

**ANJUMAN-I-ISLAM'S  
KALSEKAR TECHNICAL CAMPUS, NEW PANVEL  
School of Engineering & Technology**

**Thermal and Fluid Power Engineering**

By

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B.E (Automobile Engineering)

M.E (Manufacturing System Engineering)

**Mechanical Engineering Department**

Academic Year 2017-18

# Thermal and Fluid Power Engineering

## Objectives:

1. To study boilers, boiler mountings and accessories
2. To study utilization of thermal and hydraulic energy
3. To study gas turbine and its applications

## Outcomes: Learner will be able to...

1. Identify utilities of thermal and hydraulic energy
2. Differentiate impulse and reaction turbines
3. Analyze performance of turbines

01	<p><b>Steam Generators</b>          Fire tube and Water tube boiler, Low pressure and high pressure boilers, once through boiler, examples and important features of HP boilers, Mountings and accessories. Layout of a modern HP boiler. Equivalent evaporation of boilers. Boiler performance. Boiler efficiency</p>	08	(25 - 30)
02	<p><b>Steam Nozzle and Turbines</b>          Flow through steam nozzle-velocity at exit and condition for maximum discharge, nozzle efficiency</p> <p><b>Steam Turbine-</b> Basic of steam turbine, Classification, compounding of turbine, Impulse turbine – velocity diagram. Condition for max efficiency. Reaction turbine - velocity diagram, degree of reaction, Parson's turbine. Condition for maximum efficiency</p>	10	(30 - 35)
03	<p><b>Impact of Jets and Water Turbines</b>          Impact of jet on flat and curved plates          Types of hydro turbines - impulse and reaction, definition of various turbine parameters like gross head, discharge, work done, input power, output power, efficiencies etc., Euler's' equation applied to a turbine, turbine velocities and velocity triangles, expression for work done.</p> <p><b>Pelton Turbine:</b> Components of Pelton turbine, definition of design parameters like speed ratio, jet ratio, and estimation of various parameters like head, discharge and efficiency etc., determination of number of buckets.</p> <p><b>Reaction Turbines:</b> Types of reaction turbines - inward and outward flow</p>	10	(30 - 40)



04	<p>Similarity relations in turbines, definition of unit quantities and specific quantities, selection of turbines. Prediction of results of prototypes from the model test.</p> <p>Cavitations in turbines - causes, effects and remedies, Thoma's cavitations parameter <math>G</math>. Use of <math>G</math> v/s specific speed graphs. Determination of safe height of installation for the turbine. Characteristics of turbines, governing of turbines.</p>	06	(15 - 20)
05	<p><b>Gas Turbines</b></p> <p>Applications of gas turbine, Actual Brayton cycle, open and closed cycle gas turbine, methods to improve efficiency and specific output, open cycle with intercooling, reheat and regeneration. Effect of operating variable on thermal efficiency and work ratio</p>	08	(25 - 30)
06	<p><b>Jet Propulsion Engines</b></p> <p>Classification of jet propulsion engines, Thrust, Thrust power, Propulsive efficiency and thermal efficiency, Afterburner, Introduction to Turbojet, Turbofan, Ram jet, Turboprop and Rocket engine</p>	06	(10 - 15)
<b>TOTAL</b>		<b>48</b>	

# Distribution of Marks:

Sr.No.	Contents	Marks
01	Internal Assessment based on two test:	20
02	End semester theory exam:	80
03	Term work:	25
		<b>TOTAL</b>
		<b>125</b>

# Term Work:

Sr.No.	Contents	Marks
01	Laboratory work (Minimum 6 Experiments):	10
02	Assignments (No. of Assignment 03 based on Maximum content of the syllabus):	05
03	Visit Report (Thermal /Hydroelectric/Gas turbine Power Plant):	05
04	Attendance (Th. & Pr.):	05
	<b>TOTAL</b>	<b>25</b>



# Boilers





# Boilers

*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:

- (i) Producing mechanical work by expanding it in steam engine or steam turbine.*
- (ii) Heating the residential and industrial buildings*
- (iii) Performing certain processes in the industries.*



# Boiler properties:

- (i) Safety: The boiler should be safe under operating conditions
- (ii) Accessibility: The various parts of the boiler should be accessible for repair and maintenance
- (iii) Capacity: Should be capable of supplying steam according to the requirements



- (iv) Should be able to absorb a maximum amount of heat produced due to burning of fuel in the furnace.
- (v) It should be simple in construction .
- (vi) Its initial cost and maintenance cost should be low.
- (vii) The boiler should have no joints exposed to flames.
- (viii) Should be capable of quick starting and loading.



# CLASSIFICATION OF BOILERS

## ➤ According to what flows in the tube:

### 1. Fire tube Boiler:

In fire tube boilers, the hot gases are inside the tubes and the water surroundings the tubes.

Example: Cochran, Lancashire and Locomotive boilers etc.

### 2. Water tube Boiler:

In water tube boilers, the water is inside the tubes and the hot gases surround them.

Example: Babcock and Wilcox, Stirling boiler etc.



➤ **According to position of furnace:**

*(i) Internally fired (ii) Externally fired*

*(i)* In internally fired boilers the combustion chamber are enclosed within the boiler shell

Example: Cochran, Lancashire and Locomotive boilers

*(ii)* whereas in case of externally fired boilers the fire is outside the boiler shell

Example: Babcock and Wilcox, Stirling boiler etc



➤ **According to the position of principle axis:**

*(i) Vertical (ii) Horizontal (iii) Inclined*

➤ **According to application**

*(i) Stationary (ii) Mobile (Marine, Locomotive)*

➤ **According to the circulating water**

*(i) Forced circulation (ii) Natural circulation*

➤ **According to steam pressure**

*(i) High pressure:*

*It produces steam at pressure of 80bar and above*

*Example: Babcock and Wilcox, Lamont, Benson boiler*

*(ii) Low pressure:*

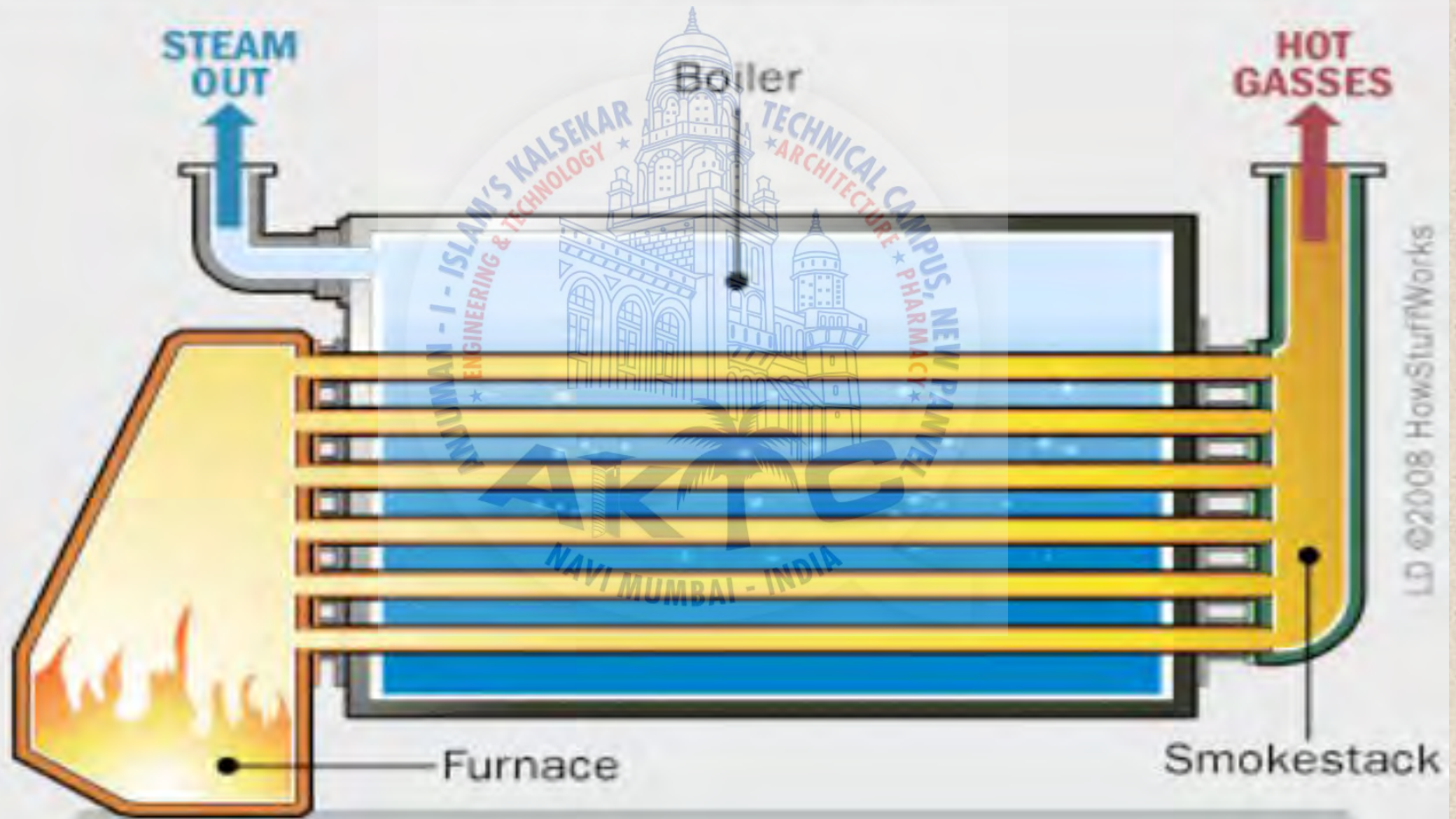
*It produces steam at pressure below 80bar*

*Example: Cochran, Lancashire and Locomotive boilers*



# Fire – tube Boilers

How Steam Engines Work Fire-tube Boiler

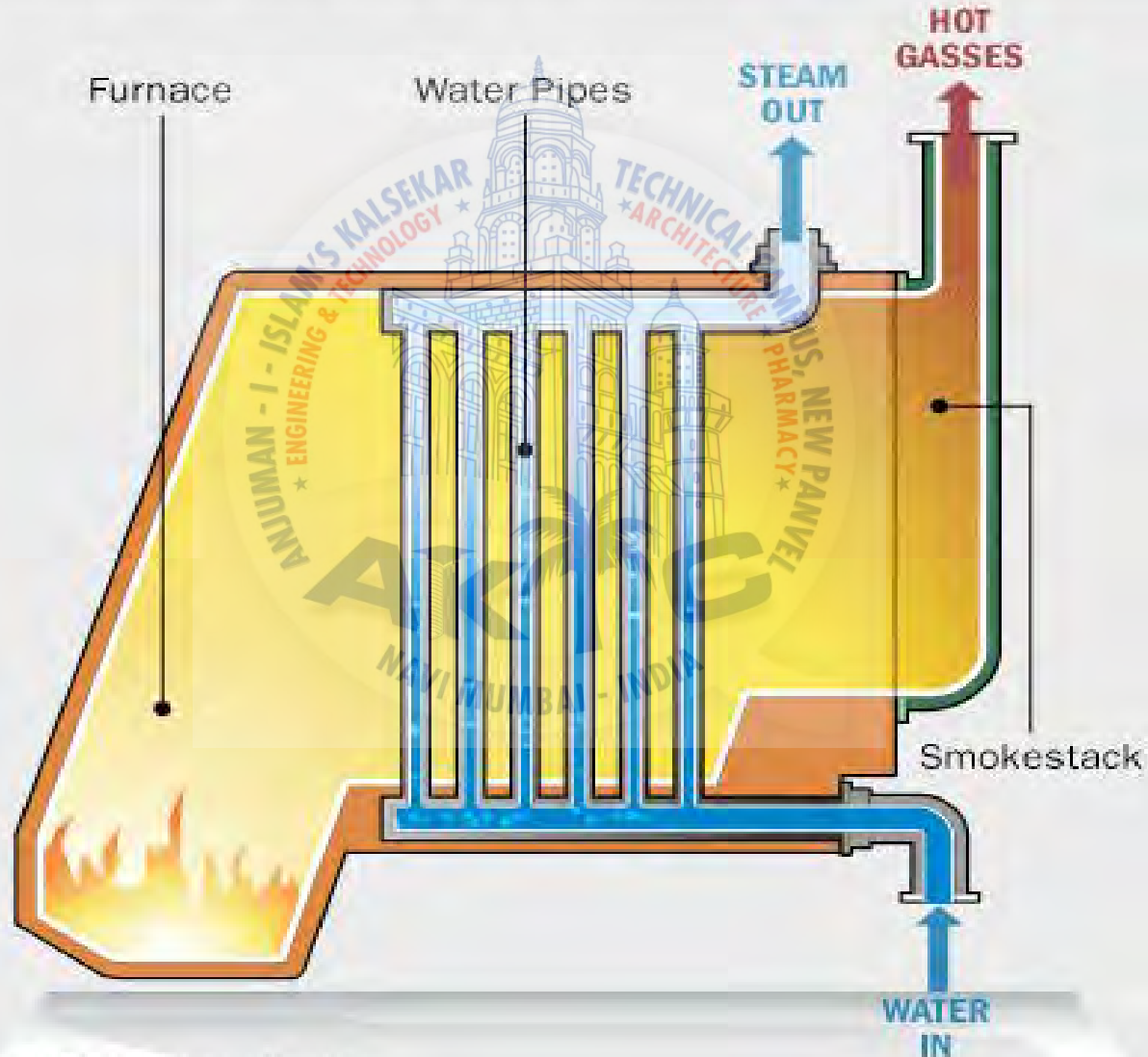


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# Water tube boilers

How Steam Engines Work Water-tube Boiler





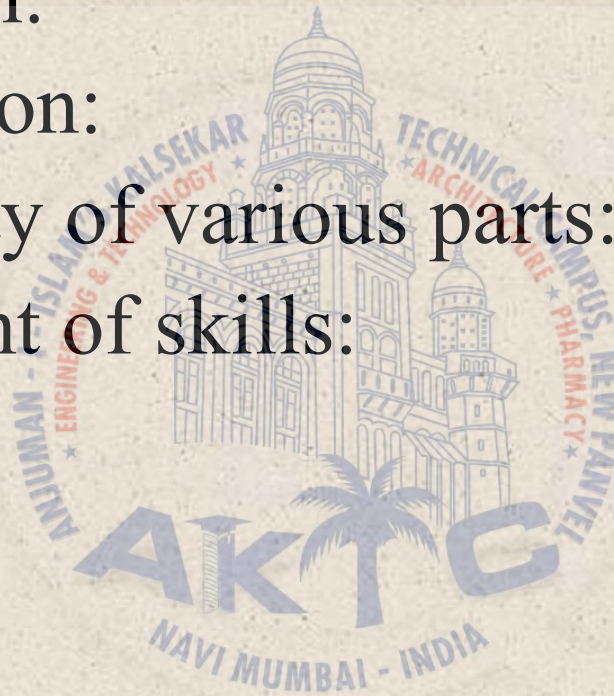
# Comparison between Fire-Tube and Water-Tube Boilers

## Particulars:

1. Position of water and hot gases:
2. Mode of firing:
3. Operating pressure:
4. Rate of steam production:
5. Suitability:
6. Risk on bursting:



7. Floor area:
8. Construction:
9. Transportation:
10. Accessibility of various parts:
11. Requirement of skills:





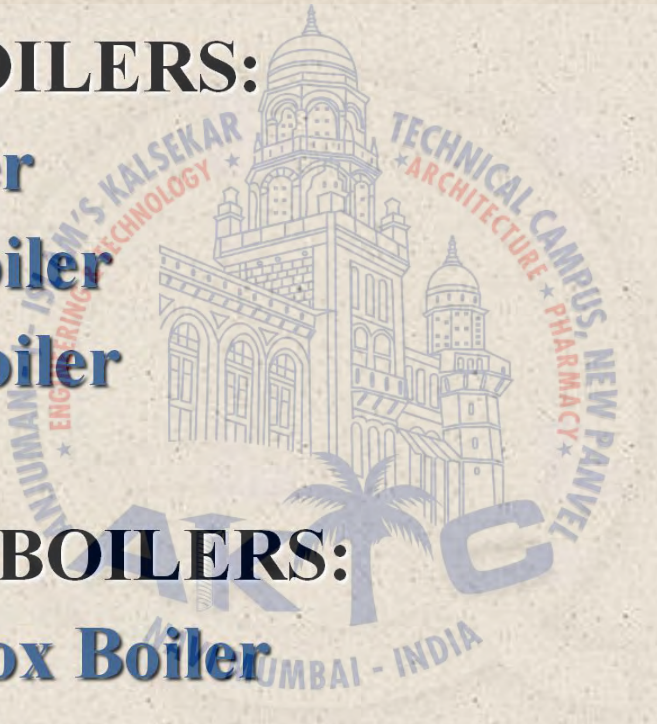
# We are gonna study.....

## **FIRE TUBE BOILERS:**

- **Cochran Boiler**
- **Lancashire Boiler**
- **Locomotive boiler**

## **WATER TUBE BOILERS:**

- **Babcock Wilcox Boiler**
- **Stirling Boiler**





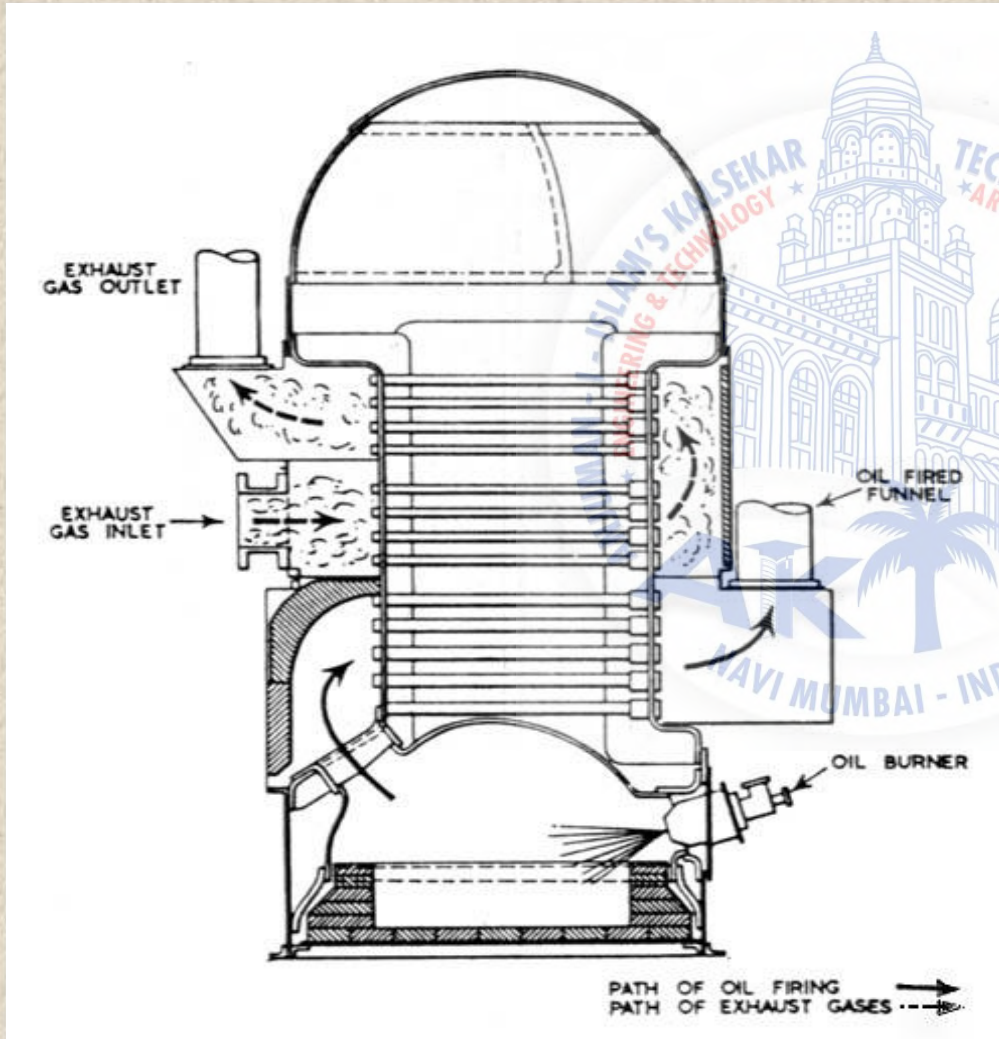
# Fire tube Boiler:



## Cochran Boiler



# Fire tube Boiler:



## Cochran Boiler



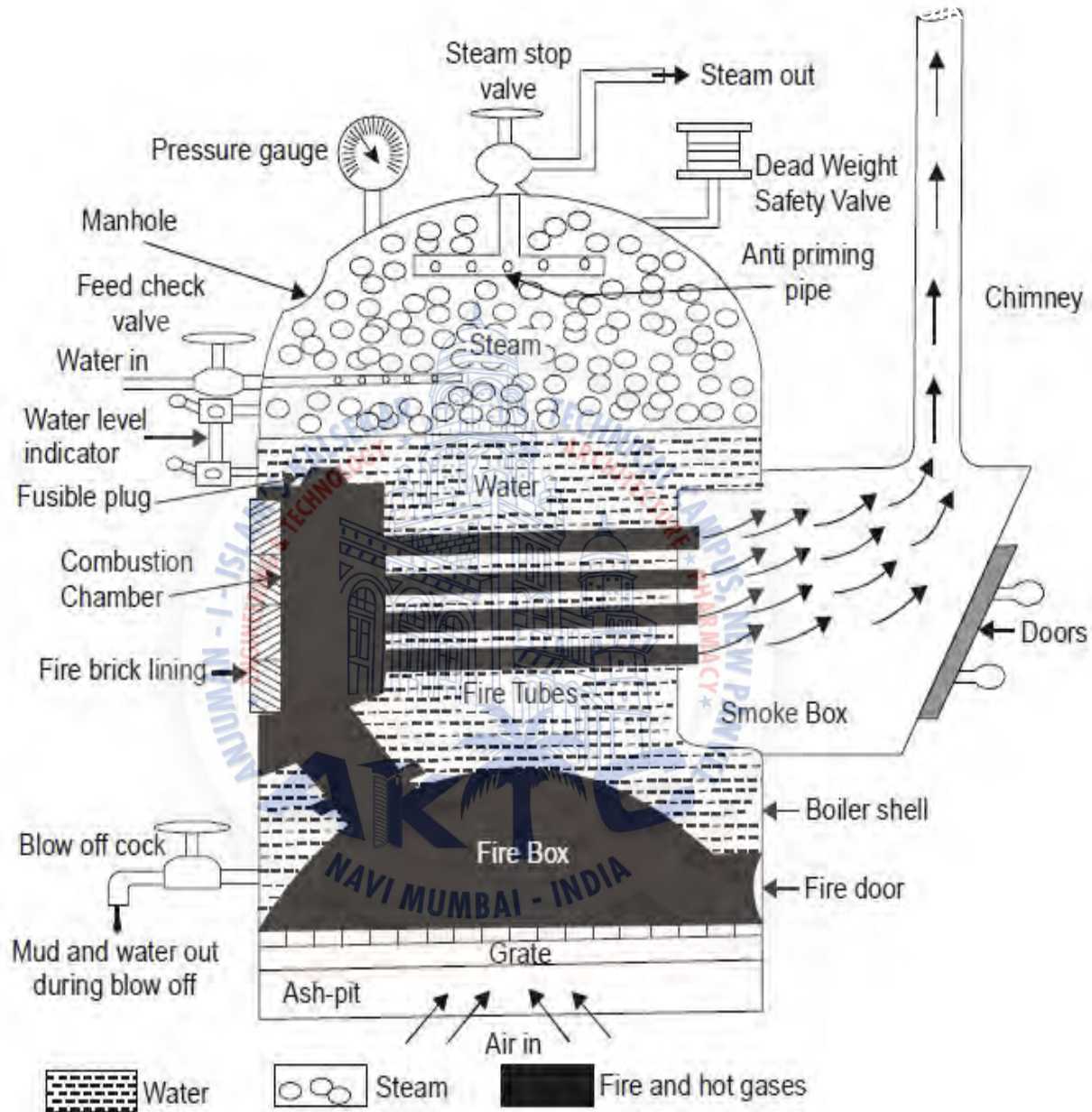
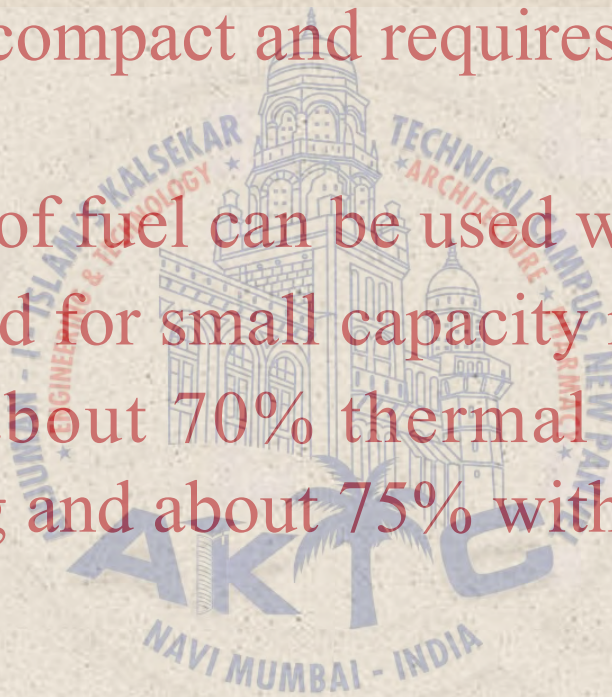


Fig. 5.1. Cochran Boiler.



- The outstanding features of this boiler are :
  - It is very compact and requires minimum floor area
  - Any type of fuel can be used with this boiler
  - Well suited for small capacity requirements
  - It gives about 70% thermal efficiency with coal firing and about 75% with oil firing





# Fire tube Boilers

## Lancashire Boiler

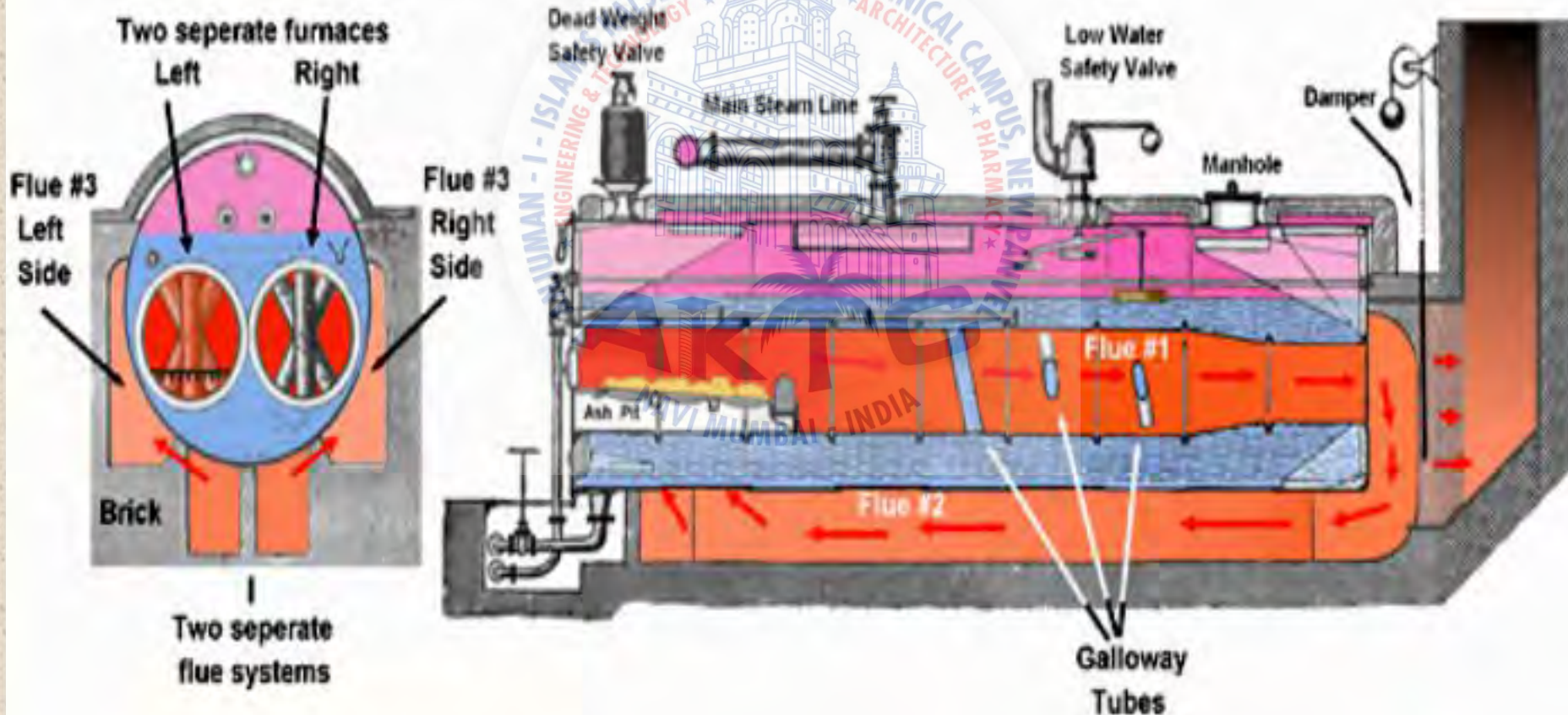
- It is stationary fire tube, internally fired, horizontal, natural circulation boiler. This is a widely used boiler because of its good steaming quality and its ability to burn coal of inferior quality.
- These boilers have a cylindrical shell 2m in diameters and its length varies from 8m to 10m. It has two large internal flue tubes having diameter between 80cm to 100cm in which the grate is situated. This boiler is set in brickwork forming external flue so that the external part of the shell forms part of the heating surface.



# Fire tube Boilers

## Lancashire Boiler

Lancashire Boiler cross section views



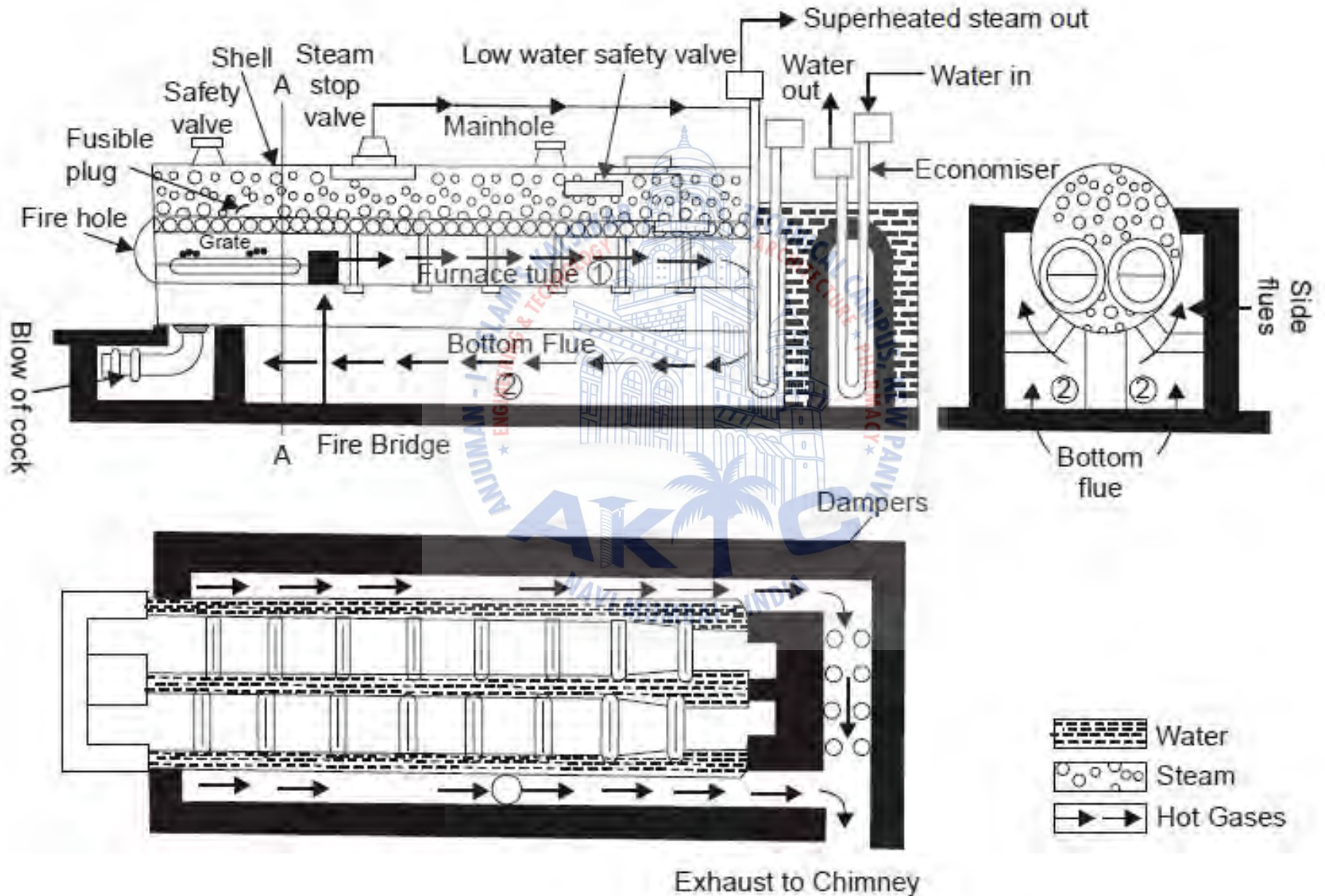


# Fire tube Boilers



## Lancashire Boiler







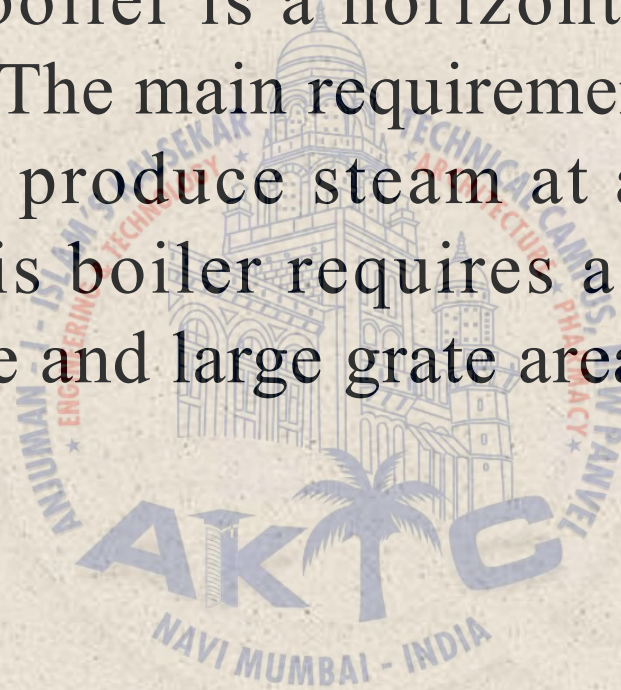
# Advantages

- The feed pipe projecting into the boiler is perforated to ensure uniform water distribution.
- Its heating surface area per unit volume at the boiler is considerably large.
- Its maintenance is easy.
- It is suitable where a large reserve of hot water is needed.
- Super-heater and economizer can be easily incorporated into the system, therefore; overall efficiency of the boiler can be considerably increased (80-85%).



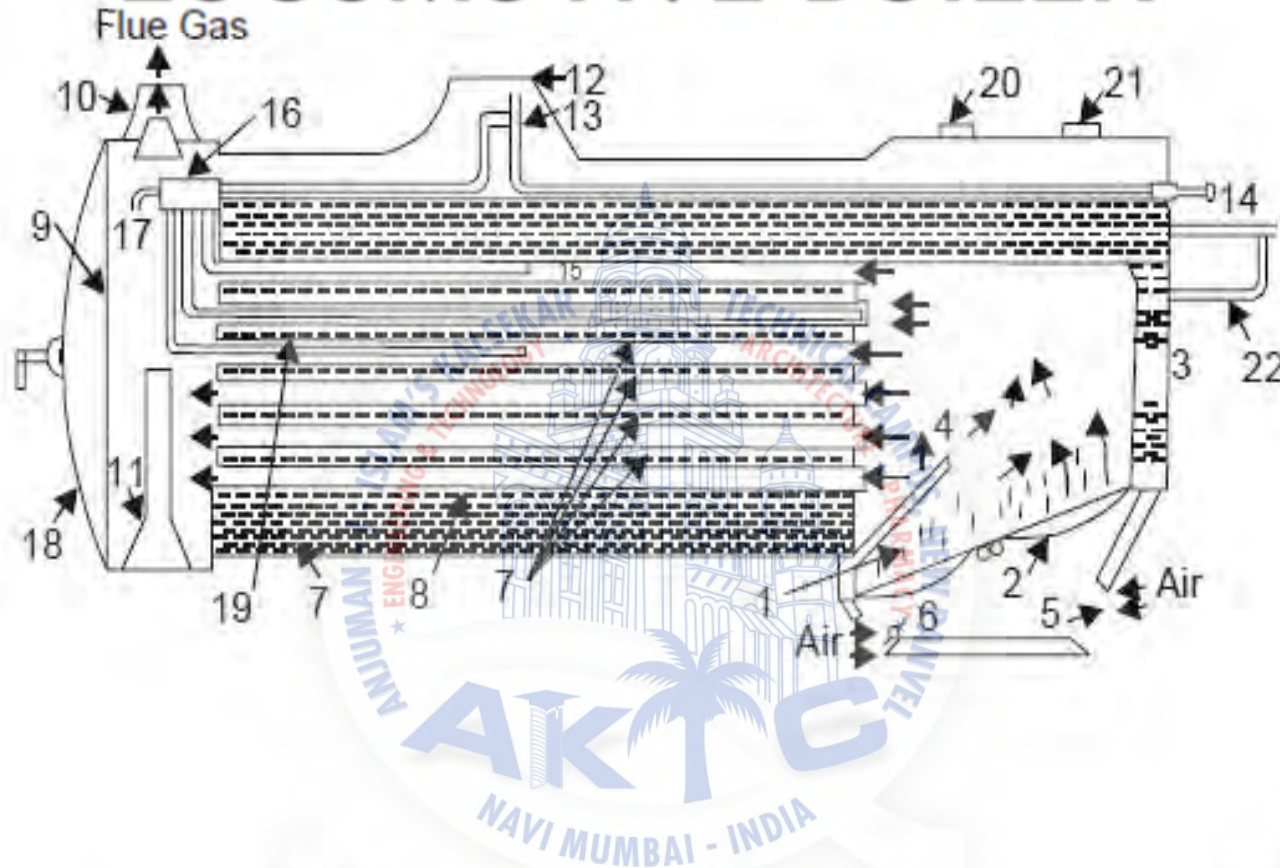
# LOCOMOTIVE BOILER

- Locomotive boiler is a horizontal fire tube type mobile boiler. The main requirement of this boiler is that it should produce steam at a very high rate. Therefore, this boiler requires a large amount of heating surface and large grate area to burn coal at a rapid rate.





# LOCOMOTIVE BOILER



- |                            |                     |                        |                        |
|----------------------------|---------------------|------------------------|------------------------|
| 1. Fire box                | 2. Grate            | 3. Fire hole           | 4. Fire bride arch     |
| 5. Ash pit                 | 6. Damper           | 7. Fine tubes          | 8. Barrel or shell     |
| 9. Smoke box               | 10. Chimney (short) | 11. Exhaust steam pipe | 12. Steam dome         |
| 13. Regulator              | 14. Lever           | 15. Superheater tubes  | 16. Superheater header |
| 17. Superheater exist pipe | 18. Smoke box door  | 19. Feed check valve   | 20. Safety valve       |
| 21. Whistle                | 22. Water gauge     |                        |                        |



# LOCOMOTIVE BOILER





# Advantages

- 1. Large rate of steam generation per square metre of heating surface.
- 2. It is free from brickwork, special foundation and chimney. This reduces the cost of installation.
- 3. It is very compact.

The pressure of the steam is limited to about 20 bar.

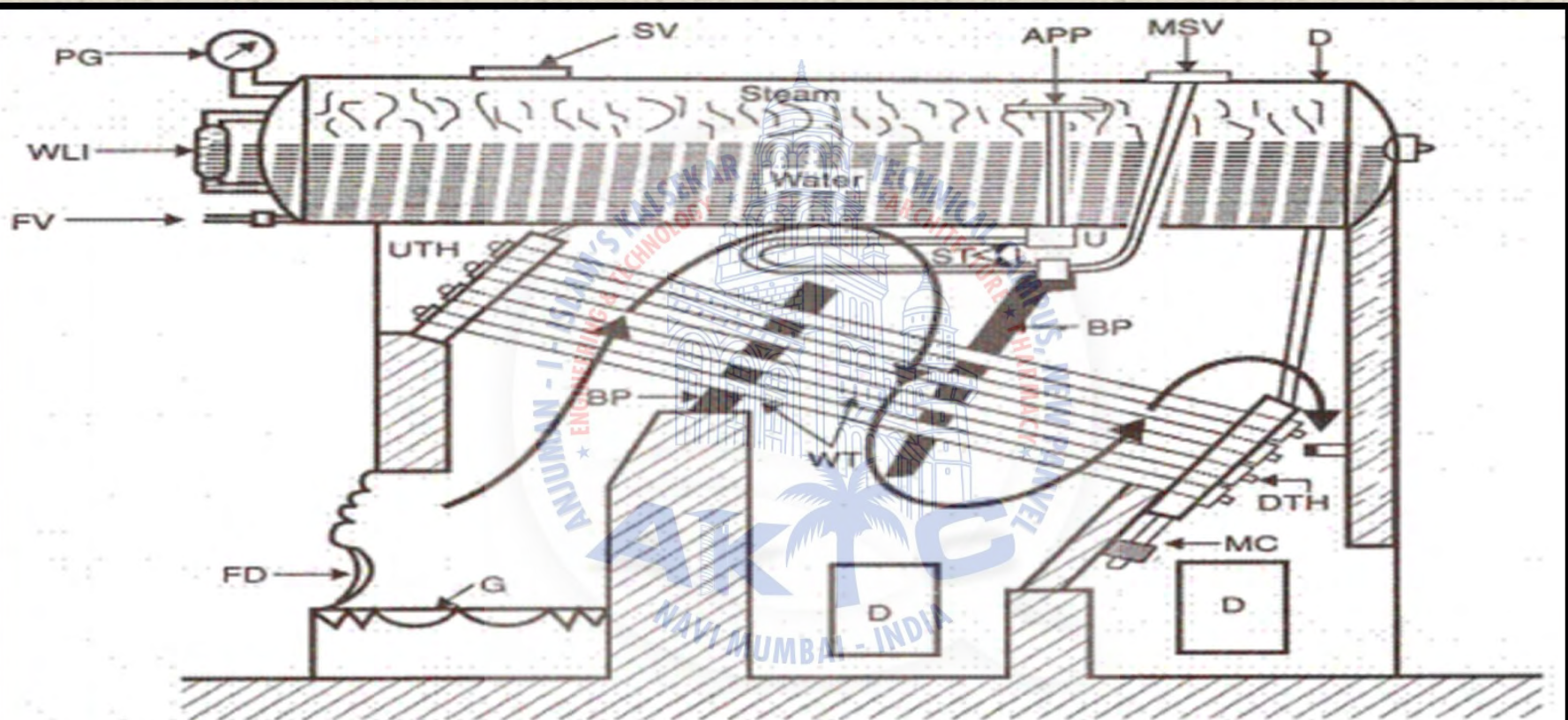






# Water tube Boiler:

## Babcock and Wilcox Boiler

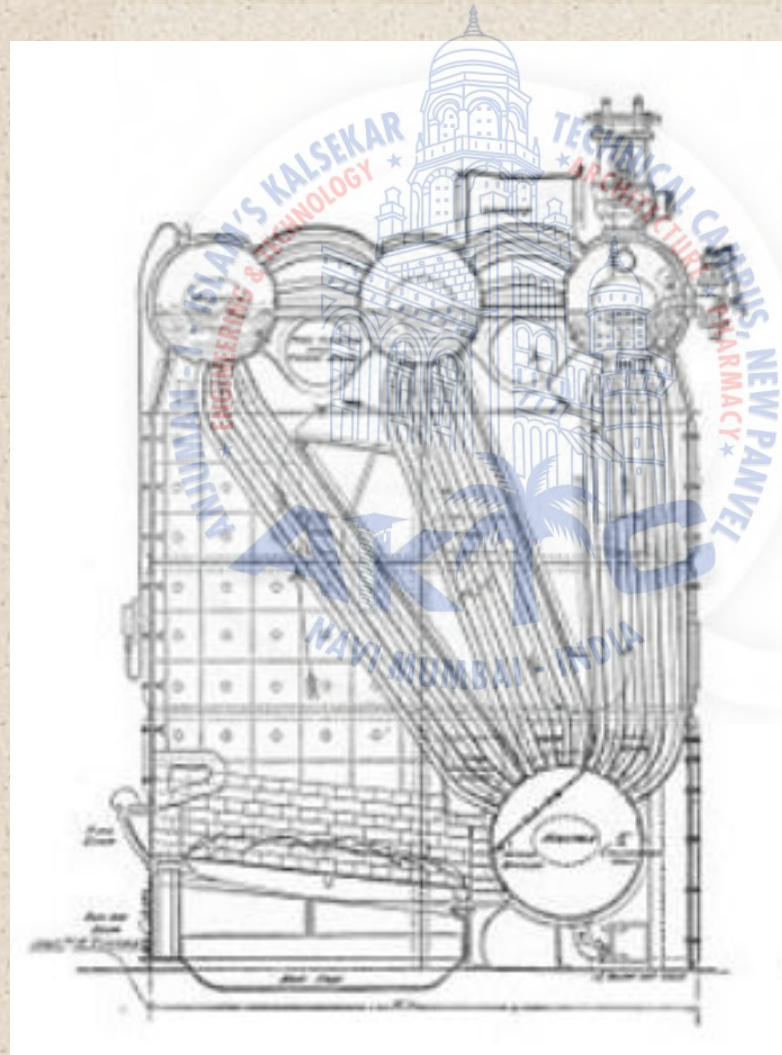


**D** = Drum  
**DTH** = Down take header  
**WT** = Water tubes  
**BP** = Baffle plates  
**D** = Doors  
**G** = Grate  
**FD** = Fire door  
**MC** = Mud collector  
**WLI** = Water level indicator

**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



# Water tube Boiler: Stirling Boiler

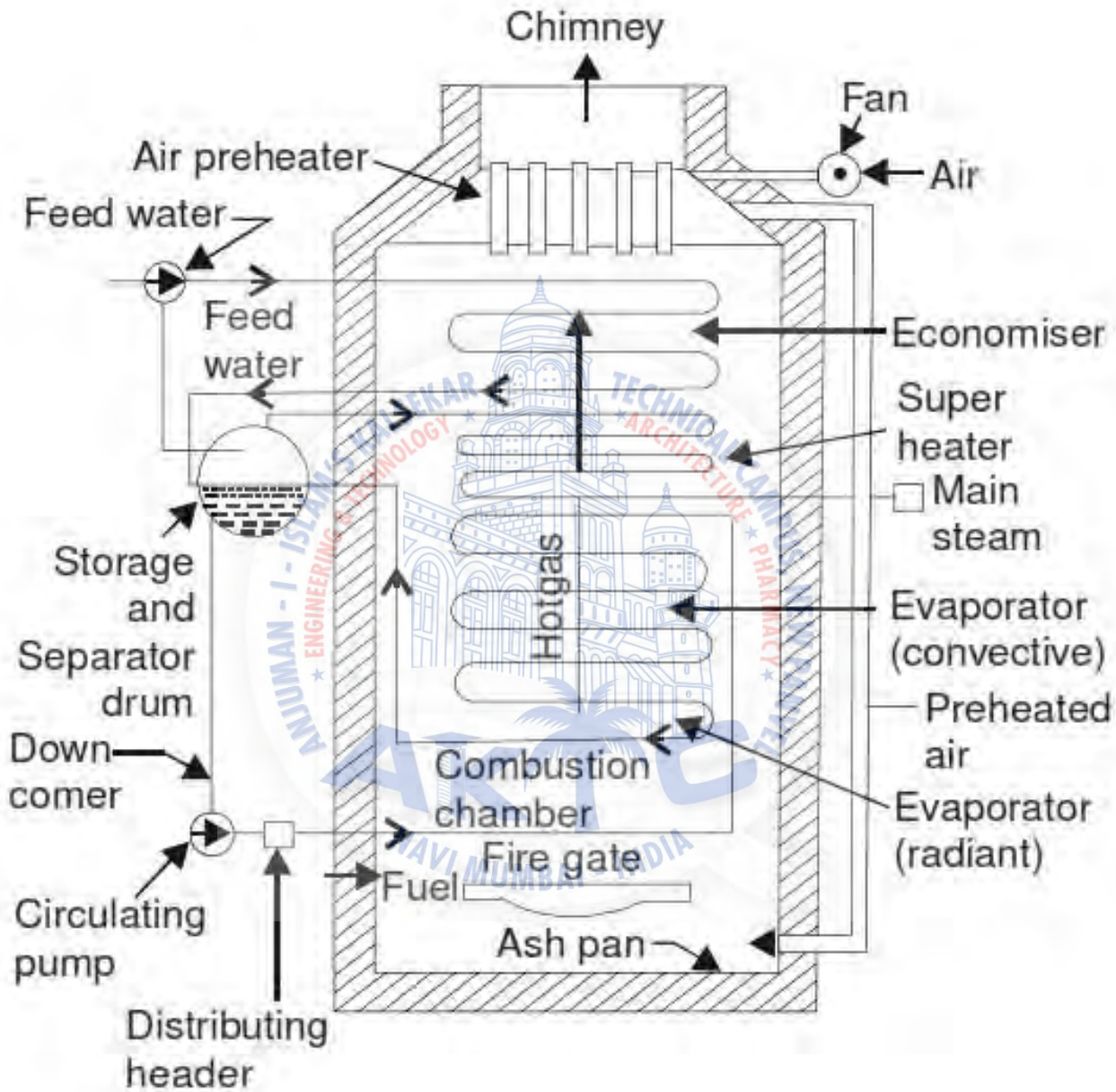




# HIGH PRESSURE BOILERS

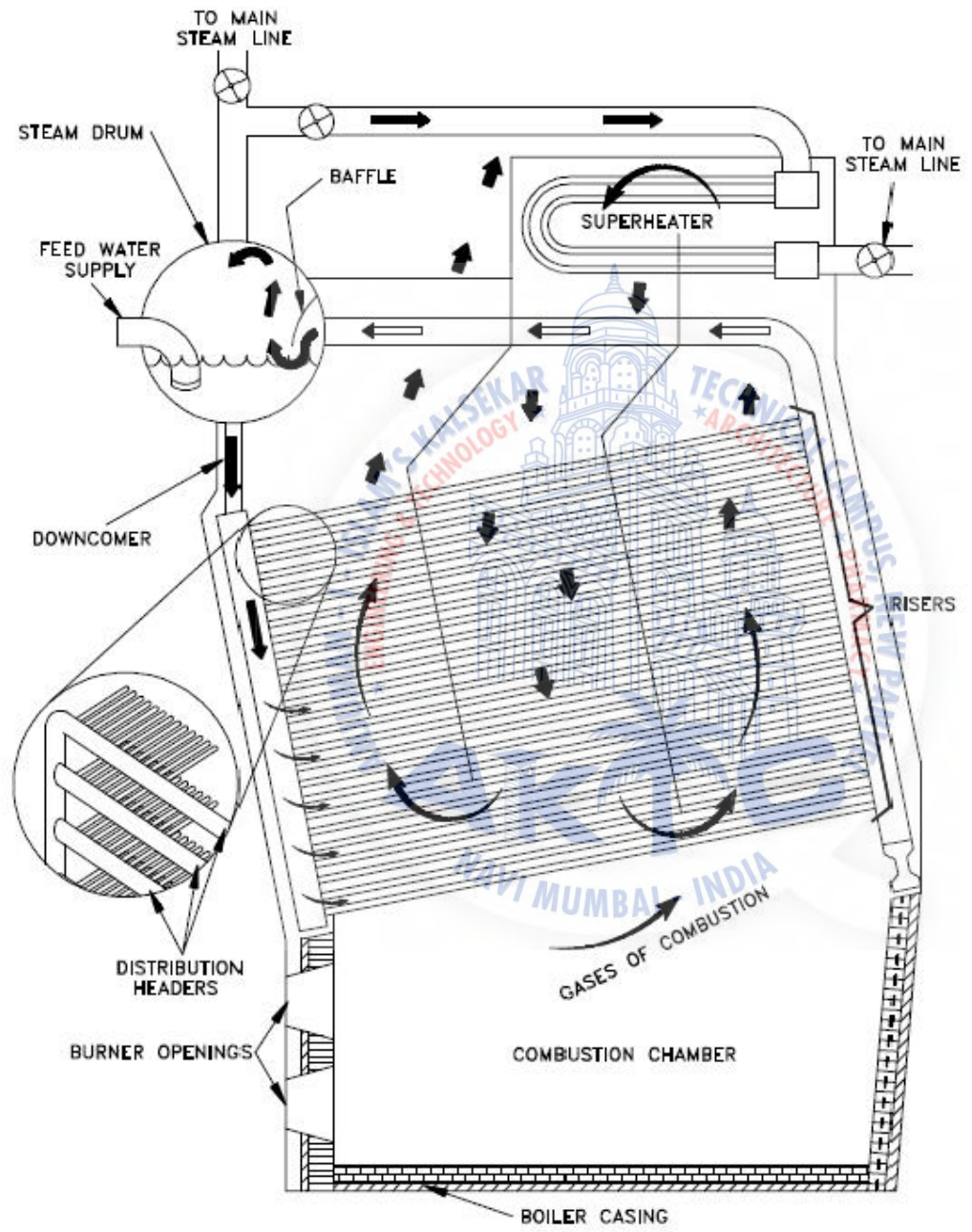






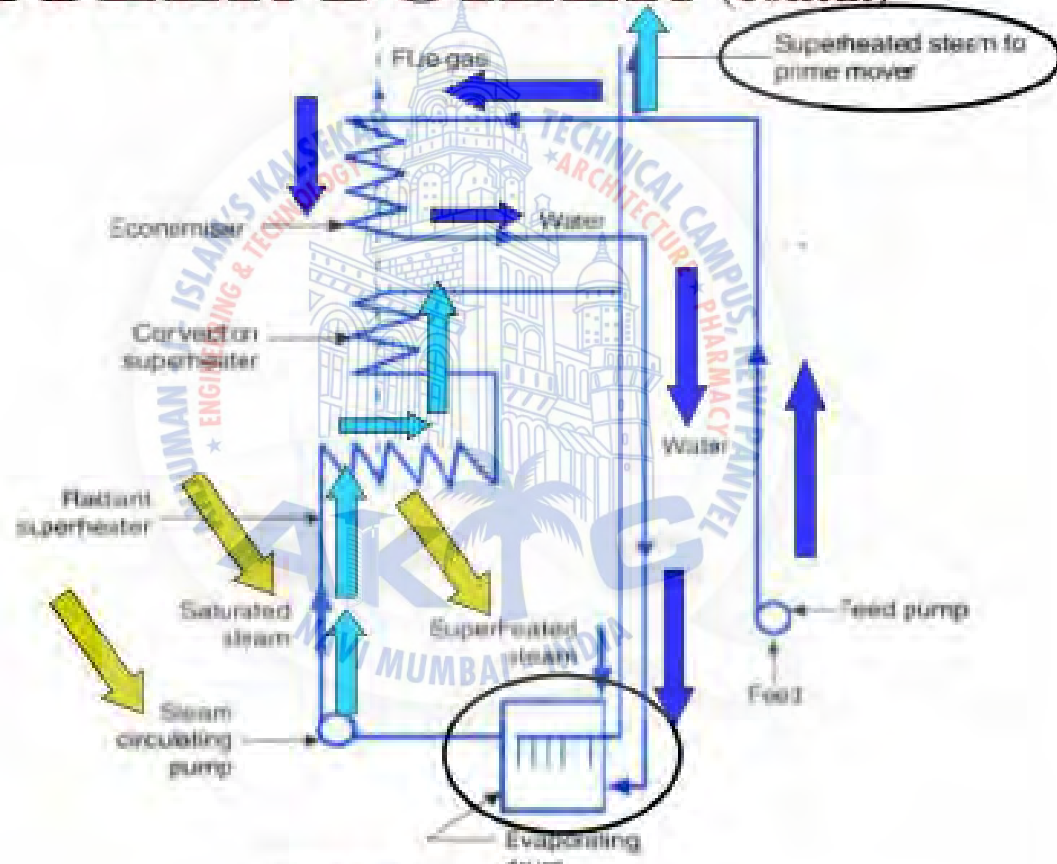
**Lamont Boiler**







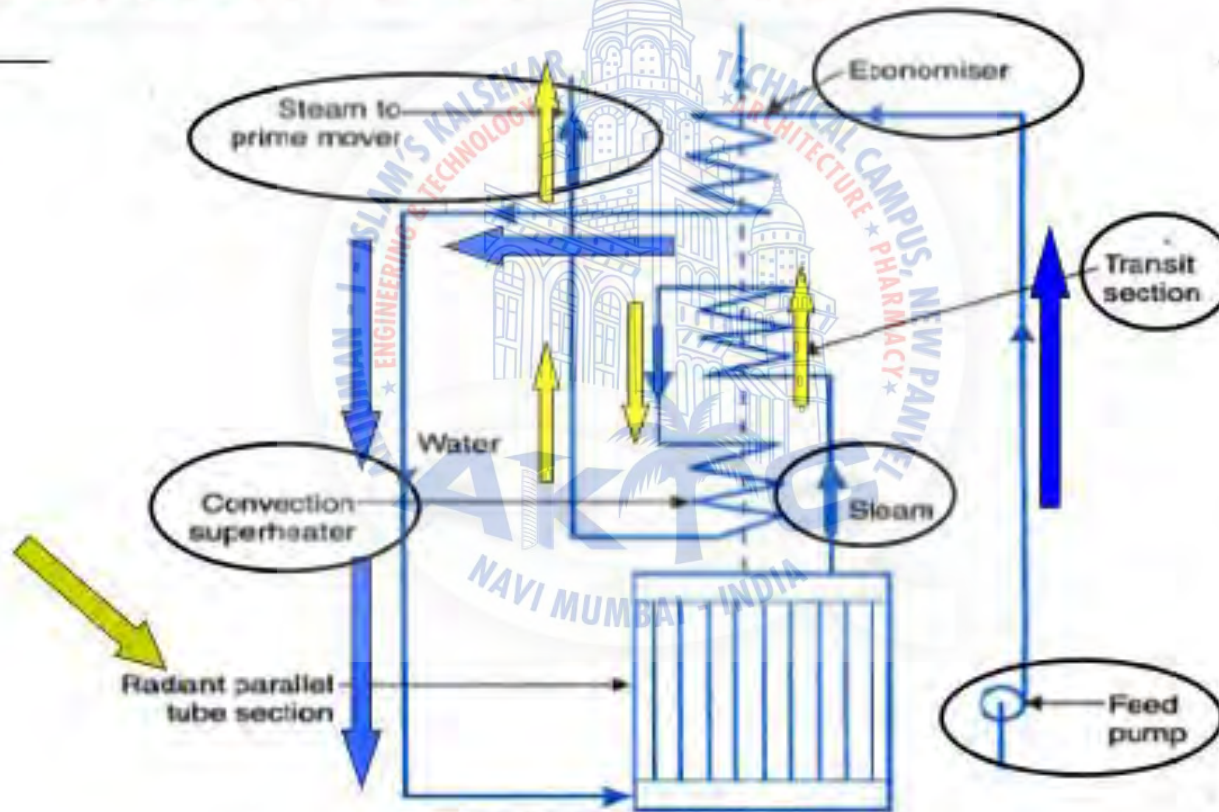
# LOEFFLER BOILER (contd.)



VANITA N THAKKAR BIT, VARNANA  
Fig. 11-10. Loeffler boiler.



# BENSON BOILER (contd.)



VANITA THAKKAR, BIT VARNAMA  
Fig. 11.11 Benson boiler.



# Benson Boiler

## ➤ **Sub critical boiler:**

1. First, in sub critical boiler water form the vapor bubbles at the tube surface, which decrease heat transfer rate, hence decrease efficiency.
2. The second one is, the sub critical boiler used the water steam separator drum to separate steam which make it too complex and heavy. It cannot be easily transfer from one station to another.

## ➤ **Super critical boiler:**

- ✓ To overcome these problems, in 1922, Mark Benson invented a boiler which works above sub critical pressure and generate steam at super critical pressure. This boiler is known as Benson boiler. This boiler works at pressure above critical pressure, at which the water instantly convert into steam. No air bubbles generate in this boiler. This boiler generate a high pressure steam which is used in various industrious processes.
- ✓ The Benson boiler is a water tube boiler, works on the basic principle of critical pressure of water. The critical pressure is the pressure at which the liquid and gas phase are at equilibrium. The water enters in the boiler at just above the critical pressure so it suddenly convert into steam without generating air bubbles. No air water separator drum is required. It also takes less fuel to generate steam. This is the basic principle of Benson boiler.



# VELOX BOILER

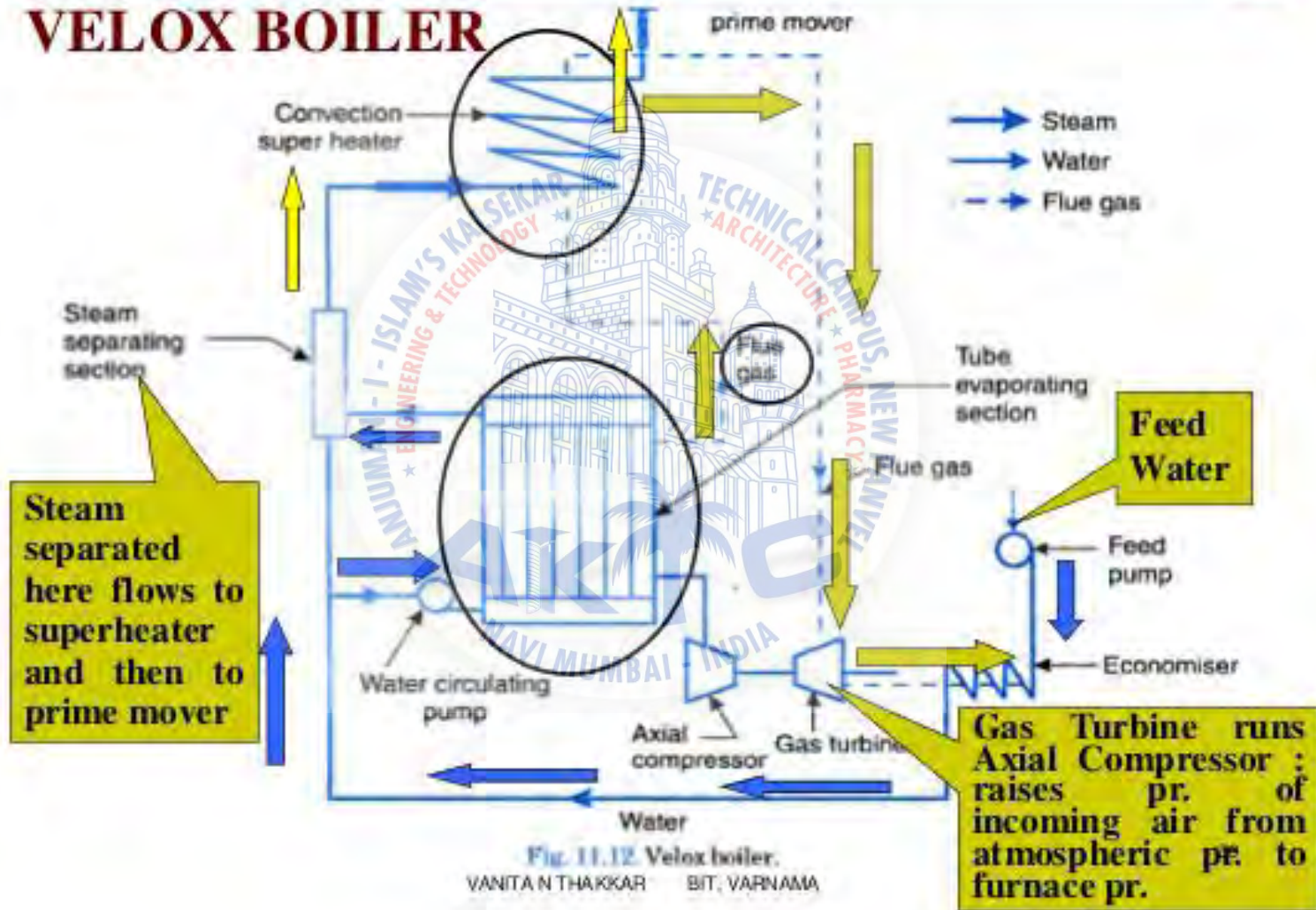


Fig. 11.12 Velox boiler.

VANITA N THAKKAR BIT, VARNAMA



## VELOX BOILER

---

- Uses **Pressurized Combustion**, i.e. When **gas velocity exceeds sound velocity**, heat is transferred from the gas at much higher rates than those achieved with sub-sonic flow. This fact is made use of to obtain large heat transfer rates from smaller surface area in Velox boilers.



# Boiler Mountings and Accessories:





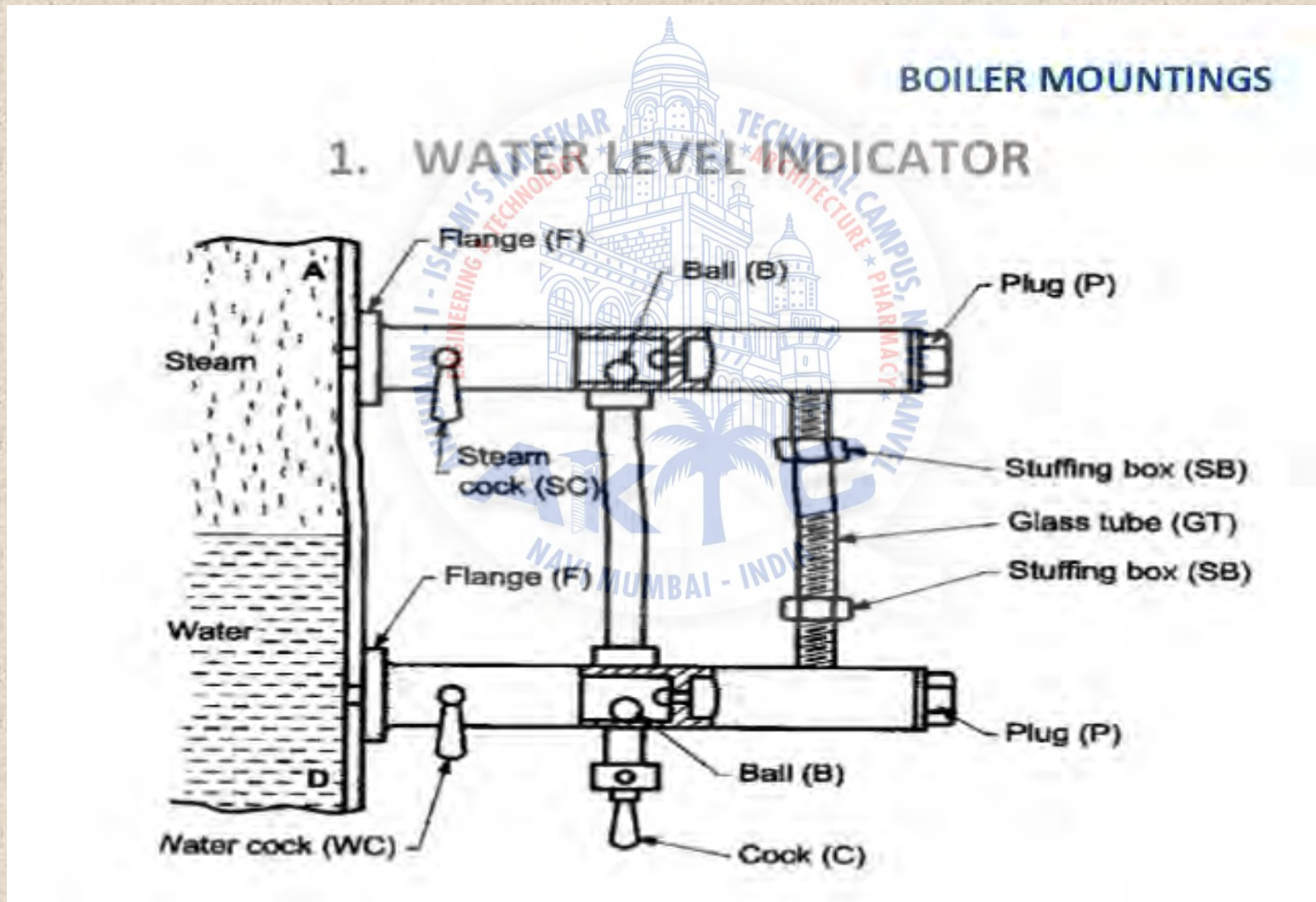
# BOILER MOUNTINGS:

- The necessary devices installed or mounted for the safety of boiler and its control are called boiler mountings.
- They are necessarily required to be fitted on the boiler shell in accordance with Indian boiler regulation (IBR) act 1923. These are as follows:
  - **Boiler mounting for safety:**
    1. Two water level indicator
    2. Two safety valve
    3. Combined high steam and low water safety valve
    4. Fusible plug
  - **Boiler mounting for control:**
    1. Pressure gauge
    2. Junction or stop valve
    3. Feed check valve
    4. Blow-off cock
    5. Man hole and mud hole.

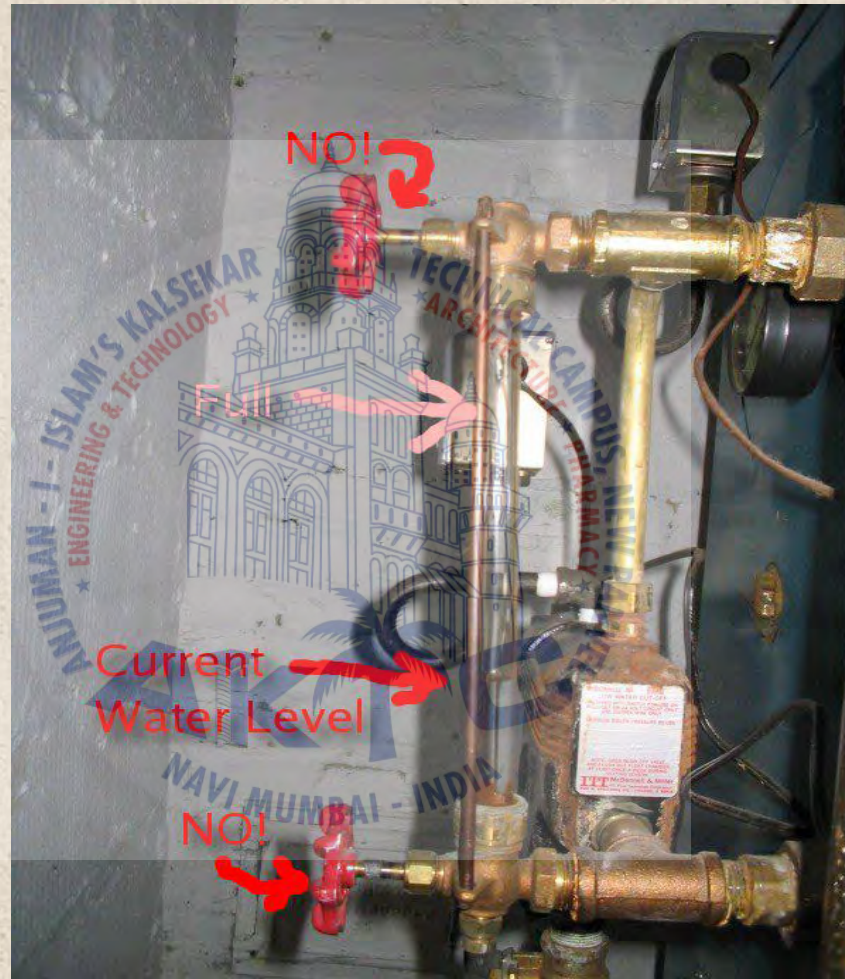


# Water Level Indicator

This indicates the water level in the boiler



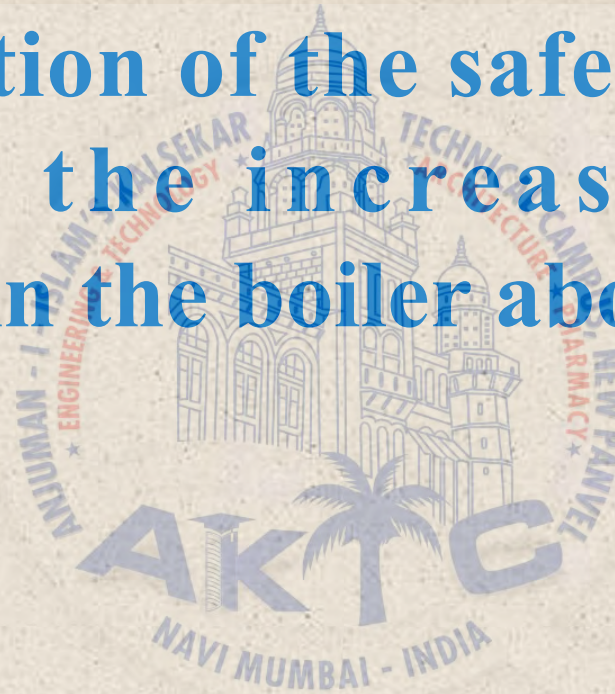






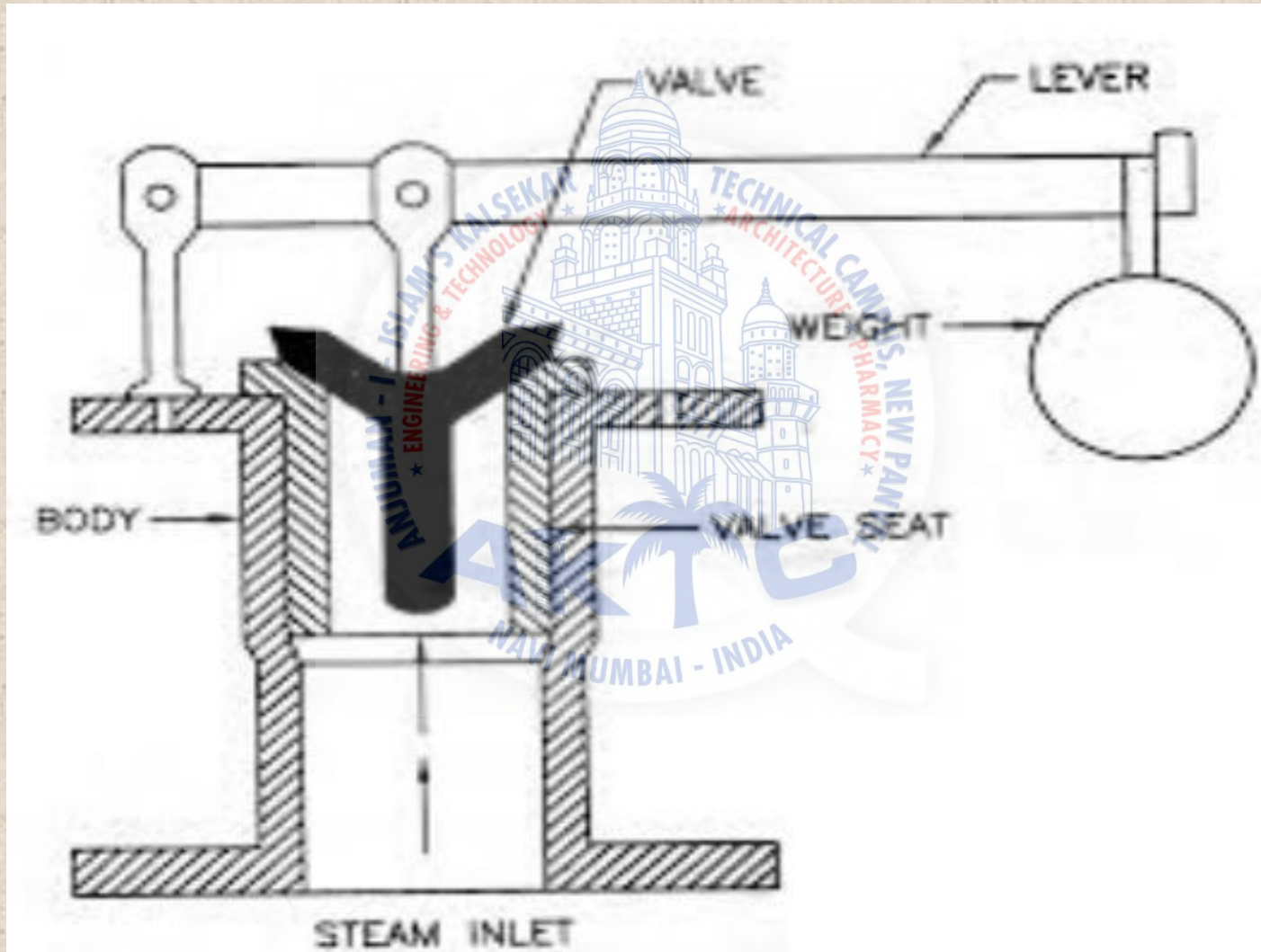
# Safety Valve

The function of the safety valve is to prevent the increase of steam pressure in the boiler above its design pressure.





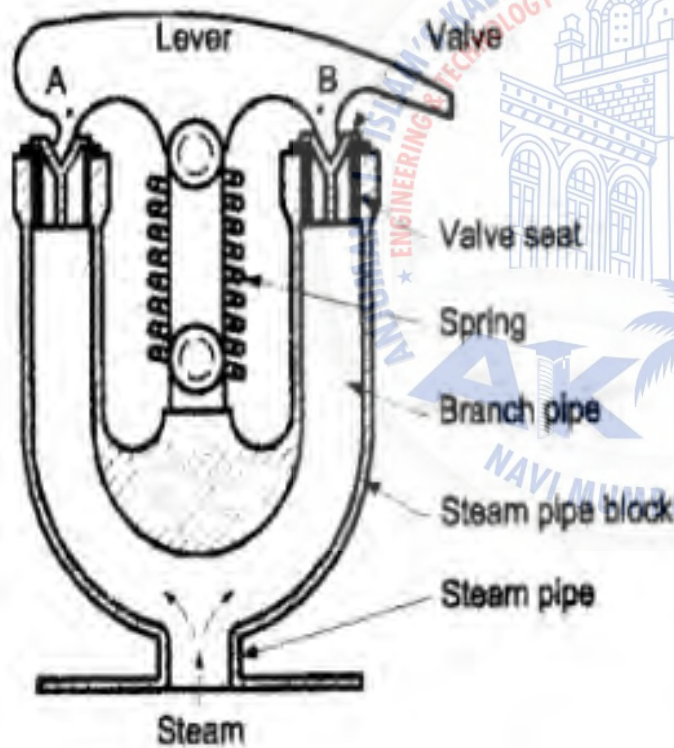
# Lever Safety valve



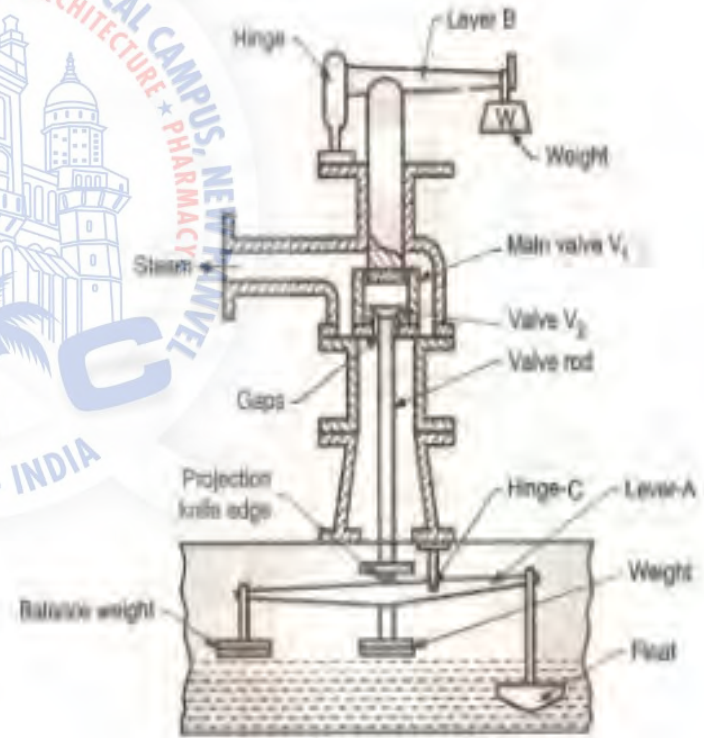


# SAFETY VALVES

### SPRING LOADED SAFETY VALVE

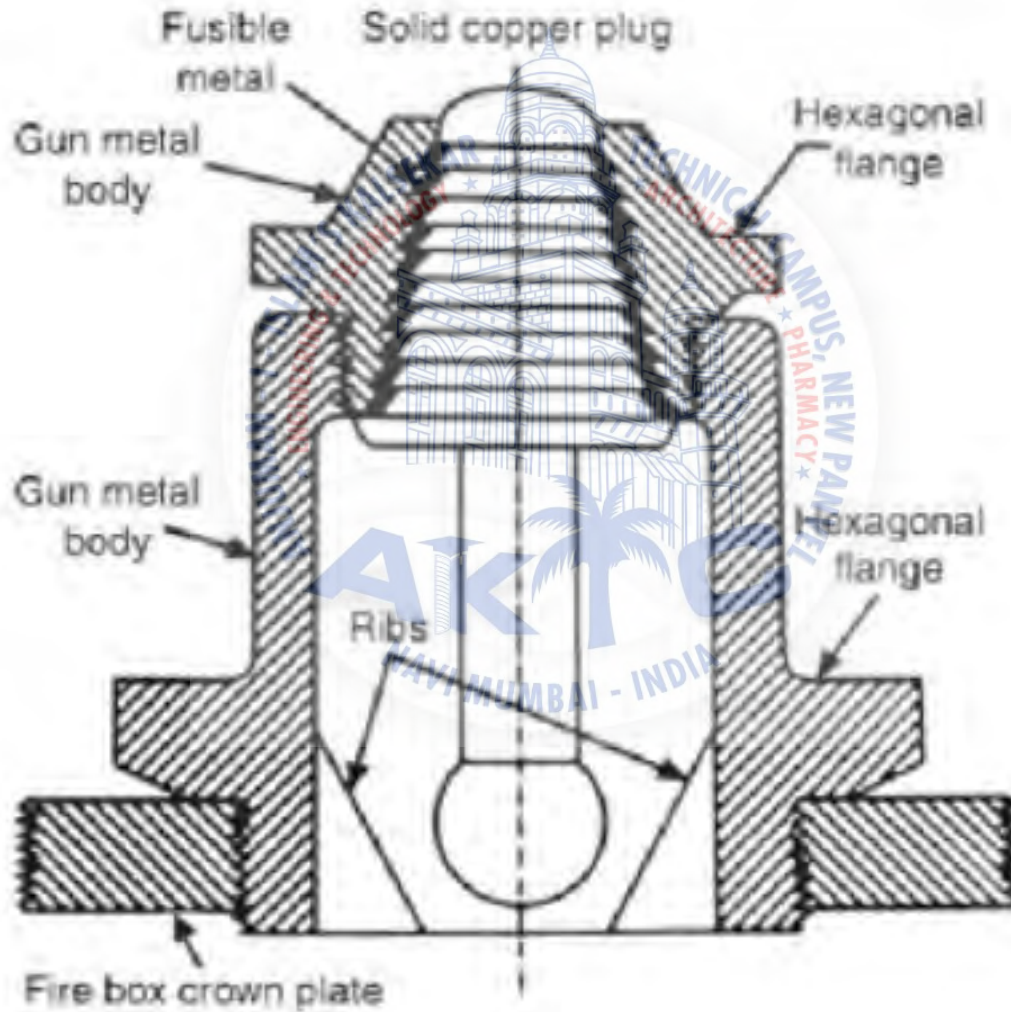


### HIGH STEAM AND LOW WATER SAFETY VALVE





# Fusible Plug





## Working of Fusible plug

- When the water level in the shell falls below the top of the plug the steam cannot keep it cool and the fusible metal melts due to over heating.
- thus the copper plug drops down and is held with in the gun metal body by the ribs.
- Thus the steam space gets communicated to fire box and extinguishes the fire.

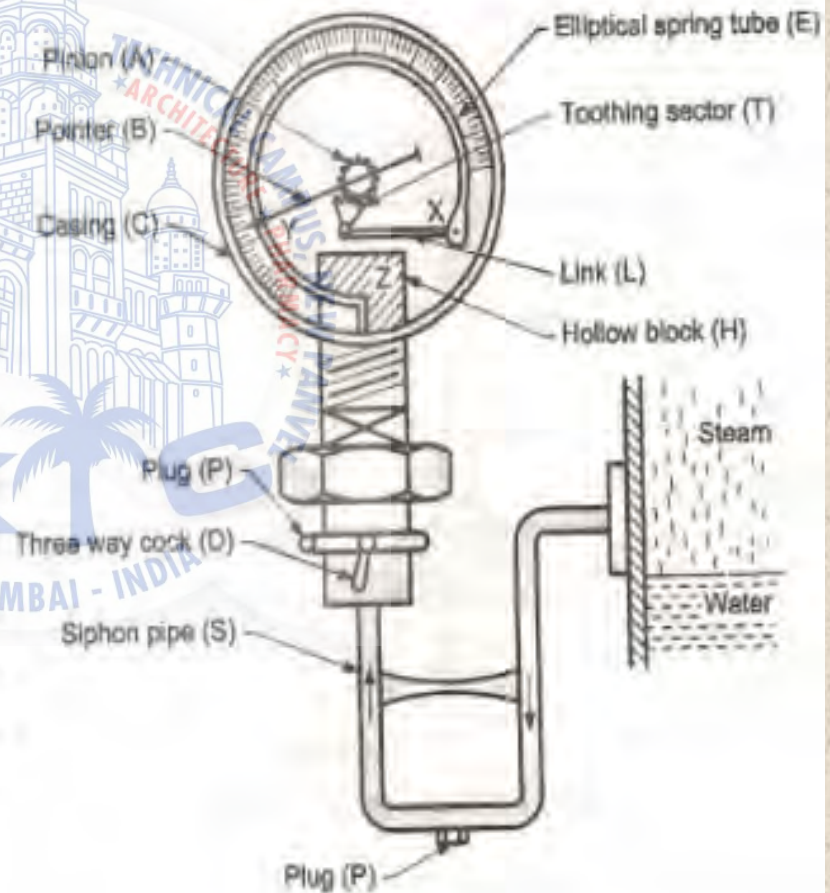


# Pressure gauge

## 2. PRESSURE GAUGE (Bourdon's)

- Records gauge pressure
- Elliptical spring tube is also called Bourdon tube and is made up of special quality Bronze.
- Plug (P) is provided for cleaning the siphon tube.
- Siphon is filled with cold water to prevent the hot steam entering into the bourdon tube and spring tube remains comparatively cool.

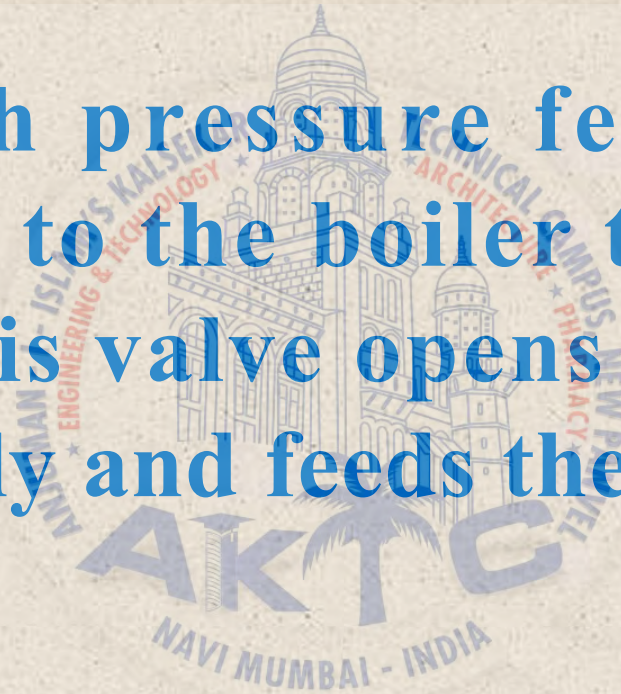
### BOILER MOUNTINGS



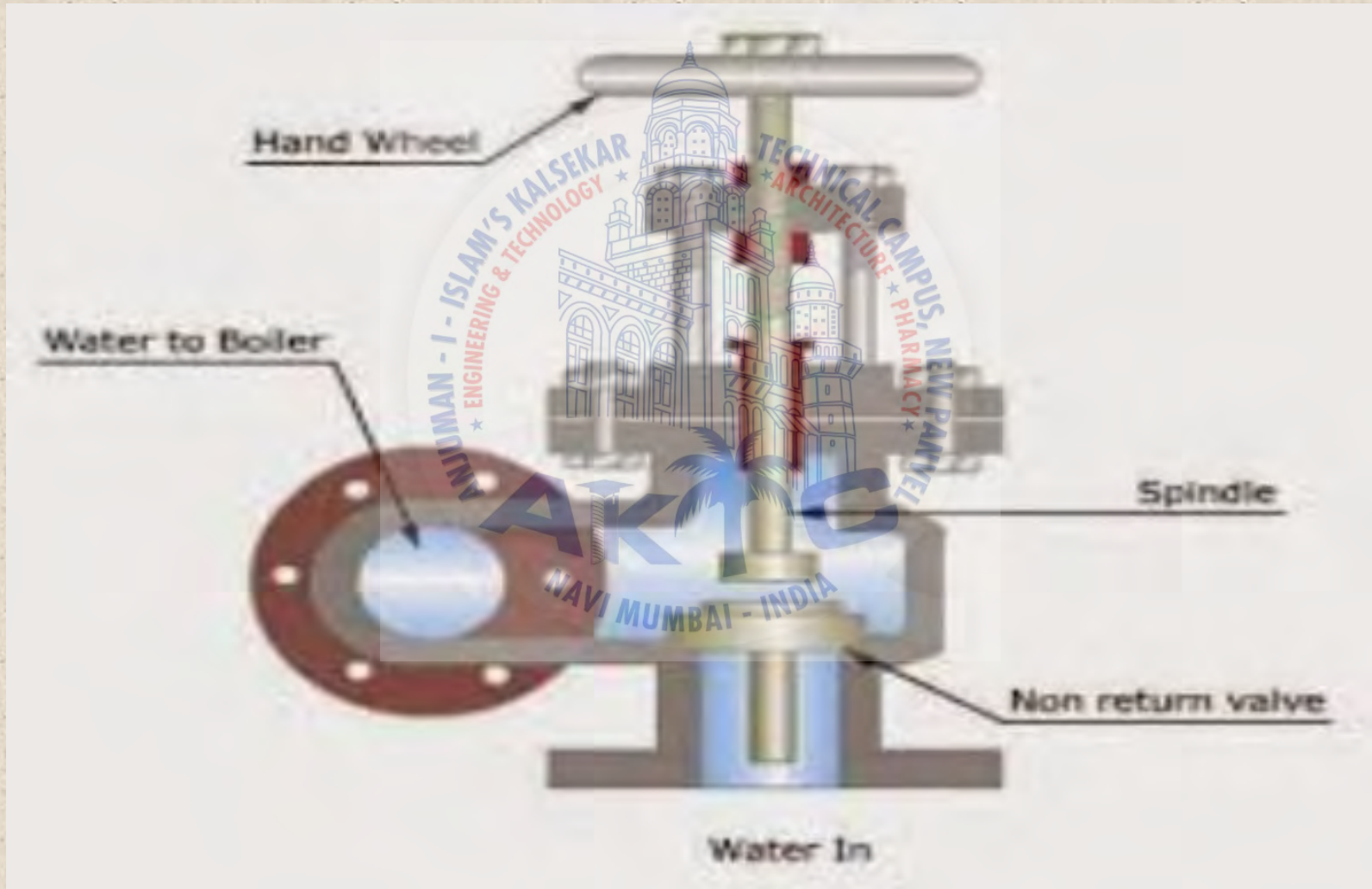


# Feed Check Valve

The high pressure feed water is supplied to the boiler through this valve. This valve opens towards the boiler only and feeds the water to the boiler.



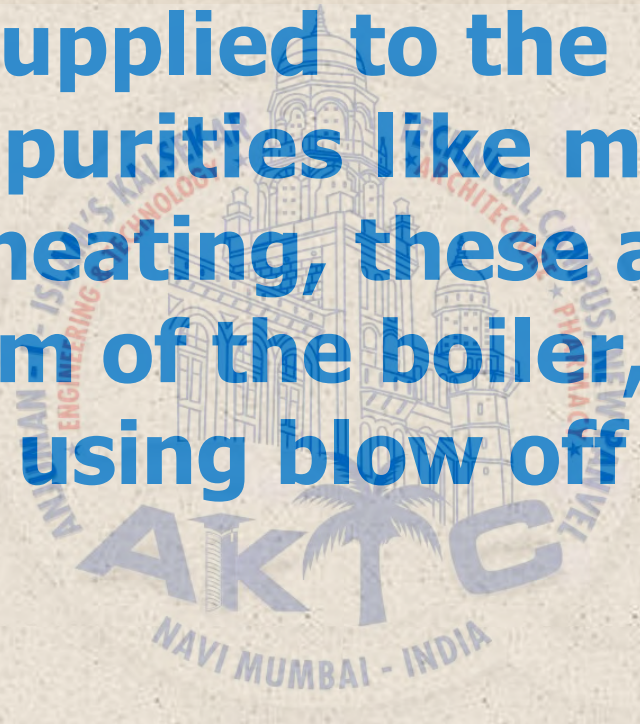






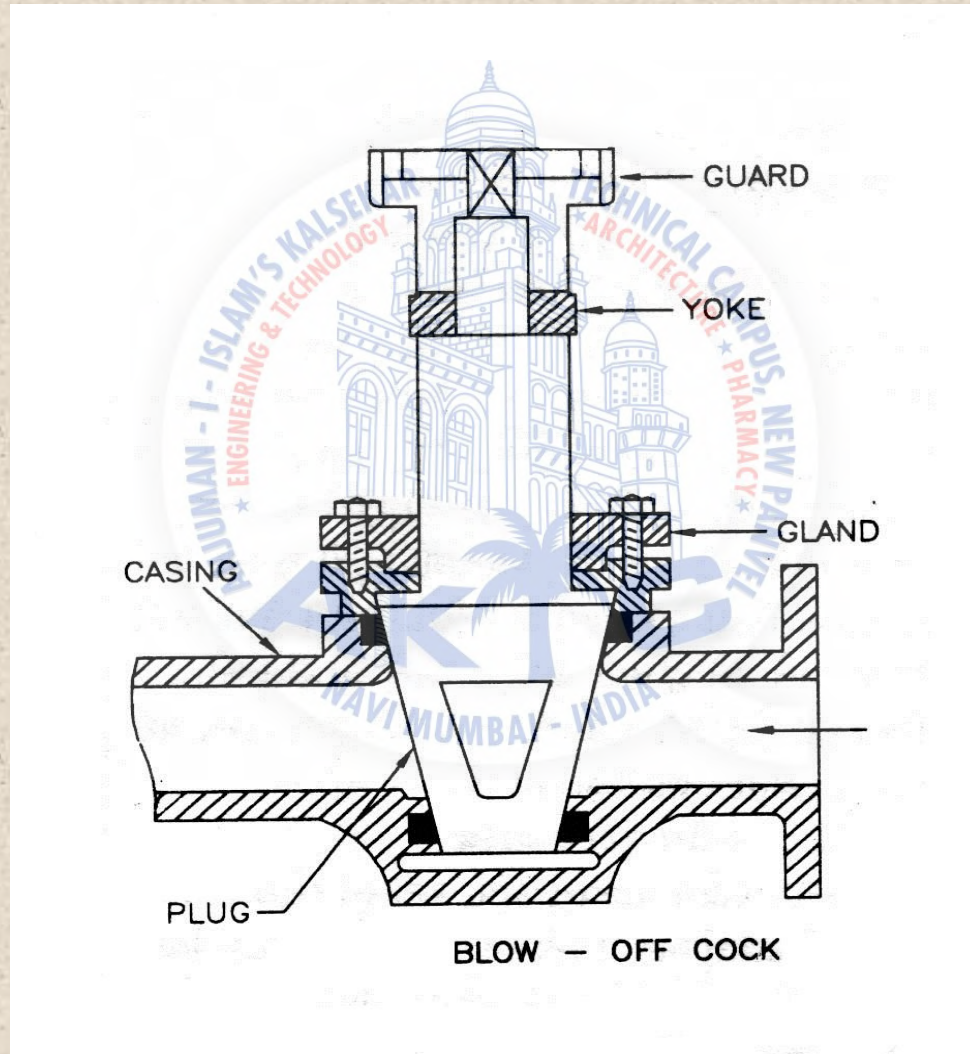
# Blow-off Cock.

- **The water supplied to the boiler always contains impurities like mud, sand and salt. Due to heating, these are deposited at the bottom of the boiler, they have to be removed using blow off cock.**





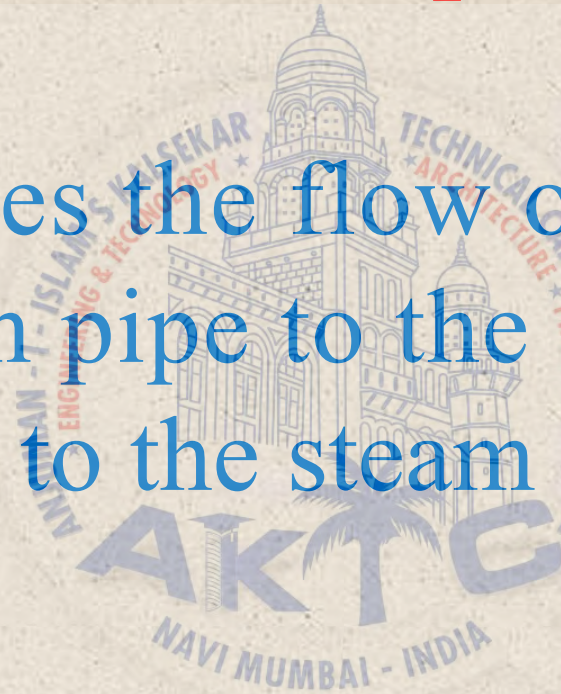
# Blow-off cock



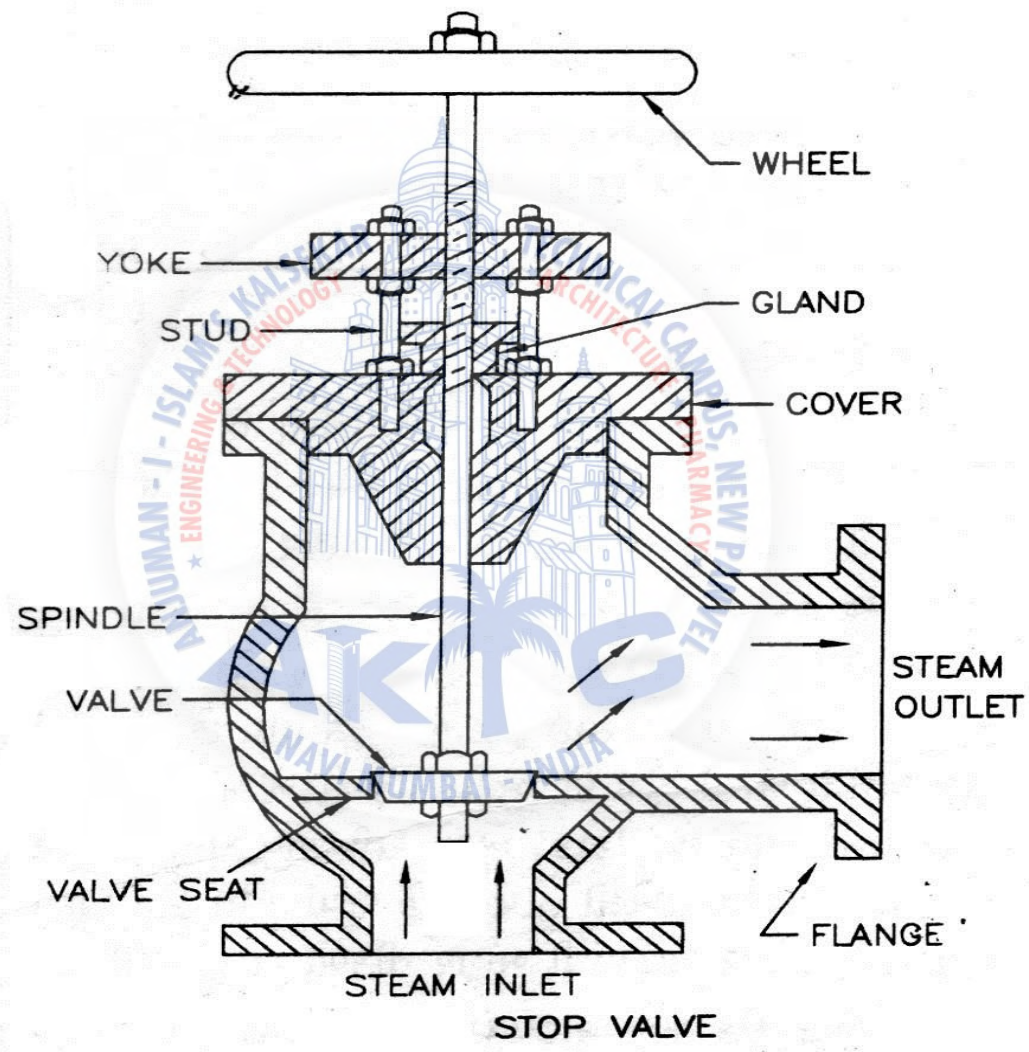


# Steam Stop Valve

It regulates the flow of steam from one steam pipe to the other or from the boiler to the steam pipe.









# Boiler Accessories

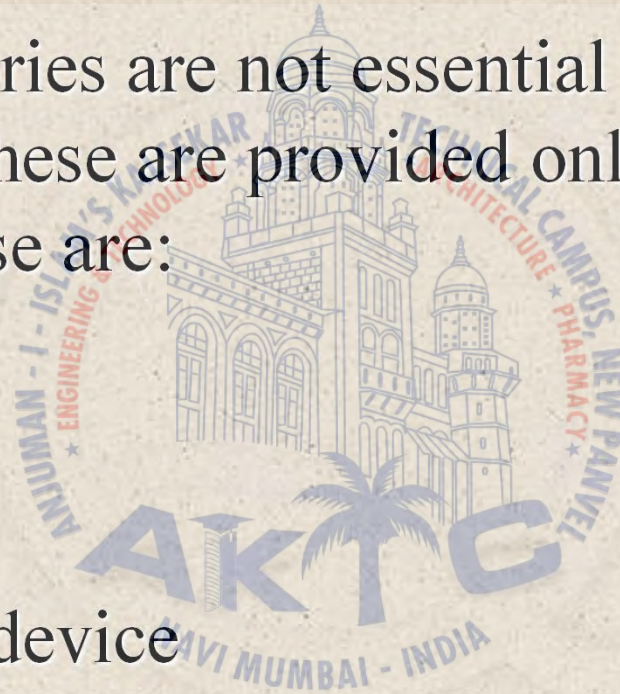




# Boiler Accessories:

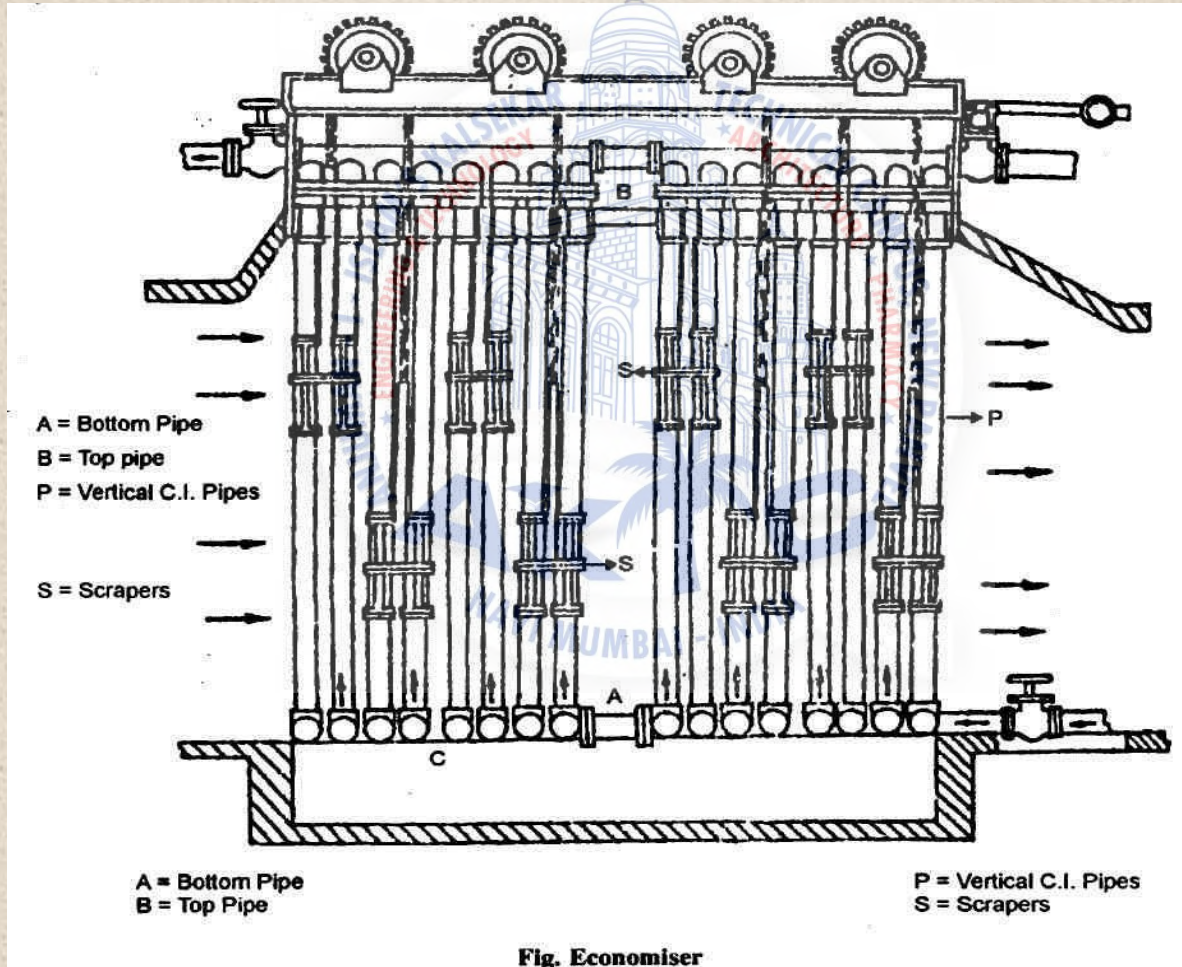
Boiler Accessories are not essential from IBR point of view since these are provided only for efficient operation. These are:

1. Economiser
2. Air preheater
3. Superheater
4. Water feeding device



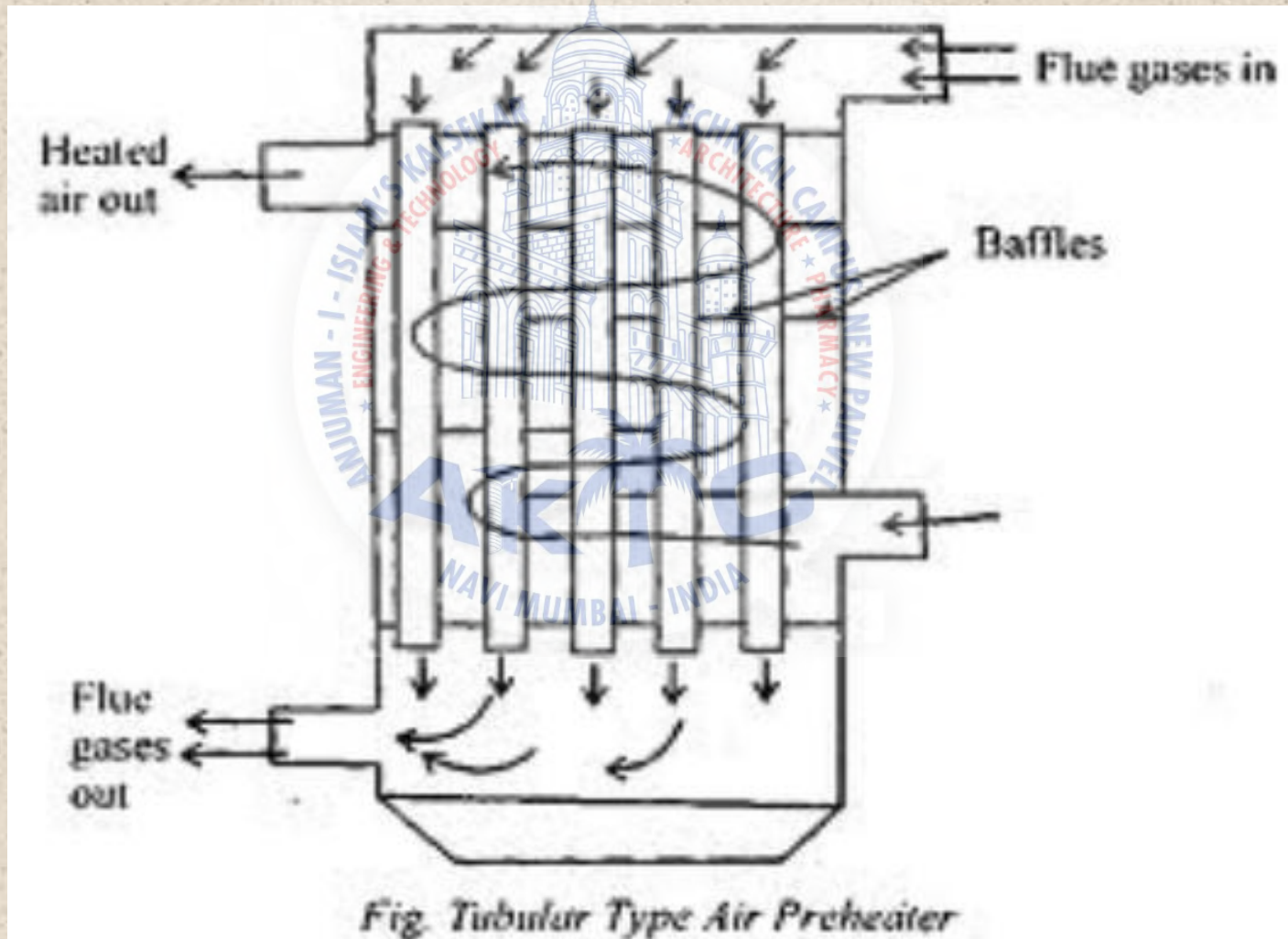


# Economiser





# Air Preheater





# Superheater

