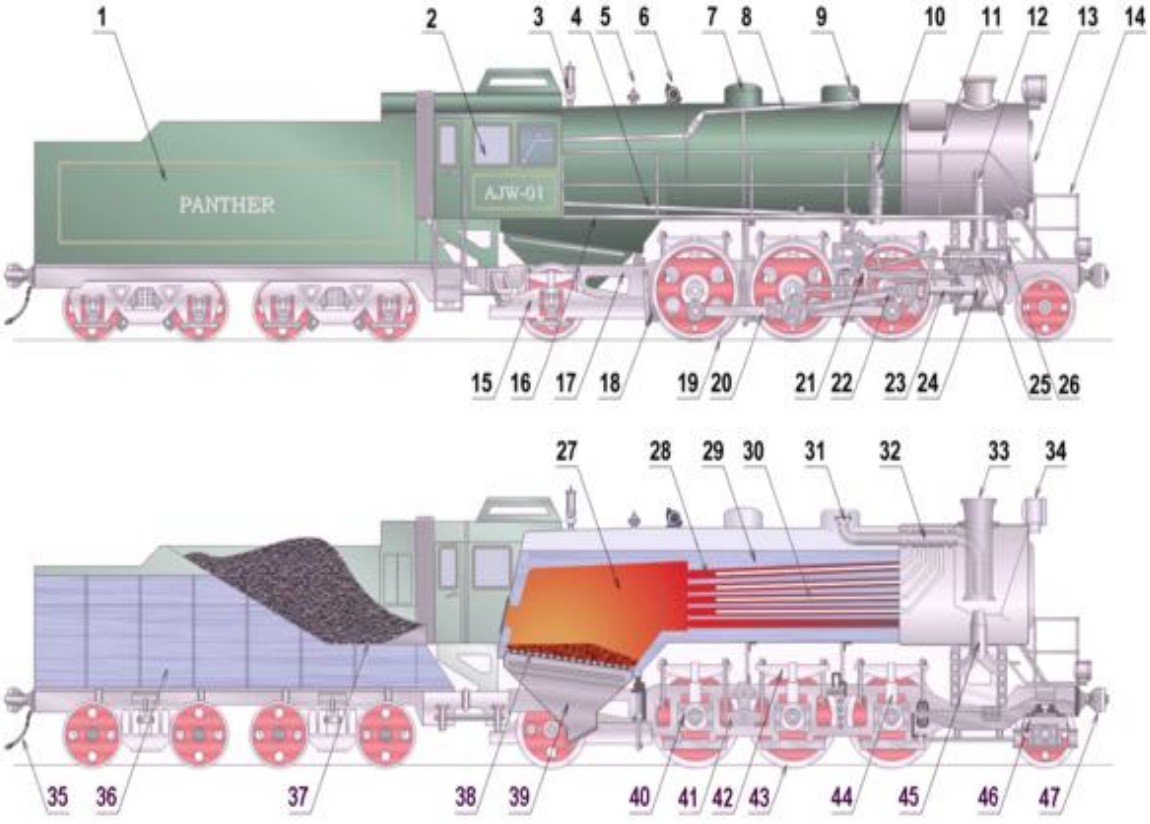
STEAM LOCOMOTIVE

Steam Engine Drive – This system was extensively used for railway work. A steam locomotive burns coal or oil, converting water into steam, and then uses the steam to drive pistons, which are connected by drive rods to the wheels. The motive power is supplied by the reciprocating steam engine. As the development of steam engines progressed through the 1700s, various attempts were made to apply them to road and railway use. The first working model of a steam rail locomotive was designed and constructed by John Fitch in the United States in 1794. The first full scale steam rail locomotive was built in Great Britain in 1804 by Richard Trevithick and Andrew Vivian. It ran with mixed success on the narrow gauge "Penydarren tramroad" at Merthyr Tydfil in Wales. Then followed the successful twin cylinder locomotive by Christopher Blackett's team built at Wylam in 1811, closely followed by Matthew Murrays' rack locomotive for the edge railed Middleton Railway in 1812. These early efforts culminated in 1829 with the Rainhill Trials and the opening of the Liverpool and Manchester Railway a year later making exclusive use of steam power for both passenger and freight trains.

The United States started developing steam locomotives in 1829 with the Baltimore and Ohio Railroad'sTom Thumb. This was the first locomotive to run in America, although it was intended as a demonstration of the potential of steam traction, rather than as a revenue-earning locomotive. The first successful steam railway in the US was the South Carolina Railroad whose inaugural train ran in December 1830 hauled by the Best Friend of Charleston. Many of the earliest locomotives for American railroads were imported from England, including the Stourbridge Lion and the John Bull, but a domestic locomotive manufacturing industry was quickly established, with locomotives like the DeWitt Clinton being built in the 1830s.

The following figure shows a steam engine alongwith its main parts



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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 electrical 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/Regulator** — 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). This is sometimes called a *Westinghouse pump* or *Knorr pump* after George Westinghouse and Georg Knorr.
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 smokebox 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. UK terminology is Footplate.
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. American locomotives usually have *bar frames* (made from steel bar) or cast steel frames, while British locomotives usually have *plate frames* (made from steel plate).
18. Brake shoe and brake block — 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** — Connects the driving wheels together.
21. **Valve gear** — System of rods and linkages synchronizing 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** — Connects 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 synchronized by the valve gear connect to the Drivers. Steam locomotives may have slide valves, piston valves or poppet valves.

26. **Valve chest/steam 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 is 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 smokebox to carry the exhaust (smoke) away from the engine so that it doesn't obscure the engineers vision. Usually extended down inside the smokebox - the extension is called a petticoat. Some railways, e.g. the Great Western Railway, fitted a decorative copper cap to the top of the chimney.
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. See air brake and vacuum brake.
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 axle's 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 centre 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.
48. **Snifting valve (not shown)** — An anti-vacuum valve which allows the engine to coast freely when the regulator is closed.

Advantages – The following are the main characteristics of the steam locomotive or steam engine drive which made it popular in the initial stages of traction systems in India:

1. It has a simple design which is easy to maintain.
2. Its initial cost is low in comparison to other traction systems

3. It is self contained unit and therefore, not tied to any particular track and hence can be put on any route.
4. The speed control arrangement is very simple and easy.
5. There is no interference with any telecommunication line adjoining the tracks.

Disadvantages – However due to the following drawbacks, the steam engine locomotive gave way to the diesel electric and electric traction systems:

1. The steam engine locomotive uses a non – condensing type boiler due to difficulty of installing a condenser which results in a very poor efficiency of 6 to 8 %.
2. An adequate supply of feedwater is required at regular intervals.
3. It has got limited availability and cruising range. For a standard passenger locomotive this cruising range is 160 km.
4. It cannot be put into service immediately since it required warming up time i.e. time to burn coal and convert water to steam which then can be used to provide motion.
5. Its overload capacity is limited.
6. Due to unbalanced reciprocating masses of steam engine, the ride quality is not good and there is considerable wear and tear of the track.
7. Due to low coefficient of adhesion, the power to weight ratio to steam locomotive is low.
8. It requires more number of crew members and hence it results in increase of wage bill.
9. A steam locomotive has very high centre of gravity because of boiler which limits its speed in negotiating curves.
10. A steam locomotive has to carry sufficient quantity of coal and water; it correspondingly reduces the payload which can be hauled by it.
11. It requires more repair and maintenance as compared to other traction systems.
12. The steam locomotive cannot be used for underground railways due to smoke.
13. It has low operational availability. The average availability of steam locomotive is 11 to 14 hours per day.
14. Bigger sizes of running sheds and workshops are needed for steam locomotives.