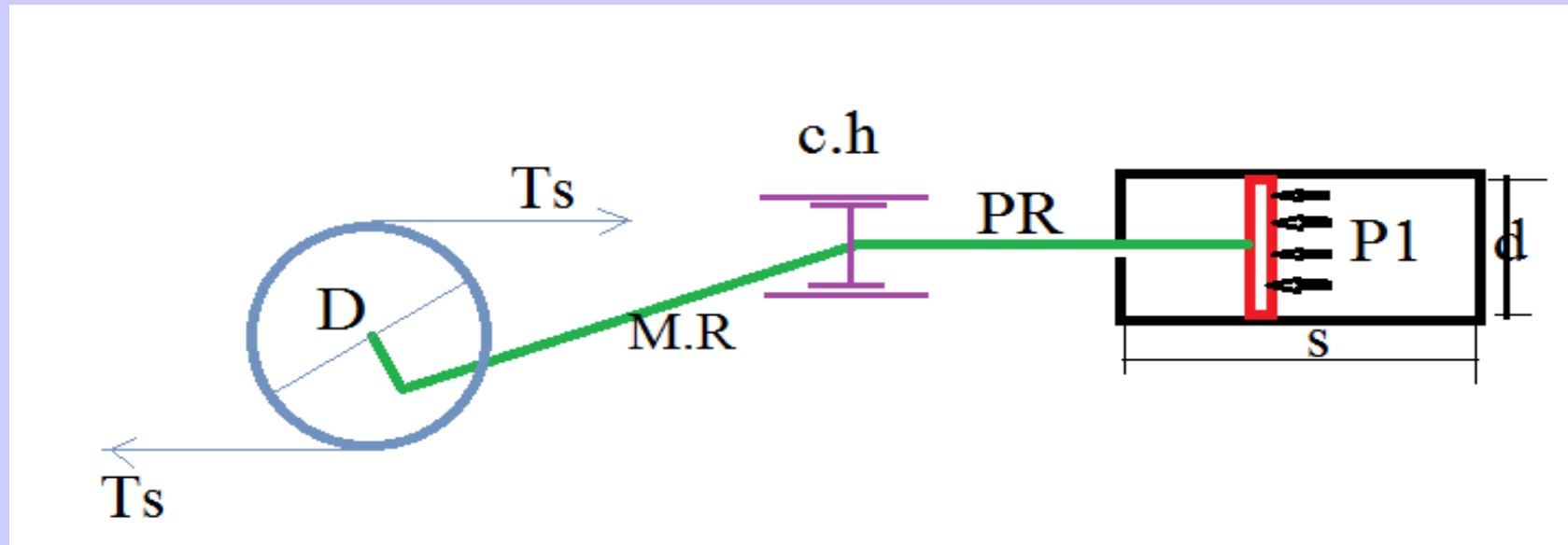


Types and Characteristics of
Locomotives
Dr. Ahmed A. Khalil

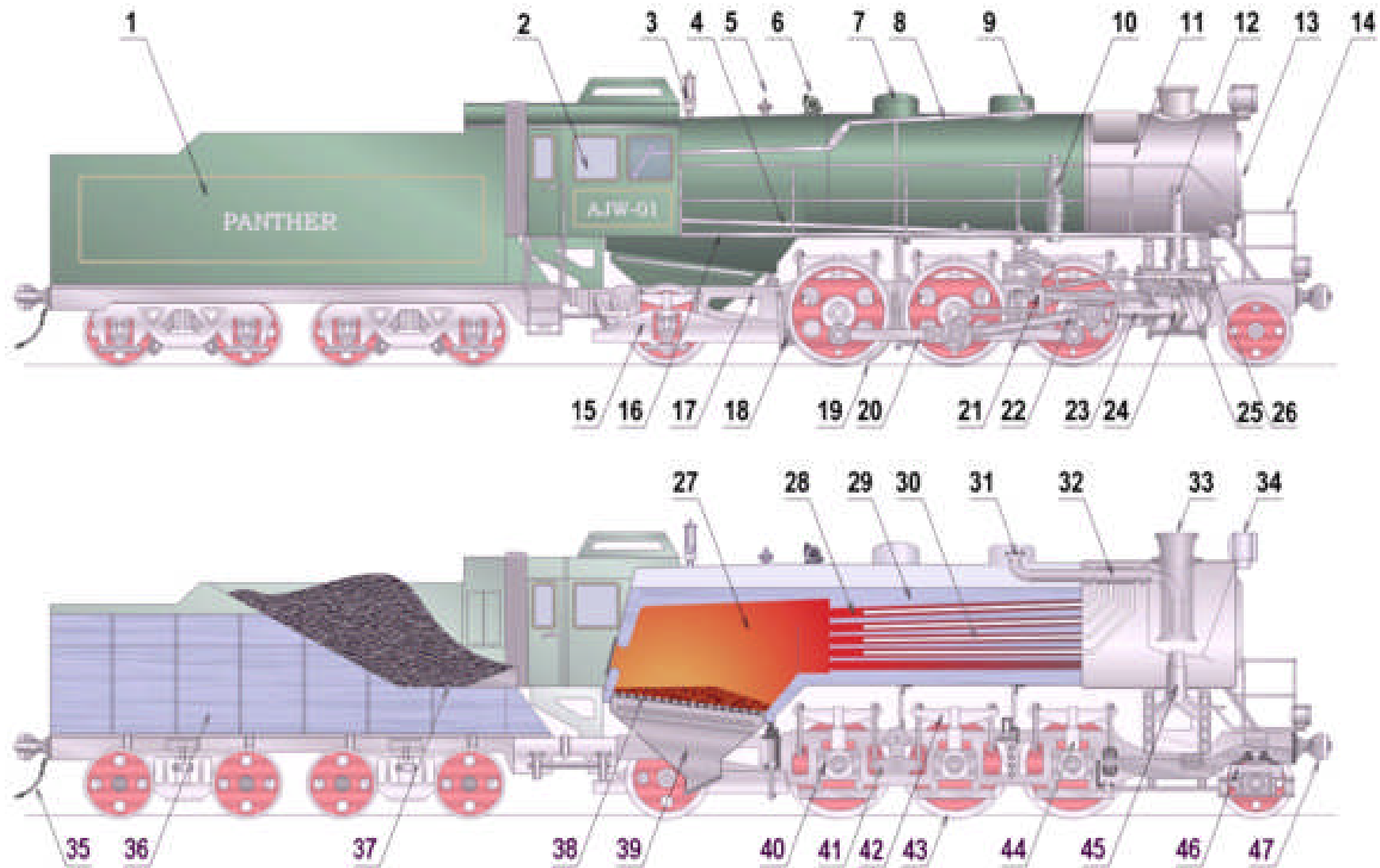
Steam Locomotives

- Operating Principle:

The wheel is connected to the rod by a crank. The rod is connected to the piston rod of the steam cylinder., thereby converting the reciprocating motion of the piston rod generated by steam power into wheel rotation.



- Main Parts of a steam locomotive:



1. **Tender** — Container holding both water for the boiler and combustible fuel such as wood, coal or oil for the fire box.
2. **Cab** — Compartment from which the engineer and fireman can control the engine and tend the firebox.
3. **Whistle** — Steam powered whistle, located on top of the boiler and used as a signalling and warning device.
4. **Reach rod** — Rod linking the reversing actuator in the cab (often a 'johnson bar') to the valve gear.
5. **Safety valve** — Pressure relief valve to stop the boiler exceeding the operating limit.
6. **Generator** — Steam powered electric generator to power pumps, head lights etc, on later locomotives.
7. **Sand box/Sand dome** — Holds sand that can be deposited on the rails to improve traction, especially in wet or icy conditions.
8. **Throttle Lever** — Controls the opening of the regulator/throttle valve thereby controlling the supply of steam to the cylinders.
9. **Steam dome** — Collects the steam at the top of the boiler so that it can be fed to the engine via the regulator/throttle valve.

- 10. Air pump** — Provides air pressure for operating the brakes (train air brake system).
- 11. Smoke box** — Collects the hot gas that have passed from the firebox and through the boiler tubes. It may contain a cinder guard to prevent hot cinders being exhausted up the chimney. Usually has a blower to help draw the fire when the regulator is closed. Steam exhausting from the cylinders is also directed up to the chimney through the smoke box to draw the fire while the regulator is open.
- 12. Main steam pipe** — Carries steam to the cylinders.
- 13. Smoke box door** — Hinged circular door to allow service access to the smoke box.
- 14. Hand rail** — Support rail for crew when walking along the foot board.
- 15. Trailing truck/Rear bogie** — Wheels at the rear of the locomotive to help support the weight of the cab and fire box.
- 16. Foot board/Running board** — Walkway along the locomotive to facilitate inspection and maintenance.
- 17. Frame** — Steel beams around which the locomotive is built. The wheels run in slots within the frames, and the cab, fire box, boiler and smoke box are mounted on top.
- 18. Brake shoe** — Applied directly to all the driving wheels for braking.
- 19. Sand pipe** — Deposits sand directly in front of the driving wheels to aid traction.
- 20. Side rods/Coupling rods** — Connect the driving wheels together.
- 21. Valve gear** — System of rods and linkages synchronising the valves with the pistons and controls the direction and power output of the locomotive.
- 22. Main rod/Connecting rod** — Steel arm that converts the horizontal motion of the piston into a rotation motion of the driver wheels.
- 23. Piston rod** — Connect the piston to the cross-head axle, which drives the main/connecting rods.

- 24. Piston** — Driven backward and forward within the cylinder by steam pressure, producing mechanical motion from steam expansion.
- 25. Valve** — Controls the supply of steam to the cylinders, timing is synchronised by the valve gear connect to the Drivers.
- 26. Valve chest** — Small chamber (sometimes cylindrical) above or to the side of the main cylinder containing passageways used by the valves to distribute live steam to the cylinders.
- 27. Firebox** — Furnace chamber that is built into the boiler and usually surrounded by water. Almost anything combustible can be used as fuel but generally coal, coke, wood or oil are burnt.
- 28 Boiler tubes** — Carry hot gasses from the fire box through the boiler, heating the surrounding water.
- 29. Boiler** — Water container that is heated by hot gases passed through boiler tubes, thereby producing steam.
- 30. Superheater tubes** — Pass steam back through the boiler to dry out and 'super heat' the steam for greater efficiency.
- 31. Regulator/Throttle valve** — Controls the amount of steam delivered to the cylinders.
- 32. Superheater** — Feeds steam back through boiler tubes to superheat (heat beyond just boiling point) the steam to increase the engine efficiency and power.
- 33. Smokestack/Chimney** — Short chimney on top of the smoke box to carry the exhaust (smoke) away from the engine so that it doesn't obscure the engineers vision. Usually extended down inside the smoke box.
- 34. Headlight** — Lamp on front of the smoke box to provide forward visibility.
- 35. Brake hose** — Air or vacuum hose for transmitting braking control to attached rolling stock.
- 36. Water compartment** — Container for water used by the boiler to produce steam that is subsequently usually exhausted from the cylinders.

- 37. Coal bunker** — Fuel supply for the furnace. Variations may hold wood, coke, or oil. Fed to the firebox either manually or, in later engines, mechanically.
- 38. Grate** — Holds the burning fuel and allows unburnable ash to drop through.
- 39. Ashpan hopper** — Collects the unburnable ash from spent fuel.
- 40. Journal box** — Contains the bearing for a driver wheel's axle.
- 41. Equalizing levers / Equalizing bars** — Part of the locomotive suspension system, connected to Leaf Springs, free to pivot about their centre which is firmly fixed to the frame.
- 42. Leaf Springs** — Main suspension element for the locomotive. For each driver wheel there is a leaf spring suspending its axles journal box.
- 43. Driver** — Wheel driven by the pistons to propel the locomotive. Drivers are balanced by weights so that the centre of gravity, of the drivers and rods, coincides with the center of rotation. There are 3 sets of driving wheels in this example.
- 44. Pedestal or saddle** — Connects a leaf springs to a driver wheel's journal box.
- 45. Blast pipe** — Directs exhaust steam up the chimney, creating a draught that draws air through the fire and along the boiler tubes.
- 46. Pilot truck/Leading bogie** — Wheels at the front to guide the locomotive along the track.
- 47. Coupler** — Device at the front and rear of the locomotive for connecting locomotives and rail cars together.

- Disadvantages of the Steam Locomotive

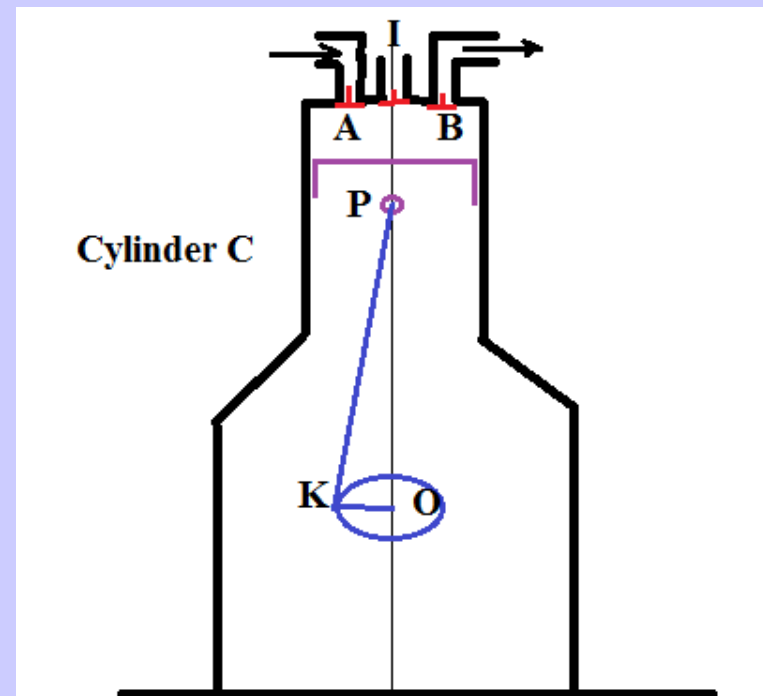
- 1- Low fuel efficiency. (Only 6% of the energy is used for train traction)
- 2- poor technical performance. Power cannot exceed 3000 hp.
- 3- The need to maintain a large number of water supply facilities .
- 4- High maintenance cost.
- 5- Time-consuming fuel replenishment procedure. It can only operate 12 to 14 hours daily.
- 6- Increased fire hazard.
- 7- Harmful to the environment .

Diesel Locomotives

- Operating Principle of Diesel Locomotive

The basic element of the diesel engine is the cylinder (C), inside which is moving the piston (P) by reciprocating motion. The reciprocating motion is transmitted as rotary motion by the rod (PK) and the Crank (OK) to the main driving shaft (OP).

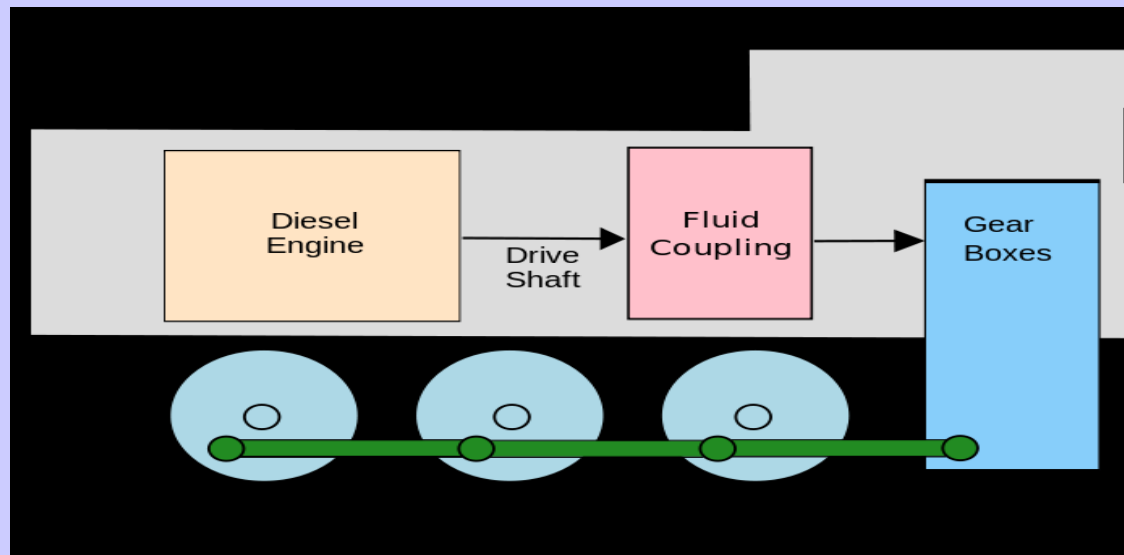
On the cylinder cover are located the valves (A), (B) and (I), performing functions.



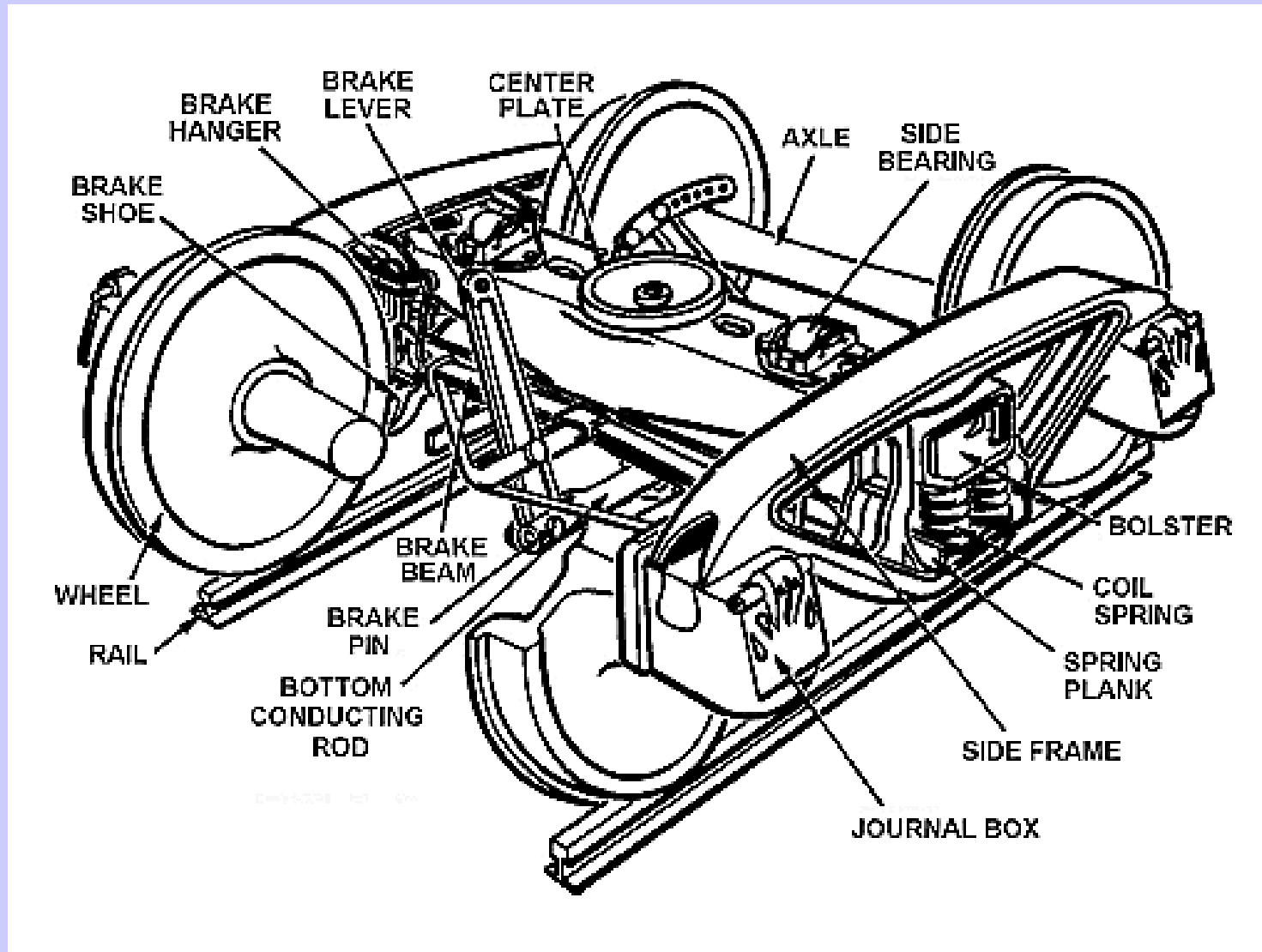
- Transmission systems

The Power is transmitted from the motor to the wheels is achieved by the following methods:

- 1- Hydrodynamic transmission and Hydrodynamic speed shifting.
- 2- Hydrodynamic transmission and mechanical speed shifting.
- 3- Electrical transmission, in which case the diesel engine drives an electric generator in turn driving series electric motors, which are mechanically joined with their driving wheels. No gear boxes are employed as in electric locomotives. It is named **Diesel electric locomotives**



The Truck





Requirements from a diesel locomotive

The diesel locomotive should meet the following requirements:

- 1- Pulling capability of medium and heavy loads on any case of ground surface, at different speeds with full train load.
- 2- Overload capability, on one hand in the low speed range, and on the other hand uphill at full load.
- 3- Capability to brake with no slippage at high speeds, as well as to keep within speed limits downhill without using mechanical brakes.
- 4- High reliability and low maintenance cost.

Advantages and Disadvantages of Diesel traction

Diesel traction in comparison with electric traction offers the following advantages:

- 1- Lower track installation cost.
- 2- Autonomy.
- 3- The rotative force is steady and continuous, therefore adhesion is increased.

However, diesel traction has the following **disadvantages** compared to electric traction:

- 1- Lower mechanical performance (power, force, speed)
- 2- Higher energy consumption
- 3- More air pollution and noise
- 4- higher maintenance expenses.

Electric Traction

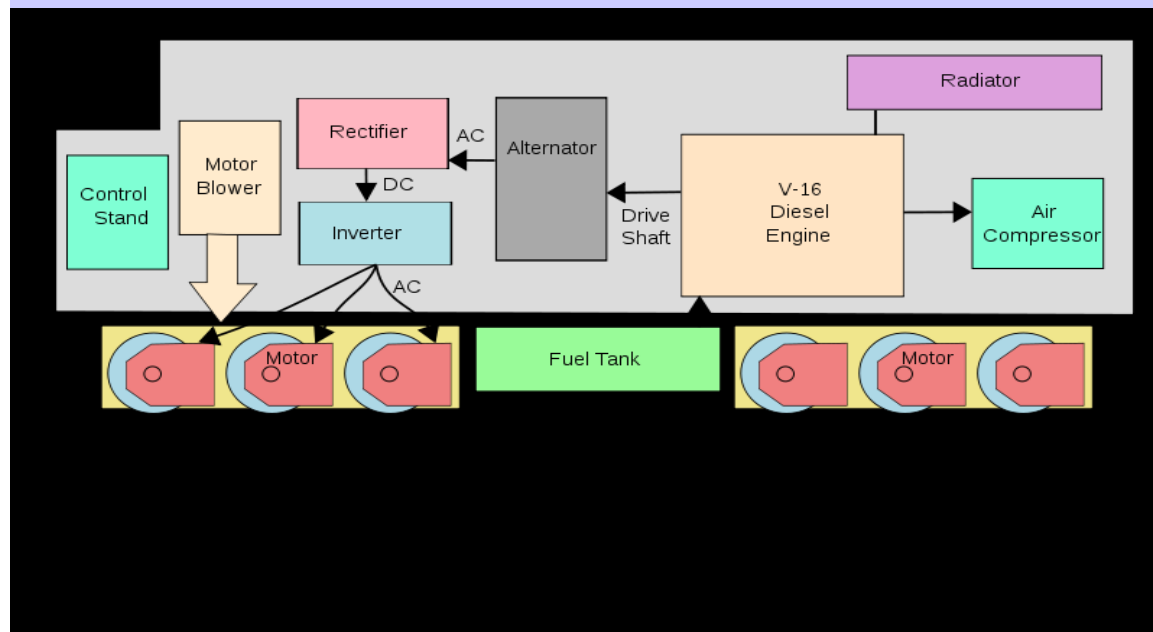
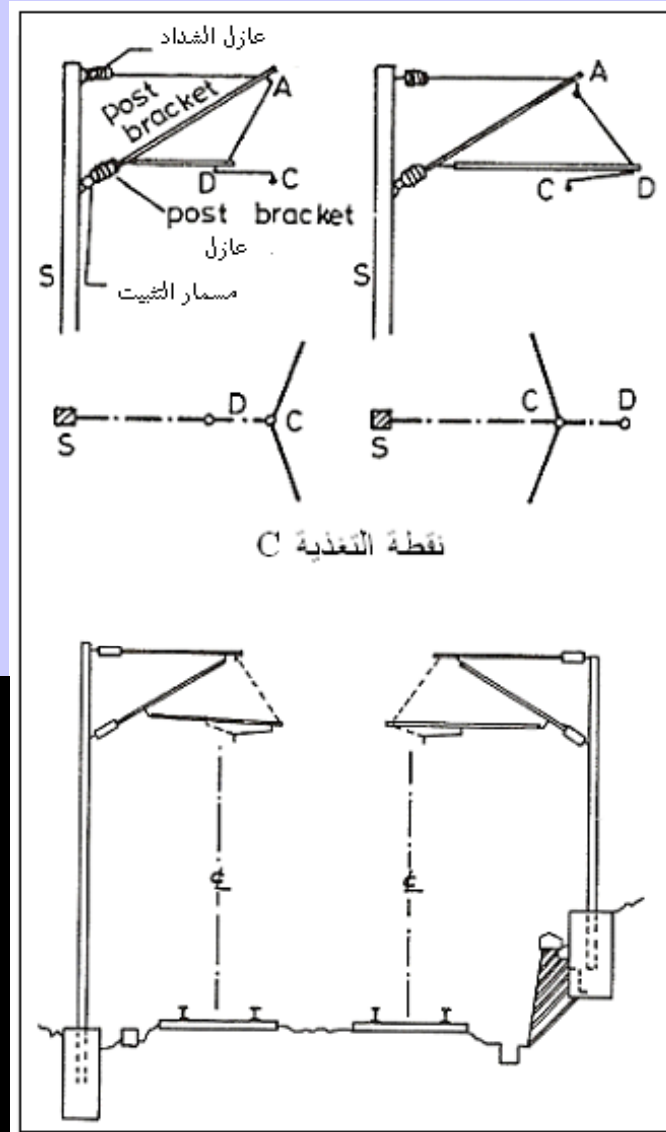
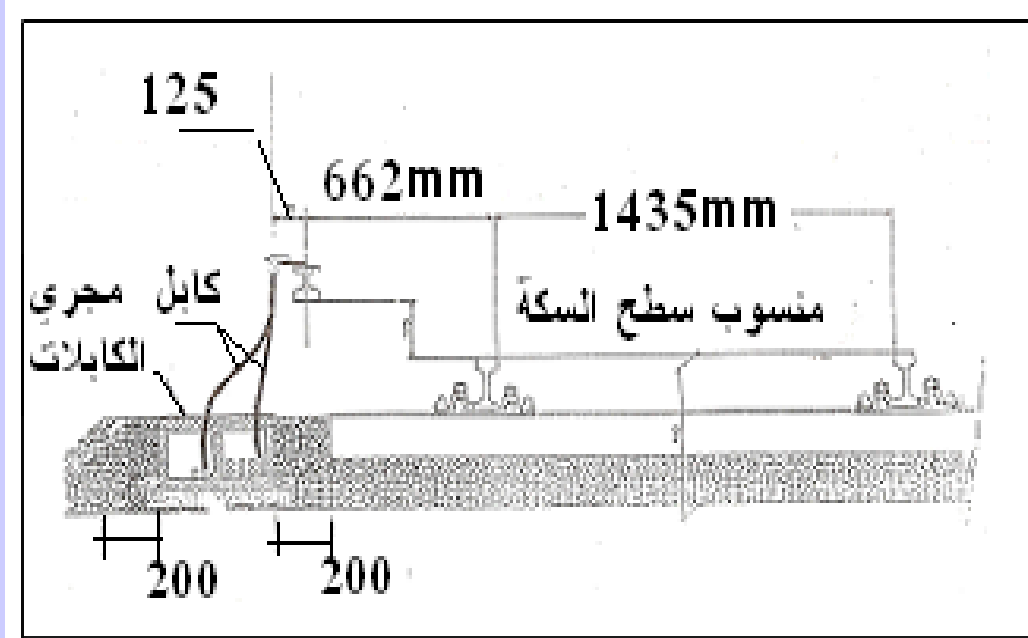
In contrast to Diesel traction where the energy required for train operation is generated within the diesel locomotive itself, the energy needed for electric traction is transmitted to the electric locomotive by an external subsystem, the power supply subsystem (substations and transmission lines).

Electric traction Engines obtain electric power from a conductor which may be:

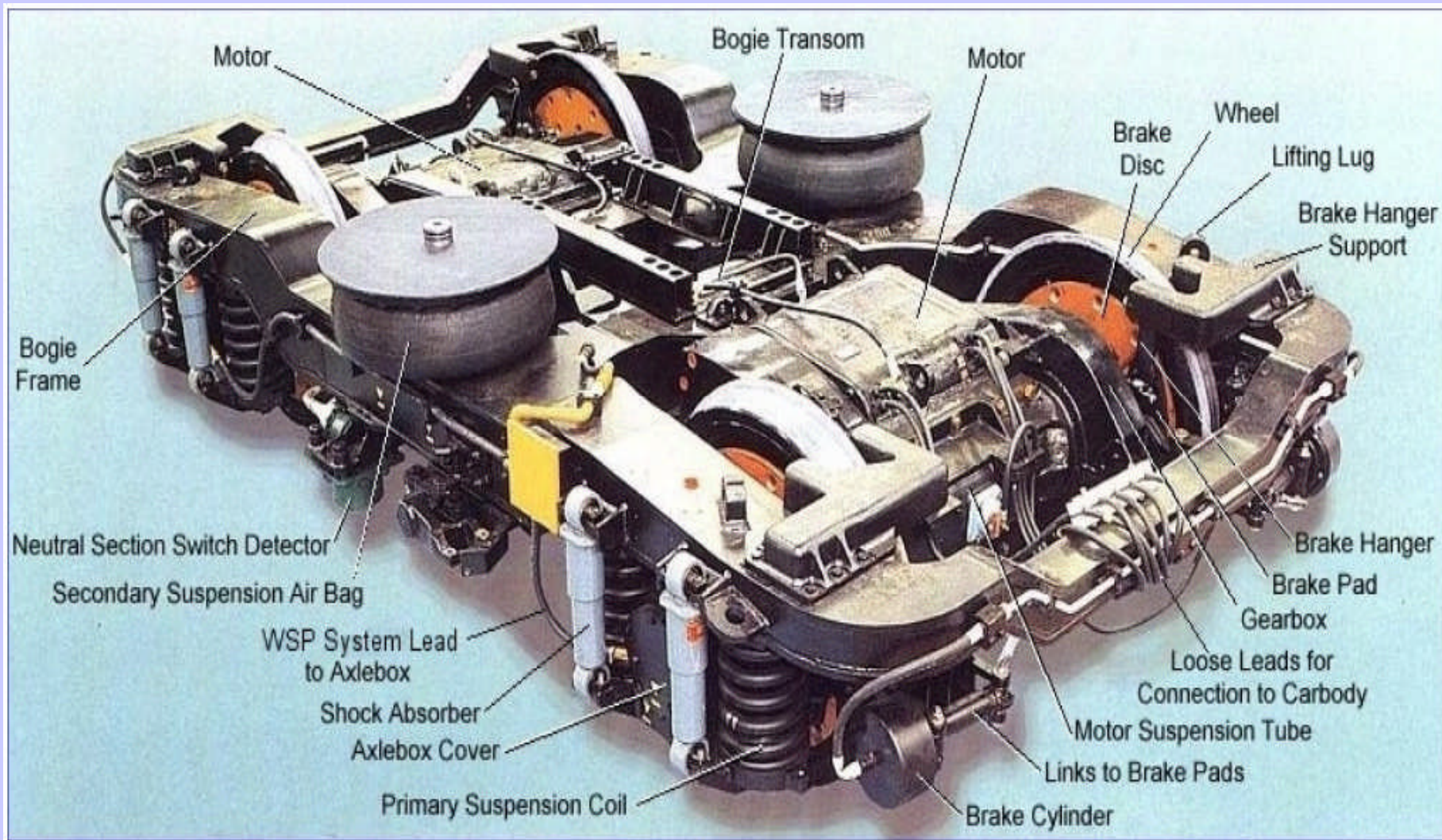
- Overhead line
- Third rail

Traction subsystem

The traction subsystem includes the electric traction engine with all its equipment and devices. The electric energy is converted into mechanical energy, which is used to operate the train.



The Truck



Advantages and Disadvantages of Electric Traction

- 1- The specific power is 50 – 55 kw/t, which is double the SP of diesel electric (20 – 25), that leads to haul heavier trains at high speeds.
- 2- Electric locomotives can sustain momentary overloads (when starting on steep gradients).
- 3- No power drop is observed on high altitude regions.
- 4- It is mandatory for operation in long tunnels due to limited air supply.
- 5- It causes little atmospheric pollution and noise.
- 6- It is far simpler and easier maintenance than diesel.