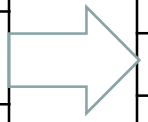
ME265: Thermal Engineering & Heat Transfer

Chapters
1. Energy Scenario
2. Thermodynamics
3. Mechanical Machines & Systems
4. Heat Transfer



3.1	IC Engines
3.2	Gas Turbines, Jet Engines
3.3	**Steam Turbines**
3.4	**Boilers**
3.5	**Refrigeration & AC systems**

Introduction to Boiler

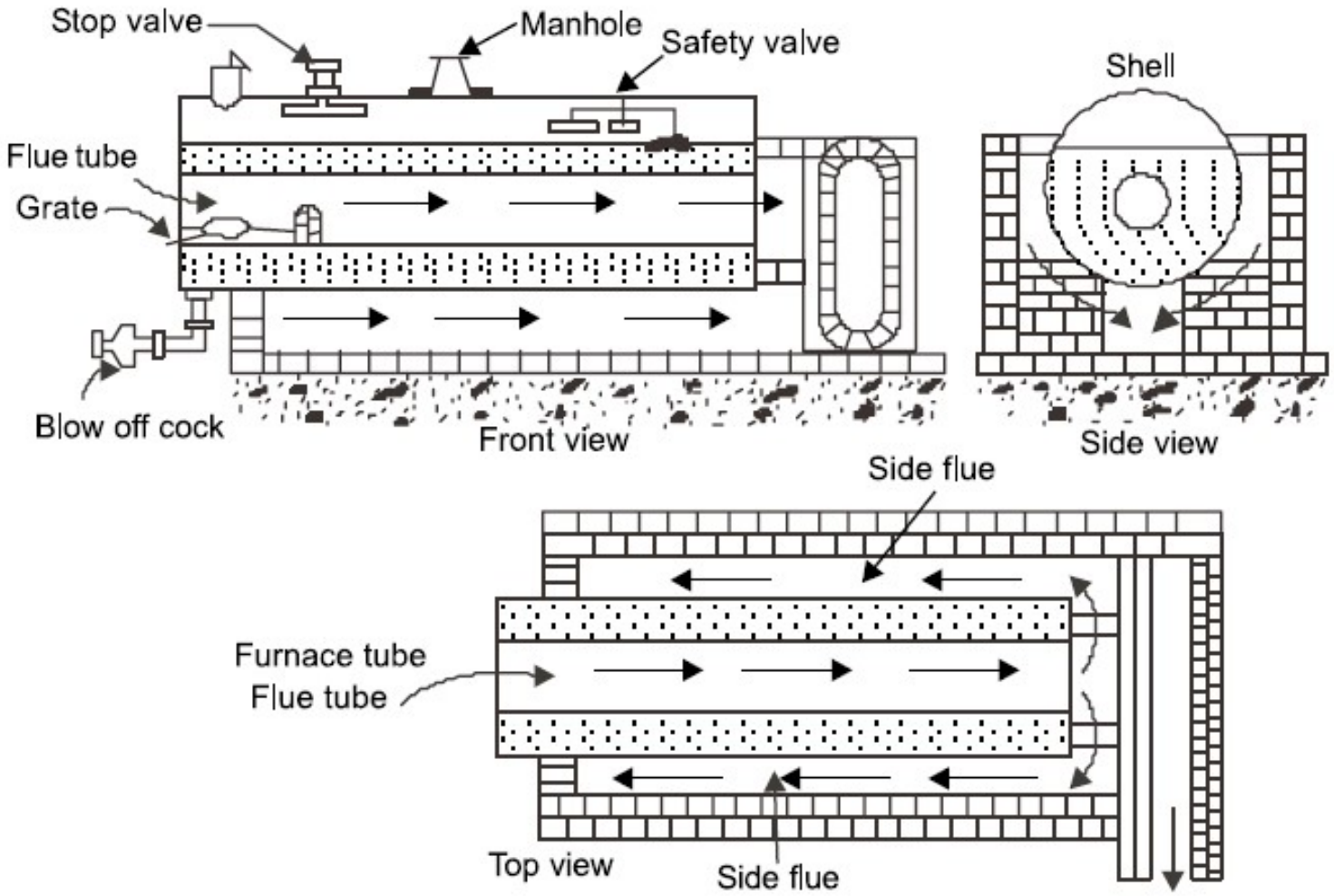
Boiler is an apparatus to produce steam

Thermal energy released by combustion of fuel is used to make steam at the desired temperature and pressure.

The steam produced is used for:

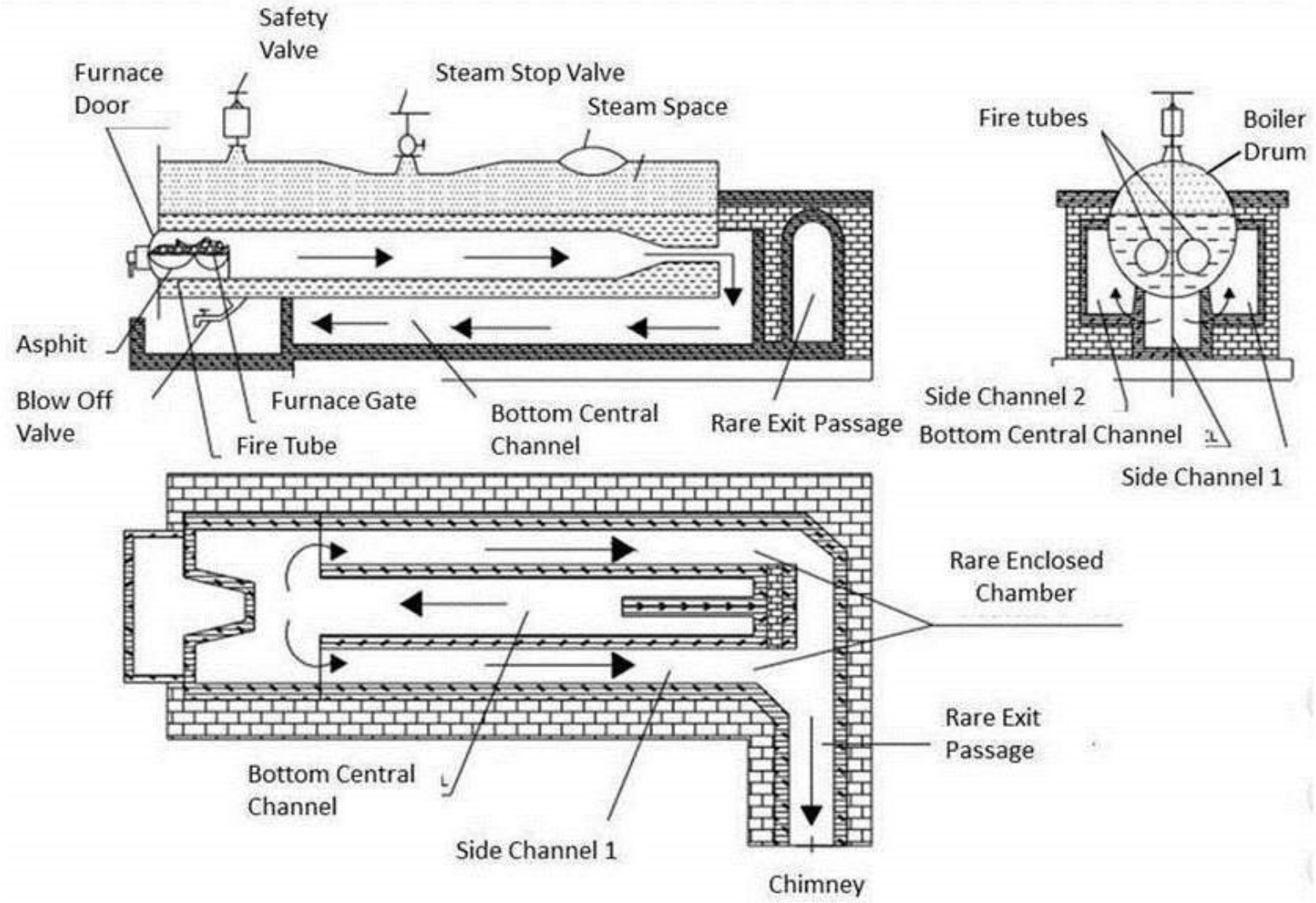
a. Producing mechanical work by expanding it in steam engine or steam turbine.
b. Heating the residential and industrial buildings
c. Performing certain processes in the sugar mills, chemical and textile industries.

Introduction to Boiler



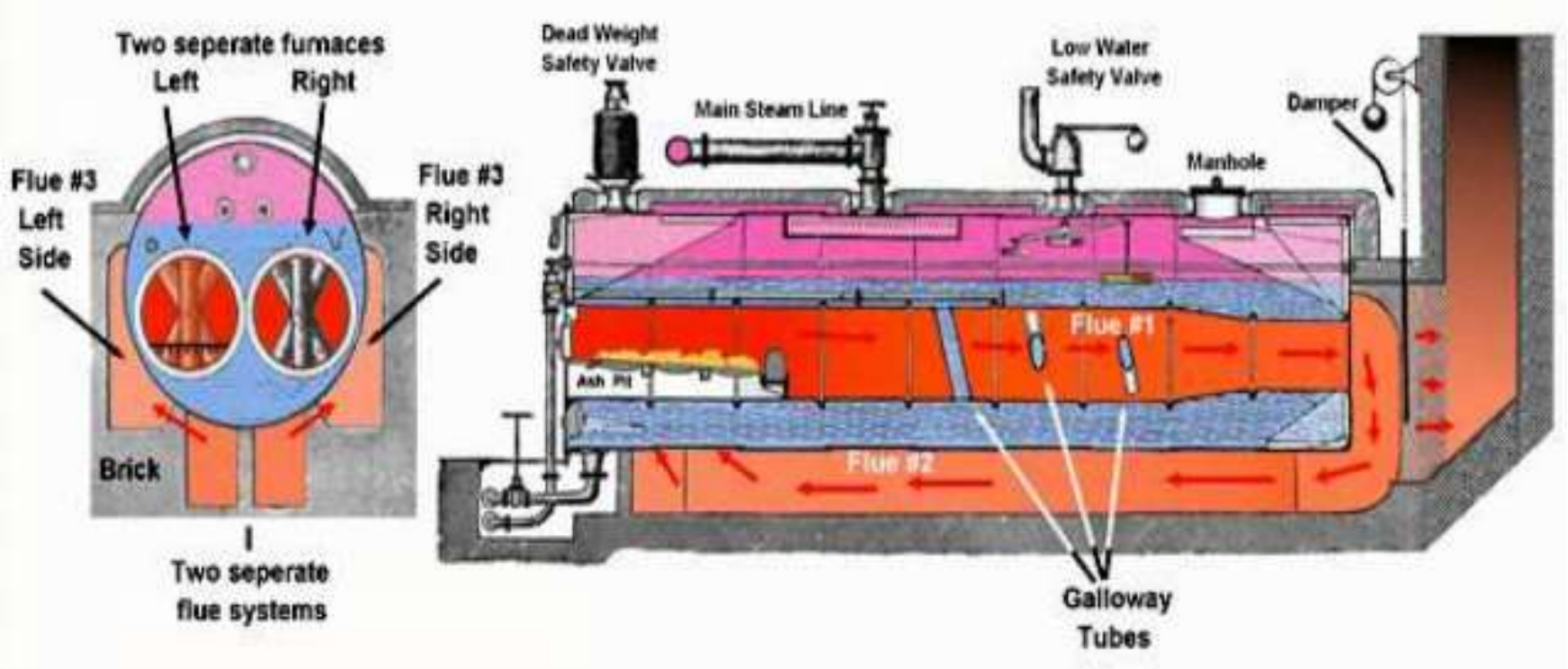
Cornish Boiler

Introduction to Boiler



Lancashire boiler

Introduction to Boiler

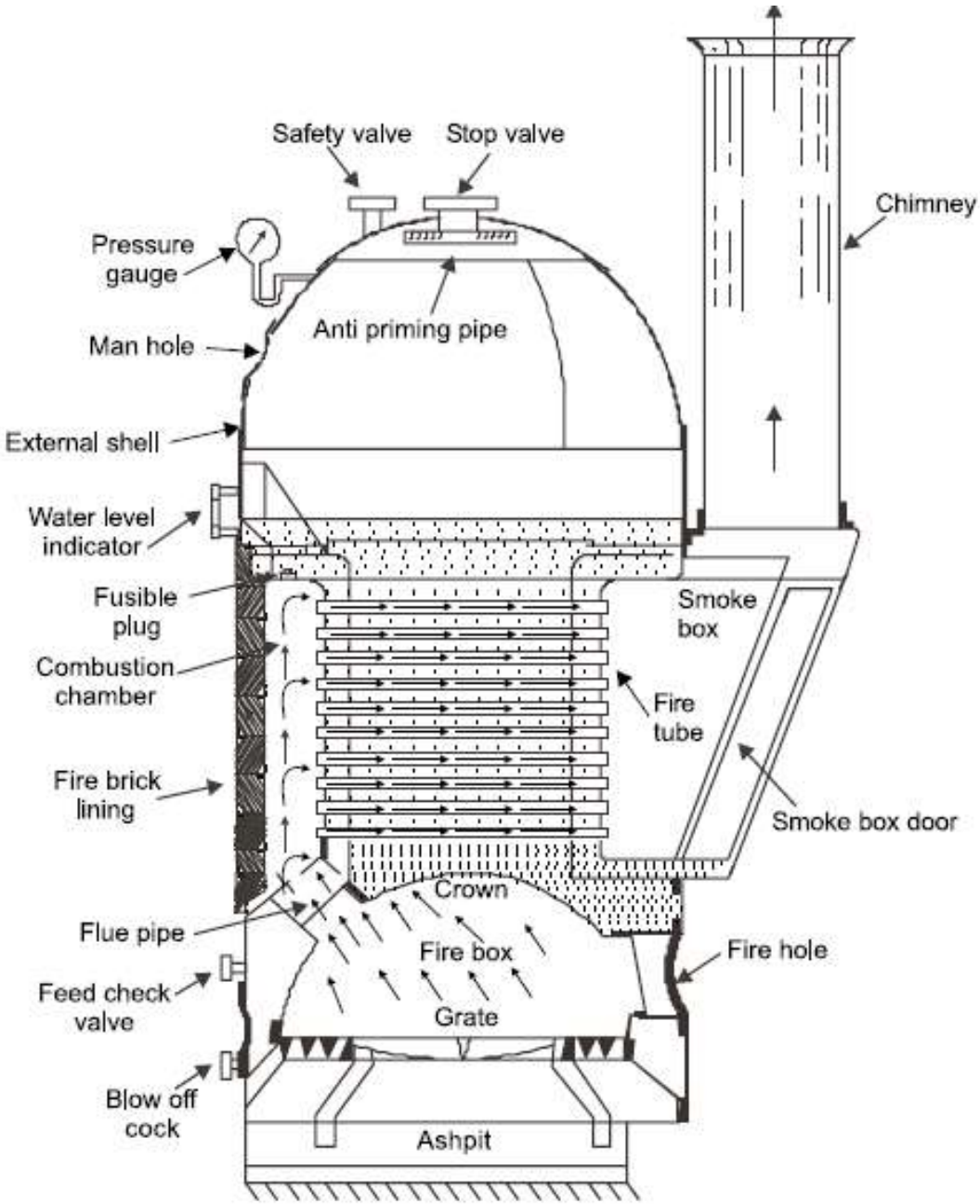


Lancashire boiler

Lancashire boiler

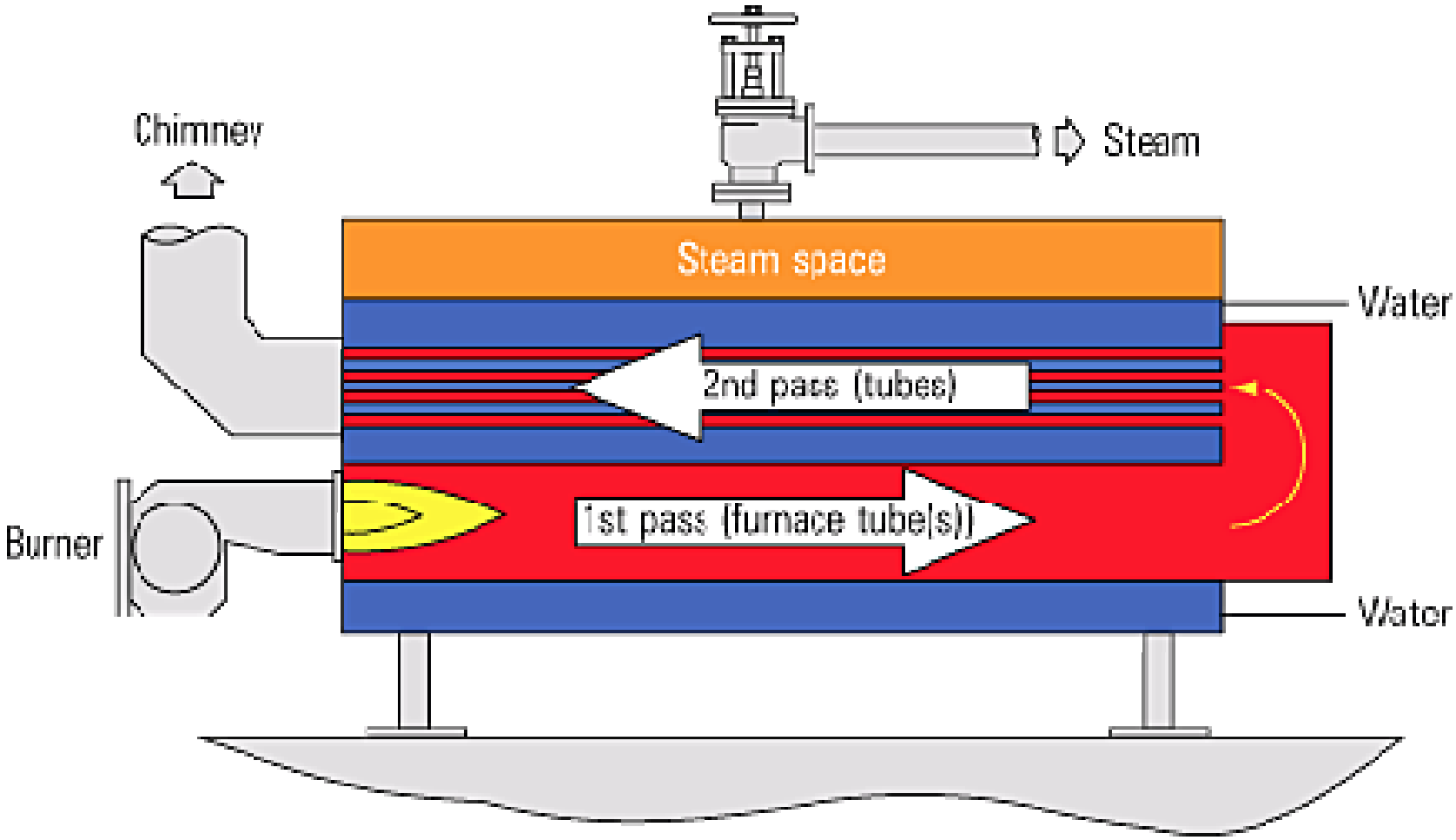
- **Sir William Fairbairn** developed the Lancashire boiler in 1844 from **Trevithick's** single flue Cornish boiler.
- The Lancashire boiler comprised a large steel shell usually between 5 - 9 m long through which two large-bore furnace tubes called flues passed.
- A furnace was installed at the entrance to each flue at the front end of the boiler. Typically, the furnace would be arranged to burn coal, being either manually or automatically stoked.
- Although only a few are still in operation, they were ubiquitous and were the predecessors of the sophisticated and highly efficient boilers used today.

Introduction to Boiler

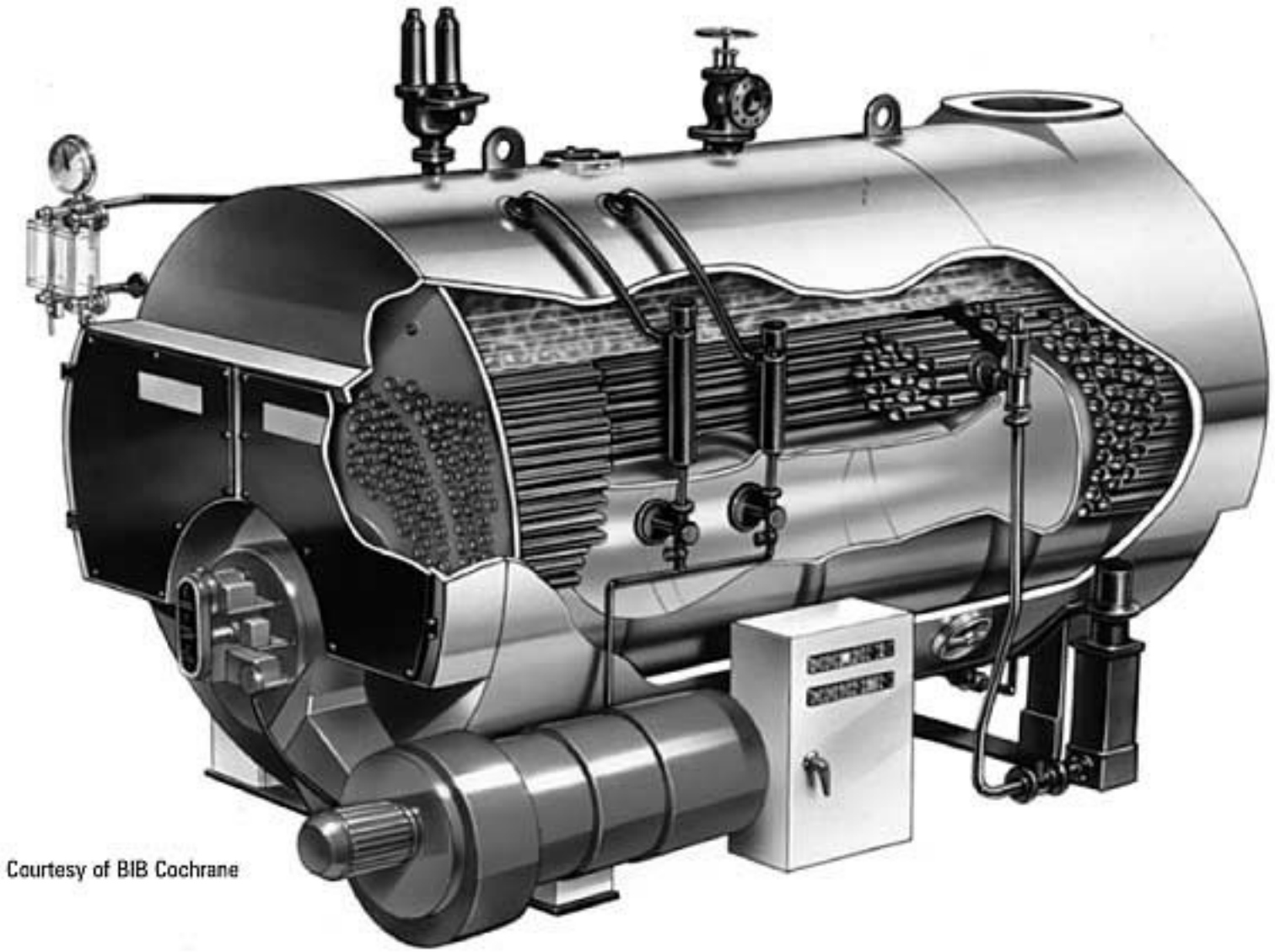


Cochran Boiler

Economic boiler, dry back type



Modern Package boiler



Courtesy of BIB Cochrane

Road transportation for Package boiler

SITONG BOILER

Warm The World With Quality

https://www.alibaba.com/showroom/top-10-boiler-manufacturers.html

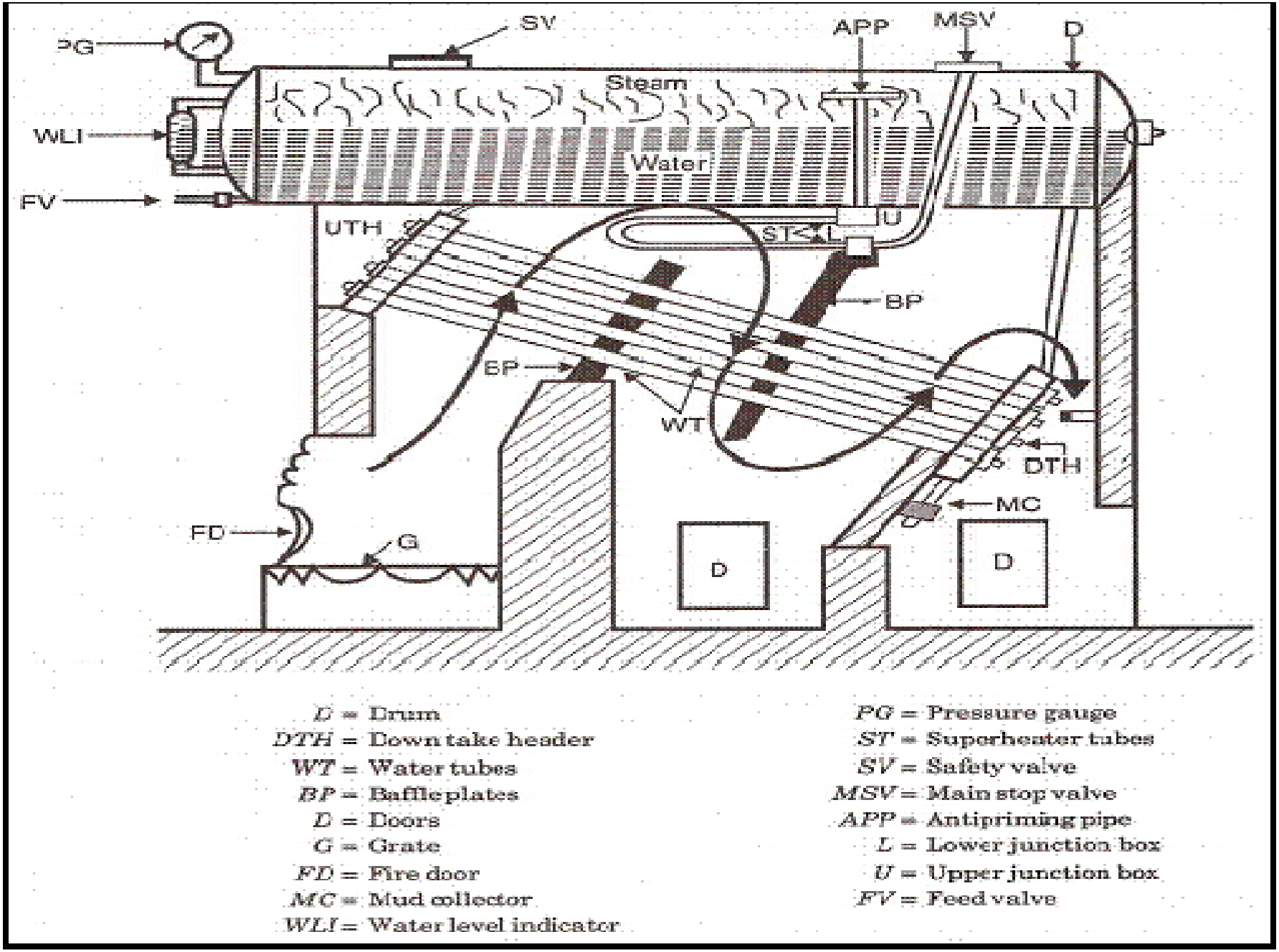
Classification of Boiler:

Boilers are classified in various aspects

<u>Considering flows of fluid inside tubes:</u>

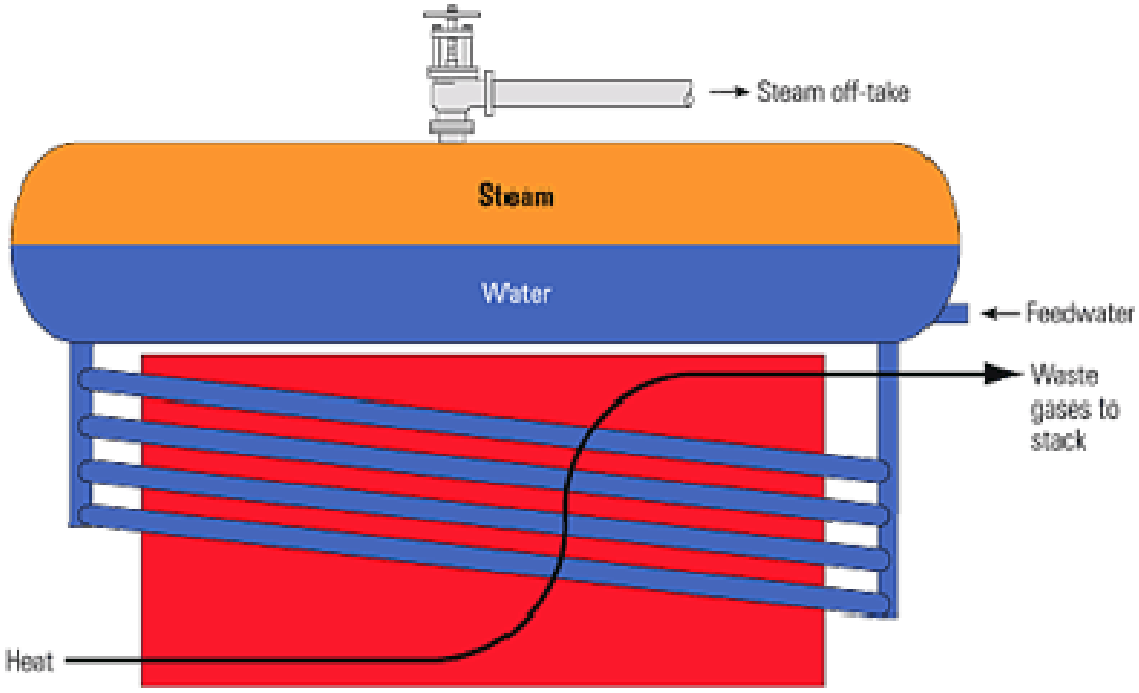
a) **Water tube boiler**

b) **Fire tube boiler**



D = Drum
DTH = Down take header
WT = Water tubes
BP = Baffle plates
D = Doors
G = Grate
FD = Fire door
MC = Mud collector
WLI = Water level indicator
PG = Pressure gauge
ST = Superheater tubes
SV = Safety valve
MSV = Main stop valve
APP = Antipriming pipe
L = Lower junction box
U = Upper junction box
FV = Feed valve

BABCOCK WILCOX BOILER



Longitudinal drum boiler

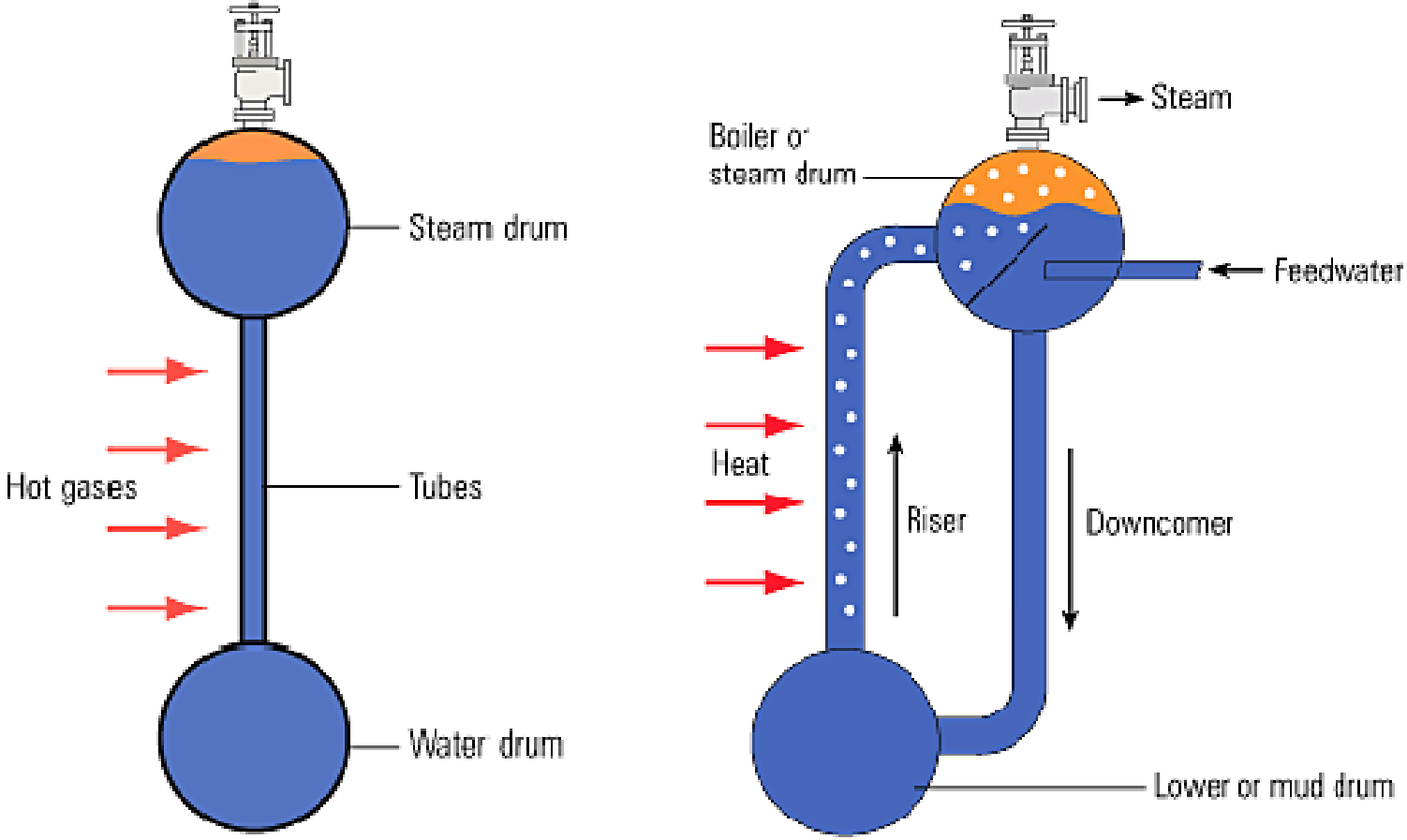
Important features:

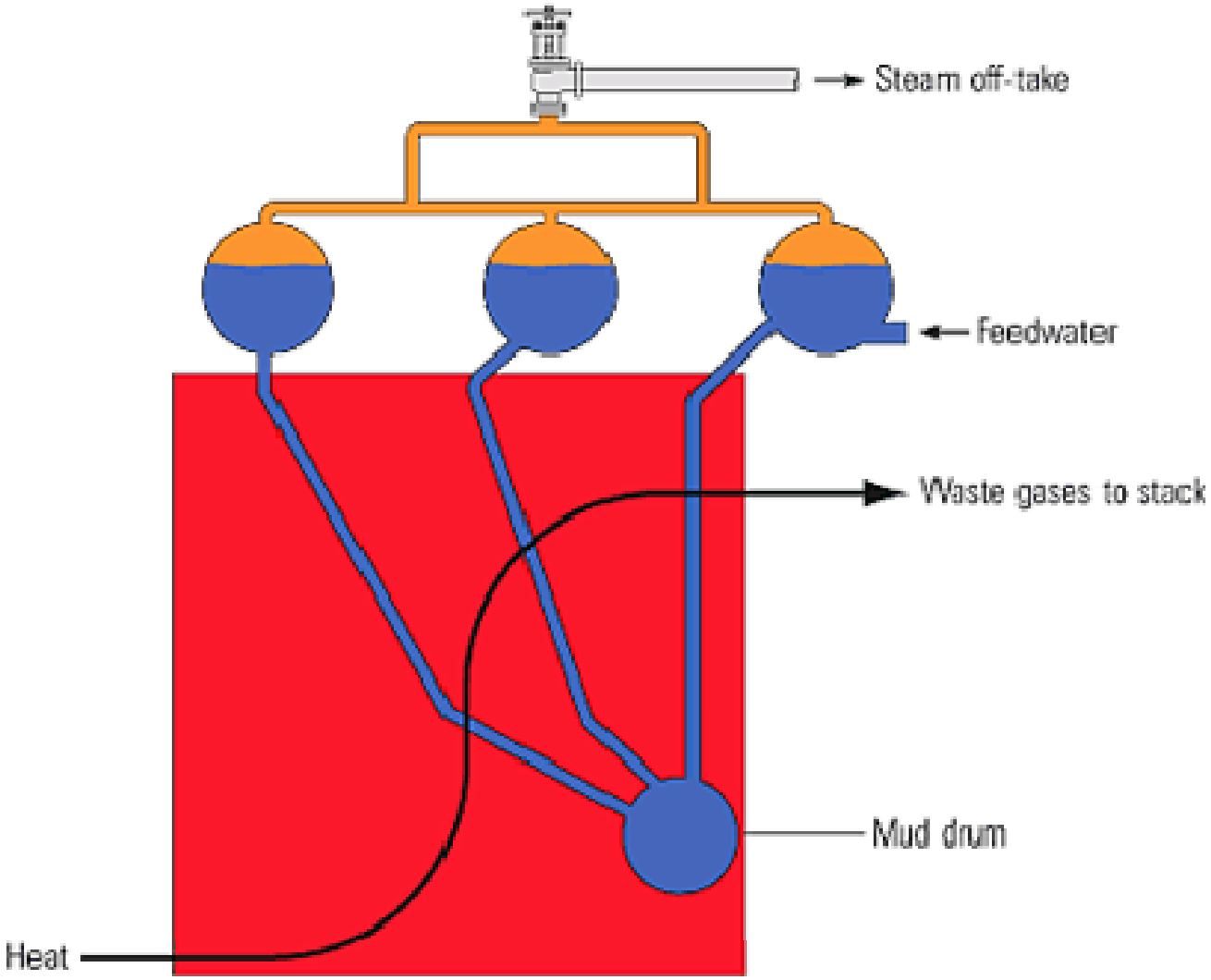
It consists of drums and tubes. Tubes are always external to the drums and serve to interconnect them.

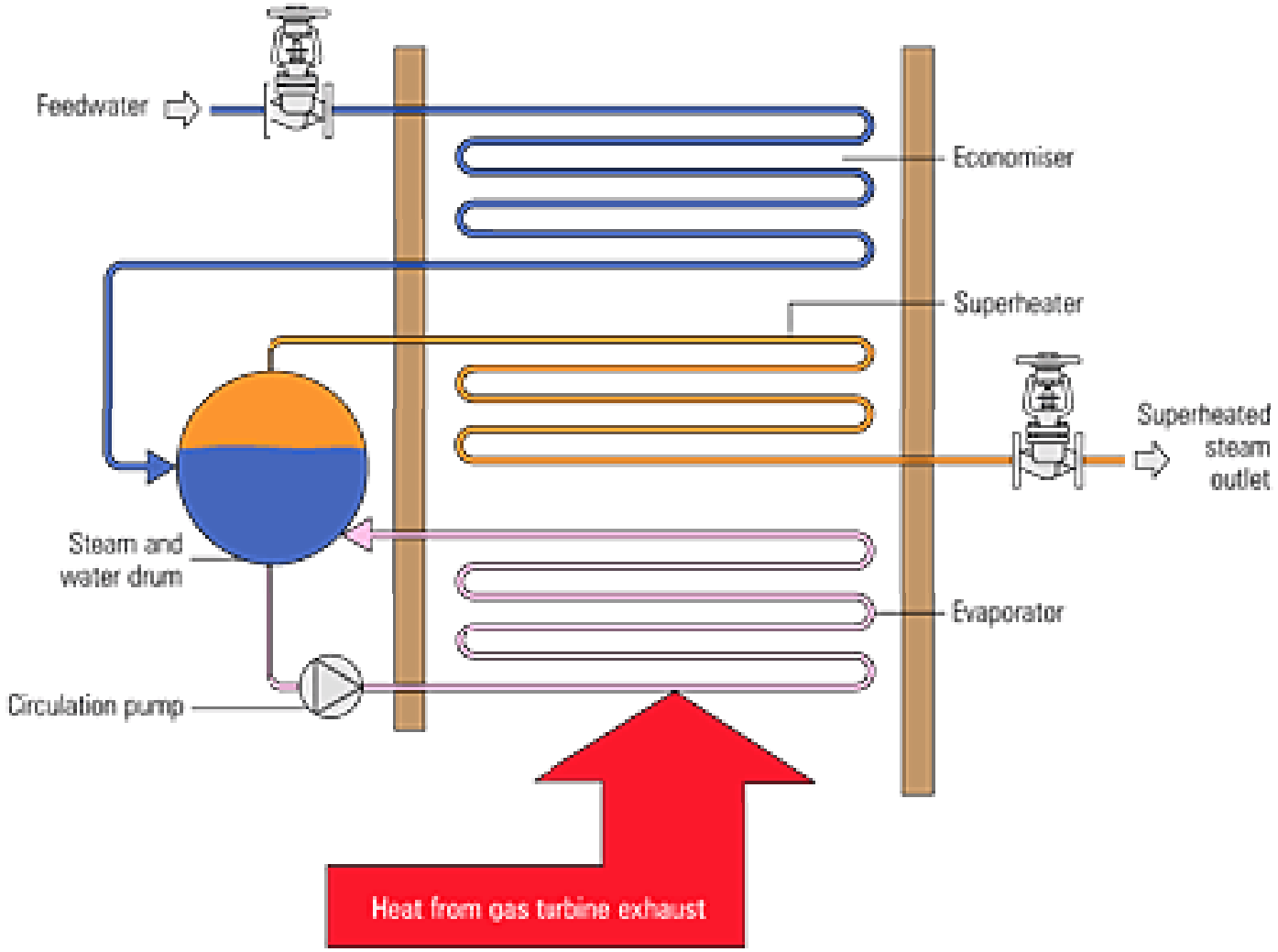
The drums are used for storage of water and steam. As they are not required to contain tubular heating surface, they can be much smaller in diameter than the fire tube shell and can, therefore, be built to resist high pressure

Generation of steam is quicker as water is subdivided into small volume.

The initial cost, operational cost and maintenance costs of water tube boiler is higher than that of an equivalent fire tube boiler,

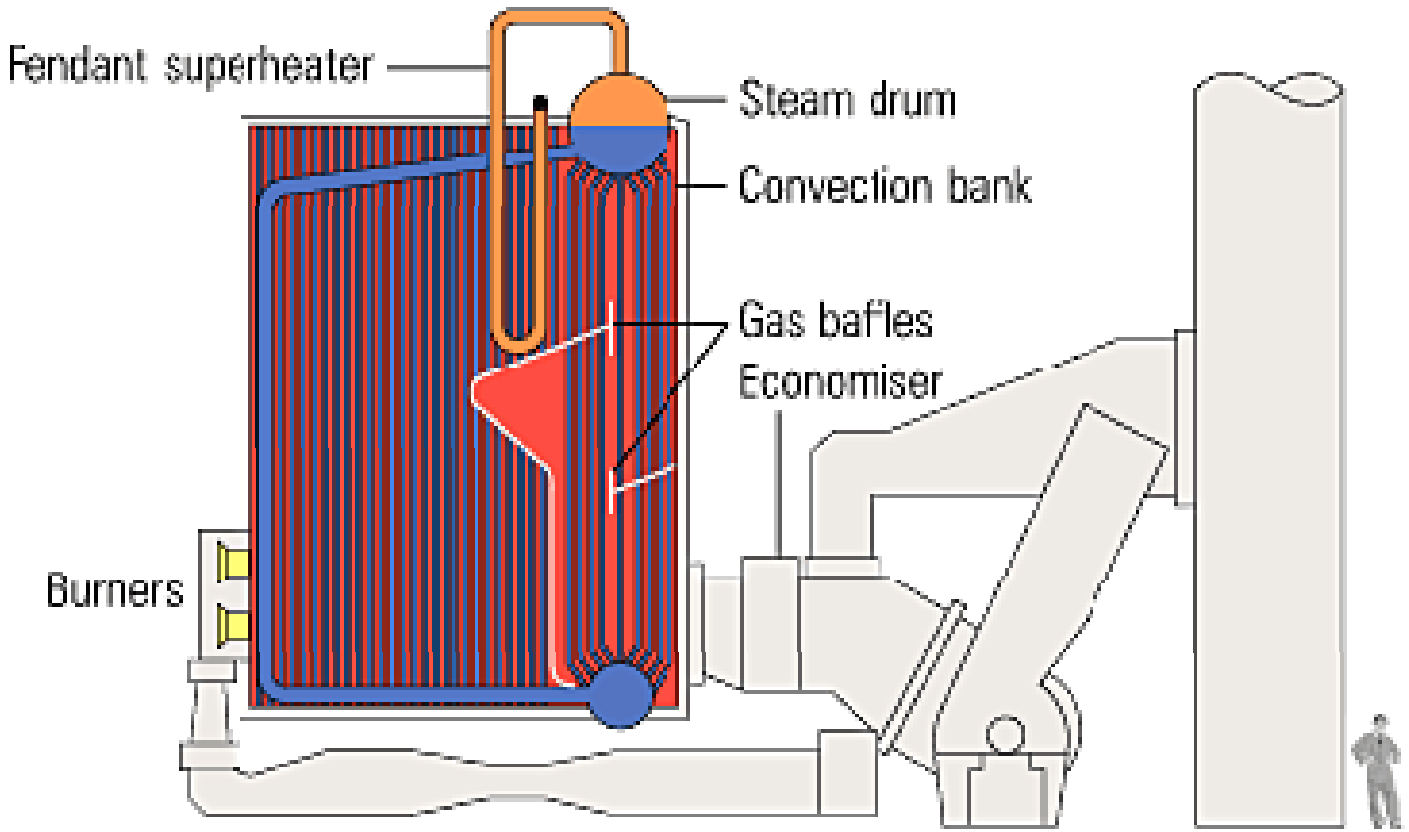

Steam drum
Hot gases
Tubes
Water drum
Steam
Boiler or
steam drum
Feedwater
Heat
Riser
Downcomer
Lower or mud drum


Steam off-take
Feedwater
Waste gases to stack
Mud drum
Heat



A forced circulation water-tube boiler

Water tube boiler



Boiler Mountings:

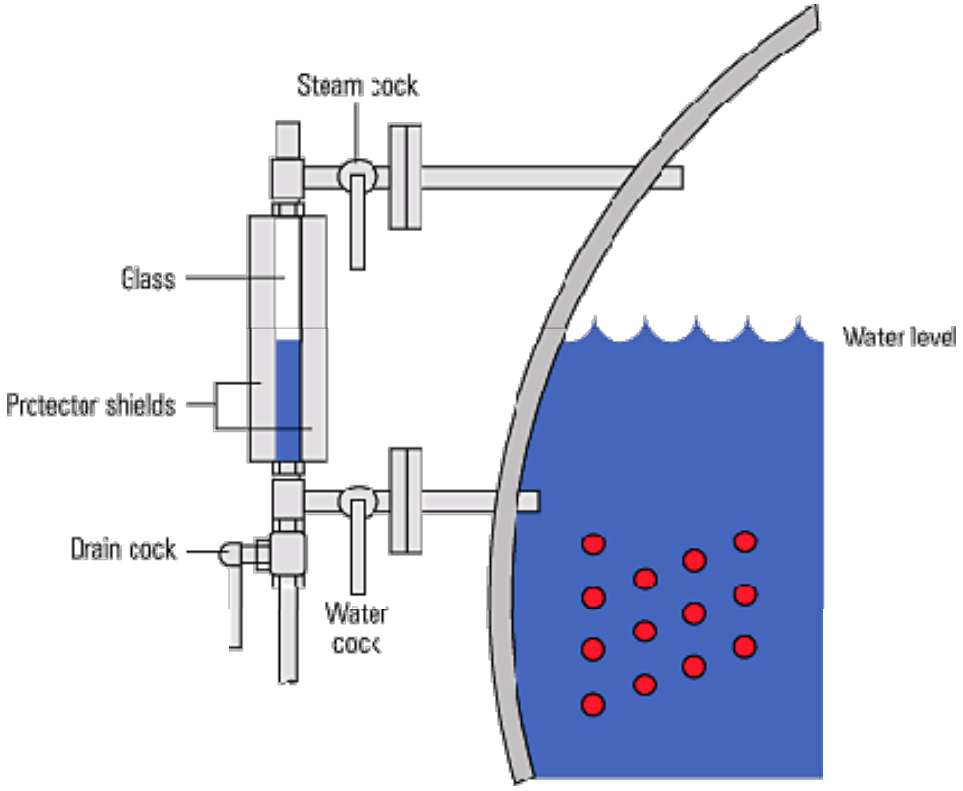
Different fittings and devices necessary for the operation and safety of a boiler are called *boiler mountings* which are generally mounted over the boiler shell.

These devices are

(1) Water gauges
(2) Pressure gauges
(3) Pressure relief valves
(4) Steam stop valve
(5) Feed check valve
(6) Blow down valve
(7) Low water alarms
(8) Fusible plug
(9) Man and mud holes covers

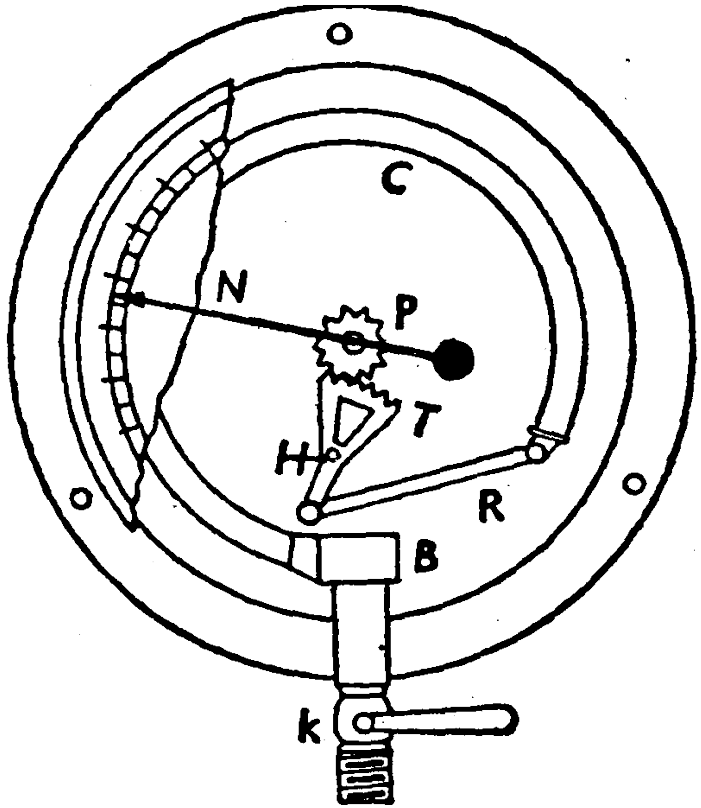
Boiler Mountings: (1) Water Gauges

The *water gauge is* needed to ascertain the water level of a boiler. So it is also called the *water level indicator. Two* water gauges should be fitted for each boiler in such a place that the water level can be constantly seen.



Boiler Mountings: (2) Pressure Gauges

A pressure gauge is an instrument by means of which the pressure exerted inside a vessel can be measured. There are two types of pressure gauges, one is *Bourdon tube pressure gauge* and the other is *diaphragm type gauge.*



C-Spring tube, B-Block, R-Rod, H-Hinged point, T-Toothed sector, P-Pinion, N-Pointer, K-Cock

Boiler Mountings: (3) Pressure relief valve

The pressure relief valve is used in a boiler to relieve the pressure of steam when it is above the working pressure. It is usually called the *safety valve.*

Its function is to discharge a portion of the steam from the boiler automatically when the steam pressure exceeds the normal limit. So there is a decrease in steam pressure until it becomes normal again. It is mounted on the top of the shell.

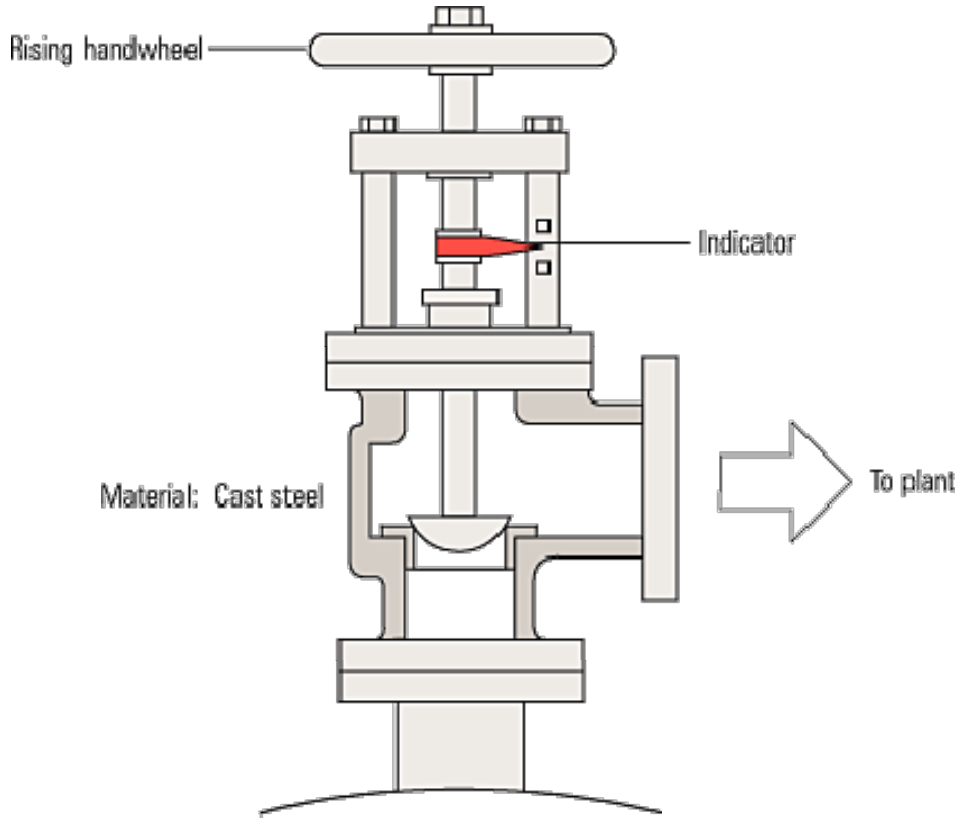
As per boiler regulation two safety valves are required to be fitted in each boiler. These two valves may be arranged in two separate casings or in a single casing.

Boiler Mountings: (4) Steam Stop valve

The function of the stop valve or junction valve is to regulate the flow of steam from one steam pipe to the other or from the boiler to the steam pipe.

When this valve is mounted over the boiler to control the flow of steam from the boiler, it is called a *junction valve.*

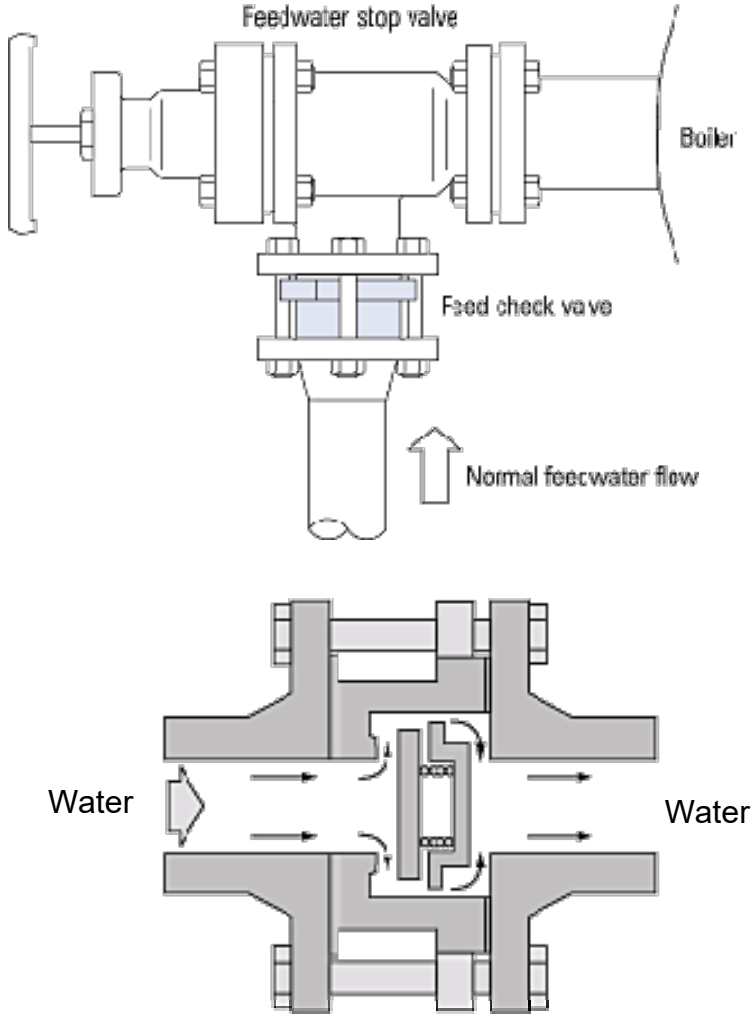
If the valve is placed near the engine or between the steam pipes, it is called a *stop valve*



Boiler Mountings: (5) Feed check valve

The *feed check valve* is used to control the supply of water to the boiler and to prevent the escaping of water from the boiler when the pump pressure is less or the pump is stopped.

It is fitted over the shell slightly below the normal water level of the boiler.

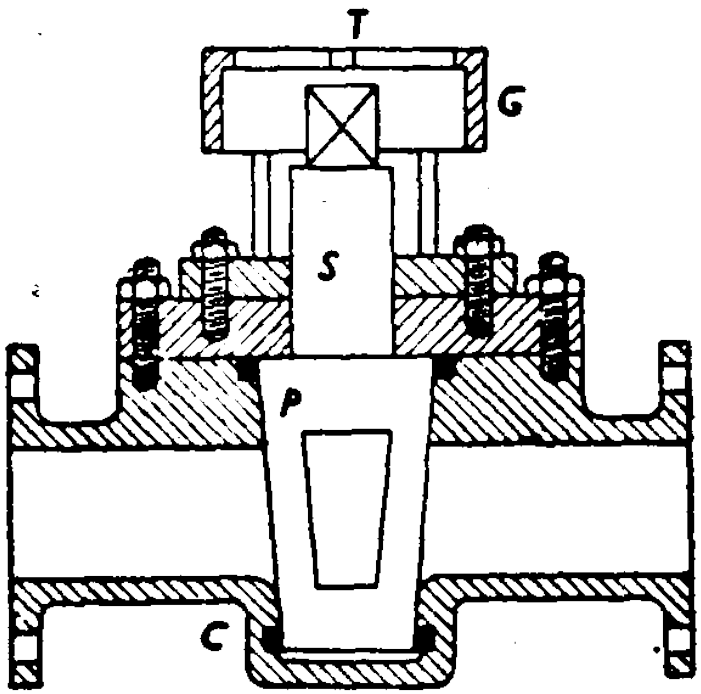


Boiler Mountings: (6) Blow down valve

The *blow down valve* or *blow-off cock* has two functions:

(i) It may empty the boiler when necessary for cleaning, inspection and repair.
(ii) It may discharge a portion of water when the boiler is, in operation to blow out mud, scale or sediments periodically.

It is fitted at the lowest part of the boiler either directly with the boiler shell or to a pipe connected with the boiler.

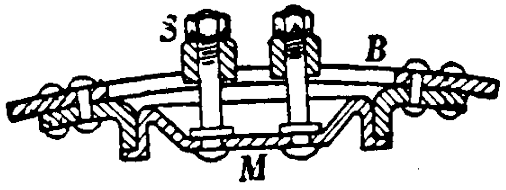


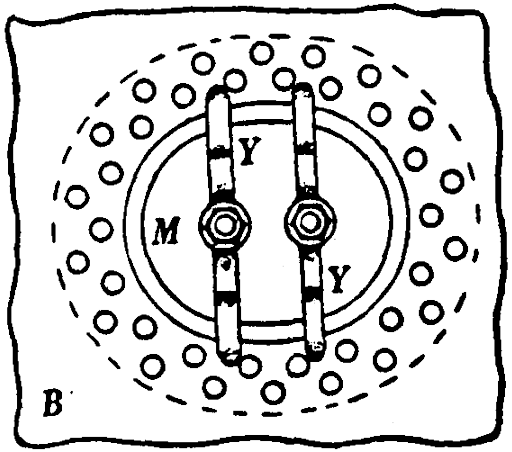
Boiler Mountings:

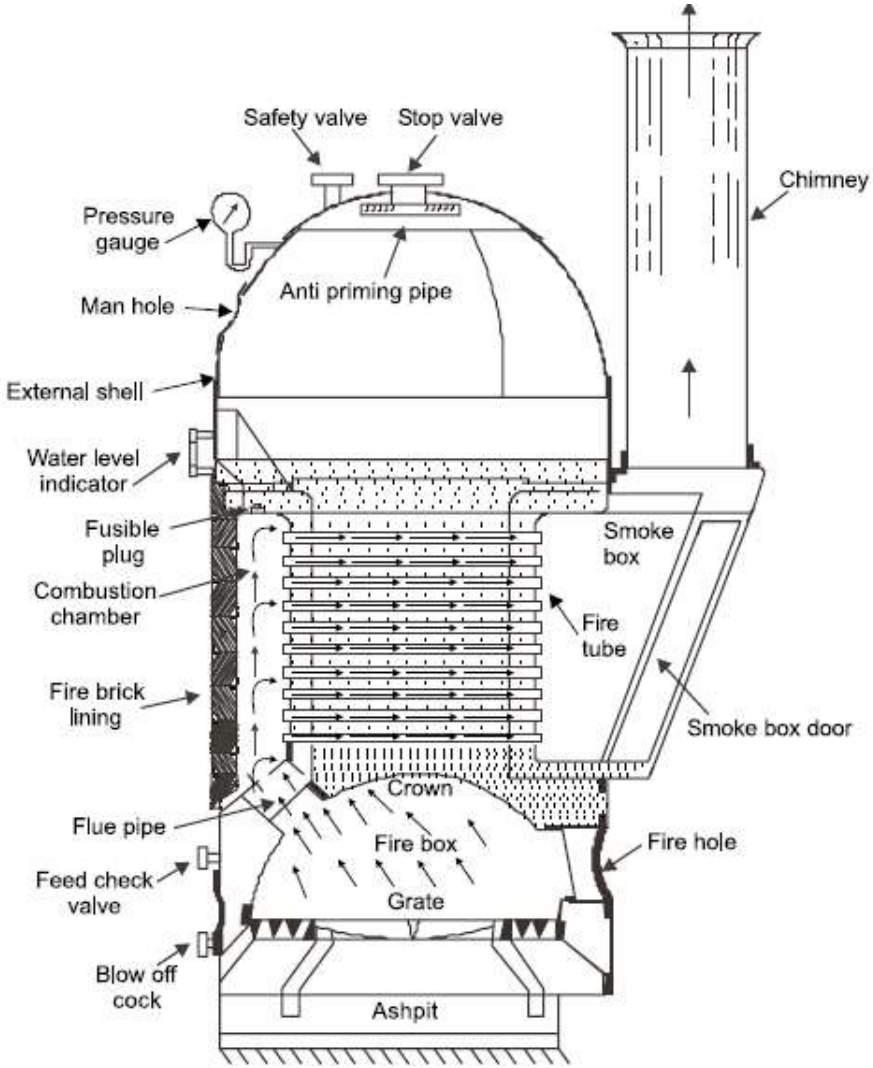
(7) Low water alarms

(8) Fusible plug

(9) Man and mud holes covers







Boiler Accessories:

Boiler accessories are auxiliary plants and devices required for the proper and efficient operation of boilers.

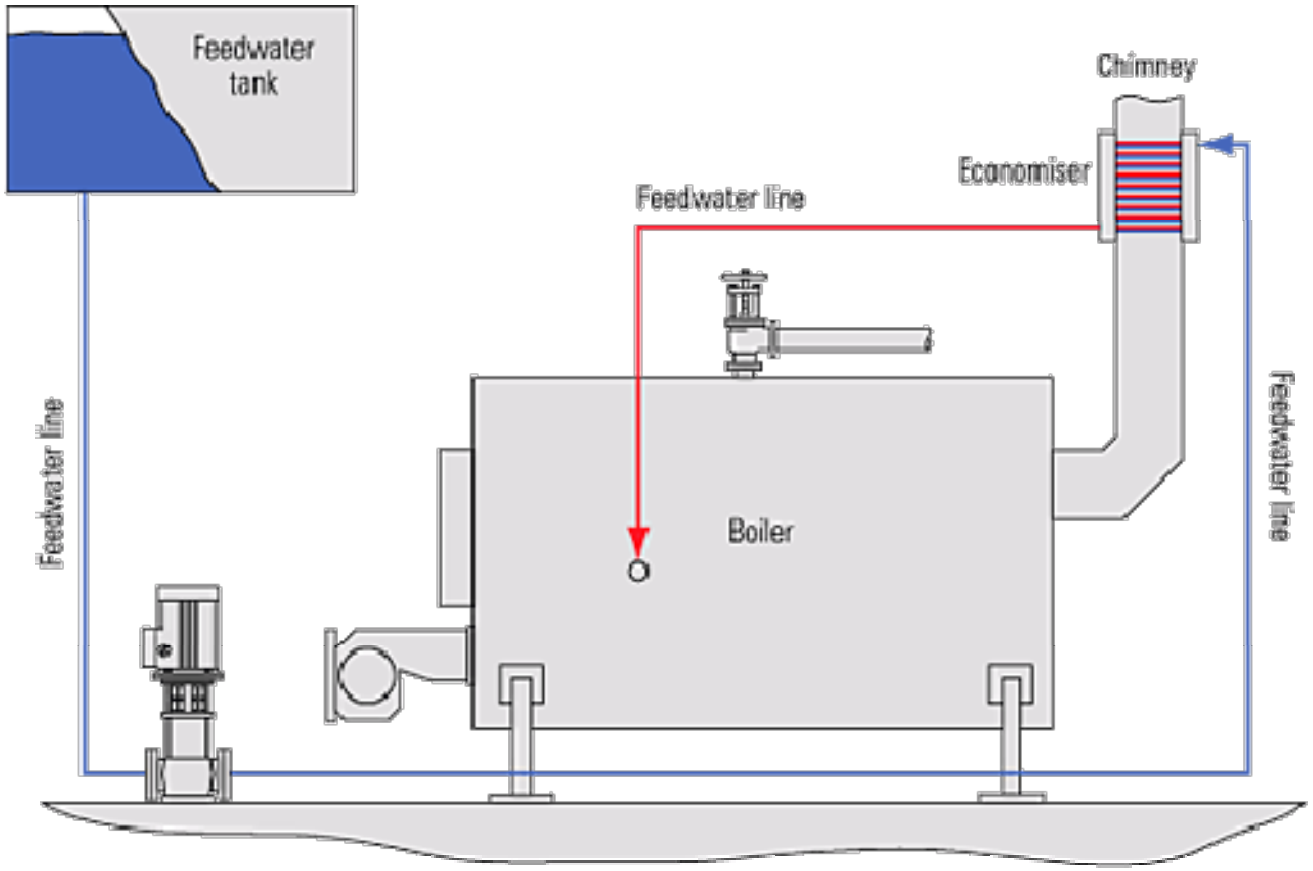
These devices are

(1) Superheaters, economizers, and air pre-heaters
(2) Feed water heaters
(3) Feed pumps
(4) Draught production equipment

Similar to the steam generating unit, superheaters, economizers, and air-preheaters also utilize the heat of the furnace gases. In a high pressure boiler they are placed inside the same boiler setting.

Feed pumps and injectors are essential accessories for the operation of the boiler plant. They are required to force water into the boiler.

The draught production equipment are required for the proper combustion of fuel.


Feedwater tank
Chimney
Economiser
Feedwater line
Feedwater line
Boiler
Feedwater line

Essential of a good boilers:

1. The boiler should be capable of generating steam at the required pressure and of the required quality quickly and with minimum fuel consumption.
2. The initial cost, installation cost and the maintenance cost of the boiler should not be too high.
3. The boiler should be light in weight, should need the least amount of brick work construction and should occupy small floor area.
4. The boiler should meet the fluctuating demands or steam supply without being overheated
5. The different parts of the boiler should be easily approachable for repairs.

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Essential of a good boilers: (contd..)

6. The boiler should have only minimum joints and those too should be away from direct flames.
7. The boiler should offer the ease of dismantling the parts and erection at site within reasonable time and labor. This is necessary for a boiler which has to be transported quite often.
8. For efficient heal transmission rate, the water and flue gases should have maximum velocity without incurring heavy frictional losses.
9. There should be no deposition of mud and other foreign particles on the heated surfaces
10. The boiler should conform to the safety regulations as laid down in the "Boilers Act".

Boiler Performance

Actual Evaporation:

As the function of a boiler is to generate steam, so the amount of water evaporated may be considered as a performance parameter of the boiler.

The quantity of steam which is actually produced in boiler at the observed conditions is known as an *actual evaporation.* The observed conditions are the pressure, quality of steam and temperature of feed water.

As the steam is usually generated in a boiler at constant pressure, so heat supplied by the fuel is equal to the enthalpy absorbed by the steam. If m_a be the mass of steam formed actually in a given time in kg, then

$$Q=m_a (h_2—h_1)$$

where *Q* denotes the amount of heat utilized and $h_2—h_1$ denotes the amount of enthalpy absorbed per kg of steam.

Boiler Performance (contd..)

Equivalent evaporation:

The mass of water that can be evaporated from and at 100°C into steam by utilizing the same amount of heat that is required by the actually evaporated steam is called the equivalent evaporation.

$$m_e = m_a(h — h_0)/h_{fg}$$

Where, m_e be the mass of equivalent evaporation
m_a be mass of actually evaporated water
h be the enthalpy of steam per unit mass
h_0 be the enthalpy of feed water
h_{fg} be the enthalpy of evaporation at 100°C.

The expression $(h — h_0)/h_{fg}$ is called the *factor of evaporation*

Boiler Performance (contd..)

Boiler Capacity

Evaporation or equivalent evaporation per hour may be taken as a measure of *boiler capacity.* It is generally measured in tons or kg per hour.

The *rated capacity of* a steam boiler is the average amount of steam generated in tons or kg per hour for a long period of time and at maximum boiler efficiency.

What is meant by Boiler Capacity of 4 ton/hr ?

Boiler Performance (contd..)

Boiler Efficiency

Efficiency of a boiler (or a boiler plant) may be defined as the ratio of heat utilized for the generation of steam to heat supplied due to the burning of fuel.

$$\eta = \frac{\text{Energy utilized}}{\text{Energy supplied}} = \frac{m_s (h - h_0)}{m_f \times HV}$$

Where, m_s be the mass of steam evaporated in a given time
m_f be the mass of fuel burnt at the same time
HV be the heating value of fuel per unit mass
h be the enthalpy per unit mass of steam
h_0 be the enthalpy of feed water

Boiler specifications

Following points should be considered to specify a boiler:

1. Type: Whether it is (i) fire tube or water tube and (ii) stationary or portable boiler
2. Pressure: At what pressure steam is delivered?
3. Quality of steam: Whether steam is superheated? If so, the outlet temperature should be stated.
4. Capacity: The amount of steam generated be given in tons/hr.
5. Heating surface: As the transfer of heat depends on heating surface, so it is required to be known.
6. Auxiliary heating devices: Whether different accessories such as superheater, economizer, etc., are fitted in the boiler?
7. Fuel: Type of fuel to be used
8. Water holding capacity.

End of Boiler study