operation.

Control circuits are designed to operate at any voltage between 45 and 110V dc and so can accept control feeds from locomotives at 110V. or from multiple-units at 70V. All traction control is effected over 27-way control lines, whose functions have been standard since Southern Region's multiple unit stock of 1951.

Auxiliary Equipment

All H.T. and L.T. current distribution is carried out from the brake vehicle - this is the trailer coach incorporating the guard's compartment. The H.T. supply is taken from the power bus lines and fed through main auxiliary fuses, in an underframe-mounted box, to an auxiliary cupboard on the brake vehicle, forming a partition between the guard's position and the luggage compartment. This houses all the fuses for the Westinghouse DH25 compressor, GEC Traction type EE704/5H motor generator set and all the heating circuits. The motor generator set, mounted on the underframe, produces a 70V. dc output with a continuous rating of 10kW, which is used for control circuits, lighting and battery charging. The motor generator output and battery are protected by fuses, but all other L.T. circuits are safeguarded by miniature circuit breakers.

In the 4REP unit the power bus lines are fed directly from the shoe gear, but on a 4TC trailer unit they have to be supplied from a powered vehicle, irrespective of whether it is a locomotive or a 4REP unit, via the standard two-pole heating jumper mounted at headstock level.

The buffet cars in the tractor units have been converted from existing loco-hauled restaurant-buffet cars. All the catering equipment is electrically operated and supplied from a GEC Traction type EE753 motor generator set mounted on the underframe of the buffet car which gives a regulated 200V. dc output at a rating of 18kW.

The 4REP tractor units and the 4TC trailer units are almost identical with respect to the auxiliary equipment, since each unit comprises two outer driving vehicles plus a brake vehicle, which carries all the auxiliary supply equipment for the unit, together with another trailer.

In the event of a collision causing damage to one motor coach of the 4REP unit, it is possible to replace one of these motor coaches with a driving trailer from a 4TC unit, or, alternatively, the motor coach can be replaced by an electro-diesel locomotive, and since it has the same characteristics, leaves the performance of the 4REP unit unaffected.

Coach Heating

On these new units, there are two slightly different heating control systems, one being used for open saloons and the other for compartment stock.

The open saloons have a 500W. 675V. heater under each pair of seats giving a total heating load of 16kW per coach. The output of the heaters is varied inversely with ambient temperature by a control unit which has two probes containing temperature sensitive transistors. One probe measures ambient temperature and is located on the solebar of the coach whilst the other probe measures the temperature of a resistor. The control unit switches the heating contactor on and off to keep the saloon temperature between 65 and 70° F. This control system has the advantage that it compensates for variation in line volts, which, since heat output has a square law relation to line volts, has presented problems previously due to excessively high seat temperatures when the line voltage has been high.

The heaters themselves are the standard metal sheath type with the heating element located and insulated from the sheath by non-conducting powder. However, a new departure from previous stock is that the underside of the seats are now left open, the heaters being enclosed in a perforated aluminium case.

Individual control is provided in each compartment. An electronic temperature controller, which is adjustable by passengers from 45 to 86° F., switches a relay-operated vacuum switch which feeds two 500W heaters mounted under the seats.

Hot water for the hand basins in the lavatories is provided by an electrically-heated tank mounted in the lavatory partition. The water temperature is maintained at 140° F by a thermostatically-operated vacuum switch controlling the 1.5kW element in the water.

Coach Lighting

All the lighting on the units is incandescent and uses 40W lamps - these being arranged to give an average lighting intensity of eight lumens per square foot at reading level. All the lamps are fed at 70V. dc from the EE704/5H motor generator set and if there is no H.T. supply present to run the set, as in the case of the units being in sheds for cleaning, the battery will give half lights down to the safe discharge voltage of the battery (at which point a relay switches off the load).

New REP Units . Nos 3012 - 3015

These new units, introduced in 1974 are operationally interchangeable with the original units but incorporate detail changes and improvements which have been developed during the intervening seven years.

Original 4VEP Units - Nos 7701 - 20

The 4VEP units for the semi-fast stopping duties are different from the 4REP tractor units in that only one motor coach is included in the four-car unit. The 4VEP unit comprises two driving trailers situated at the outer ends of the unit with a motor coach and a brake vehicle - housing all the H.T. and L.T. auxiliary supplies - located between the driving trailers.

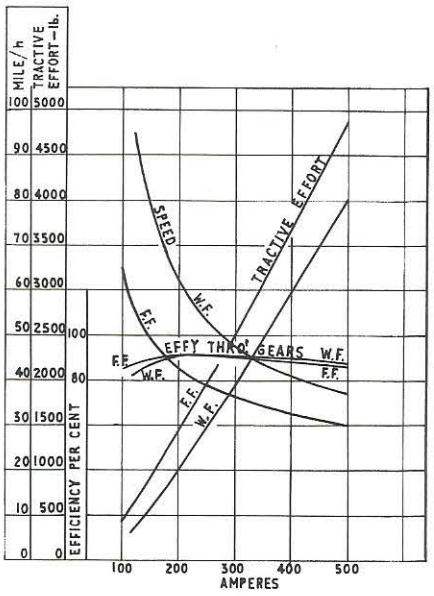
The motor coach has all four axles driven by 260 hp (1 hr. rating) GEC Traction type EE507/16F. traction motors which gives the unit a balancing speed of 115 km/h (72 mile/h). However, it is possible for both 4REP and 4VEP units to be included in the same train make-up, so the 4VEP units are geared for running at 160 km/h (100 mile/h).

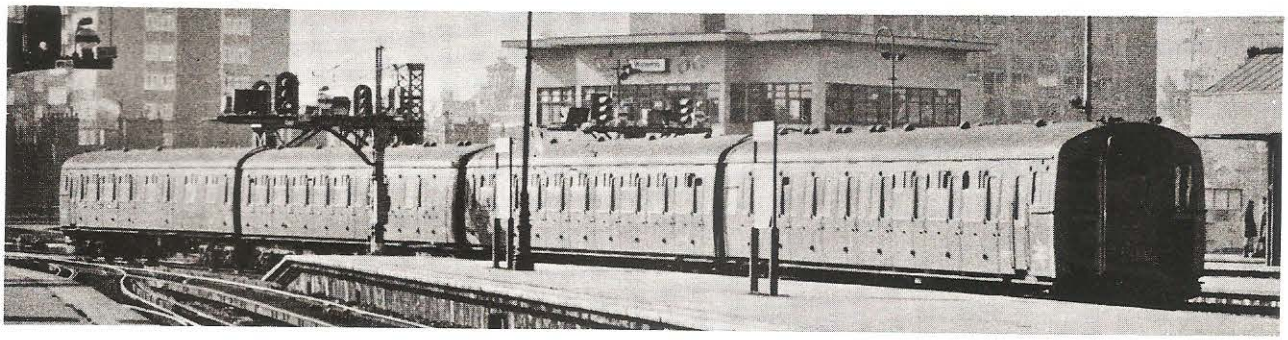
The continuous rating of the type EE507/16F traction motor is 280A, 675V and 235 hp at class B temperature rise. The general construction of the machine is similar to that of the EE546/B traction motor described earlier.

Switching of the main starting resistance is effected by the standard air/oil engine driven camshaft used previously on two-motor equipments. In order not to overload the contacts of this camshaft with the continuous duty of a four-motor equipment, a separate group switch has been added in which are included the contacts which have to carry current continuously, that is in full series or, in full parallel running.

The power equipment is, in fact, identical to that previously used on the 1963-type Brighton stock - the 4BIGs and 4CIGs - while the major differences in the control apparatus have been to eliminate the remote-controlled electrically-operated hand brake previously used and to incorporate the new pre-fabricated driver's desk.

A standard EE704/5H motor generator set is included, mounted under the brake vehicle, which provides the usual 70V. dc for control and lighting etc. Both the heating and lighting systems employed are identical to those previously described for the 4REP units.





New VEP Units

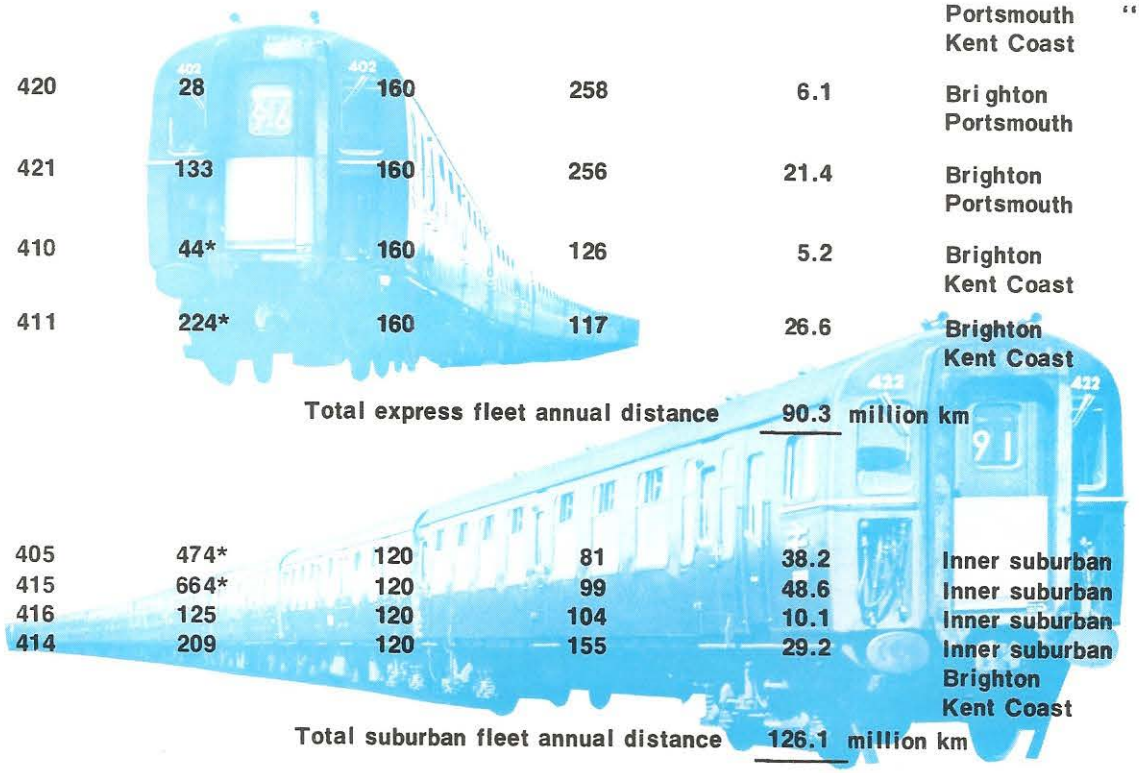
Since the original Bournemouth 4VEP units were ordered the fleet size has been increased to 194 (when current orders are completed) and these units are in service in all areas of the Southern Region.

SOME EXPERIENCE

Multiple unit and other vehicles supplied or equipped by GEC Traction and currently in Service on British Rail Southern Region.

They follow a tradition established with the first order in 1898 and continued since

Type	Class	No. of power cars in service	Maximum design speed km/h	Typical annual distance each power car km x thousand	Total Fleet annual distance (1973) km x million	Where used
Electric Express & Semifast						
4 REP	430	22 (plus 8 on order)	160	244	5.6	Bournemouth tractor unit
8 VAB	480	3	160	244	8	Bournemouth
4 VEP	423	165 (+ 30 on order)	160	179	24.6	Brighton Express Bournemouth semi fast Portsmouth " " Kent Coast
4 BIG	420	28	160	258	6.1	Brighton Portsmouth
4 CIG	421	133	160	256	21.4	Brighton Portsmouth
4 BEP	410	44*	160	126	5.2	Brighton Kent Coast
4 CEP	411	224*	160	117	26.6	Brighton Kent Coast
				Total express fleet annual distance	90.3	million km
Electric Surburban						
4 SUB	405	474*	120	81	38.2	Inner suburban
4 EPB	415	664*	120	99	48.6	Inner suburban
2 EPB	416	125	120	104	10.1	Inner suburban
2 HAP	414	209	120	155	29.2	Inner suburban Brighton Kent Coast
				Total suburban fleet annual distance	126.1	million km
Electric Baggage cars						
MLV	419	10	120	80	.8	Kent Coast
Diesel Electric multiple units						
6S 6L & 6B	60	40	120	130	10.4	Hastings
3D 3R 3H 2H	65	58	120	144	8.3	Hampshire Berkshire
				Total fleet annual distance	235.9	million km



Plus 14 Electric Locomotives
Plus 59 Electro-diesel Locomotives

* Two power units per train

GEC Traction Limited

Trafford Park Manchester M17 1PR England
Telephone 061-872 2431 Telex 667152 Telegrams Assocelect Manchester Telex