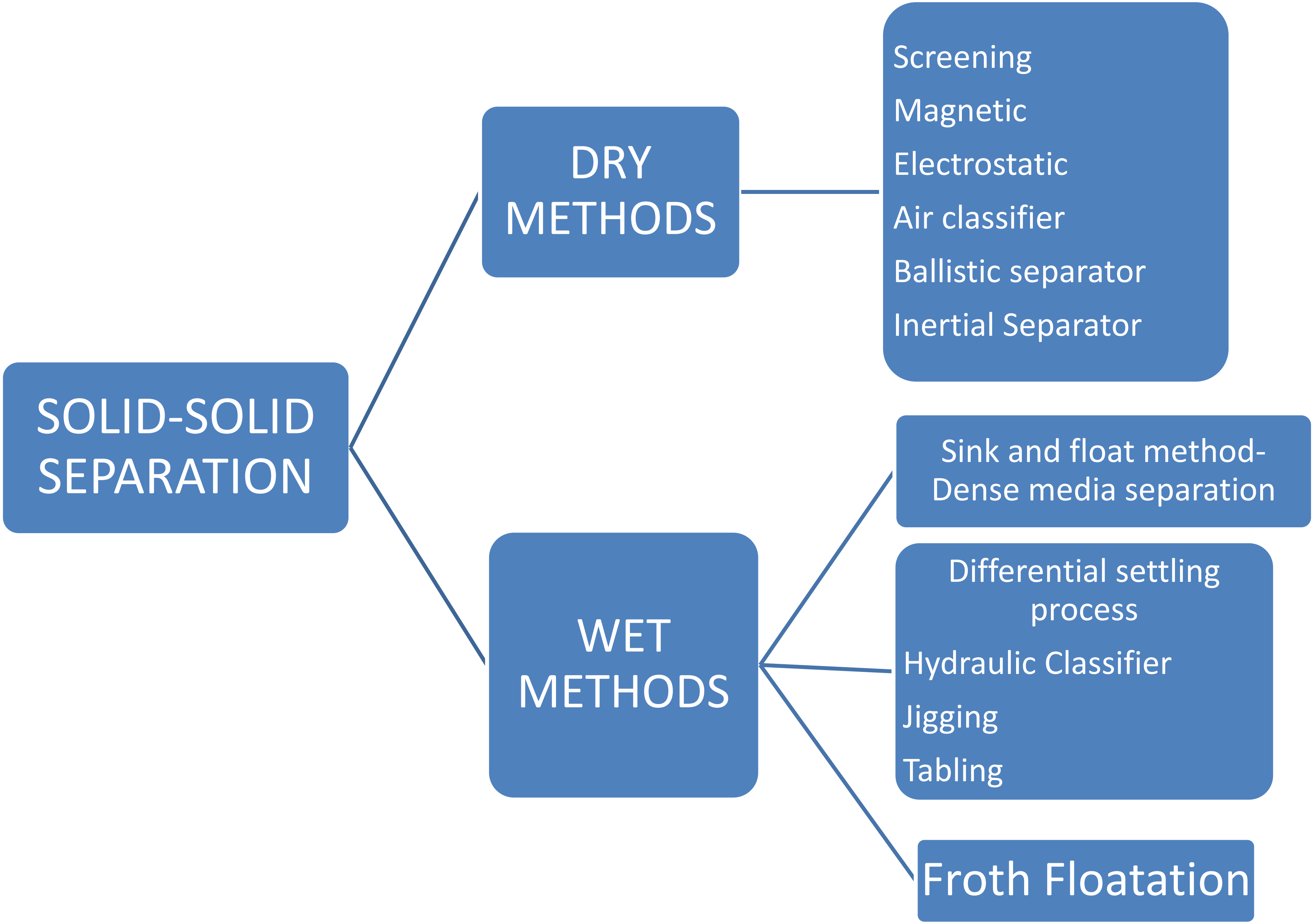
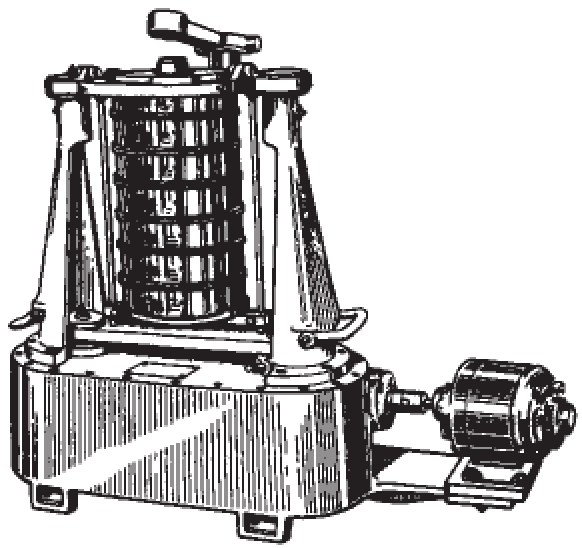
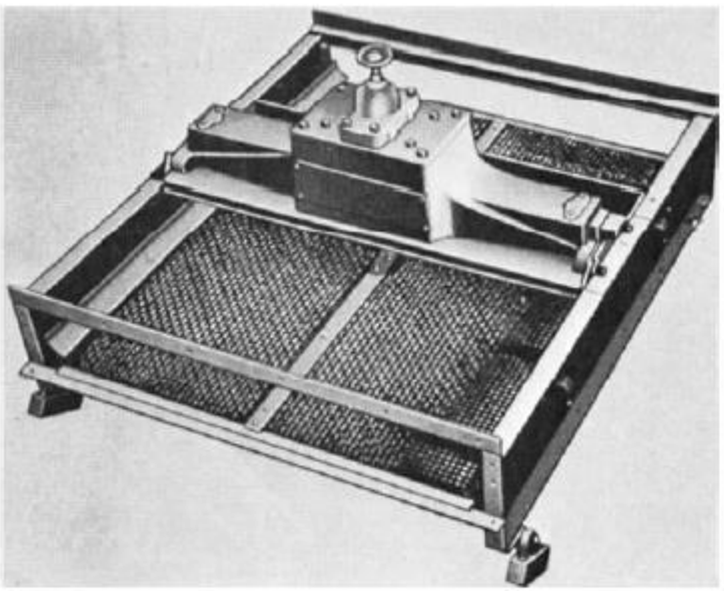
MECHANICAL SOLID-SOLID SEPARATION TECHNIQUES

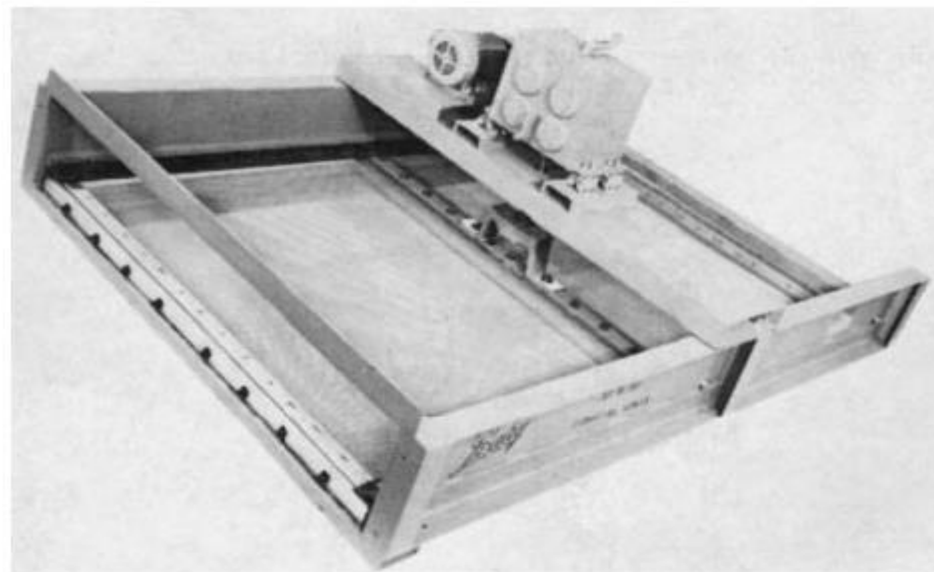

SOLID-SOLID SEPARATION
DRY METHODS
Screening
Magnetic
Electrostatic
Air classifier
Ballistic separator
Inertial Separator
WET METHODS
Sink and float method- Dense media separation
Differential settling process
Hydraulic Classifier
Jigging
Tabling
Froth Floatation

SCREENING

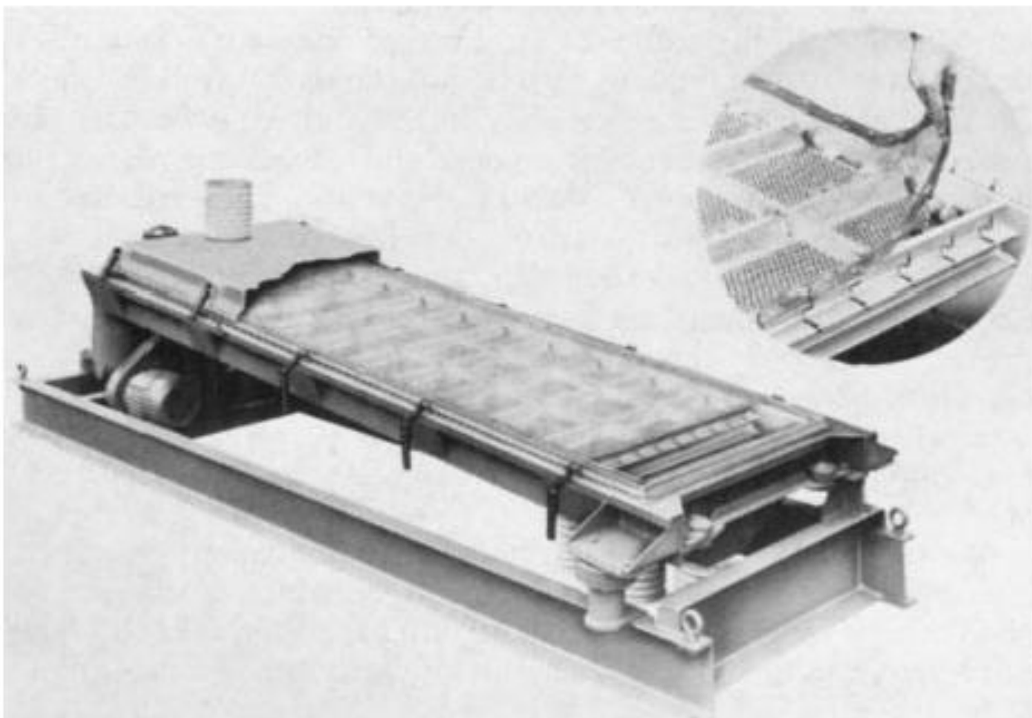


Mechanically vibrated Horizontal screen
Hummer Electromagnetic screen





Reciprocating Screen



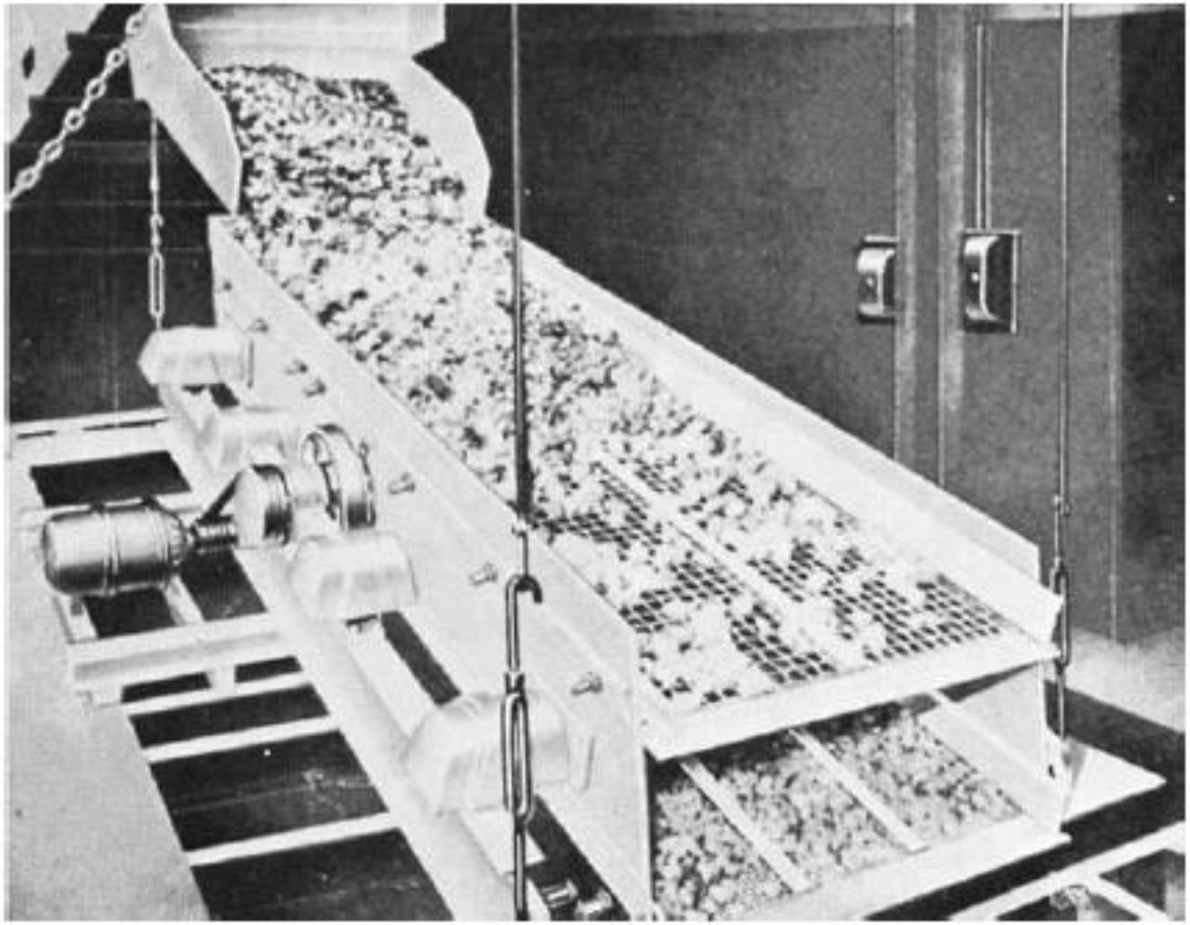


Figure 1.41. Tyrock mechanical screen

TROMMEL

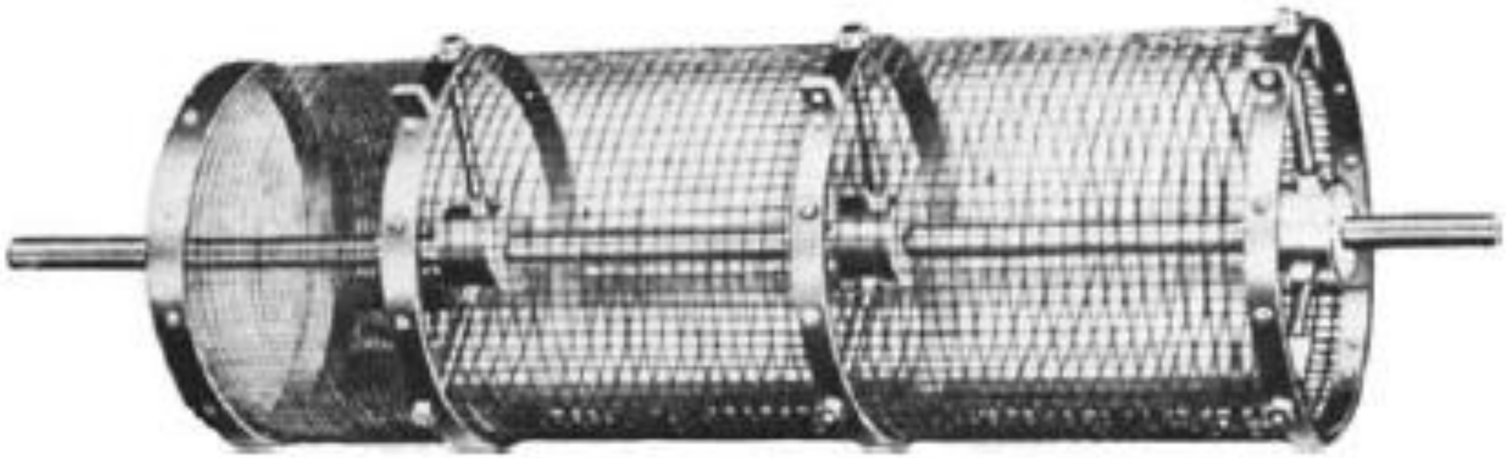
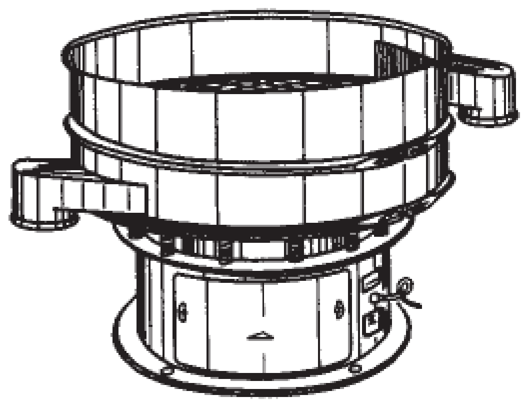


Figure 1.42 Trommel

Gyratory screen



Magnetic Separation

MAGNETIC SEPARATION

Based on magnetic behavior matrial can be classified as”

1. Ferromagnetic – very strong magnetic susceptibility- iron, nickel and cobalt.
2. Paramagnetic – weak magnetic susceptibility –
   a) Weakly magnetic
   b) Strongly magnetic
3. Diamagnetic particles – repelled by magnet
4. Non magnetic

Principle of operation : Passing material through Magnetic field which can be produced by:

1. Permanent magnet
2. Electromagnet – where, intensity of magnetic field cam be varied by varying the current, and a much higher intensity can be reached

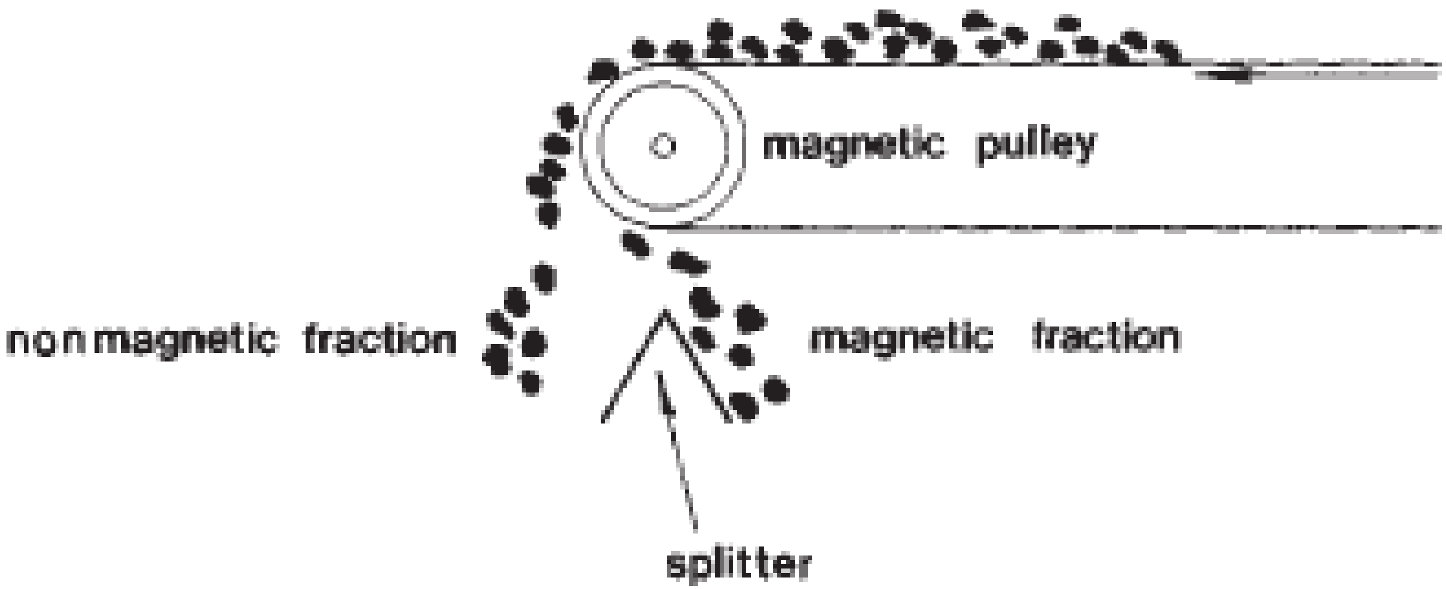
APPLICATION

1. Tramp iron removal
2. Concentration and purification

Equipment for tramp iron removal

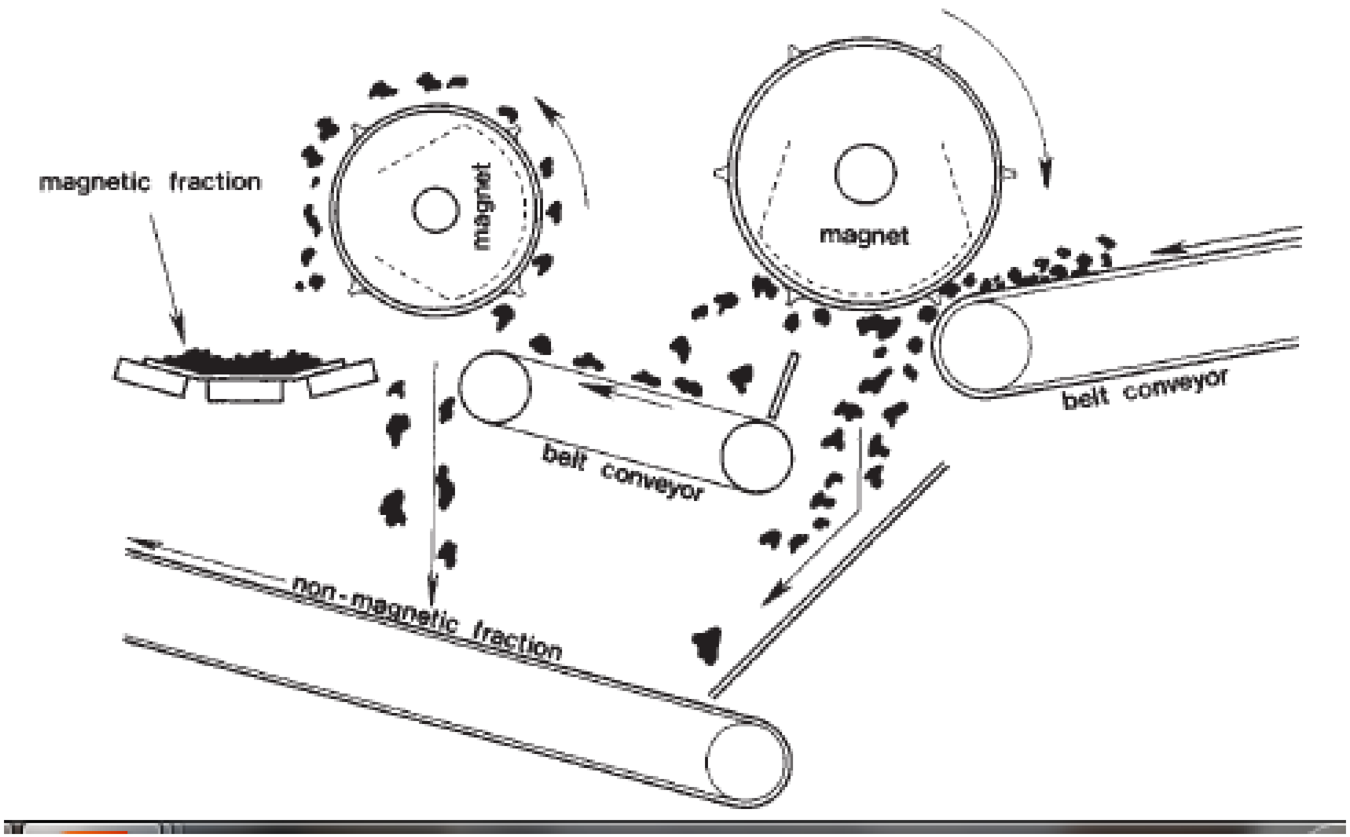
- Grate type –
    - Permanent magnets
    - Wet or dry
    - Perpendicular to flow
    - Slurry of detergent, sugar and candy, ink recycling, pulp and paper
- Plate type or magnetic humps
    - Magnetized plate, cleaned periodically
    - Permanent or elctromagnet
    - 45o chute angle,
- Lifting Magnets
- Drum and Pulley magnets
- Wet drum magnetic separators
- Induced roll magnetic separator
    - Magnetic field gradient, fractions

Magnetic pulleyj

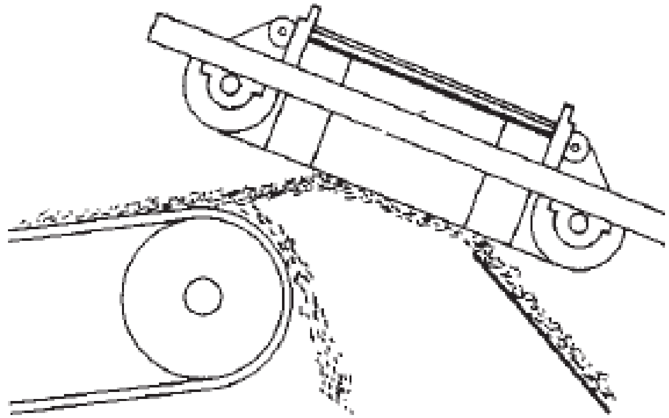


- Setr of stationary magent cover 50 to 75% of drum circumference. Magnetic material, under the action of magnetic field, adhjere to the drum or pulley and move along the pulley as long as the particles remain in the magnetic field and non magnetic material fall freely.

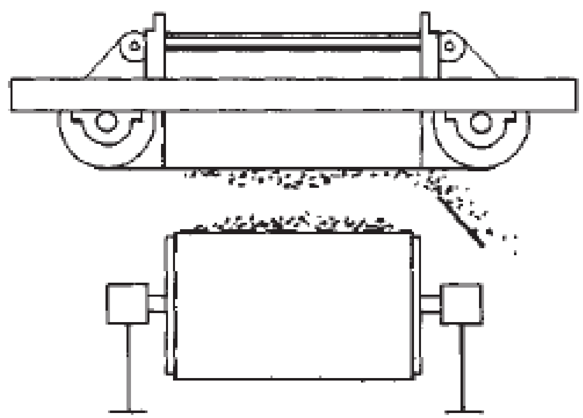
Magnetic drum as lifting magnet



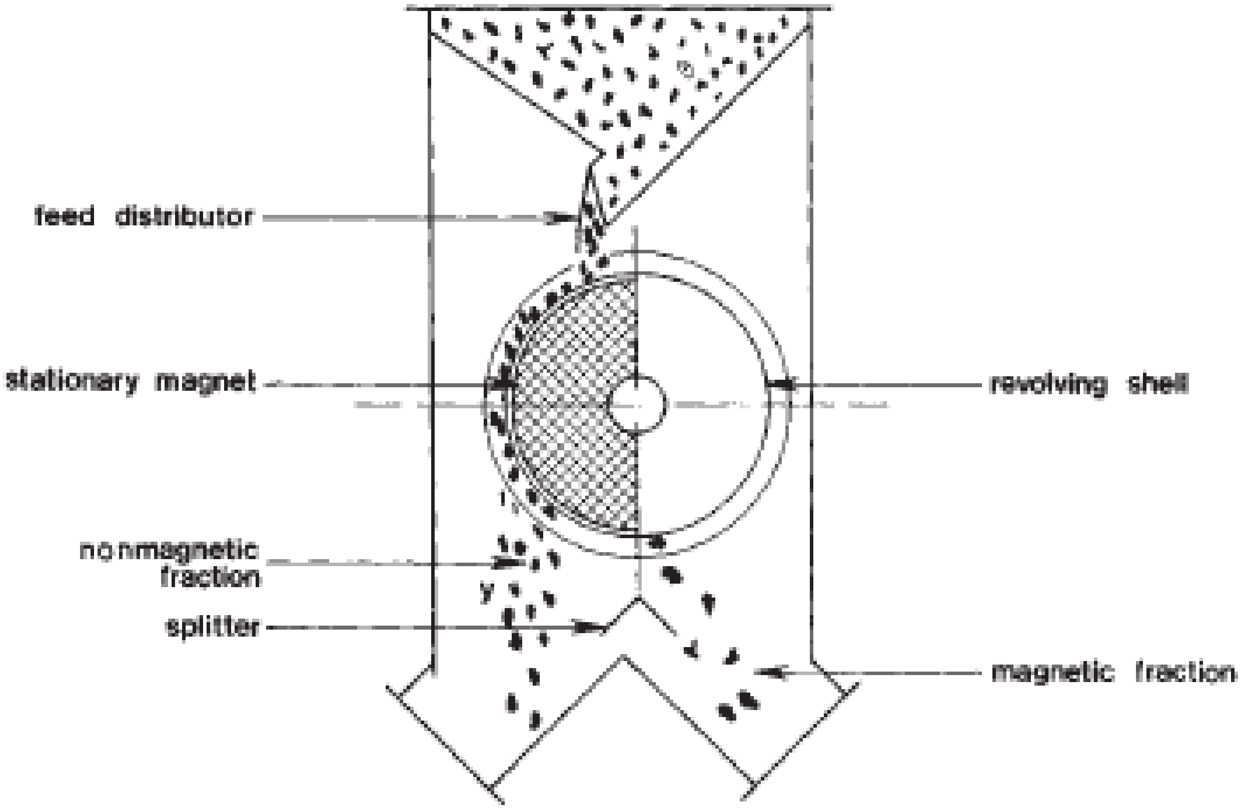
Inline and cross belt lifting magnet



(a)

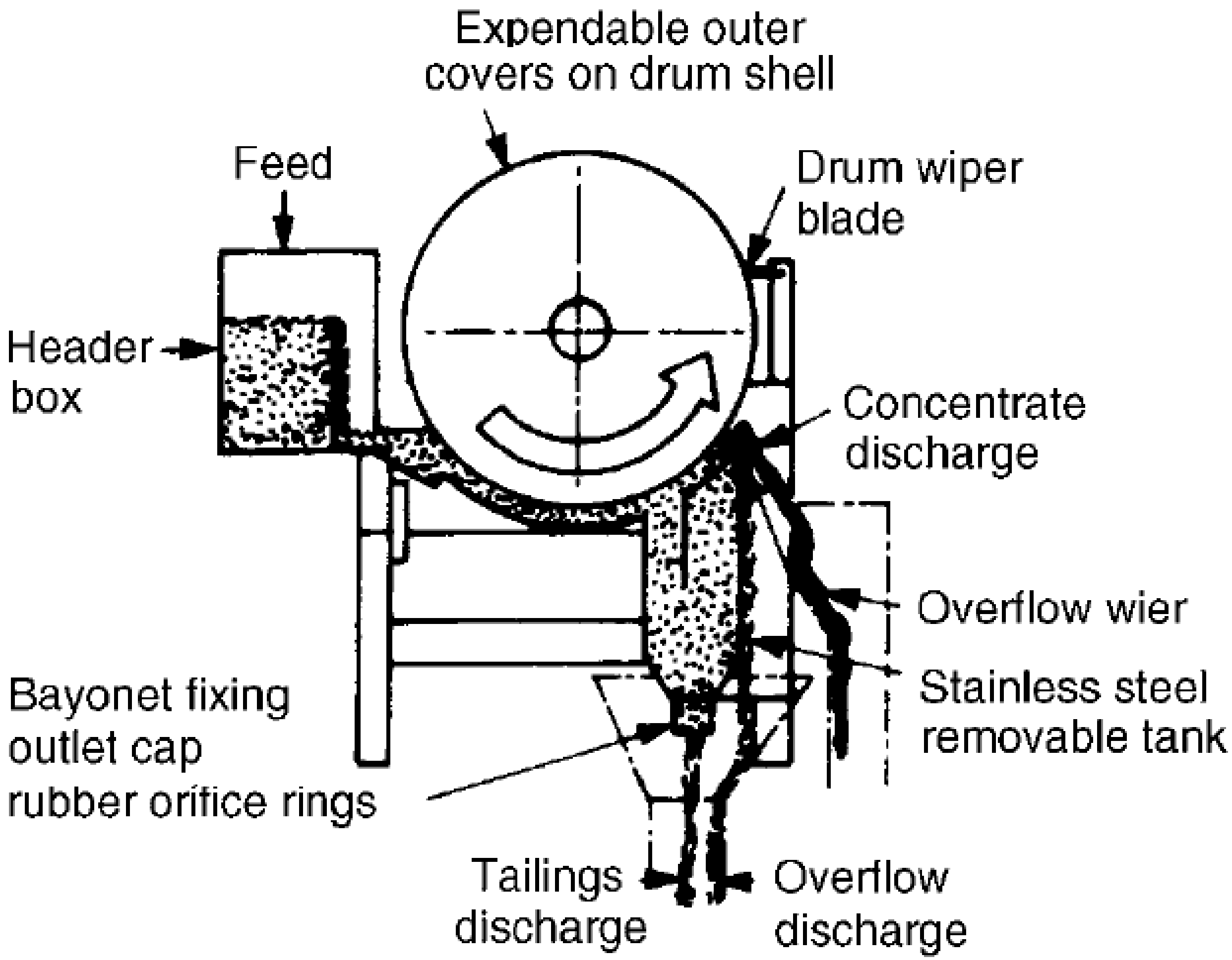


Magnetic drum operating as pulley

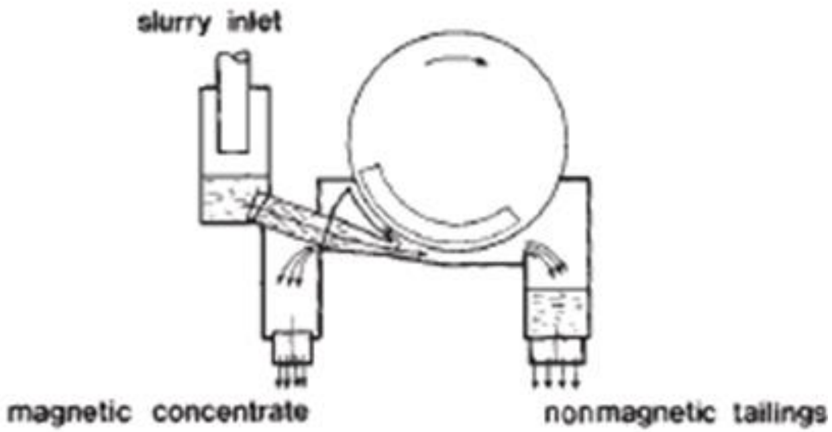


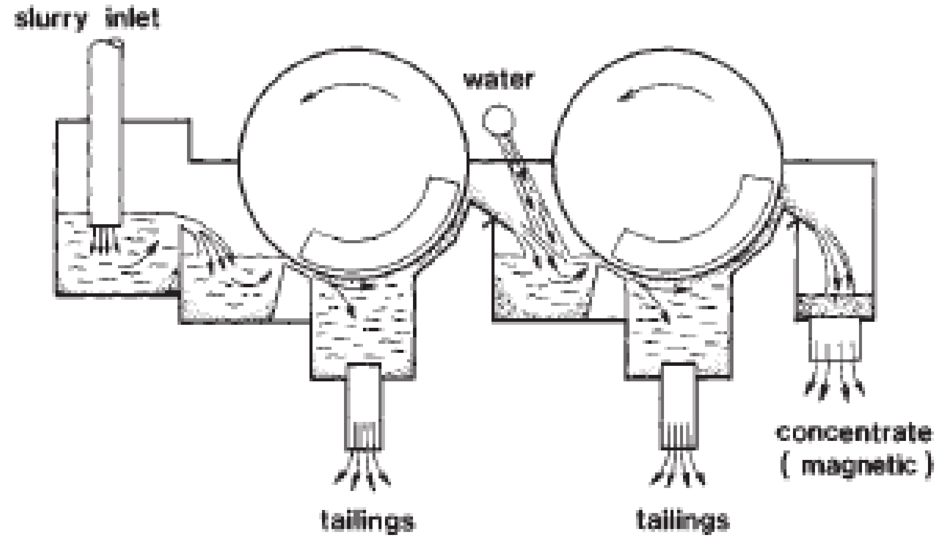
- Drums of 0.3 to 0.6 m diameter and 0.3 to 1.5 m width.
- May be wet or dry

Wet drum separator

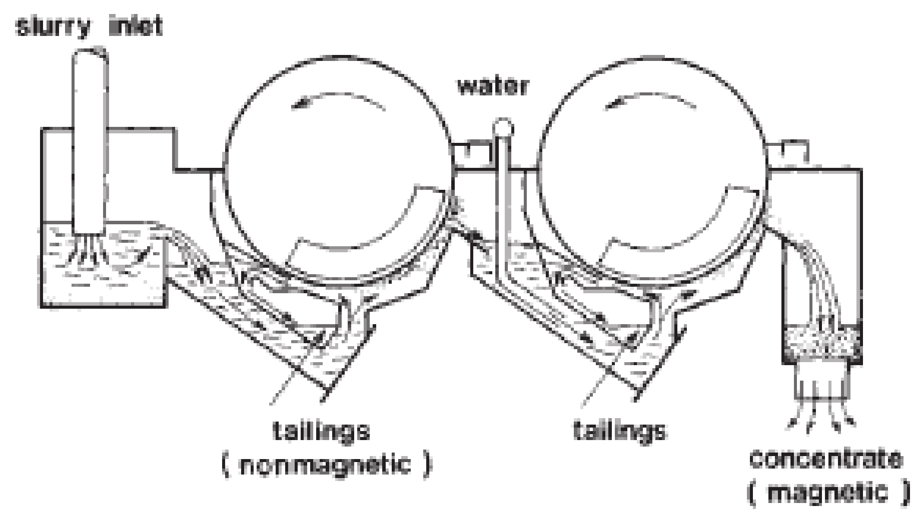


Wet drum magnetic separator



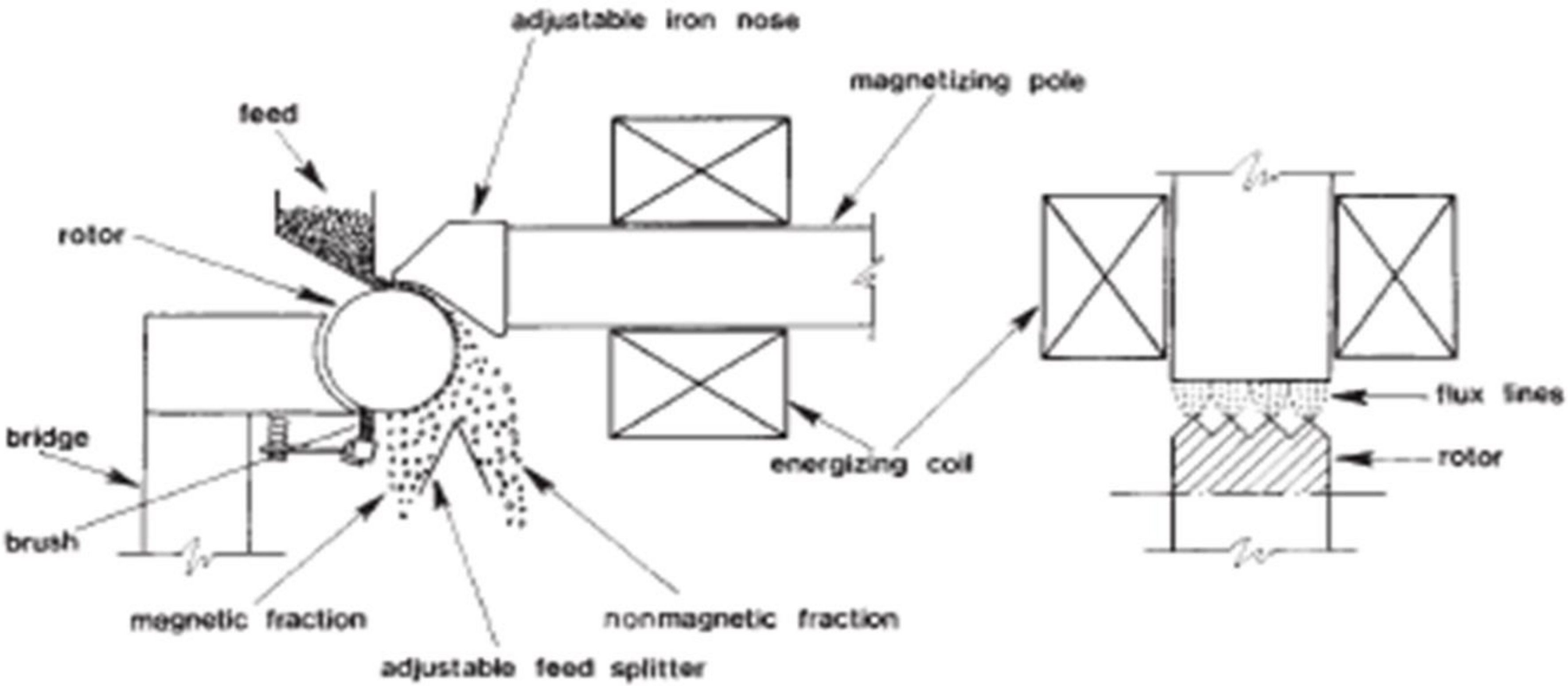


(b)



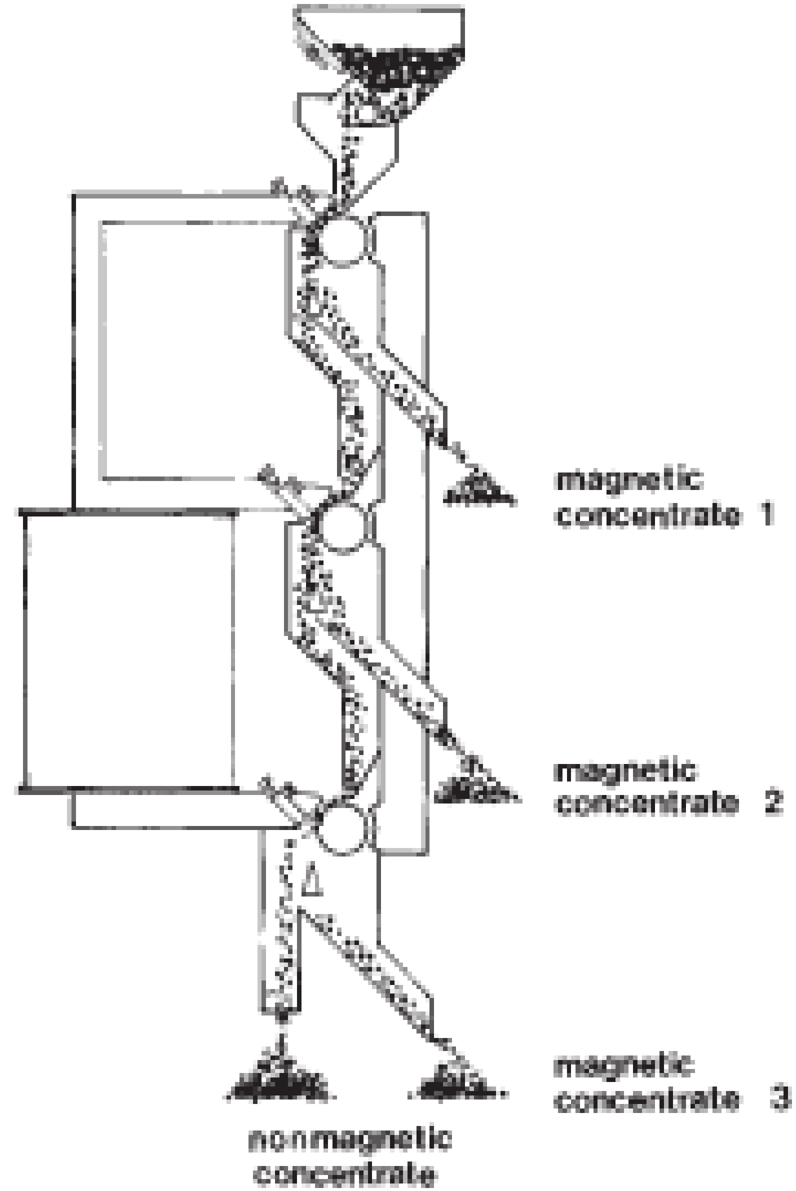
(c)

Induced Roll Magnetic Separator



- Instead of permanent magnet, electromagnets induces a magnetic field onto a roll through a cast iron magnetic pole located a short distance away.

Multiple Induced roll magnetic Separator



APPLICATION OF MAGNETIC SEPARATORS AS CONCENTRATORS AND PURIFIERS

- Concentrators – separation of large amount of magnetic feed product
- Purification –removal of small amounts of magnetic particles from a large amount of non magnetic feed material.
- Equipment – Wet and Dry types
  - Concentration of ferromagnetic iron ores - magnetite ores, iron ore other than magnetite, after preliminary conversion of iron minerals to artificial magnetite by suitable Roasting.
  - Recovery of fine ferromagnetic particles from liquid dense media plants.
  - For the removal of small quantities of iron ore minerals from Ceramic raw materials.
  - For the concentration of slightly Paramagnetic minerals such as those of Manganese, tungsten, chromium, tin, zinc, titanium, etc.

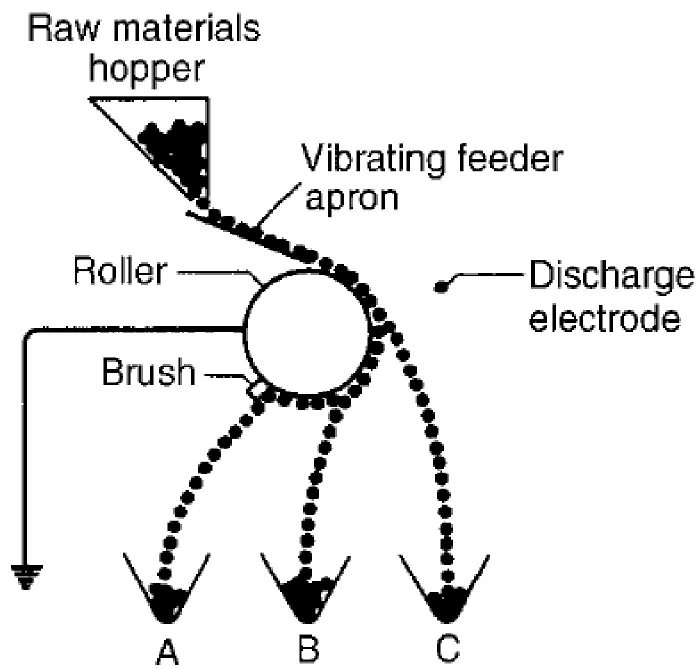
ELECTROSTATIC SEPARATORS

ELECTROSTATIC SEPETATOR

- Separates materials based the differnces in electrical conductivity of charged particles under influence of and external electrical field eg. conducting from non conducting materials
- Equipment:
  - Contact electrification
    - Tribo electric separator for recycling minerals and plastics
  - Conductive induction
    - Drum type
    - Belt type

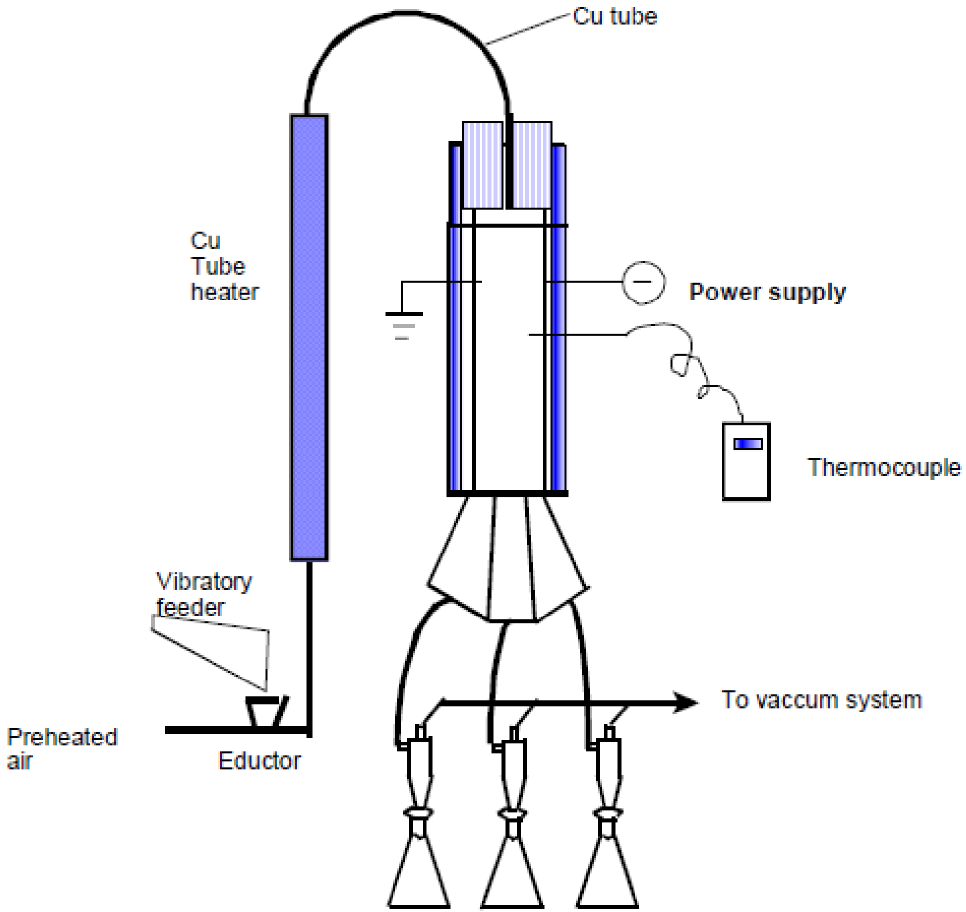
Separation by conductive induction

- Initially uncharged particle that comes into contact with a charged surface assumes the polarity and, eventually, the potential of the surface.
- A particle that is an electrical conductor will assume the polarity and potential of the charged surface very rapidly, and be repelled
- A non-conducting particle will become polarized so that the side of the particle away from the charged surface develops the same polarity as the surface and sticks to it
- Particles of intermediate conductivity may be initially polarized but approach the potential of the charged surface at a rate depending on their conductivity



- A= non-conducting particle
- B= Intermediate particle
- C= Conducting particle

Triboelectrostatic Separator



- When different insulating materials are rubbed/ friction get charged, degree of which depends on the material,
- Triboelectirc Series Table
- Equipment :

1. Mixing materials to acquire charge – tumblers/fluidized bed
2. Allowed to fall through an electric field 2-5 kV between two parallel plates

- Depending on the charge the particles are collected in different positions.

Triboelectric series

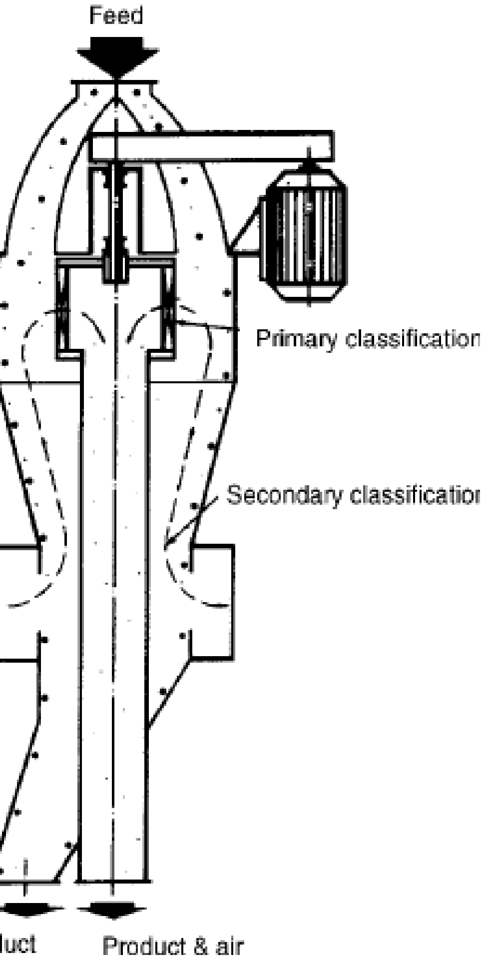
- Most positively charged
- +
- Polyurethane foam
- Hair, oily skin
- Nylon dry skin
- Glass
- Acrylic
- Leather
- Rabbits fur
- Quartz
- Micaead
- Cats fur
- Silk
- Aluminium
- Paper
- Cotton (small positive charge)
- Wool(No charge)
- 0
- Steel (No charge)
- Wood (Small negative charge)
- Amber
- Sealing wax
- Polystyrene
- Rubber
- Resin
- Hard rubber
- Nickel copper
- Sulfur
- Brass, Silver
- Gold, Platinum
- Acetate, Rayon
- Synthetic rubber
- Polyester
- Styrene and polystyrene
- Orlon
- Plastic wrap
- Polyethylene (like Scotch tape)
- Polypropylene
- Vinyl (PVC)
- Silicon
- Teflon
- Silicone rubber
- Ebonite
- –
- Most negatively charged

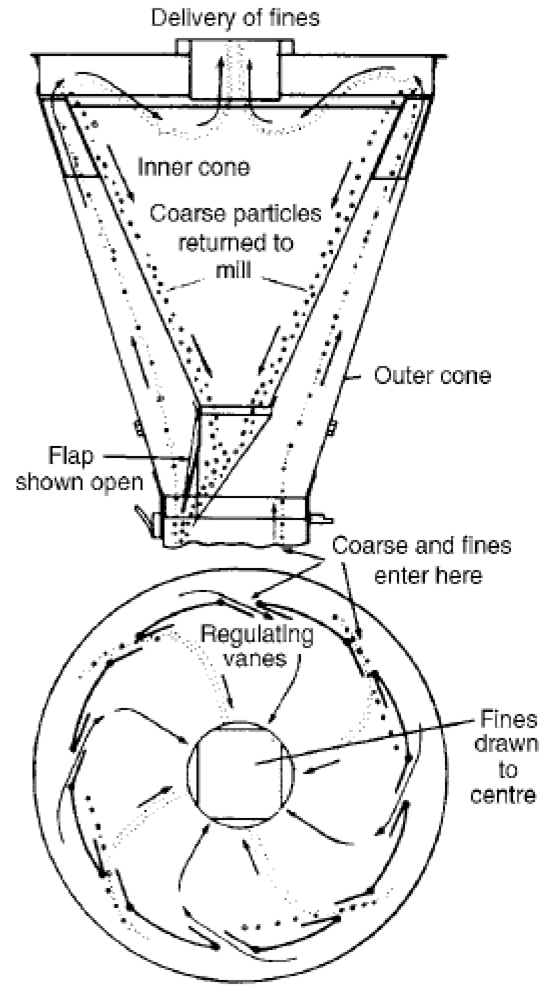
APPLICATION OF TRIBO-ELECTROSTATIC SEPARATOR

- **Mineral Beneficiation:**
  - processing of heavy-mineral beach sands from which are recovered ilmenite, rutile, zircon, monazite, silicates, and quartz.
  - High-grade specular hematite concentrates have been recovered at rates of 1000 tons/h in Labrador.
  - Processing tin ores to separate cassiterite from columbite and ilmenite.
- ***Plastic and Metals Recycling***
  - ***R***ecover nonferrous metals from industrial plastics (telephone and communication scrap)
  - Recycling of beverage bottles to reject any remaining nonferrous metals.
  - Triboelectric separation involves the separation of PVC from PET and other plastics.
  - Permit PVC to assume a strong negative charge and be removed efficiently from properly protected mixed plastic feedstocks
- **Other Applications**
  - differences in surface conductivity and shape factors.
  - seed sorting, cleaning of spices,
  - removal of textile from reclaimed plastics, and
  - separation of paper and plastic.

AIR CLASSIFICATION

Air Classifiers





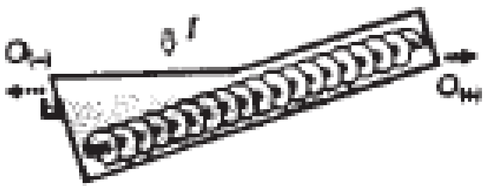
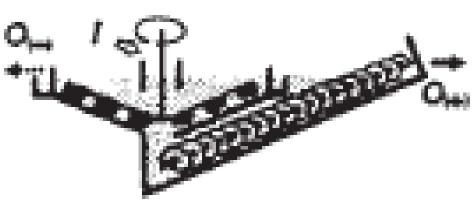
BALLISTIC SEPARATOR

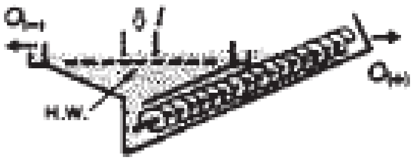
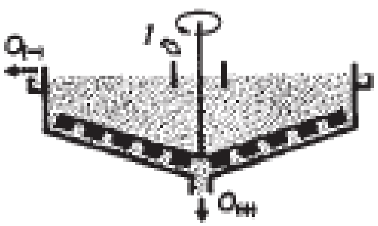
INTERTIAL SEPARATOR

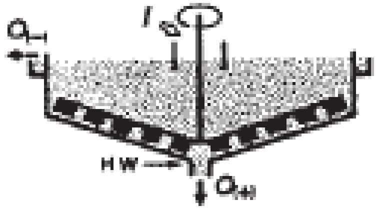
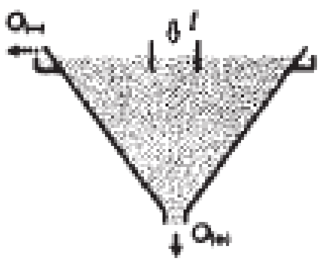
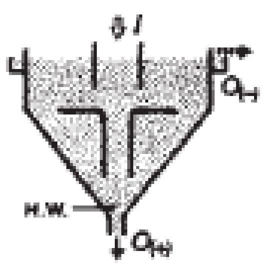
WET CLASSIFICATION

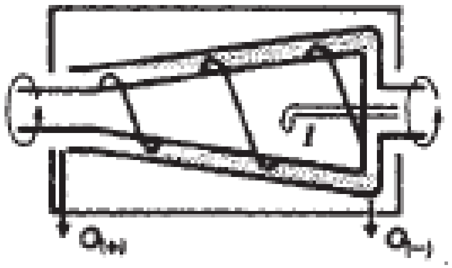
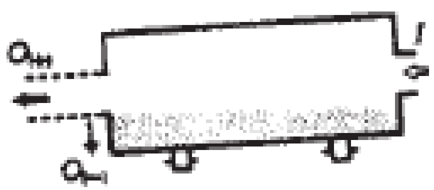
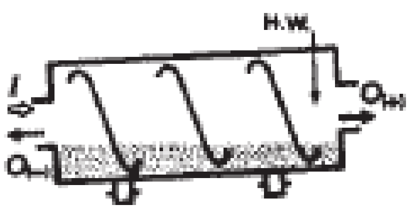
Hydraulic Classifiers

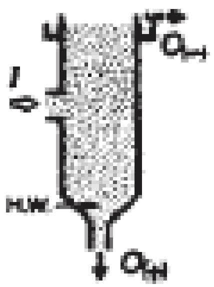
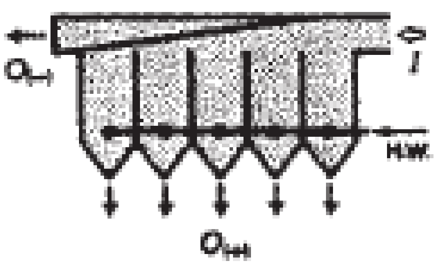
- Mechanical – (M)
- Non Mechanical – (N)
- Fluidization (F)
- Settling (S)
- Method of removal of Sand:
  - Drag – endless belt or chain to remove sand
  - Spiral – screw conveyer
  - Rake – Rakes are used
- Bowl Classifier more pool for fine separation
- Hydraulic water for fluidization

Classifier	(Type*)	Description	Suitability and applications
Sloping tank classifier (spiral, rake, drag) 	(M-S)	Classification occurs near deep end of sloping, elongated pool. Spiral, rake or drag mechanism lifts sands from pool.	Used for closed circuit grinding, washing and dewatering, desliming; particularly where clean dry underflow is important. (Drag classifier sands not so clean.) In closed circuit grinding discharge mechanism (spirals especially) may give enough lift to eliminate pump.
Log washer 	(M-S)	Essentially a spiral classifier with paddles replacing the spiral.	Used for rough separations such as removing trash, clay from sand. Also to remove or break down agglomerates.
Bowl classifier 	(M-S)	Extension of sloping tank classifiers, with settling occurring in large circular pool, which has rotating mechanism to scrape sands inwards (outwards in Bowl Desiltor) to discharge rake or spiral.	Used for closed circuit grinding (particularly regrind circuits) where clean underflow is necessary. Larger pool allows finer separations. Bowl Desiltor has larger pools (and capacities). Relatively expensive.

Hydraulic bowl classifier 	(M-F)	Basically a hydraulic bowl classifier. Vibrating plate replaces rotating mechanism in pool. Hydraulic water passes through perforations in plate and fluidizes sands.	Gives very clean sands and has relatively low hydraulic water requirements (0.5 t/t underflow). One of the most efficient single-stage classifiers available for closed circuit grinding and washing. Relatively expensive.
Cylindrical tank classifier 	(M-S)	Effectively an overloaded thickener. Rotating rake feeds sands to central underflow.	Simple, but gives relatively inefficient separation. Used for primary dewatering where the separations involve large feed volumes, and underflow drainage is not critical.

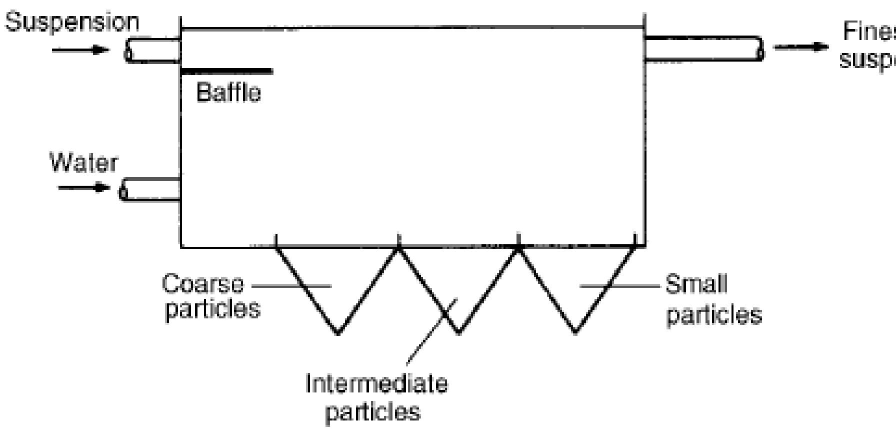
Classifier	(Type*)	Description	Suitability and applications
Hydraulic cylindrical tank classifier 	(M-F)	Hydraulic form of overloaded thickener. Siphon-Sizer (N-F) uses siphon to discharge underflow instead of rotating rake.	Two-product device giving very clean underflow. Requires relatively little hydraulic water (2 t/t solids feed). Used for washing, desliming, and closed circuit grinding.
Cone classifier 	(N-S)	Similar to cylindrical tank classifier, except tank is conical to eliminate need for rake.	Low cost (simple enough to be made locally), and simplicity can justify relatively inefficient separation. Used for desliming and primary dewatering. Solids buildup can be a problem.
Hydraulic cone classifier 	(M-F)	Open cylindrical upper section with conical lower section containing slowly rotating mechanism.	Used primarily in closed circuit grinding to reclassify hydrocyclone underflow.

Classifier	(Type*)	Description	Suitability and applications
Solid bowl centrifuge 	(M-S)	Power generates high settling forces. Slurry centrifuged against rotating bowl, and removed by slower rotating helical screw conveyor within bowl.	Relatively expensive, but high capacity for a given floor space; used for finer separations.
Scrubber 	(M-S)	Essentially a rotating drum mounted on slight incline.	Similar applications to log washer, but lighter action. Tumbling (85% critical speed) provides attrition to remove clay from sand. Also removes trash.
Countercurrent classifier 	(M-F)	One form based on scrubber, another on spiral classifier. They have wash water added to flow essentially horizontally in opposite direction to underflow which is conveyed and *resuspended* by some form of spiral.	Very clean coarse product, but relatively low capacity for a given size.

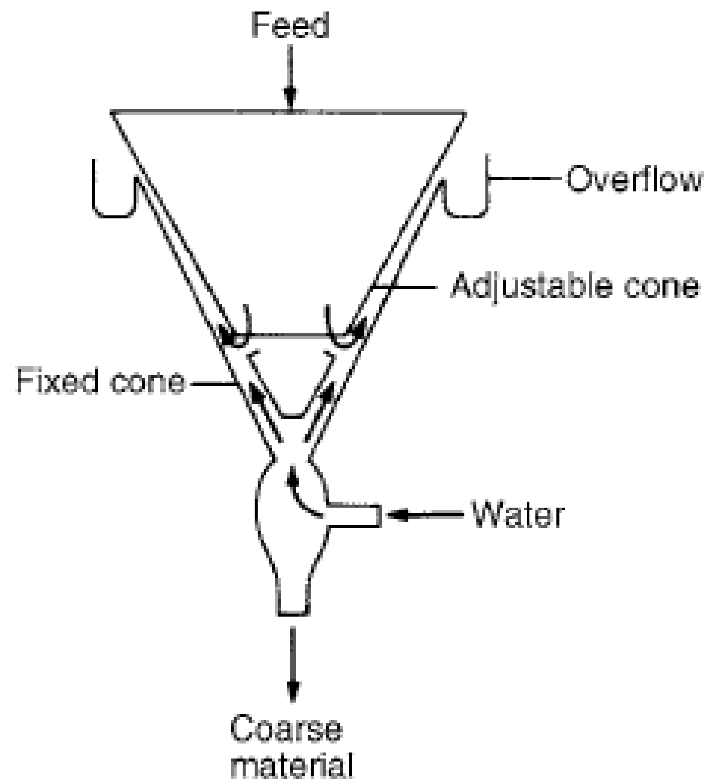
Hydrocyclone 	(N-S)	(Pumped) pressure feed generates centrifugal action to give high separating forces, and discharge.	Small cheap device, widely used for closed circuit grinding. Gives relatively efficient separations of fine particles in dilute suspensions.
Elutriator 	(N-F)	Basically a tube with hydraulic water fed near bottom to produce hindered settling. Underflow withdrawn through valve at base. Column may be filled with network to even out flow.	Simple and relatively efficient separation. Normally a two-product device but may be operated in series to give a range of size fractions.
Pocket classifier 	(N-F)	A series of classification pockets, with decreasing quantities of hydraulic water in each, producing a range of product sizes.	Efficient separations, but requires 3 t hydraulic water/t solids feed. Used to produce exceptionally clean underflow fractioned into narrow size ranges.

Gravity Classifier

GRAVITY CLASSIFIER



DOUBLE CONE CLASSIFIER



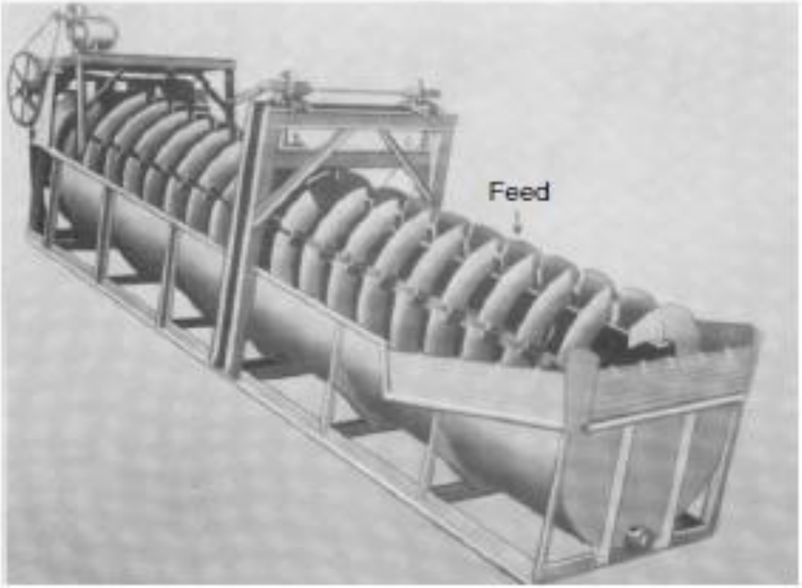


Figure 1.30. The Denver classifier

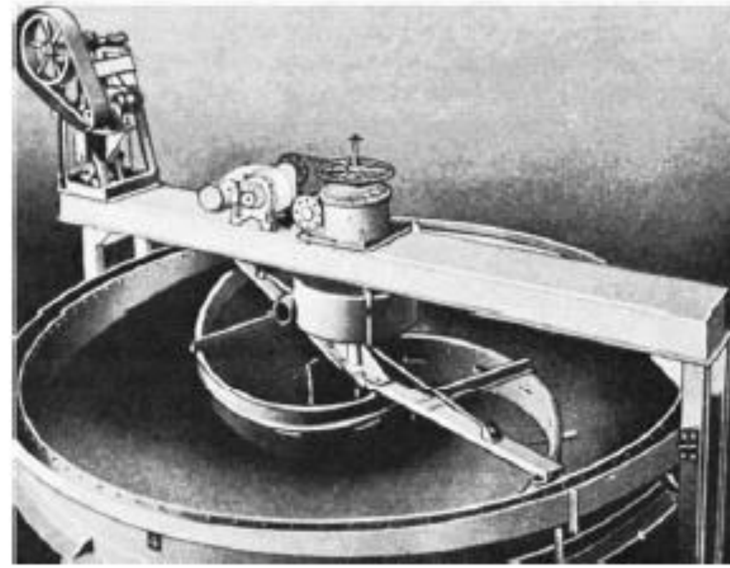


Figure 1.31 Bowl classifier

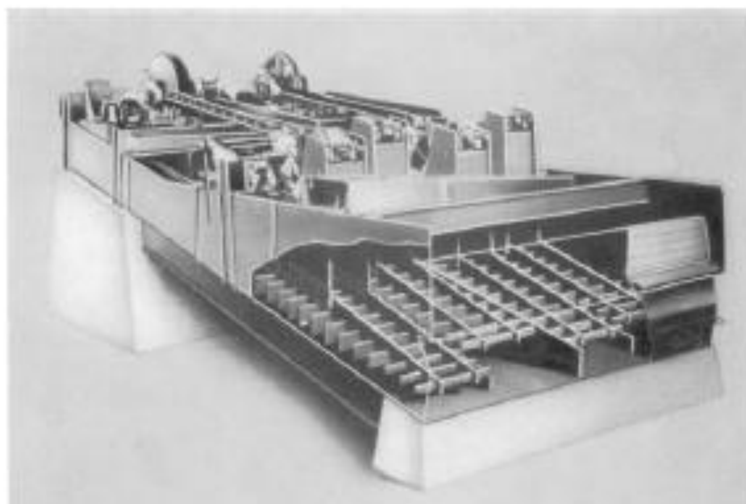
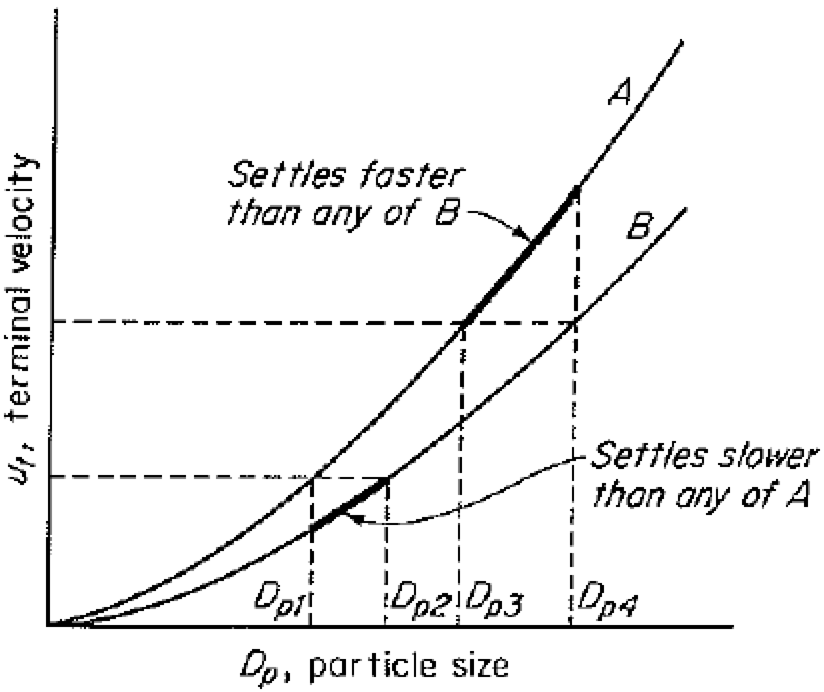


Figure 1.29. A rake classifier

DIFFERENTIAL SETTLING EQUAL SETTLING PARTICLES



- Stokes Law range, particle Reynolds number less than 1.0
- $u_{tA} = \frac{g D_{pA}{}^2 (\rho_{pA} - \rho)}{18\mu}$
- $u_{tB} = \frac{g D_{pB}{}^2 (\rho_{pB} - \rho)}{18\mu}$
- $\frac{D_{pA}}{D_{pB}} = \sqrt{\frac{(\rho_{pB} - \rho)}{(\rho_{pA} - \rho)}}$
- Newtons Law Range,
- 1000<Rep<200,000,
- $u_t = 1.75\sqrt{\frac{g D_p (\rho_p - \rho)}{\rho}}$
- $\frac{D_{pA}}{D_{pB}} = \frac{(\rho_{pB} - \rho)}{(\rho_{pA} - \rho)}$

- Particles of galena (specific gravity-7.5) and quartz (specific gravity-2.65) are to be separated by differential settling in water. The particles size varies from 1mm to 6mm. What different fractions are expected ? (Assume settling to be in Newton’s law range)

A mixture of quartz and galena of a size range from 0.015 mm to 0.065 mm is to be separated into two pure fractions using a hindered settling process. What is the minimum apparent density of the fluid that will give this separation? The density of galena is 7500 kg/m^3 and the density of quartz is 2650 kg/m^3.

Solution

Assuming the galena and quartz particles are of similar shapes, then from equation 1.42, the required density of fluid when Stokes' law applies is given by:

$$\frac{0.065}{0.015} = \left(\frac{7500 - \rho}{2650 - \rho}\right)^{0.5}$$

and: $$\rho = 2377 \text{ kg/m}^3$$

The required density of fluid when Newton's law applies is given by:

$$\frac{0.065}{0.015} = \left(\frac{7500 - \rho}{2650 - \rho}\right)^{1.0}$$

and hence: $$\rho = 1196 \text{ kg/m}^3$$

Thus, the required density of the fluid is between 1196 and 2377 kg/m^3.

Ref: Geankoplis

EXAMPLE 14.3-3. ***Separation of a Mixture of Silica and Galena***
A mixture of silica (B) and galena (A) solid particles having a size range of 5.21×10^{-6} m to 2.50×10^{-5} m is to be separated by hydraulic classification using free settling conditions in water at 293.2 K (B1). The specific gravity of silica is 2.65 and that of galena is 7.5. Calculate the size range of the various fractions obtained in the settling. If the settling is in the laminar region, the drag coefficients will be reasonably close to that for spheres.

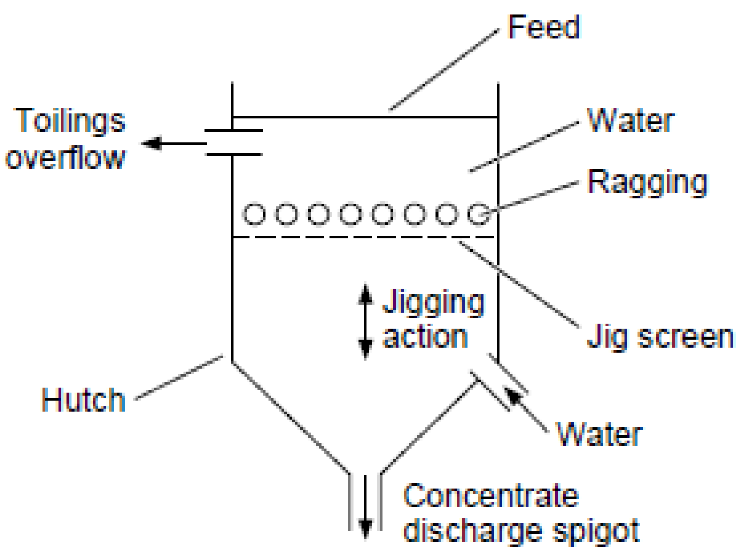
Solution: The particle-size range is $D_p = 5.21 \times 10^{-6}$ m to $D_p = 2.50 \times 10^{-5}$ m. Densities are $\rho_{pA} = 7.5(1000) = 7500$ kg/m^3, $\rho_{pB} = 2.65(1000) = 2650$ kg/m^3, $\rho = 998$ kg/m^3 for water at 293.2 K (20°C). The water viscosity $\mu = 1.005 \times 10^{-3}$ Pa · s $= 1.005 \times 10^{-3}$ kg/m · s.

Assuming Stokes' law settling, Eq. (14.3-9) becomes as follows:

$$v_{tA} = \frac{g D_{pA}^2 (\rho_{pA} - \rho)}{18\mu} \qquad \textbf{(14.3-29)}$$

The largest Reynolds number occurs for the largest particle and the biggest density, where $D_{pA} = 2.50 \times 10^{-5}$ m and $\rho_{pA} = 7500$. Substituting into Eq. (14.3-29),

JIGGING



- Principle of differential settling
- 4 fractions

1.Big particles of high density material on the screen, removed from side gate

2. Mixed material on the screen removed from side gate

3. Small particles of high density particles fall through the screen

4. small particles of light material is carried away in the liquid overflow

Types of jigs

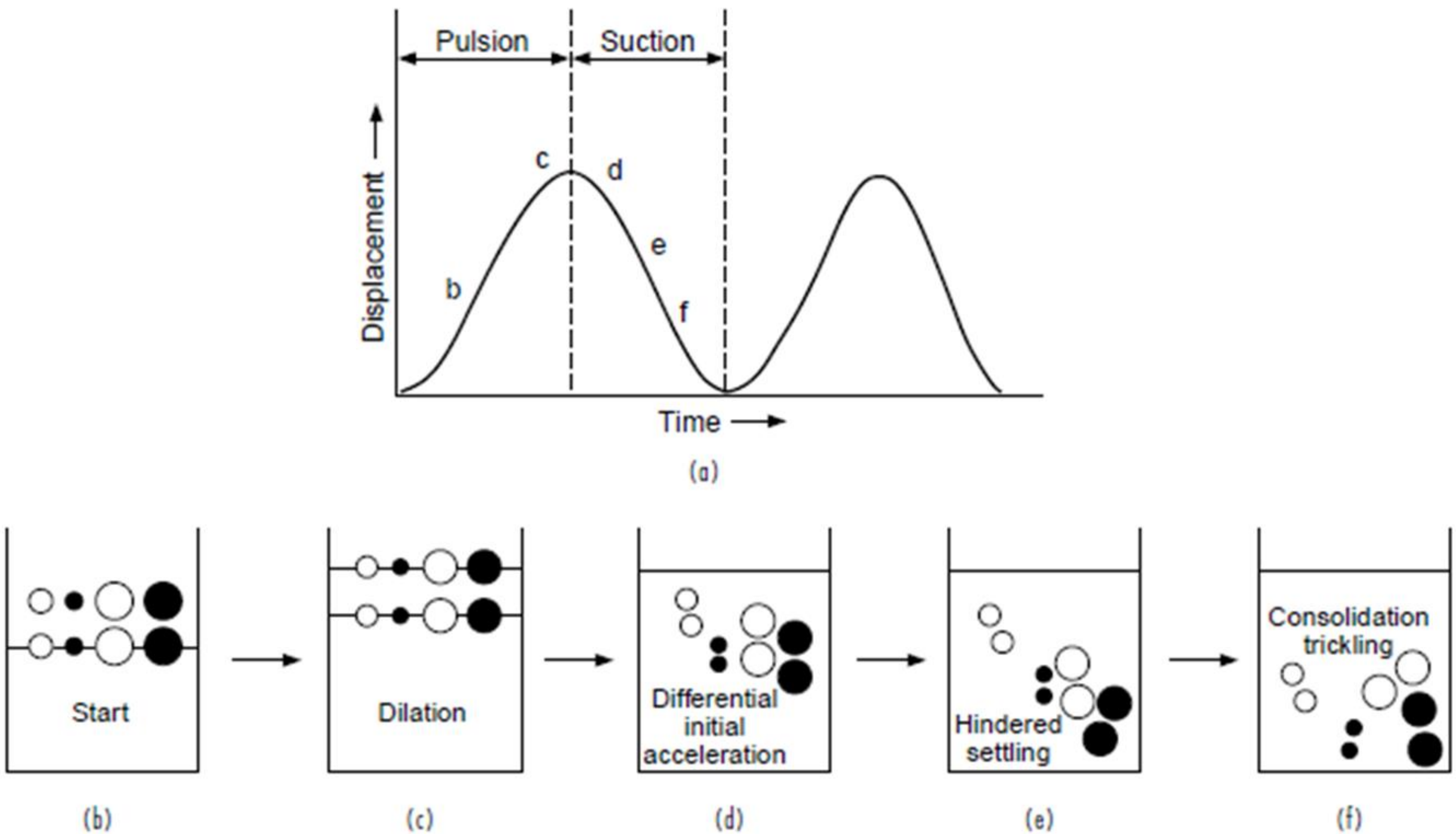
Herz

Remer

Baum

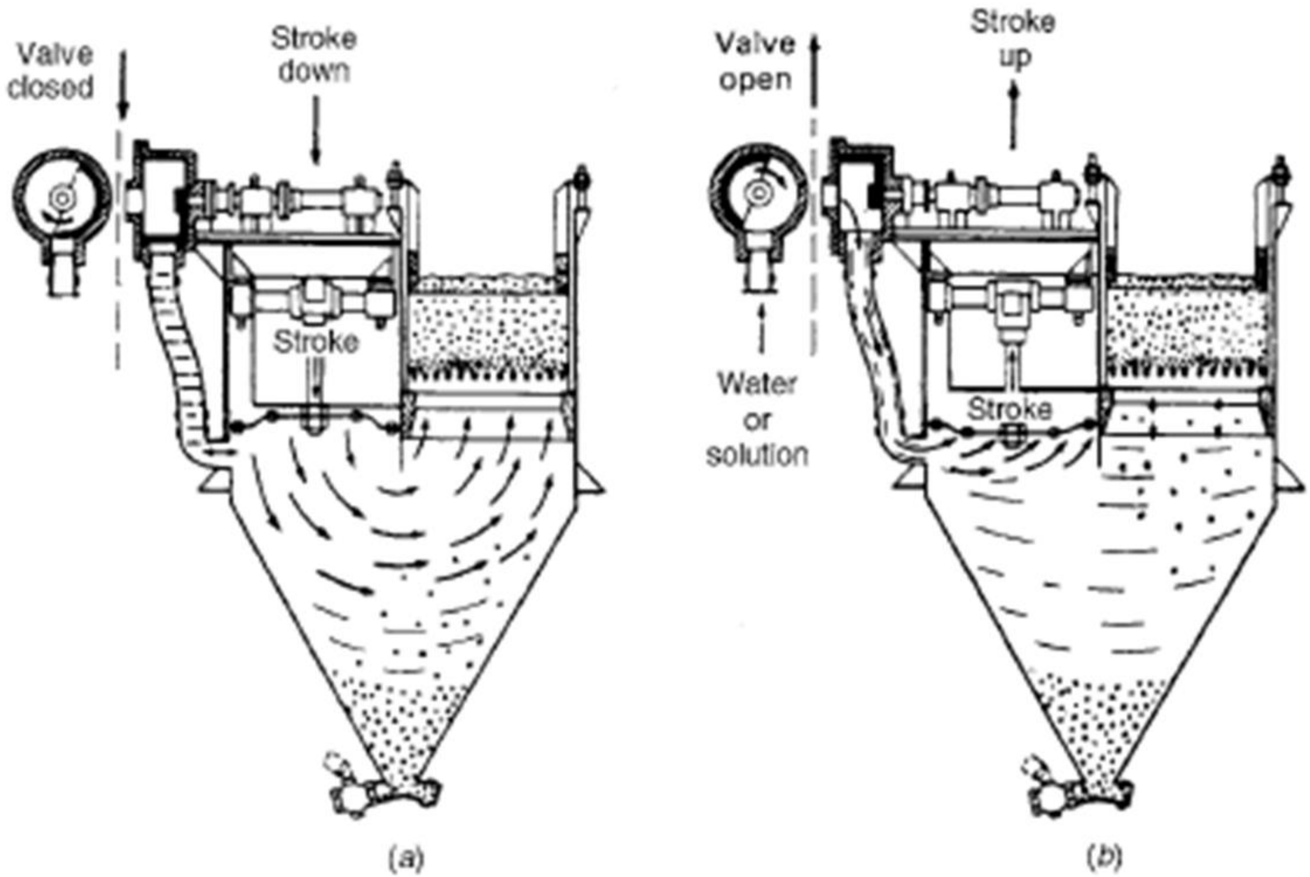
Batic

Jigging

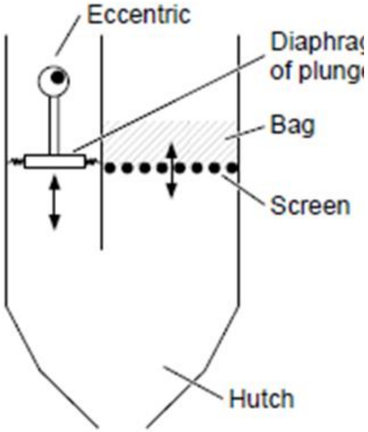
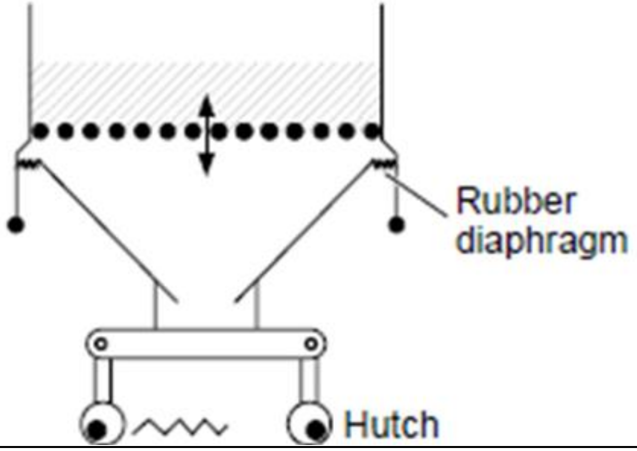


- Black – higher density
- White – lower density

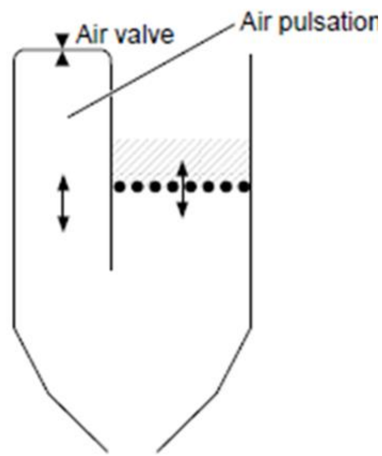
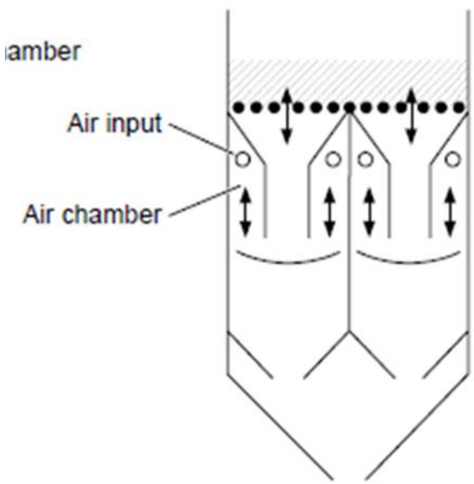
Hydraulic Jig (a) Downward stroke (b)Upward stroke



Herz and Remer Jig

	***Harz*** • Reciprocating plunger with differential piston action • treatment of gold, tungsten, and chromite ores.
	Remer jig An improvement over Harz Two motions, a normal jig pulse of 80 to 120 strokes per minute on which imposed a fast pulse in the range of 200 to 300 per minute. Commonly used in concentrating such materials as iron and barite ores and in removing impurities such as wood, shale, and lignite from sand and gravel.

Baum Jig, Batac Jig

	***Baum Jig*** • Operates by forcing air under pressure at about 17.2 kPa to pulsate the jig water which in turn pulsate the bed of particles • Several design variations exist in the removal of • lighter coal and heavier ash fractions • widely used in the coal-preparation industry to reduce the ash content of the run-of-mine coal
	***Batac jig*** • Modification of the Baum jig in that it employs multiple air chambers under the screen with electronic controls for air input and exhaust. • Uniform flow across the whole bed and a wide control of the speed and length of the jigging strokes. Batac jig is reported to treat both coarse- and fine-size coals satisfactorily for coal cleaning .

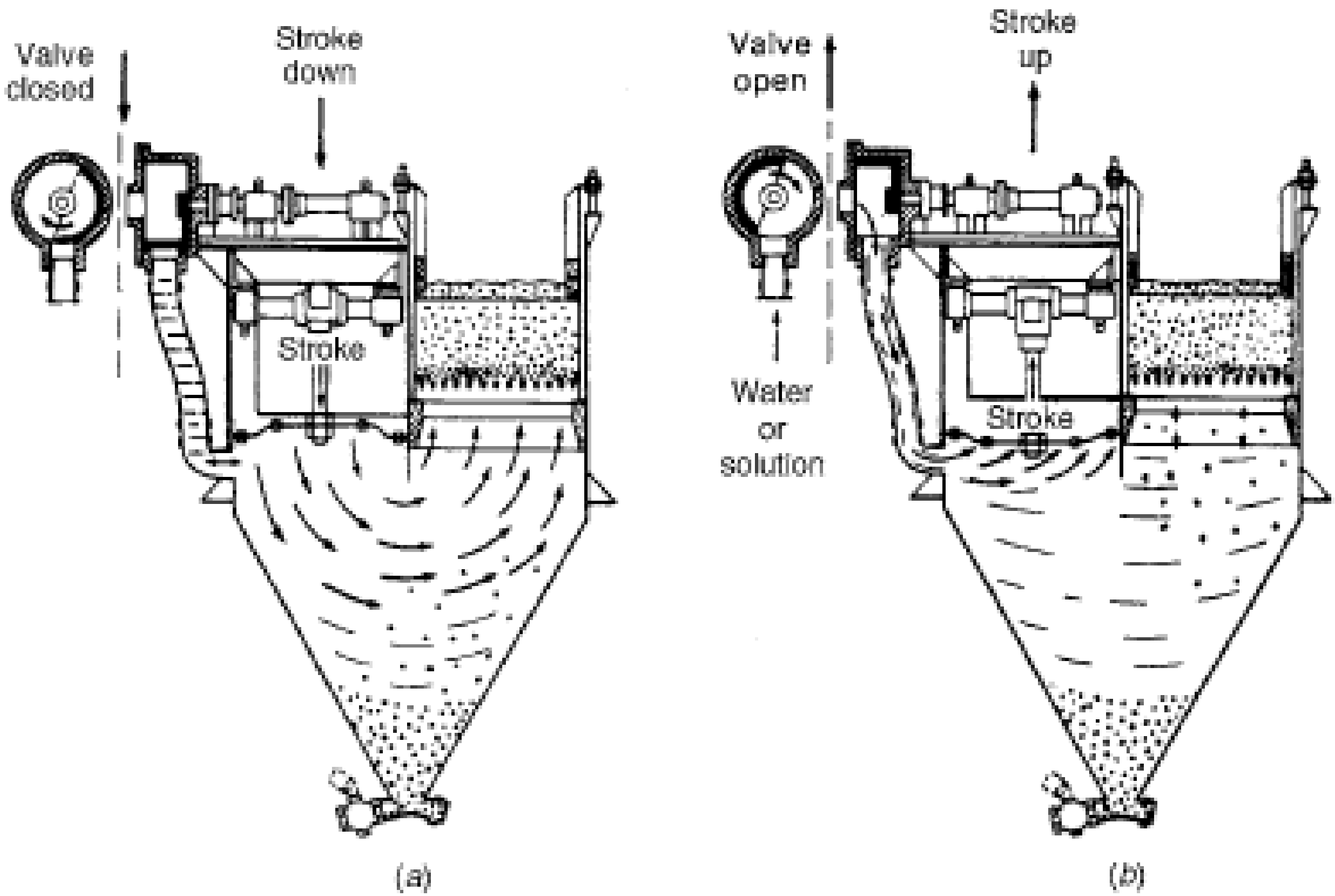
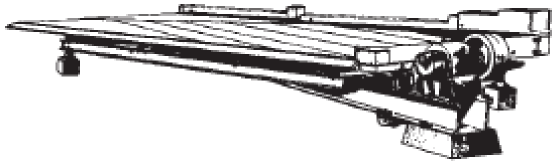
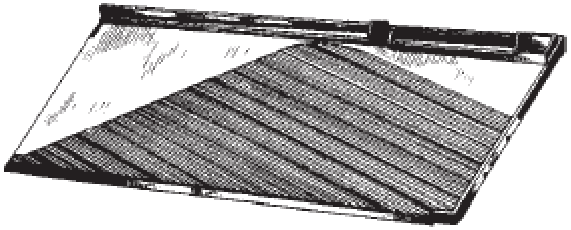


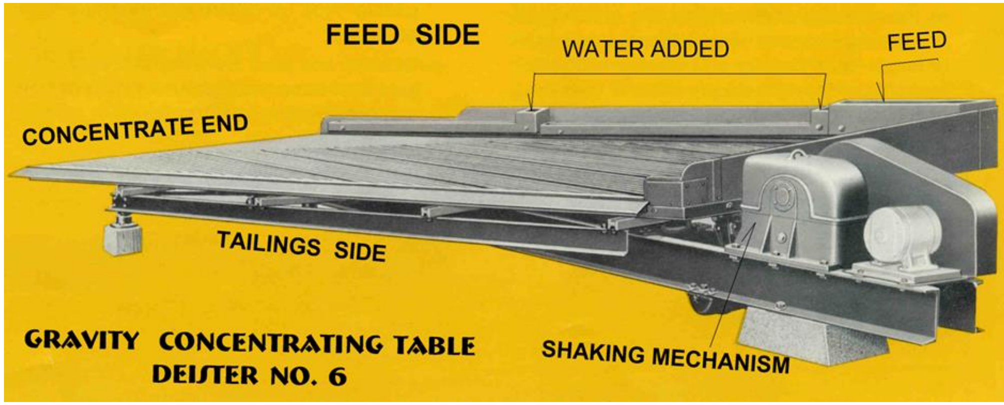
Figure 1.32. The Denver hydraulic jig (a) Downward stroke (b) Upward stroke

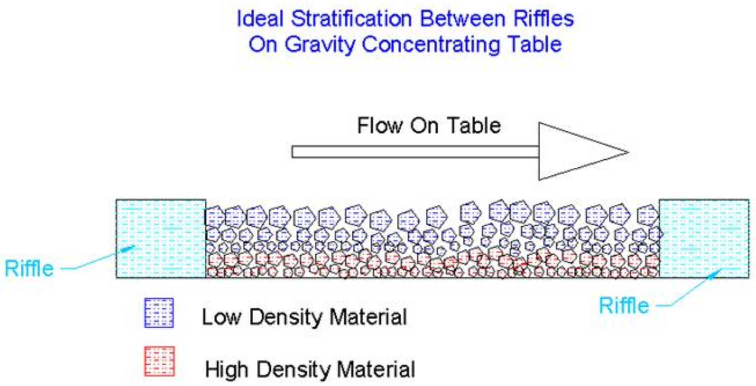
TABLING – RIFFLED TABLE/ WILFREY RIFFLED TABLE
Gravity concentrating table



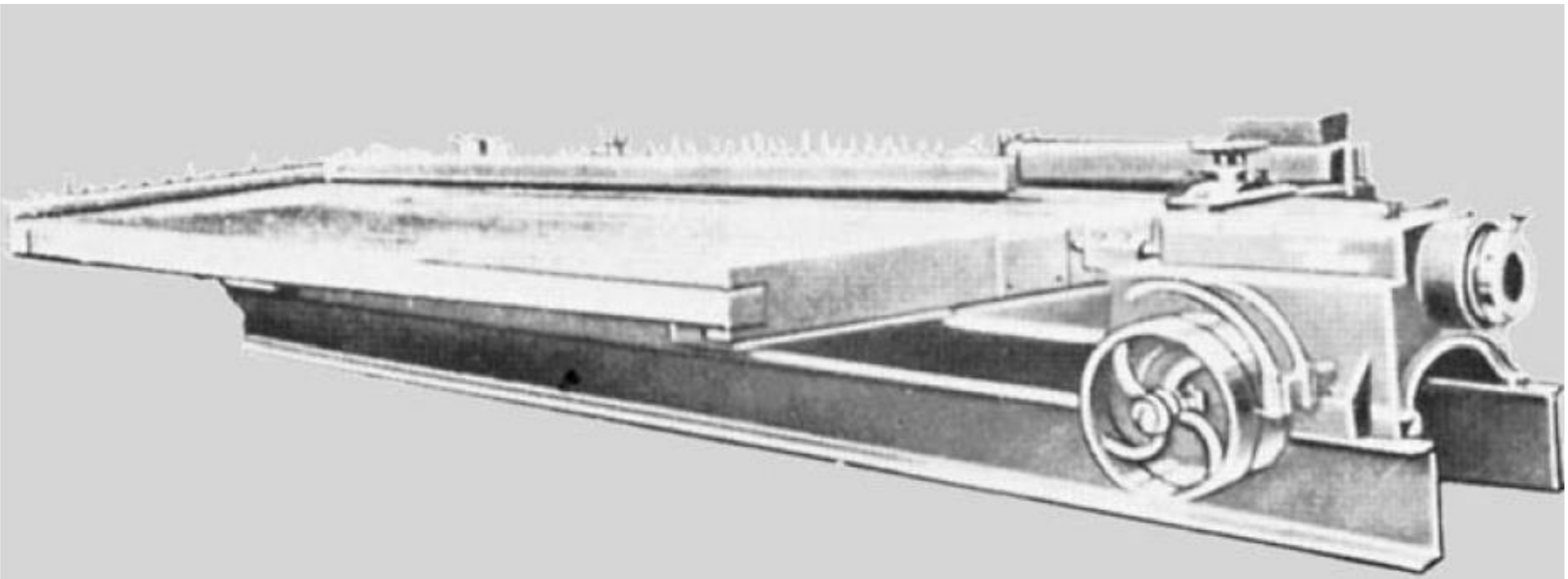


- Can separate particles up to size 5 micron, high density from low density material
- Table is inclined about 3o to horizontal, concentrate side up
- About 6 mm deep riffles or slats
- Water flown from top edge
- Materials fed at top
- Table reciprocates along the longer axis : slow forward stroke and rapid backward stroke. 1-3 cm 200-300 per minutes.
- Heavy and fine particles cannot cross the riffles
- Big and light particles crosses over with water stream





WILFREY RIFFLED TABLE



DENSE MEDIA SEPARATION HEAVY FLUID SEPARATION

Liquids of Density of 1.3 to 3.5 gm/cm3

- Halogenated hydrocarbon –eg. carbon tetrachloride
- Calcium chloride solution
- Pseudo liquids – magnetite 5.17,ferrosilicon 6.36, galena7.5 etc

- Volume fraction required can be calculated to design a fluid of desired density
- Viscosity of pseudo liquids:

$$\mu_c = \mu(1 + k''c)$$

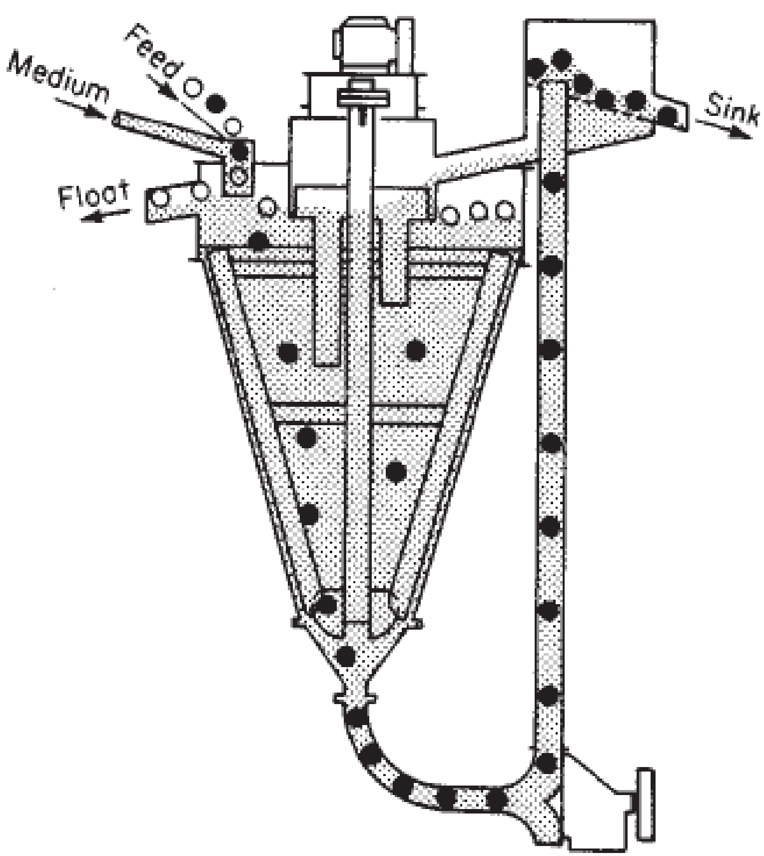
  - μ = viscosity of liquid
  - C= volumetric concentration
  - K’’= constant for shape, 2.5 for sphere

$$\mu_c = \mu\, e^{k''c/(1-\alpha c)},\ where\ \alpha = 0.61\ for\ sphere,$$

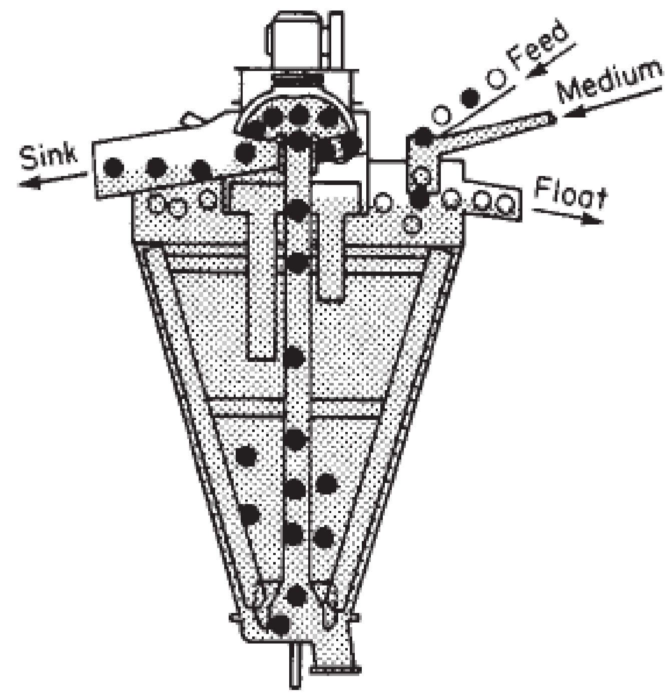
DENSE MEDIA SEPARATION

(a) two product with pump sink removal

(b)Two product with compressed air sink removal

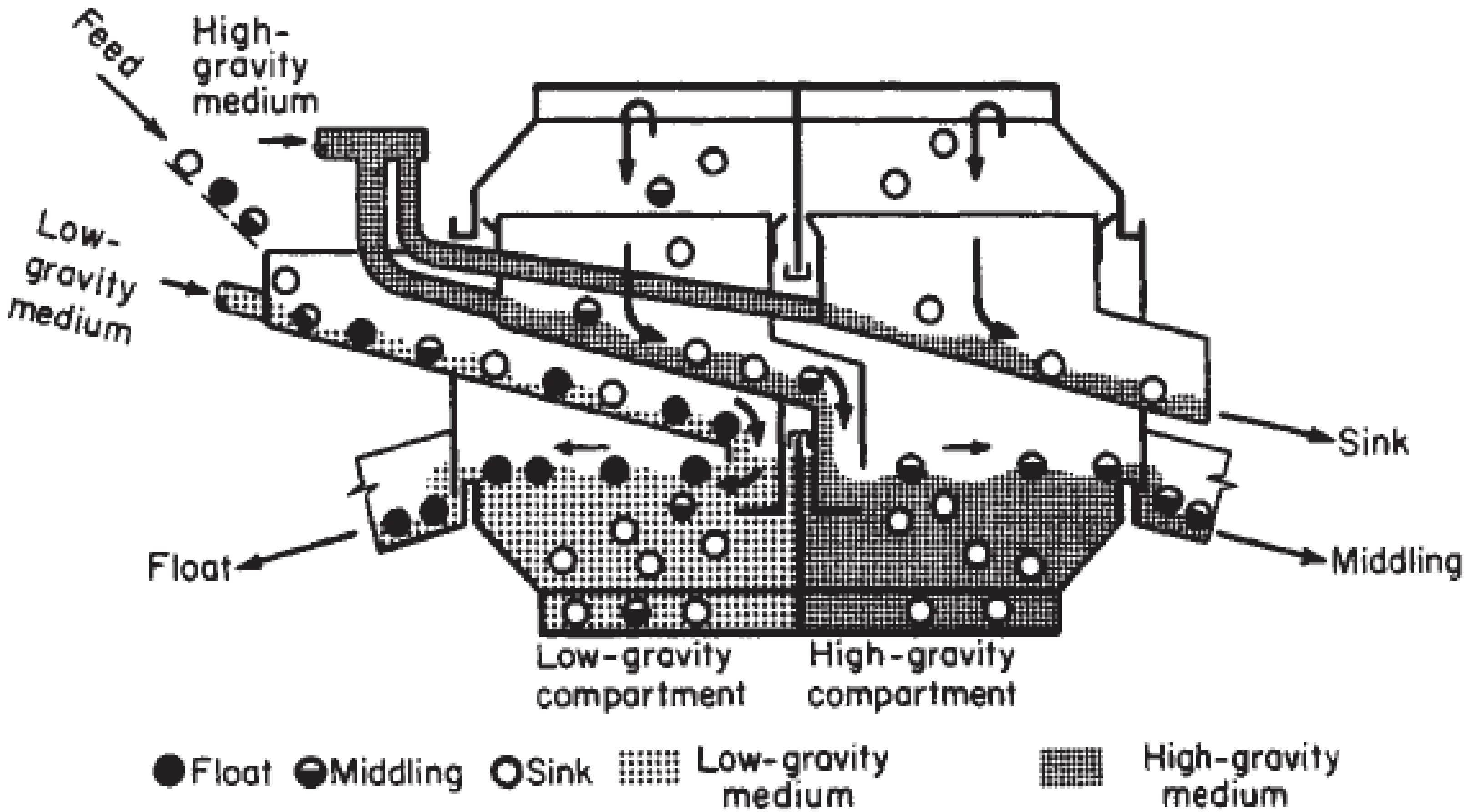


(a)

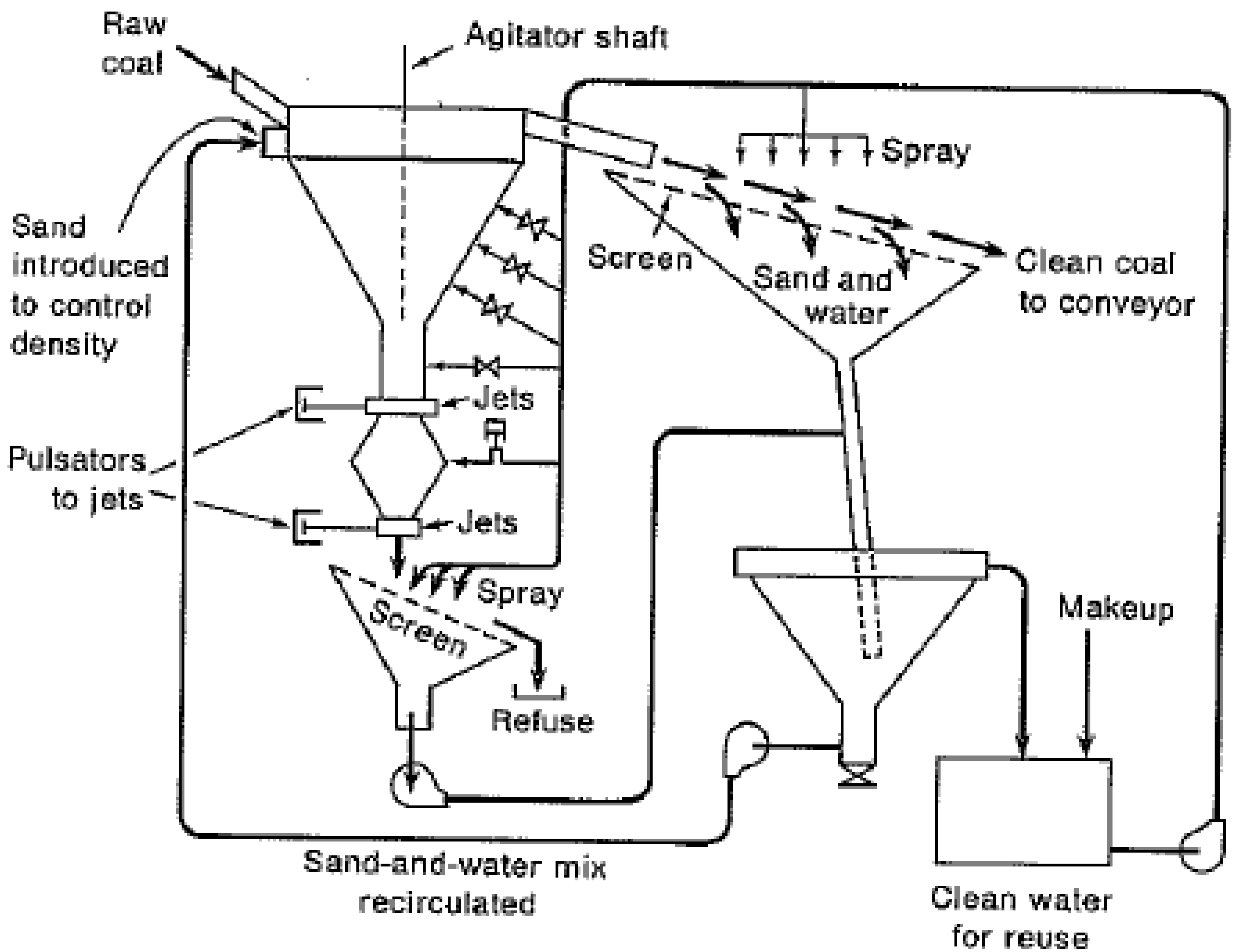


(b)

REVOLVING DRUM DENSE MEDIA SEPARATOR



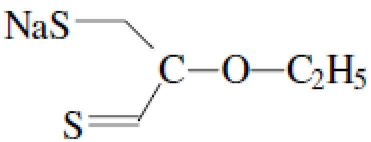
Heavy media Separation of coal cleaning



FROTH FLOATATION

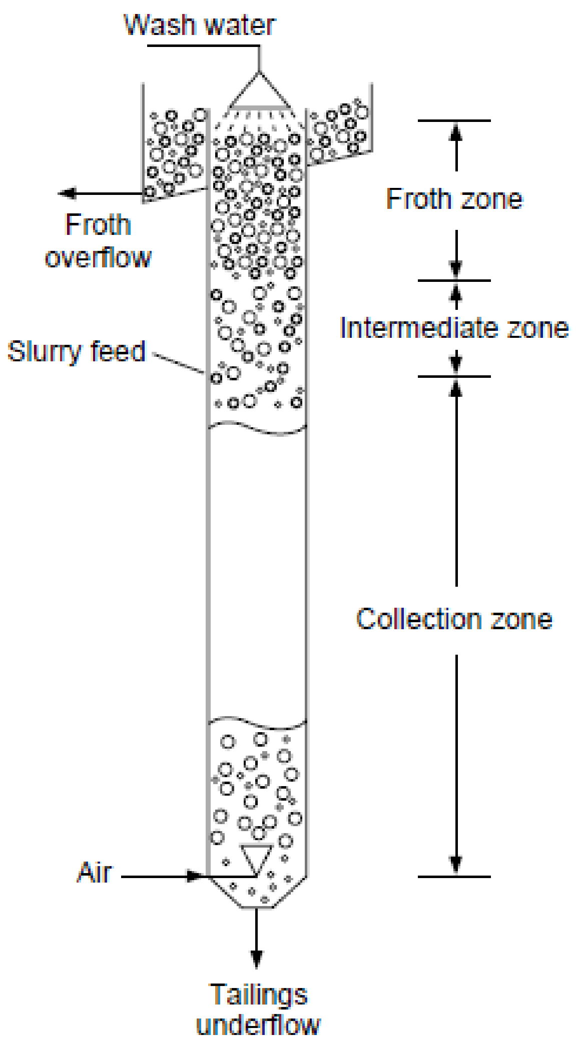
- Separation of solids based on difference in the surface properties. Particle size range of 5-250 microns
- Mixture suspended in aerated liquid-gas bubbles adhere to hydrophobic material and float.
- Hydrophilic material wets and sinks.
- **Collector** – coats material to make more hydrophilic- pine oil, petroleum compounds- 0.5kg/Mg
- **Promoter** – chemicals to forms monolayer to help coating of collector xanthates.
- 0.05kg/Mg of solids

Sodium ethyl xanthate

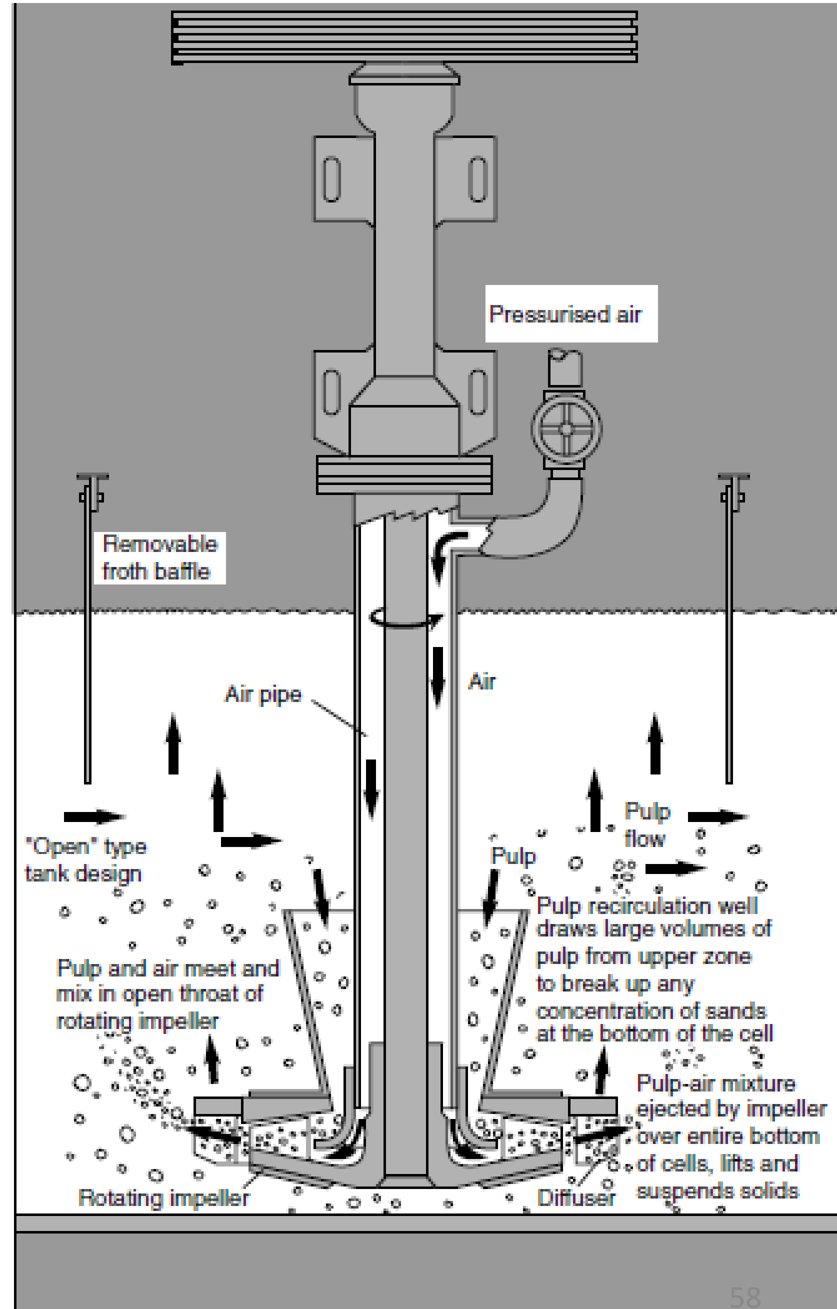


- **Depressants** –chemicals used for modifying the surface such that promoter or collectors are not adsorbed – mineral acids, alkalis and salts.
- **Frothers** – liquid soaps, soluble oil, amyl to octyl alcohol, cyclohexanol, terpineol, cresols, polyglycols etc.
- **pH regulators** – process is pH sensitive
- Equipment – Floatation Cells and Floatation columns.

FLOATATION COLUMN

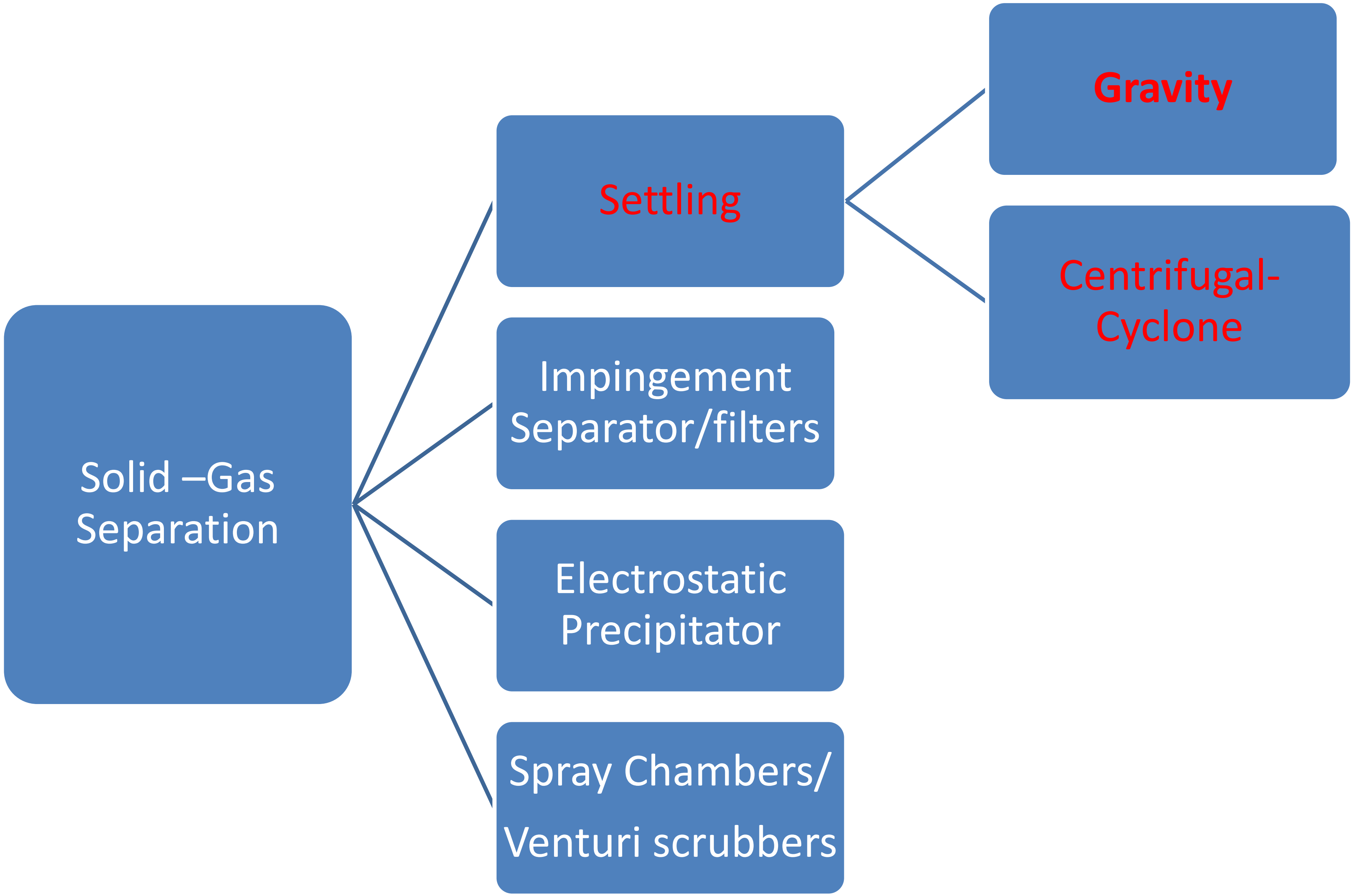


Denver Floatation machine

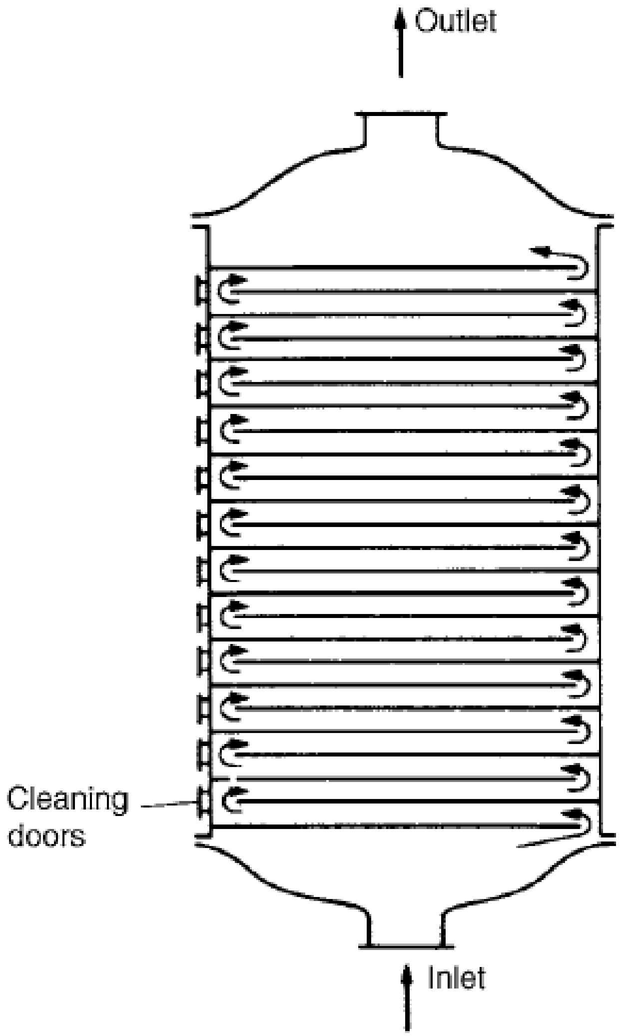


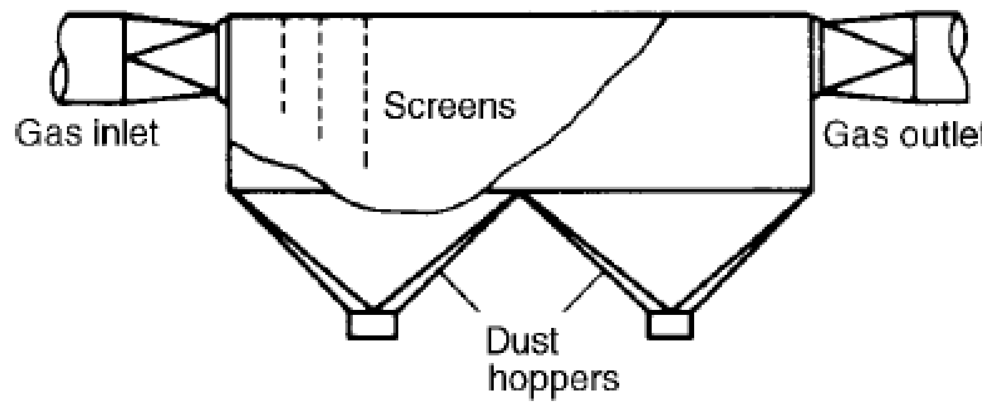
h OPERATIONS

GAS-SOLID SEPARATION

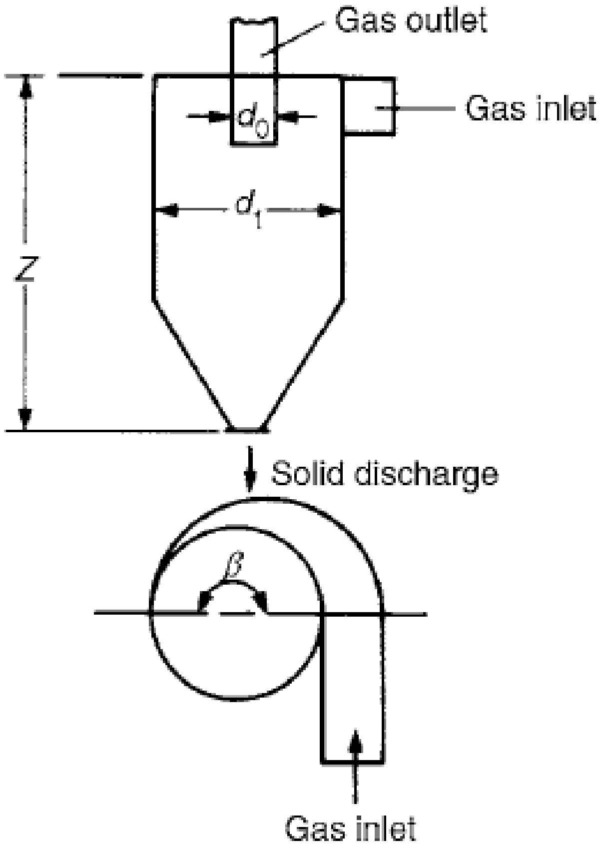

Solid –Gas Separation
Settling
Gravity
Centrifugal-Cyclone
Impingement Separator/filters
Electrostatic Precipitator
Spray Chambers/
Venturi scrubbers

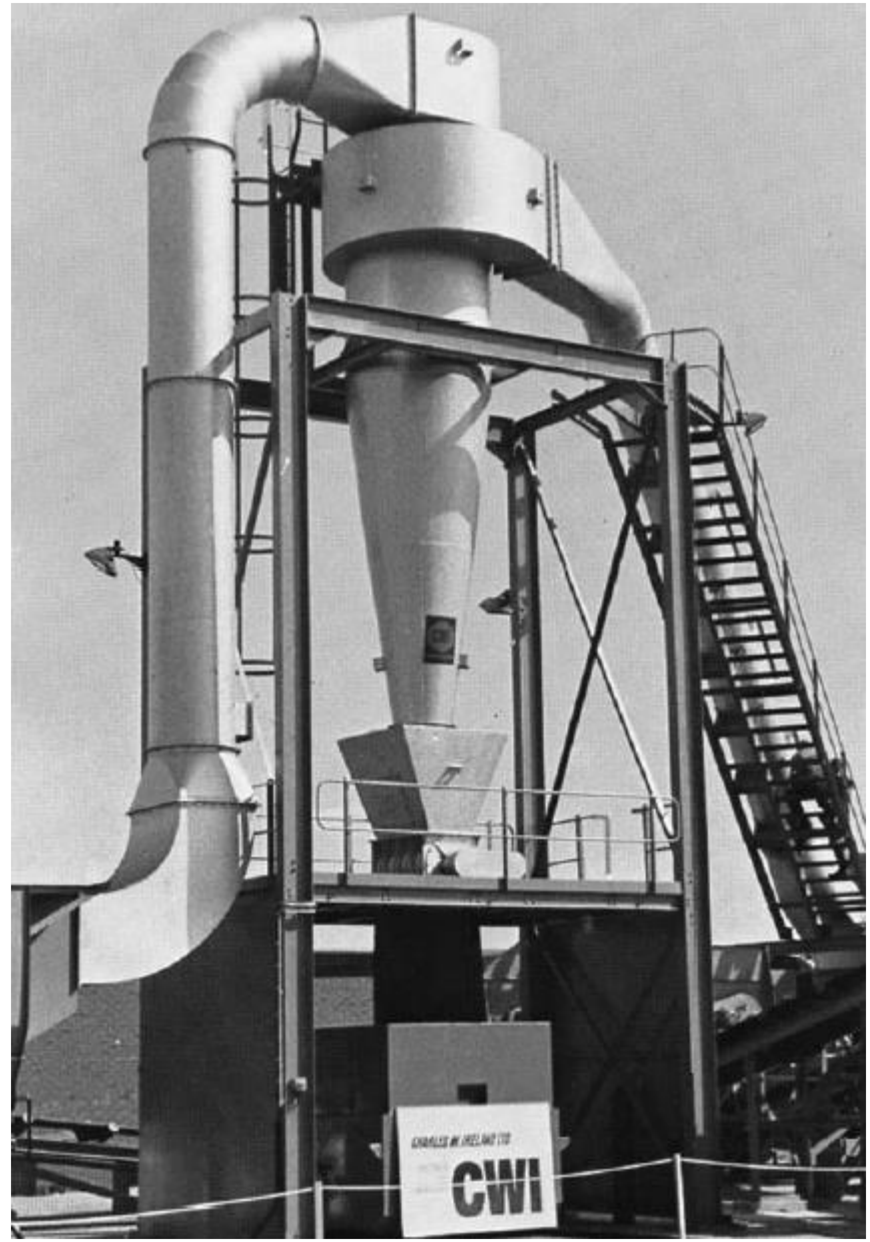
Gravity Settling





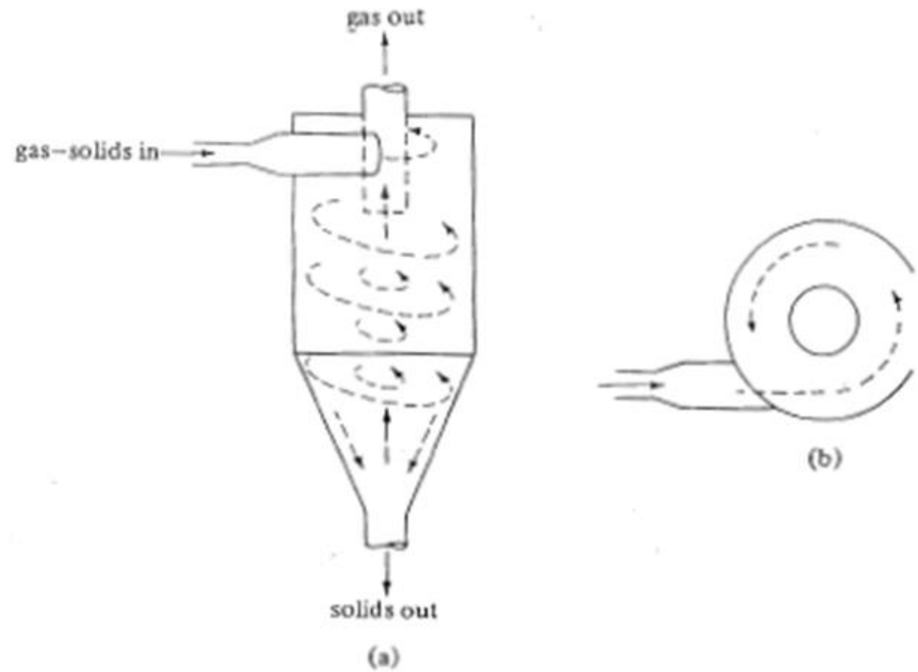
CENTRIFUGAL SETTLING IN CYCLONE SEPARATOR





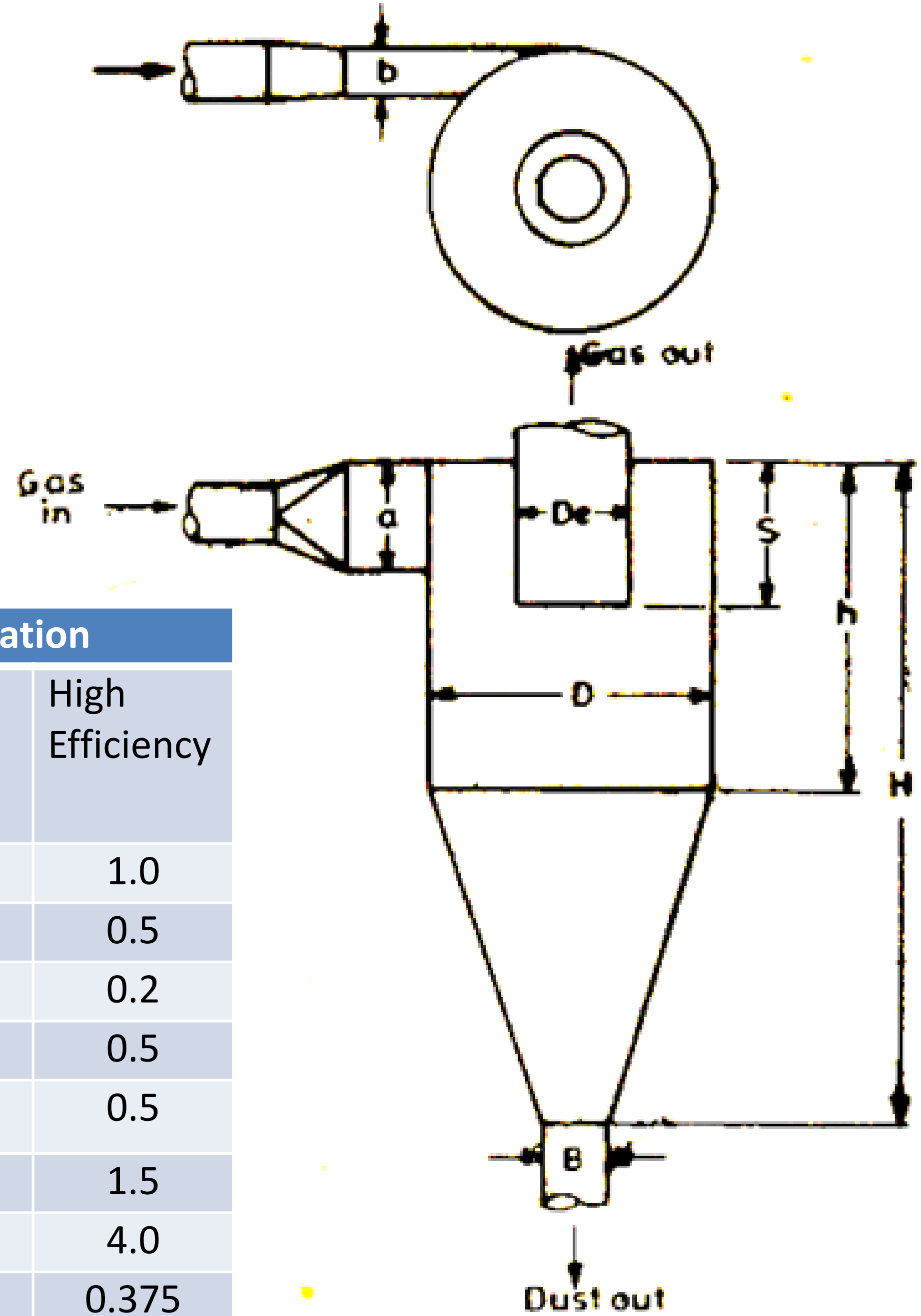
Settling in Centrifugal field

- Terminal Velocity in Stokes Law range:
- $u_t = \frac{\omega^2 r D_p{}^2(\rho_p - \rho)}{18\mu}$
- SEPARATION FACTOR= $\frac{Accelration\ in\ centrifugal\ field}{Acceleration\ in\ gravitational\ field}$
- Separation factor=$\frac{\omega^2 r}{g} = \frac{v_\theta{}^2}{r^2}\frac{r}{g} = \frac{v_\theta{}^2}{rg}$



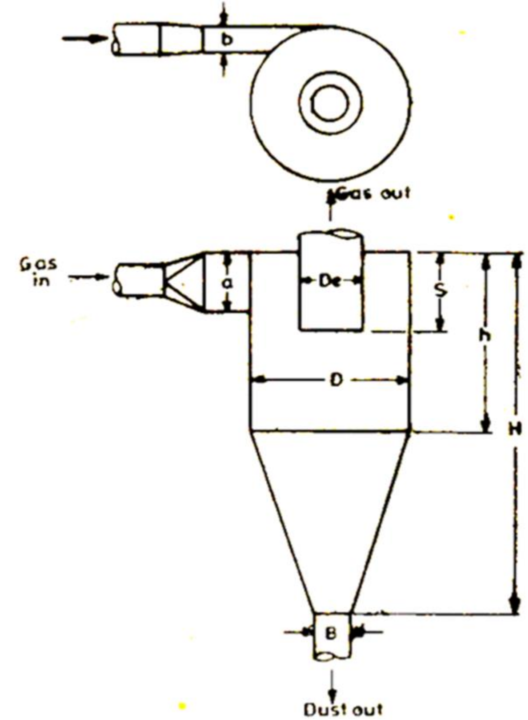
- (a) Elevation
- (b) Plan

CYCLONE SEPARATOR DIMENSIONS



Generalized cyclone design configuration			
Nomenclature		Conventional	High Efficiency
D	Cyclone diameter	1.0	1.0
a	Entrance Height	0.5	0.5
B	Entrance width	0.25	0.2
S	Exit Length	0.625	0.5
D_e	Exit diameter	0.5	0.5
H	Cylinder Height	2.0	1.5
H	Overall Height	4.0	4.0
B	Dust Exit diameter	0.25	0.375

CUT DIAMETER



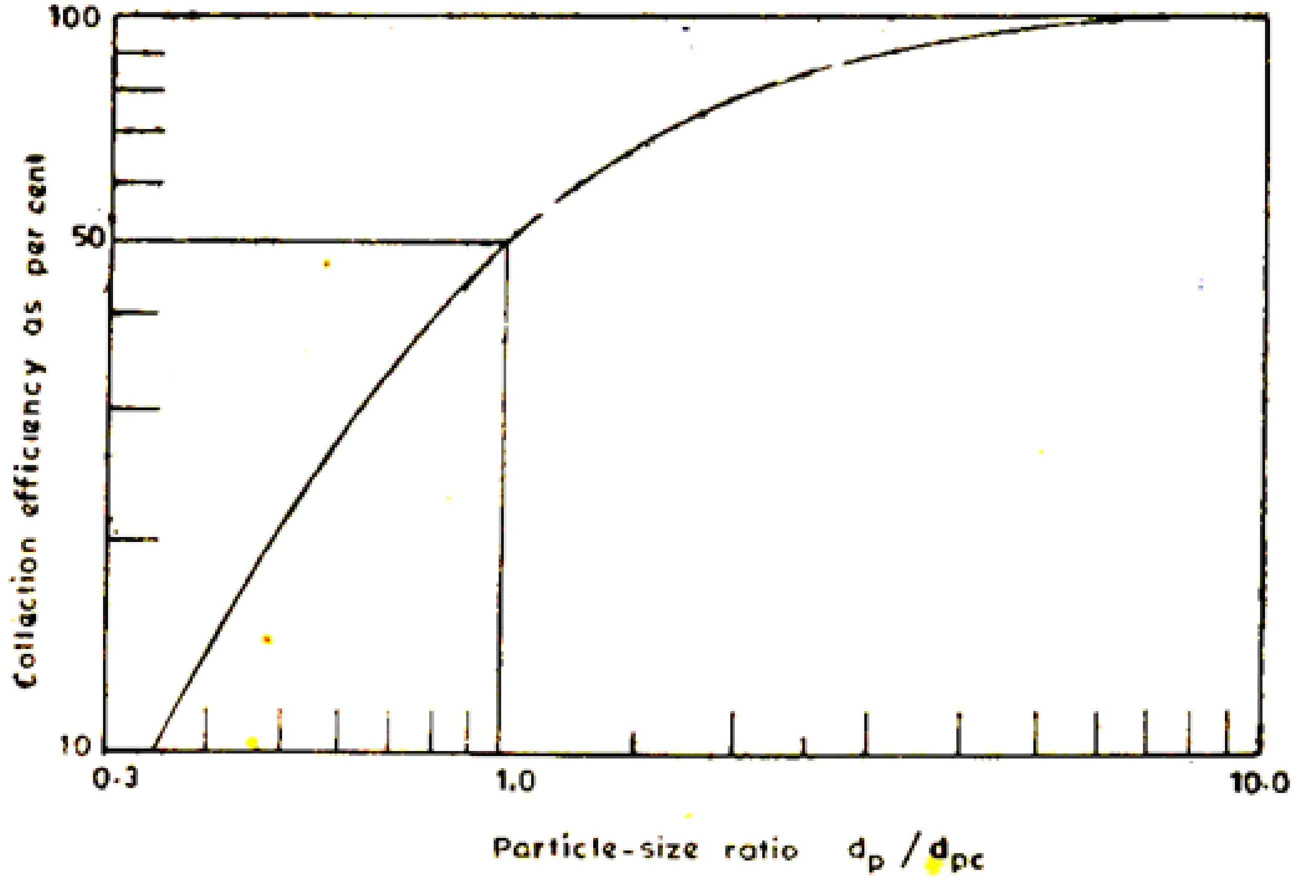
- $u_t = \frac{\omega^2 R D_p{}^2(\rho_p - \rho)}{18\mu_g}$
- $R = \frac{D}{2}$
- Q = volumetric flow rate,
- $\omega = \frac{v_i}{R}$,
- $where\ v_i = inlet\ velocity = \frac{Q}{a\ b}$
- Residence time, $\tau = \frac{\pi D N_e}{v_i}$
- N_e= Effective Number of turns the gas makes in traversing the cyclone (5 to 10 times in most cases)
- $N_e \cong \frac{h}{a}$
- Distance travelled is b/2 for cut diameter
- $u_t\ \tau = \frac{v_i{}^2}{R^2} \frac{R d_{pc}{}^2(\rho_p - \rho)}{18\mu_g} \frac{\pi D N_e}{v_i} = \frac{b}{2}$,
- $d_{pc} = \sqrt{\frac{9\mu_g b}{2\pi N_e v_i(\rho_p - \rho_g)}}$

Efficiency of cyclone

- SEPARATION FACTOR=$\frac{Accelration\ in\ centrifugal\ field}{Acceleration\ in\ gravitational\ field}$
- Separation factor=$\frac{\omega^2 r}{g} = \frac{{v_\theta}^2}{r^2}\frac{r}{g} = \frac{{v_\theta}^2}{rg}$
- v_θ= tangential velocity of gas, and$v_\theta = \omega r$
- Cyclone efficiency=$\frac{Amount\ of\ solids\ collected}{Amount\ of\ solids\ in\ feed}$

$$\eta = 1 - \frac{Conc.\ solids\ in\ outlet\ stream}{Concentration\ of\ solids\ in\ feed}$$

EMPIRICAL LAPPLE'S CORRELATION FOR CYCLONE EFFICIENCY



Lapple's correlation for cyclone efficiency

- A cyclone with diameter 1.0 m handles 3.0m3/s of standard air carrying particles with a density of 2000kg.m3.For Ne=6 determine cut size and the efficiency as a function of particle diameter.
- Plot collection efficiency vs particle size
- HINT : (1) Fill first column Dp as per range of the feed
  (2)Determine Dpc
  (3) TabulateDp/Dpc
  (4) Determine collection efficiency from lapple correlation
  (5) Plot Collection efficiency Vs Dp

D_p	D_p/D_{pc}	Colleciton Efficiency From Lapple Correlation

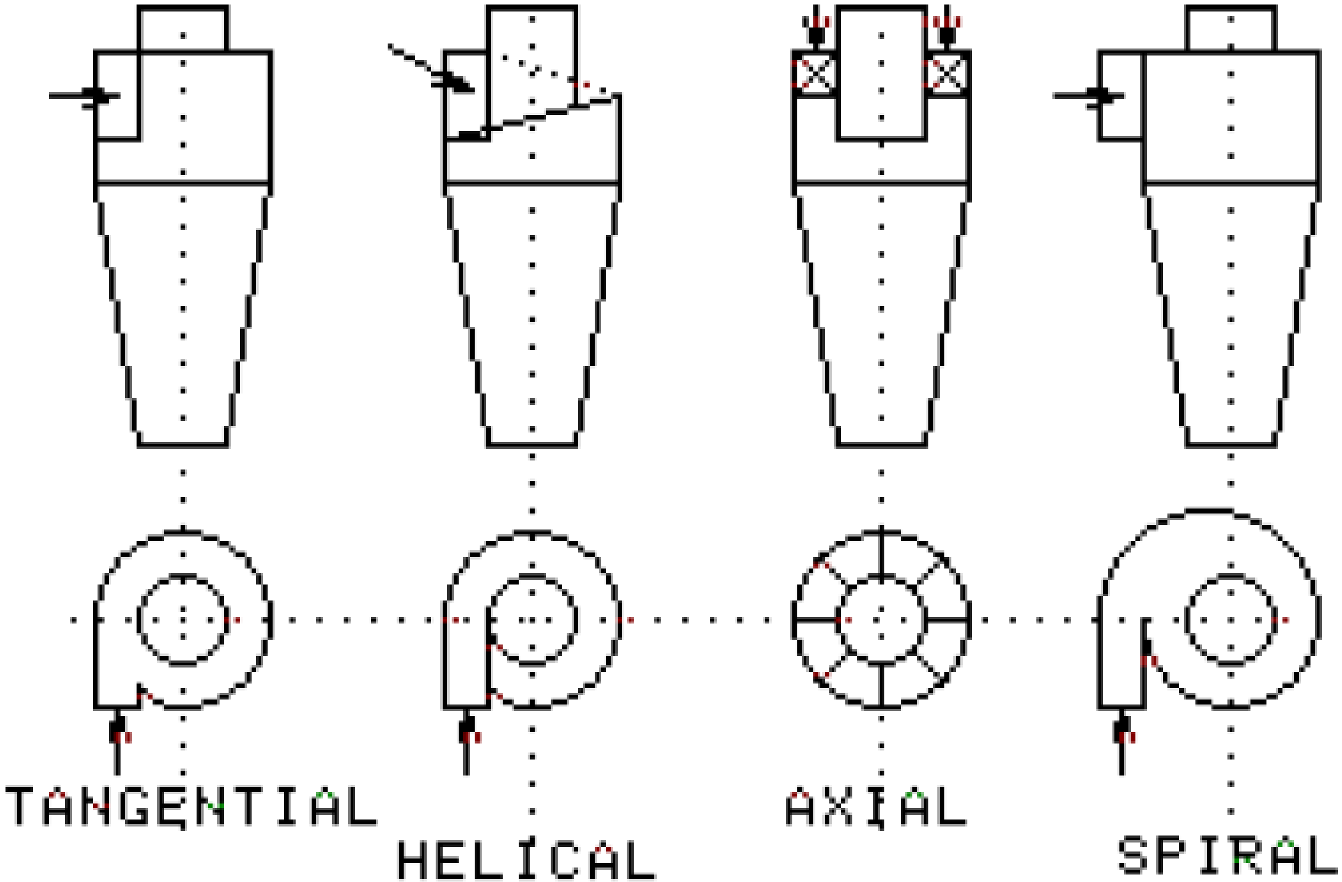
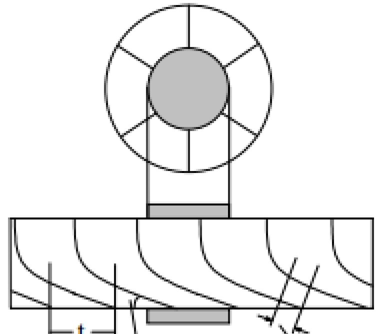
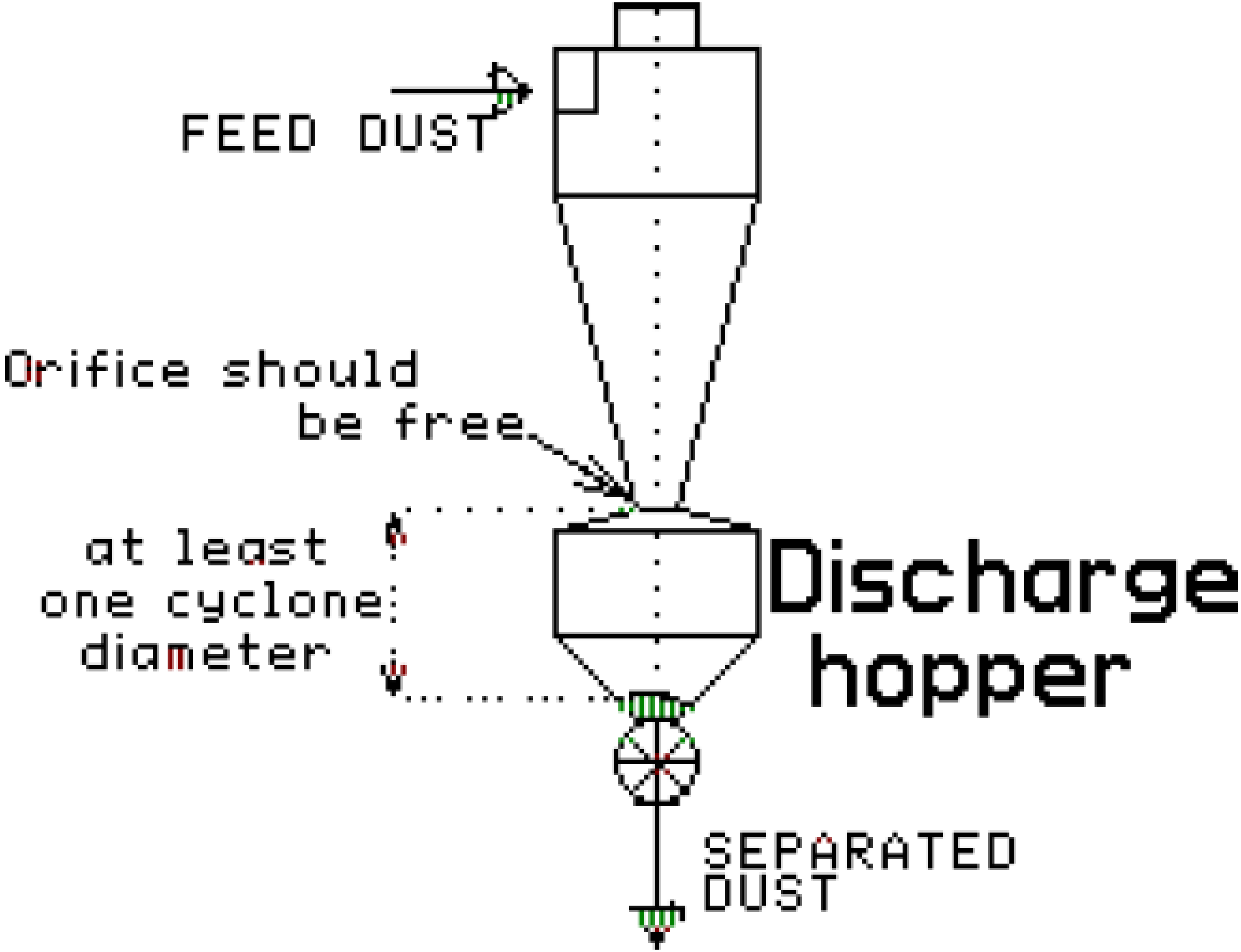


Figure 2: Types of inlet

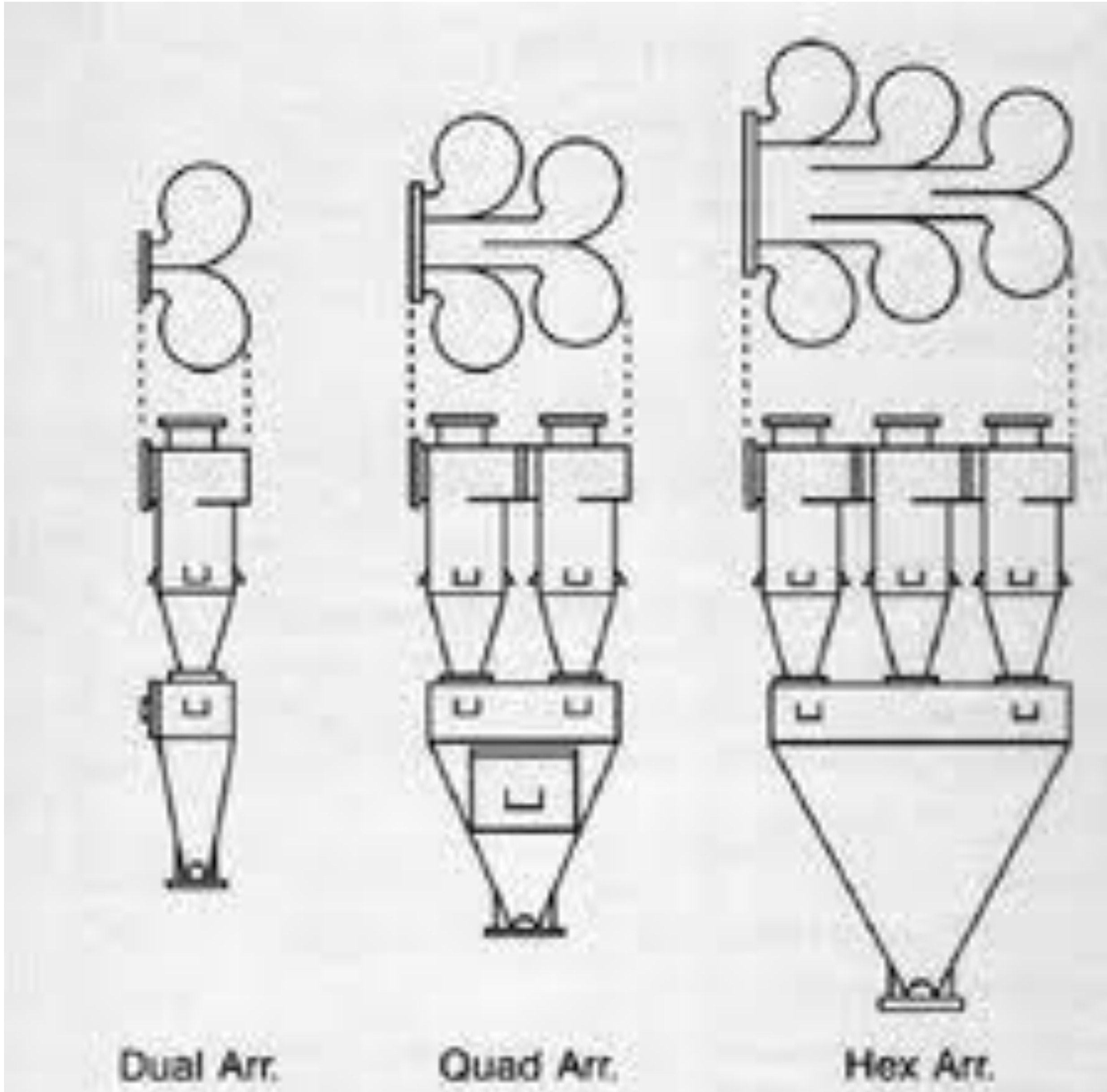


Swirl vane

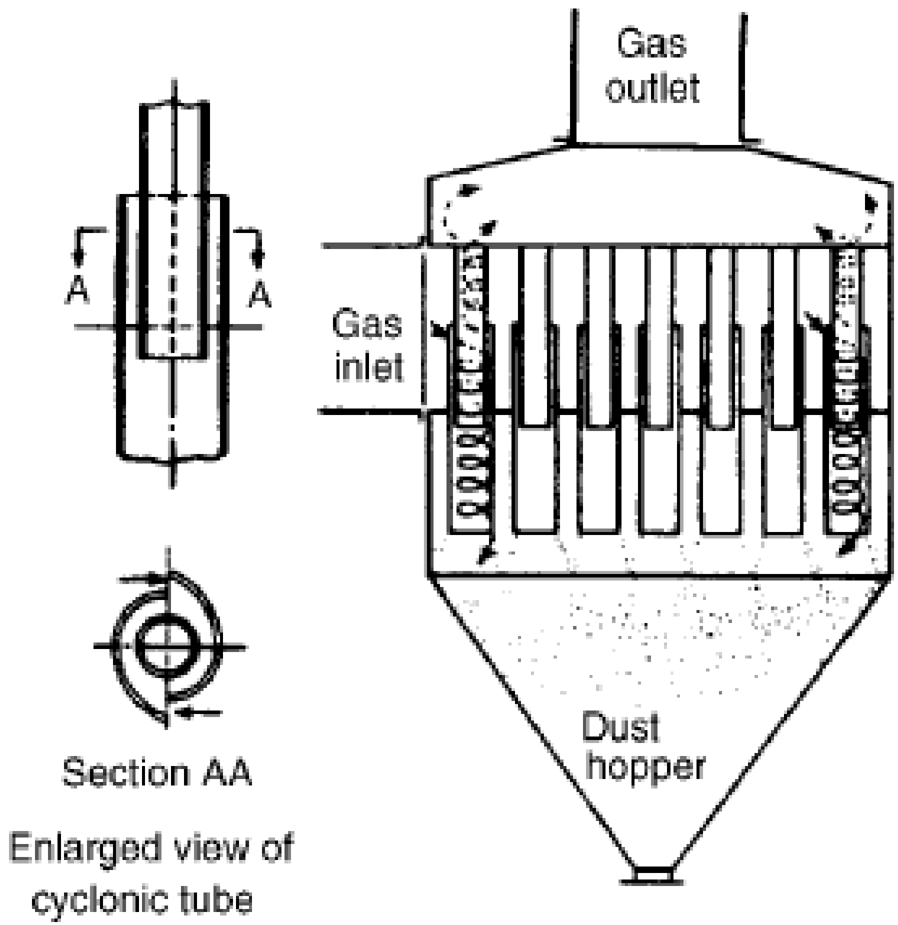
Types of cyclone inlet

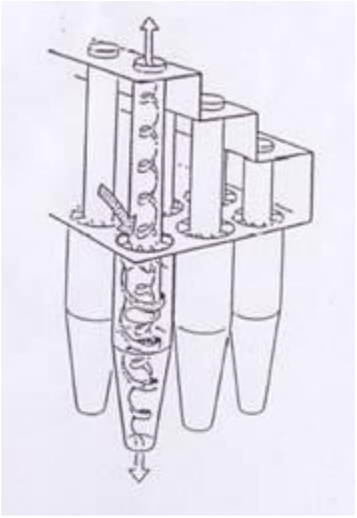

FEED DUST
Orifice should
be free
at least
one cyclone
diameter
Discharge
hopper
SEPARATED
DUST

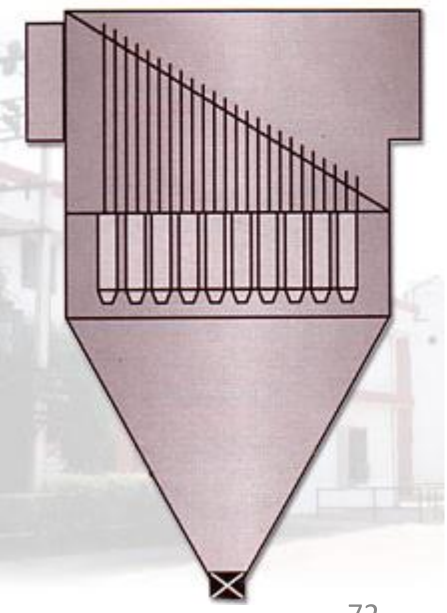
Multiple tangential entry cyclones



Multi-tube straight through Cyclone Separator



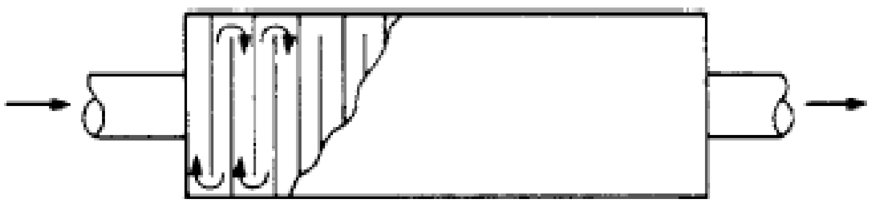


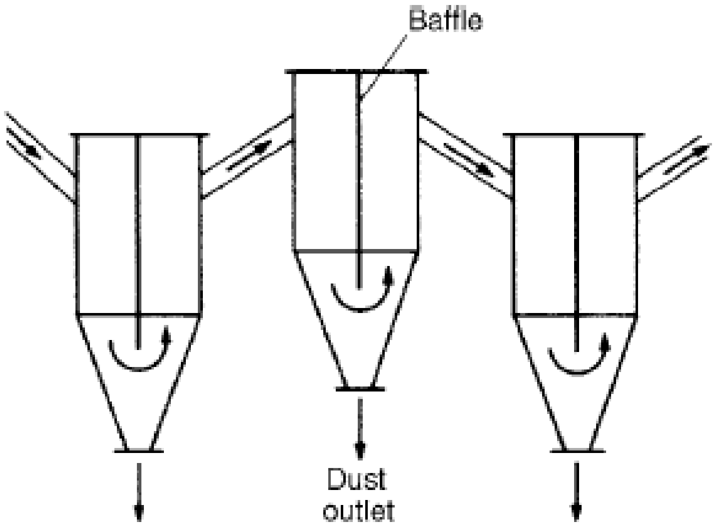


INTERTIAL AND MOMENTUM SEPARATORS

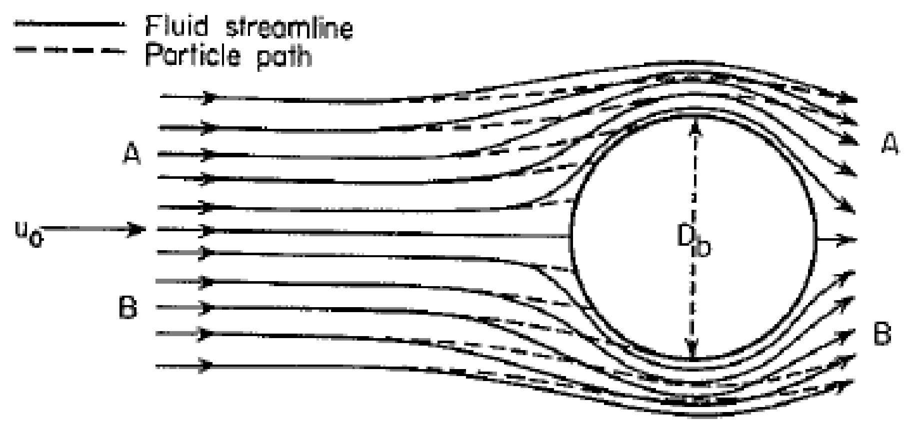
Inertial or Momentum Separator

[Baffled separator and Battery of momentum separator]

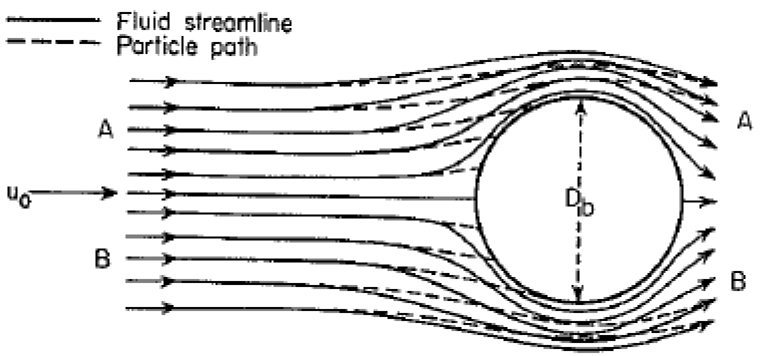




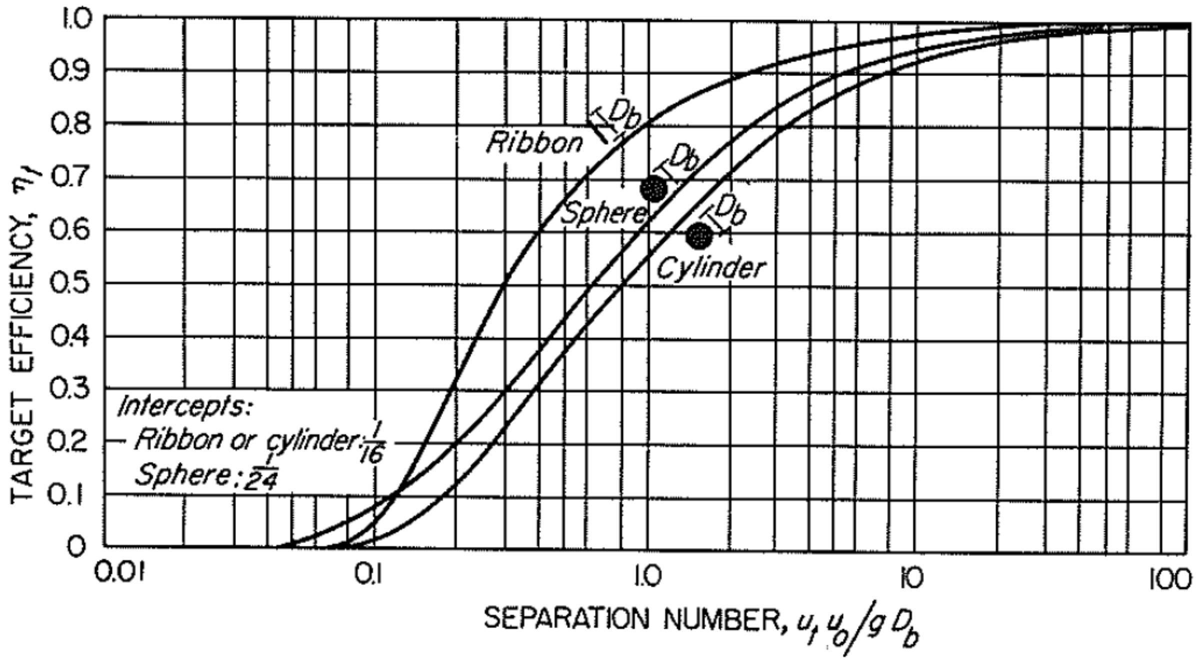
- Momentum of particles is greater than that of gas and they do not follow the same path as the gas.



Principle of Impingement Separator



- Target efficiency= fraction of particles in the gas stream directly approaching the separator element that strike the solid.
- $\eta_t = \frac{Particles\ striking\ solids}{Particles\ inlet\ stream}$
- $Separation\ number = \frac{u_t u_0}{g D_b}$
- $u_0 = velocity of\ gas$
- u_t= terminal velocity of particles in still air
- D_b= dimension of separator element [width or diameter]
- $u_t\ \alpha\ {D_p}^2$
- $D_p = diameter\ of\ particle$
- Smaller the particles lower the target efficiency

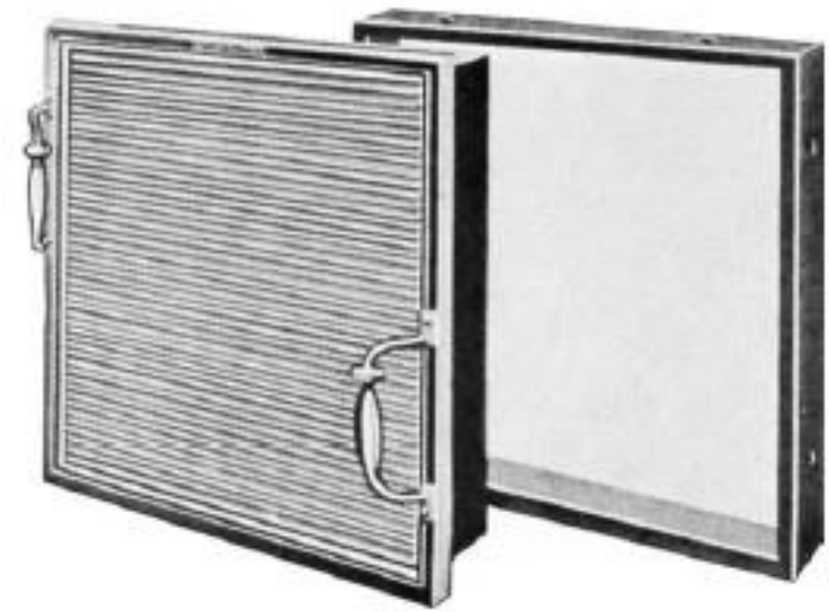


- $u_o = velocity of\ gas$
- u_t= terminal velocity of particles in still air
- u_t= dimension of solid[width or diameter]
- Target efficiency= fraction of particles in the gas stream directly approaching the separator element that strike the solid.
- $\eta_t = \frac{Particles\ striking\ solids}{Particles\ inlet\ stream}$
- $Separation\ numbe, N_s = \frac{u_t u_0}{g D_b}$

- $\underline{\boldsymbol{u_t\ \alpha\ D_p{}^2}}$
- **Smaller the particles smaller the Separation number**
- **Smaller the particles lower the target efficiency**

FILTERS FOR GAS SOLID SEPARATION

Pad/Viscous Filter for atmospheric dust



- Passing through pads of cellulose pulp, cotton, felt, glass fibre, or metal screens
- Pad may be dry or coated with viscous oil to hold the dust.
- Disposable or re used after rinsing and recoating with oil
- Principle of operation : Impingement

Process dust removal

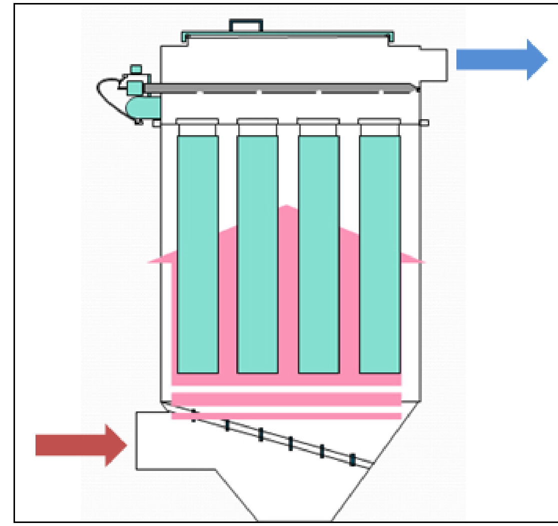
- Granular Bed filter
- Bag filters

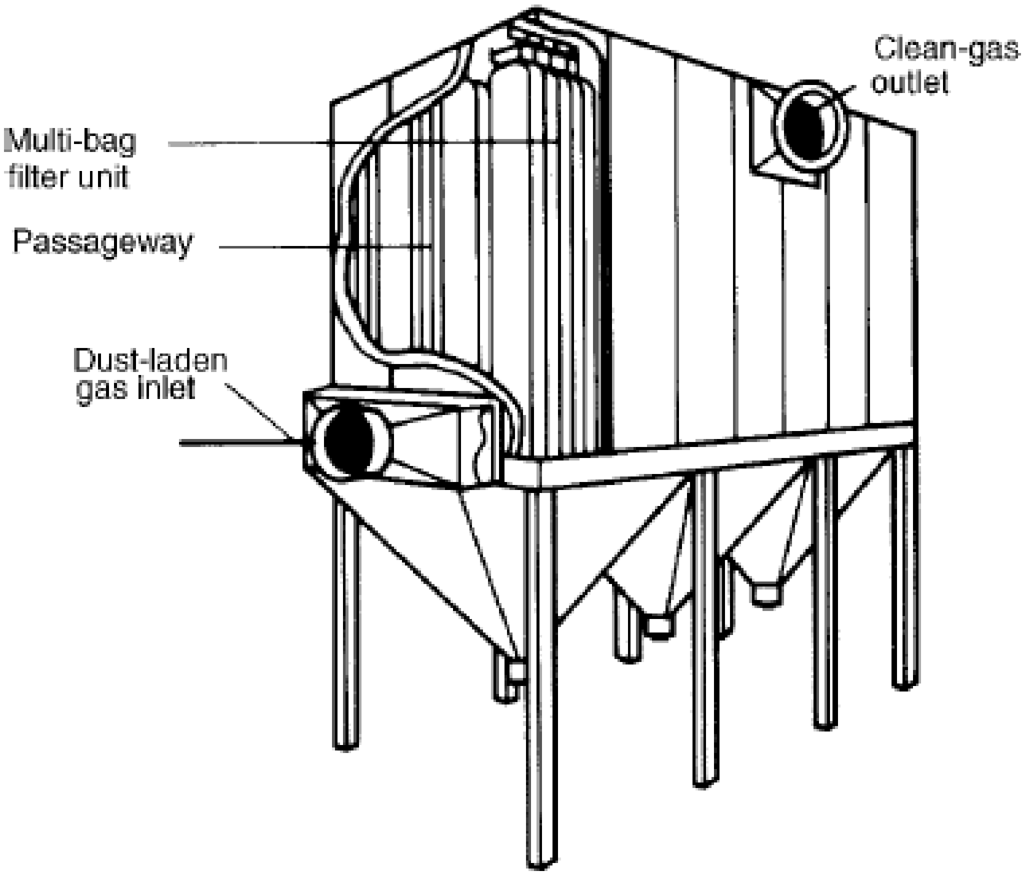
FABRIC FILTERS

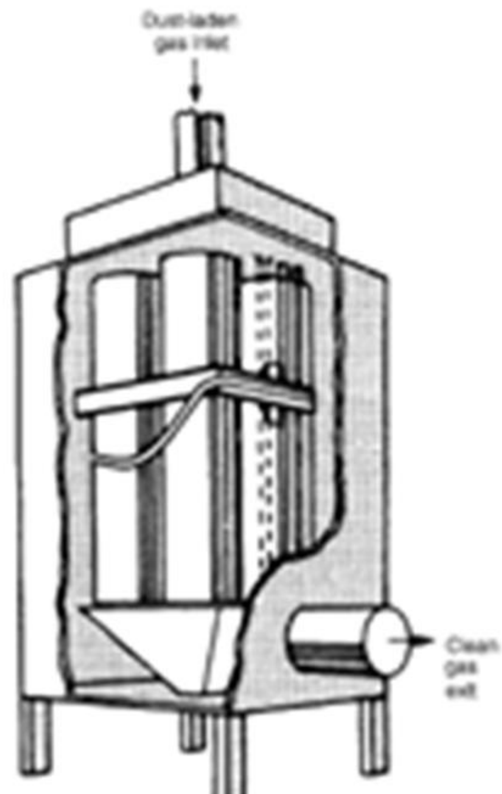
- Felt or woven fabric bag
- Cotton, PVC, PP, Nylon, PPS, Polyester, aramid, polyimide, PTFE, fibre glass
- Fibres of 500 micron, spaced 100 to 200 micron apart. Individual fibre are 5-10 micron. Due to cris cross even 1 micron particles are removes.
- Efficiency increases when loose flocs are formed.
- Velocity 0.005 to 0.03m/s
- Types of bag house filter:
  1. Simple Bag house filter max velocity 0.03 m/s
  2. Automatic Bag house filter- Heavier fabric velocity 0.02m/, with shaking facilities- mechanical, vibratory, air pulse
  3. Reverse jet filter velocity 0.05m/s

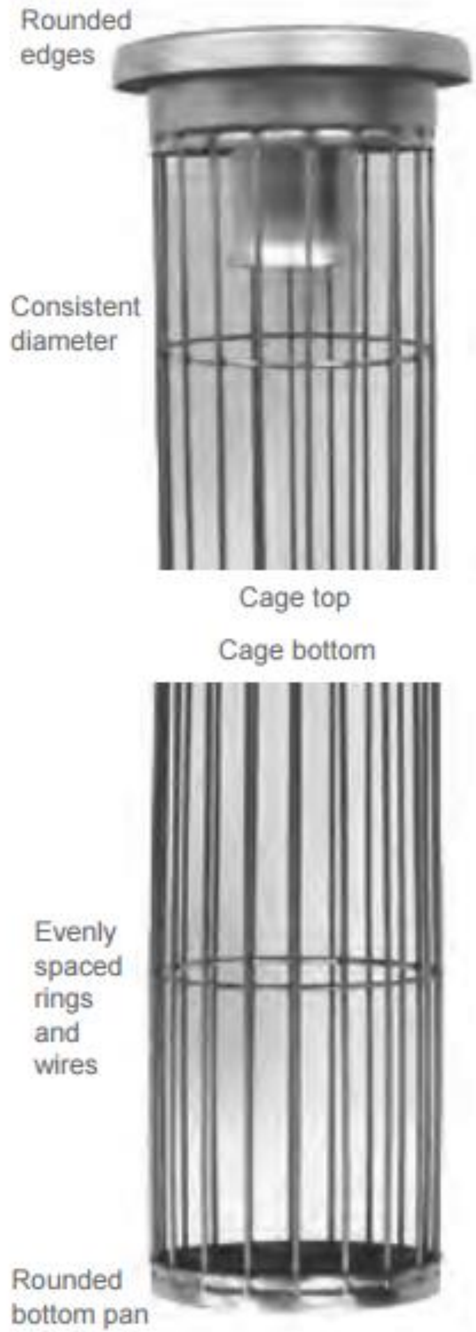
SIMPLE BAG HOUSE FILTER

Refer: Coulson Richardson



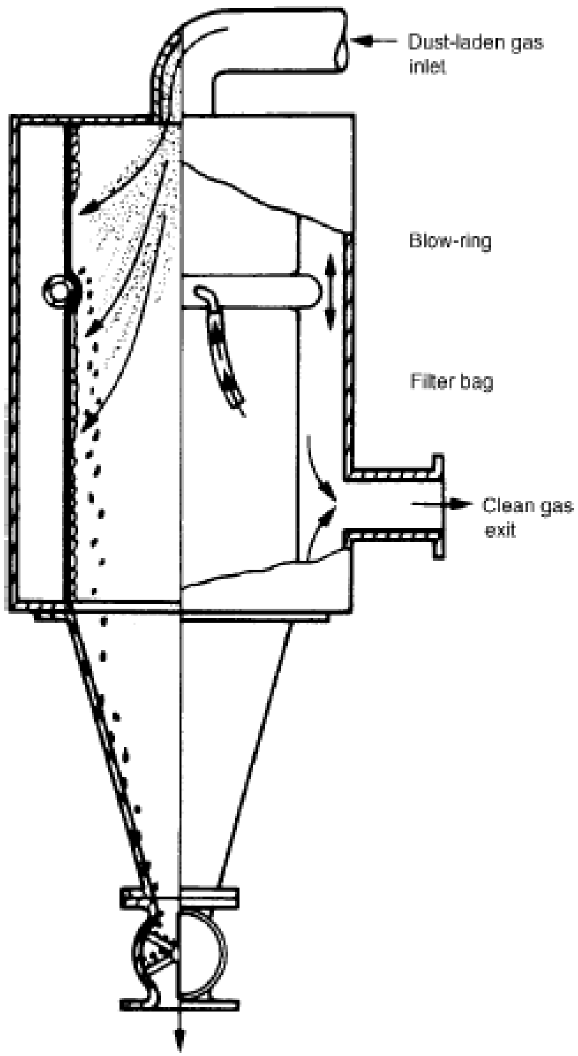


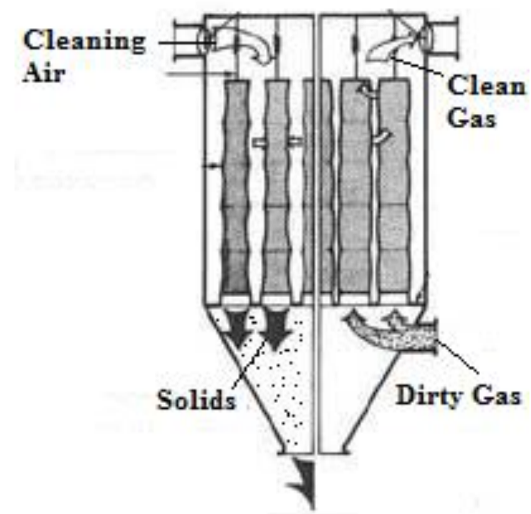



Rounded edges
Consistent diameter
Cage top
Cage bottom
Evenly spaced rings and wires
Rounded bottom pan

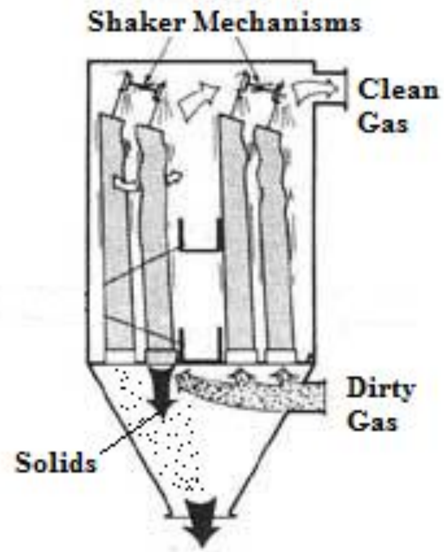
- AUTOMATIC BAG HOUSE

- REVERSE JET FILTER
  [Blow ring enables the cake to dislodge solids]





Reverse-Air Baghouse



Mechanical-Shaker Baghouse

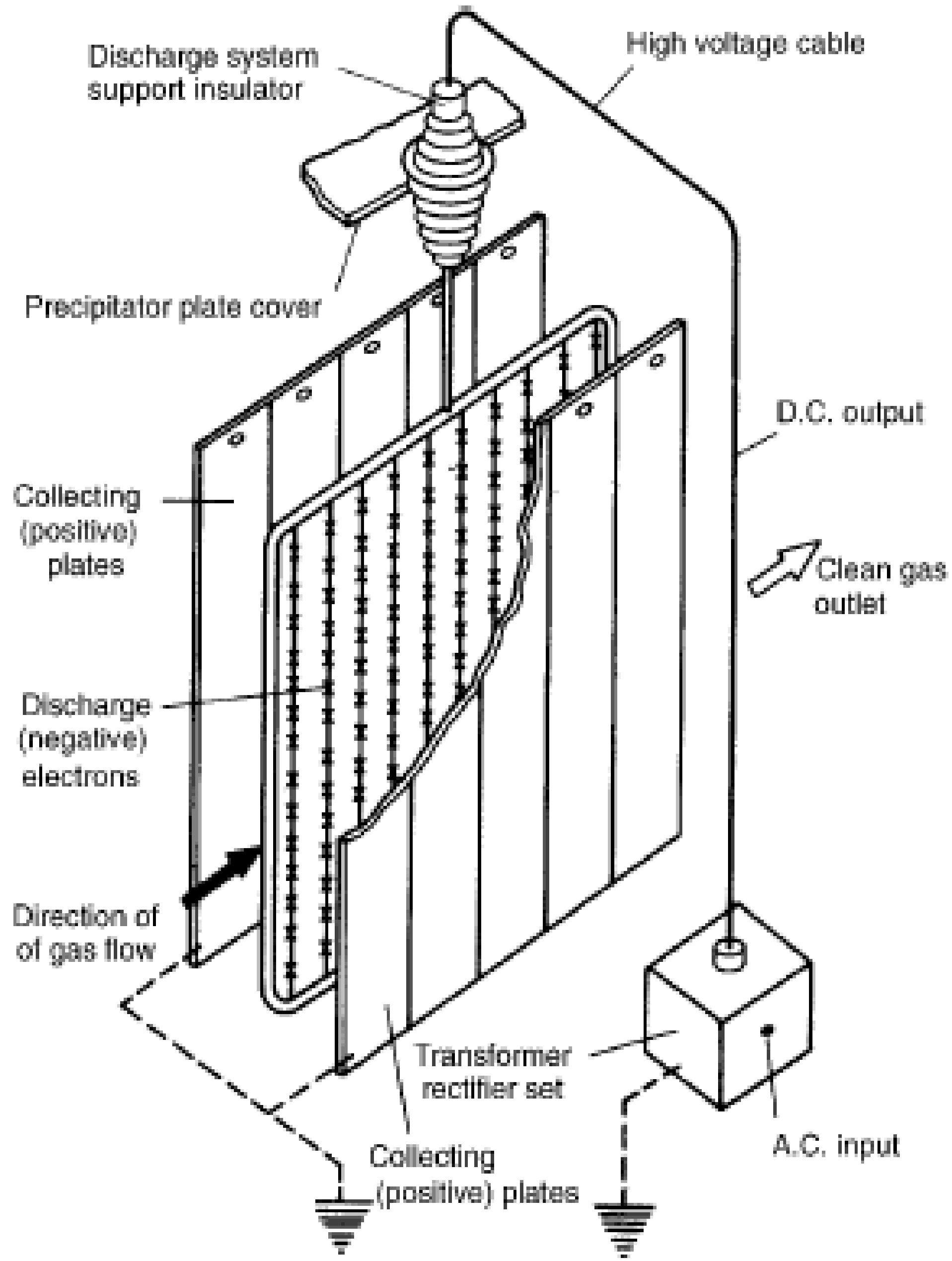
Electrostatic Precipitators

- Particles $< 2\mu m$
- Controlling particulate emissions in power plants, cement and paper mill, oil refinery.
- High voltage discharge electrode [DC voltage of about 50kV using a rectifier]
- Corona discharge occurs close to the –ve electrode
- Positively charged grounded collector
- Gas + solids entre from bottom,

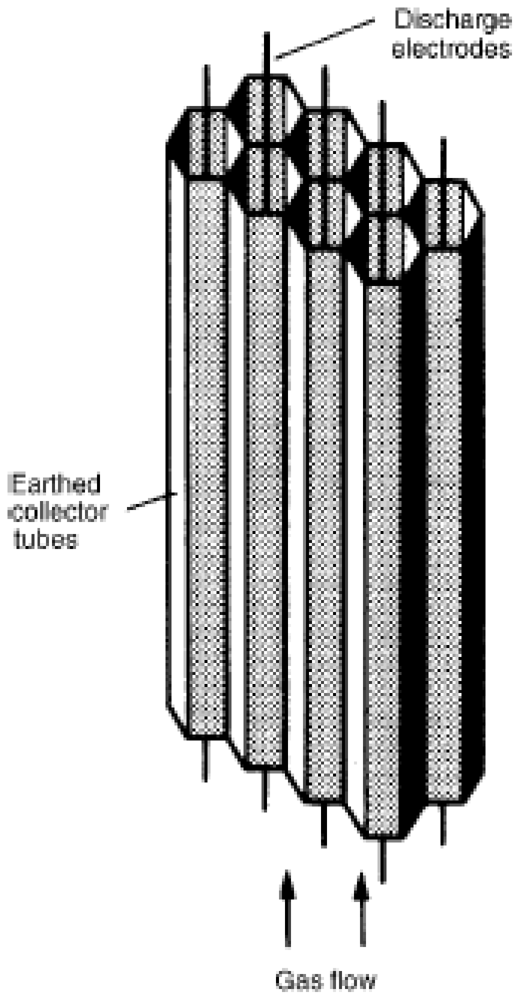
  1. gas is ionized near –ve electrode

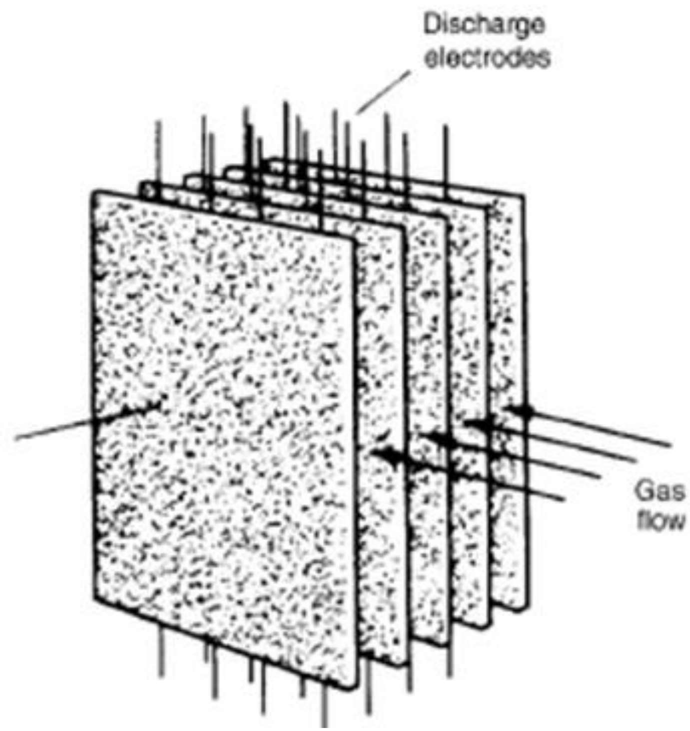
  2. As –ve ions and electrons migrate to grounded eletrode also transfer charge to particles

  3. –vely charged particles are attracted to collector.
- Periodically charghed particles are removed by tapping or vibration



Wire in Tube and Wire and plate Precipitators



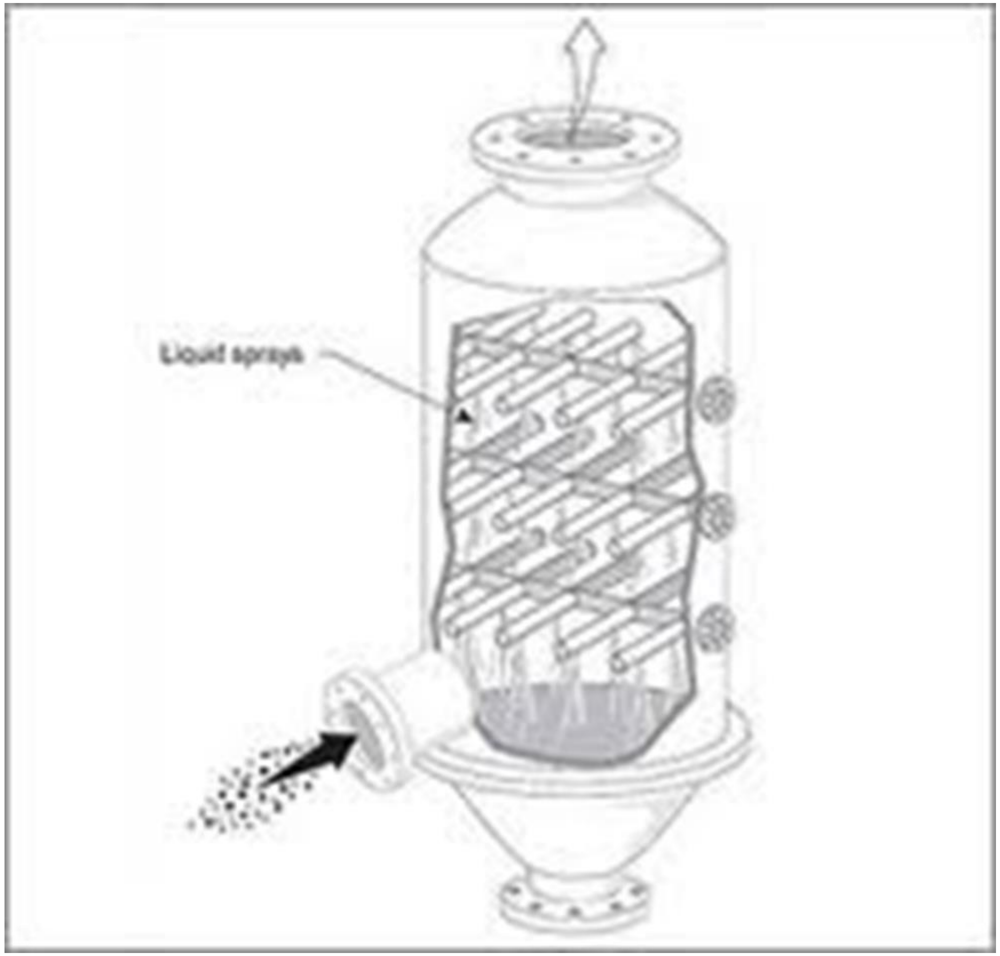


SCRUBBING - WET METHOD OF GAS SOLID REMOVAL

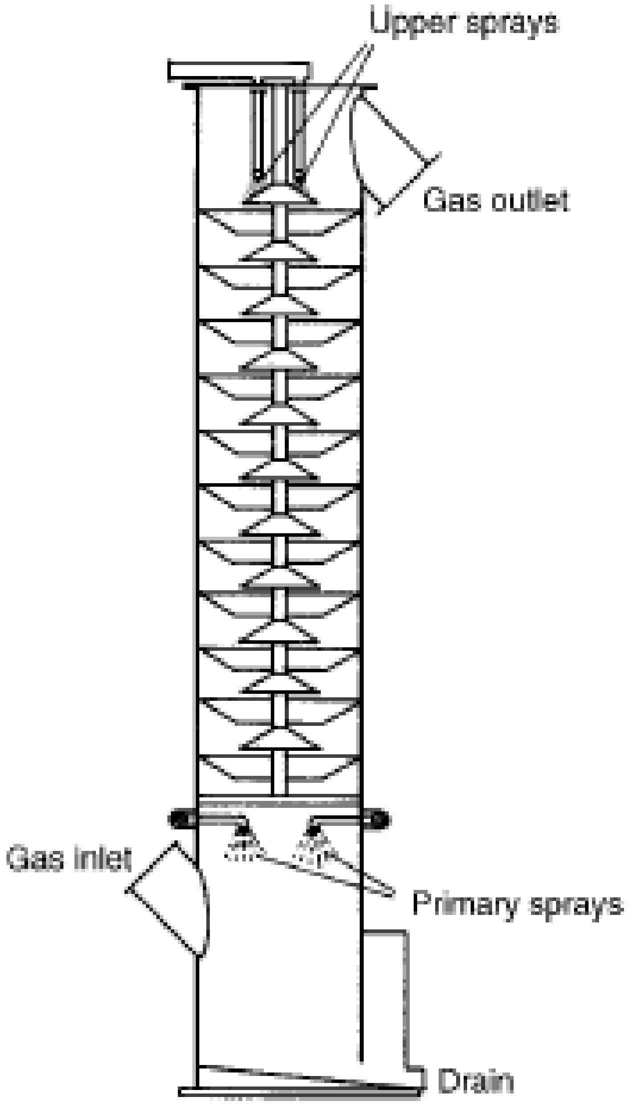
SPRAY CHAMBERS

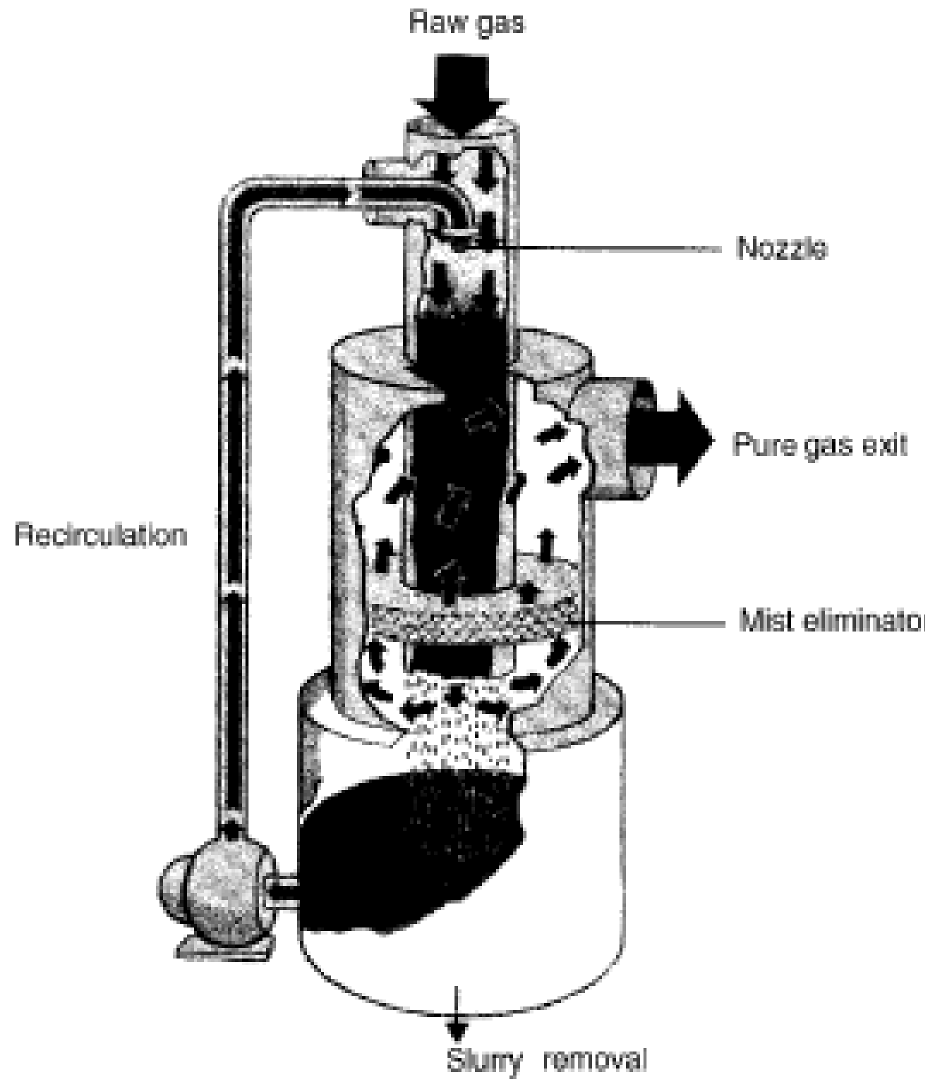
VENTURI SCRUBBERS

SPRAY CHAMBER



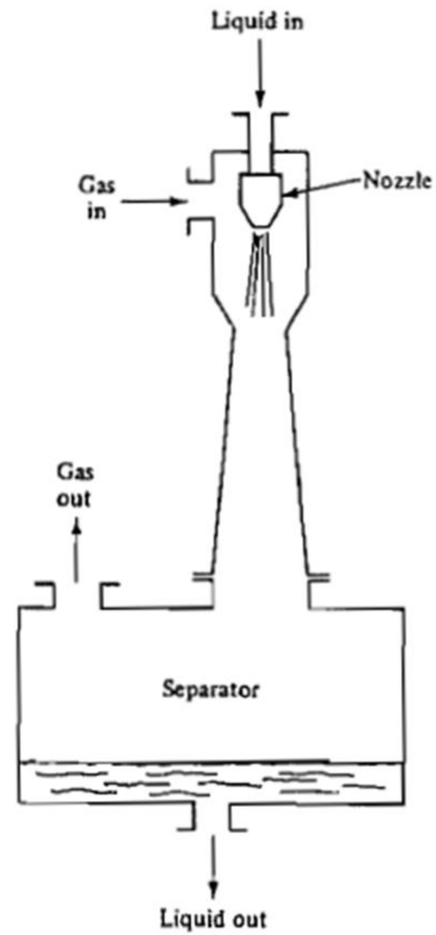
Spray washer and Sulzer Cocurrent scrubber
Ref: Coulson Richardson



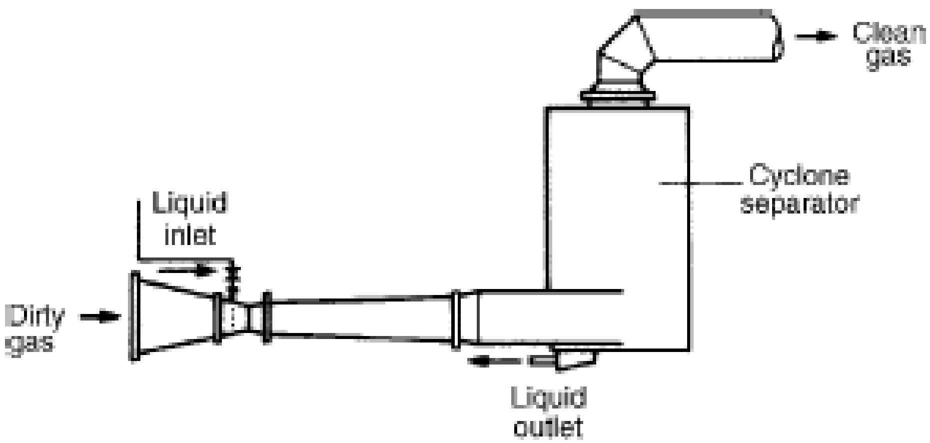


Venturi scrubbers

- 2-3micron particles
- Accelerating the gas steam to a vey high velocity 60-120m/s, so that high speed action atomized the feed liquid fed at the throat of the venturi through low pressure spray nozzles directed radially inward.
- Velocity difference between particles and droplets the particles are impacted against the slow moving droplets.
- The gas liquid mixture is directed to a separation device such as a cyclone.



Venturi Scrubber



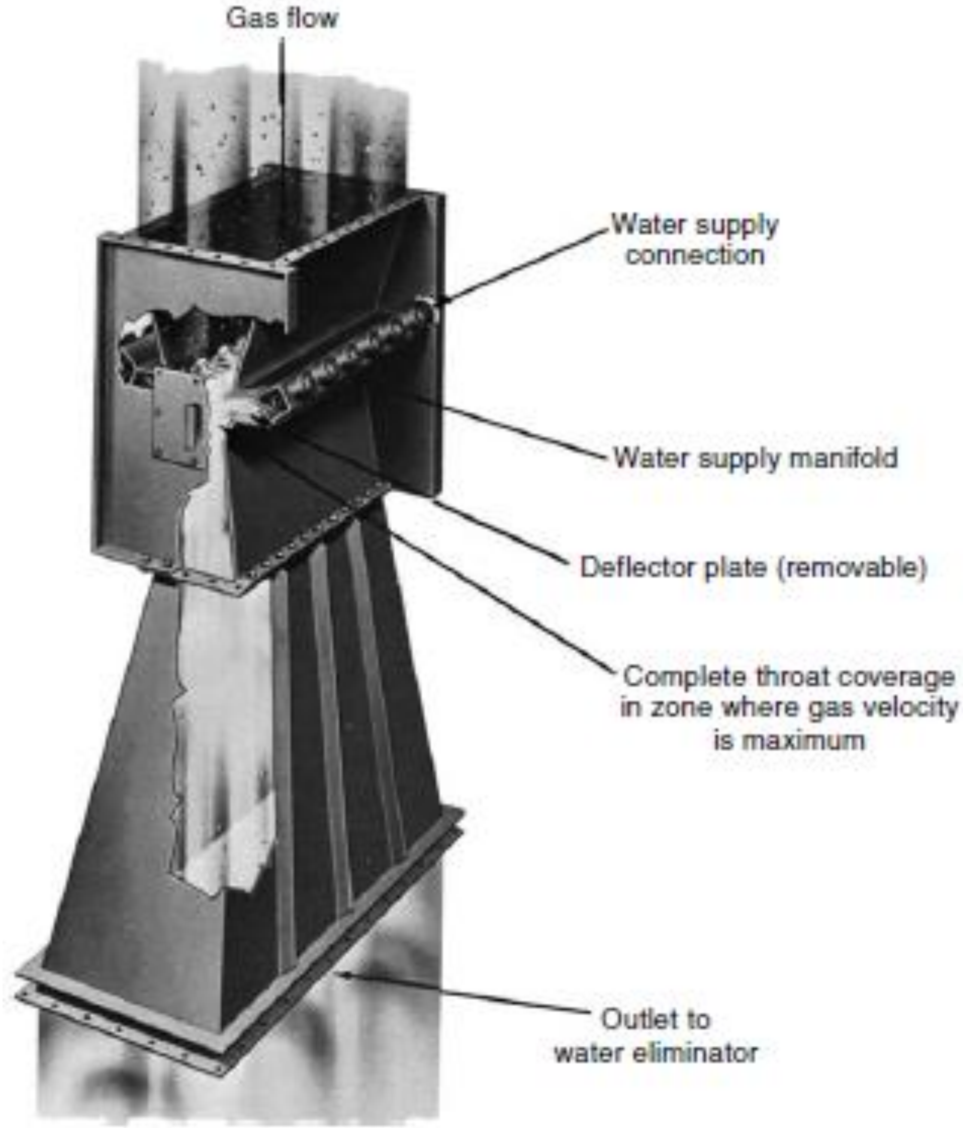


Figure 1.70. The AAF KINPACTOR venturi scrubber