
Tomorrow's train,
today.

InterCityAPT

Inter-City APT marks the biggest single advance in improved train performance achieved by any railway in the world.

APT offers:

Ability to traverse curves at speeds 20% to 40% higher than conventional trains.

Journey times reduced by 20% or more on existing tracks.

Energy consumption at 125 mile/h (200 Km/h) little more than a conventional electric train at 100 mile/h (160 Km/h), and less than a High Speed Train at full speed.

Operating costs per seat-mile similar to conventional trains.

Improved productivity through higher utilisation of trains and associated manpower.

Faster trains-commercial rewards

The Advanced Passenger Train (APT) has been developed in direct response to the need for reduced journey times achieved by high average speeds.

Market research and analysis in Britain, and many other countries, has shown conclusively that the most important factor in attracting passengers to rail travel is shorter journey time.

One solution is to build new railways designed throughout for high speed. But this can be excessively costly.

Or the existing railway can be used by trains which are designed and built to run at higher speeds without significant alteration to the basic railway infrastructure.

This latter – and radical – solution is the one which has been adopted by British Rail.

Since the late 1950's, British Rail has been following a long-term strategy to develop and improve Inter-City passenger services with higher speeds bringing reduced journey times.

The first stage was the introduction of 100 mile/h (160Km/h) high power electric and diesel locomotives during the 1960's. These enabled average speeds between cities to be increased to 70/80 mile/h (112/128Km/h), resulting in a considerable increase in passenger journeys.

Electrification of the routes from London to Liverpool and Manchester was completed in 1966/7 and provided a major improvement in speed and, thus, shorter journey times. Within four years passenger travel had doubled and British Rail entered the 1970's with plans to build on this success.

The aim was two-fold: in the short-term to meet head-on the increasing competition from Britain's growing motorway network and – on some routes – from domestic airlines. And, in the long-term, to win more and more new traffic.

Experience of the 100 mile/h (160Km/h) first-generation electric and diesel Inter-City trains indicated scope to adapt and improve existing railway technology to raise maximum speed from 100 to 125 mile/h (160 to 200Km/h) and average start-to-stop speeds from 70/80 mile/h (112/128Km/h) to 95/100 mile/h (152/160Km/h). Little alteration to existing tracks would be needed provided that the routes were relatively straight and had few severe curves.

But many principal Inter-City routes have curved track on which High Speed Trains cannot achieve their full potential. Therefore, while the High Speed Trains were developed during the 1970's from conventional railway technology, parallel development continued on a new design of train to overcome the limitations imposed on conventional trains running on sinuous routes. This is the Advanced Passenger Train.

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1. Stage I. Electrification, class 87 locomotive.
2. Stage II. Inter-City 125, high speed train (HST).
3. Stage III. Inter-City APT, electric advanced passenger train (APT).

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1. APT's smooth exterior.
2. APT in Cumbria.
3. APT nose profile.
4. Articulated (shared bogie) coaches.

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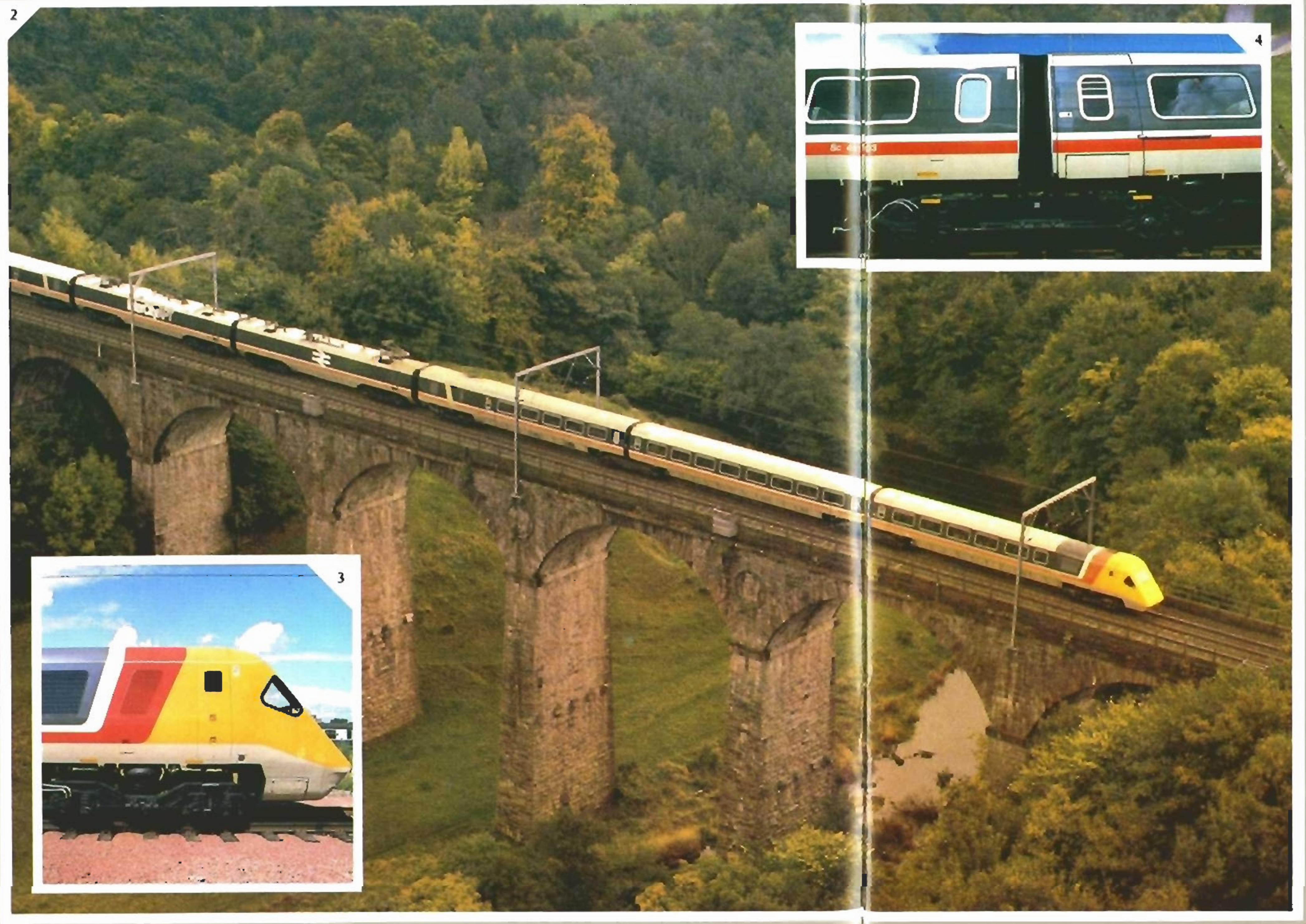

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APT-the objectives

Principal aim of the Advanced Passenger Train project has been to evolve a new design of train which enables higher speeds to be achieved on all existing tracks at an operating cost similar to slower, conventional trains.

This objective was seen by British Rail as the best solution to customers' requirements for shorter journey times because it enabled the existing system to be exploited and its productivity to be improved.

British Rail's decision was a bold one as other countries which sought significant increases in train speeds opted for the more-costly construction of new routes.

But development of a train which could operate on existing tracks meant that costs would be minimised – the capital investment being concentrated in the train itself – while the timescale for introducing faster services would be shortened.

As the new train was to use existing tracks, it also had to be capable of travelling round curves at higher speeds than conventional vehicles.

The most important factor governing average speeds of conventional trains is speed restrictions on curves, to maintain passenger comfort. Approximately 50 per cent of British Rail's major routes is on curves, and of these about half are relatively sharp.

APT allows shorter journey times to be achieved because it can take curves 20 to 40 per cent faster than conventional trains, while ensuring passenger comfort by tilting the coach bodies inwards by up to nine degrees.

Also included in the tough objectives set for APT were energy efficiency, low environmental impact, acceptable maintenance costs, and a total cost per seat-mile similar to conventional trains.

APT – the achievement

Efficient use of energy has been attained by lightweight construction, by a substantial reduction in aerodynamic drag through careful attention to streamlining of the train's nose and tail profiles, and by achieving overall smoothness of the external surface.

An APT at 125 mile/h (200 Km/h) uses only as much energy as a conventional train of equivalent passenger capacity travelling at 100 mile/h (160 Km/h). And in its electrically-powered form, APT uses less energy at 125 mile/h (200 Km/h) than a diesel-powered High Speed Train at the same speed.

Train weight has been minimised by using aluminium alloy and the use of articulation, with adjacent vehicles sharing a common bogie. This reduces the power needed to move APT. It also reduces costs and means less noise outside the train.

In order to travel round curves at higher speeds, APT has an entirely new suspension design which combines stable running and good ride quality in the train with low track wear – even at APT's designed maximum speed of 155 mile/h (250 Km/h).

Theory into practice

Inter-City APT started in 1967 as an integral part of fundamental research into the dynamic effect of trains running on steel rails.

This important project was conceived by British Rail's Research Division in Derby, and included interaction between wheel and rail, the effects of trains on the track and its foundations, the behaviour of vehicle bogies round curves, the suspension of vehicles, construction methods and electric current collection from overhead cables.

All this work pointed to the scope for building an Advanced Passenger Train and an extensive research and development programme was agreed with the Ministry of Transport which funded £6.2m of the £16m cost of APT development, between 1969 and 1976.

The programme culminated in the construction of an experimental gas turbine-powered APT – APT-E – but also included testing aluminium alloy vehicle shells; scale-model aerodynamic tests of train profiles at the Army's ballistic test facility at Pendine, in Wales; construction of vehicles to test the proposed mechanism to tilt passenger vehicles on curves; and provision of a test track.

Exhaustive safety checks were carried out, including operating APT-E with the passenger vehicles tilted nine degrees in the wrong direction. And, to prove the theory that APT would retain a very large overspeeding margin round curves before leaving the rails, a practical demonstration was carried out using a scrap vehicle on severely curved track near Dover.

After trials on a specially-constructed test track, at Old Dalby, near Nottingham, APT-E was tested on two of British Rail's principal routes. Between Swindon and Reading it attained a British speed record of 152 mile/h (243 Km/h) (subsequently beaten by an electric APT prototype train in December, 1979, which attained 160 mile/h (256 Km/h).

More importantly, however, from a commercial viewpoint, the train was tested between London and Leicester – one of Britain's most severely-curved main lines – and completed the 99 mile (158 Km) journey in only 58½ minutes, compared with a timing of not less than 80 minutes with conventional trains. This proved the dramatic reduction in journey time possible with an APT due to its higher curving speeds.

APT-E – which also gained the MacRobert Award for Design – was presented to the National Railway Museum at York at the end of its trial programme in 1976. But by then the project had already moved into its next stage: the design and construction of three pre-production prototype trains, electrically powered, to operate in passenger service.


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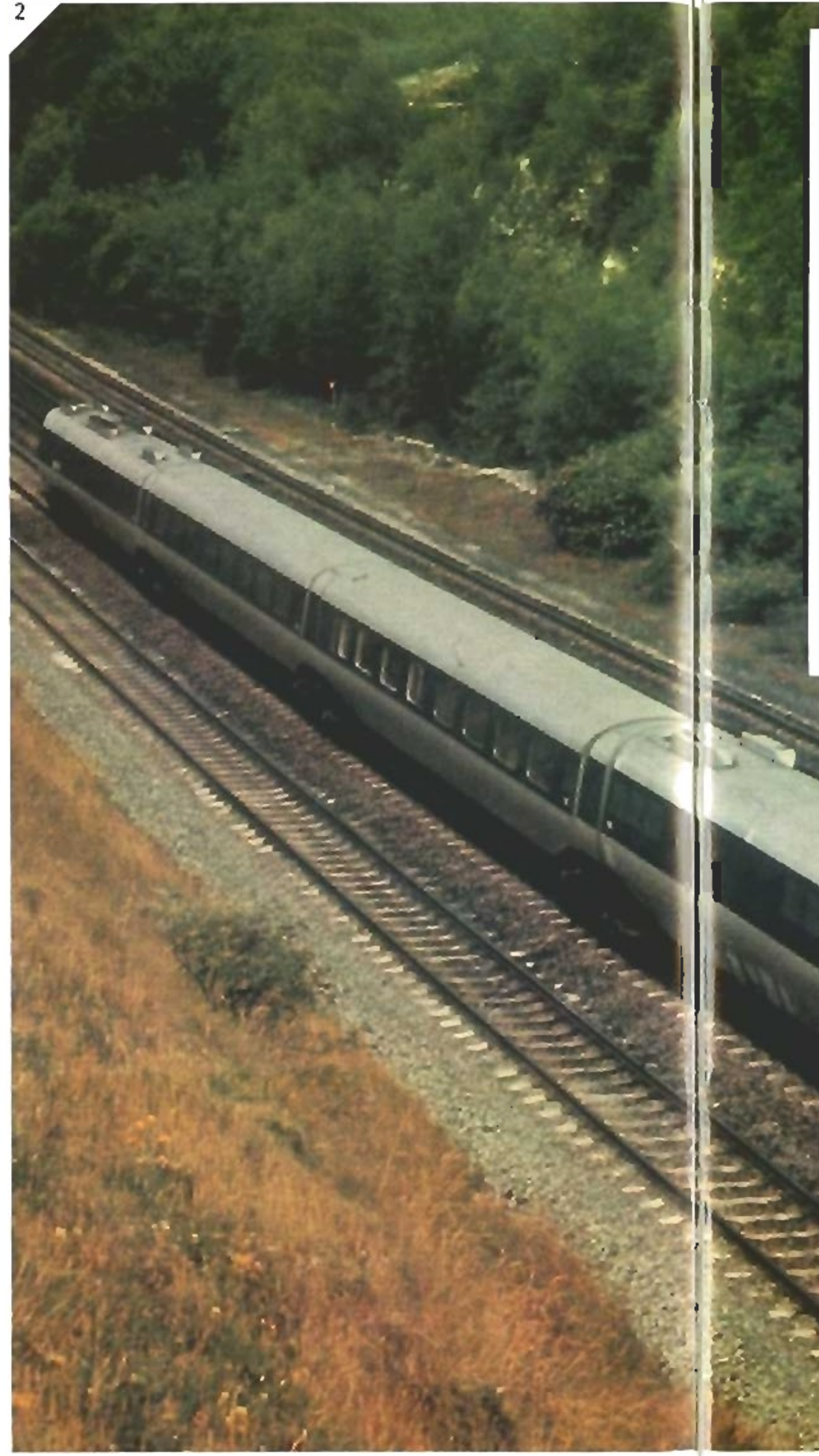
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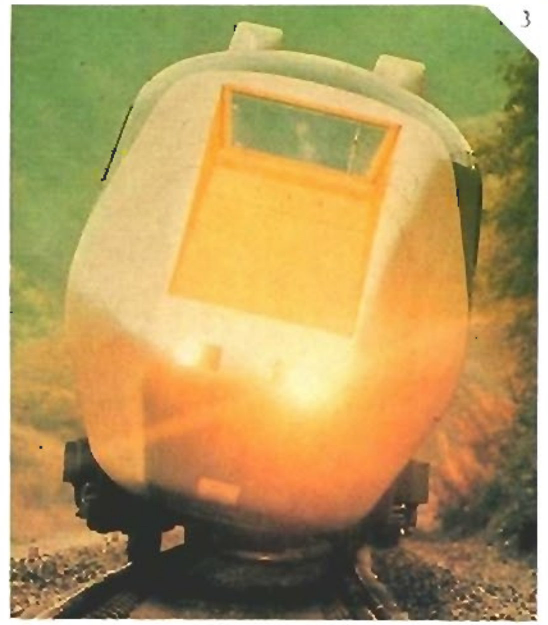
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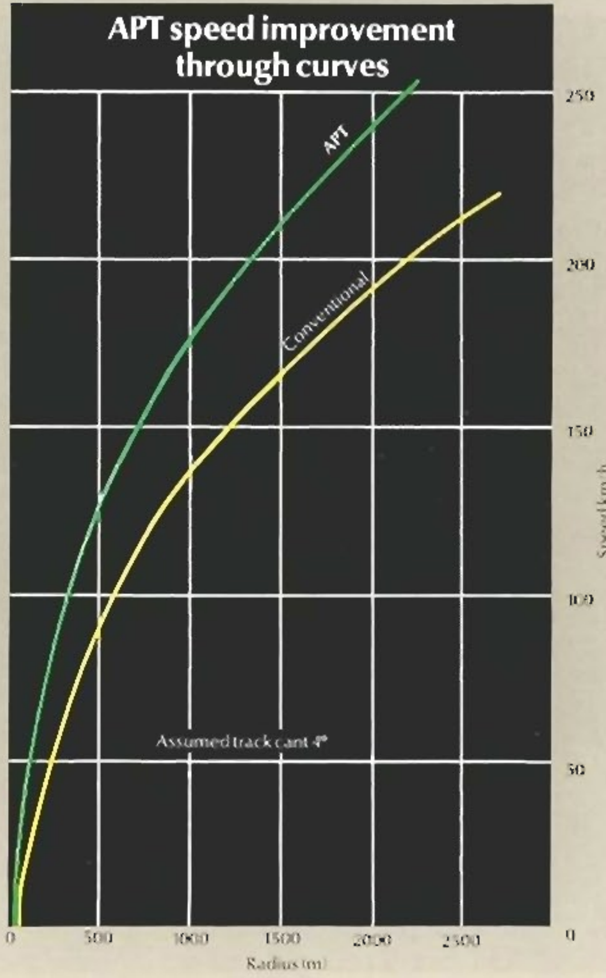
1. Aerodynamic testing at Pendine.
2. Experimental APT-E during testing on the Western Region.
3. APT-E tilt testing at Old Dalby.
4. Proof Load testing an aluminium alloy coach shell at Derby.
5. Derby's Advanced Projects laboratory.

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Building APT

The title Advanced Passenger Train was no accident, for the basic concept throughout the project has been the use of advanced technology to achieve higher speeds on all routes.

Not only has the project required the designers to incorporate and develop new technological techniques in the train itself, but it has required advanced methods and systems to be used in all its associated aspects, including the manufacturing stage.

Development of APT, from the early theoretical stages right through to construction of three pre-production prototypes has been centred on the city of Derby and, in recognition of this, one of two 4,000 horse power (3 megawatt) electric power cars for the first passenger-carrying APT has been named after the city.

Following the experimental development stage by the Research Division, the design of trains for passenger service was undertaken by British Rail's Chief Mechanical and Electrical Engineer's department at Derby, working closely with British Rail Engineering Limited.

BREL provides train manufacturing facilities and its workshops in Derby were developed to handle APT's advanced design, particularly in the construction of passenger vehicles using automatic aluminium welding techniques.


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1. Central Design Office, Railway Technical Centre, Derby.
2. Welding an aluminium roof assembly, BREL workshops.
3. Aluminium passenger coach construction.
4. Detail welding inside an aluminium coach shell.
5. APT's steel power car shell being lowered onto its bogies.


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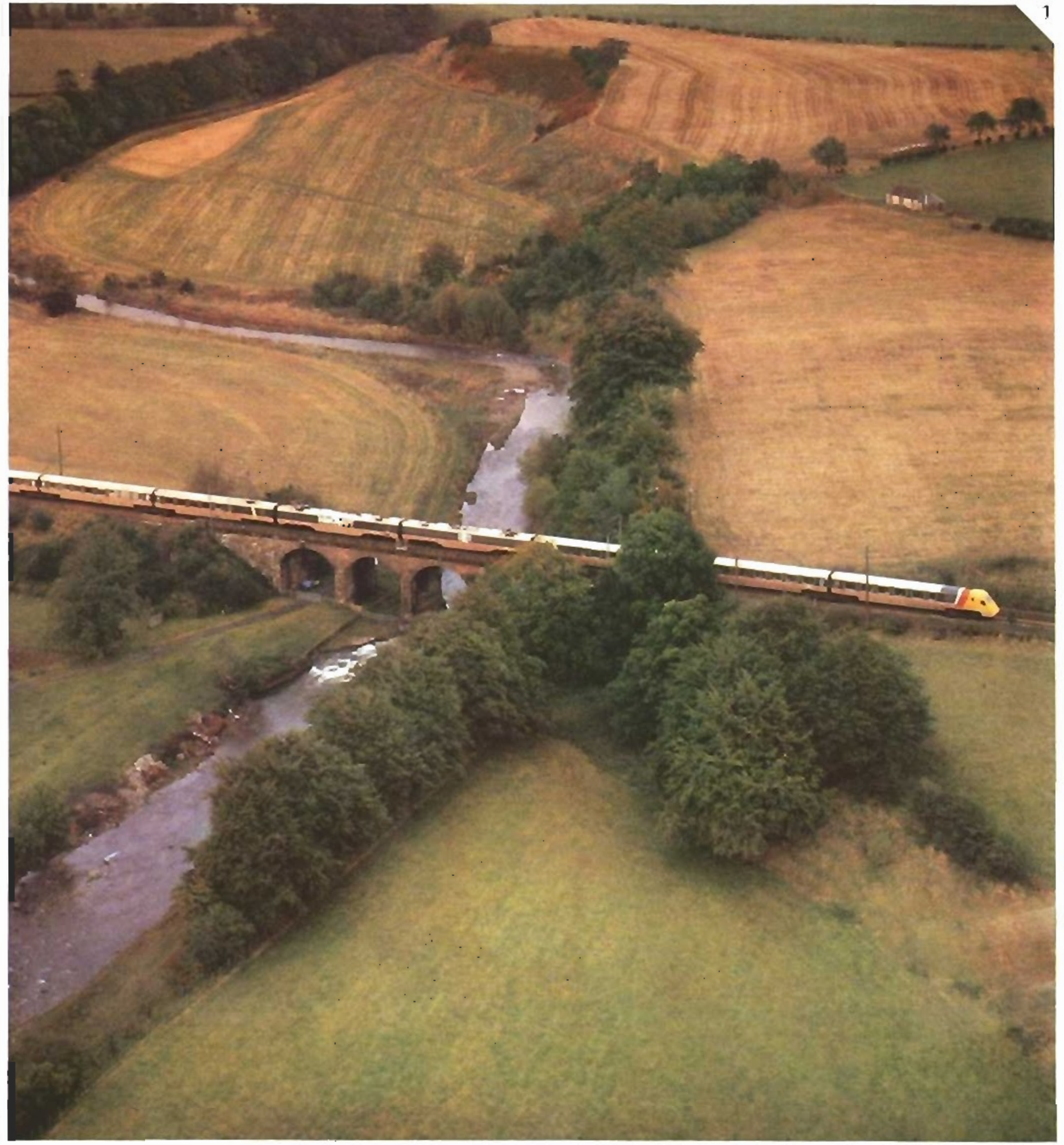
APT into service



Pre-production APTs

Experience gained from the APT-E train enabled British Rail to prepare plans for a transition to large-scale APT operation during the 1980's.

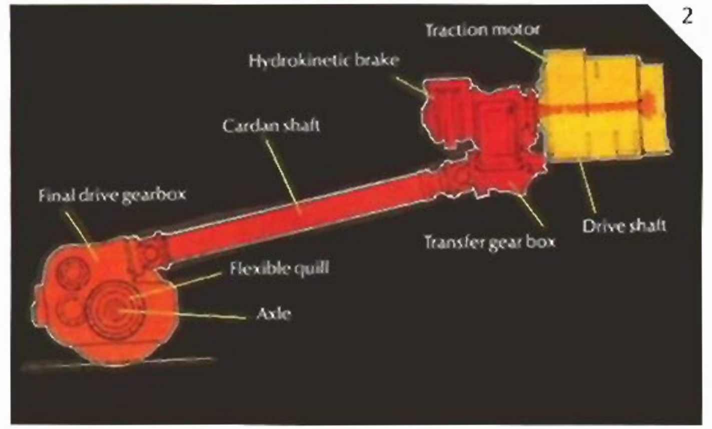
The next step was the decision to build a limited number of electrically-powered trains which would be used in passenger service. These would provide experience, of construction and operating techniques, on which quantity production of an APT fleet could be based.

Electric APTs – which offer the best combination of speed, cost and energy efficiency – can be formed in two versions. One, with 11 passenger vehicles and one power car, is capable of a maximum speed of 125 mile/h (200 Km/h). The other, with 12 passenger vehicles and two power cars, has a top speed of 155 mile/h (250 Km/h), and this configuration has been adopted for three pre-production trains.

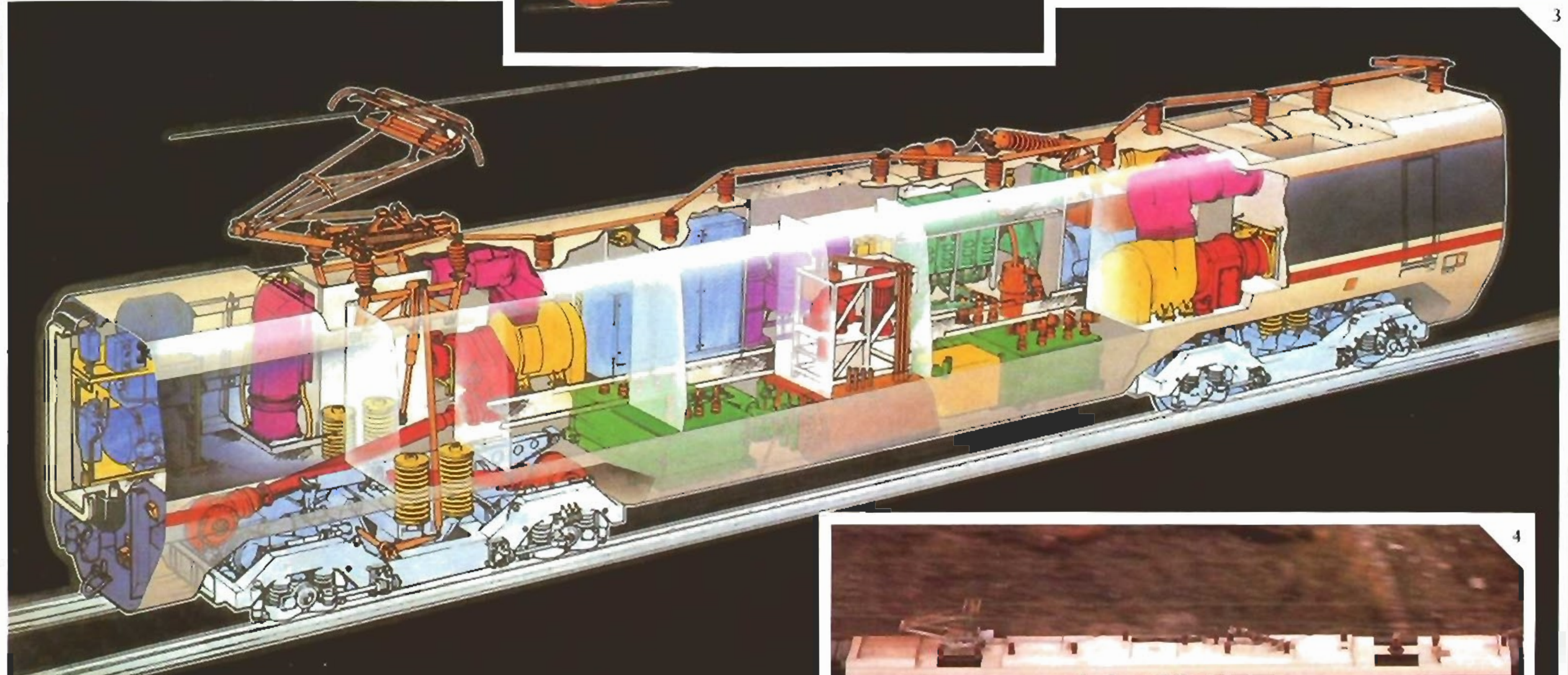
Power car

Each power car, using lightweight steel construction and thyristor-controlled electrical equipment, develops a power of three megawatts (3 Mw = 4000 horse power) at the rails, driving four axles. To reduce the impact and wear on the track, electric traction motors are mounted inside the body of the power car with cardan shafts driving lightweight gear-boxes to complete the final drive to each axle.

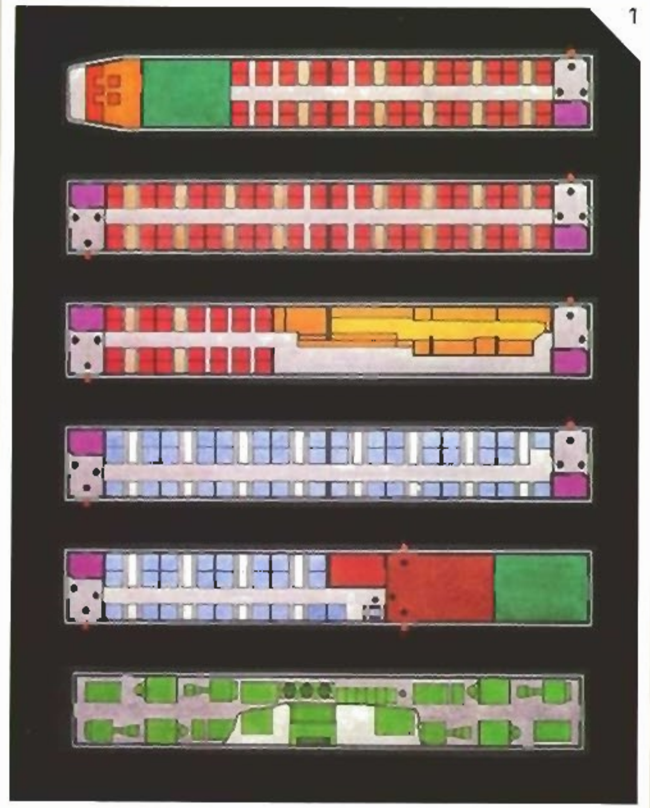
The power cars tilt round curves in the same way as passenger vehicles, but a tilt-compensation device allows the pantograph, which collects electric current, to continue to maintain adequate contact with the overhead wire.



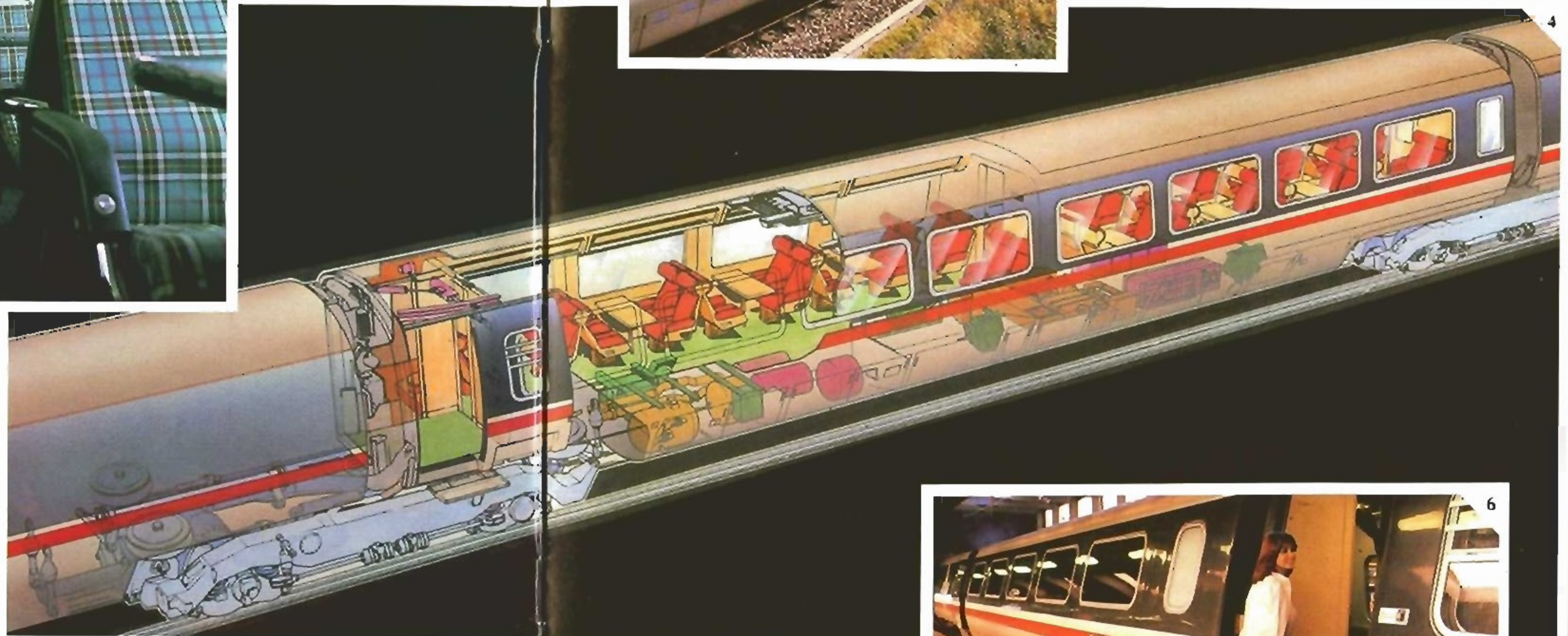
1. APT south of Beattock, Scotland.
2. Transmission diagram, power car.
3. APT Power Car – equipment layout.
4. Power Car.



1. Interior Layout of coaches.
2. First class accommodation.
3. Interior second class coach.
4. Intermediate trailer car.
5. APT passenger coaches.
6. Passenger access door.



Colour codes
- 2nd class
- 1st class
- Travellers-Fare
- Power equipment



APT into service

Passenger vehicles

The passenger vehicles, including first and second class accommodation and restaurant and buffet facilities, are grouped together, six either side of the two power cars.

This configuration, with centrally-positioned power cars, has been adopted to ensure satisfactory collection of electric current with two power cars.

Each group of six passenger vehicles is entirely self contained and communication through the power cars' corridors is allowed only in emergency and when escorted by a member of staff.

Passenger facilities

The internal environment of APT has been planned and designed to the highest standards and follows the trends already set in the popular High Speed Trains.

To save energy, the passenger vehicles are built from aluminium alloy, which gives a 40 per cent weight saving over conventional steel coaches and its stiffness helps to ensure a good ride quality at high speeds.

Doors into and out of the train are of the power-operated sliding-plug type, with retractable steps. Each passenger vehicle has two doors positioned diagonally, so saving vehicle length and weight.

Each second class coach seats 72 passengers, and 47 seats are provided in the first class saloons.

Seats are attractively trimmed in red or blue tartan upholstery and all internal fittings, including seats, luggage racks and trim panels, are modular and easy to replace.

APT into service

Catering facilities

The configuration of the prototype trains and the reduced journey times which will be achieved with APTs have led to a new approach to catering arrangements.

The popular range of food, freshly cooked on board, and snacks and drinks available on Inter-City services is continued on APT. Each six-coach section of the pre-production train has a catering vehicle with buffet-bar and kitchen.

Train staff

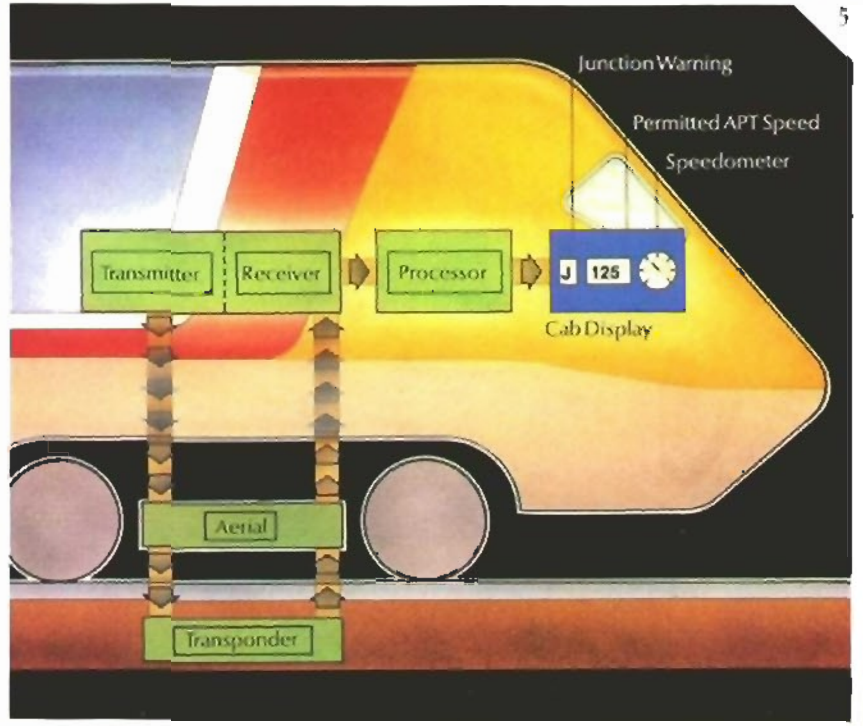
The high-quality environment for passengers is carried through to the accommodation for the train's staff, and incorporates the latest aids.

Drivers of APTs control the trains with the help of a simple electronic information system which advises them continuously of the maximum permissible speed at any point on the route. This consists of an on-train system which interrogates transponders fixed on the track every kilometre. These transponders have speed limit information encoded within them which is viewed on a digital display unit mounted on the driver's control panel.

Easy maintenance

Air-conditioning equipment, tilt control mechanisms and the brake control units are installed beneath the floor of each coach in removable packs so they can be easily withdrawn for repair or replacement.

1. Travellers-Fare bar area.
2. Removable equipment packs.
3. APT cab showing C-APT display and train controls.
4. Transponder mounted on adjacent sleepers.
5. C-APT diagram showing how speed limit information is transmitted to driving cab.



APT into service

Passenger facilities (contd.)

All the vehicles are fully air-conditioned and also incorporate devices which seal the system when entering a tunnel to protect passengers from sudden changes in pressure which can cause unpleasant "ear popping."

The air-conditioning has been specially designed to have a low energy consumption.

APTs are also fitted with chemical toilets.

Vehicle tilting

Passenger comfort is maintained when the train is running round curves at high speed by tilting each vehicle by up to nine degrees inwards.

Each vehicle is tilted individually by hydraulic jacks controlled by spirit level sensors. These transmit information to be processed electronically and ensure precise reaction to the characteristics of each bend.

Braking

British Rail's decision to develop a train capable of higher speeds on existing tracks has required the development of a braking system which enables an APT to stop within the distances between existing signals.

With a designed maximum speed of 155 mile/h (250 Km/h) and the need to stop in the same distance as a conventional 100 mile/h (160 Km/h) train, a hydrokinetic (water turbine) braking system has been developed by British Rail.

Hydrokinetic brakes are built into the trains' axles and incorporate a rotor and a stator, between which water is forced when the brake control is applied.

This provides a very effective brake. The high retarding forces generated make the water hot and radiators are provided to cool the water after brake applications.

The hydrokinetic brake has the advantage of simplicity, ability to handle high levels of braking power and energy dissipation, and adds little weight to the axle.

At low speeds, friction brakes on the wheels supplement the hydrokinetic brakes.

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1. APT curving at high speed.
2. Vehicle tilt suspension diagram.
3. Components of the hydrokinetic brake, with a non-powered wheelset.
4. Water flow between rotor and stator during braking.

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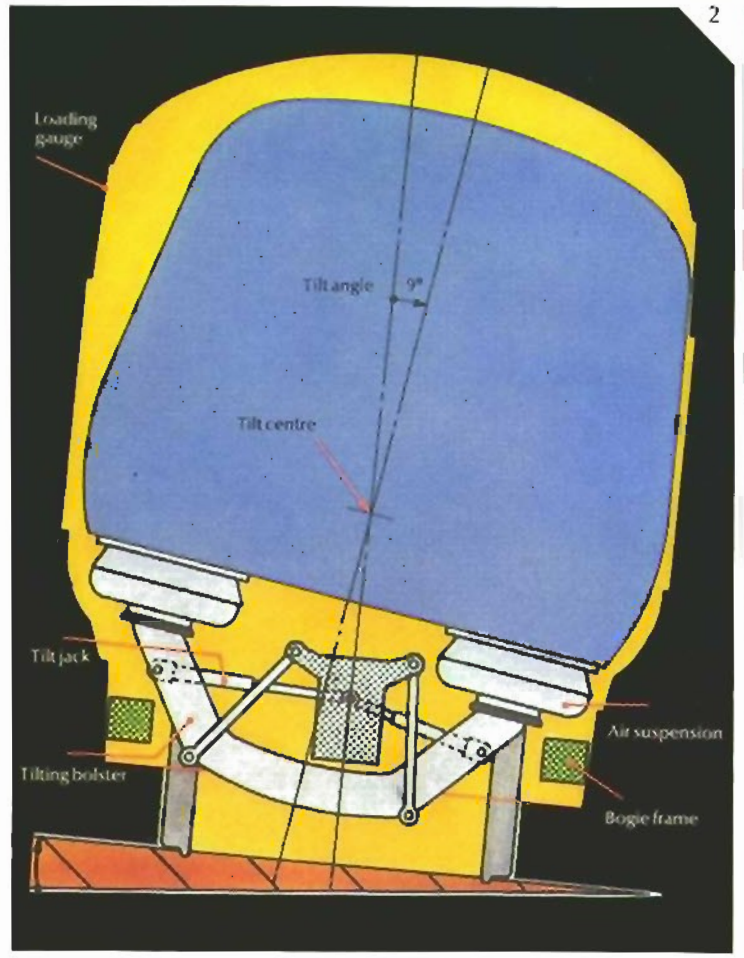

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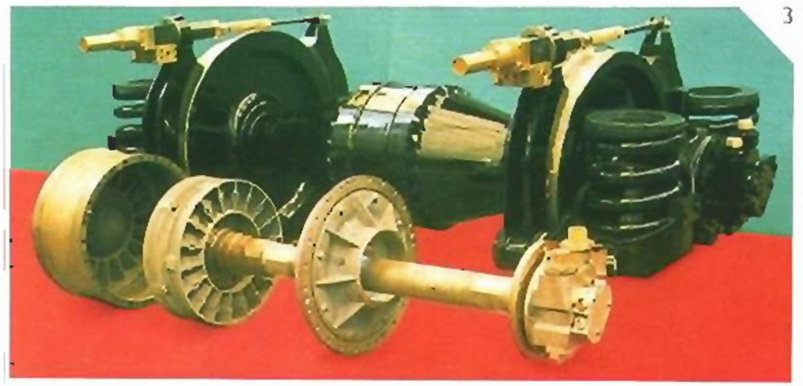

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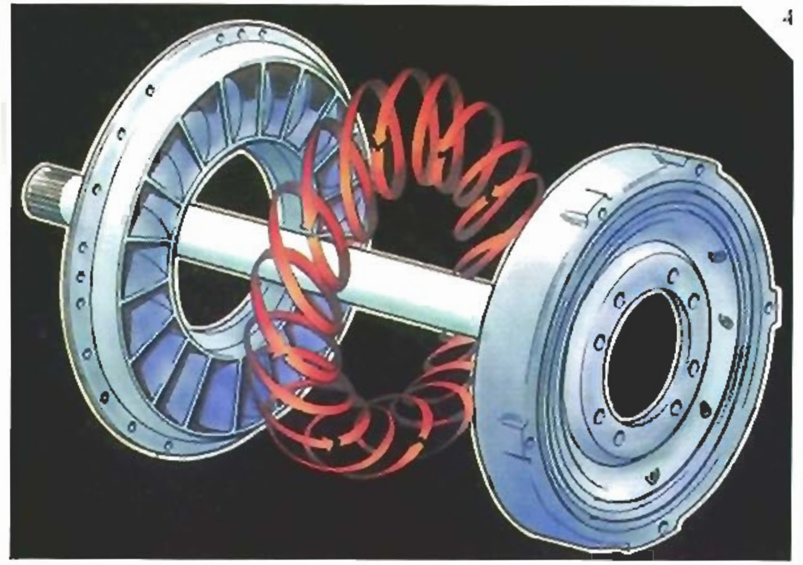
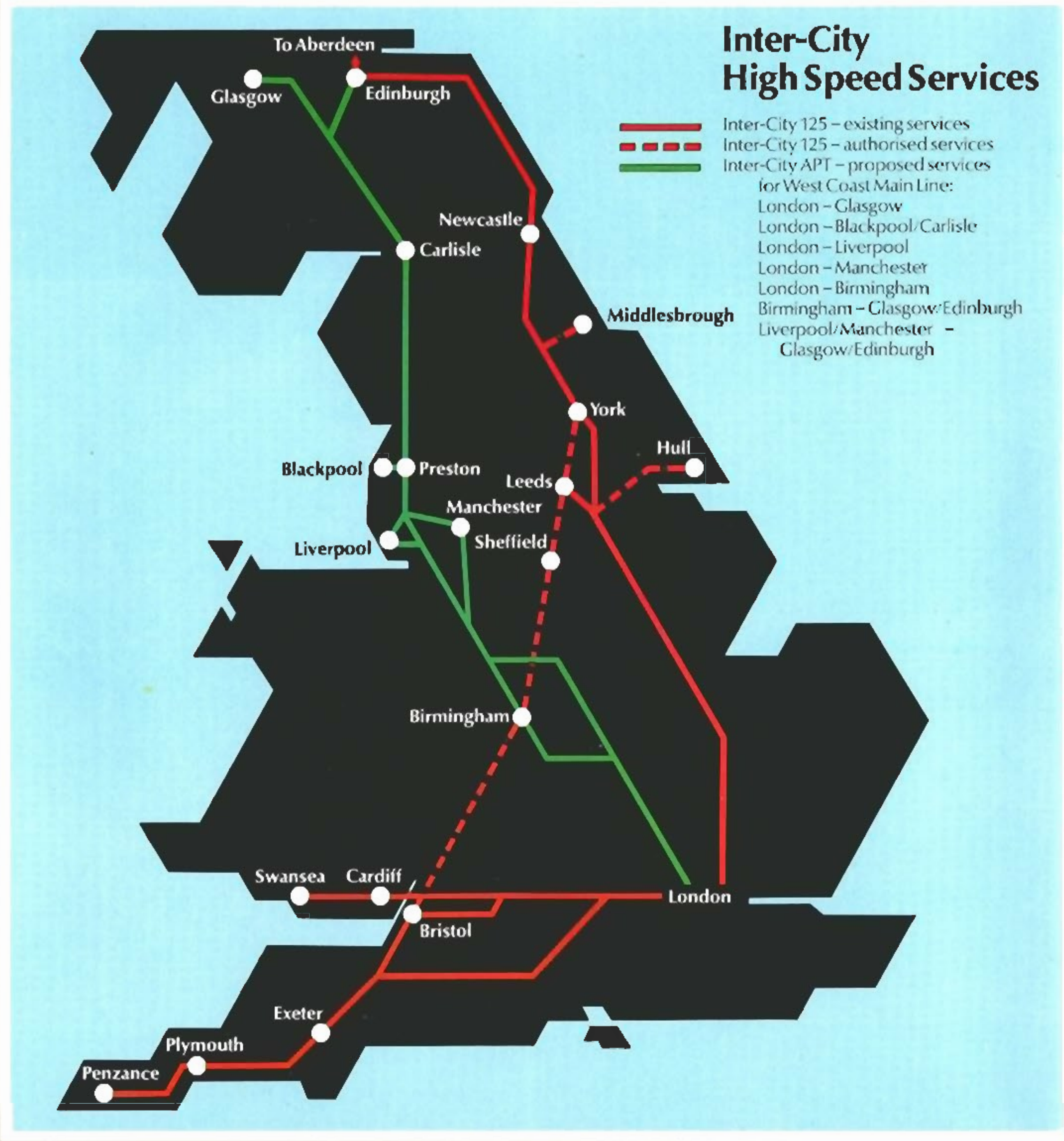
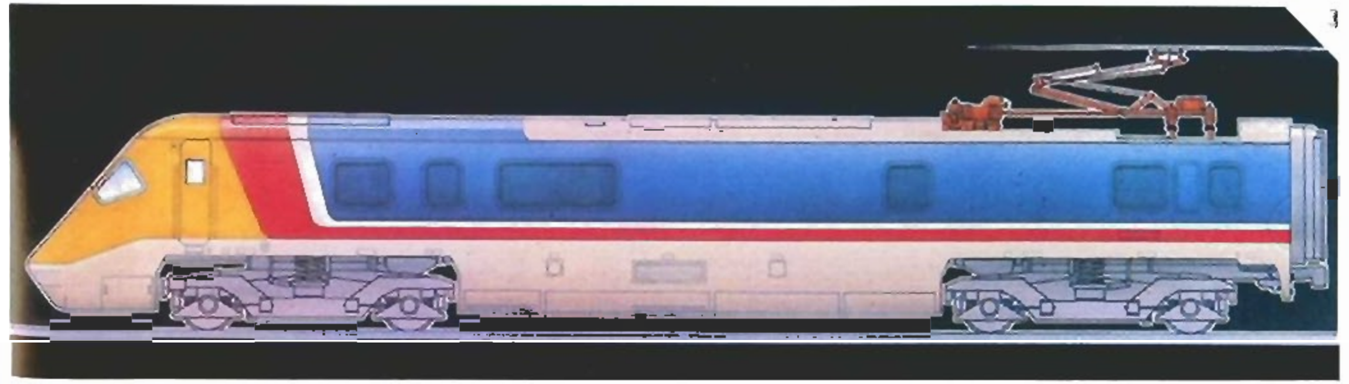


Comparison of APT/HST and Conventional Times from London				
DESTINATION	CONVENTIONAL TIMINGS		APT. TIME	
	Hrs.	Mins.	Hrs.	Mins.
Glasgow	5	00	4	10
Manchester	2	29	2	05
Liverpool	2	30	2	08
Birmingham	1	31	1	16
			HST TIME	
			Hrs.	Mins.
Cardiff	2	16	1	43
Bristol	1	47	1	27
Leeds	2	30	2	08
Newcastle	3	33	2	55
Edinburgh	5	27	4	37



Inter-City APT - the next steps

1. APT at Euston.
2. HST at Paddington.
3. A preliminary design for a production APT driving/power vehicle.



Inter-City APT, though an exceptional development in its own right, is a continuing and integral part of British Rail's total high-speed strategy for its main passenger services.

The three pre-production APT-P trains are to operate the premier passenger services between London and Glasgow because APTs' ability to maintain high average speeds through curves makes them ideally-suited for operation on BR's sinuous West Coast Main Line.

A maximum service speed of 125 mile/h (200Km/h) has been adopted initially, partly because of the need to timetable APTs on track shared with many slower services. Nevertheless, with intermediate stops at Preston and Motherwell or Watford, the time for the 401 mile (642Km) journey is about 4 hours 15 minutes. This compares with the fastest (1980/81) time, using 100 mile/h (160Km/h) electric locomotive-hauled trains, of 5 hours 8 minutes.

However, the London-Glasgow service is only one of an important group of Inter-City passenger services which use the West Coast Main line. Other key services include those between London and Birmingham/Wolverhampton, Liverpool and Manchester. A programme is therefore being progressed to convert these services to APT operation.

A squadron of around 60 APT production models (APT-S) will be needed and, subject to government investment limits, will be phased in between 1983 and 1987.

Detailed design of the APT-S trains is being progressed from experience gained during the trials and passenger service operations of the three APT-P units. The 'S' trains will be shorter than the pre-production prototypes and will utilise only one power car.

While development of the APT project continues, more Inter-City 125 High Speed Trains will be built for operation on other routes where curves present less of a problem.

During the 1980's Inter-City APT and Inter-City 125 will provide Britain with the highest quality, most comprehensive high speed rail passenger service in the world.

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