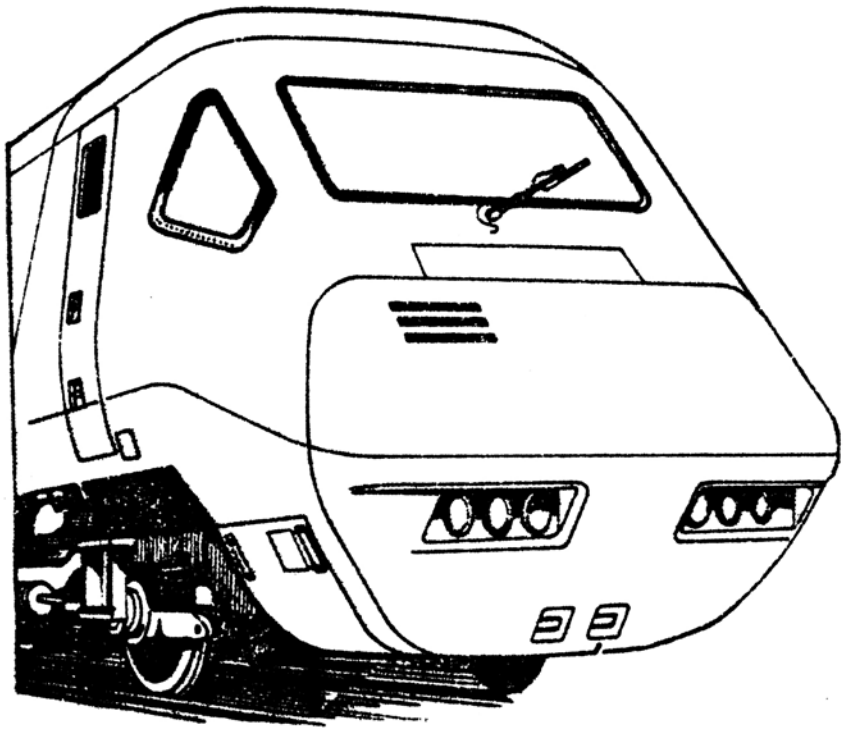
British Rail : Scottish Region

CM&EE Training Centres

APT



Course Notes

1. Introduction

1. BACKGROUND

The concept of an "advanced" passenger train grew from research during the period 1962-1967 into the dynamics of four wheeled vehicles. Such work produced a series of high speed freight vehicles and the first of these (HSFV1) reached a stable 140 mph on a roller rig at the Derby Laboratories.

A project feasibility study for A.P.T. began in 1968 to see how present journey times could be reduced, the success of our West Coast Main Line electrification and the Japanese Tokaido line conclusively supporting this aim. At an early stage it became evident that the economics did not favour new (and straighter) railway lines which are required if conventional trains are to achieve higher average speeds. On our major trunk routes approximately half of the mileage is made up on curves and half of those curves are between 1760 feet and 6600 feet radius. With a maximum track cant of 6 inches a 100 mph train can negotiate a minimum curve of 377 feet radius but if the speed is raised to 125 mph the limiting radius is 5900 feet. Vehicle "cant deficiency" is conventionally limited to 4½°, this being judged to be the boundary for passenger comfort, but such a limit is in fact below the safe levels of operations incurred. (This limit has been investigated by actually derailing a coach under controlled conditions).

To overcome the "comfort boundary" problem, A.P.T. tilts the body of each vehicle up to 9° such that the passenger does not feel any effects of a steady curving. The A.P.T. can consequently negotiate curves 20-40% faster than a conventional train. (See Fig. 1).

2. RESEARCH AND DEVELOPMENT PROGRAMME

General

The original starting point for A.P.T. was a basic theory of guidance and stability which recognised that guidance was available from a pair of coned wheels and that the guidance was maximised by increasing the cone angle. Unfortunately, increased cone angle decreased the dynamic stability of the vehicle and consequently there is conflict between the requirements of guidance and stability. This is evidenced by past railway "practices" of turning tyres at a given mileage to restore the ride of a vehicle to an acceptable level. The solution required lengthy research and development, culminating in the design of bogies which are both stable and will curve without creating high forces.

The articulated configuration of A.P.T. enables the design axle-load to be achieved in addition to supporting the requirements for stability low train mass, low energy consumption and reduced bogie costs. Noise levels were reduced (See Fig.2) simply by having less wheels.

Articulation and low train mass dictated a need for very light vehicles; trailer cars are constructed in aluminium using a unique method of welding together vehicle-length extrusions. Weight is 40% less than conventional steel construction and costs are comparable. Power cars are fabricated in steel to a Monocoque design. Trailer car axle loads vary from about 11 tonnes tare to between 13-15 tonnes depending on the type of vehicle. Power car axle load is about 17 tonnes.

Tilt System

Tilt of the A.P.T. had a strong influence upon the design of the vehicle, the most evident effects being on the body profile. Not so evident is the choice of control system characteristics to give a smooth tilting action through transition curves. The curving characteristics are such that an adequate margin exists for wind loadings and other similar forces, and to assist in this respect the centre of gravity and tilt centre are kept as low as possible. (See Fig. 3).

Brake System

A.P.T. has to stop from 155 mph within the existing signalling distances and allowance has been made for the failure of 12½% of all brakes. Conventional brakes cannot accommodate the energy of stopping from such high speeds and a new "hydrokinetic" brake has been developed. This brake blends with an on-tread friction brake to give entirely adequate braking throughout the full speed range.

Testing

To assist the research programme, tests were carried out by A.P.T. E(a gas turbine powered 4-car articulated train) "POP" train (a locomotive hauled set) and numerous equipment and systems trials were based on coaching stock and locomotives. Consequent reviews studied the future potential for the gas-turbine engine, but the growing fuel crisis and commercial pressures for an electric A.P.T. terminated our interest in this field.

3. PRE-PRODUCTION A.P.T. (A.P.T. - P.)

The 25 kV electric pre-production train (A.P.T. - P.) comprised two "rakes" of articulated trailer cars between which are positioned one or two power cars. Each trailer "rake" consists of a number of 2 - axle intermediate cars and two 3 - axle end cars. Each power car has four axles. Power cars and trailer "rakes" are easily uncoupled from each other in order to satisfy operating and maintenance requirements.

The train can be formed into alternative versions. The 125 mph (200 km/per hour) (1 + 11) low powered version, with 11 trailer cars, represents the longest train that can be hauled by a single power car. The 155 mph (250 km per hour) (2 + 12) high powered version, with 14 vehicles total, is the longest train which can be accommodated within the existing platform lengths.

The train configuration with power cars positioned in the middle, has been adopted so that current can be collected satisfactorily, using only one pantograph, and so that excessive suspension buckling forces can be avoided when pushing with two power cars.

4. DESIGN SPEED

At the outset of the project a maximum speed of 155 mph was chosen as a design target and this has been retained throughout, in association with 9° tilt. Computer simulations of A.P.T. performance enable us to accurately assess the effects that parameters such as maximum speed and tilt have upon journey time, energy consumption etc.

5. VEHICLE DATA.

Vehicle Type	Overall Length (mm)	Axle Load	Total Weight (Kg)	Seating Capacity 1st	Seating Capacity 2nd
Driving Trailer	21440	BT12 113·8kN (11·6 ton) BT11 146·3kN (14·9 ton)	38110	-	52
Intermediate 1st Intermediate Unc.	21000	139·2kN (14·1 ton)	28150	47 43	-
Intermediate 2nd	21000	146·1kN (14·8 ton)	29820	-	72
Catering Vehicle	21000	153·6kN (15·6 ton)	30530	-	28
Van trailer	21100	BT11 129·9kN (13·2 ton) BT12 118·6kN (12 ton)	37400	25(+1 invalid)	
Power Car	20400	168·1kN (17·1 ton)	68240		

6. A.P.T. - P. DESIGNATIONS AND TERMINOLOGY

Axle
Axle designation starts at the first axle at the front of the driving trailer as No. 1, and then count towards the van trailer. Power car axles start at No. 1 (pantograph end) and appertain to that vehicle only.

Vehicle Sides
Vehicle sides are designated either "A" or "B". "A" side being to the driver's right when seated, "B" side is to his left.

This terminology refers to the attached trailer cars, up to and including the van trailer. From the driving trailer to the van trailer constitutes a "rake".

Power car "sides" may be identified by standing in the corridor, underneath the pantograph, and facing the nearest vestibule (vehicle end). "A" side is to the right, and "B" side on the left.

Vehicle Ends
Vehicle ends are identified as either No. 1 or No. 2. No. 1 end is nearest to the driving trailer in that particular "rake". No. 2 end is to the power car.

No. 1 end of the power car carries the pantograph. See Fig.4.

Vehicle Type Codes (Engineering)
See Fig.5

Bogie Designations.
The three types of bogie are illustrated in Appendix 1 at the back of this Course Note.

Vehicle Running Numbers.
The number on the Nose End of the Driving Trailer indicates the class and Rake number, ie. 370 001, class 370 Rake 1.
Individual vehicle numbers may be identified as follows:

48101 Driving Trailer, Rake 1.
48201 Trailer Second, Rake 1.
48302 Trailer Unclassified, Rake 2.
48402 Trailer Catering, Rake 2.
48503 Trailer First, Rake 3.
48603 Trailer Brake First, Rake 3.
49004 Power Car, Rake 4.

The first three figures give vehicle type, the final three give the Rake number to which the vehicle belongs.

Fig. 1.

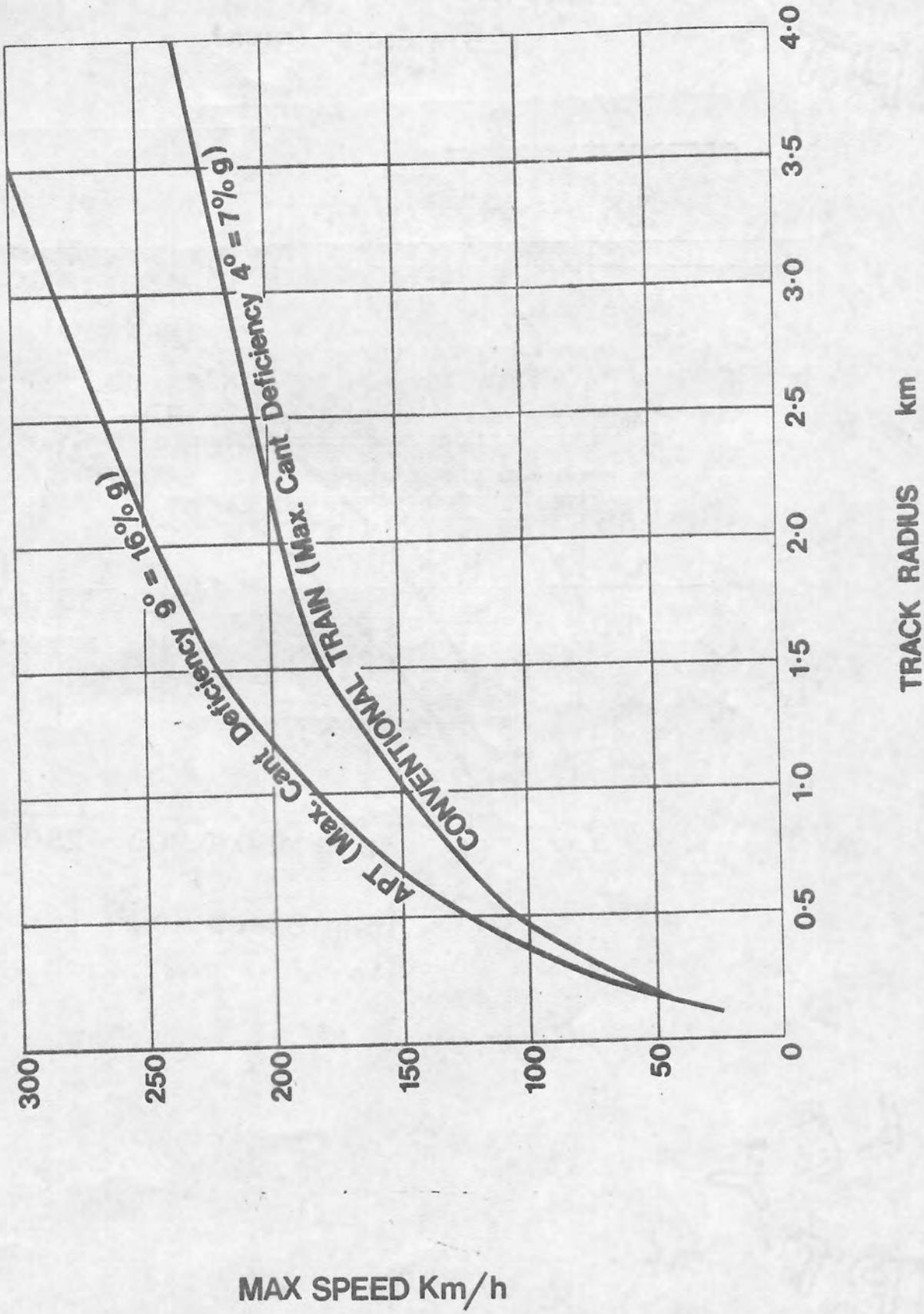
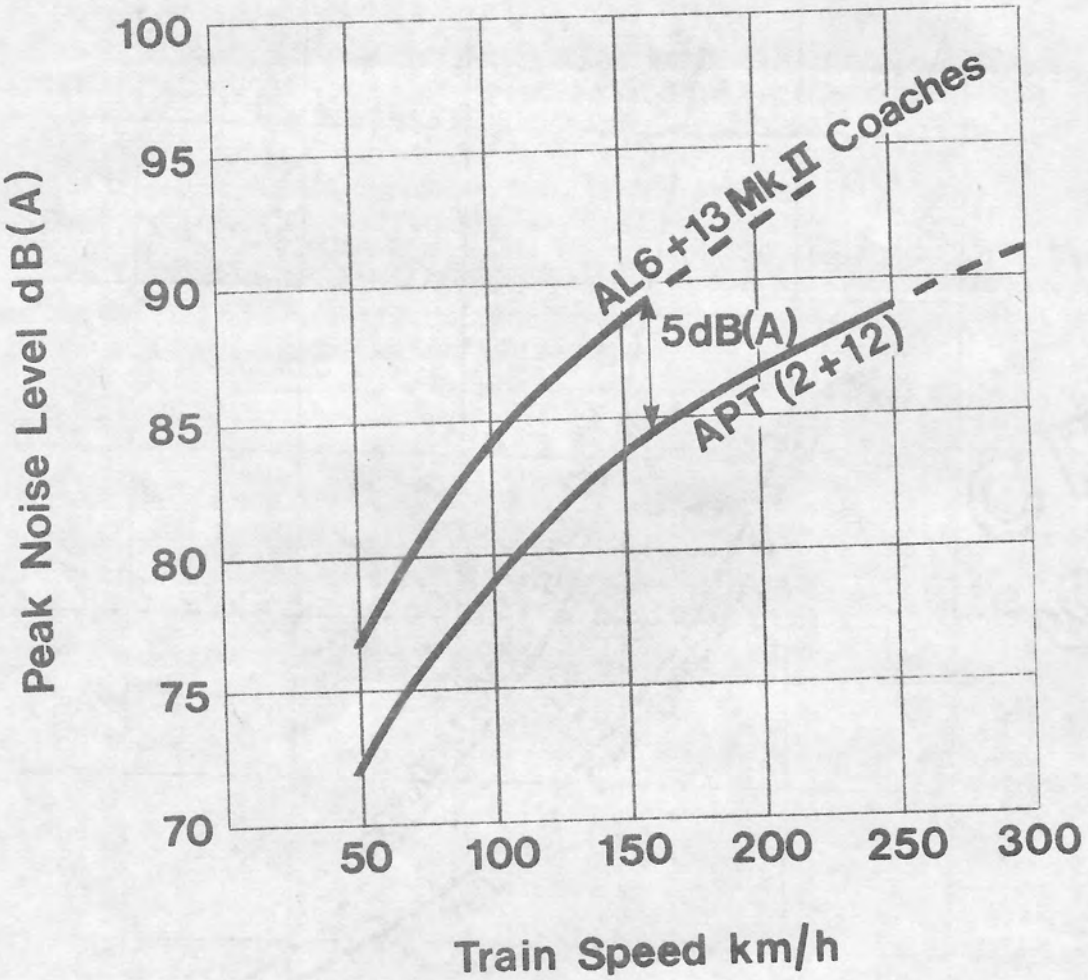
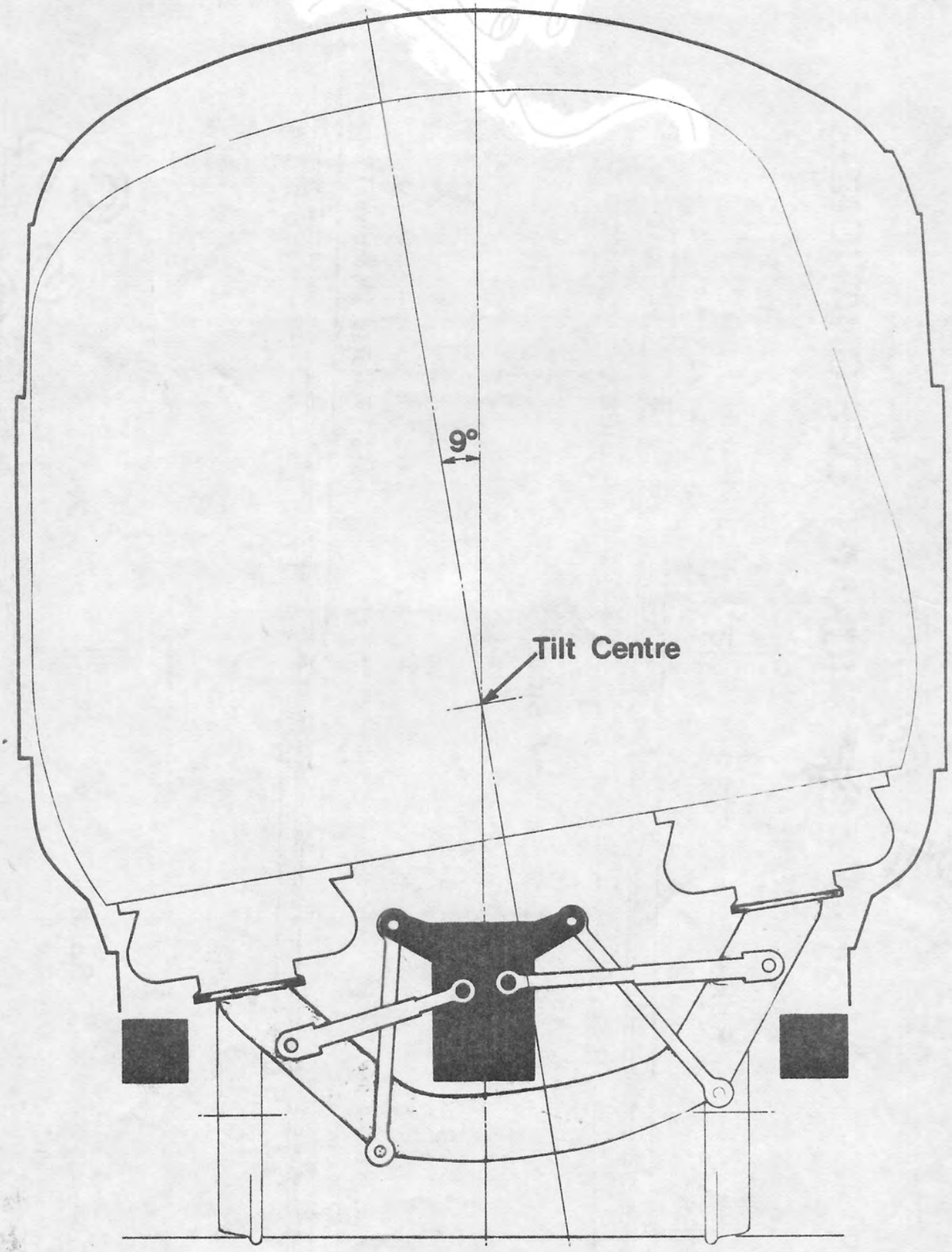

TYPICAL APT SPEED IMPROVEMENT ON CURVES
APT (Max. Cant Deficiency 6° = 16% g)
CONVENTIONAL TRAIN (Max. Cant Deficiency 4° = 7% g)
MAX SPEED Km/h
300
250
200
150
100
50
0
0·5
1·0
1·5
2·0
2·5
3·0
3·5
4·0
TRACK RADIUS km

Fig. 2.

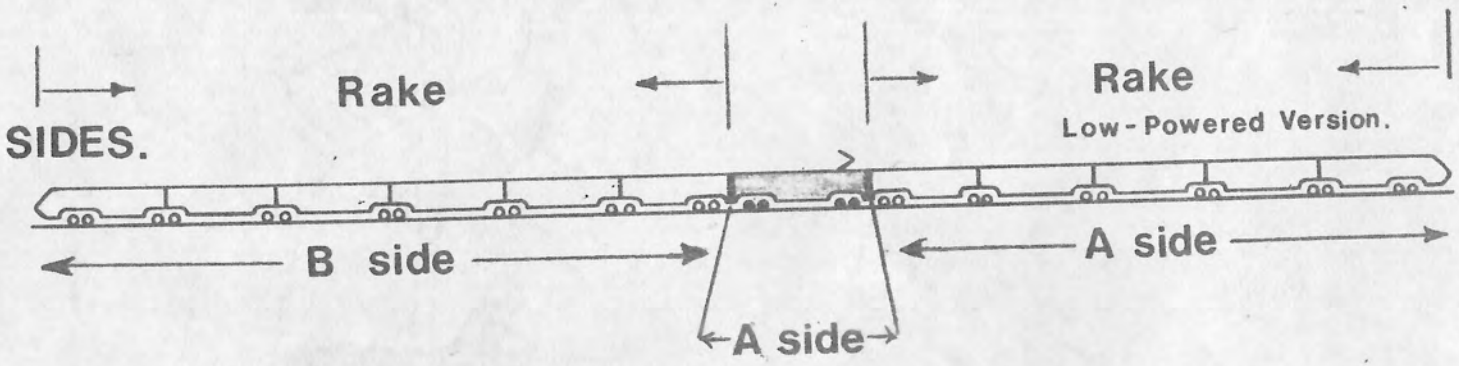
PREDICTED TRAIN NOISE LEVELS
(25 m From Track)

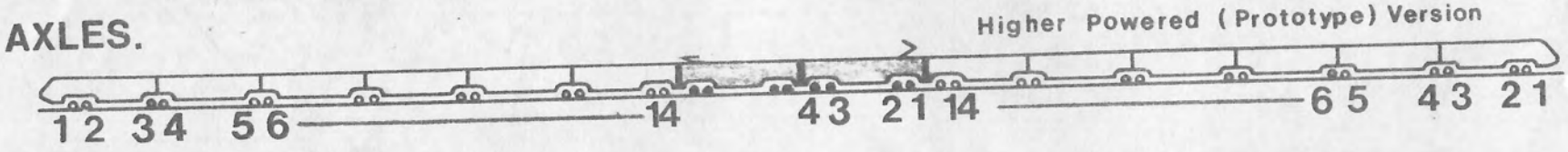


APT TILT SUSPENSION



25kV ELECTRIC APT DESIGNATIONS.





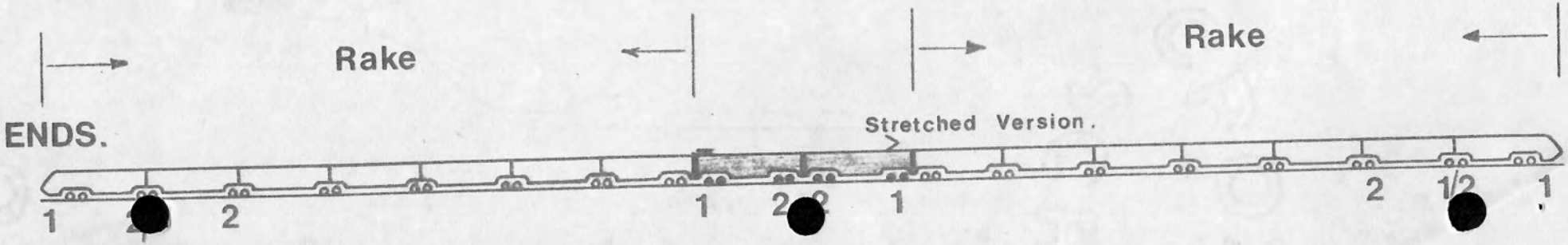
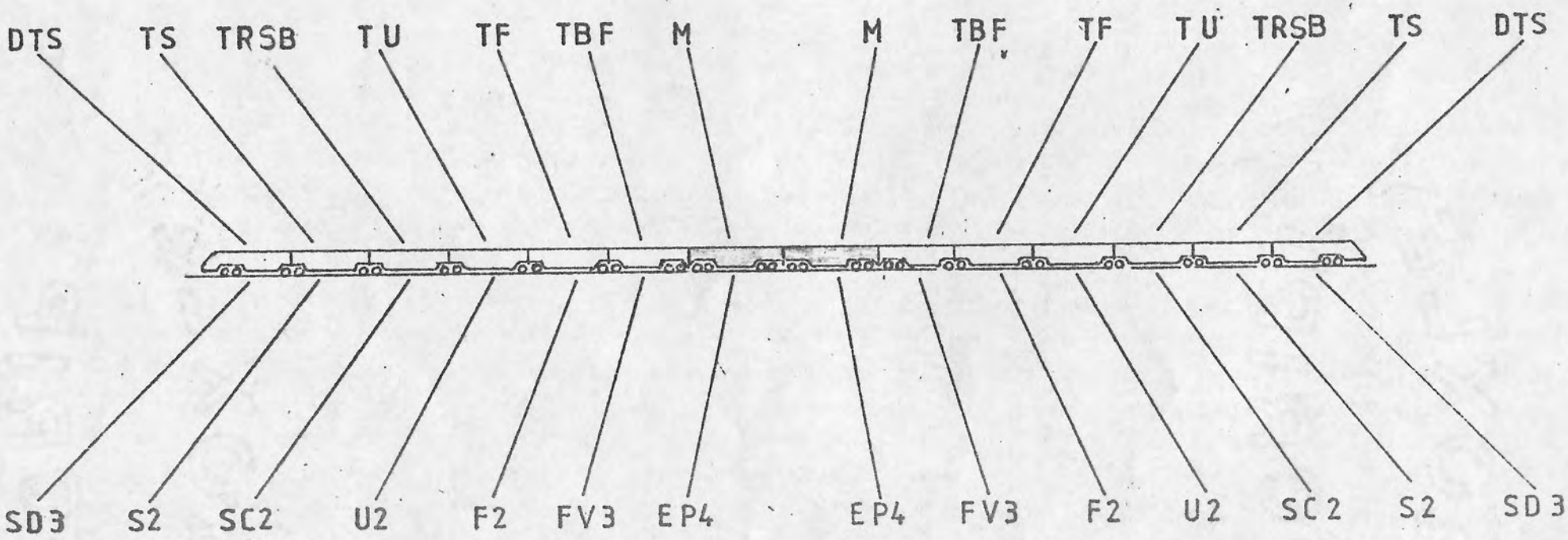


FIG.5

25kV ELECTRIC A.P.T. FORMATIONS



DTS	Driving Trailer Second	or	Second Driving	(3 axles)	SD3.
TS	Trailer Second	or	Second	(2 axles)	S2.
TRSB	Trailer Rest/Buf.	or	Uncl. Catering	(2 axles)	SC2.
TU	Trailer Unclass	or	Uncl.	(2 axles)	U2.
TF	Trailer First	or	First	(2 axles)	F2.
TBF	Trailer Brake First	or	First Van	(3 axles)	FV3.
M	Motor	or	Elect. Power	(4 axles)	EP4.

A.P.T.-P. Appendix 1.

Bogie Designations.

BT 11 type bogies provide a means of articulation between two vehicles.

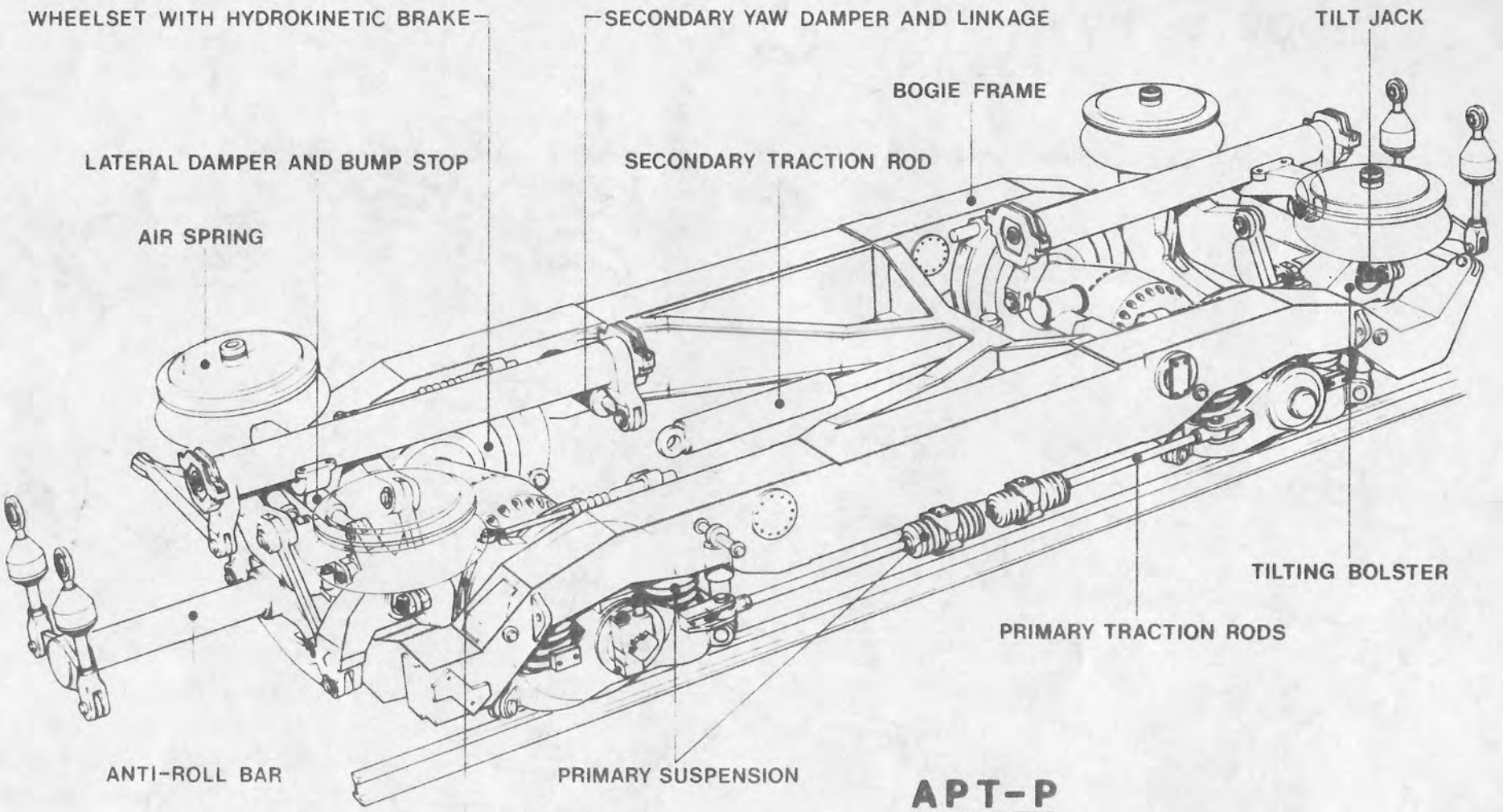
BT 12 type bogies are orthodox, fitted with a C-APT aerial.

BT 11a bogies provide a means of articulation and are also fitted with a C-APT aerial.

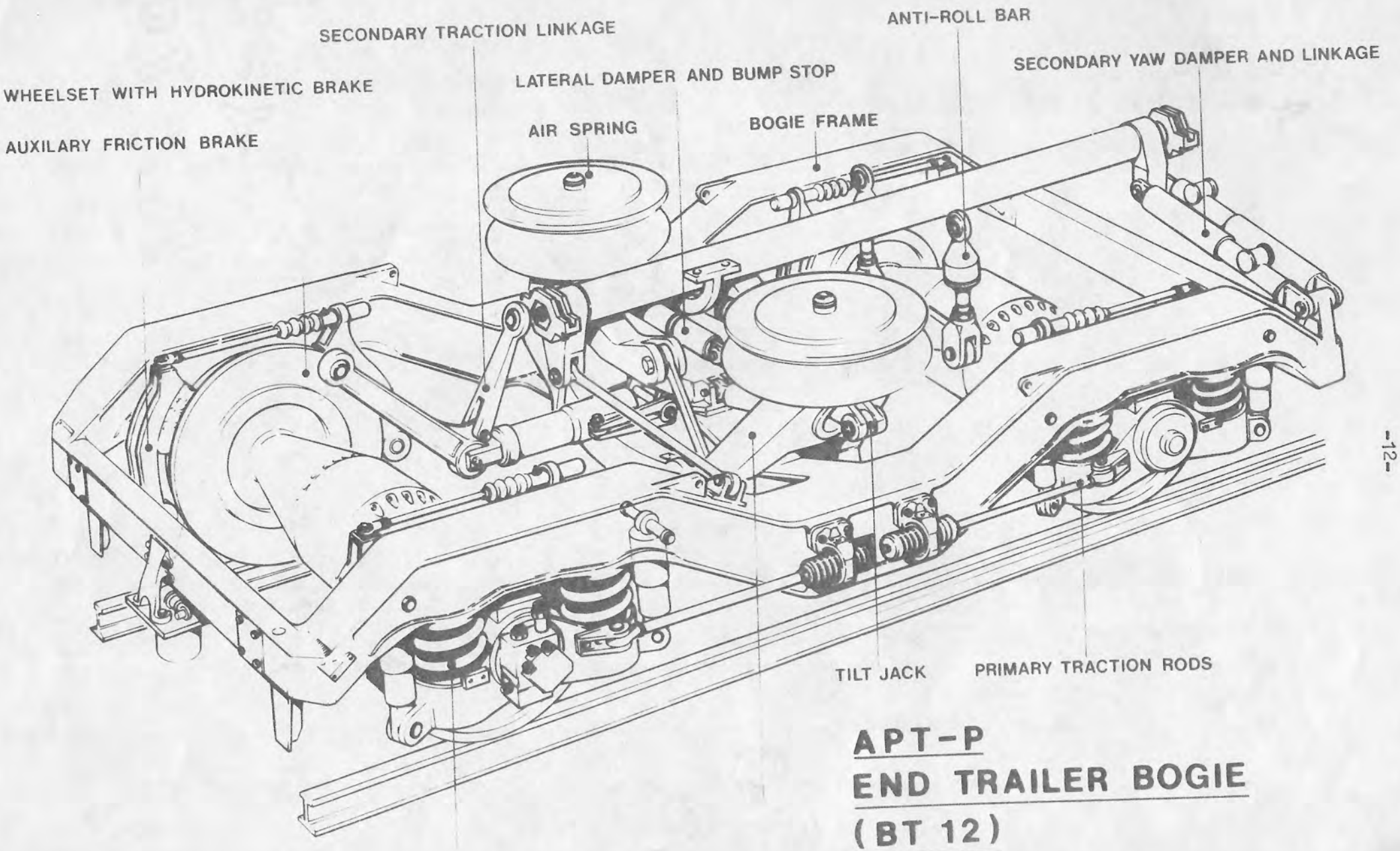
BT 12a type bogies are orthodox, and fitted with a parking brake. This bogie is not provided with a C-APT aerial.

BP 17a is the power car bogie, fitted with automatic power control pickup, parking brake and pantograph anti-tilt feature. This bogie is fitted under No. 1 end of the vehicle.

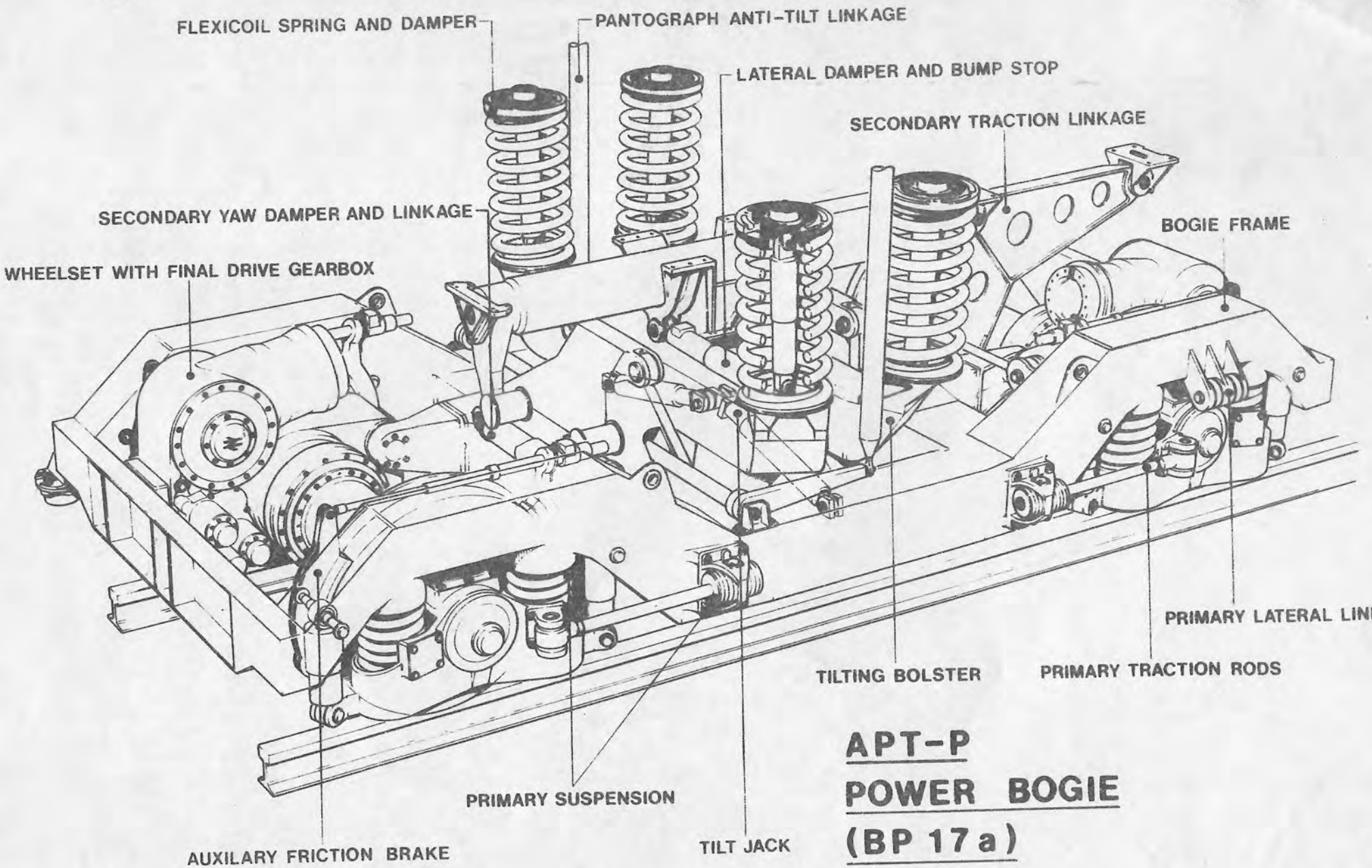
BP 17 is the standard power car bogie, fitted with parking brake. The pantograph anti-tilt feature is also provided, but not required as this bogie is fitted under No. 2 end of the vehicle.



APT-P
INTERMEDIATE TRAILER BOGIE
(BT 11)



APT-P
END TRAILER BOGIE
(BT 12)



APT-P
POWER BOGIE
(BP 17a)

STUDENT'S NOTES.