GOVERNMENT POLYTECHNIC JAJPUR

Lecture Note on

Mine Ventilation

Prepared By :

PRABHUDUTTA MISHRA

(LECT. IN MINING)

DEPARTMENT OF MINING ENGINEERING

Factors affecting Natural Ventilation :-

1) Temprature :- Due to addition of heat from various sources, the difference in air densities in the upcast & downcast shaft is caused by heating.

2) Moisture content of Air :- Addition of moisture in the downcast shaft.
   - → Decreases the density of air (moisture is lighter than air) ↑
   - → Increases evaporative cooling of downcast air, which increase its density ↓

As a result evaporation of moisture usually increases ↕ natural ventilation.

3) Barometric Pressure :- Barometric pressure of the downcast air column is higher than that of the upcast, it helps natural ventilation & vice-versa.

4) Addition of Gases :- Addition of methane to mine air reduces density in upcast shaft which aids natural ventilation. (as CH_4 is lighter than air)

Large addition of CO_2 has the opposite effect. (i.e. it reduces Natural ventilation)

5) Leakage :- Leakage of denser downcast-air to the upcast causes increase in density of upcast air, thus reducing the natural ventilation.

6) Circulation of Refrigeration Air :- It increases the density of downcast air thus aiding natural ventilation.

7) Wet D.C. Shaft :- It helps natural ventilation by increasing the density of downcast air.

In addition to it movement of cage in the shaft, unequal depth of shafts also affects the natural ventilation.

Assessment of Environmental Conditions :-

The instruments which are helpful for proper control of mine ventilation are.

- → Thermometers
- → Barometers
- → Hygrometers
- → Kata Thermometers
- → Air velocity meters
- → Water gauge for mine fans.
- → Gas detectors.

Barometer :-

→ It's an instrument to measure the standard atmospheric pressure or normal atmospheric pressure.

→ It is defined as that pressure which supports a column of mercury 760mm high at sea level when the temprature of the mercury is 0°c.

The Fortin Barometer :-

This is the standard form of Barometer used for accurate measurement of the atmosp-heric pressure.

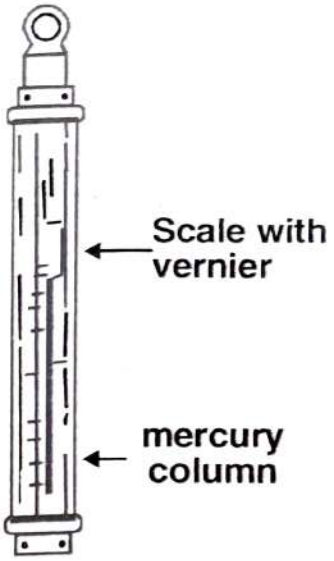


Fig. 21. Fortin barometer.

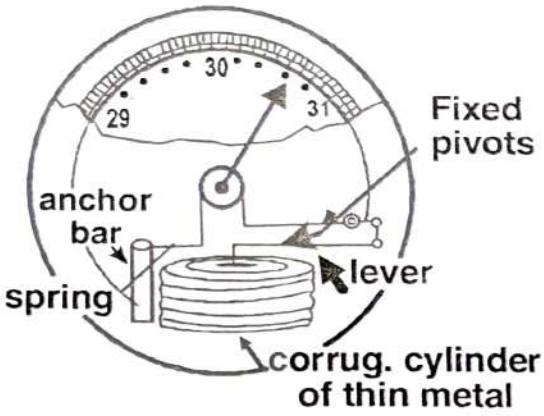
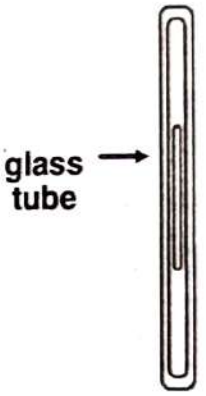


Fig. 2.2. Aneroid barometer.



Kata thermometer

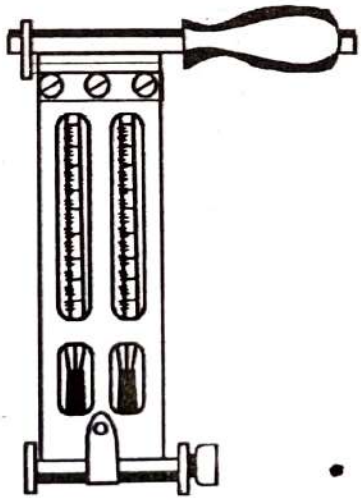
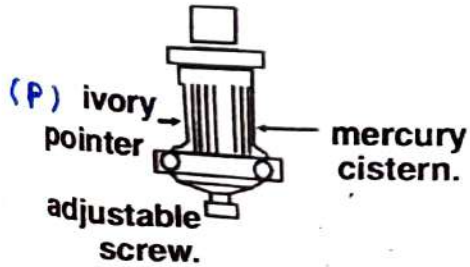


Fig. 2.3



Whirling hygrometer of N.M.C.

→ It consists of a straight glass tube about 920mm long and about 8mm inside diameter.

→ Its upper end is sealed & ~~the~~ lower end is open & dipping into a small boxwood cistern of mercury having a soft chamois leather base.

→ An adjusting screw and plate beneath the flexible bottom enable the level of mercury in the cistern to be adjusted.

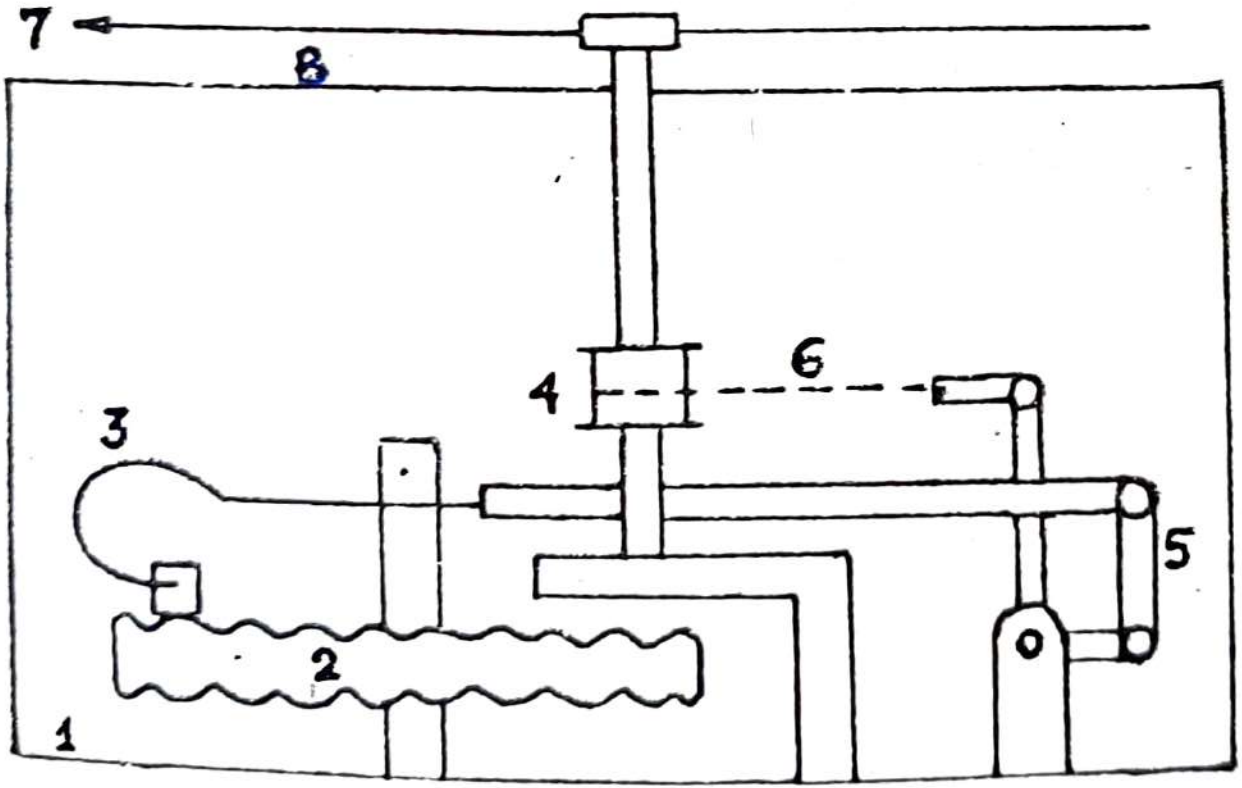
→ If the instrument is to be moved, the plate may be raised until the lower end of the tube is sealed.

→ Before any reading is taken, the level of the mercury must be adjusted so that its surface just touches the tip of the ivory pointer P.

→ This represents the level from which the height of the mercury column must be measured.

→ A scale of vernier to the nearest half millimeter is mounted along-side the tube near the top.

→ Barometers should be provided in which depillaring is done and/or which has sealed off underground workings.



1. Base Plate;
2. Evacuated Chamber;
3. Spring;
4. Drum;
5. Levers;
6. Chain;
7. Pointer;
8. Graduated Face.

ANEROID BAROMETER

Aneroid Barometer :-

For mining perposes, aneroid barometers are most convenient & portable for determining differences of level & for certain types of ventilation survey.

→ The aneroid consists of a concentrically corrugated evacuated chamber (2) & prevented from collapsing by means of a strong flat spring. (3)

→ It collapses under increasing atmospheric pressure.

→ It expands under decreasing atmospheric pressure.

→ Then it is transmitted through a sensitive spring (3) & a series of levers (5) and chains (6) to a pointer (7)

→ The hair spring (3) keeps the chain tight (6) by pulling against it to overcome axial friction.

→ The accuracy of the instrument is ± 6.66 Pa

→ The scale is graduated to read pressure from 700 to 780 mm of mercury.

→ The barometric pressure increases with depth below the sealevel & decreases with height above the sealevel at a rate of nearly 1 mm Hg difference for every 12m Vertical diff.

Kata Thermometer :-

To judge wheather a working place is suitable for a man to work efficiently and without discomfort, it is necessary to know

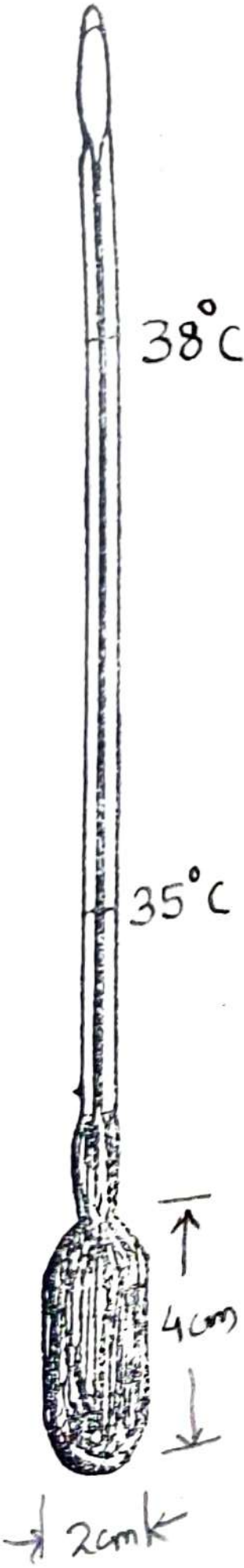
→ The temperature of air in working place ; radiation
→ The relative humidity & → evaporation
→ Air velocity → convection

The joint effect of all these factors can be known ~~with~~ with the help of Kata thermometer which measures the cooling power by a combination of the above mentioned three factors.

→ The normal temprature of human body is 36.5°c.

→ The Kata thermometer indicates the extent to which bodely heat may be lost through radiation & convection.

→ The greater part of the body heat is lost through evaporation of moisture from the surface of the body.


38°C
35°C
4cm
2cm

Construction :-

→ Kata consists of a specially designed alcohol thermometer graduated at two points, 35°C & 38°C on the stem.

→ The thermometer is having a large bulb 4cm long & 2cm in diameter & stem 20cm long.

→ The time of cooling between these points is observed. (in seconds)

→ It may be used dry or wet.

Observation :- / Procedure :-

→ The bulb is immersed in hot water carried in a thermoflask until alcohol rises above the upper graduation (38°C).

→ The bulb is wiped dry and the time required for the alcohol column to drop from upper mark to the lower mark is noted.

→ This indicates the cooling power in dry condition.

→ For wet cooling power reading, the procedure is repeated with a wet muslin cloth wrapped on the bulb.

→ An instrument factor is marked on every instrument.

→ (The Katafactor of an instrument is the number of milicalories of heat which it loses per square cm. of surface area of the bulb on cooling from 38° to 35°C. It is nearly 480)

$$\text{Cooling power} = \frac{\text{Kata factor}}{\text{Time in sec. for alcohol to fall from upper mark to lower mark.}}$$

→ The cooling power calculated is called dry if no wet cloth is used & wet if wet cloth is used.

→ The cooling power is given in millicalories per sq·cm per sec.

→ Minimum limits of the Kata thermometer cooling power for comfort working are as follows.

	Dry Kata		Wet Kata
For Sedentary Workers –	6	–	18
For light manual workers –	8	–	25
For hard manual workers –	10	–	30

→ If the dry time is used, the result is the cooling power by conduction & convection.

→ Cooling power by conduction, convection & radiation is given by using the wet bulb time.
(This is a useful guide as to the cooling power in reference to human body)

→ Most ~~Comfortable~~ comfortable condition in mines normally exist with wet Kata cooling is between 20 & 25. ✓

→ ✗ below 10 – Opressive

→ ✗ 30 is chilly unless well clothed & working.

Ventilation Door :-

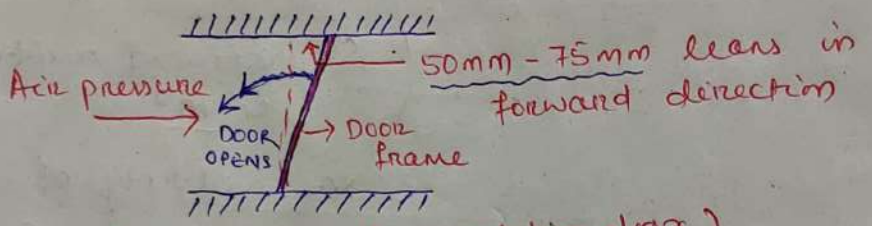
Ventilation doors are used on those roads which are required as

→ Main separation doors between upcast & downcast shafts to prevent direct short-circuit.

→ Ventilation doors on haulage roads.

→ Ventilation doors on travelling roads.

→ Ventilation doors as access to the old workings.



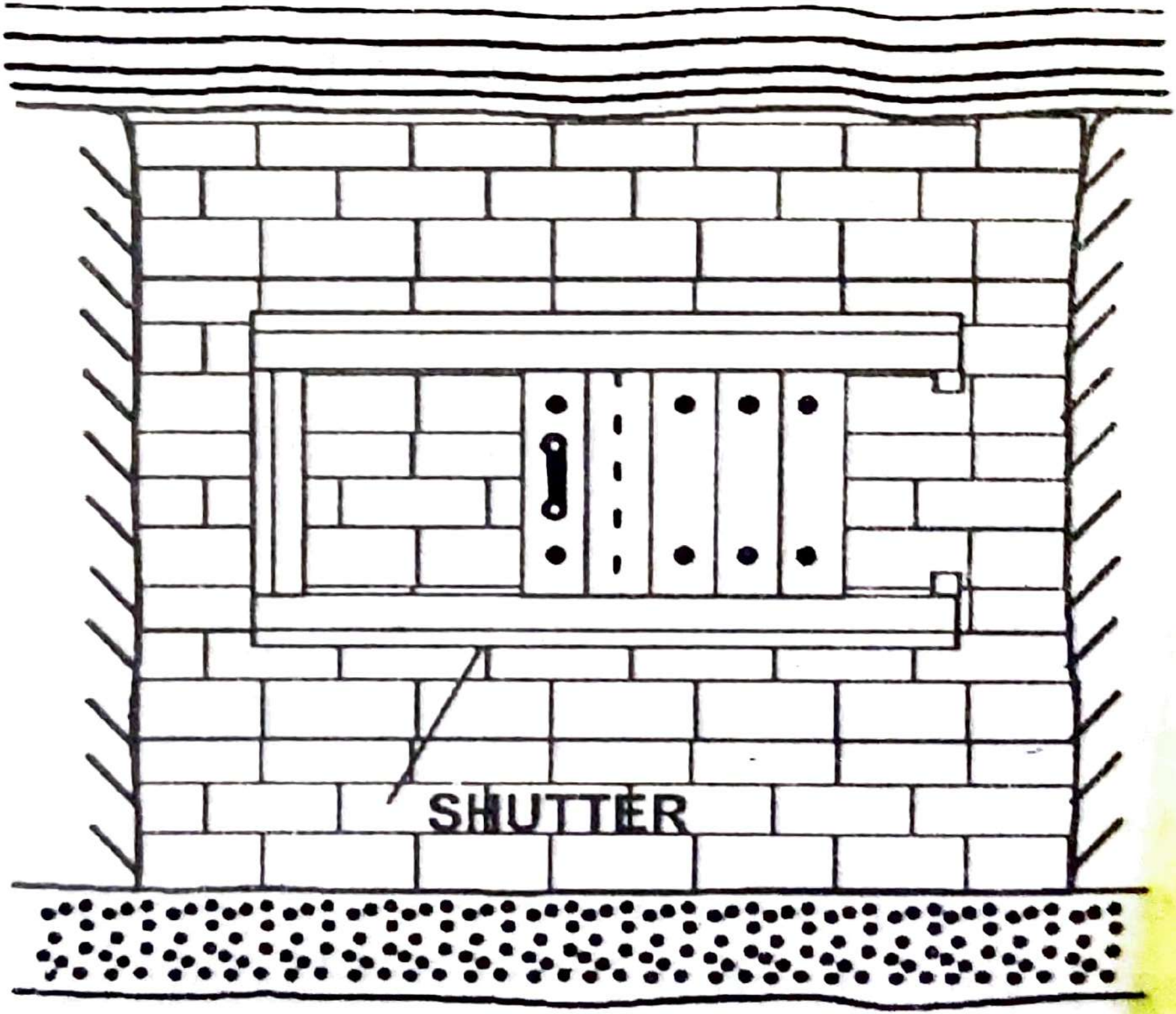
(Side view of ventilation door)

→ The ventilation door must be arranged to close automatically and with this object the frame of the door is so fitted that, top leans about (50-75) mm forward in the direction of air pressure.

→ The door should open against the intake air so that the air pressure normally keeps it closed.

→ Separation doors are provided in connection between main intake & main return airways. Normally, two doors are used forming an AIR-LOCK so that one is always closed when the other is open.

→ Gasket lining canvas or rubber strips


SHUTTER

are fixed along the edge of the door, to reduce leakage of air.

→ A small shutter fitted to a door also relieves the pressure while the door is opened.

→ Automatically operated doors may be operated mechanically or by electric motors.

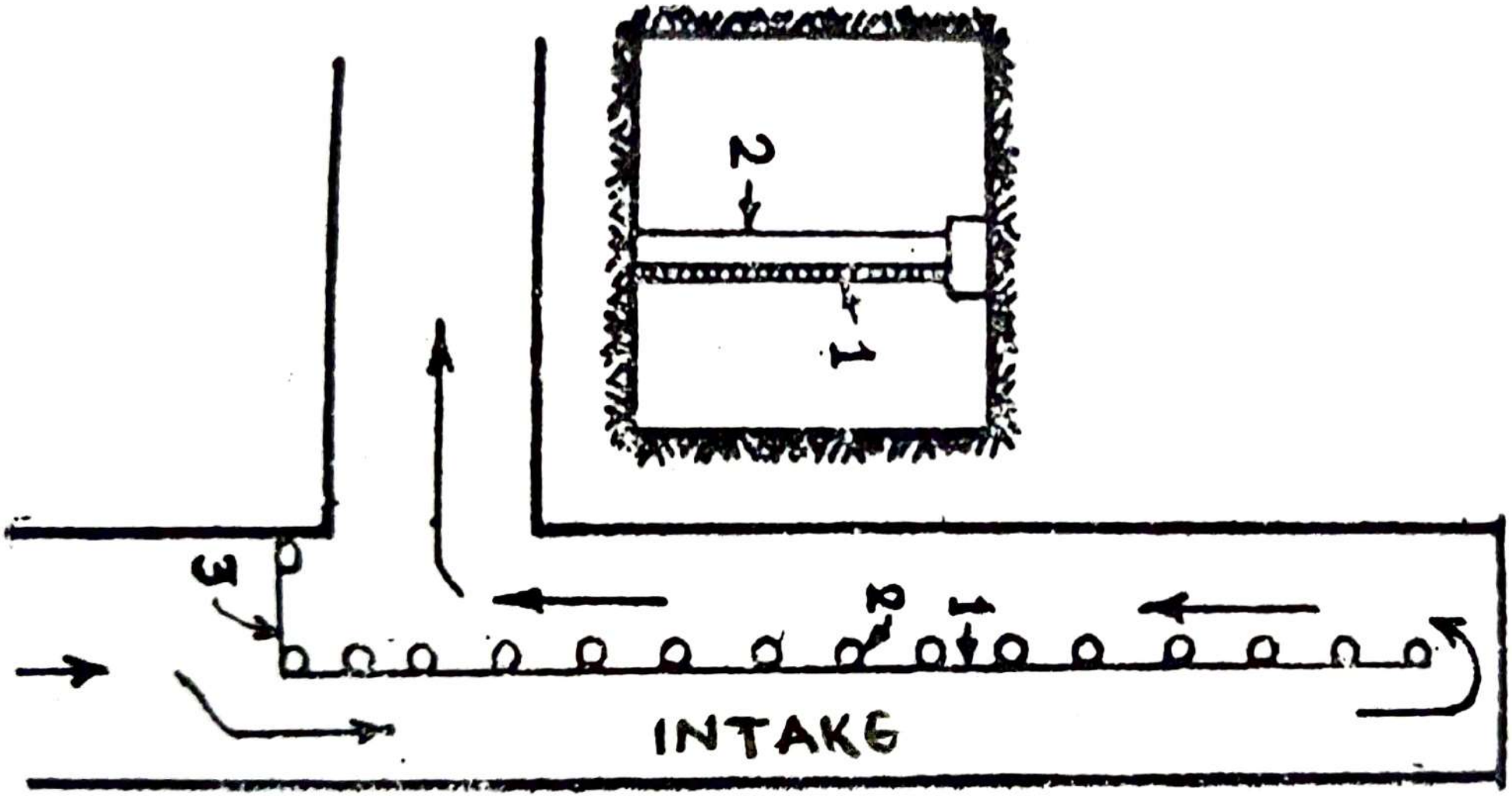
→ Remote-control doors are operated by compressed air or water under pressure.

→ Where automatic or remote-control doors are used, a smaller side door for travelling of workers should be provided.

→ Safety measures such as warning lights or whistles, along with glass panels in the doors should be introduced.

→ Where the ventilation door is required to be kept open frequently for the passage of men & material, a door attendant should be provided.

→ A manhole should be provided close to the ventilation door, in the intake side, so that the attendant can operate the door safely.


2
1
3
INTAKE

Brattice Partition:-

→ Brattice partitions are erected to course the ventilation air upto the working face in a narrow heading. It is used as a partition along an airway to divided it into two parts, intake & return.

→ It may be used as a screen across an airway to prevent or reduce the flow of air along it. (temporary stopping)

→ It may be used as handle screen to divert an air current upwards into a roof cavity to clear away any accumulation of gas.

→ Brattice cloth coated with P.V.C. is impermeable to airflow and is more suitable for line brattices to ventilate the heading.

→ But this can carry air only a short-distance into the heading due to high air leakage through the gaps between the brattice and the roof & floor.

→ Line brattices should be used to ventilate not more than 20 meters long.

→ The intake side of the brattice should be kept wider to circulate adequate quantity of fresh and cool air for work persons at the face. Brattice should be fire resistant.

→ For long headings or stone drifts, ventilation ducts and auxiliary fans are now efficient & reliable.

Laws of mine air friction:-

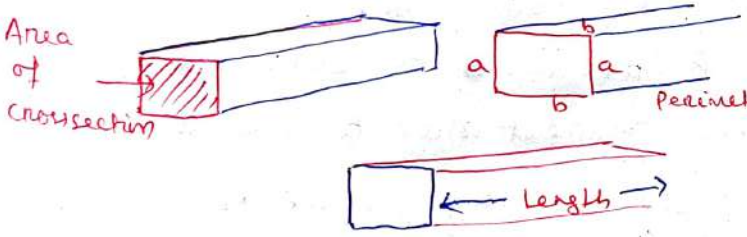
→ For air to flow between two points along an airway or air circuit, there must be difference of pressure between the two points.

Ventilating pressure = X − Y

→ The difference of pressure is called the ventilating pressure.

→ This ventilation pressure overcoming the frictional resistance between two points.

→ This frictional resistance depends on the dimensions of the airway. i.e. → cross-sectional area
→ perimeter
→ Length



→ The relationship between there various factors was given by J. J. Atkinson in 1854 in the form of following four laws which are called laws of mine air friction.

Law - I -

The pressure 'p' required to overcome friction is directly proportional to the area of the rubbing surface that is

$P \propto S$, where S = rubbing surface
= perimeter of the airway × Length

Law - II -

The pressure 'p' required to overcome friction is directly proportional to square of the velocity of air, that is

$P \propto v^2$, where v = air velocity

Law - III -

The pressure 'p' required to overcome friction is inversely proportional to the area of cross section of the airway, that is

$P \propto \frac{1}{A}$, where A = area of cross-section

Law - IV -

The pressure 'p' required to overcome friction varies with the degree of roughness of the rubbing surface. or in other words, on the co-efficient of friction of the airway, that is,

$P \propto K$, where K = co-efficient of friction.

Atkinson's equation :-

All the above four laws of mine air friction are combined in the following equation, which is known as Atkinson's Equation.

Ventilating pressure overcoming friction or pressure loss due to friction

$$P = \frac{KSV^2}{A}$$

P is in Pascal

K = co-efficient of friction of the airway in kg/m^3 (or Ns^2m^{-4})

S = area of rubbing surface in m^2

V = velocity of air current in m/sec ($V = \frac{Q}{A}$)

Q = quantity of air flowing in m^3/sec

A = area of cross-section of airway in m^2

$$P = \frac{KSQ^2}{A^3}$$

$Q = A \times V$

or

$V = \frac{Q}{A}$

Numerical problems - L.C. Kakde (Laws of Mine air friction)

CHAPTER - 5

LAWS OF MINE AIR FRICTION

1. Calculate the pressure required for ventilating a drift given the following—

Dimensions of drift = 2.5m × 3m × 300m

Quantity passing = 300 m^3min^{-1}

Coefficient of resistance = 0.0098 Ns^2m^{-4}

Sol. Surface area of the drift, S = perimeter × length

$= 2(2.5 + 3) \times 300$

$= 3300m^2$

Quantity = 300 m^3min^{-1} = $5m^3s^{-1}$

Cross-sectional area of drift = $2.5 \times 3 = 7.5m^2$

K = 0.0098 Ns^2m^{-4}

$\therefore$ Pressure required, $P = \frac{KSQ^2}{A^3}$ pascal, where S is the area of rubbing surface in m^2, Q the quantity in m^3s^{-1}, A the cross-sectional area in m^2, K the coefficient of resistance in Ns^2m^{-4}

$$\therefore P = \frac{0.0098 \times 3300 \times (5)^2}{(7.5)^3} \text{ pascal} = 1.92 \text{ pascal}$$

2. A mine has only one district at a distance of 500m from the bottom of the shafts. The average size of roadways is 4.3m × 2.7m and the average velocity of air is 320m per min. Find out the pressure difference at the pit-bottom (value of K is 0.001) **[Second Class (Coal) 1986]**

Sol. K = 0.001

Surface area S = Perimeter × Length

$= 2(4.3 + 2.7) \times 500 = 7000 \text{ m}^2$

Velocity V = 320 m min^{-1} or $\frac{16}{3}$ ms^{-1}

Cross sectional area A = $4.3 \times 2.7 = 11.61 \text{ m}^2$

$\therefore$ Pressure difference $P = \frac{KSV^2}{A}$ pascal, where K is the coeff. of resist. in Ns^2m^{-4}, S the area of rubbing surface in m^2, V the velocity of air in ms^{-1}, A the area of cross-section in m^2.

$$\therefore P = \frac{0.001 \times 7000 \times (16/3)^2}{11.61} = 17.2 \text{ Pa}$$

3. A quantity of $3300m^3$ of air passes per minute through an airway 3m × 2m by 500m long. What quantity would pass if cross-section was enlarged to 3.5 × 2m?

Sol. $P = \frac{KSQ^2}{A^3} = \frac{K(\text{length L} \times \text{perimeter C})Q^2}{A^3}$

P, K and L being the same in both cases, $Q^2 \propto \frac{A^3}{C}$

$$\therefore \quad \frac{Q_2^2}{Q_1^2} = \frac{A_2^3}{A_1^3} \times \frac{C_1}{C_2}$$

or $$\frac{Q_2^2}{(3300)^2} = \frac{(7)^3}{(6)^3} \times \frac{10}{11}$$

$\therefore \quad Q_2 = 3965 \text{ m}^3\text{/minute.}$

Hence 3965 m^3/minute of air will pass through the airway of increased cross-section.

4. The velocity of air in a 6m diameter D.C. shaft 300 m deep is 4 ms^{-1}. Calculate—

(a) quantity of air entering the mine per minute,

(b) power lost to overcome the frictional resistance of the shaft.

Assume coefficient of friction to be 0.010 50 Ns^2m^{-4}.

Sol. **(a)** Volume of air entering the mine

$$= \frac{\pi}{4} D^2 \times 4 \text{ m}^3\text{s}^{-1}$$

$$= \frac{22}{7} \times 6^2 = 113.14 \text{ m}^3\text{s}^{-1}$$

$K = 0.010\ 50\ Ns^2m^{-4}$

$$S = \pi DL = \frac{22}{7} \times 6 \times 300 = 5657 \text{ m}^2$$

$V = 4\ ms^{-1}$

$$A = \frac{\pi D^2}{4} = \frac{22}{7} \times \frac{(6)^2}{4} = 28.29 m^2$$

$\therefore$ Ventilating pressure, $P = \frac{KSV^2}{A}$

Pressure required

$$= \frac{0.01050 \times 5657 \times (4)^2}{28.29} Pa$$

$$= 33.6 \text{ Pa}$$

(b) Power lost to overcome frictional resistance

$$= PQ \times 10^{-3} \text{ kW}$$

$$= 33.6 \times 113.14 \times 10^{-3} \text{ kW}$$

$$= 3.8 \text{ kW.}$$

5. The coefficient of friction of an airway is 0.01 Ns^2m^{-4}. Calculate the Darcy-Weisbach resistance coefficient assuming air density to be 1.2 kgm^{-3}.

Sol. Coefficient of friction,

$K = \frac{f\rho}{8}$ where f is the Darcy-Weisbach resistance coefficinent, ρ the air density in kgm^{-3} and K in Ns^2m^{-4}.

$$\therefore 0.01 = \frac{f \times 1.2}{8}$$

$$\therefore f = \frac{0.01 \times 8}{1.2} = 0.0667$$

6. An airway 2.5m × 2m absorbs a ventilating pressure of 250 Pa. Calculate the saving of pressure that can be achieved by enlarging the roadway to 3m × 2.5m. Assume that there is no change in quantity of air passing and coefficient of friction. Power cost in Rs. 2.50 per kWH.

Sol. If suffix 1 & 2 refer to old and new airways respectively, from Atkinson's equation $P = \frac{KSQ^2}{A^3}$, we have

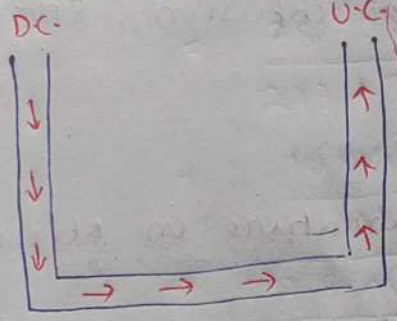
$$\frac{P_2}{P_1} = \frac{S_2}{A_2^3} \times \frac{A_1^3}{S_1} \quad \text{i.e.} \quad \frac{P_2}{P_1} = \frac{S_2}{S_1} \times \left(\frac{A_1}{A_2}\right)^3$$

Since $K_1 = K_2$ and $Q_1 = Q_2$.

Motive column :-

→ The natural ventilation occurs simply because the downcast air column is heavier than the upcast air column.
(i.e. the downcast air column is having higher pressure / density / weight than upcast air column)

→ The force causing the ~~moti~~ motion of air is the excess weight of downcast column.



→ So to cause the air flow A is always greater than B.

$A = B + (x)$ { x↓ = excess weight of D.C. column.

→ So 'x' is the force causing the motion.

→ A column of downcast air having such "excess weight is called the "motive column.

→ In describing a ventilating pressure, especially a natural ventilating pressure, it can be expressed as a difference of pressure in kg/m^2
or → mm of watergauge
or → height of motive column of downcast air which is the effective force causing air flow.

→ The height of this excess weight of air column of D.C. shaft, 1 m^2 in cross section, which gives rise to N.V.P. (Natural ventilating pressure) is called motive column.

→ Hence the motive column is the unbalanced part of the whole D.C. column.

→ The height of the motive column is given by the formula,

$$h = \frac{Tu - Td}{273 + Tu} \times D$$

where h = height of motive column (m)

Tu = av. temprature in upcast shaft (°C)

Td = av. temprature in downcast shaft (°C)

D = depth of column top of the higher level shaft and bottom of the deeper shaft (in m)

Example :-

Mean air temp. in a D.C. shaft 400 m deep is 28°C & in the U.C. shaft is 38°C.

Calculate :-

i) the motive column

ii) the N.V.P. assuming average barometric pressure in D.C. shaft to be 750 mm of Hg.

i) Motive column, $h = \frac{Tu - Td}{273 + Tu} \times D$

$= \frac{38 - 28}{273 + 38} \times 400$

$= \frac{10 \times 400}{311}$

$= \boxed{12.8 \text{ m}}$

ii) N.V.P = motive column x density of air in D.C. shaft.

$= 12.8 \times 1.157$ ✓

$= 14.81 \text{ Kgf/m}^2$

$= 148.1 \text{ Pa}$

Density of air in D.C. shaft

$= \boxed{\frac{0.4645\ B}{273 + Td}}$ { B = barometric pressure in mm of Hg.

$= \frac{0.4645 \times 750}{273 + 28}$

$= 1.157 \text{ Kg/m}^3$ ✓

Water Gauge :-

→ The atmospheric pressure in an underground mine can be measured by the aneroid barometer.

→ The difference of pressure between nearby points is measured by a watergauge, which is essentially an ordinary glass tube of U-shape.

→ One open-end of U-tube connected to the point of low pressure & the other open end connected to another point having high pressure.

→ The difference between the water levels of the two legs is the pressure difference between the two points.

→ Water rises in the leg which is connected to the point of low pressure & falls in the other leg.

→ A difference of "1 mm water gauge" represents a pressure difference of 1 kgf/m².

→ A watergauge is placed in the fan drift, one end connected to the atmosphere & the other in the fan drift very near to the fan.

Calculation of Ventilation pressure by using pitot-static tube.

→ This is a pressure measuring instrument, whose readings can be converted by calculation, to equivalent velocity measurements.

→ Like the velometer, it gives 'spot' readings, and the average velocity over an airway must be found by taking a number of observations & averaging them.

→ It consists of two tubes connected by rubber tubings to two limbs of a watergauge or manometer.

→ One tube has its end drawn out to form an elongated cone and is facing the air-current.

→ It is thus subjected to total pressure of the air.

→ The other tube is fitted with a plain disc having a hole in the centre.

→ It is arranged at right angles to the air-stream and it is subjected only to the static pressure.

→ It follows that the difference of level of the liquid in the two limbs of the manometer is proportional to the velocity of air.

→ Normally the head of the pitot static tube is turned in different directions until the highest velocity pressure is recorded.

→ The relation between the observed w.g and the velocity of the air is given by the following equation.

$$V = 4.43\sqrt{\frac{w.g}{w}}$$

V = velocity of air in m/sec

w.g. = Pressure in mm of w.g. or in kgf/m²

w = Density of air in kgf/m²

At standard air density

$$V = 4.015\sqrt{w.g.}$$
$$= 4\sqrt{w.g.} \quad \text{(Approximately)}$$

→ The instrument can be permanently connected to the fan shaft, with manometer outside, so that a reading of the velocity-pressure can be taken conveniently at any time.

Sources of Moisture content of Mine air :-

1) Original moisture content of air.
2) Moisture given off from the strata in wet downcast shafts.
3) Wet roadways, working places & drains.
4) Perspiration of men.
5) Water vapour given off during burning of lamps.
6) Water introduced in the mine for wet cutting, water infusion, spraying on coal-dust etc.

Sources of Temprature in Mines :-

1) High temprature of surface air.
2) Adiabatic compression.
3) Heat from strata.
4) Heat produced by machinery and equipment.
5) Heat given out by workmen.
6) Chemical processes (blasting, oxidation)
7) Rock movement.
8) Heat due to air passing through fans & friction of air currents.

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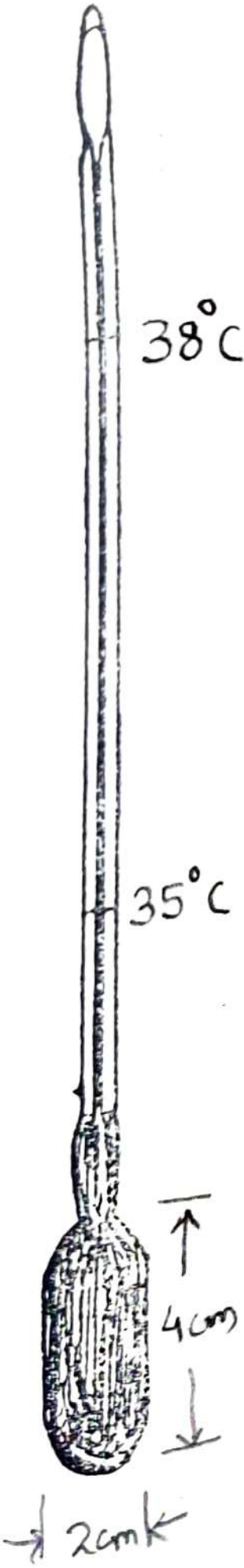
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→ The bulb is wiped dry and the time required for the alcohol column to drop from upper mark to the lower mark is noted.

→ This indicates the cooling power in dry condition.

→ For wet cooling power reading, the procedure is repeated with a wet muslin cloth wrapped on the bulb.

→ An instrument factor is marked on every instrument.

→ (The Katafactor of an instrument is the number of milicalories of heat which it loses per square cm. of surface area of the bulb on cooling from 38° to 35°C. It is nearly 480)

$$\text{Cooling power} = \frac{\text{Kata factor}}{\text{Time in sec. for alcohol to fall from upper mark to lower mark.}}$$

→ The cooling power calculated is called dry if no wet cloth is used & wet if wet cloth is used.

→ The cooling power is given in millicalories per sq·cm per sec.

→ Minimum limits of the Kata thermometer cooling power for comfort working are as follows.

	Dry Kata		Wet Kata
For Sedentary Workers –	6	–	18
For light manual workers –	8	–	25
For hard manual workers –	10	–	30

→ If the dry time is used, the result is the cooling power by conduction & convection.

→ Cooling power by conduction, convection & radiation is given by using the wet bulb time.
(This is a useful guide as to the cooling power in reference to human body)

→ Most ~~Comfortable~~ comfortable condition in mines normally exist with wet Kata cooling is between 20 & 25. ✓

→ ✗ below 10 – Opressive

→ ✗ 30 is chilly unless well clothed & working.

Factors affecting Natural Ventilation :-

1) Temprature :- Due to addition of heat from various sources, the difference in air densities in the upcast & downcast shaft is caused by heating.

2) Moisture content of Air :- Addition of moisture in the downcast shaft.
   - → Decreases the density of air (moisture is lighter than air) ↑
   - → Increases evaporative cooling of downcast air, which increase its density ↓

As a result evaporation of moisture usually increases ↕ natural ventilation.

3) Barometric Pressure :- Barometric pressure of the downcast air column is higher than that of the upcast, it helps natural ventilation & vice-versa.

4) Addition of Gases :- Addition of methane to mine air reduces density in upcast shaft which aids natural ventilation. (as CH_4 is lighter than air)

Large addition of CO_2 has the opposite effect. (i.e. it reduces Natural ventilation)

5) Leakage :- Leakage of denser downcast-air to the upcast causes increase in density of upcast air, thus reducing the natural ventilation.

6) Circulation of Refrigeration Air :- It increases the density of downcast air thus aiding natural ventilation.

7) Wet D.C. Shaft :- It helps natural ventilation by increasing the density of downcast air.

In addition to it movement of cage in the shaft, unequal depth of shafts also affects the natural ventilation.

Assessment of Environmental Conditions :-

The instruments which are helpful for proper control of mine ventilation are.

- → Thermometers
- → Barometers
- → Hygrometers
- → Kata Thermometers
- → Air velocity meters
- → Water gauge for mine fans.
- → Gas detectors.

Barometer :-

→ It's an instrument to measure the standard atmospheric pressure or normal atmospheric pressure.

→ It is defined as that pressure which supports a column of mercury 760mm high at sea level when the temprature of the mercury is 0°c.

The Fortin Barometer :-

This is the standard form of Barometer used for accurate measurement of the atmosp-heric pressure.

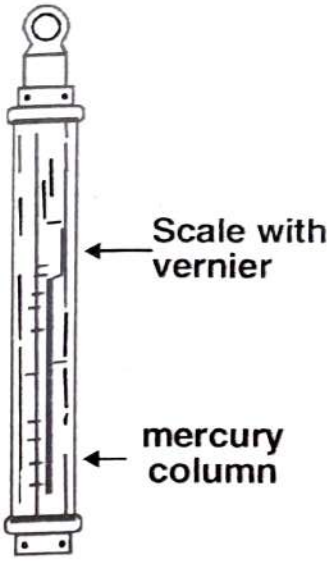


Fig. 21. Fortin barometer.

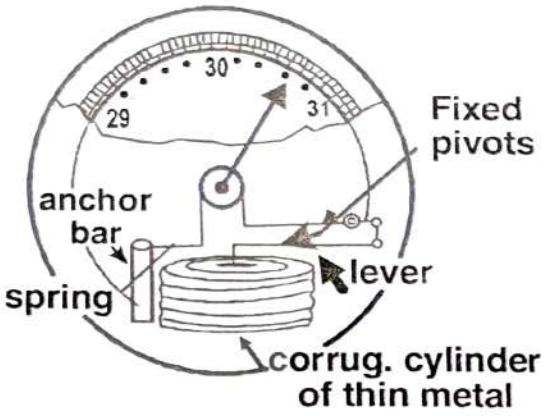
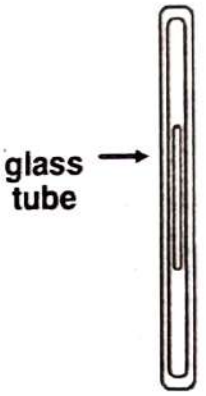


Fig. 2.2. Aneroid barometer.



Kata thermometer

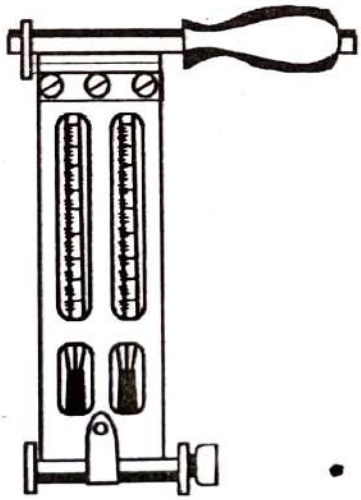
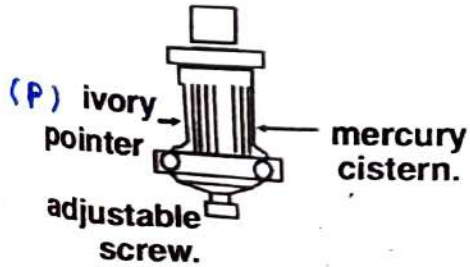


Fig. 2.3



Whirling hygrometer of N.M.C.

→ It consists of a straight glass tube about 920mm long and about 8mm inside diameter.

→ Its upper end is sealed & ~~the~~ lower end is open & dipping into a small boxwood cistern of mercury having a soft chamois leather base.

→ An adjusting screw and plate beneath the flexible bottom enable the level of mercury in the cistern to be adjusted.

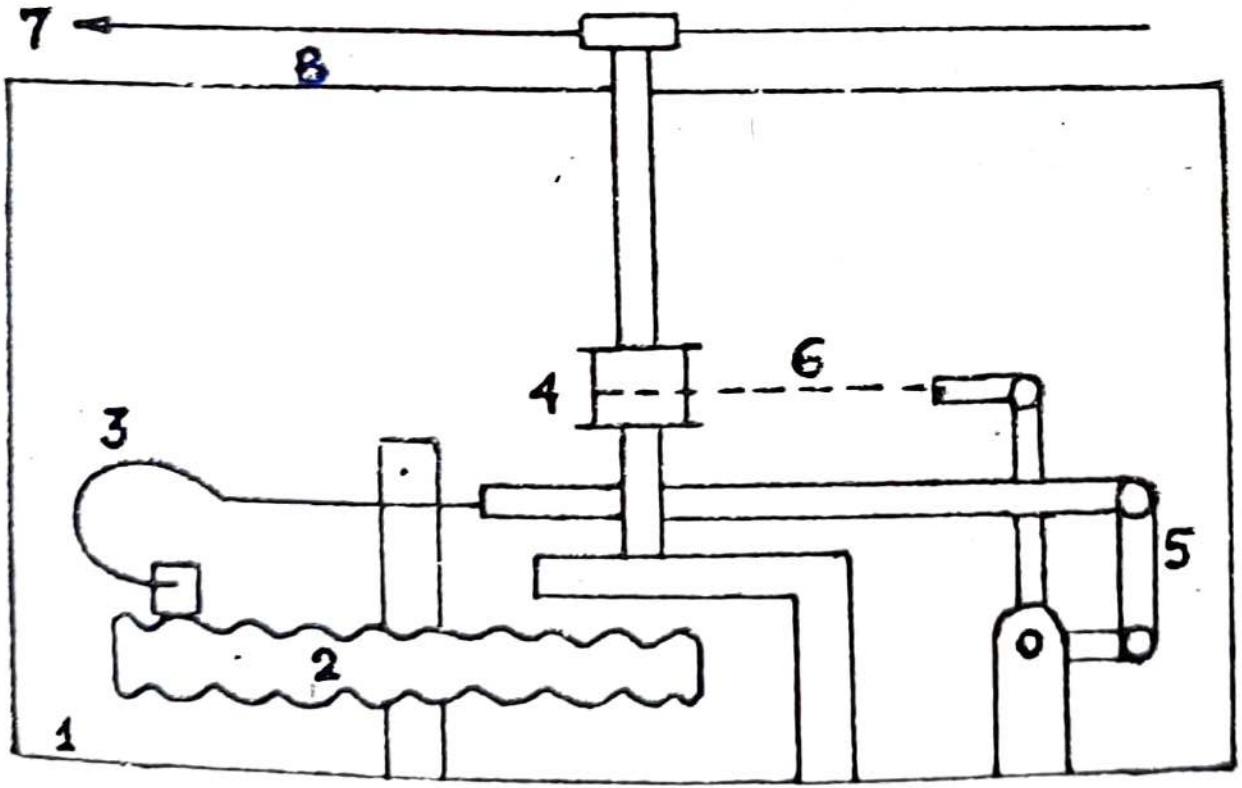
→ If the instrument is to be moved, the plate may be raised until the lower end of the tube is sealed.

→ Before any reading is taken, the level of the mercury must be adjusted so that its surface just touches the tip of the ivory pointer P.

→ This represents the level from which the height of the mercury column must be measured.

→ A scale of vernier to the nearest half millimeter is mounted along-side the tube near the top.

→ Barometers should be provided in which depillaring is done and/or which has sealed off underground workings.



1. Base Plate;
2. Evacuated Chamber;
3. Spring;
4. Drum;
5. Levers;
6. Chain;
7. Pointer;
8. Graduated Face.

ANEROID BAROMETER

Aneroid Barometer :-

For mining perposes, aneroid barometers are most convenient & portable for determining differences of level & for certain types of ventilation survey.

→ The aneroid consists of a concentrically corrugated evacuated chamber (2) & prevented from collapsing by means of a strong flat spring. (3)

→ It collapses under increasing atmospheric pressure.

→ It expands under decreasing atmospheric pressure.

→ Then it is transmitted through a sensitive spring (3) & a series of levers (5) and chains (6) to a pointer (7)

→ The hair spring (3) keeps the chain tight (6) by pulling against it to overcome axial friction.

→ The accuracy of the instrument is ± 6.66 Pa

→ The scale is graduated to read pressure from 700 to 780 mm of mercury.

→ The barometric pressure increases with depth below the sealevel & decreases with height above the sealevel at a rate of nearly 1 mm Hg difference for every 12m Vertical diff.

Boundary Ventilation :-

→ This system of ventilation normally adopted in metal mines is called 'Boundary Ventilation'.

→ This is possible where the D.C. & U.C shafts are located at opposite ends of the property.

→ The air from the intake to the return side is practically eliminated.

→ The fresh & cool intake air goes to the lowest levels where rock temprature is the hottest.

SPLITTING Of Air Current :-

→ To have fresh air in a district, unpolluted by human breathing or gas emission from the other districts, a branch of air currents called splits.

→ The splits are taken from main intake.

→ A ventilation district, as defined in the Regulations, means such part of a mine below ground as has an independent intake airway from main intake & an independent return airway from main return.

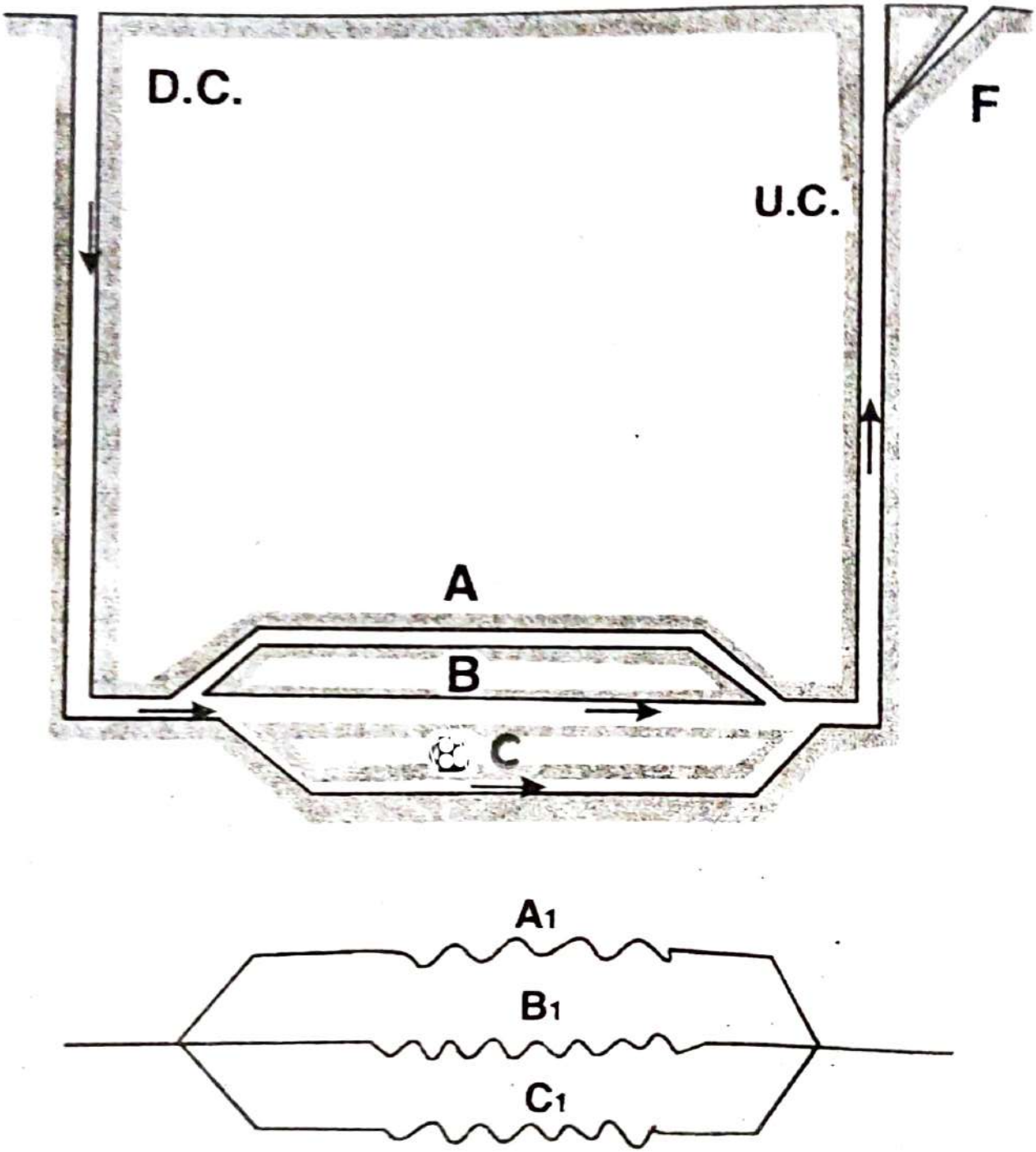
→ Splitting is necessary for both economic & safety requirements.

→ Dividing the mine ventilating system into multiple splits provide separate ventilating districts in the mine & permits better air control.

→ The advantages of splitting the aircurrent is the decrease in the resistance of the mine as a whole.

→ In the event of an explosion or outburst of gas in one district the other parts of the mine need not necessarily be affected.

→ The resistance follows nearly the same laws as are applicable to electrical resistance in parallel and in series.



Splitting of air current (Schematic) F is passage to the fan drift.

→ The overall resistance of the mine is reduced. Air velocities are reduced in the roadways & at the face and coal dust formation is lessened.

→ Splits reduce the doors on haulage roads but increases the number of aircrossings.

→ The combined resistance of an underground system of roadways having one or more splits is given by the formula.

$$\frac{1}{\sqrt{R}} = \frac{1}{\sqrt{R_1}} + \frac{1}{\sqrt{R_2}} + \frac{1}{\sqrt{R_3}} + \cdots \frac{1}{\sqrt{R_n}}$$

where, R = Combined or equivalent resistance of the system.

$R_1, R_2 \cdots R_n$ = The resistance of individual splits.

Problem - 1

A total quantity of 100 m³/min of air is passing through two splits. One airway is 2.5m × 1.5m & 100m long, and the other with similar lining is 2m × 1.5m & 125m long. Calculate the quantity of air passing in each split.

Soln :-

Since the two splits are subjected to same pressure & the nature of lining is the same, from the equation, $P = \frac{KSQ^2}{A^3}$,

$Q \propto \sqrt{\frac{A^3}{S}}$ or $Q \propto \sqrt{\frac{A^3}{\text{perimeter} \times \text{length}}}$

$\therefore$ Relative quantity in Split 1 $= \sqrt{\frac{(2.5 \times 1.5)^3}{2(2.5+1.5) \times 100}}$

$= 0.2567$

Relative quantity in Split 2 $= \sqrt{\frac{(2 \times 1.5)^3}{2(2+1.5) \times 125}}$

$= 0.1757$

Sum of relative quantities $= 0.2567 + 0.1757$

$= 0.4324$

$\therefore$ Actual quantity of air in Split No. 1 $= \frac{0.2567}{0.4324} \times 100$

$= 59.37 \text{ m}^3/\text{min}$

Actual quantity of air in split No. 2

$= 100 - 59.37 = 40.63 \text{ m}^3/\text{min}$

Check :- Quantity in Split-2 $= \frac{0.1757}{0.4324} \times 100$

$= 40.63 \text{ m}^3/\text{min}$ ✓

Problem-2

Three splits in parallel, of similar cross-section & same type of roadway surface & respectively, 300m, 600m & 900m long. Calculate the quantity of air which would flow in each if the total quantity is 200 m³/min.

Soln. We know, $P = \frac{KSQ^2}{A^3}$

$$Q^2 = \frac{PA^3}{KS} = \frac{PA^3}{K \times L \times \text{perimeter}}$$

Since K, A & perimeter are constant.

$$Q \propto \frac{1}{\sqrt{L}}$$

$$\therefore Q_1 : Q_2 : Q_3 = \frac{1}{\sqrt{300}} : \frac{1}{\sqrt{600}} : \frac{1}{\sqrt{900}}$$

or $$= \frac{1}{\sqrt{1}} : \frac{1}{\sqrt{2}} : \frac{1}{\sqrt{3}}$$

$$= 1 : 0.709 : 0.579^*$$

Sum of relative quantities = 1 + 0.709 + 0.579

= 2.288

Quantity

In split 1 = $200 \times \frac{1}{2.288} = 83.03 \text{ m}^3/\text{min}$

In split 2 = $200 \times \frac{0.709}{2.288} = 61.97 \text{ m}^3/\text{min}$

In split 3 = 200 − (83.03 + 61.97)

= 50 m³/min

Check:-

In split 3 = $200 \times \frac{0.579^*}{2.288} = 50.6 \text{ m}^3/\text{min}$

Describe Air-Locks at Pit-top :-

To achieve maximum efficiency of ventilation, it is essential to eliminate leakage between intake & return airways, which causes air to short circuit without passing through active workings.

→ At a number of mines the type of air lock provided consists of only simple covering at the top of the shaft, which is lifted up by the upcoming cage.

→ In this design heavy leakage of air, as much as 30% of the quantity of air circulated by mechanical ventilator, takes place when the cage is resting at the pit top. Such types of airlocks are therefore avoided.

The suitable airlock designs are :-

1) Standard type of air-lock at the top of a shaft enclosing part of the pit top. (In the simplest form)

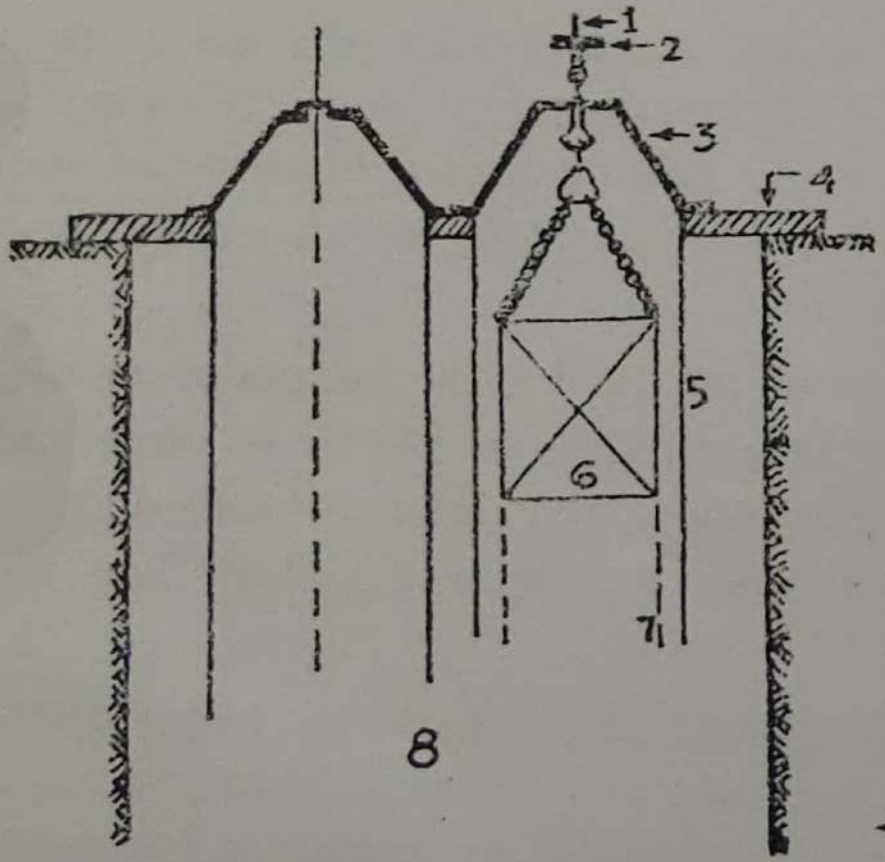
2) Guillotine type of doors which are provided in a vertical steel box fitted within the headgear.

3) German type of a airlock which forms an airlock inside the shaft.

The German type air-lock below ~~bottom~~ banking level.

German type air-lock :-

⇒ Compared to the other air locks the German type air-lock is not constructed above the banking but below it.



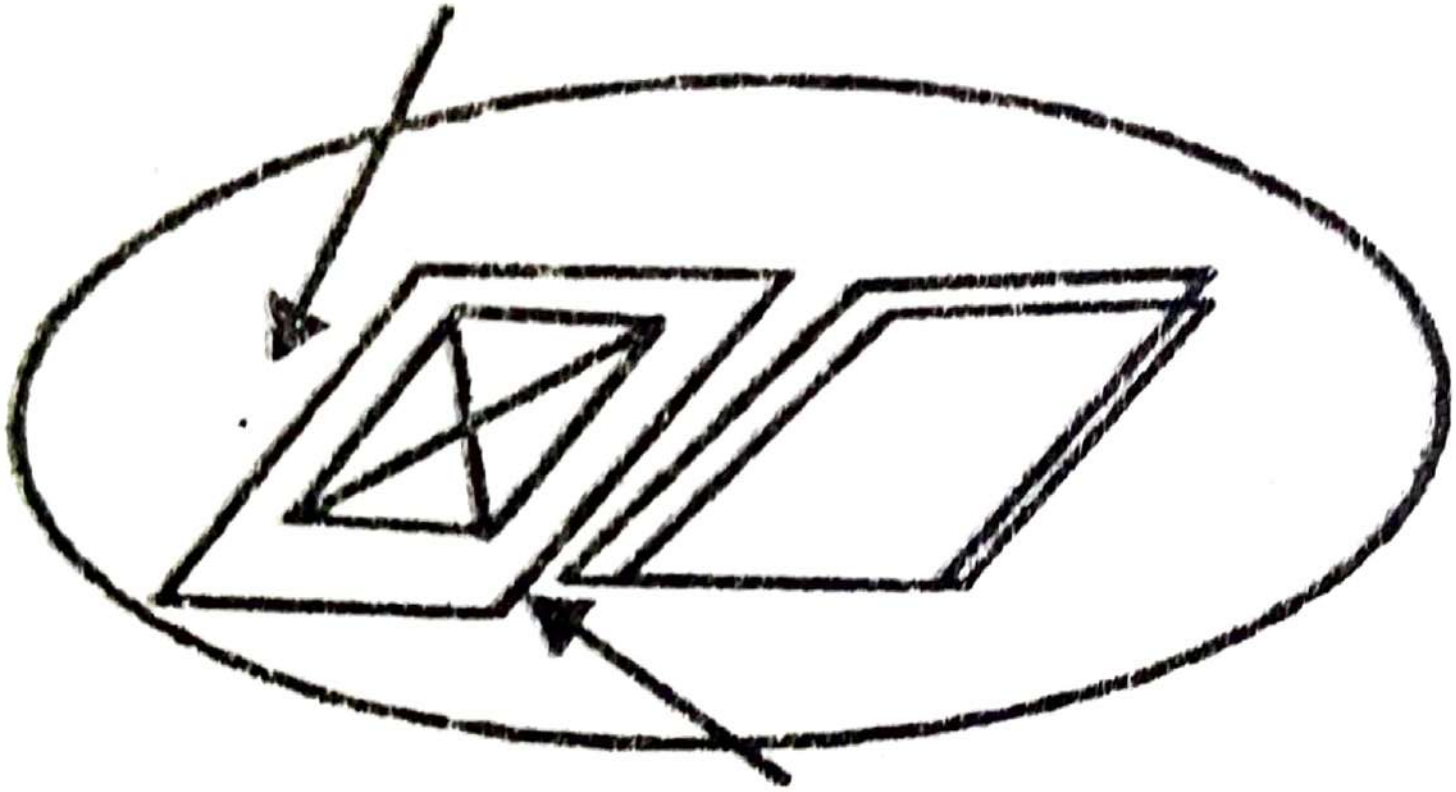
←*German Type Air-lock*

1. Winding Rope
2. Circular lid
3. Box Door
4. Deck
5. Sheet metal box
6. Cage
7. Apron
8. Shaft.

3) The pit top is completely covered with Steel joists & thick wooden planks except for two rectangular openings for passage of the cages

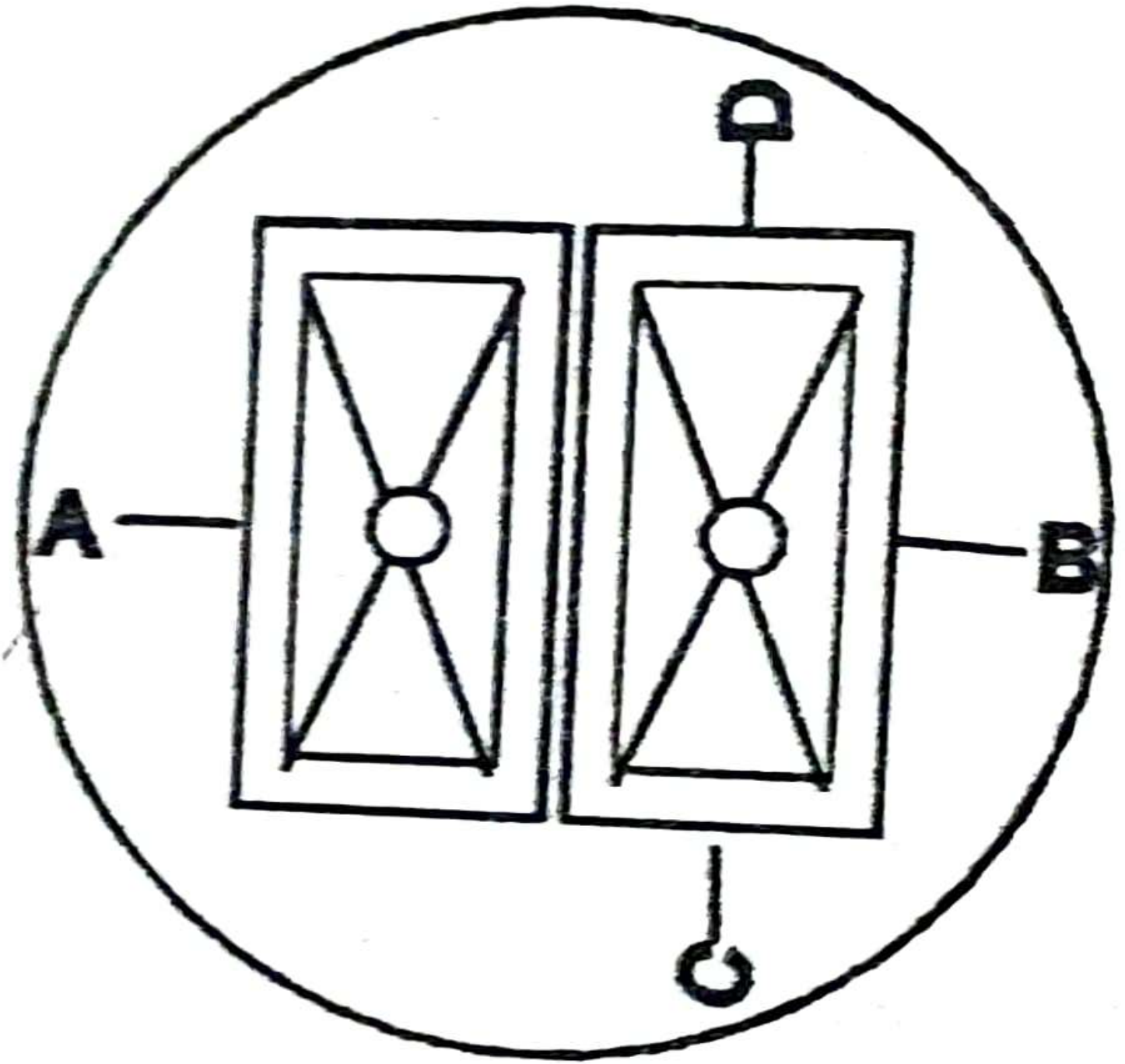
→ In these openings two hollow boxes of M.S. plates, open at the top & bottom, are suspended rigidly from the shaft top & their length is equal to the height of the ~~cages~~. cages.

WOODEN COVER
WITH RUBBER LINING
ALL ROUND SHAFT

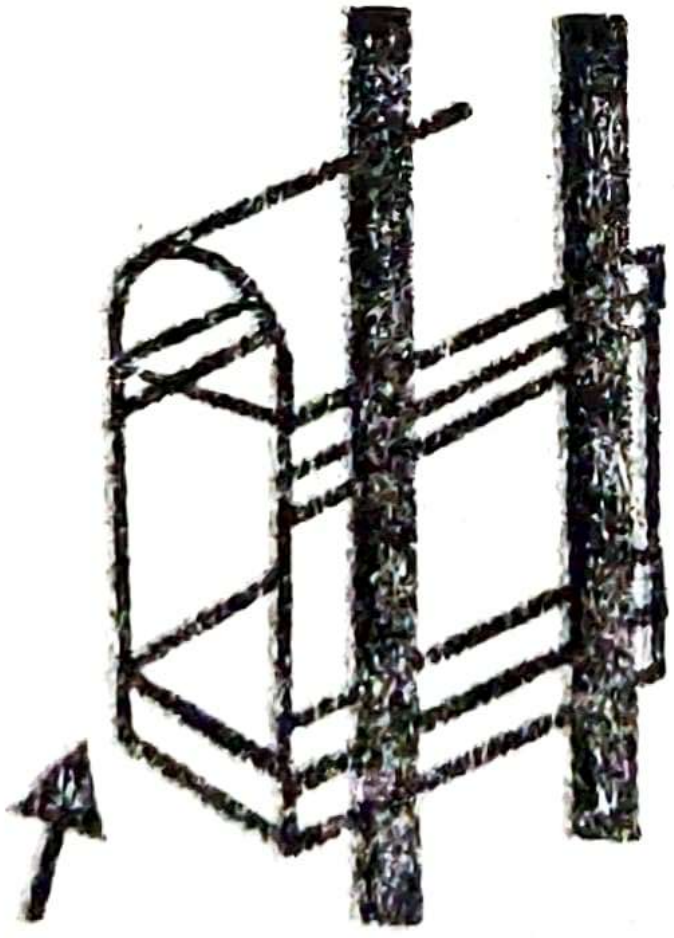


WOODEN BLOCKS TO
GUARD GUIDE ROPES

⇒ The pit top banking level is flush with the pit top covering & the space between the shaft walls & pit top wooden covering is closed by rubber linings.


D
A
B
C

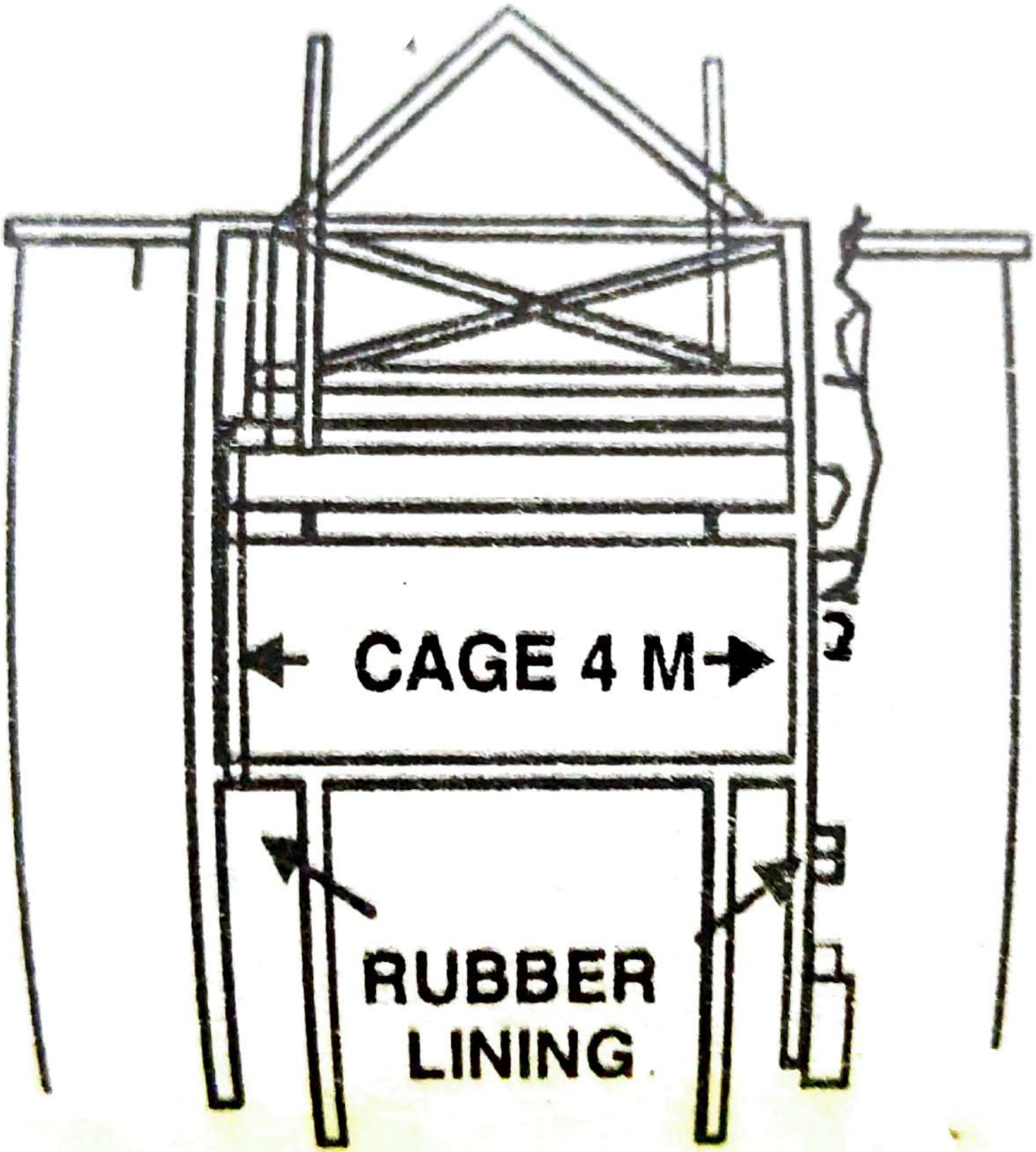
→ 4) The hollow steel boxes suspended from the pit top covering are also lined with rubber sheets throughout the length and also at the top & bottom openings.



RUBBER LINING

→ A trapezoid shaped covering of aluminium box rests on the pit top covering & has a small opening for the passage of safety hook.

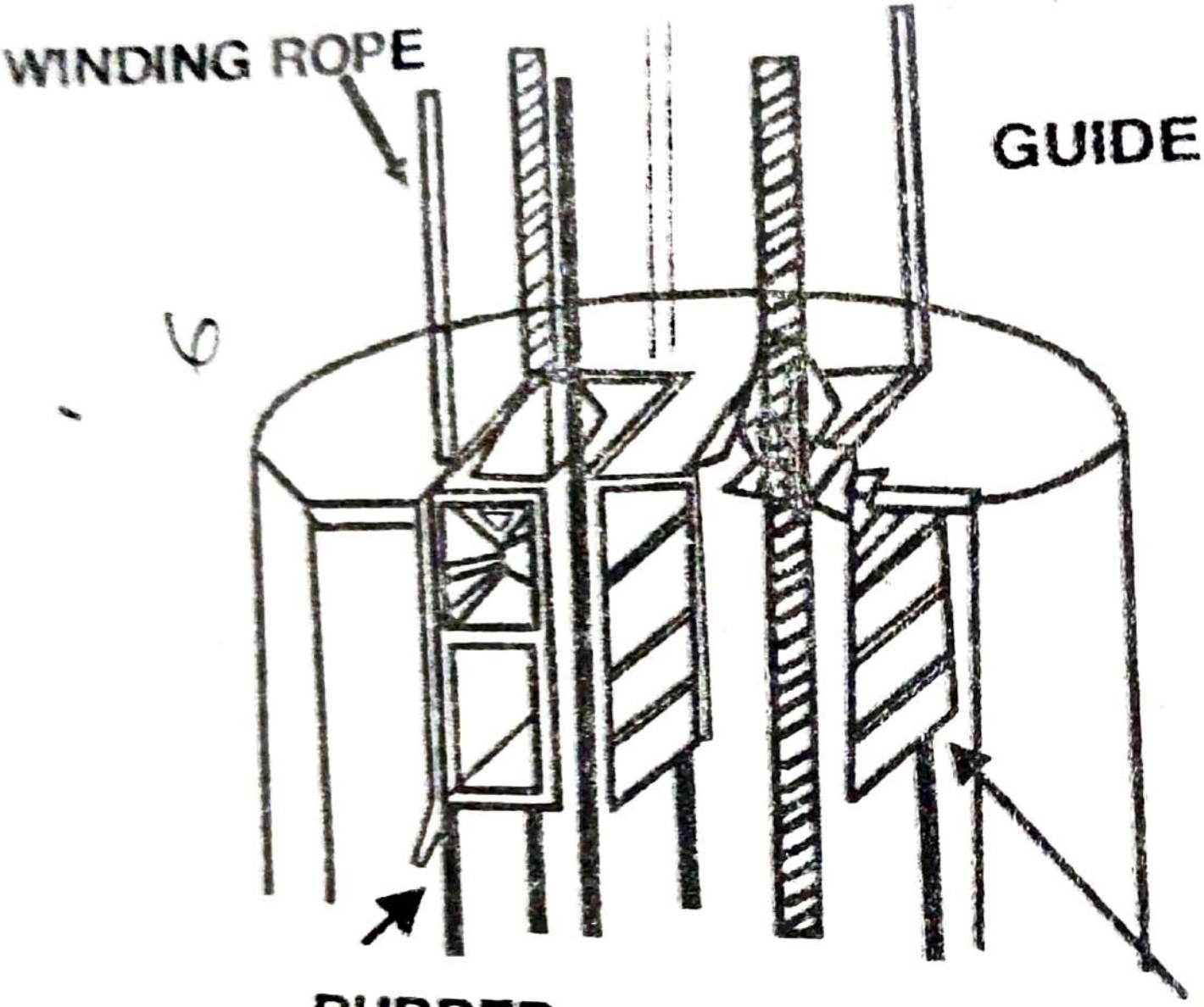
→ This trapezoid shaped aluminium box is lifted by the ascending cage.


CAGE 4 M
RUBBER
LINING

→ The smalling opening at the top of the trapezoidal aluminium body is covered by a separate wooden lid with a small hole for the winding rope.

→ When the ascending cages approaches the banking level the safety hook first lifts the wooden lid & then trapezoidal box is lifted.

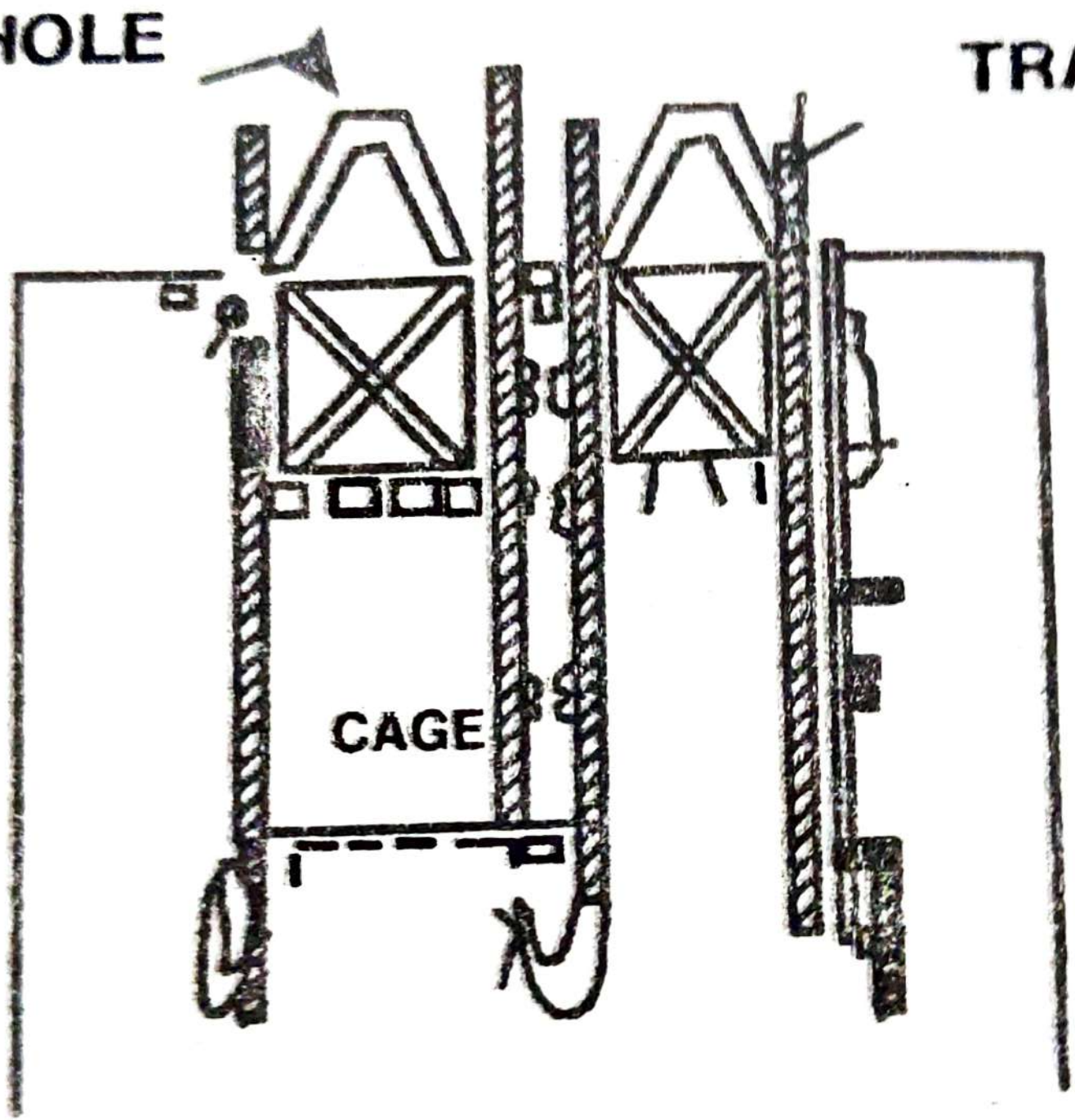
⇒ Note that, when the trapezoidal box is lifted, the ~~cage~~ ascending cage has already entered between the hollow boxes of M.S. plates, so that the air can't be leaked from the space between cage & shaft openings.



ISOMETRIC VIEW

7→ The space of guide ropes between adjacent cage is also covered with a wooden frame lined with rubber-sheets and small openings are provided in the frame for the requirement of guide rope shoes as the cage moves up & down.

→ The rubber linings at various openings prevent leakage of air.



SECTION ON A- B

Fan Laws

The following laws are applicable on a mine of constant resistance (or equivalent resistance).

→ Any fan working on a mine of constant resistance

→ Mainly for centrifugal fans with radial blades for practical purposes.

→ Fans with blades curved backward or forward.

→ Also applicable to Air-screw fan.

The laws relating to Quantity, pressure & power in relation to the fan speed are

1st law :- For a given mine resistance

$$Q \propto N \text{ or } V.$$

2nd law :- The effective ventilating pressure developed by a fan, $\text{Water gauge} \propto N^2 \text{ or } V^2 \text{ or } Q^2$

3rd law :- The power required to drive a fan

$$H.P \propto N^3 \text{ or } V^3 \text{ or } Q^3$$

Where Q = Quantity of air in m^3/sec

N = Revolution of fan per minute (RPM)

V = Peripheral speed of blade tips in m/sec.

Fan Efficiency :-

✓ Fan efficiency = $\frac{\text{H.P. of ventilation or Air H.P.}}{\text{Fan shaft H.P.}}$

If the fan is direct driven, the output of the motor or engine may be accepted as the fan-shaft H.P.

✓ Overall mechanical efficiency

= $\frac{\text{H.P of Ventilation or Air H.P.}}{\text{H.P. input to engine or motor.}}$

Reversal of Air current :-

(As per regulation 131(4), CMR, 1957)

The current of air can be reversed when necessary.

Reversal of air-flow can be considered in the case of fire occureing.

a) In the downcast shaft.

b) In intake airway or loco-shed near d.c. shaft

c) On the surface of the mine close to the D.C. shaft

d) For fire damp or coal dust explosion near D.C. shaft.

e) For clearing off sealed district.

Axial-Flow fan reversal arrangement

→ It is obtained by reversing the direction of rotation of the fan.

→ The volume of air flowing in reversal is reduced due to its design.

→ If necessary, the fan may be fitted with reversal doors just like a centrifugal fan.

→ The direction of rotation of the fan can be reversed by reversing the belt drive or ropes using a reversing switch.

→ A common practice is to interchange the leads (+/-ve) either at the motor terminal box or in the starting unit.

→ The position of the controlling lever, corresponding to the forward & reverse direction of rotation of fan should be marked on the Reversing switch.

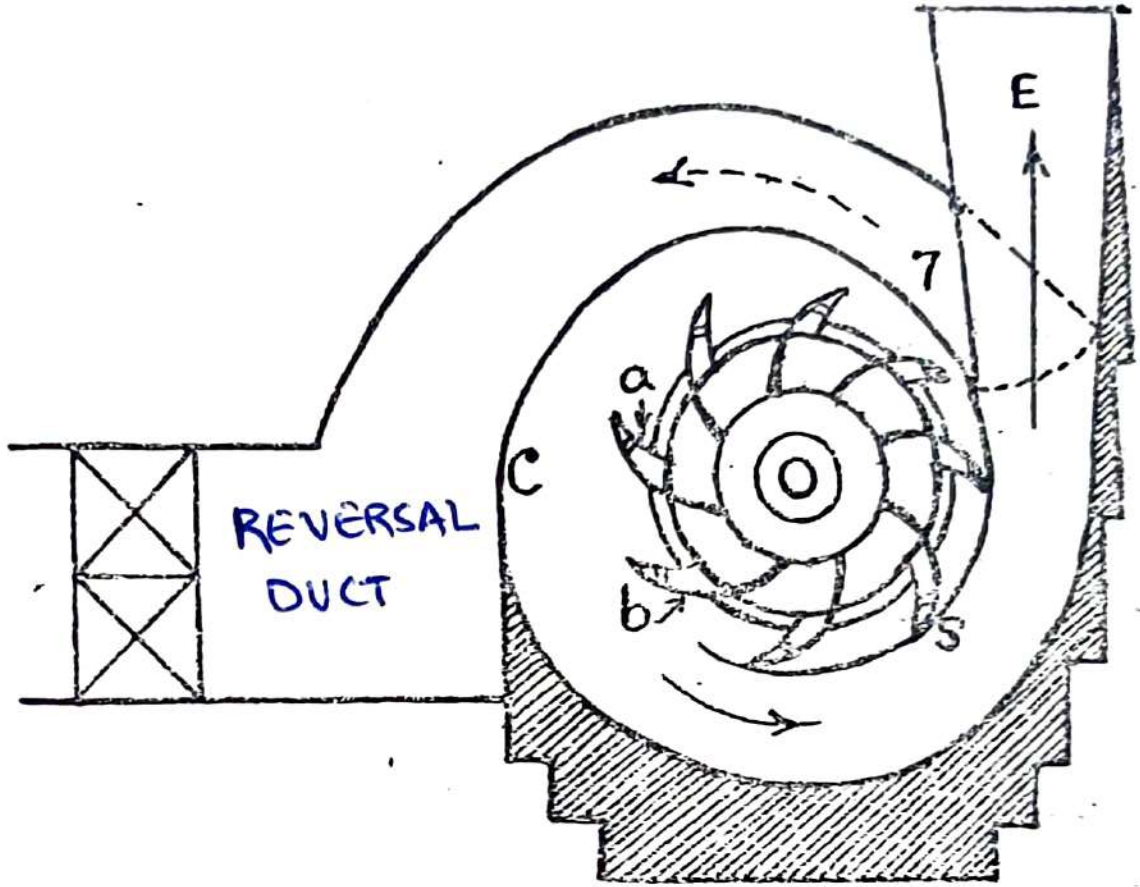
→ The reversing switch should be kept under lock & the key in the custody of the authorised fan attendant.

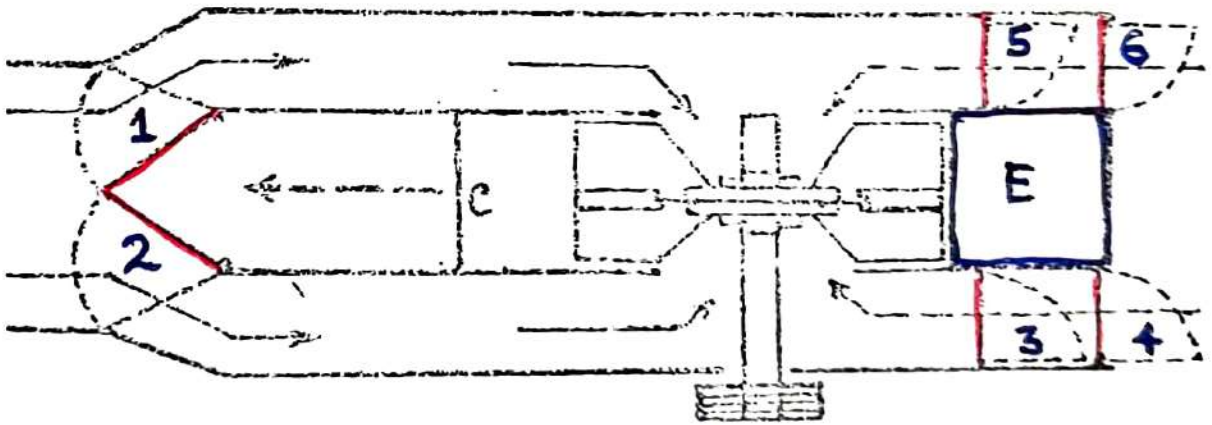
Centrifugal fan Reversal arrangement :-

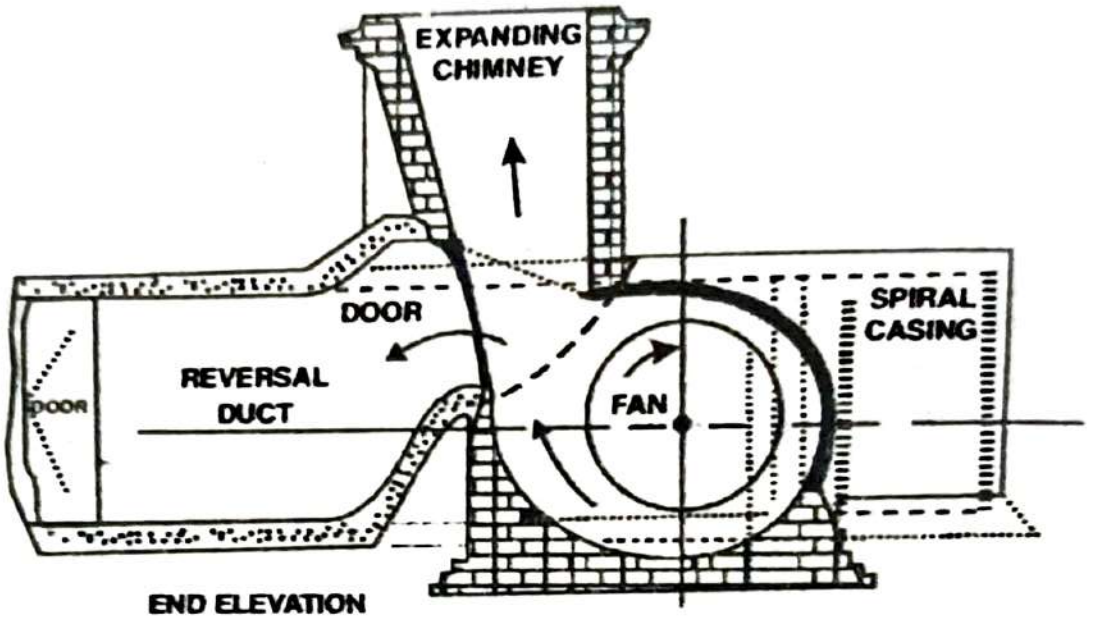
In centrifugal fans reversal of the direction of rotation does n't affect the direction of airflow. (Always rotates towards evasee)

→ So special arrangements are made by using dampers or doors to reverse the direction of air from or to the shaft.

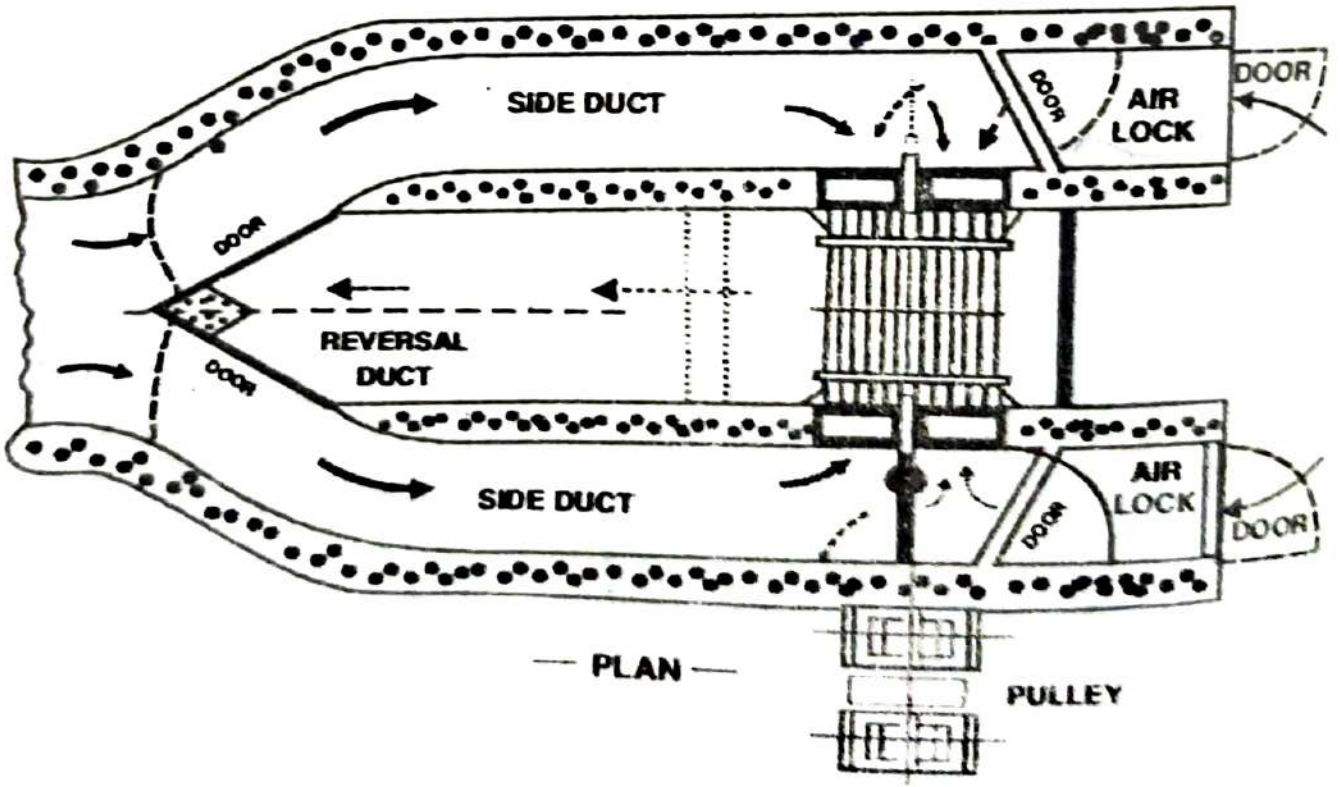
a = Steel arms
b = Curved blades
C = Spiral casing
E = Expanding chimney
S = Shutter
1–7 = Doors







END ELEVATION



DRIFT

— PLAN —

PULLEY

→ The door arrangement ⑦ cut off the discharge of air to the atmosphere by a shutter placed across the base of the fan chimney (evasee)

Exhausting:-

→ Under normal conditions the air from the upcast shaft (↑) splits to the two side ducts ① & ② shown by firm arrows (→), when all the seven doors occupy the position shown by the firm lines.

→ Air then passes through the fan & is discharged via the chimney.

→ Two doors ① & ② are pivoted at the end of the walls forming the side ducts & normally meet, so closing the reversal duct.

→ Behind the fan, shutting off each inlet from the open air (atmosphere) are two pair of doors ③ ④ ⑤ ⑥ normally kept closed and forming two air-locks.

→ One side of the expanding chimney is also fitted with a door ⑦ which hangs vertically.

Reversing to Forcing:-

→ To reverse the air (forcing fan), the fan is stopped & the doors are placed as shown dotted. (- - - - →)

→ The air enters the fan drift through the two pair of open doors ③ ④ ⑤ ⑥ at the air locks.

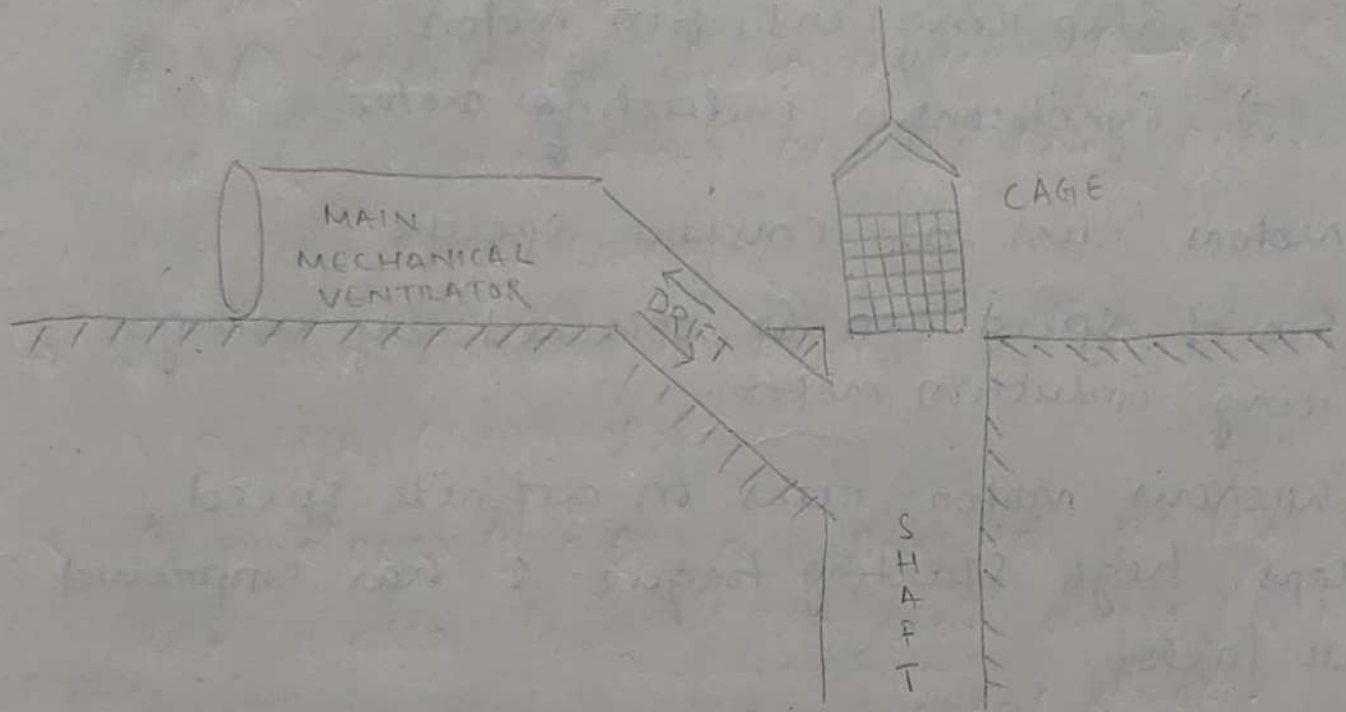
→ The shutter ⑦ placed across the base of the evasee is kept closed.

→ Air then passes along this reversal duct through the open doors at the end forming D.C. shaft.

Fan drift :-

→ The short tunnel connecting the U.C / D.C shaft with exhaust / forcing fan.

→ It is the airway leading from a mine shaft or airway to a fan.



Fan Drives :-

Along with general requirements of electricity for all purposes at mines, it is also required for driving of fans as main mechanical ventilators.

→ Two common types of electric motors are used for driving fans
  → Slip-ring induction motor
  → Synchronous induction motor.

→ Both motors runs at constant speed.

→ Reduction of speed can be obtained by using slip-ring induction motor.

→ Synchronous motor runs on definite speed, develops high starting torque & has improved power factor.

→ With A.C. supply synchronous induction motor is preferred for large fans.

→ Centrifugal fans & large diameter axial-flow fans are driven speeds varying from 300 to 600 RPM. Small axial flow fans at 1500 RPM.

→ High speed fans are coupled directly to the motor.

→ Low speed motors are costly, so high speed motors are used with some form of reduction gearing → totally enclosed helical gearing
  → Vee-rope drive
  → Ordinary cotton rope drive.
  → belt drive

→ Rope & belt drives = more flexible & less efficiency (90%)
Gear drives = high efficiency (95%)

→ A duplicate standby main mine fan driving motor is provided so that adequate ventilation may be provided in the event of any breakdown.

Evasee :-

It is a chimney which provides a gradually increasing area to the air discharged from the fan.

→ The best angle for expanding chimney in all directions is 7° & for an evasee expanding on one side only is 11°.

→ Height of the expanding chimney
$= 8\sqrt{A}$ } A is the casing area.

→ Cross-sectional area of expanding chimney is 3 to 4 times the area of fan casing.

→ In case of forcing fan the evasee is called a diffuser.

→ Evasee reduces the final velocity of discharged air by a passage of gradual increasing cross-sectional area.

→ By reducing the velocity in the evasee, some of kinetic energy is converted into pressure energy within the chimney which improves mechanical efficiency.

→ It eliminates turbulance, promotes smooth air flow, prevents re-circulation of air from atmosphere. ← (Advantages)

→ It lowers the W.g. required, improves mechanical efficiency.

Characteristic Curve :-

A characteristic curve is a curve which shows how the magnitude of one quantity varies with the change in some other related quantity. It shows the variation in

pressure → The fan-draft W.g.

power → The B.H.P. developed by the driving motor

volume of air → The mechanical efficiency of the fan on a basis of volumes.

Mine Characteristic :-

→ The curve shows the pressure - quantity relationship.

→ It indicate the quantity of air passes through the mine for a given pressure.

→ The curve is the equation $P = RQ^2$ where 'R' is the resistance of the mine.

Operating point :-

→ It is the point of intersection of mine characteristic curve with the pressure-volume (fan characteristic) curve, plotted to the same scale.

→ The intersection point is the operating point which determines the pressure & volume for which the fan would be mechanically suited.

Uses of Characteristic curve :-

1) To asses the efficiency of a fan.
2) To compare two or more fans.

3) To chose the most efficient fan for a given mine resistance.

4) To anticipate changes in performance of a fan when the resistance of the mine is changed.

5) To chose a prime-mover (motor) of suitable H.P. (power) & type. (slip-ring / synchronous)

6) To detect leakage through air locks.

7) To know the performance of a combination of fan in series or in parallel.

08.

DETERMINATION OF FAN CHARACTERISTIC CURVE.

AIM OF THE EXPERIMENT:

DETERMINATION OF FAN CHARACTERISTIC CURVE.

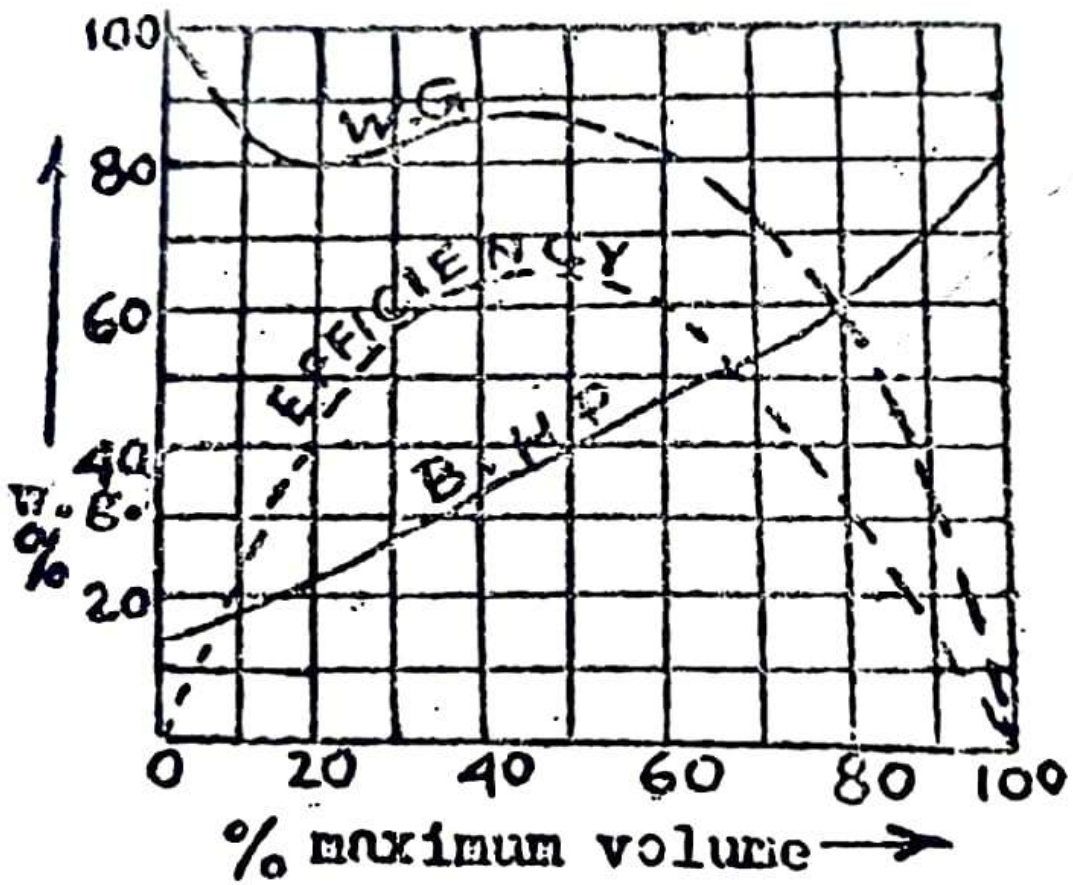
THEORY:

A "CHARACTERISTIC CURVE" IS A CURVE WHICH SHOW HOW THE MAGNITUDE OF ONE QUANTITY VARIES WITH THE CHANGES IN SOME OTHER RELATED QUANTITY. IT SHOWS THE VARIATION IN

[i] THE FAN DRIFT W.G.,
[ii] THE B.H.P. DEVELOPED BY THE DRIVING MOTOR
[iii] THE MECHANICAL EFFECIENCY OF THE FAN, ON THE BASIS OF VOLUMES .

THE FIGURES SHOW THE CHARACTERISRIC CURVES OF DIFFERENT TYPES OF FAN.

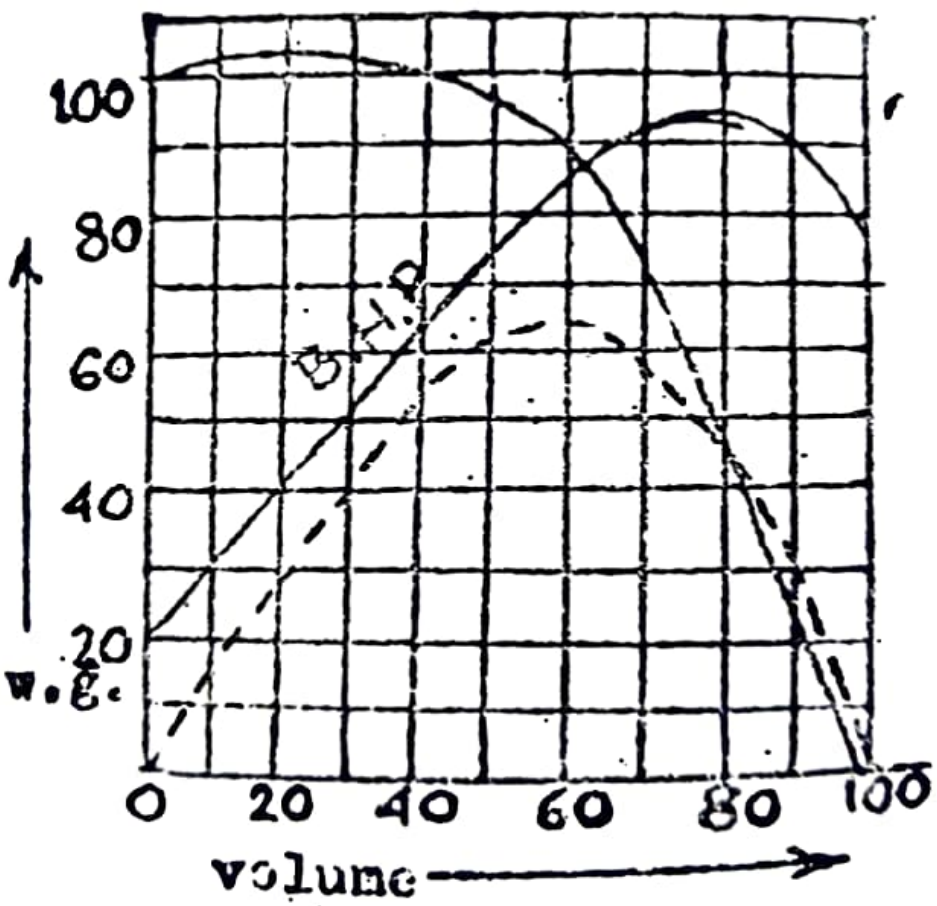
[i] FORWARD BLADED CENTRIFUGAL FAN:



Forward-Bladed

- THE PRESSURE OR VOLUME OR P-V CURVE, ALSO KNOWN AS W.G. CURVE AND "FAN CHARACTERISTIC", SHOWS THAT AFTER PRILIMINARY FALL AT LOW VOLUMES, THE W.G. REMAINS FAIRLY CONSTANT FOR AWIDE RANGE OF VOLUMES AND THEN FALL STEEPLY AS MAXIMUM VOLUME IS REACHED. THE WG. READING WOULD BE ZERO[0] WITH FAN WORKING ON OPEN AIR.
- THE POWER CHARACTERISTIC OR B.HP. CURVE OF THE FAN RISES STEADILY AT LOW VOLUMES BUT STEEPENS AT HIGH VOLUMES ,SO THAT IF FOR ANY REASON THE MINE RESISTANCE DEACREASES, I.E. IF THE VOLUME OF AIR INCREASES, THE MOTOR WILL BE OVERLOADED. HENCE, THE FAN IS UNSUITABLE WHEN THERE ARE CHANGES OF SUDDEN SHORT CIRCUITING OR SUDDEN CHANGES IN THE MINE RESISTANCE.
- THE MAXIMUN EFFECIENCY OF A FORWARD BLADED FAN IS ONLY ABOUT 72%, AND THIS OCCURS AT A CERTAIN POINT WHEN THE FAN IS OPERATING ON A FLAT PORTION OF W.G. CURVE. IT FOLLOWS THE SMALL CHANGES IN THE W.G. WILL CAUSE QUITE LARGE VARIATIONS IN VOLUME, POWER AND EFFECIENCY, A CONDITION WHICH IS UNDESIRABLE.

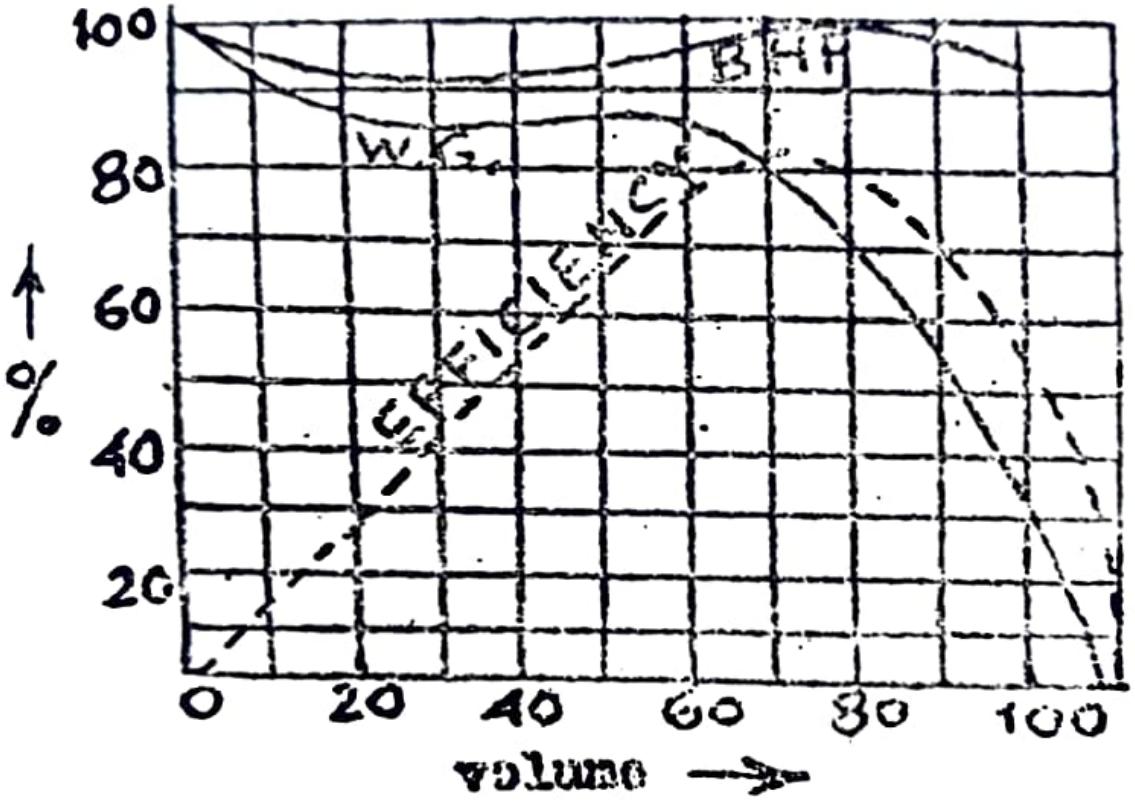
[ii] BACKWARD BLADED CENTRIFUGAL FAN:



Backward-Bladed

- A SET OF CURVES FOR A MODERN AEROFOIL BLADED CENTRIFUGAL IS SHOWN IN THE FIG.
- THW W.G. CURVES FALLS FAIRLY STEADILY FORM A MAXIMUM PRESSURE AT LOW VOLUME AT AND TO ZERO AT MAXIMUM VOLUME. THE FAN IS WORKING ON STEEPLY FALING PART OF THE W.G, CURVE AND CONSIDERABLE VARIATIONS IN PRESSURE WILL CAUSE COMPARATIVELY SMALL CHANGES IN THE VOLUME AND POWER AND SMALL REDUCTION IN EFFECIENCY.
- THE B.H.P CURVE IS ALMOST A RISING STRAIGHT LINE PASSING ABOVE THE ORIGIN TENDING TO FLATTEN AND THEN FALLING AS THE VOLUME INCREASES. IT SHOWS THAT POWER INCREASES WITH INCREASE OF VOLUME BUT AS THE MAXIMUM VOLUME IS APPROACHED, POWER BECOMES ALMOST CONSTANT AND THEN DECREASES. THUS, IT INDICATES THE "NON-OVERLOADING CHARACTERISTIC" OF THE FAN.
- THE EFFECIENCY CURVE SHOWS THAT THE MAXIMUM EFFECIENCY IS 85% IN THIS CASE, THE CURVE IS REASONABLE FLAT TOPPED AND A HIGH EFFECIENCY [SAY 80%] IS MAINTAINEDWITH VOLUMES OVER A WIDE RANGE. THE FAN IS THEREFORE SUITABLE TO A MINE IN WHICH THE RESISTANCE VARIES OVER A CONSIDERABLE WIDE RANGE.

[iii] FIXED-PITCH AXIAL-FLOW FAN:



Axial-Flow

- THE W.G. CURVE SHOWS THE MAXIMUM W.G. IS DEVELOEPED AT ZERO VOLUME, THERE AFTER FALLING A CONSIDERABLY AND RISING AGAIN, SUBSIQUENTLY FALLING RAPIDLY TO THE ZERO IN OPEN AIR WHEN THE VOLUME IS MAXIMUM WITH MINIMUM MINE RESISTANCE. TO LEFT OF 50% VOLUME, THE FAN WILL OPERATE IN A THROTTLED AND STALLED CONDITION. THE BEST OPERATING RANGE OF THE FAN LIES TO THE RIGHT WHERE THE FLOW CONDITIONS ARE STABLE. THE OPERATING POINT OF THE FAN AT MAXIMUM EFFECIENCY LIES ON THE STEEPLY FALLING PART OF THE CURVE.
- THE B.H.P. CURVE SHOWS THE MAXIMUM POWER IS DEVELOPED AT THE MAXIMUM EFFECIENCY AND DROPS ON EITHER SIDE. THE FAN IS THEREFORE SAID TO HAVE A NON-OVERLOADING CHARACTERISTIC.
- THE EFFECIENCY CURVE SHOWS THAT THE MAXIMUM EFFECIENCY IS 82% BUT A HIGH EFFECIENCY IS MAINTAINED OVER A LIMITED RANGE OF VOLUMES. AXIAL FLOW FANS FITTED WITH VARIABLE PITCH BLADES GREATLY EXTENDS THE RANGE OF DUTY OVER WHICH A HIGH EFFECIENCY IS MAINTAINED.

CONCLUSION:

DIFFERENT TYPES OF "FAN CHARACTERISTIC CURVE" ARE STUDIED.

Booster Fan :-

→ This is the mine fan commonly used inside the mines or ventilating district to improve the quantity of air circulated by the main surface fan.

→ A booster fan is a more or less permanent installations designed to pass the whole of the air circulating in the district or district concerned.

Booster fan is used, when the desired quantity of air flow in the district can not be achieved economically either by

- → putting up a regulator in neighbouring split.
- → By enlarging the airway.
- → Increasing the speed of the fan.
- → By installing new mine fan with higher speed.

→ Booster fans are driven by flameproof squirrel-cage a.c. electric motors at speed 200 to 300 rpm for largest sizes & 2000 to 3000 rpm for smallest sizes.

→ Axi screw fans are generally suitable for its compactness, portability & non-overloading power characteristics.

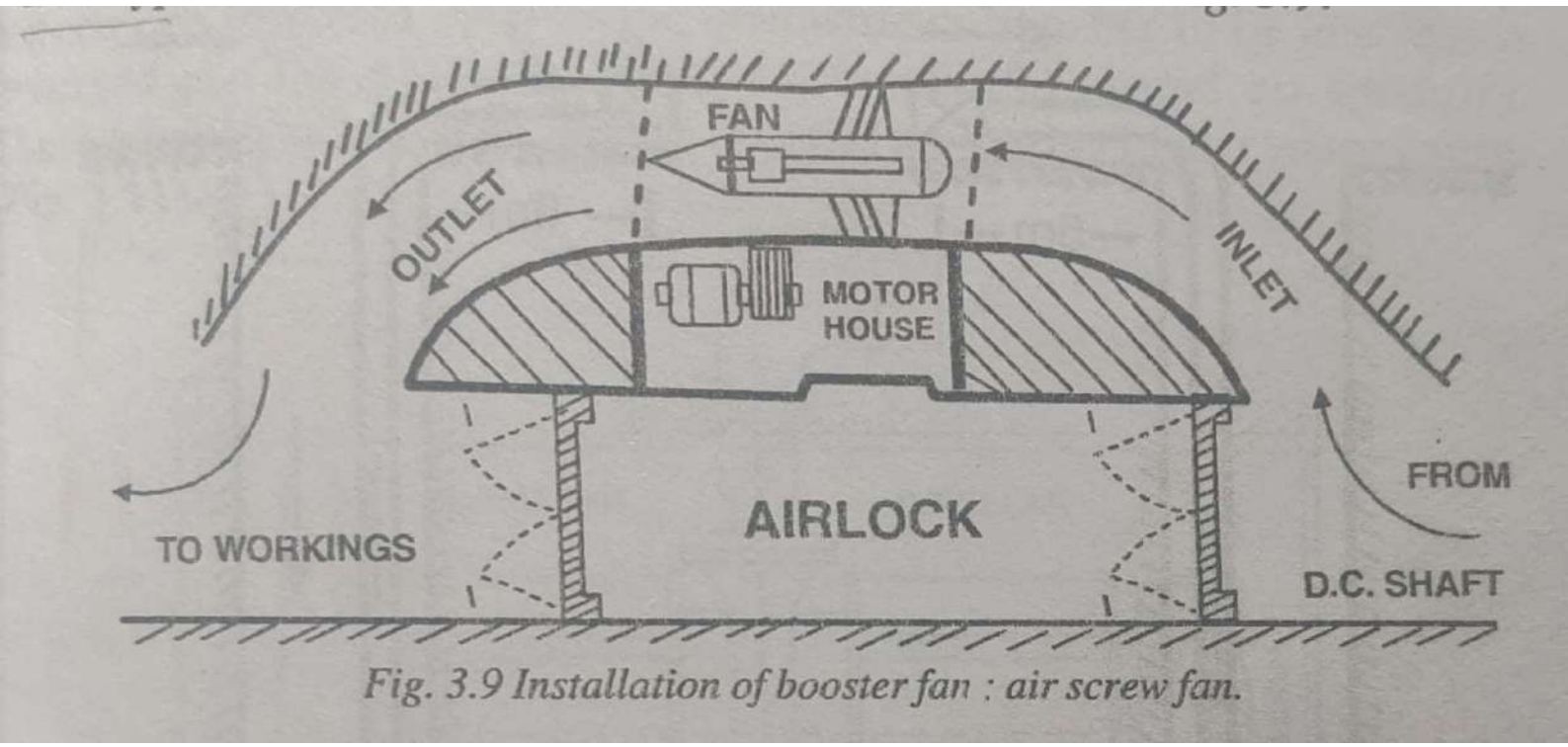


Fig. 3.9 Installation of booster fan : air screw fan.

→ A booster fan may be placed in the return to act as an exhaust fan or it may be placed in the intake to act as a forcing fan in a district.

→ Booster fan are used to force the air into a split of higher resistance, without disturbing the ventilation of other splits. This increases the quantity of air in the split.

→ The axial flow fan placed in the by-pass of an intake air way is shown in the figure.

→ It is a forcing fan in this case.

→ If the fan is installed in the by-pass of an return airway, it is act as exhaust fan.

→ A door provides access to the motor house.

→ Air lock provides for passage of men & materials.

→ A haulage track may be equipped for passage of materials.

→ A small size axial flow fan up to 0.5m dia. fitted with a direct driving motor can be mounted for ventilating a long split.

Location of Booster fan :-

The location of the booster fan should be such that, there is no pressure drop between the intake & the return. Such position is known as the neutral line.

→ Other practical considerations such as - nature of ground, the conditions of packs, & problems of transport are to be considered.

→ The fan should be in settled ground with proper airtight & fireproof lining on each side.

→ It should be preferably near the neutral line, but any position between the neutral line & outbye end of the split will be safe.

Purpose of Booster fan :-

1) To increase the quantity of air in one or more districts of higher resistance far inbye.
2) To improve the working conditions in deep, hot mines by speeding up the air & increasing its cooling power.
3) To reduce the excessive leakage between intakes & return.
4) To reduce or adjust the pressure-difference between intakes & returns in mines liable to spontaneous heating.
5) To ventilate long headings or stone drifts, those are far away from normal ventilating current.
6) Clearing off the dust produced by roof fall.

Disadvantages of Booster fan :-

1) Recirculation of air results in dagerous accumulation of inflammable gas.
2) Pressure produced by booster fan results in heavy leakage of air leads to spontaneous combustion.
3) Installation & maintenance of booster fan is not as good as surface fan.
4) In case of fire or explosion, the fan itself may get damaged.

Auxiliary Ventilation :-

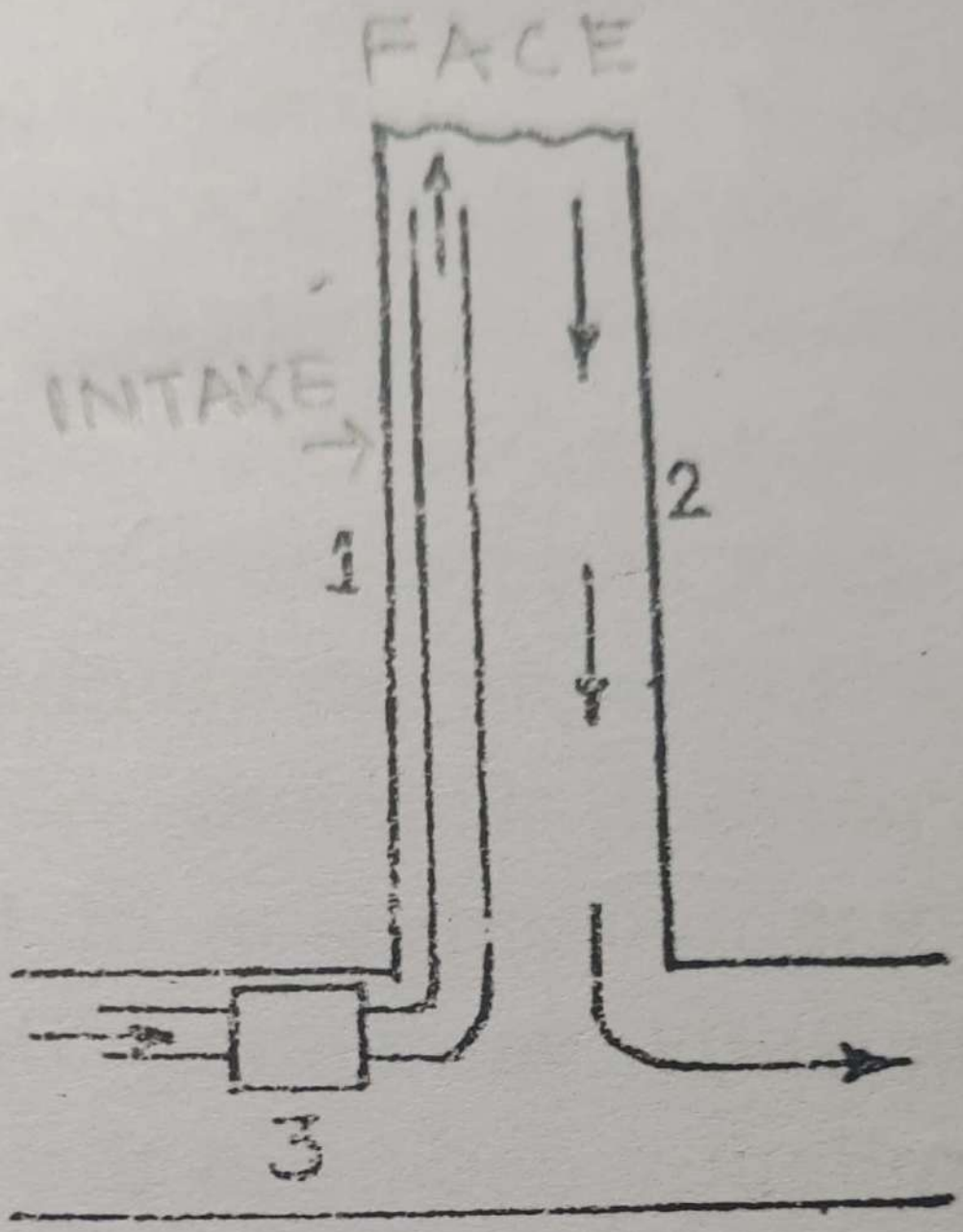
Auxiliary ventilation is used belowground Mainly for -

→ The ventilation of development headings
→ Narrow workings in coal &
→ Stone drifts, which are far away from normal ventilating current.
→ Blocked roadways due to collapse of the roof.
→ Ventilation of long drivages of coal
→ Ventilation of gassy mines.

→ Axial flow fans are preferred rather than centrifugal fan as auxiliary ventilators.
→ It should be so installed that, there is no possibility of recirculation of ventilation.
→ The quantity of air taken by the auxiliary fan should not exceed 1/3rd of the quantity in the air current from which the fan takes its supply.
→ The site/location of the installation is sufficiently outside the the actual heading intended to ventilate.
→ A forcing fan therefore should be placed on the intake side & exhaust fan on return side of the drift/heading it has to ventilate & the minimum distance between the fan & the corner of drift/heading to be ventilated should ~~be~~ be 5 meter.

Four systems of auxiliary ventilations are used

1) Forcing or blowing system
2) Exhaust system
3) combined or overlap system
4) Reversible System.



Forcing System

1. Air tube
2. Heading
3. Forcing Fan

Forcing or Blowing System :-

→ The air is forced inside a duct of the air tube to the face of the heading.

→ As the air travels inside the air tube, it is therefore can not pick up moisture or dust on its journey to the face.

→ The air arrived in clean & dry condition to the face.

→ This ventilation is used for wet-heading with high rock temprature.

→ The high speed air jet leaving from the duct of the air tube thus removes dust, noxious gases & fumes from explosives blasting.

Disadvantages :-

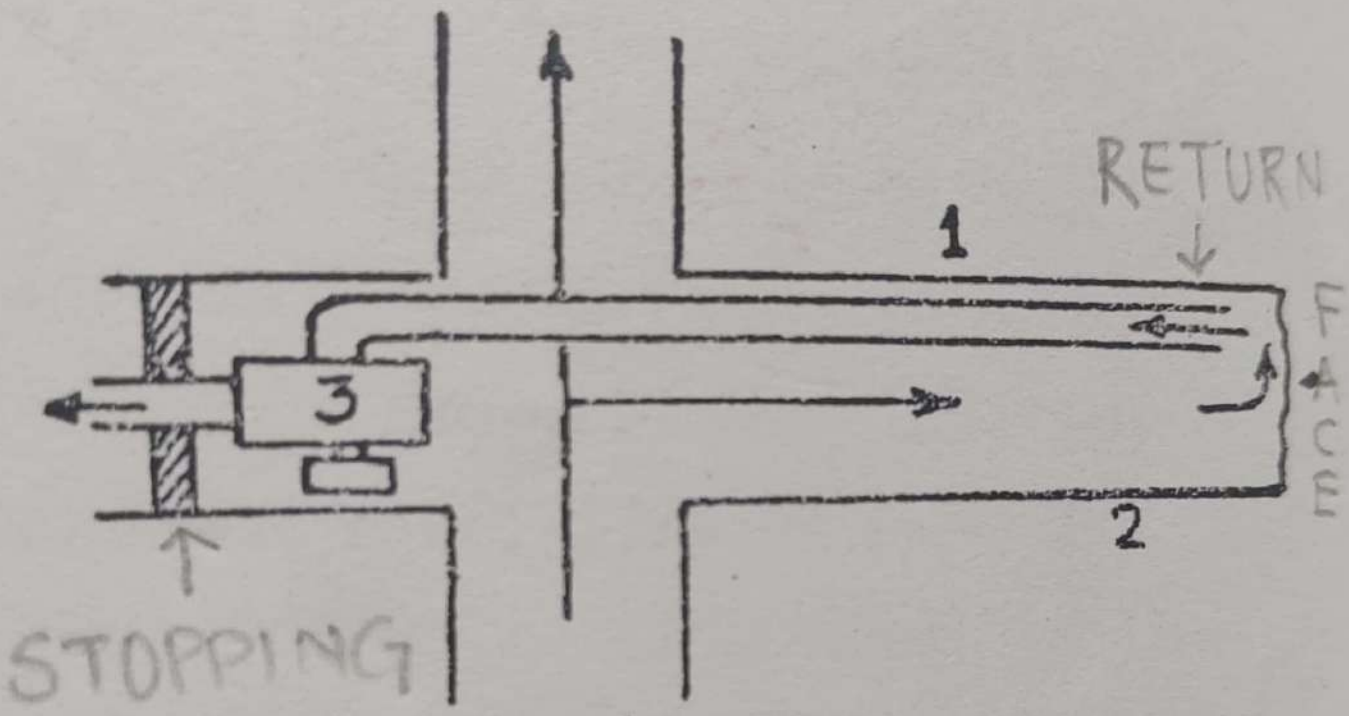
→ It causes serious discomfort to the workmen at heading face.

→ The dust & fumes from shotfiring passes very slowly out of the heading.

→ It may take some hours to clear off the dust & fumes in long headings.

Advantages :-

→ Fan electric motor can safely be mounted in the airstream, & and this results in compact fan unit, which require small space for installation.



Exhausting System

1. Air tube
2. Heading
3. Exhaust Fan

Exhaust system :-

→ The heading is used as intake & air-tube ducts as return.

→ The fan is placed in the intake & the air is delivered into the return through a stopping.

→ An electric motor is used for driving the fan.

Advantages :-

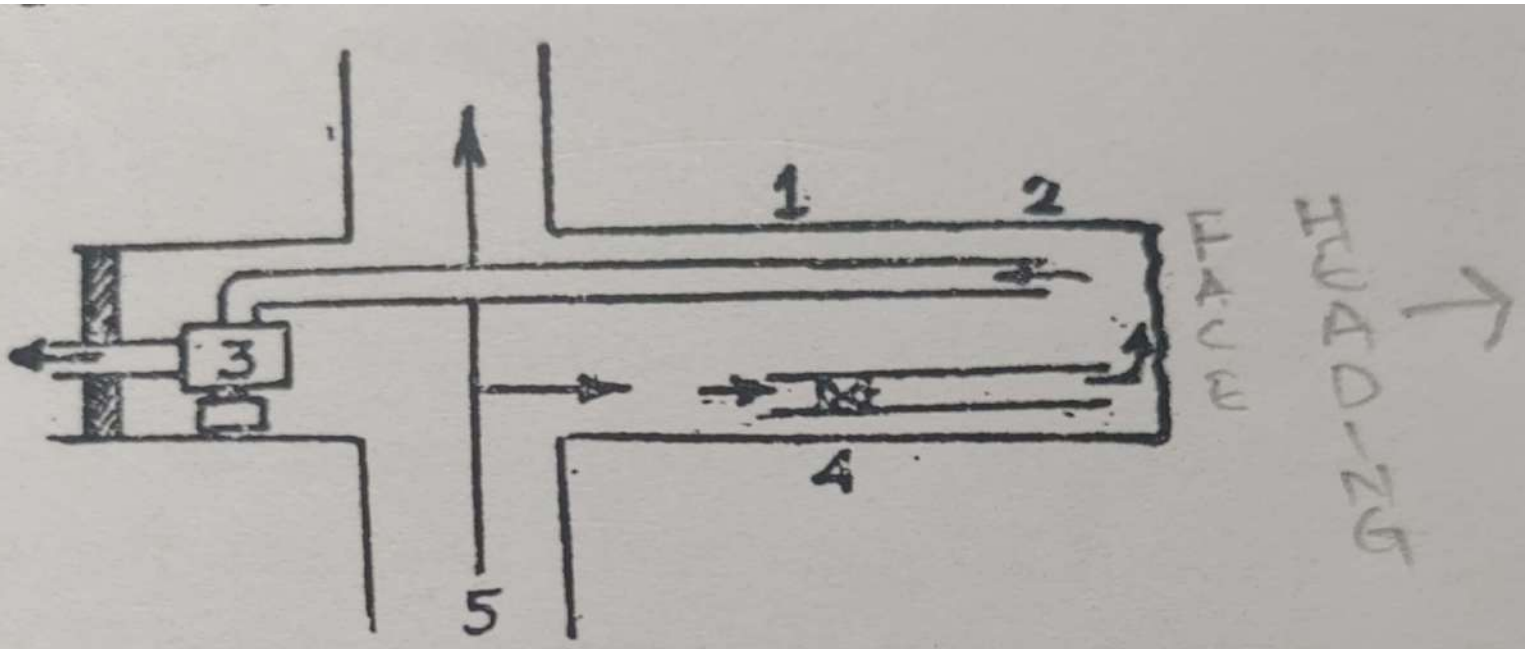
→ The firedamp, dust & blasting fumes at the face are drawn direct into the ducts & the heading is kept clear for persons working & travelling therein.

Disadvantages

→ The face of the heading is quite unventilated unless the end of the air-tube duct is very near to the face.

→ It results in high dust concentration at the face of the heading.

→ In this exhaust system the ingoing air picks up heat & moisture, hence the air arriving at the face will be warm & humid.



Overlap System

1. Exhaust tube
2. Heading
3. Exhaust Fan
4. Blower
5. Intake air

Overlap system :-

→ In this system both exhaust fan for return & blowers for intake is used.

→ In order to prevent recirculation of air, this auxiliary fan should be located at least 4-5 m outby end of the end of suction duct.

→ 50 % of the airflow given by the blower is exhausted by the exhaust fan.

→ This system have a advantages of both forcing & exhaust system.

Disadvantages :-

→ Two ducts to maintain & extend. (forcing & exhaust)

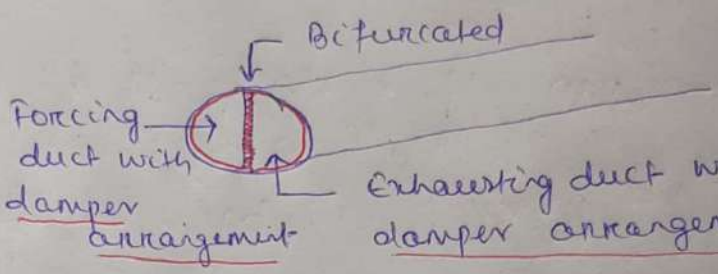
→ If the exhaust fan stops, a dangerous concentration of firedamp may buildup at the face of gassy mines.

→ An interlocking power supply to the two fans is required to stop the fans simultaneously.

Reversible System :-

→ This system is used for the ventilation of sinking shafts.

→



→ Single duct having means of reversing or exhausting the airflow by reversing the direction of rotation of impeller in case of axial-flow fan.

→ In case of radial-flow fan, a bifurcated duct at the outlet to enable the direction of airflow as required.

→ Damper arrangement is also there at the bifurcated ducts to control the airflow as required.

Ventilation Survey :-

A ventilation survey is carried out -

Purposes

- → To investigate the ventilation system of a mine
- → To find out adequacy (required amount) of ventilating air.
- → To find out the leakages spots & amount of leakage.
- → To find steps necessary for improvement of ventilatin system.

The investigatin is done in three ways.

1) Quantity surveying :- Measurement of the air velocity & Quantity of air flowing in various parts of the mine.

2) ~~Pressure surveying~~ →

Quantity of air passing per minute at a place is

$$Q = A \times V$$

Q = quantity of air
A = crossectional area of roadway
V = average velocity of air.

→ The instruments used for ventilatin survey are - Anemometer, velometer, pitot tube.

2) Pressure surveying :- The basic principle of pressure surveying is 'Bernoulli's Theorem'.

→ pressure survey can be carried out in two ways.

- → By calculating the total pressure at each point with aneroid barometer & calculating the pressure difference.
- → By using very sensitive inclined Manometer.

3) Qualitative surveying :-

This surveying involves determing firedamp at different strategic points in the mine by using Methanometer & flame safety lamp.

→ Chemical analysis of the air samples to maintain the standard of ventilation.

→ If the firedamp content in the general body of return air of ventilating district exceeds 0.75%. the ventilation is inadequate.

Pressure survey using Gauge & tube method :-

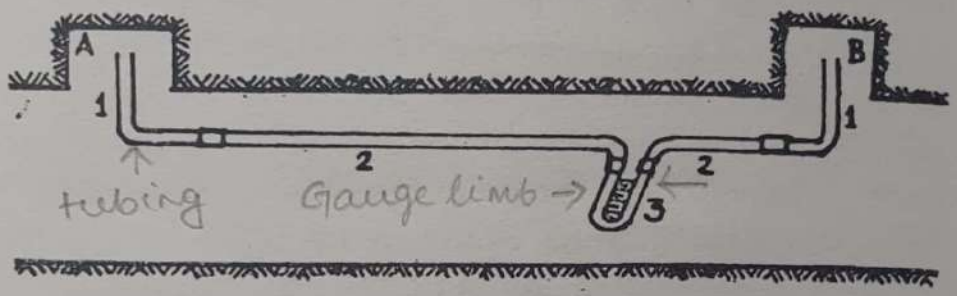
In this method the pressure difference between stations (A & B) are read directly from an inclined gauge or manometer (tube).

→ One limb is exposed to one point of observation (A) & other limb is open to the atmosphere of next station (B) through a rubber tube or hose pipe.

Equipments required :-

→ A sensitive inclined gauge or inclined manometer.
→ Tripod stand
→ Two flexible rubber hose pipe 12.5 mm dia 60 m to 100 m long each.
→ Two rubber tubing about 2 m long each.
→ Anemometer
→ whirling hygrometer
→ Stop watch, measuring tape, a copy of ventilation plan, measurement book etc.

1 = Light rubber tubing
2 = Hose pipe
3 = Inclined gauge



Procedure:

→ Select the stations (A & B) where pressure difference is to be measured.

→ Mark the points in the ventilation plan.

→ Measurement of cross-sectional area of each station.

→ Survey is started from bottom of D.C. shaft to the bottom of U.C. shaft.

→ The inclined gauge is clamped to the tripod stand & levelled.

→ Connection between the gauge limb & hose pipe by short rubber tubing.

→ A similar length of light tubing is attached to the open end of the hose pipe.

→ The inclined gauge is placed between adjacent stations.

→ The hose pipe ends are placed to face the air current at both ends & automatically take account the total pressure.

→ An average of six readings of instrument is taken & noted for calculation.

→ The instrument & tubes are taken forward & the procedure is repeated in all the stations.

→ Air velocity, quantity & wet & dry bulb temprature reading is also measured at each station.

→ All the readings are tabulated as follows.

1	2	3	4	5	6	7	8
Station	Length (m)	Air velocity m/s	Quantity m^3/s	Mean Gauge reading (mm)	Pressure difference mm of w.g	Velocity correction	Corrected Pressure drop mm of w.g
A - B							
B - C							
C - D							

Precautions

1) To ensure the hosepipe to be air tight.
2) Survey should be avoided during fluctuated atmospheric pressure.
3) Accurate leveling of the gauge.
4) Rubber tubes must be hooked to ensure reading of static pressure.
5) All fans & doors should be operational & undisturbed.
6) W.g readings to be taken at separation doors.

Pressure survey using Barometer :-

→ Aneroid barometer (precision type) are used in ventilation surveys.

→ A regular measurement of barometric pressure is done at pithtop near the entrance of the mine & reading is taken after each 15 minutes interval.

Equipments Required :-

1) Two barometers { i) At selected base station. ii) for use of travelling observer.
2) An anemometer
3) A whirling hygrometer
4) Measuring tape
5) Two watches { i) Base station ii) Travelling observer
6) A complete ventilation plan showing all details.

Procedure :-

1) Both the barometers are taken belowground a day before to adjust themselves into new pressure.
2) The observation stations established should be marked on the ventilation plan.
3) Pressure survey begins at the base station & two barometers are compared.
4) Relative humidity is measured at that station.
5) The observer takes the reading several times at the base station at regular intervals of 5 to 10 minutes.
6) The travelling observer proceed from station to station as marked on the plan. & taking observations of → Pressure, → Temprature, → Air-velocity } All these readings are properly recorded.
   → Cross-sectional area of each station.

7) The aneroids are compared with standard mercury barometer & if any correction needed is applied

8) It also calibrated at ~~deft~~ certain temprature, so it is corrected for different air temprature variation.

9) Correction is also applied to the value of acceleration due to gravity (g), atmospheric pressure, also difference in level between the stations.

10) The finally corrected pressure difference gives the pressure drop between two stations.

11) This method of pressure survey is recommended for large nets which have long length of roadways.

12) A high level of skill is required for the manupulation of the instruments & application of corrections, observed readings, estimation of time, & computation of result.

1	2		3	4		5	6		7		8	9	10	11	12
	Stn. Levels			Hygrometic Readings			Traverse Barometer mm		Correction for temp						
Stn.	Height below O. D.	Difference in level	Time	Dry Bulb	Wet Bulb	Reading of control barometer in mm	Actual	Corrected	Diff. in temp.	Correction mm of mercury	Correction for level mm of mercury	Correction for variation of atmosph. pressure in mm	Corrected readings of traverse barometer mm	Difference of pressure from pit bottom (mm)	Difference of pressure from pit bottom mm w. g.
A															
B															
C															
D															
.... X															

Pressure survey using Manometer :-

The sensitive inclined manometer (containing alcohol) are mostly used for measurement of fan pressure for determining the pressure differences across separation doors between intake & return, at pit bottom & at several other places in the mine.

Accessories required

- → Two flexible rubber hose pipes (150m long)
- → Spirit level
- → Measuring tape
- → Ventilation plan
- → A tripod.

Procedure :-

- → The stations at which pressure drops have to be measured are marked on the ventilation plan after a reconnaissance of the mine. (A & B station)
- → All the ventilation apparatus should be undisturbed during the time of survey.
- → The fan speed should be constant.
- → The hose pipes are connected from (A & B) stations to the manometer, which is placed midway between the (A & B) stations.
- → The manometer rests on tripod should be level. & there is no leakage at the joints of hose pipes with the limbs of the manometer.
- → Note the total pressure drop readings of the manometer & record them in measurement book.

Station & Length in	Air velocity m/sec	Quantity of air m^3/sec	Gauge reading in mm of w.g	velocity correction	Corrected pressure drop mm of w.g

- → The points where pressure & quantity survey are made are marked underground as permanent stations.

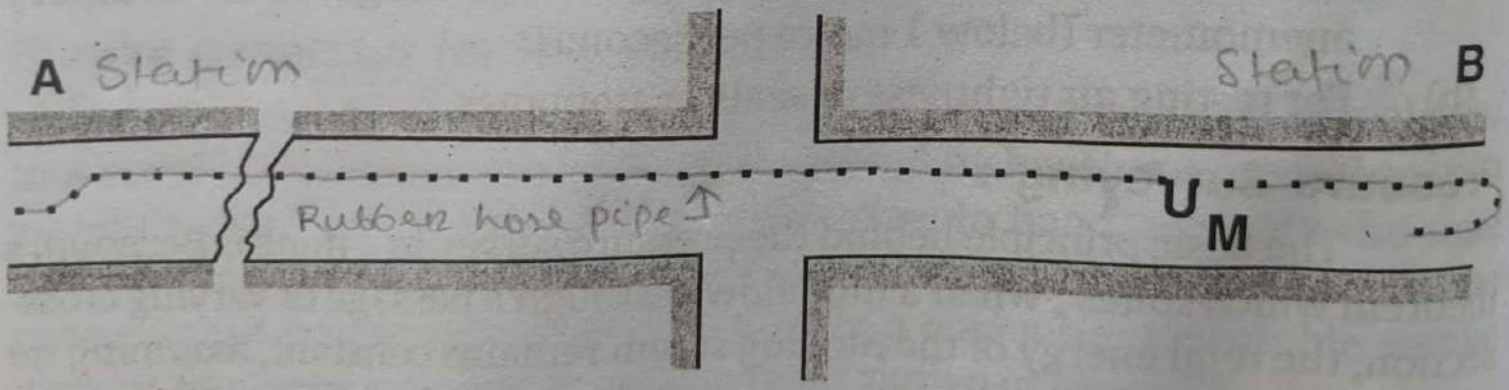


Fig. 3.20 Pressure survey with inclined manometer. A and B are stations; dotted line indicates, rubber tubing; M-inclined manometer.

Measurement of cross-sectional area :-

As we know quantity of air flowing

$Q = A \times V$ { A = cross-sectional area.

→ If the cross-sectional area is fairly uniform area (i.e., rectangle, square, half-circle), ~~than~~ that is easily determined from ordinary linear measurements.

→ But for irregular cross-sections the instruments like sunflower apparatus & profilometer can be used to measure the area accurately.

→ In a mine the cross-section of a roadway is rarely of a ~~rectangular~~ regular shape. For measuring irregular shape, a suitable device is a profilometer.

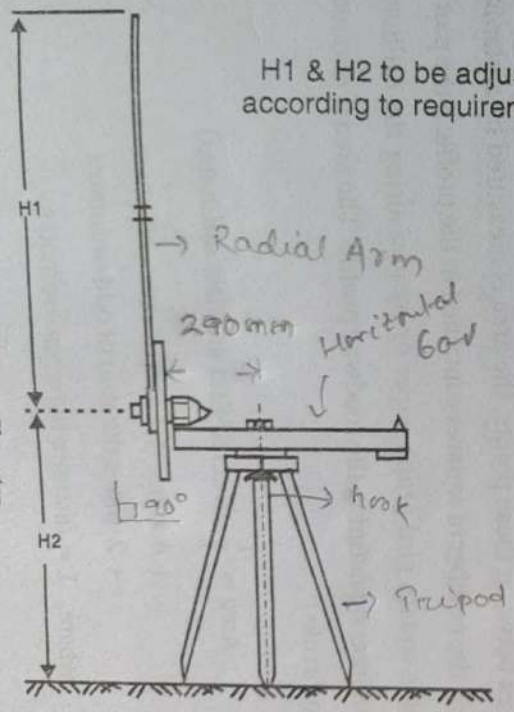
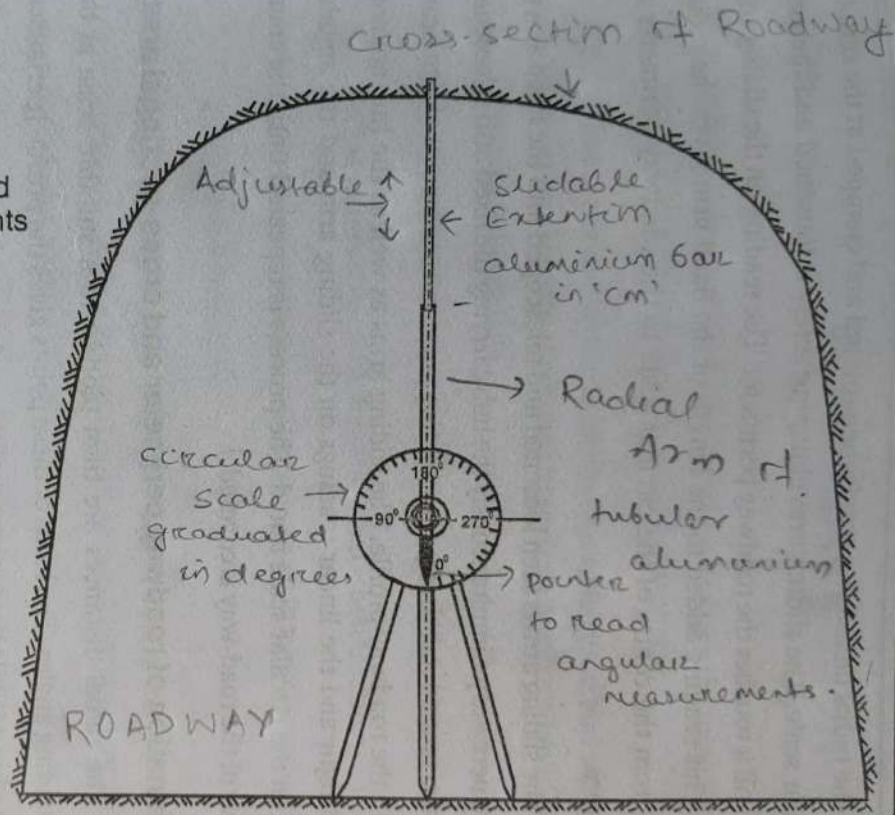


Fig. 3.22 roadway profilometer



ROADWAY PROFILOMETER

Construction:

The profilometer consist of

→ a tripod stand with adjustable legs.
→ quick clamping swivel for centring purpose.
→ A horizontal bar on the top of swivel head.
→ Circular scale graduated in degrees with its plane right angle & 290 mm away from the swivel.
→ A horizontal axle can be rotated & clamped in any position.
→ The hub carrying a light radial arm of tubular aluminium, 9.3 mm in dia & 1.06 m in length, into this soled slideable extension aluminium bar graduated in centimeters.
→ A clamping screw to clamp the extension in any desired position.
→ A pointer to read angular position at the radial arm.

Operation:-

→ The tripod is set on the roadway section to be measured such that the circular scale lies roughly at the centre of the cross-section of the roadway.
→ The horizontal bar is set along the axis of the roadway & is levelled.
→ The radial measuring arm is then rotated & clamped at the zero of the circular scale.
→ The arm extended till it touches the roadway perimeter
→ The reading of the sliding arm from the centre of circular scale & angular reading is taken & noted.
→ This process is repeated & reading of the sliding arm with respect to angular measurements is taken, until the entire perimeter of the roadway is covered.

→ The radial distances are then plotted to a suitable scale at the corresponding angles.

→ The locus of these points give the profile (perimeter) of the roadway.

→ The area is measured by a planimeter or by counting the number of squares contained in the profile in a suitable square grid by a graph paper.

→ The area can also be obtained from the Simpson's rule:

Simpson's Rule}

$$\text{Area} = \frac{L}{3} (\text{sum of first \& last ordinates}) + 4 \text{ times the sum of even ordinates} + 2 \text{ times the sum of odd ordinates}$$

where L = distance between ordinates

Velocity measurement by Anemometer :

→ It is a common velocity measuring instrument.
→ It is cheap & very convenient for mining practices.
→ The instrument determines the distance travelled by air in a given time & used for measurement of air velocity ranges between 60m/s to 1000m/s.
→ The instrument consists of a small fan having its vanes at 40° to 50° to the direction of air flow & is propelled by moving air.
→ The travelling air rotates the vanes & through gearing arrangement the pointers on the dial of the anemometer records the distance travelled.
→ There is one large & 3-4 small inner dials for taking readings.
→ When using the instrument in an underground roadway ~~the~~ it should be held by a stick away from the body & the plane of rotation of the vanes should be normal to the direction of air flow.
→ To determine the velocity of air a stop-watch is essential in conjuction with an anemometer.
→ To determine the average velocity, set the stopwatch & gear of anemometer simultaneously.
→ The instrument now records the distance travelled by the air.
→ Move the instrument throughout the cross-section of the roadway as shown by the path in the figure.
→ After, 2, 3 or 4 minutes declutch the instrument & simultaneously stop the stopwatch & take the reading.

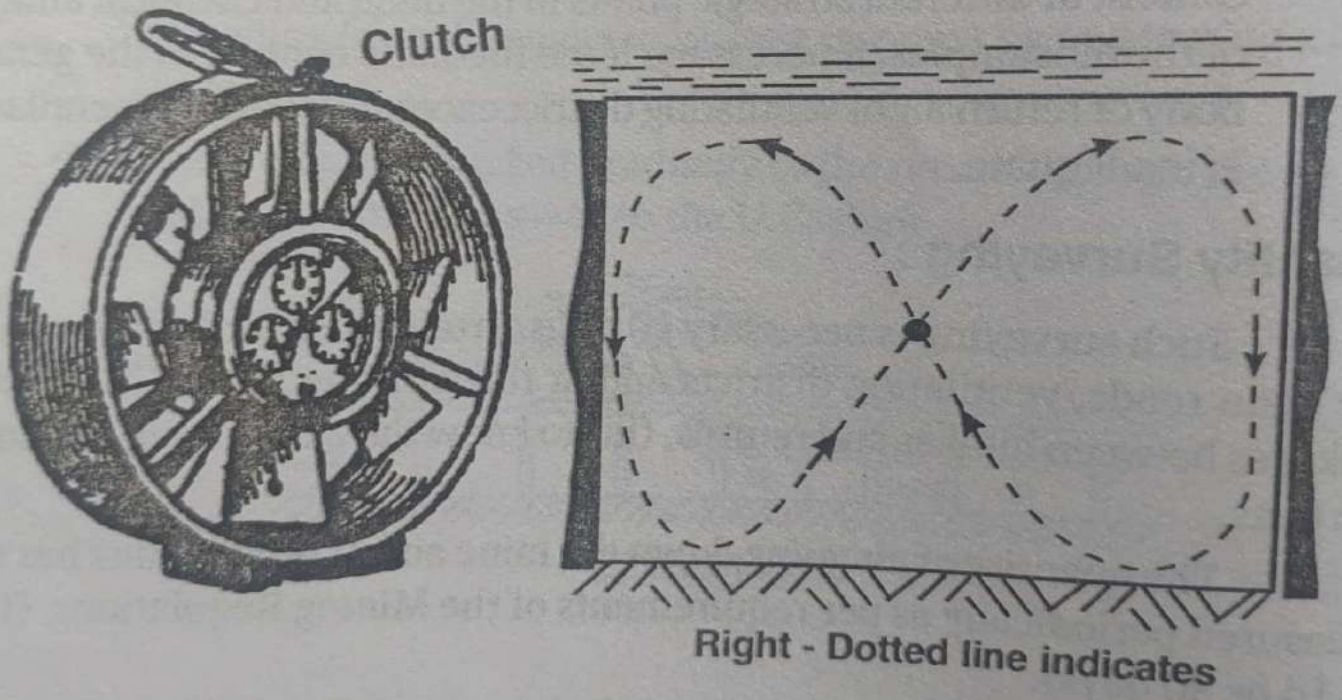


Fig. 3.15 Left-Anemometer.

Anemometer Range : 0 – 1.00.000m

Possible measuring wind speed 1 – 15 m/s

Right Dotted line indicates path of anemometer movement

→ The distance travelled by the air & the time taken is recorded.

→ The average velocity of air is then calculated.

Location of velocity measurement :-

→ The location should be straight & uniform cross-section.

→ The cross-section should be such that the area can be easily calculated.

→ Free from obstruction, bends, junctions & variable cross-sections.

Velocity measurement by Pitot-tube :-

→ This is a pressure measuring instrument, whose readings can be converted by calculation to equivalent velocity measurements.

→ Like velometer, it gives spot reading & average velocity is found out by taking equally spaced readings & averaging them.

→ It consists of two tubes connected by rubber tubing to two limbs of a watergauge or manometer.

→ One tube has its end drawn out to form an elongated cone and it is arranged to point up-stream, facing the air current.

→ It is subjected to total pressure { static pressure + velocity pressure

→ The other tube is fitted with a plain disc having a hole in the centre & arranged right angles to the stream of air

→ The difference of level of the liquid is directly proportional to the velocity of air.

→ Normally the head of the pitot static tube is turned in different directions until the highest velocity pressure is recorded.

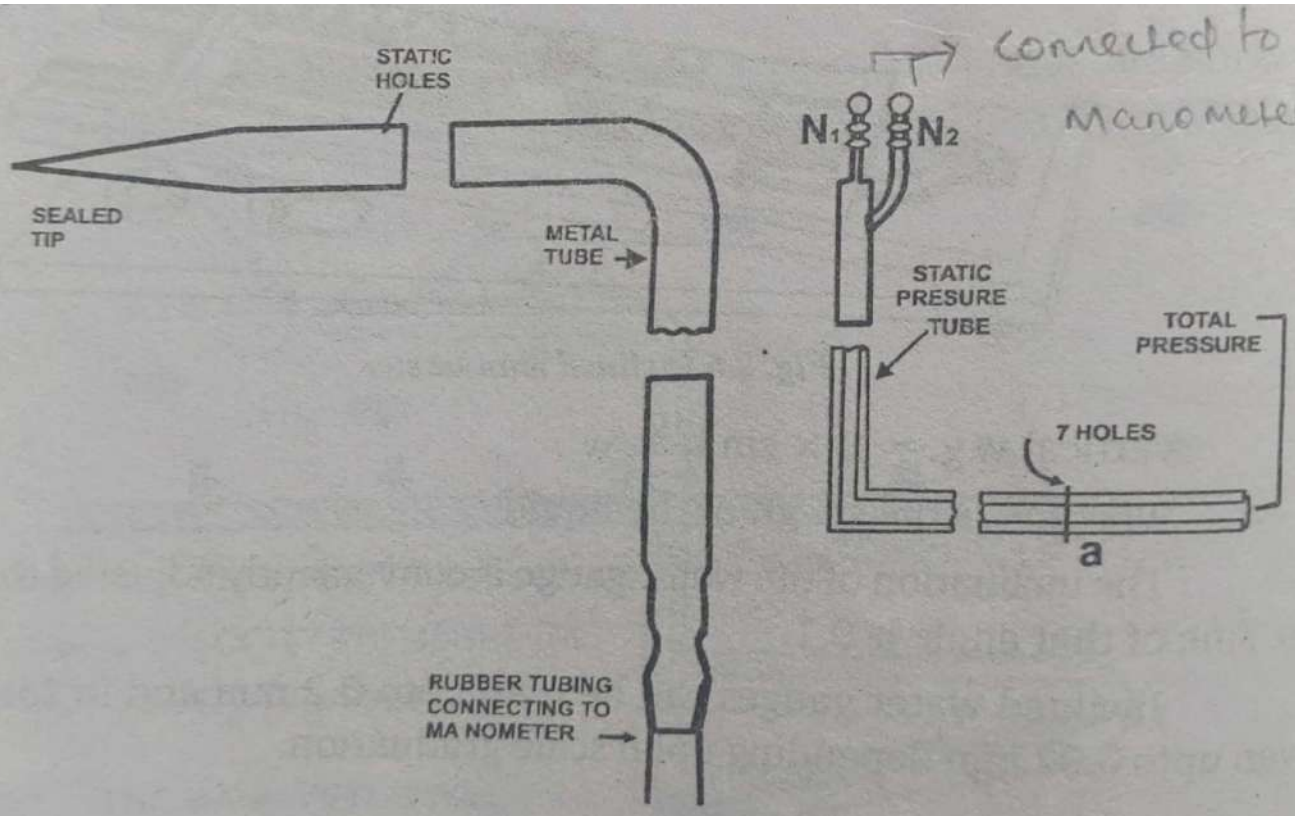


Fig. 2.7 Pitot tube

Airflow meter of Nanda Manufacturing Co. comprises.
(a) Portable inclined manometer. (b) Pitot static tube.

The relationship between the observed w.g. & the velocity is given by

$$V = 4.43 \sqrt{\frac{w.g.}{w}}$$

Where,
V = velocity of air in m/sec
w.g. = pressure in mm of w.g. or Kgf/m^2
w = Density of air in Kgf/m^3

At standard air density

$$V = 4.015 \sqrt{w.g.}$$

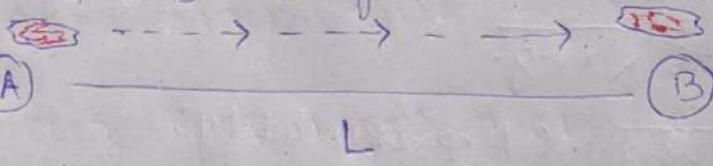
$$= 4 \sqrt{w.g.} \quad \text{(Approximately)}$$

The instrument can be permanently connected to the fan drift, with manometer outside, so that a reading of the velocity-pressure can be taken conveniently at any time.

Velocity measurement by Smoke & cloud method :-

→ In this method the cloud of smoke travels over a measured distance.

→ A straight line roadway is selected & two station A & B length is measured out.

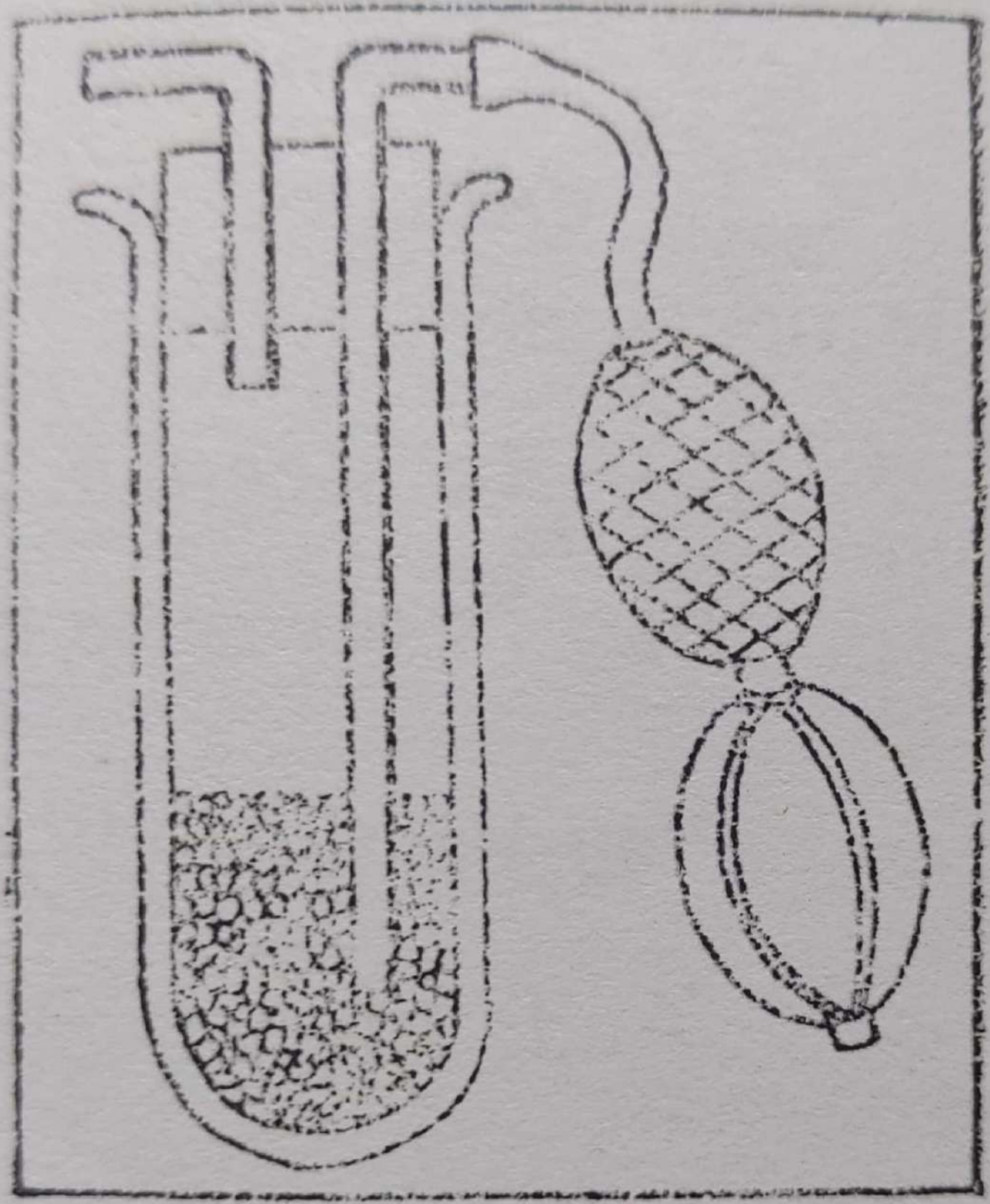


→ Let 'A' & 'B' be the two stations, the operator at 'A' will signal the operator at 'B' when releases the volume of smoke from smoke generator.

→ Now the operator at 'B' starts the stopwatch until it reaches the station 'B'. & the time 'T' taken by the smoke to travell 'L' distance is noted.

→ The velocity is calculated $V = \frac{L}{T}$ m/s

or $\left(\frac{L}{T} \times 60\right)$ m/min



Smoke Generator

Smoke Generator

→ It consists of a glass tube containing broken pieces of pumice stone, in which titanium tetrachloride (a liquid) or stanic chloride is absorbed.

→ It is fitted with a glass tubing with a rubber bulb at its outer end.

→ The air is allowed to pass when this rubber bulb is squeezed, a dense vapour from the second tube is formed & form white vapour by interaction with the moisture of the atmosphere.

→ The smoke may also be produced by a similar apparatus containing hydrochloric acid & ammonia.

Velocity measurement by Velometer :-

→ It is an instrument, which directly indicates the velocity in m/s at any point of observation.

→ In underground mine the spot reading is taken over the cross-section at equally spaced points to find out the average velocity.

→ Velometer gives direct reading where no calculation or calibration chat is needed.

→ The instrument consists of a sensing head & an indicator unit.

→ When the instrument is put against the air current, the vane rotates & transducer generates electrical signals directly proportional to the rate of air flow through the head, which in turn indicates the flow rate in the display.

→ Air density affects the velometer reading slightly & a correction factor is then multiplied to get the correct value where great accuracy is required.

Advantages

→ Instaneous reading, less time required, less errors, sensitive to low range of velocity etc.

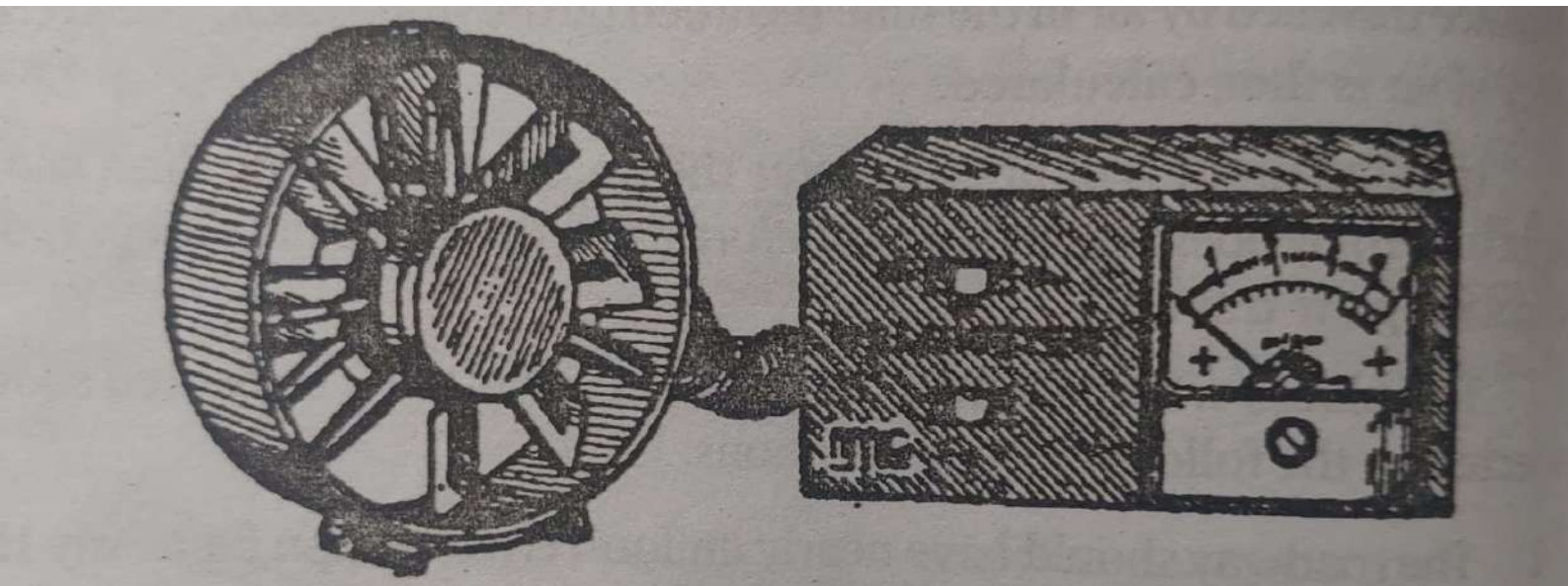


Fig. 3.16 Velometer, Directly reads air Velocity. Range 0 – 15 m/s (N.M.C.)

Leakages of Air in Mines :-

Sources & causes :-

→ Doors of the fan drift & air lock. If the air lock is provided with glass windows to admit natural light at the pit top, a broken glass pane may cause heavy leakages.

→ When air lock is not provided
  → space between cage & shaft walls
  → cages & pit top landing level.

→ If the pit top landing level is covered by a wooden lid, which is lifted by the ascending cage, this arrangement causes substantial leakage.

→ Ventilation stoppings, ventilation doors & air crossing.

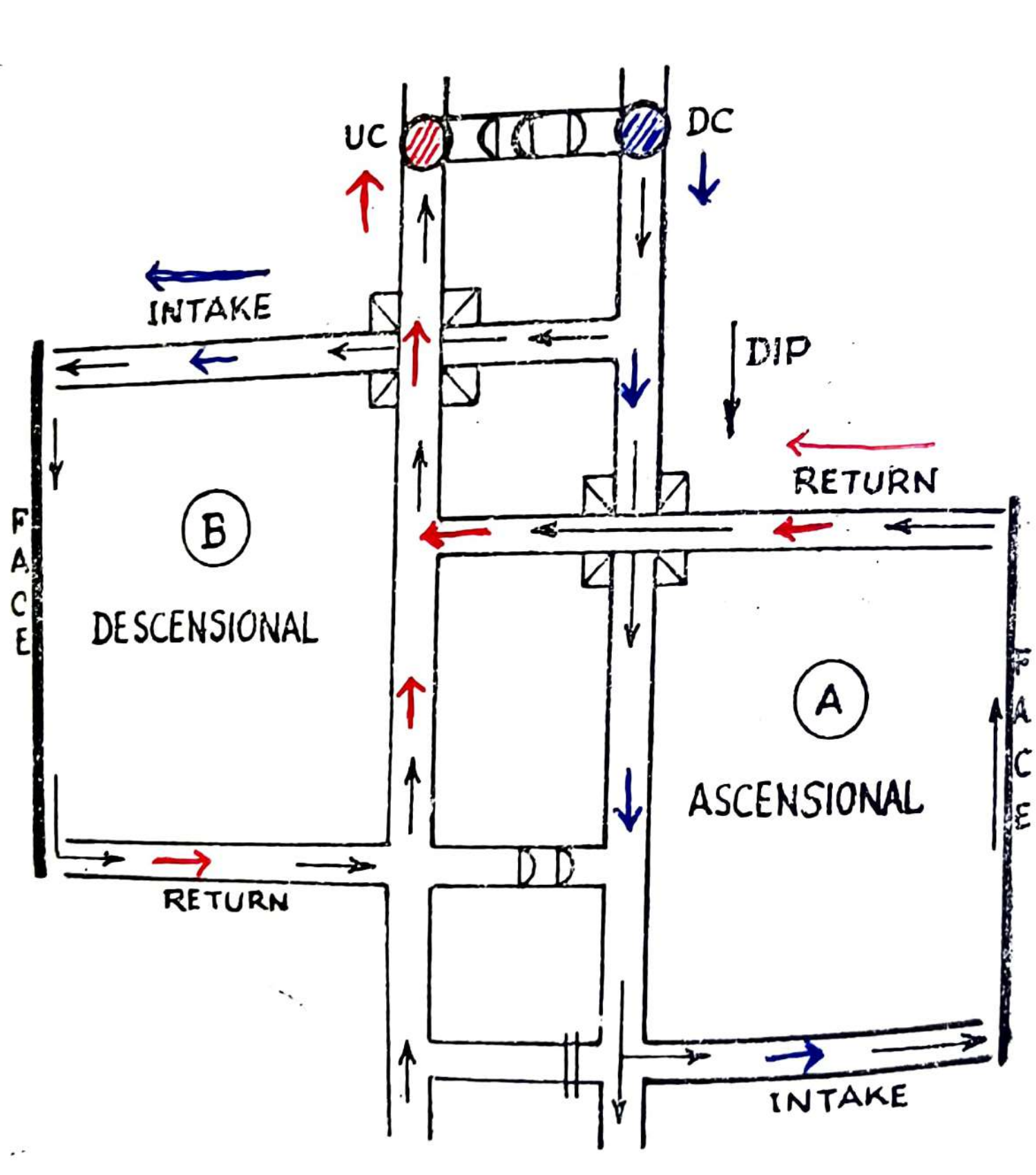
→ In case of long wall mining, leakages into the goaf.

→ Broken or crushed pillar of coal.

→ Wrong siting of underground booster fan.

Preventive measures :-

→ Air lock at pit top should be properly designed.
→ Doors of the air locks & fan drift should have rubber linings.
→ The doors should be mechanically interlocked of an air lock, so that both the doors can't open simultaneously.
→ Intake & return should be far apart & minimum connection in between them.
→ Intake & return airways must be located in strong undisturbed ground & should be kept in different seams.
→ All the underground ventilation doors, ventilation stoppings & air crossing should be well constructed & maintained.
→ In longwall method the roadside packwall should be well constructed to avoid leakage through them.
→ The pillars of coal / mineral if cracked due to heavy roof pressure, should be coated by a spray of cement mortar.
→ For reducing leakage it is preferable to use a large number of low pressure fans in series than a single fan producing high pressure.


UC
DC
INTAKE
DIP
RETURN
FACE
B
DESCENSIONAL
A
ASCENSIONAL
FACE
RETURN
INTAKE

Different types of Ventilation :-

Ascensional Ventilation :-

→ Ascensional ventilation implies taking the intake ventilating air to the lowest point of a district or face and allow it to travel to higher levels to ventilate the district or face before it goes to the return.

Advantages :-

1) The air is heated by conduction, as it courses along the newly exposed faces, & therefore has a natural tendency to rise towards the return airway.
2) In gassy mines it results in rapid dilution of the gas.
3) The general comfort & safety of workperson is increased.
4) Natural ventilation pressure assists the fan ventilation.
5) If the fan stops, the air will continue to flow in the same direction by natural ventilation.

Disadvantages :-

1) In case of ascentional ventilation, if reversal of air current is purposefully made, there is a possibility of a large increase in the amount of methane.
2) The intake air passing over drains of water coming out from stowed goaf increases humidity in air.

Descensional Ventilation :-

→ Descensional ventilation implies taking the air ~~gets to~~ to the rise side of a district & allow it to travel to the lower levels as it ventilates the working places.

Advantages :-

1) The air has not to pass over water drains of the dip side and it reaches the working face in drier & cooler condition.

2) Blackdamp, which is heavier than air, made to move downhill ↓ along the face, which will improve the ventilation standard by diluting the gas effectively.

3) Both dry bulb & wet-bulb temprature are found lower by descensional ventilation in deep & hot mines.

(In Raniganj field a deep mine worked by advancing longwall with hydraulic stowing had a relative humidity of 93% with ascentional ventilation, but the particular face when ventilated by descensional ventilation the relative humidity came down to 65%)

4) Improvement of dust condition on face is possible by elimination of intake contamination on a homotropal descensionally ventilated face.

Disadvantages :-

1) Firedamp given off migrate to the rise side in a thin layer on the roof & in opposite direction to the air current.

2) Hot gases from fire ↑ on descensionally ventilated ↓ face will increase N.V.P. resulting in lesser quantity of air flow with possibility of reversal of ventilation & this will put the fire-fighters in trouble.

3) Water mains provided on dip working & their valves, fittings outbye will be inaccessible due to smoke etc.

4) High pressure air current is required to eliminate firedamp.

Homotropal Ventilation :-

Ventilation is homotropal when the ventilation air & the coal flow / mineral flow in the same direction.

Antitropal Ventilation :-

Ventilation is antitropal when the ventilation air & the coal / mineral flow in opposite direction.