

Byrne Seminar
The History and Future of High Speed Passenger Trains
Fundamentals of High Speed Trains

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What is a High Speed Train ?

- There is no single worldwide standard defining high speed trains (high speed rail)
- Common definition
 - New rail lines with maximum speeds in excess of 250 km/hr (160 mph)
 - Existing rail lines with maximum speed in excess of 200 km/hr (120 mph)



Japanese Bullet Train

What Makes a High Speed Train ?

- Railway track
- Wheel coning
- Switches
- Locomotive
- Passenger cars
- Power lines
- Engineers and staff



Chinese CRH5 train-set at Qinhuangdao Station

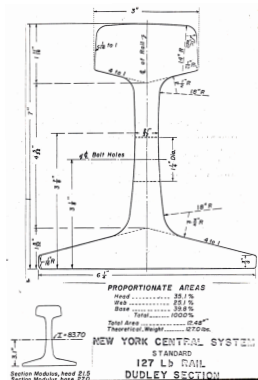
The Railway Track

- The railway track comprises
 - Rails
 - Fasteners
 - Railroad ties (known sleepers in UK)
 - Ballast (or slab track)
 - Subgrade
 - Switches



Rails

- Rails are constructed from high tensile steel
- Typical cross section
- Flat bottom attaches to railroad ties
- Wheel rides on the top
- Different sizes indicated by weight/yard
 - Heaviest was 155 lb/yard for Penn Central



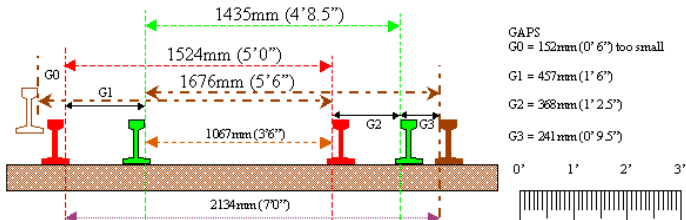
Rail cross section

Rails

- Track gauge is the distance between rails
- Track gauge varies between countries
- The Standard Gauge is 4 ft 8.5 in (1435 mm)
- Named after George Stephenson
- Most widely used track gauge in world (55%)
- All high speed trains use standard gauge except in Russia, Finland, Portugal and Uzbekistan



George Stephenson
(1781-1848)



Wheel Coning

- Typically the wheels on a locomotive or passenger car are coned
- The coning angle is 1 to 20 (2.86°)
- The wheel diameter therefore increases from the outside to the inside



Wheel truck (bogie)

Wheel Coning

- Wheel coning maintains stability on a straight track
 - If the train moves sideways to the left, the diameter of the left wheel touching the rail increases, and the diameter of the right wheel touching the rail decreases
 - Due to the rotational inertia of the wheels, the rotation rate is initially the same as the train moves sideways to the left
 - Thus, the left side of the train moves faster than the right side
 - This results in the train moving to the right, thereby stabilizing the forward motion



Switches

- A railroad switch enables a train to change from one track to another
- Also known as turnout, point or set of points
- Consists of pair of linked tapering rails
 - Also known as points, switch rails or point blades
- The points can be moved laterally to one of two positions



Switches

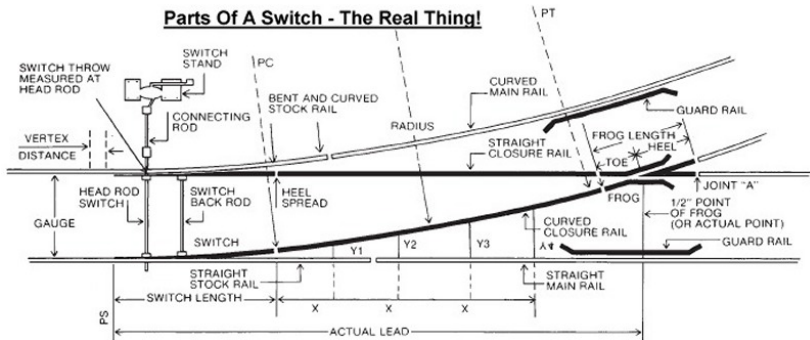


Diagram of railroad switch

Switches

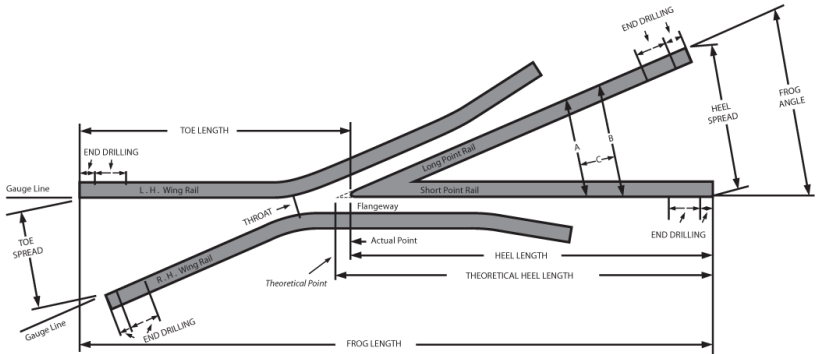


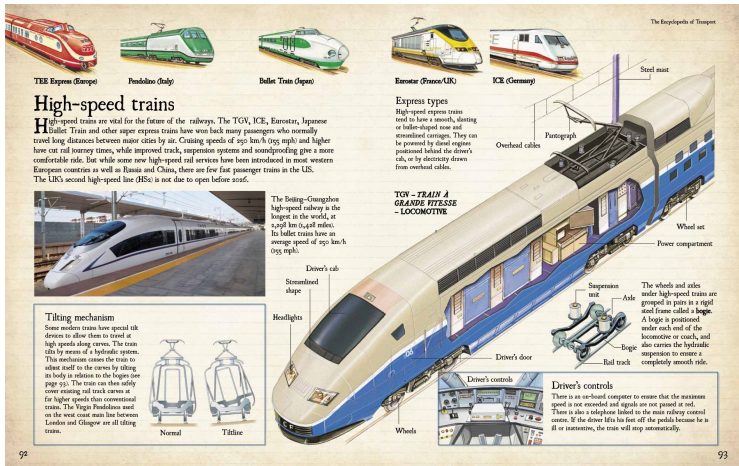
Diagram of railroad frog

Switches



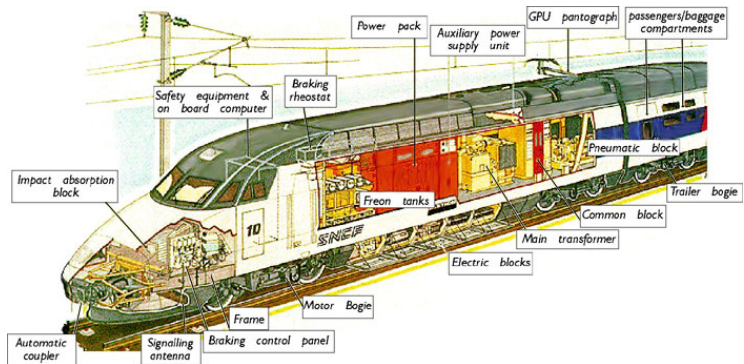
Combination of railroad switches

Locomotives



Types of high speed train locomotives

Locomotives



Cutaway drawing of TGV 24000

Locomotives



Acela engineer's view

Locomotives

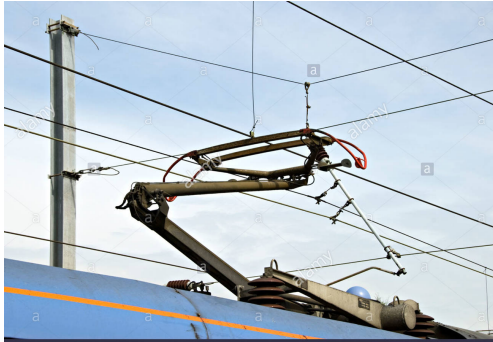
TGV 24000

- Pantograph
- Main transformer
- Thyristor controlled rectifier bridge
- Common block
- Traction inverters
- Synchronous AC traction motor
- Mechanical transmission



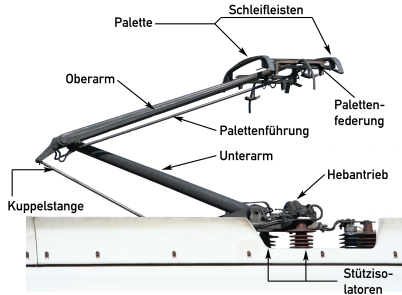
Locomotives

Pantograph



Pantograph in contact with power line

Locomotives Pantograph

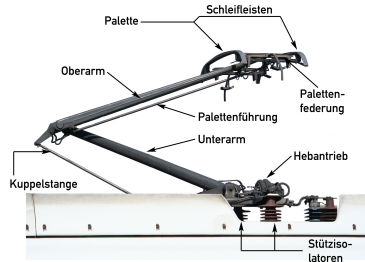


<i>Item</i>	<i>Definition</i>
federung	suspension
hebantrieb	hoist drive
oberarm	upper arm
palettenführung	palette guide
schleifleisten	sanding strips
unterarm	forearm

Locomotives

Pantograph

- Pantograph connects the electrical power supply to the locomotive
- Spring loaded to push shoe against underside of wire
- Steel rails of the tracks are the electrical return
- Contact force typically 70 Nt



Locomotives

TGV 24000 Main Transformer

- Takes 25 kV, 50 Hz single phase overhead power and converts this to 1500 V, 50Hz
- Weight 8 metric tons
- Located in lower frame of locomotive
- Contained in oil bath and air cooled



Locomotives

TGV 24000 Thyristor Controlled Rectifier Bridge

- Thyristor is which passes current only in one direction provided that a suitable voltage is applied to its control electrode (“gate”)
- Rectifies the output of the main transformer to 1500 V DC
- Two thyristor-diode bridges, one for each pair of traction motors.



Locomotives

TGV 24000 Common Block

- Comprises the DC circuit breaker and the main filter capacitor
- Smooths the “chopped” 1500 V waveform to a lower DC voltage, depending on the duty cycle.



Locomotives

TGV 24000 Traction Inverters

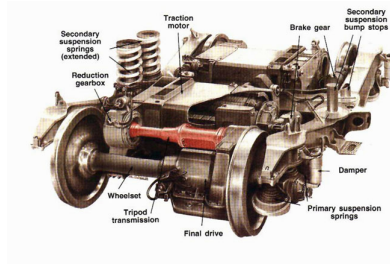
- Convert the DC input into three phase, variable frequency AC waveform to control traction motors
- One inverter per traction motor
- For each truck (bogie), the two inverter/motor pairs are connected in series



Locomotives

TGV 24000 Traction Motor

- Synchronous AC traction motors are excited at a frequency proportion to its rotational speed
- The traction motors are attached to the locomotive, not the truck (bogie)
- Weight 1460 kg
- Max power 1100 kW
- Max 4000 rpm

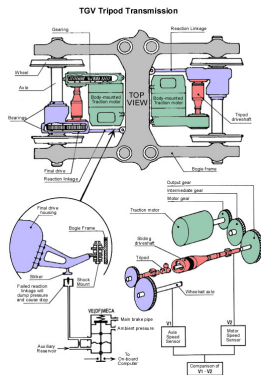


TGV 24000 bogie

Locomotives

TGV 24000 Mechanical Transmission

- The traction motor is connected to the axle gearbox by tripod transmission using sliding universal joint shafts
- Final drive is gear train riding on the axle which transfers power to wheels



Tripod transmission

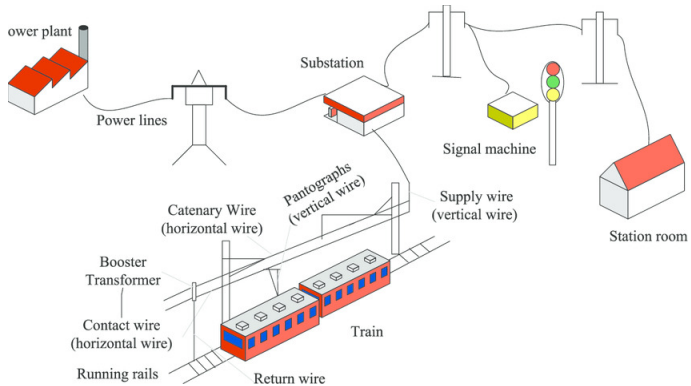
Passenger Cars AMTRAK Acela



Passenger Cars South Korea KTX



Power Lines



Train Engineer

