NARAYANI INSTITUTE OF ENGINEERING AND TECHNOLOGY

Affiliated to AICTE, New Delhi & Approved by SCTE & VT, Odisha

LECTURE NOTE ON

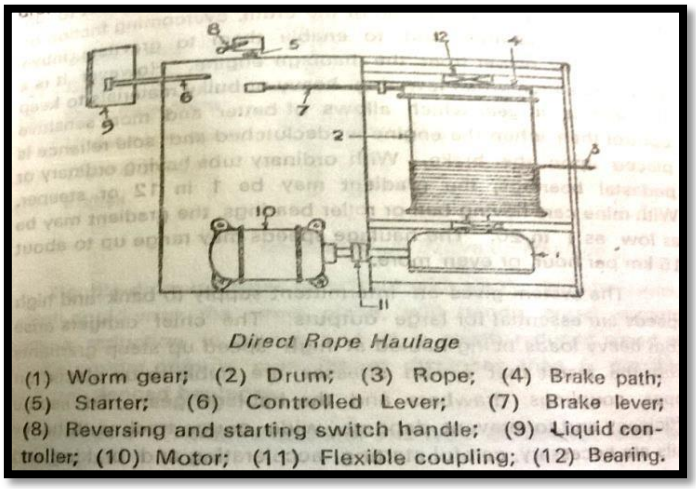
MINE MACHINERY-I

DEPARTMENT OF MINING ENGINEERING

A) Rope haulage

1) Direct Rope Haulage

a)Single Drums Direct Rope Haulage:
This is simplest system of rope haulage. It consists of one track, one rope & one drum which are connected to a motor through gears. One end of the rope is connected with the train of tubs on the track & another end of the rope is connected to the drum. When the drum rotates situated at the top of the incline, the loaded tubs moves upwards. But for the downward journey of the empty tubs it does not require any power because a tub moves downward due to their own weight. The system can run on inclines steeper than 1 in 12 & the speed of the haulage is 8 – 12 km/h.



Direct Rope Haulage

(1) Worm gear; (2) Drum; (3) Rope; (4) Brake path; (5) Starter; (6) Controlled Lever; (7) Brake lever; (8) Reversing and starting switch handle; (9) Liquid controller; (10) Motor; (11) Flexible coupling; (12) Bearing.

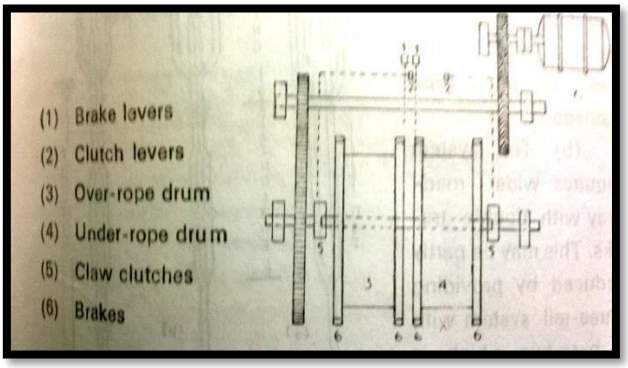
Advantages of Single Drum Direct Rope Haulage

1. Simple in operation.
2. Only one brake is required.
3. Extension is easy.
4. Branched roads can also be served, if gradient is suitable.
5. Can be used in narrow roads.

Disadvantages of Single Drum Direct Rope Haulage

1. High power demands for upper journey of loaded tubs.
2. Efficient breaking system required for downward journey.

3. High speed haulage demands more maintenance of track.
4. Cannot be used for less incline roadways.
5. A derailment is associated with heavy damages.
6. Due to high speed more dust, more wear & tear.



b)Double Drum Direct Rope Haulage: It consists of two drums, two ropes & two tracks but only one driving motor. One end of each rope is connected with two drums & another end of rope is connected with the set of tubs. In such a way that when one set of tub is at incline top, the other set is at incline bottom. The two drums are connected with each other. When drum rotates, the rope coils on one drum & uncoils from another drum. It can be used if inclination is more than 1 in 12. The speed of the system is 8 to 12 km/h.

Advantages of Double Drum Direct Rope Haulage

1. Higher output.
2. Less power demand.
3. Branched roads can also be served, if gradient is suitable.

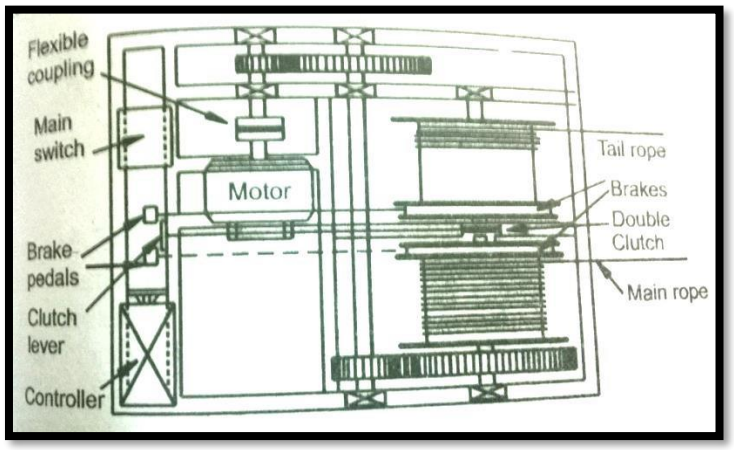
Disadvantages of Double Drum Direct Rope Haulage

1. Wider roads required.
2. Efficient breaking system required for downward journey.

3. High speed haulage demands more maintenance of track.
4. Cannot be used for less incline roadways.
5. A derailment is associated with heavy damages.
6. Due to high speed more dust, more wear & tear.

2) Main & Tail Rope Haulage:-

In this type of haulage engine is provided with two separate drums, one for main rope which hauls the loaded tubs, one for tail rope which hauls the tubs downward the gradient, when one drum is in gear the other drum revolves freely but controlled. The name implies the haulage has a main rope and a tail rope.

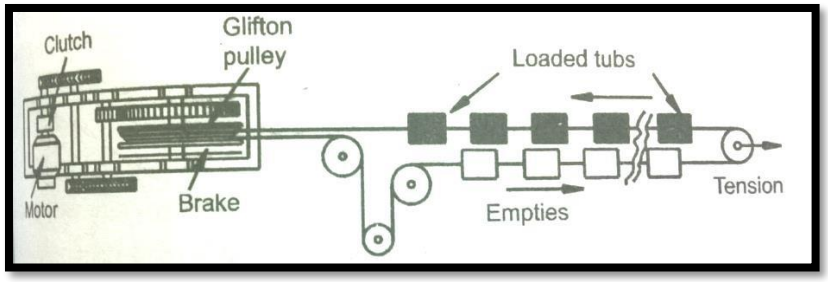


The engine being provided with two separate drums one for each rope. The main rope coils on a drum, is attached to the front end of the loaded drums to haul them out bye. The tail rope from a second drum, passing over a return pulley sheave in bye, is attached to the rare end of the full tubs .n the tail rope hauls the empty tubs in bye. brakes are fitted to each drum and the drums are so arranged that each may be driven independently through clutches when one drum is in gear other revolve freely but it is controlled , when necessary it is kept tight with the brake . The length of the rope needed is more than three times the haulage road – the main rope is equal to the length of haulage and the tail rope is twice the length of the main rope. This system can be operated 12-18 km or even up to 20 km per hour.

This system needs only a single track except in the landings and pass byes, and can be employed in narrow road ways. The engineman has complete control of the train right throughout its journey. Motive power is used only when the train is making itsjourney. Special shackles are used to attach the tubs or set to the rope.

3) Endless rope haulage:-

In this system an endless rope made up of several length spliced together , passes from the driving pulley at the out bye end of haulage plane to a return pulley the driving pulley also known as the surge pulley it is moved by electric power from the motor through number of gears wheel's turning through sustainable shaft . The rope may pass around pulley only 2 and a half- 3 and a half times and then return. The friction between the rope and the pulley surface prevent the rope slipping. But too few turns of the rope on the pulley might allow slip. Again too many turns might cause the rope to fasten itself on the pulley. Expect on very haulages it is necessary to have rope tensioning arrangements.

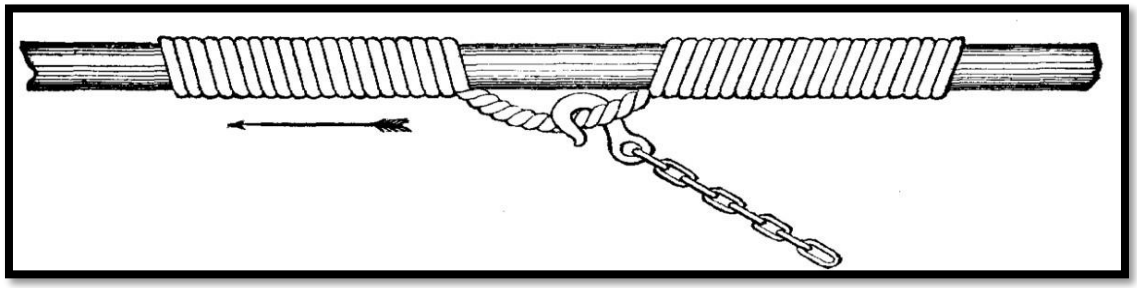


The endless haulage speeds range about 2 – 5 km per hour this system is ideal for roadways 1 in 16 gradients. Two sets of rails are required for endless haulage system, one for the empties going in bye, one for the full tubs being drawn out bye.

a)Under Rope Endless Rope Haulage:-

Under rope haulage has the advantage that there is a more direct pull on the draw bars, the tubs may be fully loaded, curves are more easily worked, automatic detachment of clips can be readily arranged and the moving rope, being near the floor, is less liable to personal injury.
The method is suitable for roadway of varying gradient.

b) Over Rope Endless Rope Haulage:-It requires fewer rollers the rope is not affected by wet floor and there is less friction and wear of rope and slippers. The rope is not liable to corrosion. The rope is at a better working height for person engage in attaching and detaching tub. The method is suitable for roadway of varying gradient.



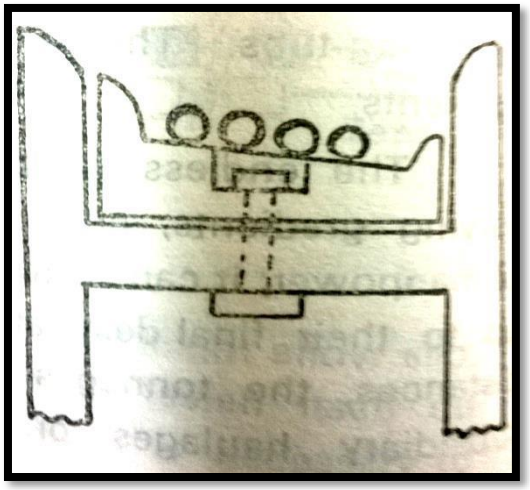
The endless haulage is simple to work, effective on varying gradients and can negotiate curves usually at the cost of manpower: it can be readily extended and tubs taken right to their final destination. It is capable of hauling over long distances, the tonnages normally collected from a number a subsidiary haulages or conveyor loading points. further advantages of this method are : coping with larger outputs than other types of rope haulages , simple in layout and operation : low speed , lowered risk of accident of accident and other damages : reduce liability to airborne and roadway dust , less wear and tear track and rolling stock ; applicable

to level , undulating and inclined roadways , while negotiating bends of moderate nature , constant load imposed on motor: less maintenance on the hauler due to elimination of high speed revolving parts and simplified layout.

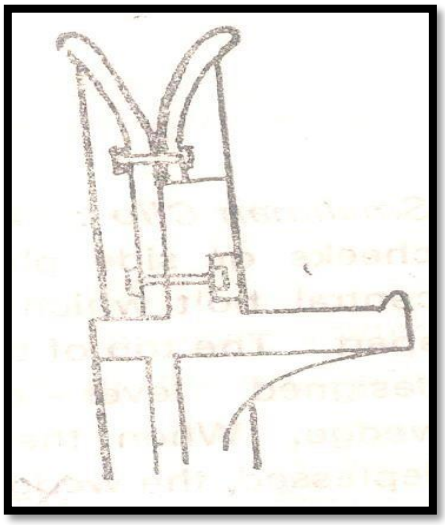
Driving Pulley or Surge Wheel Pulleys or wheels which are used for driving purposes on haulages must have its throat so shaped as to give the necessary grip to prevent jar and shock

Types of Driving Pulley & Surge Wheel

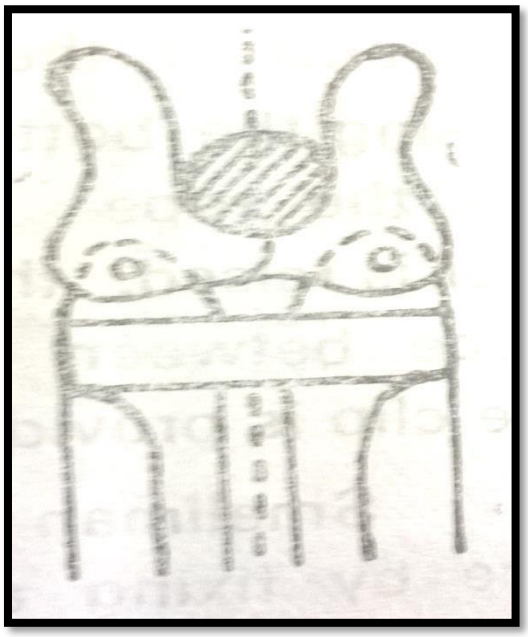
1.Clifton Pulley: This pulley has tapered throat lining of renewable cast iron or soft steel segment having a tape of about 1 in 8. These segments are bolting to the rim to protect the main pulley from wear. The rope is coiled several times (3 ½ - 4 ½) around the pulley & it enters the pulley at larger diameter & leave the pulley at smaller diameter. This pulley is commonly used in mines in endless haulages.



2. **V-Grooved Pulley:** A v grooved pulley or clip pulley is suitable for light haulages. A good grip fob the rope is obtained, thereby preventing slip. Both sides of the throat are made in segments and bolted to the rim of the wheel. These pulleys have a rim of the wheel. These pulleys have a tendency to flatten the rope by wedging and greater the load the greater the wedging.



3. **Fowler's pulley:** This is a form of clip pulley, the throat of which is made in several segments. This is an improvement on the v- groove type and is designed to overcome the friction resisting the entrance to and resisting from the taper throat of the pulley. When the rope passes on to the open groove of the pulley, the segments are passed down and rotated about their pivots, thus increasing the grip on the rope. The segments are adjustable to allow for wear and ropes of different diameter.



Rope clips

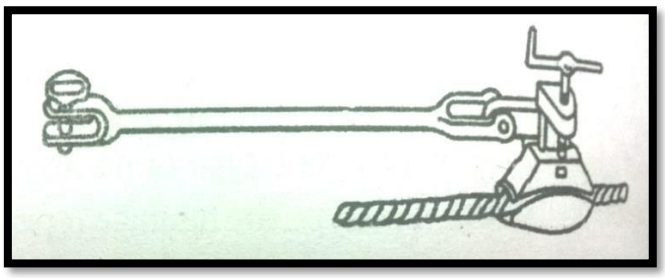
The endless ropes moves at a slow speed over pulleys or rollers situated between the rails in the haulage way. Special clips are used for detaching tubs or cars to the moving rope. The design of such clips depends on whether the rope travels under the tubs, or over the tubs.

The clips used for under rope haulage are-

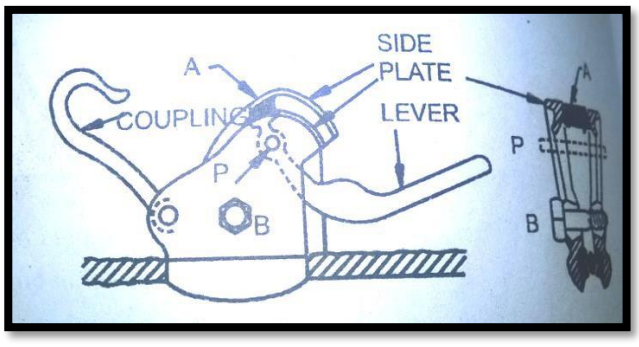
1.Screw clip or Hadfield clip

2. Small man clip

1. Screw clip:-The clip is tightened on the rope by a handle and a screw. It is coupled to the tub drawbar by a long steel rod hinged to the clip.



2) Small man clip: - A small man clip consist of a pair of steel cheeks or side plates, loosely held together by an adjustable central bolt it has a spring surrounding it to keep the plates apart. The top of the clip is expanded by means of special designed operated lever wedge. When the lever I depressed, the wedge enters the narrower part of the space between the plates, so forcing them apart at the top, and at the same time causing the bottom jaws to grip the rope. When the lever is raised, the wedges move the wider part of the space between the plates so releasing the top from the jaws. The clip is provided with a coupling hook attached with the tubs.



Small man clip can be automatically detached from the tubs by fixing a trip bar at a convenient height so that the lever of the clip strikes it to make the grip ineffective.

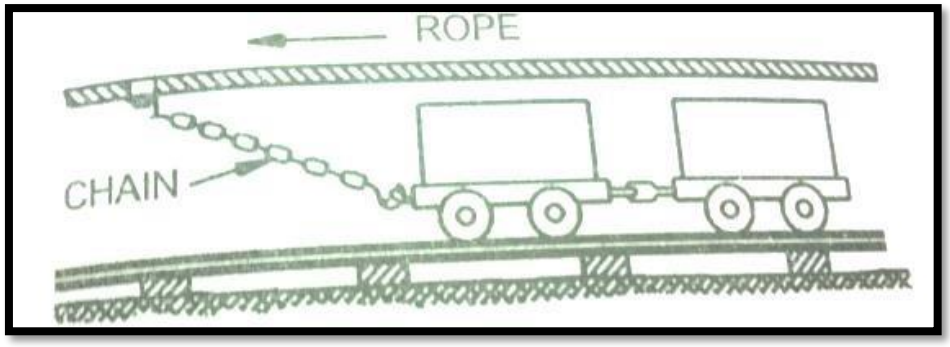
Clips used for over-rope haulage

1) Lashing chain

2) Goose neck clip

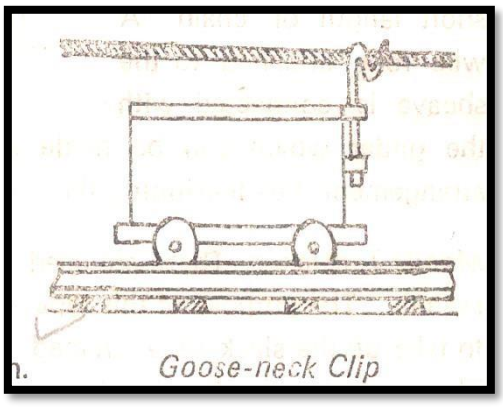
3) Cam clip

1) Lashing chain-

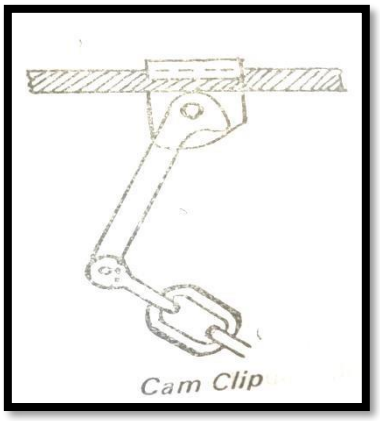


This is the simplest means of attachment of tubs to haulage ropes which are used for over rope haulages. On steep gradient, they provide reliable attachment, but clips are better for passing round pulleys. The chain is about 3 m to 4 m long and has a hook on at each end. One hook is attached to the tub drawbar and the other end of the chain is twisted two or three times around the rope and the second hook is linked to the chain. On uniform gradients one chain can be used in front. But in undulating one chain should be attached at both ends.

2) Goose neck clip-This is S-shaped hook or fork slotted into two holders on the end of the tub. When the rope is in position the hook turns about 30˚so producing a local bend in the rope and thereby gripping it. Automatic detachment may be obtained by passing the rope through a pair of guide frames placed near enough together to prevent the clip passing between them.



3)Cam clip –This consists of a plate and a cam shaped lever which is pivoted and is connected by a chain to the tub hauled. The pull it off the tub turns the lever around the pivot so that grip of the clip on the rope is proportional to the load. On undulating roadways, a clip must be provided at each end of the tubs.



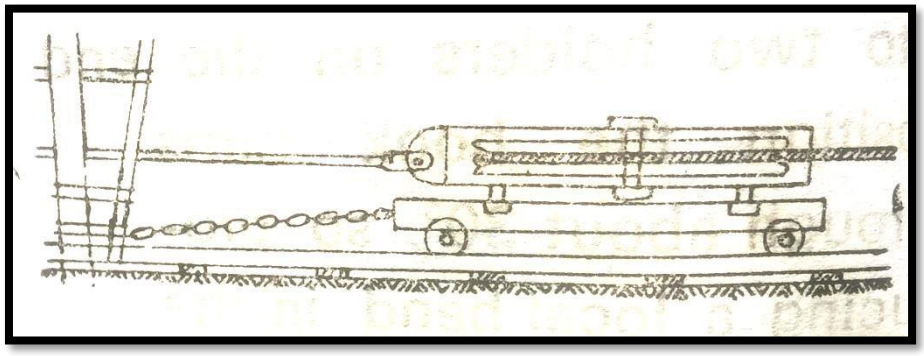
Tensioning arrangement for endless haulage rope:

To ensure that the endless rope is always kept in suitable tension, it is essential to take up any slack rope that occurs due to stretching of necessary the rope. Numerous methods are employed in applying necessary tension in endless rope haulage. The methods commonly are:-

1. **Fixed tension**
2. **Mobile tension**
3. **Gradient operated mobile tension**

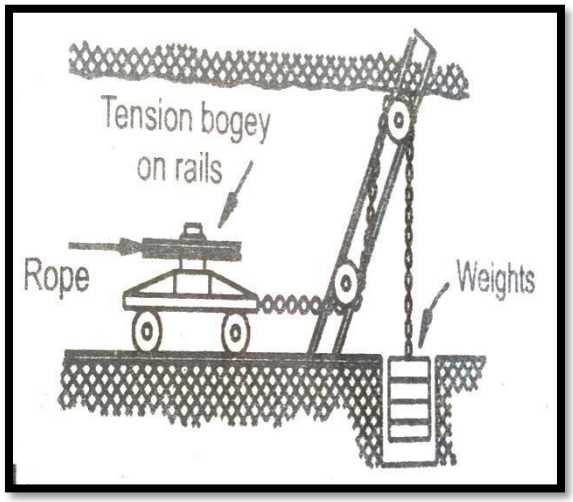
1. **Fixed tension:** This arrangement is very useful on short haulage planes up to about 750m.

It takes up less room. The endless rope return sheave is mounted on a special tension bogie or carriage running on the rail. The bogie is attached to a set of strong girders vertically placed behind through a short length of the chain. A wire rope attached to the sheave. Is connected with the girder which can be made shortened by special screwing arrangement the slack rope.

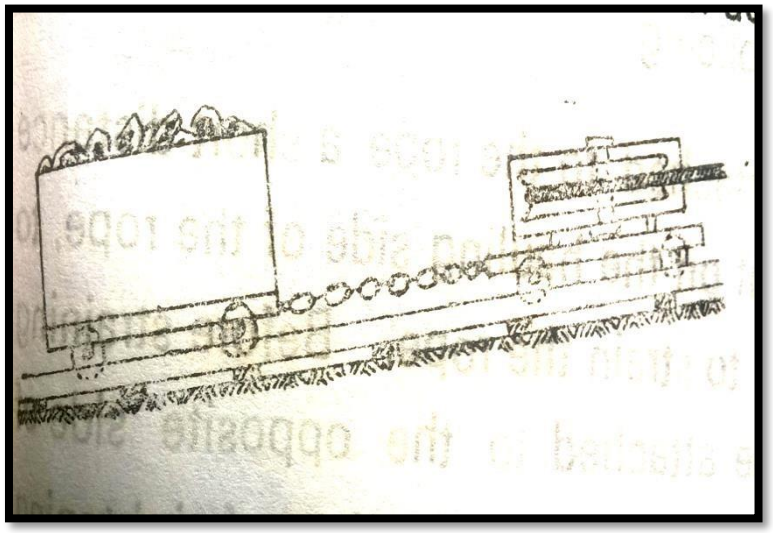


2. **Mobile tension:**

These are used for extensive endless haulage system. The purpose of this type of extension arrangement is to take up the slack rope created by variable loads on ropes. These varying loads would cause the rope to slip on the surge pulley. To take up the slack rope, the endless rope mounted on the special tension bogie or carriage running on rails. The bogie is controlled by heavy weights as required in a manner as shown in the figure.



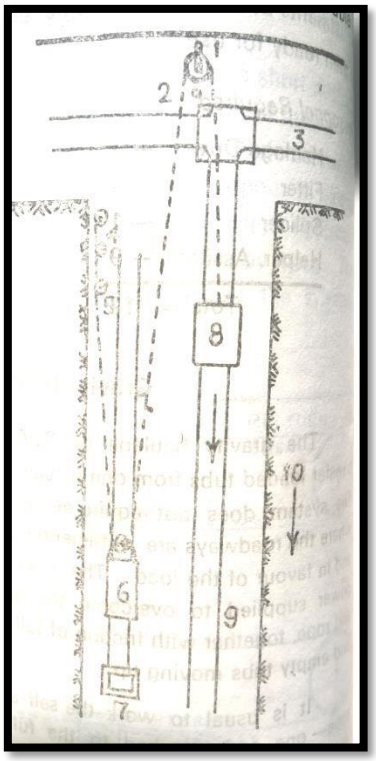
3. **Gradient operated tension**: This is also a mobile tension where the gradient allows in vicinity of the haulage engine a bogie sheave can be placed on an inclined roadway which may be connected with loaded tubs with sufficient weights to move backwards and forwards in accordance with necessity.



Where reverse gradient are met with it might be necessary to install a take up tension at each end of the haulage plane. Since slack rope would have to be taken up on both sides of engines. The correct places for the tension device is at the point where slack are most likely to occur.

Gravity haulage

The gravity haulage or self-acting incline is adopted to transfer loaded Kid from one elevation to a lower one in mines. The system doesn't require any motor or any source that of power where the roadways are sufficiently steep and gradient uniform and in favor of the load.



The gravity haulage of the full load is the power supplied to overcome the gravity load of the empty set and rope, together with friction of full tubs running downwards and empty tuba moving up.

It is usual to work the self-acting incline with a single rope -one end attach to the full set. The rope passes 1½ times the around the cast iron pulley known as jig pulley or brake wheel 1.3 m to 2m diameter, with a Frodo - Line lever operated strap brake , firmly secured in an anchor prop in the top of the incline near the advancing coal face. A safety prop is placed in front of the pulley .The other end of the top passes to a bogie, around a pulley there on and so back uphill to a holding of prop where it is firmly secured by a clamp. It is also secured to safety prop where it is firmly secured bay clamp. It is also secured to a safety prop and the surplus prop rope is coiled on a drum nearby in readiness for when the face advances. By operating the brake wheel, chi trolling the lever the loaded tubs may be automatically move downward pulling the balancing bogie up the track. It is possible to maintain an ordinary double track in the gateway, the bogie may be dispensed with empty tubs pulled up by each descending full tubs. The system having a double track for the full tubs. The system having the double track for the full length of the incline for a set or train of full tubs, in descending, pulling an equal number of the tubs is known as train incline. Such inclines call for a well - laid track, good rope and roller, and a

strong brake wheel. Three rails may also be used in above meeting or pass byes having four rails or double track and an ordinary single track below.

The least gradient for a gravity haulage depend on-

The length of the plane.

The size, capacity, weight, and conditions of tubs and their numbers.

The state of the roadway in regard both of layout and maintenance

Some authorities suggest 1in20 is being the least gradient, but each case requires its own diagnosis.

Safety precautions: The safety measures to be taken for the gravity haulage include-

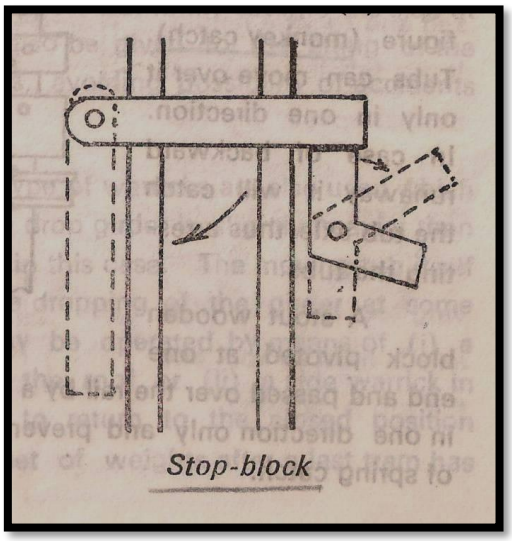
I. Large roadways, adequate lightning, well- laid tracks with proper maintenance, strong and reliable couplings chains etc.
II. Backstays behind ascending tubs, and back catches or spring catches to prevent empty tubs running downwards down the incline.
III. Safety prop in the front if the jig wheel to hold the rope in the event of pulley anchorage failure.
IV. Drop Warwick near the top of incline and a bottom to rests tub in case of forward runway. Runaway switch to derail tubs and arrest them for a same reason.
V. A second brake on the brake wheel should be provided which acts directly on the rope itself to prevent runaway of full tubs if they should be lowered into the incline without an empty set having been attached to the top at the bottom the brake wheel securely fenced and a guard erected to prevent men running into the handle of brake.

Safety devices Apart from the falls of ground, haulage and transport operations have been responsible for a greater number of accidents involving deaths and injuries than any other single cause. The major proportion of haulage and transport

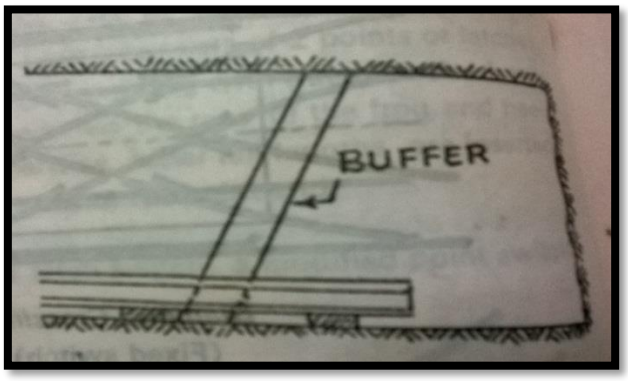
accidents results from runaways. The various safety devices used on haulage roadways are as follows:

1. **Stop blocks**
2. **Buffers**
3. **Back catch**
4. **Pointer plate**
5. **Drop warrick**
6. **Age craft device**
7. **Back stays or drags**
8. **Runaway switches**
9. **Jazz rail**
10. **Retarders and stoppers**
11. **Approach warning devices**
12. **Signalling arrangements**

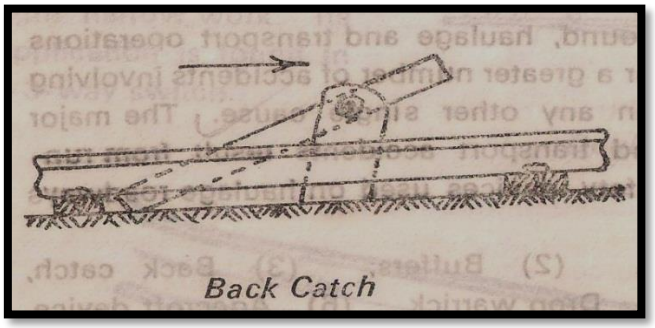
1.Stop blocks: A stop block is a common arrangement placed near the top of inclines. It consists of a stout beam or blocks lying across the rails, pivoted at one end and held against a pivoted side block at the other .the side –block may be straight or bent. When it is desired to open the blocks, side block is opened and then the stop –block is turned as shown in the figure



2. BUFFERS: When any roadway or face is in direct line with a haulage track and persons may be exposed from runaway tubs, strong buffers is provided and maintained on haulage road to prevent danger. Buffers may be horizontal or vertical.



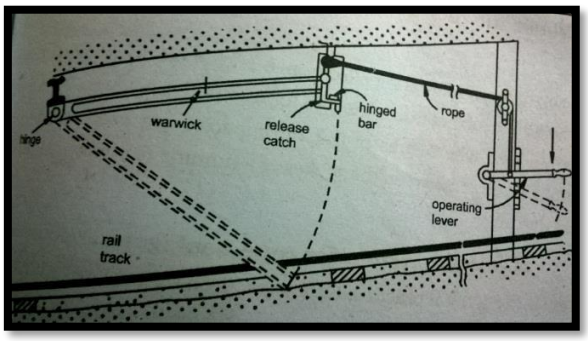
3. Back catches: These are made in different forms. It may consist of a pivoted piece of steel rail placed between the two rails as shown in figure. Tubs can move over it only in one direction. In case of backward runway it will catch the tub axel thus arresting the tubs.



A shout wooden block pivoted at one end and passed over the rail by strong spring allows the tubs in one direction only and prevents runaway in case of spring catch.

4. Pointer plates: This is fitted on the main haulage track to deflect a backward runaway into the prepared side of the roadway. The derailed tubs may be automatically re-railed when drawn forward.

5. Drop warrick: It consists of a girder hinged at one end to a specially set roof girder and held up at the other by an eye bolt and pin. The warrick is released when required in emergency by a haulage worker pulling the wire to withdraw the pin.



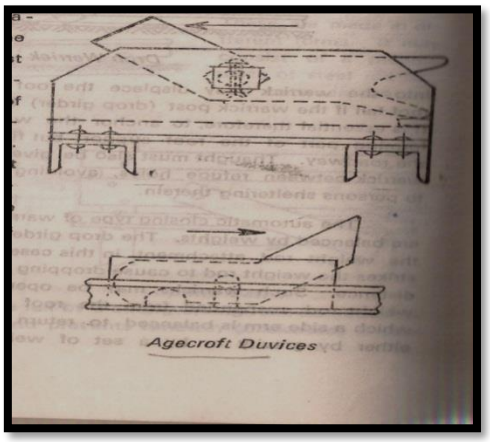
It may also be operated automatically when the uncontrolled movement of tubs give a long swing to an operating handle. An obvious disadvantage is that excessive impact into the warrick may displace the roof support thus causing a roof fall if the warrick post is hinged to a roof bar. It is essential therefore to anchor the warrick to a girder not forming part of the roof support but firmly set into the sides of the roadway thought must also be given to the sitting of the warrick between refuge holes, avoiding possibility of accidents to persons sheltering therein.

The automatic closing type of warrick are also used which are balanced by weights. The drop girder is slightly heavier than the weight of the rod attachment in this case. The moving tub itself strikes the weight rod to cause dropping of the girder at some distance. Such warricks can be operated by means of 1) a weight rod

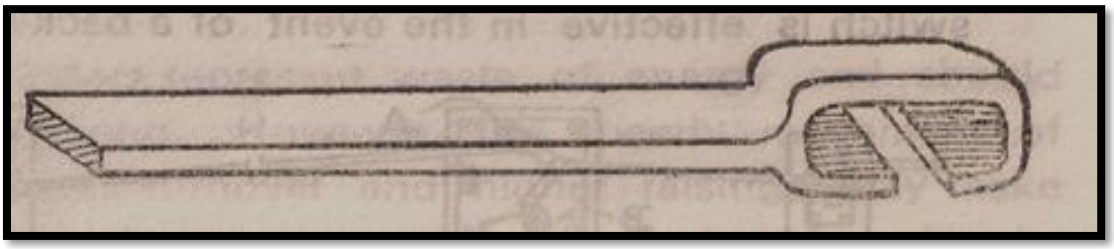
suspended from the roof 2) a side warrick in which a side arm is balanced to return to the closed position either by gravity or by asset of weights after a last tram has passed the type has the swinging movement controlled by balance weights and pulleys.

Warricks can be arranged to have an automatic tripping device in corporate that comes in an operation when the normal speed is exceeded. This works on the principles that the trams travelling at normal speed move a pendulum without disconnecting the slip link which is holding the drop girder by means of a chain and cable. If the certain speed is exceeded the pendulum is struck a harder blow and the sufficient to release the slip link and thus causing the girder to drop to the closed position.

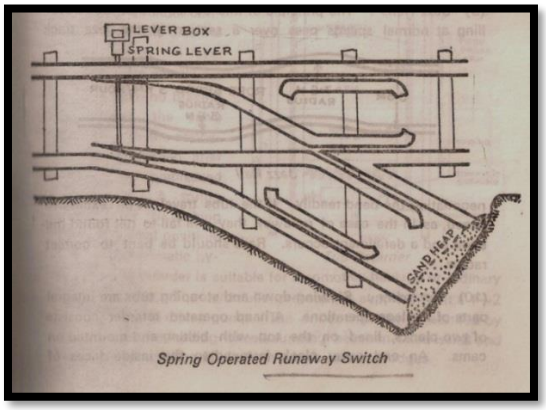
6. **Age craft device:** This is designed to arrest forward runways automatically. These work on the principle that the first axle of the tubs depresses the forked end to axle height. If the tub is passing on the normal speed, the forked and the drops before the back axle reaches it. If the tub is moving fast, the back axel is held by fork and the tub is stopped.



7. **Backstays**: Any train of tubs ascending an incline shall have a drag or backstay attached to the rear tub so as to prevent the train from running back. These may be attached to the tub axel or to the tub drawbar according to their types.

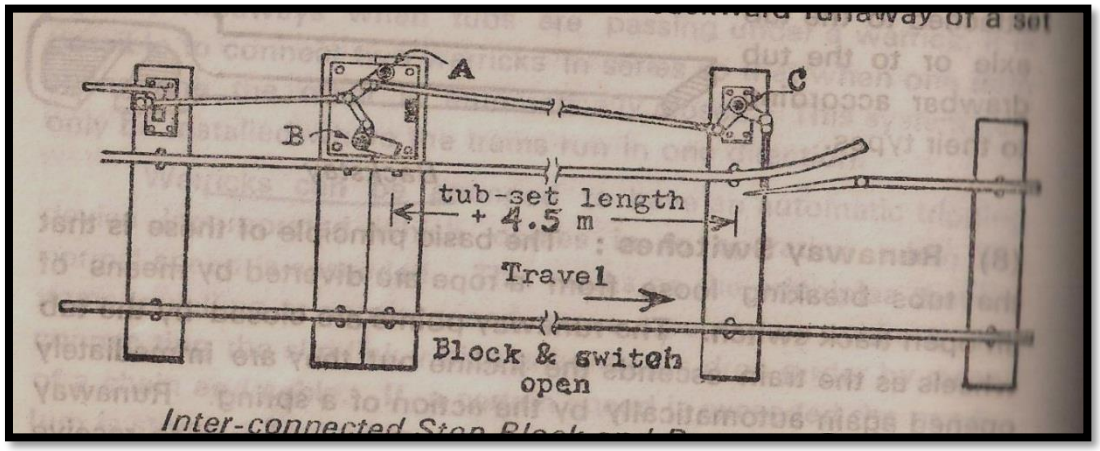


8. **Run Away Switch :** This switch is normally kept open by a spring. When a lever handle is operated by an operator, the switch gets closed. And tubs can pass over it otherwise the tub derails when they pass over the runaway switch. It is used with direct rope haulage & main & tail rope haulage.



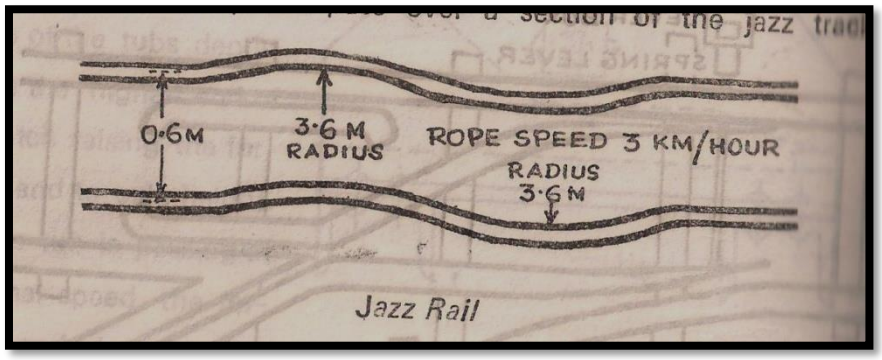
Spring Operated Runaway Switch

9. **Runaway Switch & Stop Block:** This safety device is situated at the incline mouth of direct or main & tail rope haulage. In this safety device the stop block & the runaway switch are so interconnected that at any time one of them is working. The distance between stop block & run away switch should be more than the train length (train length + 4.5 meter). The stop block & the primary switch are connected by a lever. When the lever is operated to clear the track from the stop block the runaway switch is open. But as soon as the tubs crosses stop block the lever is again operated to close the runaway switch & at the same time it is on the stop block.

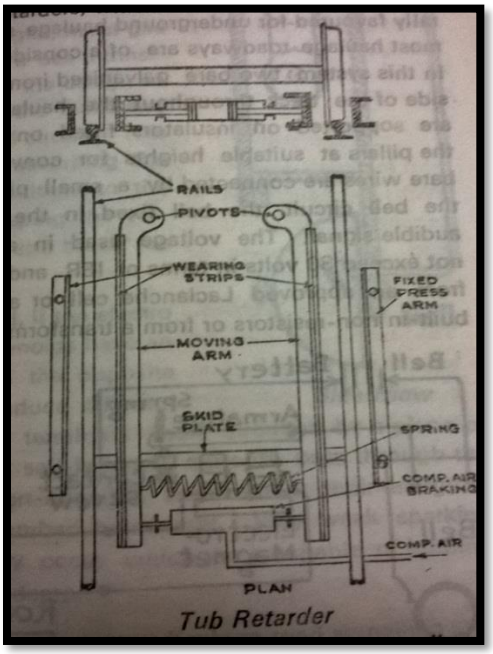


10.Jazz rails: The principle of this device is that tubs travelling at normal speed passes over section of the jazz track negotiating the bend readily.

If the tubs travel at excessive speed, as in the case of the runaway. They will fail to get round the bend and a derailment occurs. Rails should be bent in the correct radius.



11. Retarders: Slowing down and stopping tubs are integral parts of haulage operation. A hand operated retarder consists of two planks, lined on the top with belting and mounted on cams. An end cover plank fastened to the inside faces of planks serves to hold the plank in position. They are operated by a single lever. When the cams are fully raised, the tub wheels are lifted clear to the rails and a braking action is provided on the axle.



The tub retarders represents waste of energy and should be avoided in planning. However, the speed movement of tubs required for quick turn over and higher rising may make its application essential at pit top, pit bottom haul brow heads etc. There are many types of elaborate designs and manually control. Smooth breaking may be affected by air or hydraulic breaking.

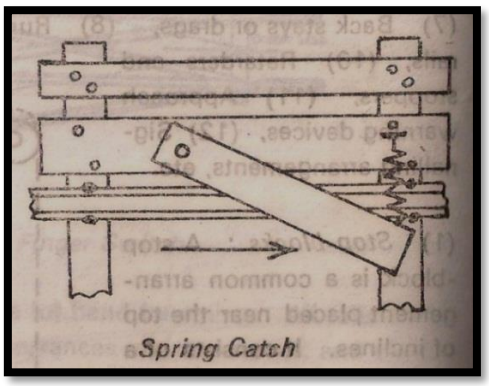
Fully automatic retarders, which are released by pneumatic cylinder, are widely used. The device consist of two pairs of hinged bars faced with renewable skid plates and breaking action effected by movement of two opposing pistons of in a cylinder containing air. The bars are raised above the rail level and grip the wheels.

When no braking is desired, the value releasing to the atmosphere is opened after cutting of compressed air supply. A spring draws back the breaking bars to normal position.

An automatic hydraulic tub retarder is suitable for locomotive haulage or ordinary rope haulage. The hydraulic pressure is supplied from 1-2 KW eclectically driven pump. The oncoming tramp is retarded by the tread of the leading wheels running fixed skids and an inclined hinged platform which acts as a wedge.

12. APPORACH WARNING DEVICE: It is sometime necessary to warn man working or travelling in a haulage roadway. A simple way of operating a warning device in a rope haulage roads is an arm protruding into the path of oncoming trams which, when deflected closes an electric circuit connected to a signal lamp or a bell. The device is operated by a lever depressed by tram axle.

13. Spring Catch: It consists of a wooden block at one end & pressed sideways over the rail at the other end by a spring as shown in figure. The tub moving in proper direction pushes aside the wooden block & passes over it, but due to spring the wooden block at once returns to its original position to arrest a backward run away tub. It is used in endless rope haulage.



14. Manholes: Height should be more than 1.8 meter, depth should be more than 1.2 meter & width should be more than 0.7 to 1 meter. When person are allowed to work or pass through an incline, when the haulage is in motion, the manholes are made along the roadways so that person travelling can take shelter in the manholes. The interval between two manholes should not be more 10 meters, but if the gradient is less than 1:6 the interval may be up to 20 meter. If the roadways are less than 1.8 meter in height the manhole should be made up of full height of the roadway it is used in direct, main & tail & endless rope haulages.

LOCOMOTIVES

Main Parts of Locomotives

1) **Chasis:**Chesis is rigid frame work of steel section.
2) Driving wheels, axles, springs & brake blocks etc. mounted below the Chasis.
3) **A power Unit:** it may be a diesel engine, an electric motor, a battery or compressed air.
4) **Operator's Cabin:** Having control panel with brakes, operating system, horn etc.
5) Lights at both ends.
6) A screw brake for emergency.
7) For large size locomotives an air compression for power brakes.

Locomotive Haulage: In case of rope haulage the power to move the load is available from external fixed motor to the haulage. While in case of locomotive haulage the driving unit i.e. locomotive is coupled to a train due to which more safety can be attained. The locomotives are very flexible in nature & they can be used for men transport also.

Types of Locomotive Haulages are:-

1) Diesel locomotive
2) Electric locomotive

1) Over head wire locomotive
2) Trolley wire locomotive

3) Electric battery locomotive
4) Compressed air locomotive

1)**Diesel Locomotive:** Diesel locomotive are commonly used in number of mines. Their weight varies from 3 tonne to 15 tonne & power from 50kw to 75kw. The power unit is a diesel engine. The locomotives used in underground coalmines have a power unit in a flame proof enclosure as a safe guard against ignition of fire damp. In coal mines the diesel locomotives are not allowed where the percentage of inflammable gases is more than 1.25% in the general body of air. Hence these are generally used in intake roadways. The exhaust of the diesel engine includes oxygen, nitrogen, carbon dioxide & small quantities of oxides of sulphur & nitrogen & other aldehydes which smell badly &causes irritation of the nose, throat & eyes. To remove these oxides & aldehydes the locomotives are fitted with exhaust conditioner

Advantages of Diesel Locomotives

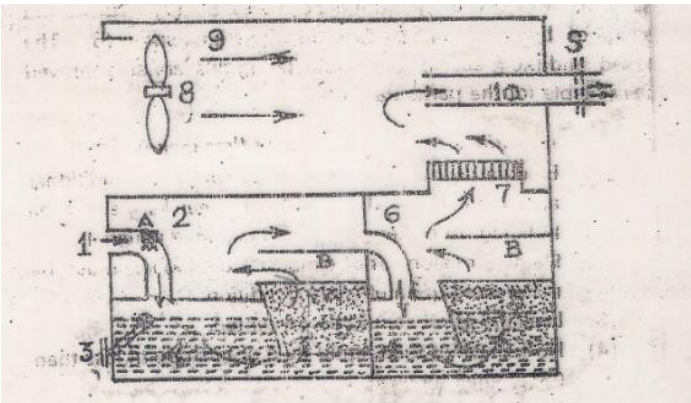
1. Cheaper
2. Completely self-controlled

Disadvantages of Diesel Locomotives

1. Danger of fire in handling the diesel.
2. production of poisonous gasses
3. Adds heats to the atmosphere.
4. More maintenance required.
5. More employees required.

Exhaust Conditioner & Flame Trap: The exhaust gases from the engine strikes on the surface of the water in the chamber A. This traps hot particles & washes out the sulphur oxides & aldehydes. The gases then rise through a flame proof slag wool which is kept moist by water & thereafter pass through second chamber. Similar chamber B, where gases are further cooled & filtered before passing through the flame trap. A flame arrester consists of a removable stainless steel plates 1/2mm apart. Finally gases are mixed with about 30 to 40 times their volume of fresh air before entering in the atmosphere. In chamber A, a water level indicator is installed in such a way that if water level falls below certain level, the brakes are applied

automatically. The exhaust conditioner should be replaced by a clean set after every 24 hours.



Exhaust Conditioner

(1) Engine exhaust, (2) Conditioning chamber-I, (3) Contro valve with float, (4) Water, (5) Filter box, (6) Conditione chamber-II, (7) Flame trap, (8) Fan, (9) Mixing chamber (10) Exhaust outlet atmosphere. (A) Fine water spra (B) Baffles (S) Silencer.

2)**Electric Locomotives:** The electric locomotive is equipped with an electric motor which draws the current from the overhead wires through a pantograph or through a long pole which is kept pressed against the overhead conductor by spring tension. The DC supply to overhead wires is 250 volts. These locomotives may be used in degree I gassy mines. The overhead wires are suspended through insulators over the track at a height more than 2 meter.

Advantages of Electric Locomotives

1) More reliable
2) Light weight
3) Less maintenance
4) Good control
5) Small size
6) No exhaust gases

Disadvantages of Electric Locomotives

1. High initial investment
2. Danger of shock & fire
3. Derailment is major problem

3)**Electric Battery Locomotives:** The power unit of an electric battery locomotive is a DC electric motor which receives current from a storage battery carried in the locomotive itself. Such locomotives are for light & medium duties. The batteries are of lead acid type & each battery consists of a number of 2 volt cells & their no varies from 40 to 70. The capacity of the battery to work is 8 hours & its charging time is also 8 hour.

Advantages of Battery Locomotives

1) Less maintenance.
2) No poisonous gases.
3) No overheads wire's problem.
4) Quite in operation.

Disadvantages of Battery Locomotives

1. Hydrogen gas is liberated.
2. Flame proofing is not possible.
3. Overheating of cell may cause sparking or fire.
4. Large cross section.
5. Expensive batteries & less life.
6. Special charging stations involve more cost.

3) **Compressed Air Locomotive:** There are no compressed air locomotives in Indian coal mines. The source of power used in air locomotive is compressed air cylinder, installed over the locomotive. This cylinder supplies the required quantity of compressed air to the locomotive. These locomotives are very safe, reliable & very useful in hot & deep mines. Even though their working cost is very low, they are not used in Indian coal mines due to their high cost of installation. These locomotives are used for light duty work only.

Advantages of Compressed Air Locomotives

1) Very safe.
2) Very reliable.
3) Less maintenance required.

4) Cooling effect of air.

Disadvantages of Compressed Air Locomotives

1)High initial cost
2) Danger of pipe leakage.
3) Efficiency is less.

Super Elevation/Cant: On a curve, centrifugal action creates a tendency for the train to leave the track & proceed along a line tangential to the curve. This makes the wheel flanges very hard against the inner edge of the outer rail, causing more wear on wheels & rails. To counter act this; the outer rail should be raised above the inner one. This level difference between the inner rail & outer rail is known as super elevation.

S.E. = AV2/g.r meter.

Where,

A = gauge width in meter.

V = velocity in meter/sec.

g = acceleration due to gravity (9.8 meter/sec)

r = radius of curve in meter.

Ideal Gradient: If the Tractive force required to haul the loaded trail down the gradient is same as it is required to haul the empty train of the gradient with the same velocity, this gradient is known as ideal gradient. Let,

WL = Weight of loaded train.

WE = Weight of empty train

1 in n = Ideal gradient

 = coefficient of friction

Case I: When loaded train is moving downward

GL = WL.g.1/n

FL = WL. g. (

TF = FL – GL

TF = WL. g. (- WL.g 1/n---------- (I)

Case II: When empty train is moving upward

GE = WE.g.1/n

FE = WE.g

TF = FE+GL

TF = WE.g (+ WE.g.1/n----------(II)

As per the definition equation (I) = (II)

WL.g. (-WL.g.1/n = WE g + WE g 1/n

WL -WE = WE.1/n + WL.1/n

((WL-WE) = 1/n (WE+WL)

n= (WL+WE)/ ((WL-WE)

Drawbar Pull: This is that part of the Tractive force which remains available for pulling connected load, hence drawbar pull can be calculated after deducting from the total Tractive force, the Tractive force required to haul the locomotive itself.

TF=TM Wloco = kg

TF= TM Wloco. g = N

TM= Coefficient of adhesion

Force = mass X acceleration

(TF+GL+FL=mass X acceleration.

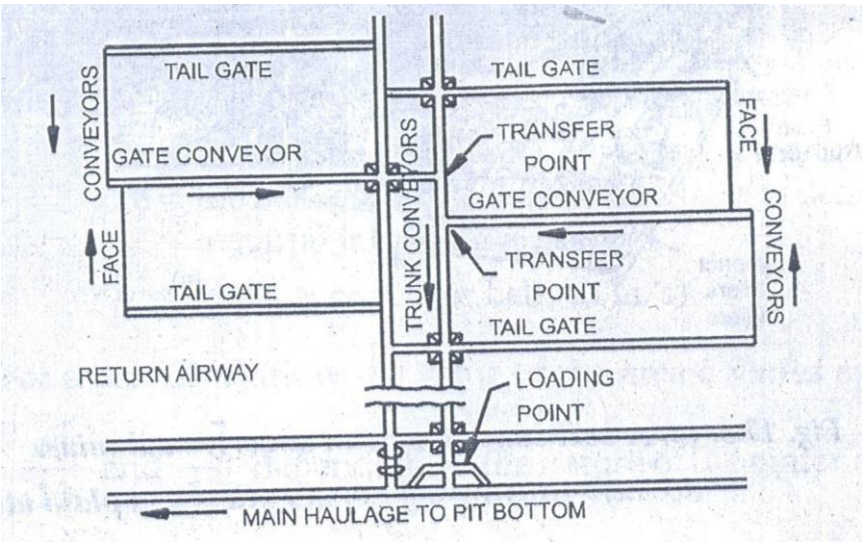
C) Conveyor system of haulage

1) Belt conveyor
2) Chain conveyor

1) **Belt conveyor**

The belt conveyor is basically an endless belt in a straight line stretched between two drums, one driving the system and the other acting as a return drum.

In coal mines and other mines of stratified deposits, where the underground mineral if won by longwall method, the transport media which often consists of conveyor.



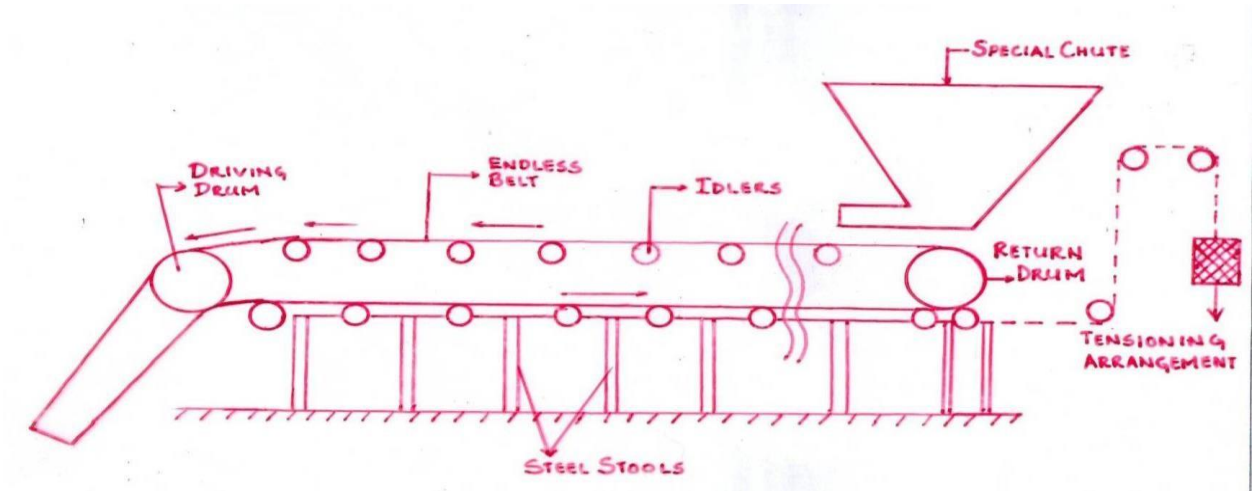
Layout of face, gate and trunk conveyors in a coal mine

The system of transport by belt conveyor consists of the following:

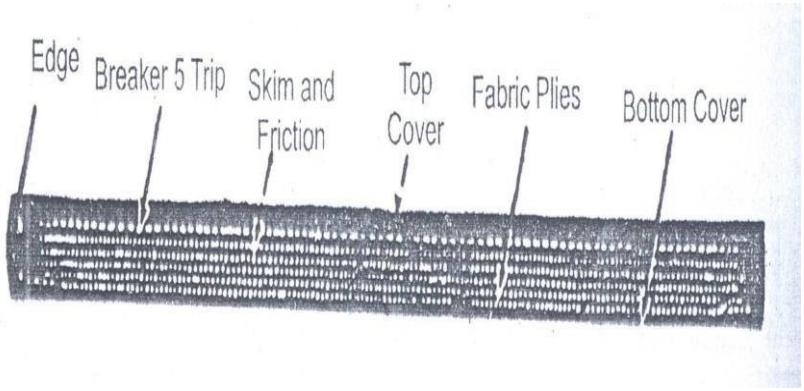
1. A flat endless **belt** which moves continuously and carries at its top surface the material to be conveyed.
2. The **idlers** which support the belt.
3. The structure of channel iron on which the idlers are mounted.
4. The tensioning arrangement for keeping the belt in proper tension.

5. The drums at the discharge and tail end over which the belt passes.

6. **The drive** head which comprises the electric motor, coupling, gearing and snub pulleys



Arrangement of a belt conveyor



Cross-section of belt for conveyor system

Selection of belt conveyor:

1. Amount of material to be conveyed

2. Continuity of operation needed

3. Size of lumps

4. Distance of transportation

5. Environmental allowance

6. Gradient

7. Method of coal winning, i.e. Longwall or Bord and Pillar

8. Capital Available

Advantages:

1. A continuous supply of material.

2. Low operating cost than road transportation system.

3. High rate and speed of supply.

4. Bunding can be done to get fair grade.

5. More efficiency and low cost.

Limitations:

Belt conveyor:

1. Cannot be used for long distances

2. Required high one time capital

3. Lumps should not be of big size.

4. Place should be dry enough and air velocity should not be high

5. Cannot be worked for high inclinations

Factors for designing of belt conveyor:

1. The average tonnage (t/h), peak rate (t/min) and frequency of peak rates.

2. Characteristics of the material i.e. density, maximum lump size, nature of material-dry, wet, sticky, dusty, chemical action on belt.

3. Graphical layout of conveyor profile and motive power available (i.e. electric motor).

4. Operating conditions - hours of working, climatic conditions etc.

5. Suitability of a belt conveyor & width and speed of belt

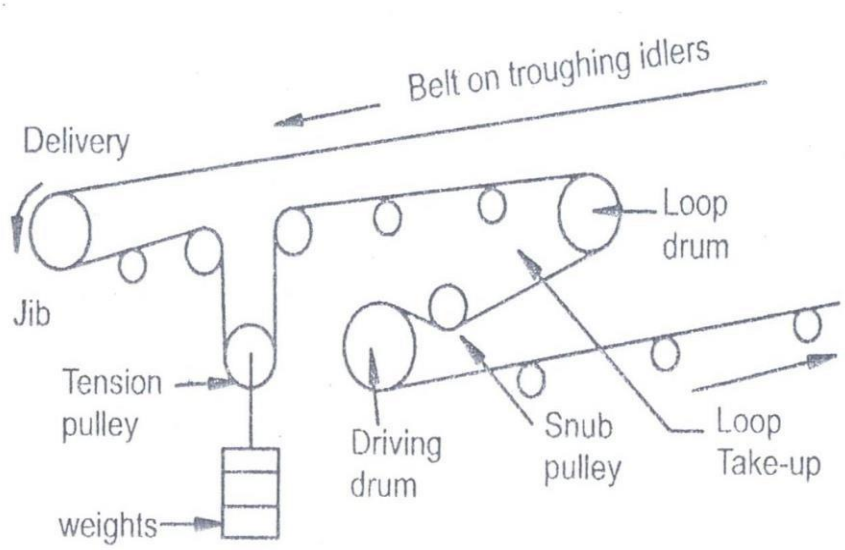
6. Belt shape.

7. Power and layout required.

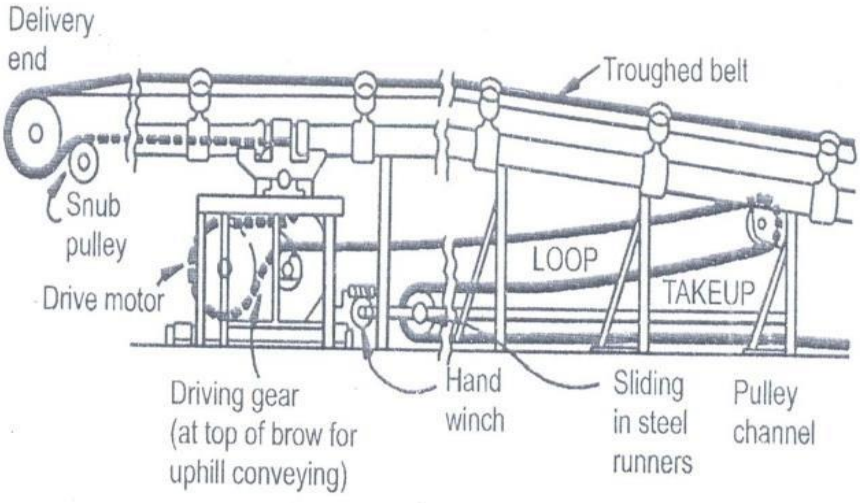
Take- up arrangements (Tensioning device):

Tensioning of the belt is necessary to prevent excessive sagging of the belt or belt in good contact with the driving drum.

1. Automatic take ups
2. Gravity take ups.
3. Take up pulley with counter weight.
4. Counter weighted loop take.
5. Counterweighted wheel mounted tail end pulley
6. Power take ups
7. Electric motorized winch and load cell loop take up.
8. Pneumatically operated take up
9. Hydraulically loop takes up.
10. Rigid or manual take ups
11. Screw take up
12. Jack take up
13. Winch take up



Arrangement of a drive motor, loop take-up and tensioning weights on a belt conveyor discharging downhill

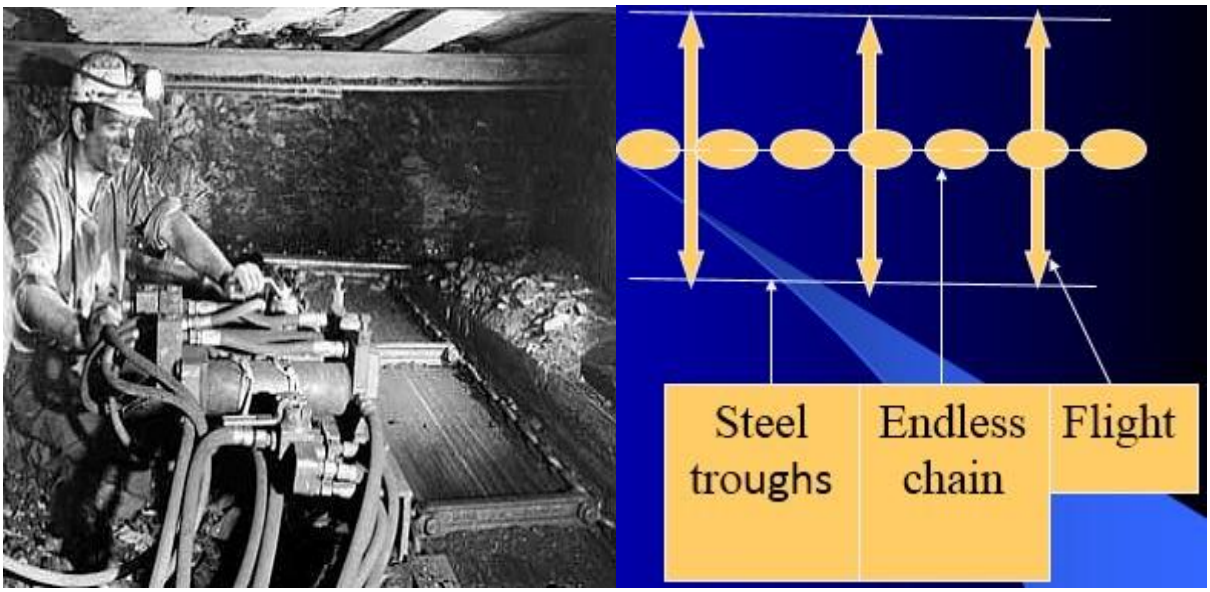


Arrangement of a driving gear and loop take- up for a belt conveyor on level or uphill

2) **Chain conveyor**

It is mostly used in the longwall face. The capacity of a commonly used scraper chain conveyor is 30 to 40 tph on a level roadway, nearly 50 m long and the drive motor is of 12- 15 KW. The main application of scraper chain conveyors in underground is

transportation at the face and adjoining short workings, where they are ready to withstand mining condition. They are also used to haul the coal along gate roads over short distances before it is feed to gate belt conveyor. They are also used for transporting on inclines having an angle of inclination exceeding 180 where belt conveyors are not used. They are also used on the surface for conveying coal from shaft to bunker as well as in screening and washing plants.



Scraper chain conveyor

Different parts:

1. Trough: These are stationary things usually 2m long, and consisting of detachable section bolted together or joined by hooks,
2. Flights: An endless chain with flights moving in the troughs, which are nearly 450 mm wide at top and 300 mm at bottom.
3. Chain (endless): The chain of endless character is installed there. The chain consists of links and after 3-4 links a flight is provided so, that the flights are 2-2.5m apart.
4. Tensioning head: The return or, tail end of the conveyor with its totally enclosed sprocket drum, is provided with telescopic trough by which the tension of the chain can be adjusted through Sylvester chain

5. Drive: For enabling movement a power arrangement with driving arrangement.

6. Angle iron frame: to support the troughs.

Types:

On the basis of flexibility—

1. Rigid chain conveyor

2. Flexible / armoured chain conveyor

On the basis of number of chains used—

1. Single chain conveyor

2. Double centered chain conveyor

3. Double outboard chain conveyor

4. Triple chain conveyor

Rigid chain conveyor: A rigid chain conveyor essentially consists of stationary steel troughs, each usually 2m long, connected together end to end, and an endless chain with flights moving in the troughs. Troughs supported on angle iron frame work, slightly dished at one end. So, that the next one fixed in to form a flush point. Adjacent troughs are secured together and to the frame underway by both. This gives rigidity to conveyor. The return end is provided with a tensioning arrangement. The capacity is 30- 40 tph on a level roadway, nearly 50m long and 15KW motor.

Armoured chain conveyor: Used generally on long wall faces, it can be advanced without dismantling, with hydraulic rams. They can work with lateral or, vertical undulations, and coal cutting machine and shearers can be mounted on them. Motor power varies between 30 to 185 KW.Pan width at top varies from 750 to 850 mm and pan length from 1.3 to 1.8 m. the vertical flexibility of pans is 3-40 and horizontal flexibility is 2-30.Limiting gradient with flights 1 in 1.5 and without flights 1 in 3.Length may be upto 360 m and capacity is upto 100 tph.

Advantages:

1. Can convey uphill against relatively steep (1 in 3 or more) gradient as well as of downhill gradient.
2. Much stronger and can be roughly handled.
3. Flexible so, as to dismantle, extended or shortened.

Disadvantages:

1. High initial cost.
2. High power consumption
3. Wear and tear more
4. Highly noisy
5. Producing high percentage of fine dust

D) Aerial ropeway

An aerial ropeway is an installation in which transportation of material or men is effected by moving carriers pulled by ropes suspended above the ground.

Types:

On the basis of number of ropes and the mode of transportation, the ropeways are classified as:

1)**Mono-cable Ropeway–** the ropeway has a single running endless rope which both support and moves the carriers.

2) **Bi-cable Ropeway-** the ropeway has two fixed track ropes along which the carriers are hauled by an endless traction rope.

3) **Twin-cable Ropeway-** the ropeway has two pairs of track ropes to support the carriers and one endless traction rope.

Applicability

Aerial ropeway provides the only economic means of long distance transport over rough country, hilly and difficult terrain, even it can pass through the congested areas, marshy lands, nallahs, rivers, forests and important agricultural land.

Aerial ropeways have found wide application in:

1)Transporting and conveying bulk materials between two fixed pts.

2)Aerial dumping of load at any point along the line of route

3)Stocking of materials

4)Dumping of waste materials

5)Transporting of persons in mountainous regions **Advantages:**

1) A relatively high transport capacity (upto 500 t/hr)

2) Regularity of service and immunity to all weathers

3)Ability to overcome natural obstructions (rivers, marshy ground etc.)

4)Inherent ability to keep the ground free for other purposes

5) Ability of negotiating steep gradient (70% and over)

6) Possibility of using automation

7) Minimum time lost in transportation

8) Low initial and operating cost and short time for return on capital

Disadvantages:

1)Fixed location of loading station

2) Susceptibility to damage by string winds.

3) The length of the line and transport capacity is limited by economic and technical consideration.

Bi-cable Ropeway

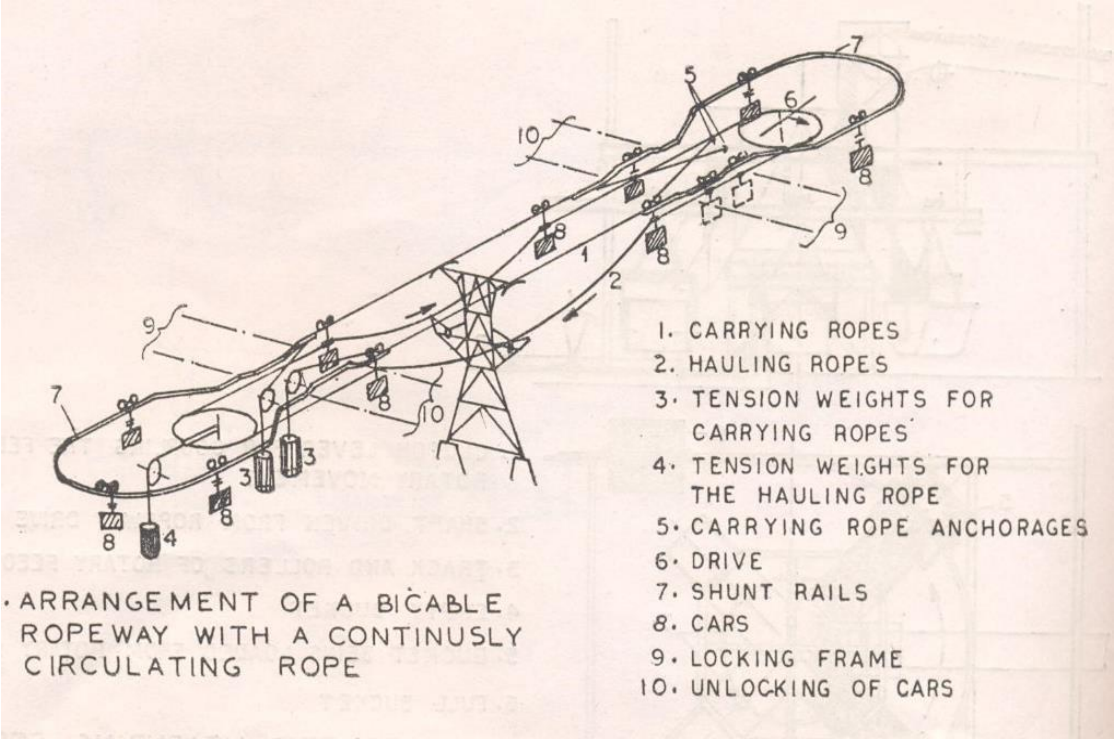
It has following components:

1. Two track ropes or cables stretched at required tension

2. An endless traction rope for handling the loads,

3. Carriers suspended from the track ropes and hauled by the traction rope

4.Machinery and other arrangements for loading and unloading carriers, suspending the track ropes and driving the traction rope.



ARRANGEMENT OF A BICABLE ROPEWAY WITH A CONTINUSLY CIRCULATING ROPE

<u>Bi-cable Ariel ropeway</u>

Scope of applicability and Limitations

a.Bi-cable ropeways are suitable for capacities 100 to 400 t/hr.

b. lengths up to 6 km in one section of traction rope.

c. For capacities less than 100 t/hr. and distances less than 300 m, bi-cable ropeway cannot provide the desirable economy.

Different parts Ropes:

Track ropes:

1.Track ropes are usually locked coil ropes made of large size wires in order to have longer life.

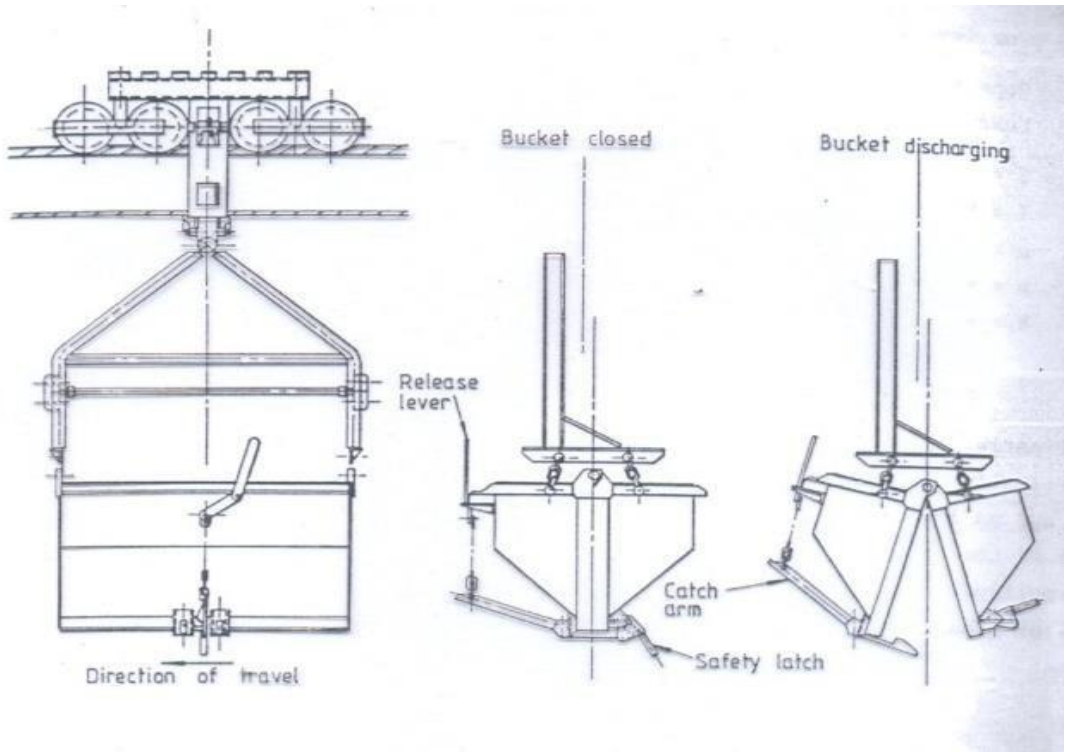
2. Locked coil ropes provide a smooth surface for the movement of carrier wheel and the surface wear of it is relatively uniform.

3. The factor of safety for track rope during installation should be 3 and must be withdrawn from service when it reduces to 2.5.

4. Average life of the rope is 5 to 7 years.

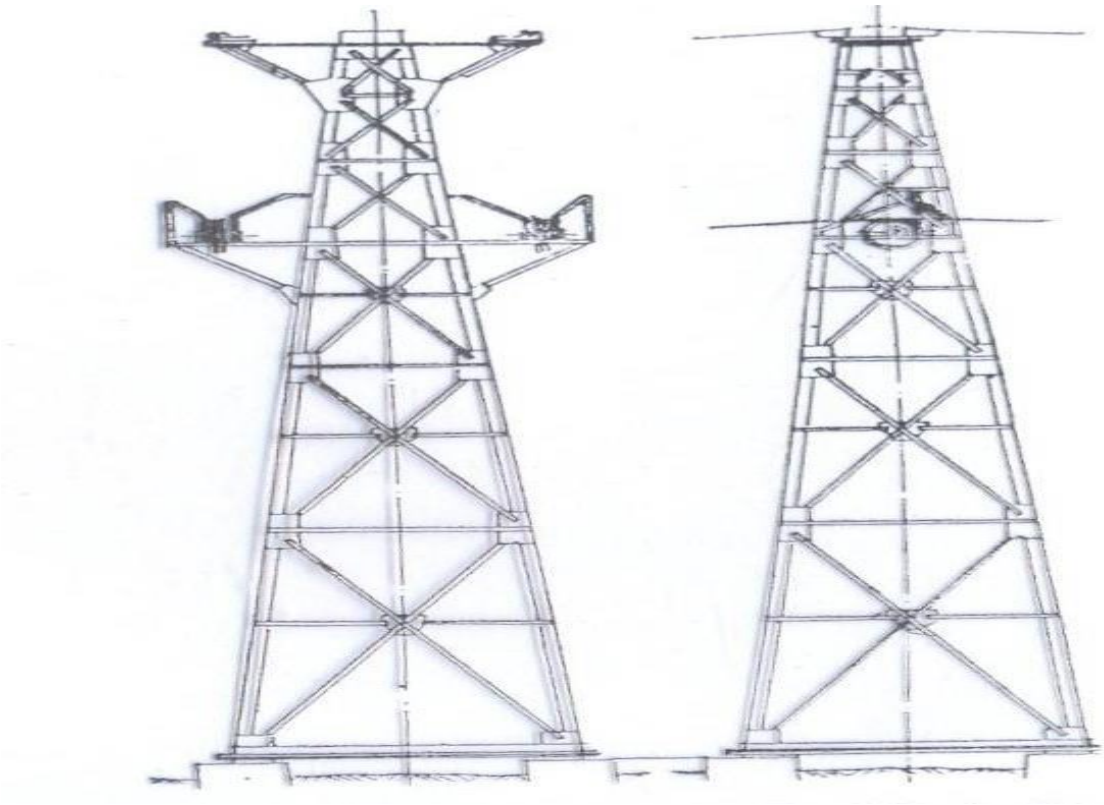
Traction rope: Traction ropes are Six-strand lang's lay with fibre core. The rope diameter varies from 12 to 46 mm. The factor of safety should be 5 during installation and ropes should be withdrawn when it comes down to 4.

Carriers: A carrier has the carriage, hanger, bucket and grip for traction rope. Carriage runs on track rope with wheels, and it runs on the track rope, with the help of wheels (20 – 30 cm/diameter) mounted on it. The number of wheel is 2 for light loads and 4 for medium or heavy loads. The hanger is suspended from carriage to make its axis vertical. The bucket is supported by the hanger and grip on carriage. Three types of carriers are commonly used namely rotating carrier, bottom discharge carrier and fully enclosed bucket.



Carrier of bi-cable ropeway

Trestles: The trestles for bi-cable ropeways provide support to both the track and traction ropes. As well as giving necessary profile to the ropeway. The track ropes rest on the saddles at the top crossbeam and the traction rope on the sheaves at the cross beam below. Trestles are constructed either in steel, reinforced concrete / timber. The height of the trestles is usually in the shape of a truncated pyramid. The ht. of the trestles is usually 8 to 12 m on level ground and spaced at intervals of 100-250 m. But in a mountainous region, they must be as high as 100 m and spaced at 500 m or more. The trestles should be erected on firm ground.



Steel trestles of a Bi-cable aerial ropeway

Saddles: These are rolled steel section bent along their longitudinal central line to allow rope curvature on the support. The upper part of the saddle is grooved to accommodate and support the track rope. For safety against unloading of the rope, the groove dia. should be 1.5 d and the depth of the groove 0.8d, where d is the diameter of the rope.

Stations:

Loading station: Station where carriers are loaded are called loading station and in bi-cable ropeway it is more complicated than mono cable ropeway. At the loading stations, the track rope tensioning device is avoided and the end of it is anchored instead. However the tensioning of the traction rope may be incorporated. At the entry to station, the carrier leaves the track rope and rides on the station rail and while leaving it, rides back on the rope. To facilitate those, rope deflecting saddles are put at the transition point. The carriers passes through the arrangement of

releasing and gripping of the traction rope movement of the carrier is controlled manually or by running chain at automatic station.

Unloading station: It is the discharged end of the rope way. The unloading station should be sufficiently high enough above the ground level to make possible unloading by gravity.

Intermediate station: When a bi-cable ropeway has more than one section, intermediate stations are provided where it passes from one section to another. Arrangements are there for tensioning.

Angle station: When it is not possible to take a straight line route, angle station are provided to change the direction of route. Here the track ropes of adjacent arms terminate by means of anchorage or tensioning arrangement.

Chapter No. 2 – Winding In Shaft

WINDING:- The Purpose of Winding is to

1) Hoist the coal or mineral from underground to surface.
2)
3) Lowering & rising of men.

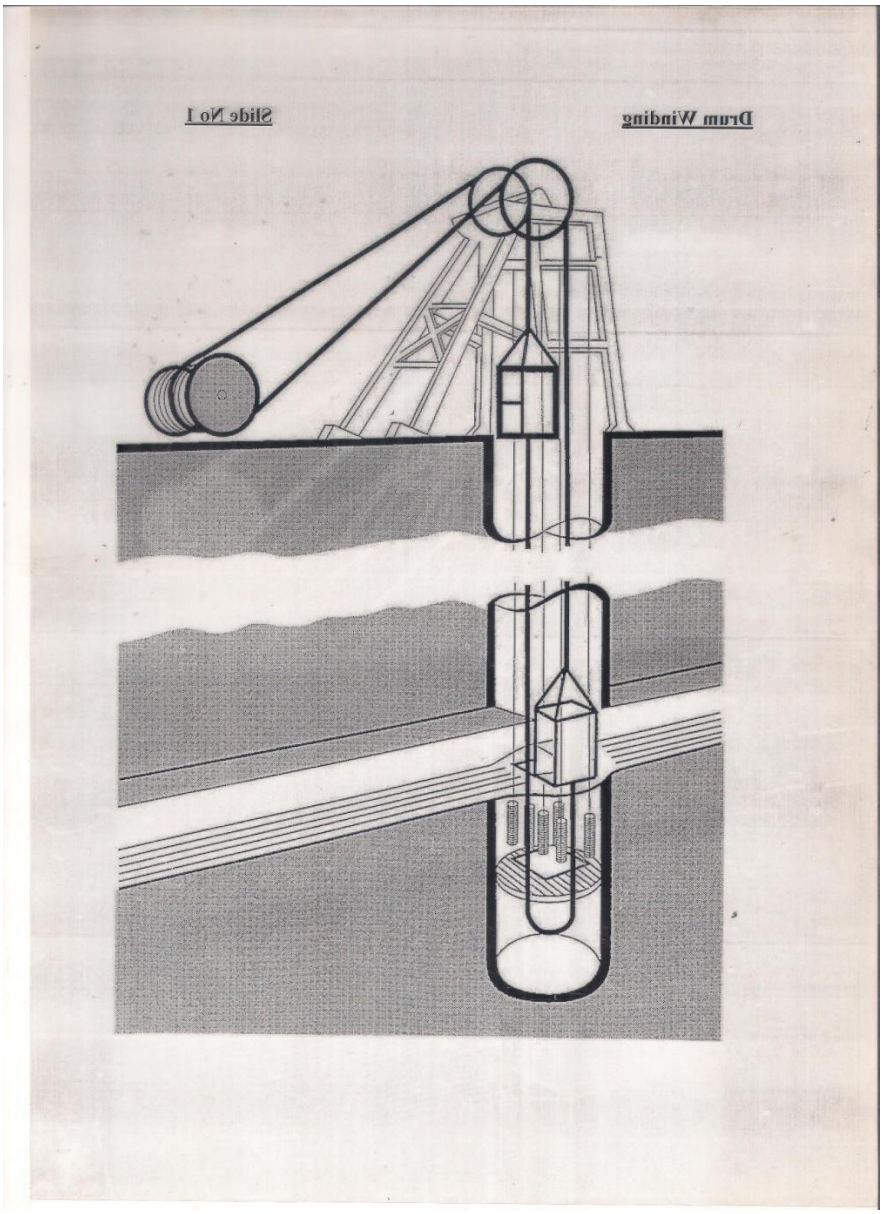
4) Transport the material from surface to underground
5) Winding is a transport system from surface to underground through shaft when the mine is dip. It is more or less same as we see a lift in a multiplex building.

Main Equipments used for Winding

1) Headgear
2) Pulley (headgear pulley)
3) Cage
4) Skip
5) Winding rope
6) Winding drum
7) Guides
8) Keps
9) Suspension gear
10) Electrical motor

1) **Headgear:**It is a steel or concrete framework on the mouth of the shaft. The purpose of headgear is to:
   a) Support the headgear pulley, the weight of cage, ropes & rope guides.
   b) Guide the cage to banking level.

The headgear consists of four girders inclined towards the centre of the shaft at an inclination of 1 in 8 to 1 in 10. A network of steel girders joins these four girders to each other. Two real legs situated towards the winding engine room are connected to the headgear to prevent its building. This rear legs are also used as ladder way. Two headgear pulleys are installed at the tope of the headgear & a bell plate is installed below the headgear pulley.



c) These types of headgears are used in drum winding & are known as six legs tied headgear.
d) **Four-leg Headgear:** This type of headgear is used in friction winding. The construction is same as that of six-leg type headgear but only the difference is that it does not have two rear legs.
e) **Two-leg Headgear:** It consists of only two legs inclined towards the shaft. The headgear pulley is installed on a cross member mounted between two legs. This type of headgear is not used.

Design of Headgear depends on following parameters

1) **Total Static Loads:** Weight of cage, rope, pulley, guide rope, tub & mineral.

2) Rate of acceleration & retardation 3) Maximum velocity.
4) Depth of shaft
5) Diameter of shaft 6) Size of cage/Skip 7) Wind pressure.

Heights of Headgear depends on

1) Banking level
2) Height of the cage
3) Cage suspension gear
4) Diameter of headgear pulley
5) Inspection platform

Height of a Headgear

Sr. No.	Name of attachment	Cage in meter	Skip in meter
1.	Height of cage/skip	1.8 to 6	1.8 to6
2.	Suspension gear	3 to 4.5	3 to 4.5
3.	Height of banking level	4.5 to 6	6 to 8
4.	Over winding distance	1.8 to 7.2	1.8 to7.2
5.	Diameter of winding pulley	3.6 to 7.2	3.6 to7.2
6.	Inspection platform	3.6	3.6
		18.3 to 30.9	19.8 to 32.9

2) **Headgear Pulley:** It is made up of hard steel. Its construction should be such that its weight is less. Its diameter should be such that it should minimise the bending stresses in the rope. Generally its diameter is 100 to 120 times diameter of the rope. The large size pulleys are made in two parts& bolted together. The groove is made of renewable soft steel & its diameter should be 110% of the ropes diameter for stranded ropes & 105% for locked coil ropes.

3) **Cage:** It is a lift like structure suspended from winding rope by means of suspension gear arrangement. It is used for the transportation of men & materials. It is made up of steel & very strong in construction. A track is provided on the floor with catches to prevent the movement of the tubs. It is open with two sides & provided with collapsible door. Man travelling in the cage provides a hand bar on the sides for holding. The types of cage are as follows:
    a) Single deck single cage (only one tub).
    b) Tension cage – two tubs or more in one cage.
    c) Double deck single cage (one tub on each floor).
    d) Double deck tension cage (two or more tubs on each floor).

4) **Skip:** Skips are generally used for coal or mineral transport only, but, in new construction type; the men can also travel in the upper portion of the skip. It does not accommodate tubs but coal or mineral is directly filled in the skip from the roof& it is discharged from the bottom. Its capacity is very high but if the mineral is of different grade then mixing of the mineral & degradation of mineral is a problem.

5) **Winding Ropes**

Type of Winding Ropes: A rope, which is used for winding, is generally a stranded rope, fibre core & Lang's lay construction. This type of rope is having more flexibility & smooth external surface this reduces the wear & tear of the rope.

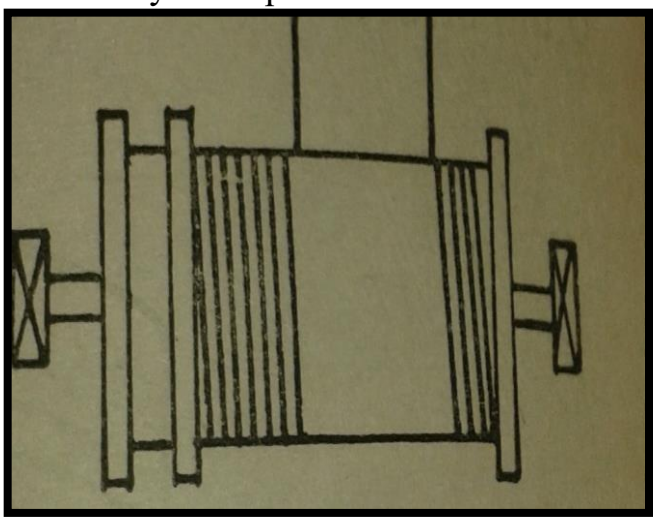
Winding Drum

Drum profile: -The power required for winding resulted in the use of various drum profiles or shapes in order to afford the efficient design there are four different shapes of drum used in India these are

1. **Cylindrical drum.**
2. **Conical drum.**
3. **Cylindro-conical drum.**
4. **Bi-cylidro-conical drum**.

1.Cylindrical drum: - A cylindrical or parallel drum is a simple and robust in construction. The winding ropes are attached at each end of the drum barrel, and arrange to coil on the drum in the opposite direction, so that when the drum rotates

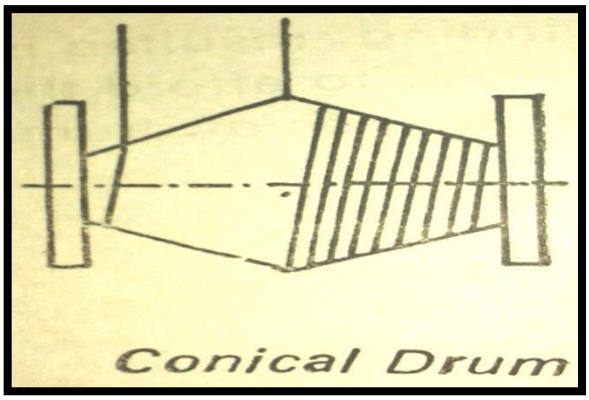
one cage will be raised and the other lowered. The rope coiling underneath the drum is called under lap and the rope coiling over the top of the drum is the overlap. It may be either grooved or plain. Its serious drawback is that it can be used for shallow shaft only. In winding from deep shaft, the weight of one winding rope will exceed the weight of coal raised per wind. Thus there will an excessive load on engine when starting and negative load towards the end of the wind causing heavy brake wear. This unbalancing of load in cylindrical drums can be reduced by tail ropes.



The **advantage** of using tail rope is that only load against the engine wil be the constant load of coal raised, resulting in better control of engine and reduce power consumption. But the use of tail rope has the following **disadvantages:**

a. The total masses to be accelerated and decelerated are increased.
b. Extra cost of tail rope is incurred.
c. Weight on cappel is increased.

2.Conical drum: - It is provided with flanges on two sides of the conical portion for even coiling of rope. Rope supporting the full cage is coil on the small radius and that holding the empty cage on large radius at the commencement of the wind. These portions are reserved at the end of the wind.

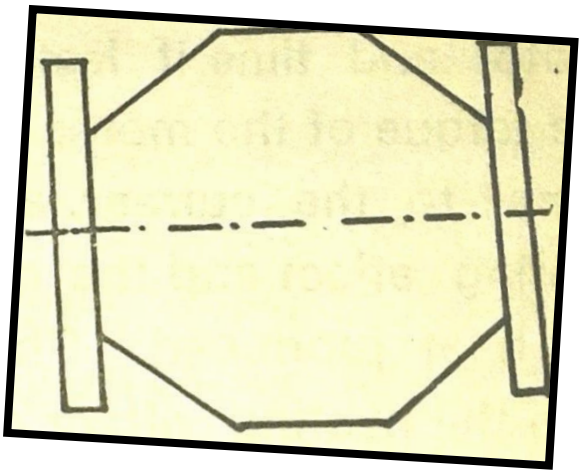


A conical drum has the following **advantages:-**

a. No tail rope is required.
b. At the commencement of wind, torque against engine, leaving the engine to accelerate the moving masses and to overcome friction.
c. At end of wind, instead of negative load there will be a positive load because the descending rope has now come on small diameter, reducing its toque while the ascending rope is on large diameter and its torque correspondingly increases.

The serious disadvantage of conical drum is that only the half width of drum can be used for coiling at each rope. Hence for deep shaft a huge size of drum will be required which may prove prohibitive proposition

3. **Cylindro-conical drum**:- This is an improvement upon the conical drum in which the apex of conical portion is provided with cylindrical drum. This is a combination of cone and a cylinder. The ascending rope is wound on the smaller diameter of the cone at first, and as the engine reaches full speed after the period of acceleration the rope is wound on the larger cylindrical part. For deep shaft the rope is wound back on itself for the last part of the hoisting period. The double winding materially reduces the total width of the drum.

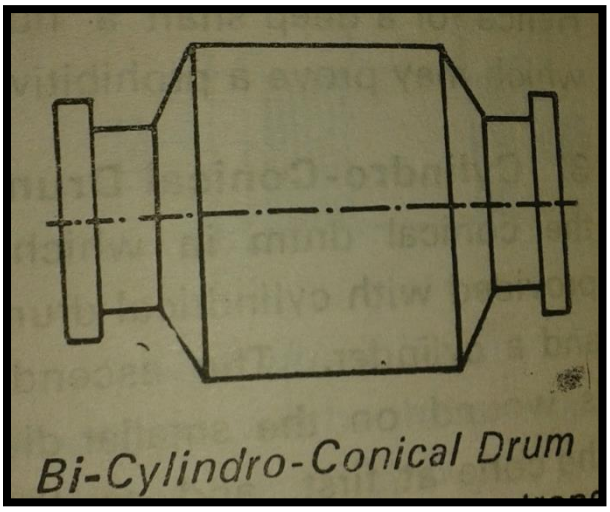


A cylindro-conical has the following **advantages**

a. The conical section improves the balance of the system at the beginning of the wind when the difference between the static torque due to suspended load is greatest.
b. The parallel or cylindrical section provides for additional space for coiling of ascending rope,provided that the fleet angle ratio is less than 1 in 40.if the condition is not obtained,additional capacity of ropes on parallel portion can be provided by fitting a centre plate to the drum and adopting double layer coiling

The main **disadvantages** are that the design is not so simple and the operation is not so smooth.

4. Bi-cylindro-conical drum: - It is composed of two cylindrical section, one of small diameter, the other of large diameter, joined by a conical section or scroll of uniform or variable pitch. At beginning of hoisting period the loaded rope is wound on the smaller cylinder until the full speed is attained, when the rope is transferred by the cone or scroll to the large diameter. Near the end of the hoist but just before the beginning of retardation, the descending rope is transferred from the large to the small cylinder.



The design of electric motors is largely controlled by the heating effect due to the hoisting cycle. Heating is proportional to the square of the current passing through the motor and time it lasts. Since the torque of the motor is proportional to the current, the high starting torque entails a strong heating effect and the motor must be large to properly dissipate the head produced. The bi-by-cylindro-conical drums serves to keep the heating effect of hoisting cycle below that of the cylindrical drum. It reduces the peak load on the motor and lands itself better than any other type of drum to a more definite control of torque especially during the starting torque.

A bi-cylindro-conical drum suffers from the following **Disadvantages:-**

a. It is heavier and more expensive than a cylindrical drum.
b. It cannot be used for multideck cages for simultaneous decking.
c. For deep winding the drum size becomes excessive.
d. Rope lying on conical portion may occupy more space than parallel sided drum and they may cause trouble due to angle of fleet.

Provisions of Winding Drums

1) Flanges.
2) Depth indicator.
3) Mechanical brakes.
4) Automatic contrivance.

1) **Flanges:** The flanges are provided on each side of the winding drum to prevent the rope from leaving the drum from the sides due to slip or slate in the rope. Its depth should be 10 to 15 cm.
2) **Depth Indicator:** A depth indicator is used to indicate the position of cage in the shaft. It is mounted on the drum winder through the gear arrangement as shown in figure. It consists of a dial & pointer moves in anticlockwise direction & during second half second the pointer moves in anticlockwise direction. When one cage is moves from bottom to top, the pointer moves from A to X1 to X2 to B. in this AX1 is the acceleration distance & X2B is the retardation distance. As soon as the pointer reaches the point X2, the power supply to ht engine should be cut off & brakes should be applied.

   When the cage moves from top to bottom the pointer move from B to X2 to X1 to A. in this BX2is the acceleration distance X2 X1 is the constant speed distance & X1A is the retardation distance. As soon as the pointer reaches the point X1, the power supply to the engine should be cut off & brakes should be applied.

3) **Mechanical Brakes:** Requirements of mechanical brakes are as under:
   1) When the cage is at rest, brakes should be in on position.
   2) When the cage in motion, brakes should be in off position.
   3) In case of power failure, the brakes should come in on position automatically.
   4) Brakes should not be used for speed control. 5) Types of mechanical brakes
   6) Anchored post brakes.
   7) Centre suspended calliper post brakes

   a) **Anchored Post Brakes:** It is made of two 'H' section girder pivoted at P1 & P2. Each post carries its own curved brake block fitted with brake lining. The front post carries a triangular lever at its top. This lever is connected with rear post by a tie rod T2 & the main lever through tie rod T1. The main lever is pivoted at P & its anchor end carries a suspended weight. The main lever is also connected to a hydraulic cylinder through a piston rod.

   Working: When there is no rod to the brake engine, the main lever fails down under the suspended weight due to this tie rod T1 is pulled downward to operate a triangular lever in anticlockwise direction due to which the tie rod T2 is pulled. Force acting on a front post towards the brake path, applied the brakes & anchor force which is acting on the rear post by tie rod T2 applied the braking effect to the drum.

To operate a winding drum power is supplied to the brake engine to raise the piston rod which lifts the main lever upwards against the upward against the suspended weight. It will push the tie rod even upward to operate the triangular lever, which pulls the front post & at the same time pushes the rear post through tie rod T2. Thus the brakes are away from the brake path & the drum is free to rotate.

The main disadvantage of this brake is that the wear & tear of the brake lining is not uniform & it is more at top & minimum at the bottom.

b) **Centre Suspended Calliper Post Brake:** It consists of two-curved arm namely front & rear, front curved are consist of two triangular levers L1 & L2. These triangular levers are connected to the main lever at point A & B through tie rod T1 & T3 as shown in figure. Triangular lever L1 & L2 are also connected to rear curved arm to tie rod T2 & T4. Main lever, which is pivoted at P1, consists a suspended weight & a piston rod to another end.
Working: When there is no power to the brake engine the suspended weight falls so that main lever moves in anticlockwise direction about P1. Due to this tie rod T1 & T3 are pulled to operate the L1 & L2 in anticlockwise & clockwise direction respectively. These triangular levers pull the tie rod T2 & T4 so that rear curved arm is closed to the brake path & also pushes the front curved arm towards the brake path. In this way a uniform braking effect is obtained.

To operate the winding drum, power is supplied to the brake engine to raise the piston rod against the suspended load. Now the main lever rotates in clockwise direction around P1 in such a way that it pushes the tie rod T1 & T3 to operate the L1 & L2. L1 & L2 moves clockwise & anticlockwise direction respectively to release the front curved arm from the brake path & pushes the T2 & T4 to push the rear curved arm away from the brake path to release the brake.

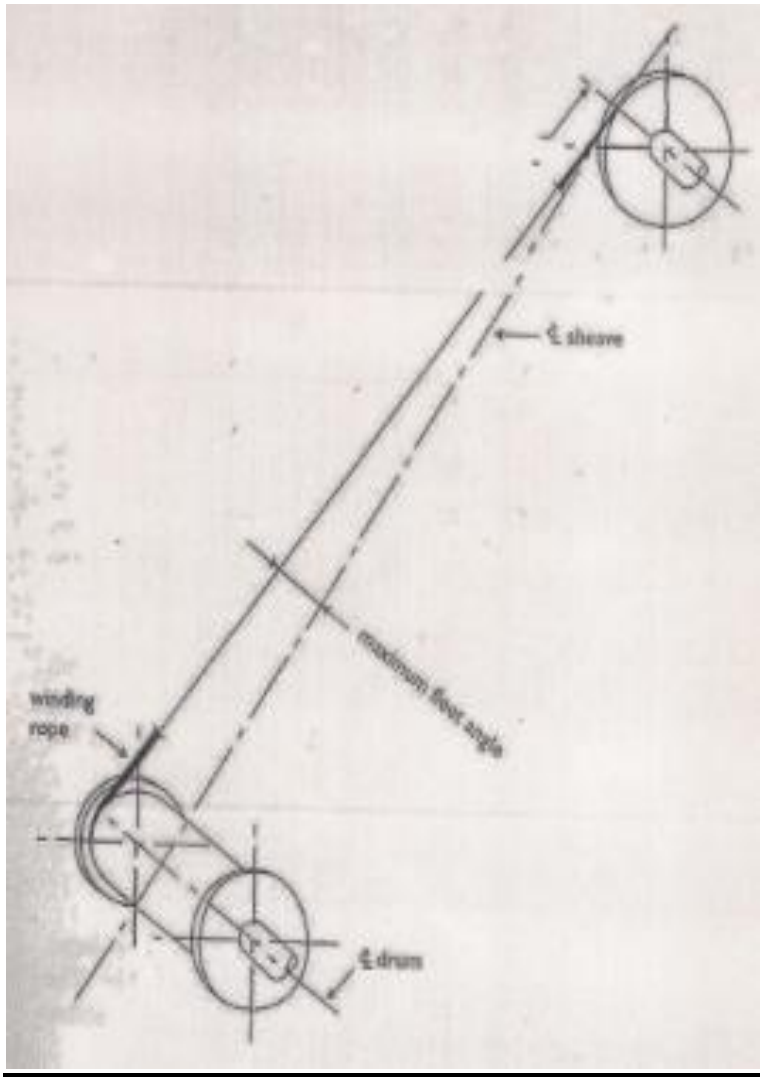
4) **Automatic Contrivance:** Its function is to prevent over winding, over speeding & to ensure slow banking.
Description: The winding drum is connected to two bevel gears, one bevel gear consist a stem, which consist of two governors pivoted at the top & connected with the sleeve. The sleeve carries a long floating lever, which consist a roller

ball at the cam wheel side. The floating lever is pivoted at point ‘K’ which is situated & stem, ‘A’ which is having a knife-edge contact or an electrical contact.

The cam may indicate the position of the cage. During first half cycle cam wheel rotates in anticlockwise direction & during 2 1/2 cycles the cam wheel rotates in a clockwise direction. The cam plate is designed in such a way that there is always a hair gap between the roller & cam plate.

Working: When the winding cycle starts, the winding drum rotates which is then rotates the cam wheel & centrifugal governors through the bevel gears as shown in figure. As the winding speed increases the centrifugal governors go up to the centrifugal action. As a result to it the floating lever also moves upwards. If the speed exceeds a certain limit, roller touches the cam wheel. As well as roller touches the cam wheel; the cam plate exerts a thrust on it. These force acts at the point ‘K’, which either break the power, supply to the engine or apply the mechanical brake to the winding drum.

Angle of Fleet



It is the angle between the vertical plane of the pulley & the rope when the cage is at the pit top, angle is known as inside fleet angle & when the cage is at the pit bottom, the angle is known as outside fleet angle. As the angle of fleet increases, the wear & tear of the rope & pulley also increases. As per D.G.M.S. the fleet angle should not be more than 1.50.

Guides

Guides are used to give the direction to the cages in motion in the shaft to avoid collision between them.

Types of Guides

1) Rigid guides
2) Flexible guides (rope guides)

1) **Rigid Guide:** These guides are made of steel or wood. They are of rectangular cross section, usually 10 X 20 cm. & are fixed by countersunk bolts to the bun tons of places across the shaft of the intervals of 1.8 to 3 meter. The weight of the rail section varies from 20-to 55-kgf/m. lengths & length of the rail piece is up to 13 meter. Only one line of bun ton is required in the middle of the shaft for fixation of rigid guide. Generally one line of guide is enough but sometimes two guides /cages are used. These guides are used for dip shaft. But now day's wooden guides are not used.
2) **Flexible Guides:** These guides are made of steel wire ropes. The ropes used may be of locked coil construction or a guide rope itself. These guides are suspended in a vertical shaft from two headgears, by using a reliance rope capel which is a screwed on the on the cross member of the headgear as shown in figure. At the pit bottom the rope passes through the holes provided in the pit bottom deck & the required amount of tensioning weight is attached to the rope. In shallow shaft 2 or 3 rope guides or cage are sufficient but for dip shaft four guides or cages are used.

   The tensioning weights are about 10 KN per 100-meter depth in shallow shaft & about 5 KN per 100-meter depth in dip shaft.

Causes of Cage Oscillation in Rope Guide

1) **Depth:** If the depth of the winding increases, the length of the guide rope is also increases. Due to this more oscillation takes space as the cage travel.
2) **Winding Speed:** Oscillation of the cage increases as the winding speed increases its normal speed. To reduce this winding speed should not exceed its normal approved value or limit.
3) **Rate of Acceleration:** As the rate of acceleration increases the oscillation of the cage also increases. To reduce this rate of oscillation should not exceed its normal approved value or limit.
4) **Rate of Retardation:** As the rate of retardation increases the oscillation to the cage also increases. To reduce this rate of oscillation should exceed its normal approved value or limit.

5) **Tension in the Rope:** If the rope having less tension it will cause more oscillation to he cage, hence to reduce it correct tension in the rope should be used.
6) **Rubbing of guide shoe:** If there is more friction between guide shoe & rope it will cause more oscillation to the cage. To reduce this should the proper lubrication between rope & guide shoe.
7) **Sudden Power Failure:** Oscillation to the cage will increase suddenly if there is a sudden power failure.

Comparison between Rigid Guide & Rope Guide

Rigid Guide	Rope Guide
1) No oscillation.	1) Oscillation of cage is there
2) Less space required.	2) More space required
3) Costly	3) Cheap
4) Difficult installation	4) Easy installation
5) More maintenance	5) Less maintenance
6) More resistance to fire	6) Less resistance to fire
7) No load on headgear	7) Complete load on headgear
8) Only damaged parts can be replaced	8) Any damage causes replacement
9) Bun tons are required through the shaft	9) No bun tons are required
10) More life	10) Less life full

Cage Suspension Gear

When the steel wire rope is used for winding, it can't be directly attached to the cage. Hence the attachment used to attach the rope with cage is known as cage suspension gear.

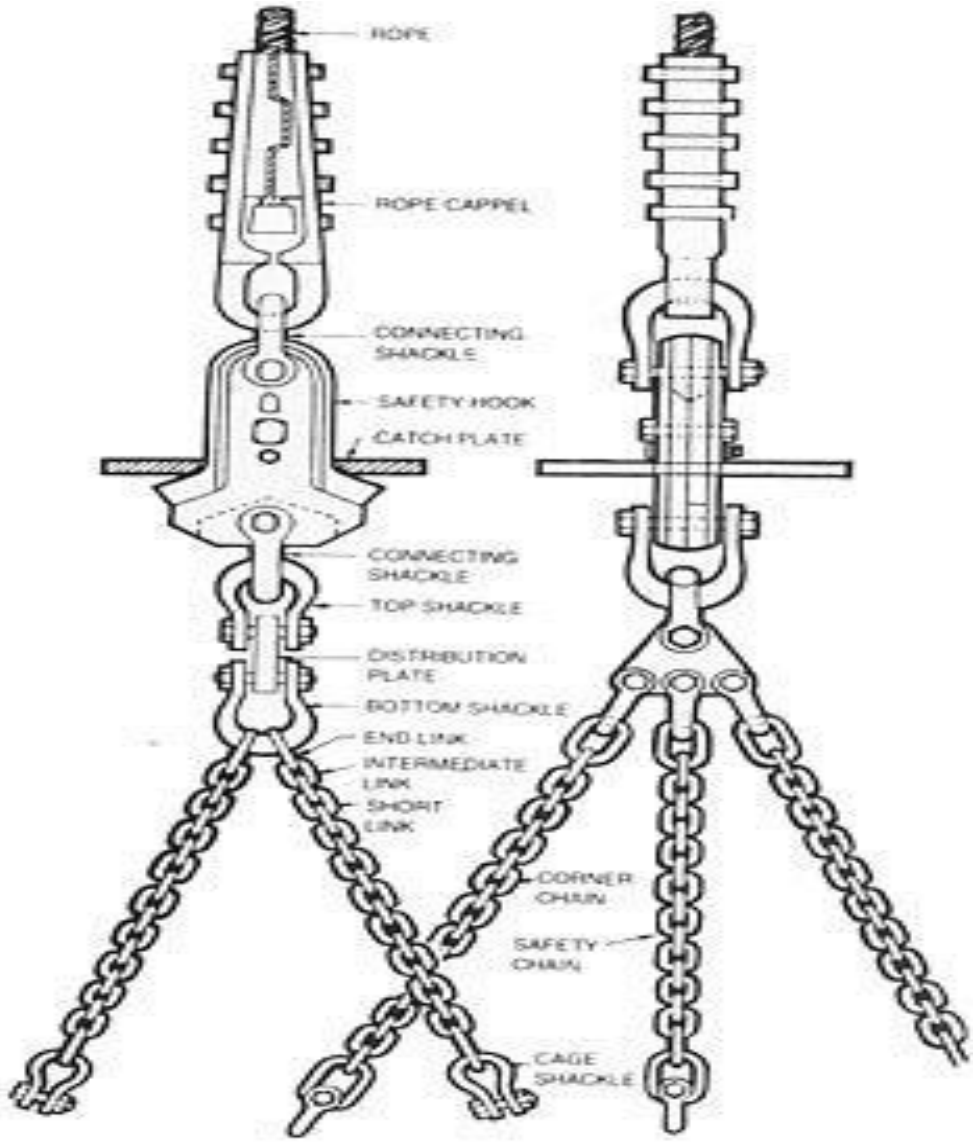
It consist of a rope capel which is attached to one end of rope & it's another end is attached to a safety hook through 'D' link & bull chain. The another end of the safety hook is attached to a triangular plate to a 'D' link & bull chain & the triangular plate is further connected to the cage through four or six bridle chains. The main parts of a Cage Suspension Gear are

1) Rope capel (Reliance rope capel)
2) 'D' link & bull chain
3) Safety hook
4) Triangular plate
5) Bridle chain

CAGE SUSPENSION GEAR IN INDIAN COAL MINES

- Steel rope was introduced in our coal mines in the beginning of 20th century Prior to that Hemp rope or Flat
- Chains were used for winding.
- With the introduction of steel wire ropes, demand for rope end attachments arose.
- If required collaborative efforts of manufacturers, users, mining officials of statutory authorities to envolve
- Attachments which are safe and reliable.

CAGE SUSPENSION FOR DRUM WINDING

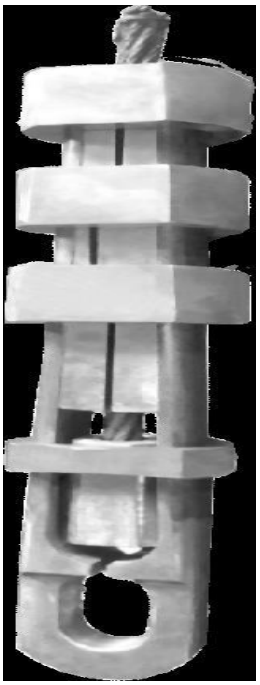


In Drum Winding general requirements can be taken as follows :- •
method of connecting winding rope to suspension gear

- Incroporation of a safety device.
- Four-point suspension of the cage.
- Free movement of the gear in two planes.

Method of connecting winding rope to suspension gear.

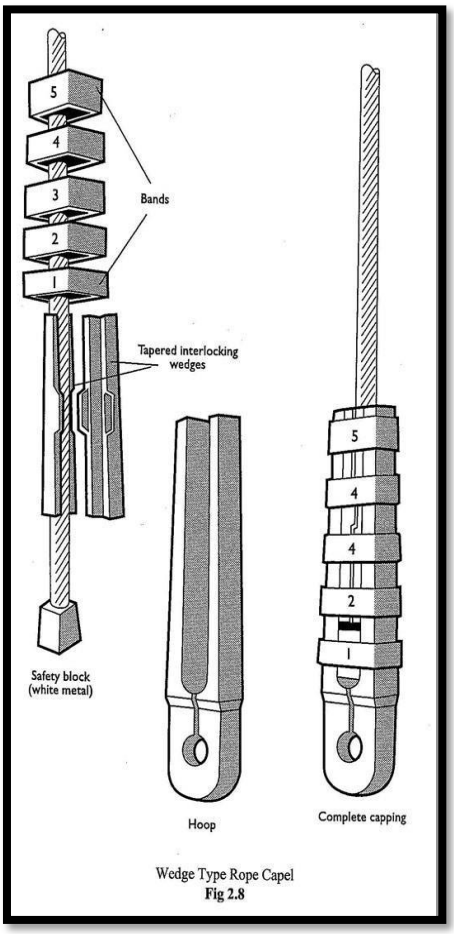
WhiteMetalSocket orFrictionWedgeRopecappel are usually used for this purpose.*White Metal Socket*- solid machined with open jaws are widely used forconnecting the winding rope to the suspension. The mouth of the socket isrounded to prevent the damage to the rope and short length of parallel bore is provided next to the mouth. After carefully preparing and securely binding the rope with soft iron, seizing wire, anti-friction bearing alloy is poured into thesocket (IS 3937 Part 2). A properly carried out capping of the rope in the socket will withstand the breaking strength of the rope.



The length of taper of the socket is usually not less than six times and not more than eight times the diameter of the rope. The angle of the taper is between 3^0 and 6^0.

Friction Wedge Rope Cappelwas introduced by Mr. Becker in 1904. It was an interesting development. In this type of rope cappel, holding power of the cappel is more than the strength of the rope. A metal block is fitted at the end of the rope. If there is any movement of the rope between the two wedges, it can be checked by measuring the distance between the safety block and bottom of the wedges. It provides a warning to the operating supervisor and calls for remedial action.

B. ***Incorporation of a safety device. Safety Hook***



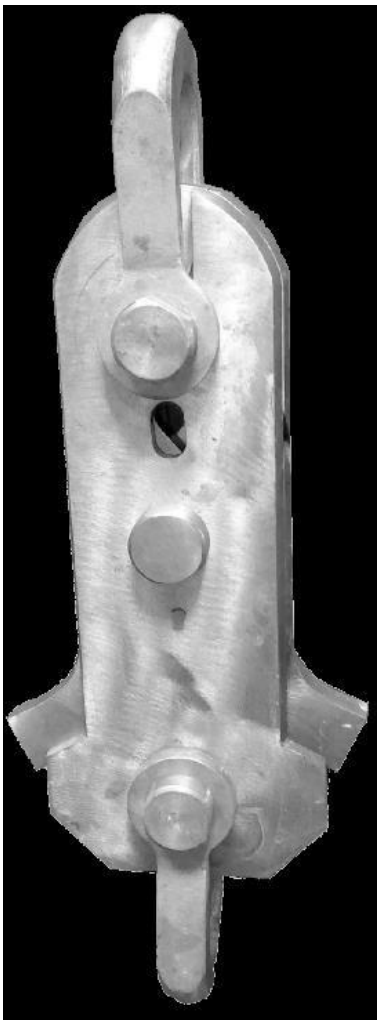
Wedge Type Rope Capel
Fig 2.8

The use of a detaching hook is a basic requirement for safety in winding practice is demanded by law. The intention is to provide a safety device which will come into operation if the other protective equipment fails to prevent an over wind and the winding engine fails to stop at the end of the normal wind. In the absence of such a preventive device, the ascending cage would be taken up into the head frame to collide with the winding sheaves. This cage would then fall down the shaft with disastrous consequences. Detaching hooks must, therefore, be installed as part of the suspension of all cages and skips, except with the Koepe winding system. The detaching hook operates in conjunction with a releasing device, the detaching plate, through which the winding rope travels and which is mounted some 1.8m to 3.6m below the winding sheaves. The equipment is designed to fulfill two functions, if the cage should be taken past the normal overwind trip position, first to release the winding rope from the cage and second to prevent the cage from falling back down the shaft when the rope is released. This is achieved by arranging the main members of the hook to rest on the detaching plate when thedevice is opened to release the rope and secure the cage.

There are several types of detaching hook in regular service, and the following description of humble safety hook, which is mostly used in our Indian coal mines, will serve to illustrate the general principles of the design and operation of these devices.

Safety detaching hook

The detaching hook consists of four plates; the two outer plates fixed together by rivets passing through a V-shaped spacing blocking at the lower and two inner plates shaped like a hook at their upper ends. The inner plates are connectedtogether scissor-wise and to the outer plates by the hinge pin at the centre. The lower end of each inner Plate is shaped to provide the striking horn and the notched projection for resting on catch plate in the event of an overwind. The inner plates have an extra thickness of material in the hook region. With this type of hook, both the inner (hook) plates and the outer (containing) plates are load bearing. The inner plate transmitthe load from the top connecting shackle pin to the hinge pin from which point the outer plates transmit the load to the lower shackle pin. The hook is prevented from opening during winding by a shear pin made of copper which is sheared as thehook is drawn through the catch plate.



C. Four point suspension of the cage.

To achieve even suspension of the cage, distribution plate is fitted below the adjusting device and from the platechains are attached by means of shackles. Four corner, chains, identical in length are fitted to the cage hangersby shackles and two safety chains are provided where safe working load is 8 tons or more. These being attachedvertically from the distribution plate to the top of the cage. Sufficient slack is allowed to ensure that they do notcarry the load.

D. Free movement of gear in two planes.

Free movement of the suspension gear in two planes is allowed by the connection used between the variouscomponent parts of the suspension gear.In our system, rope

cappel in directly connected to the top shackle of the safety hook. Bottom shackle of the safetyhook is connected to the top shackle of the distribution plate.
By this type of connection we can have freemovement of cage suspension gears in two planes.

Steps for making White Metal Rope Cappel

1. Before cutting off the old cappel or rope end, fit sufficient temporary seizing or clamps to prevent the rope from ' kicking' when cut through. With locked coil ropes clamps are absolutely necessary and about four clamps for every 25mm of rope diameter should be used.

2. Thread the socket on to the rope and push it along out of way.

3.Seize the rope with soft iron wire for a length Xy equal to twice the diameter of the rope,leaving the rope end free of this seizing YZ equal to the length of the socket barrel less half a rope diameter.

4. Unlay the rope end beyond the seizing, separate all the wires out into a brush, but do not bend any of them too sharply at the seizing and do straighten the wires. Cut out the fibre core or cutas deep into the brush as possible

5. Clean all the wires carefully with petrol, emery cloth etc, and remove all dirt and grease before going any further. This cleaning is most important. Do not let the petrol run into the unopened rope or it will wash out the lubricant and allow corrosion to occur next to the cappel.

6. Pull the brush of opened wires into the socket and fix the socket upright in a soft jawed vice or clamps with the large end up, ready for pouring the metal. See that the rope hangs straight down under the socket for a length ofat least 36 rope diameter (Sketch 3).
7. Make a dry string binding round the rope at the small end of the socket to prevent the molten metal from escaping (Sketch 3). Do not use damp clay for this purpose as it will give off steam and may cause blow holes in the metal.

8. Heat the socket evenly with blow lamp to a temperature of 1000-2000c temperature more than boiling water. Atthis temperature drops of water placed on the socket will fly off.
9. Dust powdered rosin among the wires in the socket. This acts as a flux and help grip the wires.

10. Heat the standard white metal to a temperature of 3500C and pour it, in one ladleful if possible, while it is at this temperature or 130C above or below. The pouring temperature should be measured with a thermometer. If the metal is poured too hot it may affect the rope wires, whereas if it is poured too cold it may not flow or grip the wires properly. (See Coal Mines Regulation 1957:83 (5) (d). Metaliferous Mines Regulation 1961: 88(5) (d).

11. Allow the cappel to cool before using it. If there is not enough time for natural cooling, let the metal become solid and then apply wet sacking or direct a current of cold air on to the socket. Do not dip the socket in cold water or use it until it has cooled to air temperature.

12. Finally lubricate part of the rope which is near the socket.

White Metal Safety Block is fitted as detailed in W.M. Cappel Installation. After fitting the White Metal Block, the cappelshould now be fitted as follows:

Note: Prior to assembly, remove any portective paint, grease or backing strip from cappel limbs and wedges. Remove any trace of of rust which may have accumulated on the wedge back and grooves, and also on the inside of the limbs over the area on which the wedges operate. Emery cloth only should be used for this purpose. Remove any burrs or damage on wedges and limbsection particularly the area over which the wedges operate which may have occurred in handling, storage or transit, (if left they may interfere with the movement of the wedges.) Thread cappel bands on rope in reverse number order i.e. No. 1 is threaded onlast. Make sure that the taper of the inner sides of the bands accords with the outside taper of the cappel limbs. This is shown by an arrow stamped on the limbs. Thoroughly clean any grease and lubricant from that portion of the rope which will be gripped by the wedges and ensure that the rope is straight, clean and dry, Clean also the *Backs* of the wedges and the inner sides of the cappel limbs. Then apply alight smearing of grease to the *Backs (not The Grooves)* of the wedges and the inside of the limbs. *The Groove Of*

The WedgesMust Be Clean And Dry. Place the wedges around the rope approximately in the position they will take up when in the cappel.

Fit the cappel limbs over the wedges and draw downwards until the ends of the limbs are flush with the thin end of the wedges. The rope should then be drawn through the wedges until the safety block is approximately 20mm from the bottom of the wedges. The bands should now be drawn over and tapped down on the cappel limbs. The band numbered 1 should be fitted adjacent to and encircling the safety block.

Using drifts which should fit snugly on the edges of the bands adjacent to the cappel limbs (starting with No. 2) should be driven down until they sound tight and solid. The driving down should be on alternative bands so that all the bands are driven down progressively. Preferably two strikers should be employed tofacilitate uniform tightening. The sides of each band adjacent to the wedges should never be struck, as otherwise burrs can be caused which may foul the wedges and retard their movement.
Band No.1 is intended only as a protection for the safety block and need not be driven on to a very tight fit. It is not a "working" band and its position on the limbs is not critical. The top ("point") band at the cappel mouth (No. 4 in the illustration) being the last and easiest to drive on may receive the hardestblows.

This Must Be Avoided. It needs to be tight, but not excessively so.
The "Working" bands (Nos. 2, 3 and 4) in the illustration properly driven on, should be spaced about equally along the cappel limbs, the top ("point") band being slightly short of the end of the cappel.

Notes on Safety Hook:

Inspection: Coal Mines Regulation 1957 No. 81 (2) (a) requires inspection of all parts of Suspension Gear including safety hook every six months and if necessary at shorter interval.

<u>Maintenance:</u>

1. Check all nuts and split pins for wear of safety Hook and slackness. Renew split pins at regular intervals.

2. Check outer plates for wear and cracks around shackle eye positions. Do not weld up.

3. Check the copper pin for wear and partial shear which may be due to wear and slackness in platework and pivot pin. Pivot pin must be good fit in platework.

4. Check all plates for flatness by means of straight edge.

5. Ensure that hooks are always well lubricated and as clean aspossible. Avoid excessive accumulation of grease and coaldust. Ensure that the locking bolt slot is free from grease andother matter which may hinder the action of the bolt in an overwind.

6. Ensure that the Lifting shackle (for release of hook afteroverwind) is maintained in a clean and corrosion-free condition. Ensure that it is the correct one for the hooks in useand always ensure that several persons are certain where theshackle is located.

Precaution:

1. Ensure that the catch plate position is such that sufficientclearance exists to allow complete detachment of the hookbefore the cappel makes contact with the sheave in anoverwind.

2. Ensure that adequate clearance exists between catch plate hole and all attachments including rope cappel so that unrestricted passage through the catch plate is possible.

Humble Safety Hook

Step 4 for fitting F.W.R.C.

18

1. Check that the jaws of shackles are parallel.
2. Check that the safety chains are slack after installation incase of six-legged C.S. Gear.
3. Ensure that the length of the slings are 2230mm for fourlegged CS gear & 2725mm for corner chains and 2575mmfor safety chains in case of six-legged C.S. Gear.

4. Ensure that there is not much slackness between jaws forshackle and the cage hangers. DGMS (tech.) circular No.7 of 1987 has given the following guidelines to the industrywhich must be followed.

Installation

- Inspections of attachment of bridle chains to cage hangers have revealed that at some of the installations the fitment between D-shackle pins and cage hangers was not proper causing excessive wear. This happens mainly due to abnormal clearance between shackle pins and cage hanger hole as well as improper inclination, width and thickness of cage hangers.

- To deal with the above difficulties, guidelines given above must be followed.

Inspection

Coal mine regulation lays down following periodicity for inspection

Coal Mine Regulation 83-

1. Daily Inspection:
Every part of cage suspension gear shall be examined carefully for its proper and safe working.

2. Monthly Inspection:
Every detaching plate of safety hook shall be examined and its opening dimension shall be measured and recorded once in at least thirty days.

3. Half Yearly Inspection:
For proper maintenance, it is required that all cage chains in general use and other parts of suspension gear between rope and the cage including the detaching hook, shall be taken apart, cleaned and carefully examined as to wear and tear by gauging and for rust and cracks once atleast every six months or if necessary at shorter intervals.

4. It is suggested that where the conditions are severe, the present visual method of detection of cracks and flaws always does not indicate the correct health of Cage Suspension Gear or its components. In such case magnetic and ultrasonic tests or any other N.D. Test can be done, to detect any crack or flaw in the suspension gear or its components which are regular in service.

PROPER STORAGE OF CAGE SUSPENSION GEAR & ITS PARTS.

- C.S. Gears and it's components must be stored in shelves above floor level.
- They must not be exposed to direct sunlight.
- Proper labeling of components identifying the manufacturer must be done.
- If storage is likely to be more than one year then anti-rust lubricant must be used.
- Principal of first-in first-out must be implemented.

NORMS OF DISCARD OF CAGE SUSPENSION GEAR COMPONENTS.

-Rope Cappels (Wedge Cappels)

1. Tightening bands being damaged, becoming out of shape due to mishandling or any other reason.

2. Marked pitting/corrosion appearing on the bands and the body.

3. Deformation in the body or excessive were on the outer or inner surface.

4. Whether the last tightening band could be tightened up to 6mm or less measured from the bottom of thetapered wedge.

5. Wear to an extent of 5% to 6% or more on the eye portion of the cappel.

Safety Hook

1. Wear on the centre pin exceeding 10% in top and bottom shackles and pins.

2. Wear exceeding 1% in top and bottom shackles and pins.

3. In the top portion of the safety hook if slackness in the pin in more than 1.6mm.

4.(a) Wear on the outer plate shall to be not more than 0.3 mm. (b) Pitting/corrosion on the inner/working plates.

5.(a) Obliquity in the hole for the copper pin.
(b) Obliquity of holes in the top and bottom shackles (outer) limited to 10%

6. Where the shackle eye has rubbed on the plates and the wear due to such rubbing exceeds 1.6mm.

7. Any deformation, pitting/corrosion or any other defect on the projected fins of the working plates as wellas the protion which rests on the catch plate.

Note: The detaching plate or safety hook is considered as a part of the hook. In case of any notch/groove due to rubbing of rope or otherwise on the circumference of the plate hole, the plate should be rejected. If there is no defect like corrosion, groove in the hole of the plate and obliquity in the holes of the tightening bolts,the plate can be allowed further use after proper heat treatment and tests for cracks etc.

Distribution Plates:

1. Marked pitting and corrosion.
2. Obliquity in the holes exceeding 10% of the original dia.
3. Where the shackle eye has rubbed on the distribution plate and wear due to rubbing exceeds 1.6mm.

Shackles and Pins:

1. Wear on shackle eye sides exceeds 1.6mm.
2. Wear on the shackle eye hole exceeds 10% of the original diameter.
3. Obliquity in the hole exceeds 10% of the original diameter.
4. Wear on pin exceeds 10% of the original diameter.

Suspension Chain Slings:

1. Marked pitting and corrosion.
2. The wear on the contact surface of the links exceeds 10% to 12% of the nominal diameter of the link.

POINTS TO PONDER

1. No rusting used to appear on the imported C.S. Gear, Humble safety hook or Reliance Friction Wedge Rope Cappel even after long storage & exposure to adverse environment.Indigenous C.S. Gear & Components gets rusted much earlier.

Suggestion: Grit Blasing of components is advocated to prevent earlier rusting.

2. During the installation of friction wedge rope cappel, bands get deformed and damaged due to sledge hammering. Availability of expert strikers is decreasing. Mining industry is not attractive to the present generation.

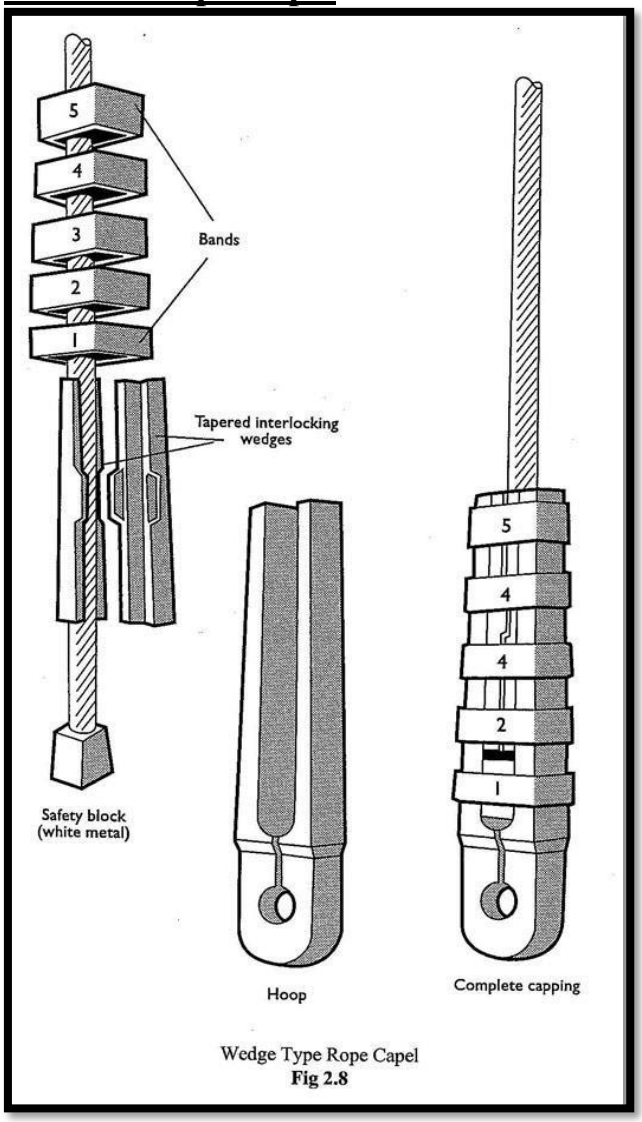
Suggestion: Adopt Hydraulic Rope Cappel Banding. Fig. 18 It ensures consistent and specified pressure on all bands.

3. Avoidance of repeat testing-CS Gear & components are tested 100% at CMFRI for proof load & NDTincluding magnetic particle test, ECL repeats these tests in their own work shop.Due to this procedure acceptance of material is delayed.

Suggestion: Testing may be carried out at either National testing house or at ECL Testing House.

4. DGMS has specified inspection of CS Gear & components every six months by the manufacturer. Thisobligation is for six years. As per the present purchase norms and porocedures the vendor is supposedto carry out these inspections without any further pecuniary benefits.

1) **Reliance Rope Capel**



Wedge Type Rope Capel
Fig 2.8

a) In this capel there are two iron wedges, which grip the rope near the required end where a white metal block is prepared. There is U-shaped steel strapped which is placed over the two wedges & on which 4-5 iron clamps are fitted by hammering.
b) Prepare a white metal block at the required end of the rope.
c) Insert the iron clamps on to the rope in order of numbers (largest number first). The jaws of capel are about 24 times more diameters.
d) Properly clean any grease or lubricant from that portion of the rope which will be griped by the wedges.
e) Place the two wedges around the rope approximately in the position they will occupy when in capel.

f) Fit the U-shaped strip over the wedges such that the U-shaped strip & wedge top are in one line. Draw the iron clamps over the U-shaped strip.
g) Hammer the iron clamps for proper grip. The ring number 1 should not be hammered because it is only for the safety of the white metal block. With this capping operation is over.

2) **<u>'D' Link & Bull Chain</u>:** These are used to attach any two components of cage suspension gear & to adjust the height of cage suspension gear. The diameter of link rod should be 1.5 times the rope's diameter & should not be any join in the link.

3) **<u>Safety Hook/Detaching Hook/King Detaching Hook</u>:** It is a safety device which acts when an over wind takes place. Its purpose is to suspend the cage or skip in the headgear if an over winding occurs & at the same time to release the rope capel to go over the headgear pulley. It is always placed just below the rope capel.

It consists of two inner plates & two outer plates, which can rotate around a common point 'H'. The outer plate is fixed & inner can move. The inner plates are arranged face to face on each other between 'H' & through all the plates assemble the hook. A copper pin is placed through the hole 'C' in all the four plates.

In case of over winding, the hook passes through the detaching plate, which is fitted in the headgear, while pulling through detaching plate, the lower portion of the hook is pressed inside & the copper pin is sheared. The inner plate moves around 'H' so that rope capel release from the top & the catches of inner plates are fill apart. The cage rests on detaching plate with the help of catches. Thus the cage & the persons travelling in the cage are safe.

Recovery of over winding cage: Before starting the recovery operation, the shaft top is covered with rails. Now the winding rope is brought up to the hook & the rope capel is attached to the hole 'F' through the 'D' link, when the winding rope is pulled slightly. The inner plate comes in their original position since the hole 'F' is inclined. The catches are now inside & the safety hook can freely pass down through the detaching plate. The cage is now slowly lowered on the rails placed over the pit top.

After the over wind, the safety hook is to be inspected & refitted with new copper pin & the rope is to be replaced after every over winding.

4) **<u>Triangular Plate/Load Distributing Plate</u>:** Its function is to distribute the load of the cage, hence it is known as load distribution plate. It consist of one hole at

the top which is connected to the safety hook & at the lower end it consist of two or three holes which are connected to the cage through bridle chains.

5) **Bridle Chain:** These are used to attach the cage with the triangular plate, for a small cage only four chains are used at the four corners of the cage while in case of large cage total six chains are used. Out of these six chains two central chains doesn't carry any load & these are used in case of failure of corner chains.

Keps/Keps Gear

Keps are used to support the cage at the pit top for proper alignment of the cage floor & the decking level. **Type of Keps**

1) Rigid keps
2) Davies improved keps gear

1) **Rigid Keps:** These are retractable supports for cages & have to be used at the pit top. Their use is not necessary at pit bottom as the cages rest on rigid platform of steel girders & wooden planks. Keps ensure not only support to the cage but their use results in proper alignment of cage floor & ducting level so that stretch of winding rope creates no difficulties during decking. The banks man at the pit top manually operates Keps. The ascending cage pushes the keps back & as it is raised slightly higher than the decking level, the keps fall back in position by gravity as the banks man release the operating lever. The cage after it has come to half is lowered by the winding engine man to rest on the keps. When the top cage is to starts on its downward journey, the winding engineman raises the cage only slightly to make it clear of keps, the banks man withdraws
the latter by manual operation of a lever which is held by him till the cage is lowered past the keps.

Disadvantages of Rigid Keps

1) Accumulation of slack rope on pit bottom cage when the top cage is raised a little for withdrawal of keps subjected to shock loads.
2) Loss of time & power in lifting the cage.

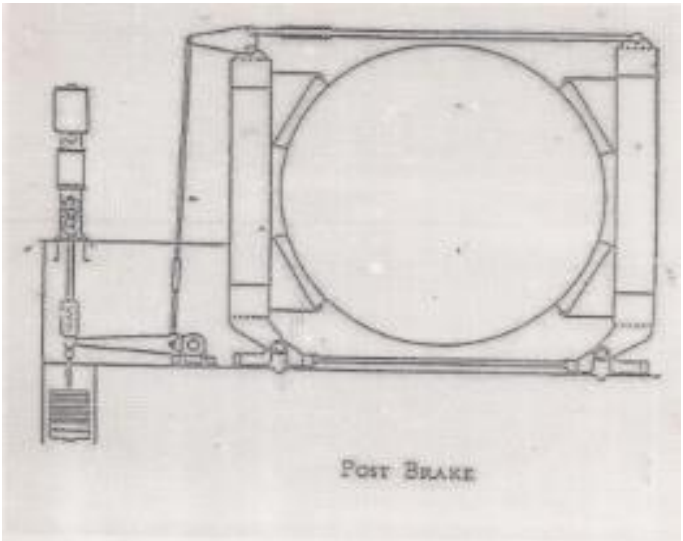
2) **Davies Improved Keps Gear:** Because of the defects of rigid keps, they have been devised which can be withdrawn from under the cage without lifting it, hence keps are stausskeps& the Davies improved keps gear has been designed.

The gear consists of shaft 'S' to which is keyed the hand lever & a pair of arms 'A' with a steel rollers 'R' mounted on a pin between the arms. The roller presses against a renewable roller path on a swing lever 'L' which is pivoted at 'P' & carries a pallet mounted on a steel pin at its other end. The pallet is free to move upward & around this pin as shown in dotted lines. Thus permitting the upward passage of the cage, but it is prevented from moving downwards by a projection on the lever 'L'. The cage is thus securely supported on the upper surface of the pallet. The gear may be withdrawn, however without first raising the cage, in the manner shown in figure. It will be seen that when the hand lever is moved to the left, the roller 'R' moves upward along the roller path on lever 'L', thus allowing the lever to rotate downwards by gravity around the pin 'P' until the pallet is clear of the cage.

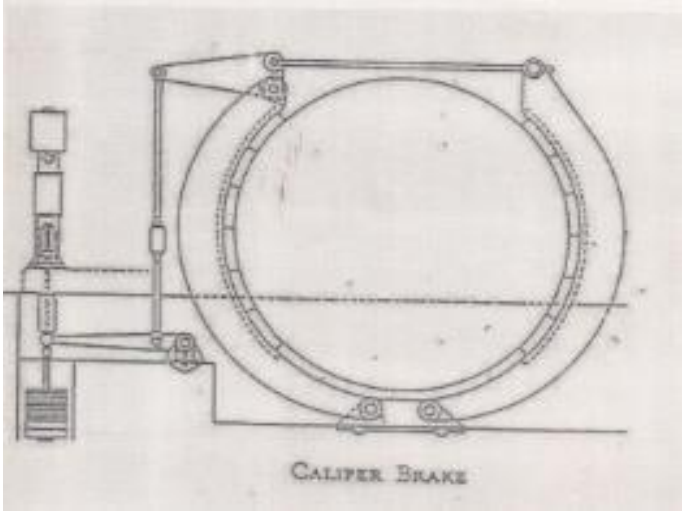
Safety Devices

1) **Electrical Brakes:** Electrical brakes are used to reduce the speed of the cage, as soon as the speed of the cage comes to near zero, the mechanical brakes should applied. Electrical brakes are also known as service brakes.

2) **Mechanical Brakes:**



Post Brake



Caliper Brake

Requirements of mechanical brakes are as under:

1) When the cage is at rest, brakes should be in on position.
2) When the cage in motion, brakes should be in off position.
3) In case of power failure, the brakes should come in on position automatically.
4) Brakes should not be used for speed control. 5) Types of mechanical brakes 6) Anchored post brakes.
7) Centre suspended calliper post brakes

a) **<u>Anchored Post Brakes</u>:** It is made of two 'H' section girder pivoted at P1 & P2. Each post carries its own curved brake block fitted with brake lining. The front post carries a triangular lever at its top. This lever is connected with rear post by a tie rod T2 & the main lever through tie rod T1. The main lever is pivoted at P & its anchor end carries a suspended weight. The main lever is also connected to a hydraulic cylinder through a piston rod.

Working: When there is no rod to the brake engine, the main lever fails down under the suspended weight due to this tie rod T1 is pulled downward to operate a triangular lever in anticlockwise direction due to which the tie rod T2 is pulled. Force acting on a front post towards the brake path, applied the brakes & anchor force which is acting on the rear post by tie rod T2 applied the braking effect to the drum.

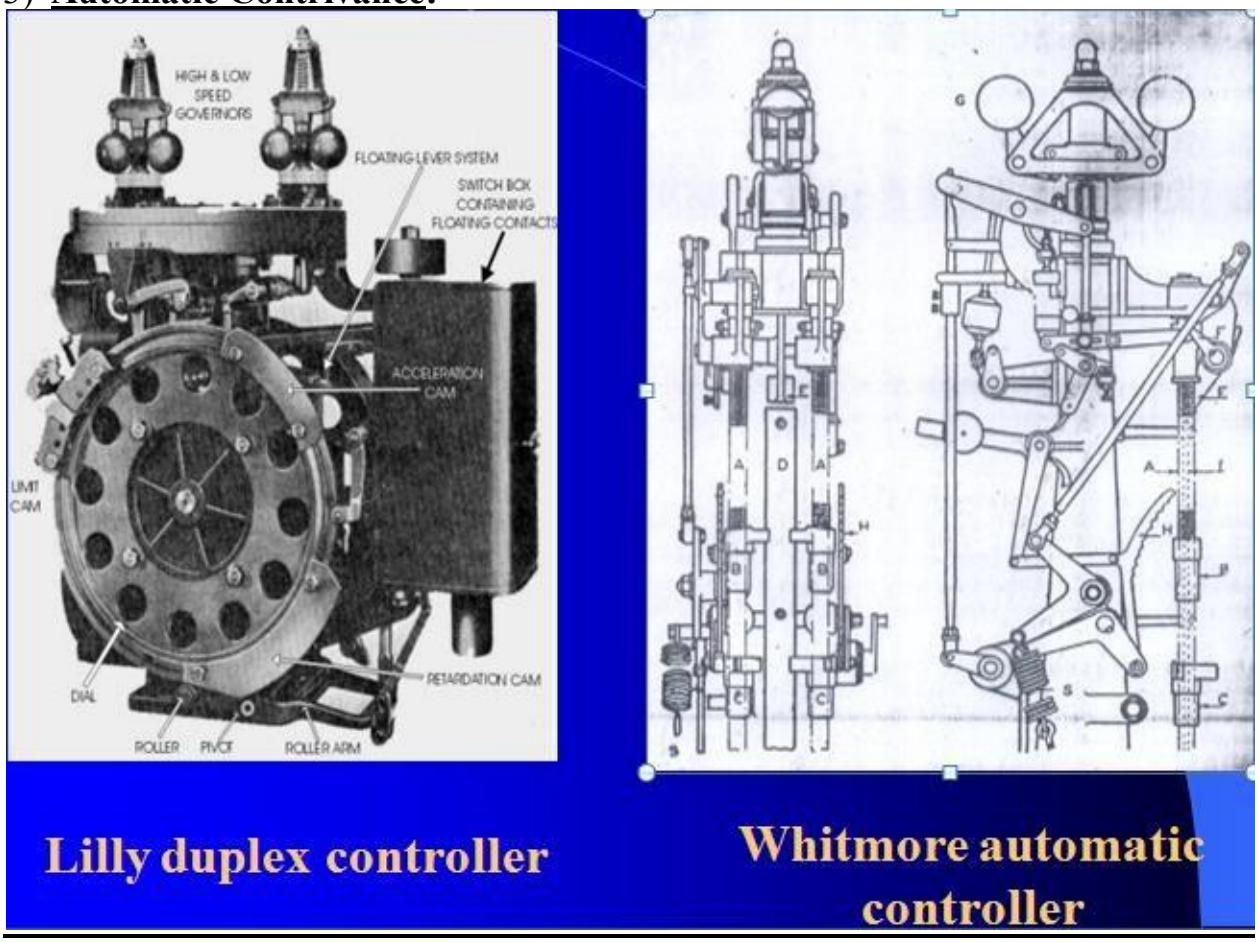
To operate a winding drum power is supplied to the brake engine to raise the piston rod which lifts the main lever upwards against the upward against the suspended weight. It will push the tie rod even upward to operate the triangular lever, which pulls the front post & at the same time pushes the rear post through tie rod T2. Thus the brakes are away from the brake path & the drum is free to rotate.

The main disadvantage of this brake is that the wear & tear of the brake lining is not uniform & it is more at top & minimum at the bottom.

b) **Centre Suspended Calliper Post Brake:** It consists of two curved arm namely front & rear, front curved are consist of two triangular levers L1 & L2. These triangular levers are connected to the main lever at point A & B through tie rod T1 & T3 as shown in figure. Triangular lever L1 & L2 are also connected to rear curved arm to tie rod T2 & T4. Main lever, which is pivoted at P1, consists a suspended weight & a piston rod to another end.
Working: When there is no power to the brake engine the suspended weight falls so that main lever moves in anticlockwise direction about P1. Due to this tie rod T1 & T3 are pulled to operate the L1 & L2 in anticlockwise & clockwise direction respectively. These triangular levers pull the tie rod T2 & T4 so that rear curved arm is closed to the brake path & also pushes the front curved arm towards the brake path. In this way a uniform braking effect is obtained.

To operate the winding drum, power is supplied to the brake engine to raise the piston rod against the suspended load. Now the main lever rotates in clockwise direction around P1 in such a way that it pushes the tie rod T1 & T3 to operate the L1 & L2. L1 & L2 moves clockwise & anticlockwise direction respectively to release the front curved arm from the brake path & pushes the T2 & T4 to push the rear-curved arm away from the brake path to release the brake.

3) **Automatic Contrivance:**



Its function is to prevent over winding, over speeding & to ensure slow banking.

Description: The winding drum is connected to two bevel gears, one bevel gear consist a stem, which consist of two governors pivoted at the top & connected with the sleeve. The sleeve carries a long floating lever, which consist a roller ball at the cam wheel side. The floating lever is pivoted at point 'K' which is situated & stem, 'A' which is having a knife-edge contact or an electrical contact.

The cam may indicate the position of the cage. During first half cycle cam wheel rotates in anticlockwise direction & during 2 1/2 cycles the cam wheel rotates in a clockwise direction. The cam plate is designed in such a way that there is always a hair gap between the roller & cam plate.

Working: When the winding cycle starts, the winding drum rotates which is then rotates the cam wheel & centrifugal governors through the bevel gears as shown in figure. As the winding speed increases the centrifugal governors go up to the centrifugal action. As a result to it the floating lever also moves upwards. If the speed exceeds a certain limit, roller touches the cam wheel. As well as roller touches the cam wheel, a thrust is exerted on it by the cam plate. These force acts

at the point 'K' which either break the power supply to the engine or apply the mechanical brake to the winding drum.

4) **Safety Hook/Detaching Hook/King Detaching Hook:** It is a safety device which acts when an over wind takes place. Its purpose is to suspend the cage or skip in the headgear if an over winding occurs & at the same time to release the rope capel to go over the headgear pulley. It is always placed just below the rope capel.

   It consists of two inner plates & two outer plates which can rotate around a common point 'H'. The outer plate is fixed & inner can move. The inner plates are arranged face to face on each other between 'H' & through all the plates assemble the hook. A copper pin is placed through the hole 'C' in all the four plates.

   In case of over winding, the hook passes through the detaching plate, which is fitted in the headgear, while pulling through detaching plate, the lower portion of the hook is pressed inside & the copper pin is sheared. The inner plate moves around 'H' so that rope capel release from the top & the catches of inner plates are fill apart. The cage rests on detaching plate with the help of catches. Thus the cage & the persons travelling in the cage are safe.

5) **Recovery of Over Winding Cage:** Before starting the recovery operation, the shaft top is covered with rails. Now the winding rope is brought up to the hook & the rope capel is attached to the hole 'F' through the 'D' link, when the winding rope is pulled slightly. The inner plate comes in their original position since the hole 'F' is inclined. The catches are now inside & the safety hook can freely pass down through the detaching plate. The cage is now slowly lowered on the rails placed over the pit top.

   After the over wind, the safety hook is to be inspected & refitted with new copper pin & the rope is to be replaced after every over winding.

6) **Reverse Direction Prevention Switch:** It trips power if the winding engineman by mistake operates the motor in wrong direction.
7) **Time Limit Switch:** It is mounted on the headgear. It trips power if the ascending cage crosses decking level.
8) **Tachometer Generator:** It is connected to the winding drum for normal rpm it generates a normal amount of current, but if the gearbox is faulty, the tachometer generator will not generate the normal current & it will trip power to the motor.
9) **Safety Caches:** These are mounted on in the headgear at an interval of 0.3 to 1.0 meter above the normal decking level. In case of over winding, the cage presses

the safety caches which are pivoted levers as shown in figure & it crosses it. In case of failure of the safety hook the cage falls downward over the safety caches. Hence the damage to the cage can be reduced. To clear the cage these safety catches can be removed from the cage path by operating a lever.

10) **Depth Indicator:** A depth indicator is used to indicate the position of cage in the shaft. It is mounted on the drum winder through the gear arrangement as shown in figure. It consists of a dial & pointer moves in anticlockwise direction & during second half second the pointer moves in anticlockwise direction.
When one cage is moves from bottom to top, the pointer moves from A to X_1 to X_2 to B. in this AX1 is the acceleration distance & X2B is the retardation distance. As soon as the pointer reaches the point X_2, the power supply to ht engine should be cut off & brakes should be applied.

When the cage moves from top to bottom the pointer move from B to X_2 to X_1 to A. in this BX_2 is the acceleration distance X_2 X_1 is the constant speed distance & X_1A is the retardation distance. As soon as the pointer reaches the point X_1, the power supply to the engine should be cut off & brakes should be applied.

11) **Warning Bell:** When the cage is at a distance of two revolutions before reaching the decking level, a warning bell warns the operator to remains alternative.

Characteristic Curves

These are the curves between torque & time during the complete winding cycle. Torque is of two types as follows

1) **Static Torque:** Unit of torque KNm. It is due to cage tub, mineral & weight of rope. During complete winding cycle the torque for the unbalanced coal or mineral load. But the torque due to cage, tub suspension gear etc. is zero. It is constant throughout the winding cycle for the unbalanced coal or mineral load, but the torque due to unbalanced rope charges continuously & the total static torque reduces continuously as shown in figure. In the figure it is represented by O, A, B, C, D, 3.

   In the graph 0-1 is the acceleration period, 1 - 2 is contact speed period & 2 - 3 is the retardation period & 3 - 4 is decking period.

2) **Dynamic Torque:** It is there during acceleration & retardation period only. It is due to the total masses moving in the linear direction i.e. cage, rope, mineral

etc. & due to the rotating masses i.e. pulley & drum. As the sum of this total mass is constant, the dynamic torque due to their masses will also be constant but it is positive during acceleration period & negative during retardation period. In the figure O, A2, B2, 1, 2, C2, D2, 3, shows it.

3) **Total Torque:** it is the total torque on the drum at any moment. Total torque= Static torque + Dynamic torque. In figure total torque is represented by O, A, B, B_1, C_1, C, D, 3.

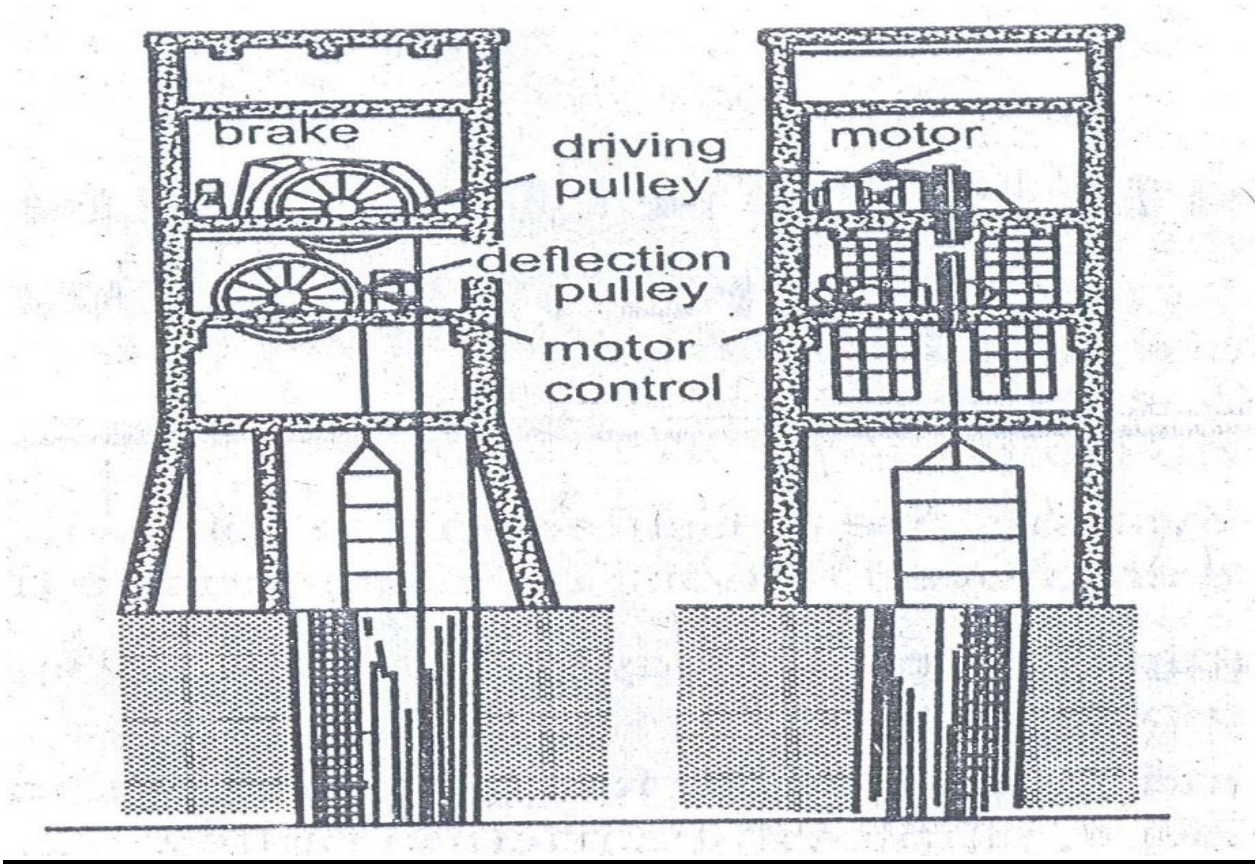
   During decking period when the cage is resting on the keps, the static torque, the dynamic torque & the total torque are zero.

Smooth Winding cycle (Balancing System of Winding)

If the torque requirement during the complete winding cycle is more or less uniform is known as smooth winding cycle. In a winding system, using a tail rope or balancing rope may obtain a smooth winding cycle. It is of the some diameter & some weights as the winding rope. Its length is equal to the depth of the shaft & is attached to the bottom of the two cages.

Another method to obtain a smooth winding cycle is the use of conical or Cylindro conical drum which are preferred for dip shaft winding. A tail rope is not used with this type of drum.

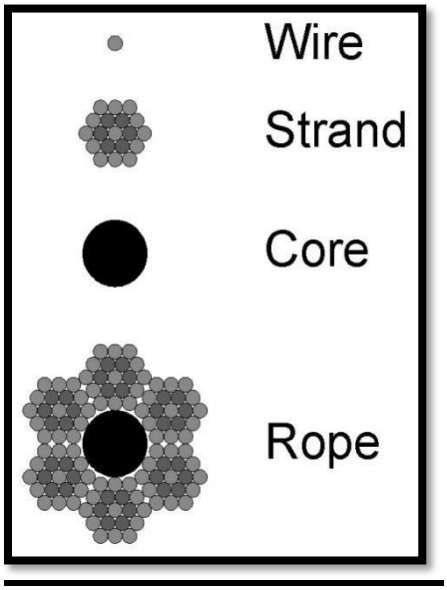
Friction Winding/Koepe Winding



It consist a single rope passing over a friction pulley which is electrically operated & installed at the top of the headgear. The two ends of the rope passes over the pulley & connected with the cages. A tail rope is always used in friction winding. It is connected to bottom to bottom of the two cages & hangs freely in the shaft. The winding rope along with the attached cages is raised or lowered by power transmitted to the friction between the winding rope & the friction pulley. The driving motor is installed at the top of the headgear to operate the system at a time 2 to 4 or 6 ropes can be used for the winding.

Chapter No 3- Wire Ropes

A Rope is a length of thick strong cord made by twisting strands made of wire around a core of suitable material depending upon the suitability of the work.



Components Of Ropes:

Wire : It is a metal drawn out into the form of a thin flexible thread or rod made of ductile metal. It is used to make a strand in a rope.

Strand: A strand is formed by laying up one or more layers of wires around a strand core. A strand core is either a single wire or made up of a number of wires.

Core: It is the centre of the wire rope around which the strand of wire is laid or coiled. There 3 types of cores :-

1) **Fibre Core:** It is made of fibres & generally used as a main core in stranded ropes. It provides more flexibility to the rope.
2) **Steel Wire Core:** It is a steel wire, which is used as a core. Generally it is used in strands & locked coil ropes.
3) **Independent Wire Rope Core (IWRC):** If a rope itself is used as a core, it is known as independent wire rope core. It is used when rope is subjected to kinetic shocks.

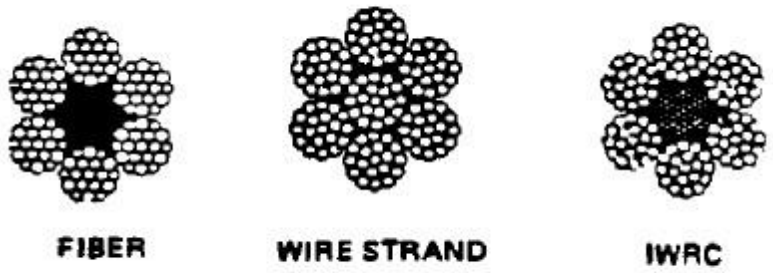
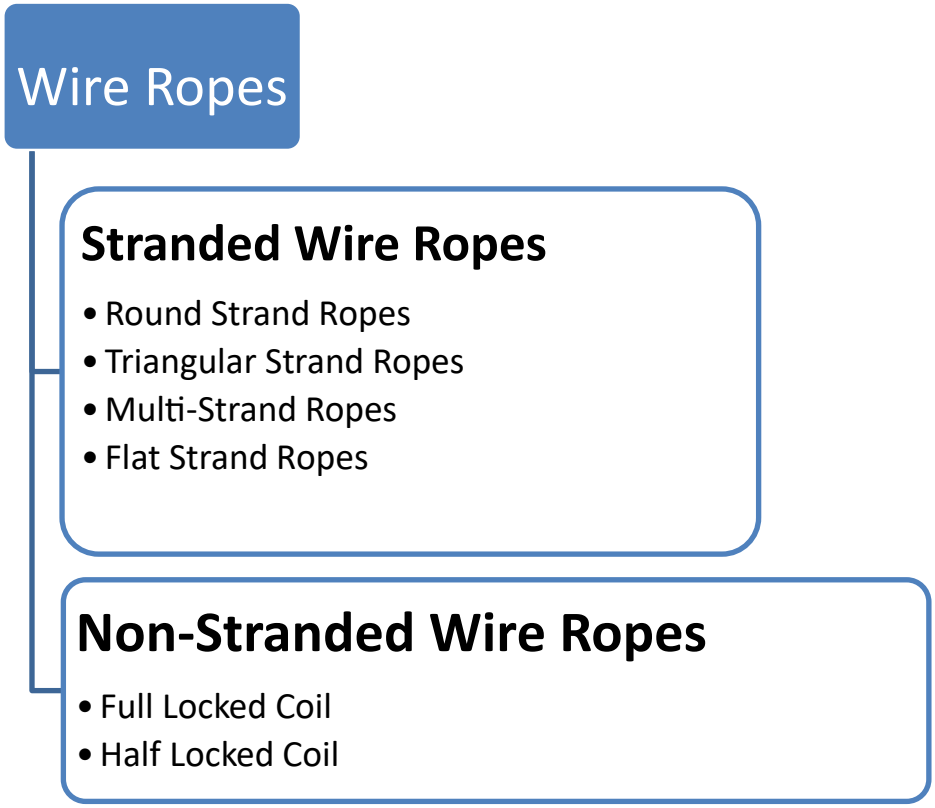
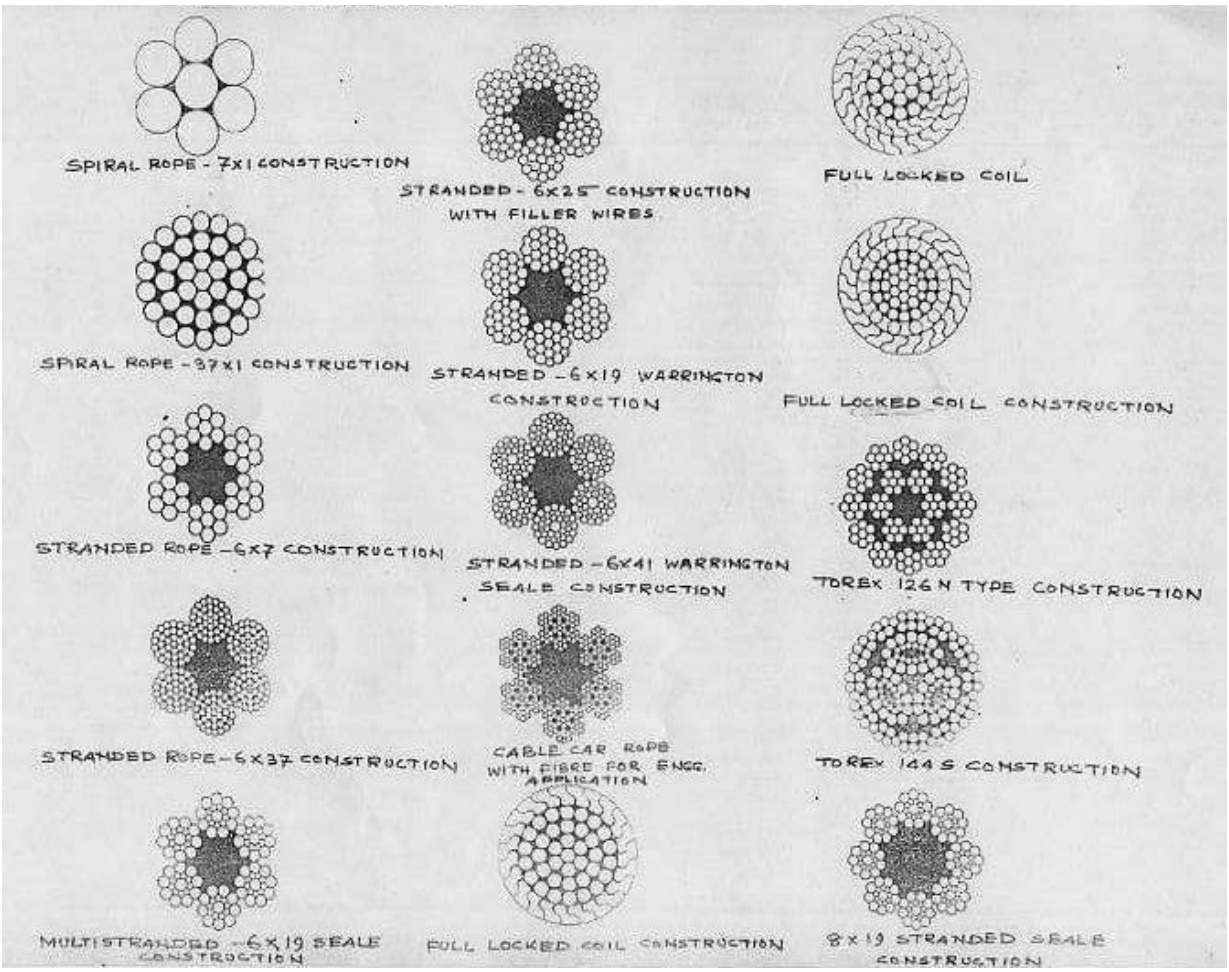


Figure 613-1-2. Core Construction

Classification Of Wire Ropes:-



Types of rope:



1) Stranded rope
2) Non-stranded rope

<u>Stranded Rope</u>: A stranded rope is built up of number of strands. The strands are laid around the main core to make a stranded rope.

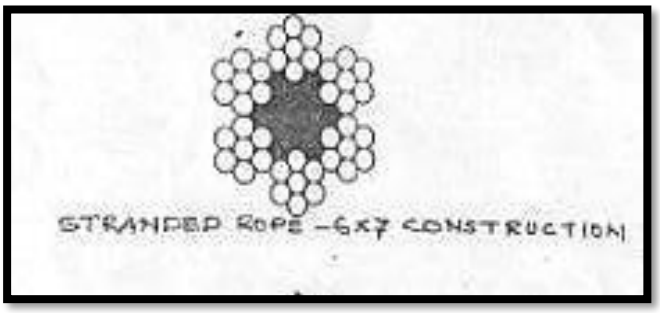
- **<u>Types of Stranded Rope</u>**

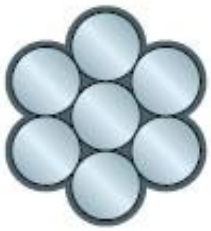
1. <u>Round Stranded Rope</u>:

It consists of six round strand laid around a main core. It is known as a simple construction of strands is having only one layer of wire & of the compound

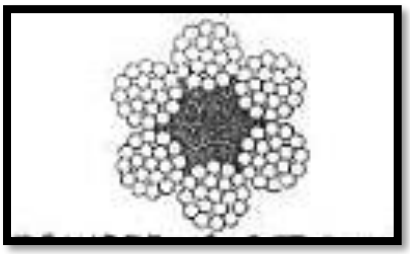
construction if strands are having more than one layer of wire. There two types of Round Stranded ropes:-

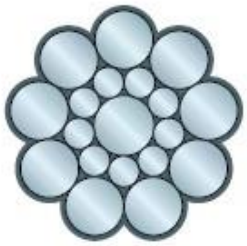
A. <u>Simple Round Strand:-</u>





Rope usually consists of six similar strands laid around a central core of fiber or soft material each strand consist of six wires around similar central wire. The fiber core as a yielding cushion in which the strands embed thus preventing frictional wear when bending on sheaves or drums **B. <u>Compound strands</u>**:





These ropes contain wires commonly of different diameters and may be arranged in different ways. In a 6x8/6/1 (or 6x8-6-1) wire rope, there are eight larger outer wires to give flexibility .The larger outer wires provide for wear. This being common construction for winding ropes.

<u>Advantages of Round Stranded Rope</u>

1) Simple in construction.
2) Cheap.

3) Easy to examine visually.
4) Flexibility is more.

Disadvantages of Round Stranded Rope

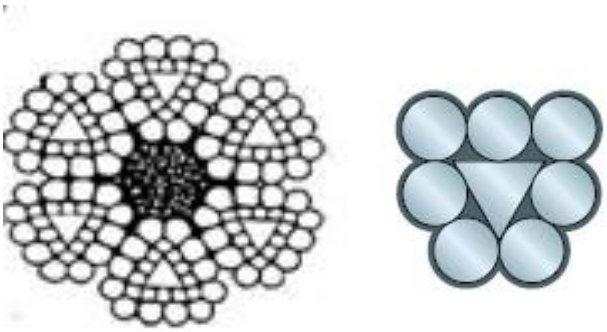
1) Turning tendency (rotating tendency as the load change).
2) More external wears.

2. Triangular Strand Rope or Flattened Strand Rope:

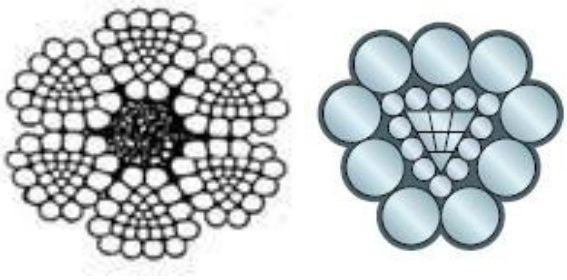
It consist of six triangular strand laid around a main. It is known as a simple construction of strand is having only one layer of wire & of the compound construction if the strands are having more than one layer of wire.

There are two types of triangular strand:-

A. Simple triangular strand:-



B. Compound triangular strand :-



Advantages of Triangular Strand Rope

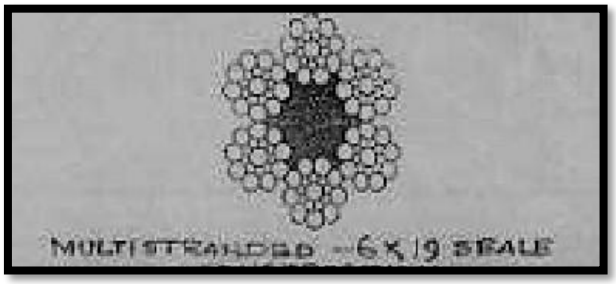
1) Strength is more (10% more strength than the round strand rope).

2) Life is more.
3) Crushing strength is more.

Disadvantages of Triangular Strand Rope

1) Costly.
2) Less flexible.
3) Rotates as the load changes.

3. Multi-Strand Rope:



A multi-strand rope is built up of two or more layers of strand laid around a main core. Each layer of strand may be composed of round strand or triangular strand. It is known as round strand multi strand rope. The two layers of the strand are always laid on the opposite direction to reduce the rotating tendency of the rope. **Advantages of Multi-Strand Rope**

1) Non-rotating.
2) More flexible.
3) Strong & more durable.

Disadvantages of Multi-Strand Rope

1) Interior of the rope cannot be examined visually.
2) Costly.

4. Flat Rope: It is made up of several strands laid side by side. The strands are stitched together with one stitching strand or wire so as to hold the rope together & equalized the load between the several strands. **Advantages of Flat Rope**

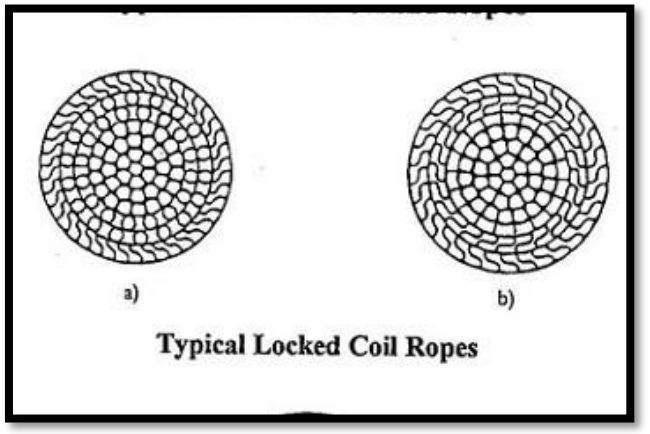
1) Non-rotating.

2) More flexible.

3) More external surface hence easy examined. **Disadvantages of Flat Rope**

1) Costly.
2) Life is less.
3) Flexible in only one direction.

- **Types of Stranded Non-Stranded Rope:-**



Typical Locked Coil Ropes

1. **Locked Coil Rope or Full Locked Coil Rope:** It consists of one straight strand & containing as many wires necessary to give the required rope strand. Its main core is single wire as present in any round strand. The wires in the rope are laid in the opposite direction to make the rope non-rotating. The outermost layer is always composed of full a locked wire that gives a smooth external surface & a locking action to any rotating tendency of rope.

Advantages of Locked Coil Rope

1) Greater strength.
2) Smooth external surface hence can be used as guide rope.
3) Non-rotating.
4) Permanent stretch is less.
5) External wear is less.
6) Crushing strength is more.

Disadvantages of Locked Coil Rope

1) Inner wire cannot be examined.
2) Less flexibility.
3) External portion of the rope cannot be lubricated. 4) These ropes cannot be splices.

2. **Half Locked Coil Rope:** It consists of one straight strand containing as many wires as necessary to give the required rope strand. Its main core is a single wire as present in any round strand. The layers of the wire are always laid in the opposite direction to make the rope non-rotating. The outermost layer of the wire consist of the wires consist of the half locked wires to give a smooth external surface & to provide a locking action, if the rope tries to rotate.

Advantages of Half Locked Coil Rope

1) Greater strength.
2) Smooth external surface hence can be used as a guide rope.
3) Non-rotating.
4) Permanent stretch is less.
5) External wear is less.
6) Crushing strength is more.

Disadvantages of Half Locked Coil Rope

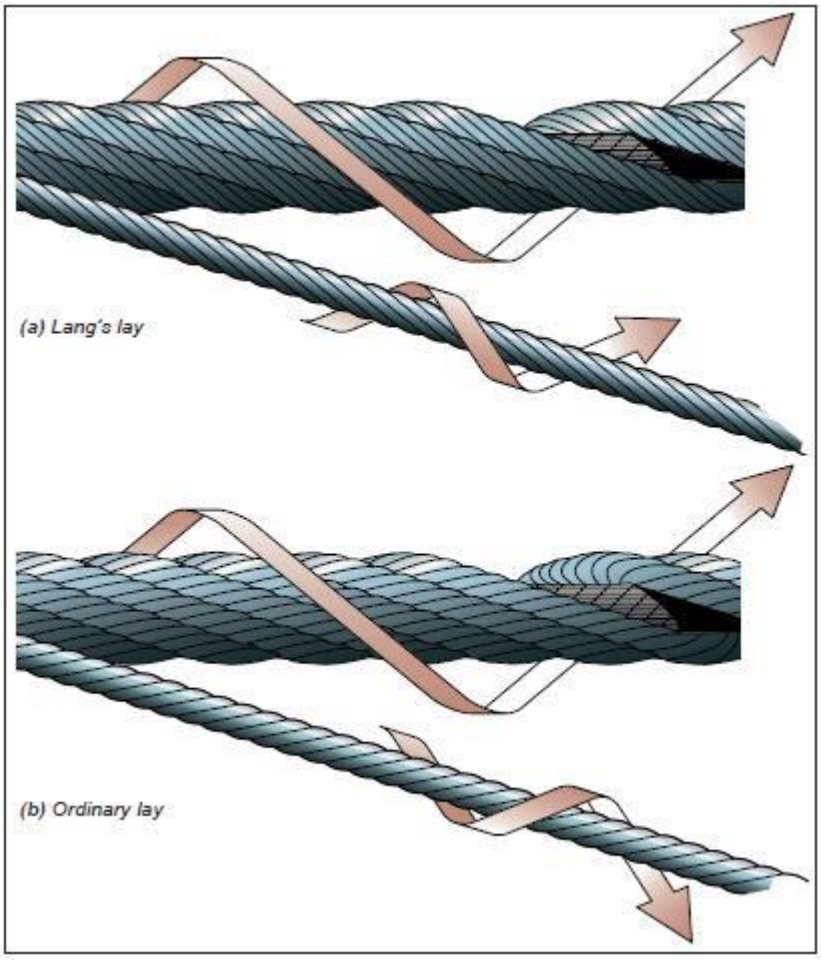
1) Inner wire cannot be examined.
2) Less flexibility.
3) Inner position of the rope cannot be lubricated.
4) These ropes cannot be spliced.
5) Less costly than full locked coil rope.

✞ **Guide ropes: -**

These ropes are usually made up of mild steel wires or ropes of large diameter, so sometime 12mm in circumference. The ultimate tensile strength ranges between 5.5to13.5 ton/sq.cm.

A single strand guide rope is simply 6 around 1. A locked coil rope as a guide rope consist of 6 around 1in the Centre and the outer layer has shaped wires so that they interlock.

Lay of ropes:



The twist or lay of the strands in rope may be either right hand or left hand. In a right hand lay rope, its helix when viewed vertically upwards in directed rightward in a left hand lay rope, leftward. The right hand lay ropes must be used when there are to be wound up the drum clockwise when viewed from the operator's site and vice-versa. It is a good policy to use alternately right

hand and left hand lay type ropes at its change of the ropes to allow uniform wear of the guides

The wires in each strand are laid spirally around the central core and the strands are also laid around the core. Strands and the wires is each strand may be laid either in opposite direction or in the same direction amongst themselves. In ordinary lay has the strand wire twisted in opposite direction to twist or lay of strands.

<u>Lang's lay & ordinary lay</u>:

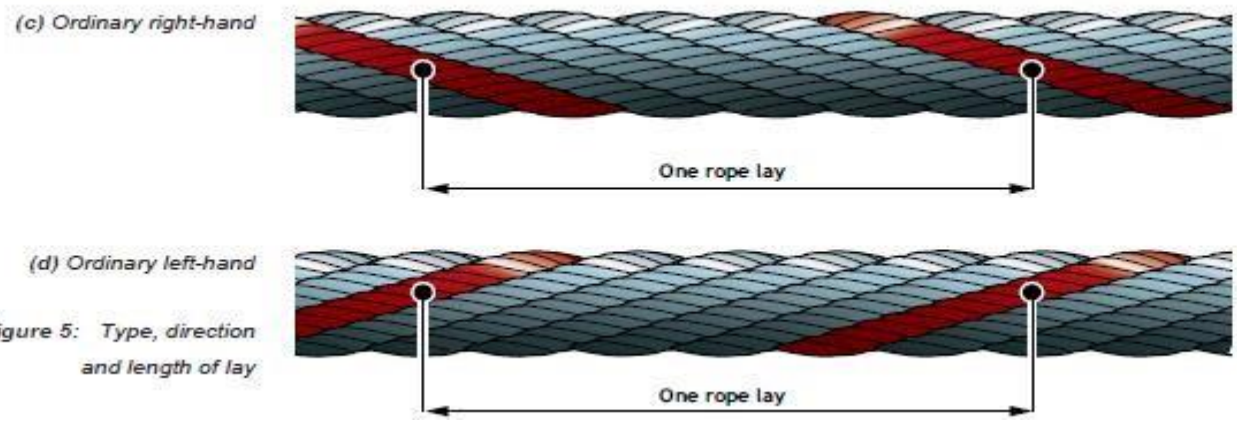
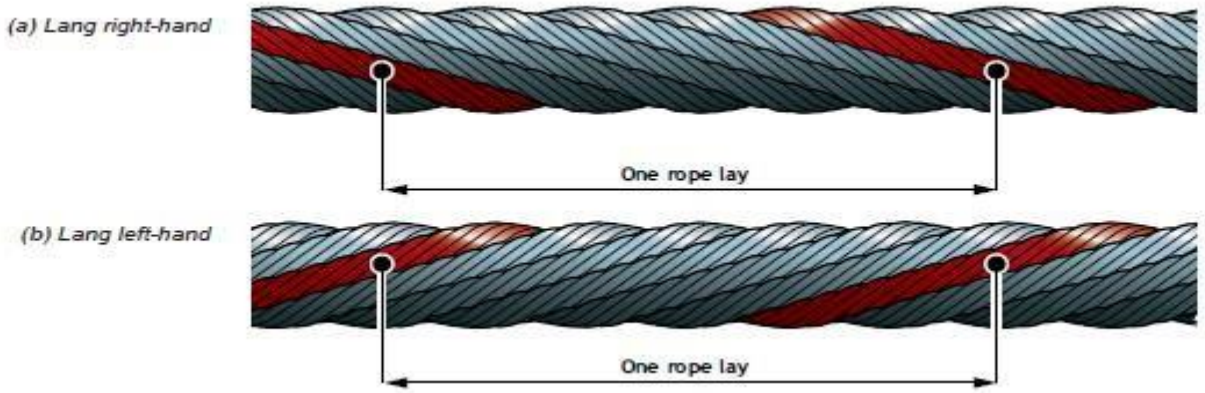


Figure 5: Type, direction and length of lay

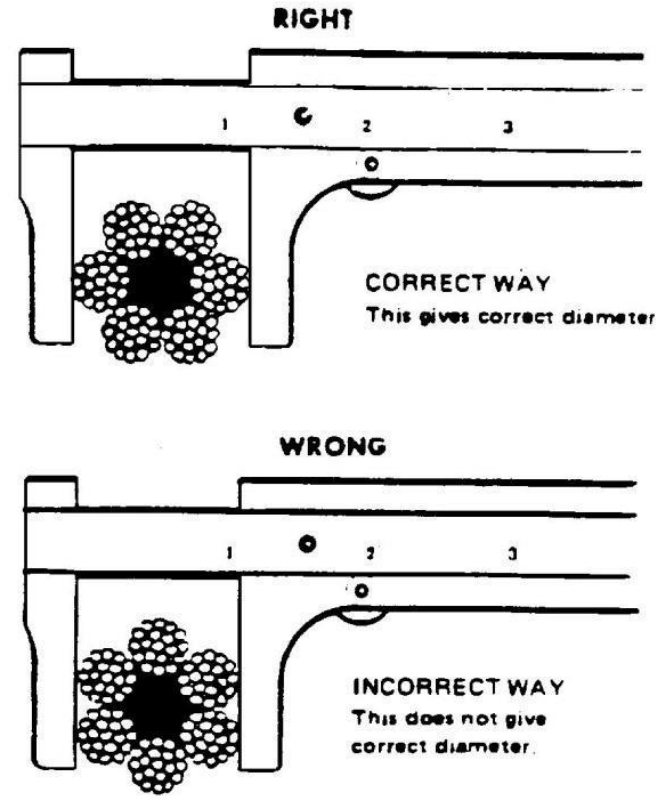
A rope is of ordinary lay construction if the wires in the strand and the strands in the rope are laid in opposite direction. Ordinary lay is also known as regular lay.



A rope is Lang's lay construction if the wire in the strand is laid in same direction as the strands are laid in the ropes. Such construction cause the rope to spin for this reason Lang's lay rope must never be used if there is free end to rotate. The

advantage of these lay is that the rope offer a better working surface than one of ordinary lay but also more resistance to bending fatigue. Lang's lay ropes are favored for winding and haulage purposes.

✞ **Size (Measurement) :-**



The diameter of a wire rope is the diameter of the circle which will just enclose all of the strands. In the case of strands, the diameter is that of the circle which will just enclose all of the wires. The correct diameter is the greatest diameter of the rope or strand shows the correct and incorrect ways of measuring wire rope

✞ **Space Factor (Fill Factor)**

It is the percentage of steel present in the given cross section of the wire rope. S. F. = Sum of individual wires cross section/Cross section of wire rope X 100.

Assume, d= Diameter of wire n=

number of wires used in the rope D=

Diameter of the rope

S.F. = {n.∏ d2/4}/ {∏D2/4} X100

S.F. = nd2/D2 X100

Static Load

It includes,

1) The weight of the tub
2) The weight of the cage
3) The weight of coal or mineral
4) The weight of suspension gear
5) The weight of the rope itself 6) Dynamic load: It includes,
7) Force due to acceleration.
8) Force due to retardation.
9) Kinetic shock.
10) Bending of rope.

✞ **Factor of Safety**

It is the ratio of nominal breaking strength of the rope to the minimum static load acting on the rope. F.O.S. = Nominal breaking strength of the rope/Maximum static load.

Factors Affecting the Factor of Safety

1) **Depth:** As the depth increases, the weight of rope itself becomes very excessive hence to control it factor of safety is reduced slightly so that the weight of the rope can be controlled.
2) **Rate of Acceleration:** As the rate of acceleration increased, the factor of safety used for rope also increases.
3) **Rate of Retardation:** As the rate of retardation increases, the factor of safety used for the rope also increases.
4) **Working Conditions:** If a rope is used under adverse working conditions such as on the ground, wet conditions etc its factor of safety should be more.
5) **Man or Material Transport:** If a rope is used for man transportation it should have higher factor of safety.
6) **Bending of Ropes:** If a rope is subjected to frequent bending it should have higher factor of safety.
7) **Shock Loads:** If a rope is subjected to shock loads, it should have higher factor of safety.

✞ Selection of Wire Rope

1) **Watery Places or Corrosive Atmosphere:** Under such conditions a galvanised rope should be used to prevent rusting & effect of corrosive water.
2) **Stationary or Running Coiling Rope:** If a rope is used as a working rope etc. it is known as running coiling rope. These types of rope should have more flexibility than it is required for a stationary rope i.e. guide rope.
3) **Rotating Quality:** In a crane one end of the rope is free to rotate hence a rope which is having a non-rotating property should be used. In case of haulages rotating property of the rope is not a problem.
4) **Shock Loads:** If a rope is subjected to frequent shock loads, in that case a rope with steel core should be used.
5) **Resistance to Wears:** Ropes used for haulage & winding should have high resistance to wear, in other words such ropes should have a smooth external surface, under such conditions it is preferred to use a Lang's lay construction.

6) **Factor of Safety (Men/Material Transport):** If a rope is used for men winding it should have higher factor of safety than it is required for material transport.
7) **Crushing Strength:** If a rope is subjected to crushing load, it should have high crushing strength. Under such conditions if flatten strand rope, steel core rope or locked coil rope can be used.
8) **Bending of the Rope:** If a rope is subjected to frequent bending, then a rope used should have more flexibility.
9) **Groove Size:** The rope should not be loose or too tight in the groove of the pulley or drum.

Machine/Place	**Rope Used**
1. Winding.	A rope of suitable size, round strand fibre core, Lang's lay construction
2. Haulage rope.	A suitable size, round strand fibre core, Lang's lay construction
3. Guide rope.	Suitable size, guide size, full/half locked coil.
4. Shaft sinking.	Suitable size, round strand, ordinary lay, steel core or locked coil rope.
5. Cranes.	Suitable size, regular lay or ordinary lay with steel core.
6. Drag line.	Suitable size, Lang's lay with IWRC (steel core).
7. Shovel.	Suitable size, Lang's lay with IWRC (steel core).

- **Care & Maintenance of Steel Wire**

1) Buy right construction of rope suitable for the job.
2) Under corrosive atmosphere use the galvanised rope.
3) Do not load the rope beyond its safe working load.

4) Ensure that the rope is strongly tight before it is cut.

5) Fibre core should not be used if the rope is subjected external pressure (crushing load).
6) Flexibility of rope should be suitable to the size of drums & pulleys.
7) Grease the rope & cover properly before starting in a dry ventilated shade.
8) Handle the rope carefully while transporting & uncoiling to avoid kinks.
9) Inspect the rope frequently & lubricate with acid free lubricant.
10) Judge the safe life of the rope for the conditions under which it is used & replace it in proper time.
11) Kinetic shocks to the rope should be avoided.
12) The rope must be recapped after every six months.

Type of Deterioration in the Ropes

1) **Wear:** Wear in the rope can be classified as external wear & internal wear. Internal wear is due to the movement of the wires which cannot be controlled, but if the external wears become excessive in nature, the cause should be found & it should be corrected.
2) **Corrosion:** The water spray, unsuitable lubricants, acids, salts etc cause it. Any water will cause corrosion if it gets in contact with the steel surfaces. Corrosion can be denied by using proper lubrication & galvanised ropes.
3) **Water-Corrosion:** Corrosion produces a weak layer of oxides & this layer of oxides is removed very fast by the wearing action & again a fresh steel surface is present for further corrosion. Hence the joint effect of wears & corrosion is much higher than their individual effect.
4) **Fatigue:** If a rope is subjected to rapid reversal of stresses i.e. loading & unloading of the rope, bending of the rope etc. the rope fails as much lower stress level. This is due the fatigue.
5) **Corrosion-Fatigue:** It occurs when there is a combination of the conditions favouring both corrosion rate increases, which can be reduced by using the sufficient & suitable lubricant.

6) **Accidental Dangers:** It is not a form of deterioration but it is very important that the rope man should realise that any cause may lead to rapid deterioration of the rope.

Testing of Wire Rope

1) **Tensile Test:** In this test the tensile strength of one wire which is used in the rope, it obtained by using this tensile strength are approximate tensile strength of the complete rope can be calculated.
2) **Tension Test:** In this test one end of the wire is fixed & the other end is rotated at 1 to 2 revolutions/second until failure occurs. The number of rotations to the failure is noted & by using the torsion strength of the complete rope can be calculated.
3) **Reverse Bend Test:** In this test one end of the wire is fixed & then it is bent backwards & a forward continuously through till the wire fails. The number of bends before failure gives an idea about the flexibility of the rope.
4) **Wrapping Test:** In this test the wire is bent & one end of wire is wrapped tightly around the other, usually for 8 turns. It is then unwrapped & if there is no sign of cracking, it means that the rope is still suitable for the job.
5) **Hand Test:** In this test the operator takes the two ends of the wire, one in each hand & forms a loop in it. Then pulls it out & again repeating the procedure until the wire fails. Based on this experienced operator can decides the approximate strength of the rope.

Capping

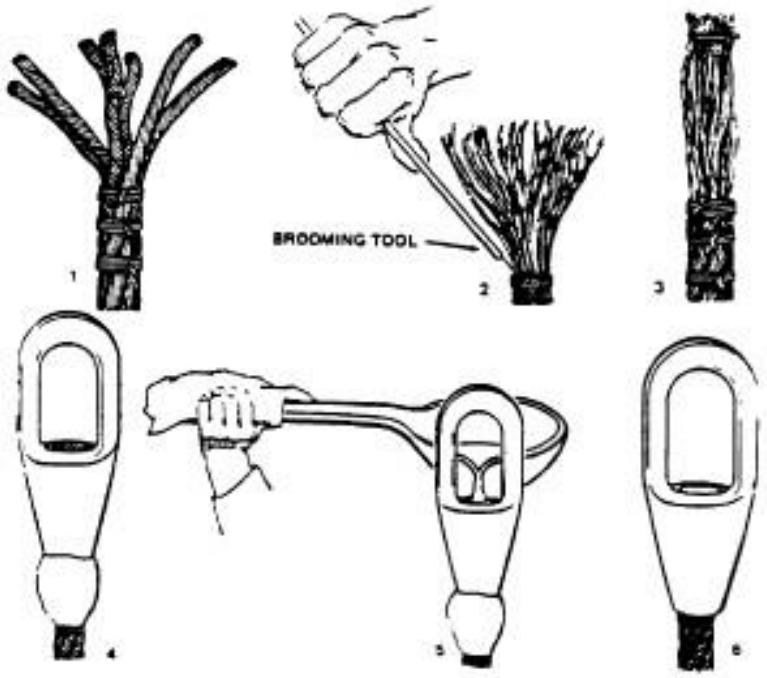
The end of the rope where load is to be attached should be such that it may be attached to load in a simplest way. An attachment is known as capel & is attached to one end of the rope so that rope can be attached to the load. The attaching to the capel to the rope is known as capping.

- **Types of Capping**

1) White metal capping (Cone socket type capel)
2) Wedge type capping (Reliance rope capping)
3) Capping with split capel & rivets (Split capel)

○ White Metal Capping (Cone socket type Capel)

1) White metal= Lead 80% + Tin 5% + Antimony 15%, melting point: 260□ C to 300□ C, maximum temperature: 360□ C.
2) Before cutting the extra length of rope or old capping, the rope should be tied properly to prevent any loosening of the rope.
3) Cut the rope by any suitable method & tie a thin wire up to a length 40d + L, where d is the diameter of rope & L is basket length.
4) Insert the cone in the rope & clamped the rope below cone & at a point F is shown in figure such that XL = L – 2d.
5) Open the rope between X & F & separate all the wires.
6) Cut the fibre core if it is there. Thoroughly clean each wire to ensure proper grip of white metal.
7) By means of a single turn of thin wire repair a brush at the required end of the rope.
8) Remove the clamp P & position the brush in the cone, & again clamp the rope just below the cone.
9) Heat the cone & brush up to a temperature of 100□ C & pour the molten white metal in the cone.
10) As soon as white metal achieves the atmospheric temperature, the clamp & thin wire are removed. With this capping operation is over.



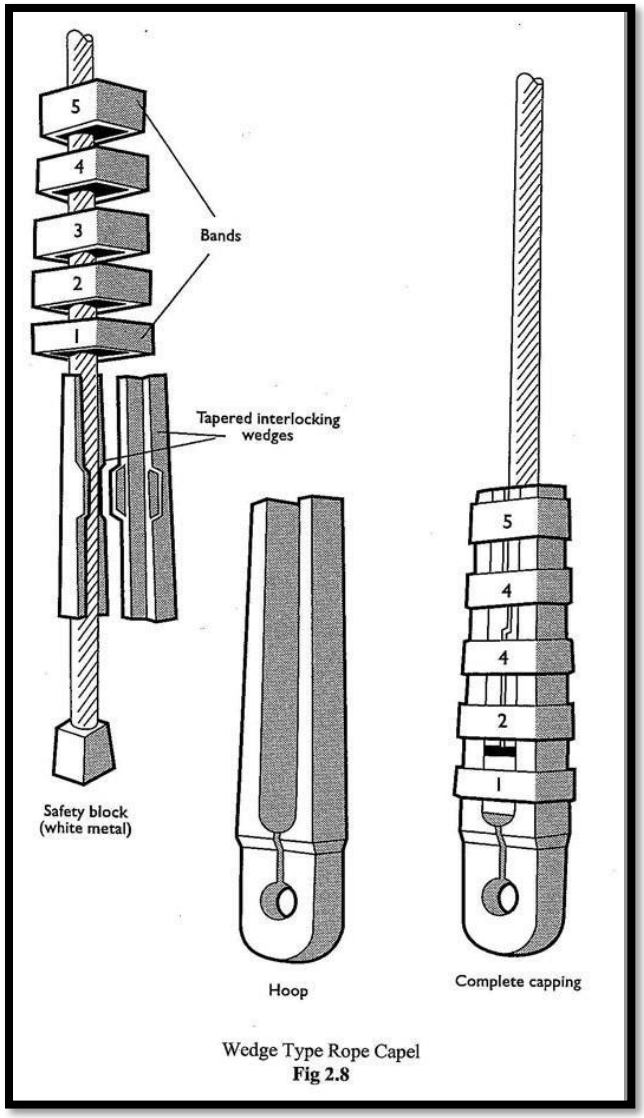
O Capping with Split & Rivets

1) Near the required end of the rope, mark these points A, B & C such that AB= BC = capel length. Between A & B wrap a number of turns of thin wire tightly to form a layer. Near b, give more turns of wire as shown in figure.
2) Open wire between B & C.
3) Cut 1/3rd wires to 2/3rd length & clean all the wires.
4) Turn back all the wires on the rope position B - A to give a cone & tie them on that rope position with a thin wire.
5) Cut the exposed core.
6) Lay a thin layer of white metal on the cone.
7) Hammer a thin wooden wedge into the cone at end B.
8) Push a split capel with its mouth slightly widened onto the cone & hammered the widened arms in position to grip the coned portion of rope.

9) Rivets are then hammered into the capel & through the rope at 3-4 points nearly 20 cm apart. With this capping operation is over.

Wedge Type Capping (Reliance Rope Capping):-

Reliance Rope Capel:-



Wedge Type Rope Capel
Fig 2.8

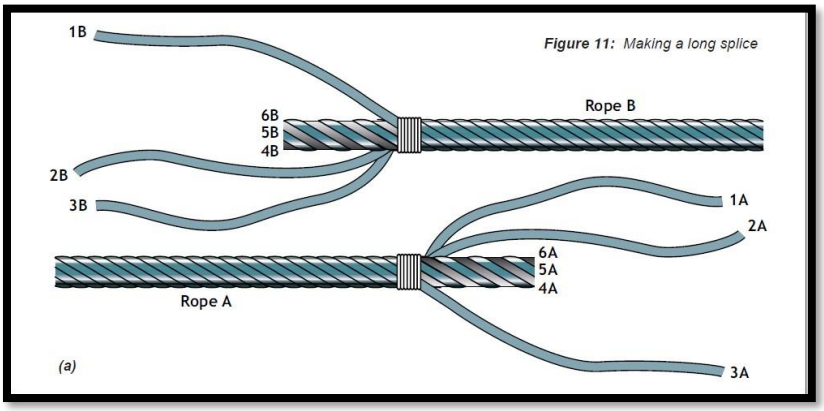
In this capel there are two iron wedges which grip the rope near the required end where a white metal block is prepared. There is U-shaped steel strapped which is placed over the two wedges & on which 4 - 5 iron clamps are fitted by hammering.

1) Prepare a white metal block at the required end of the rope.
2) Insert the iron clamps on to the rope in order of numbers (largest number first). The jaws of capel are about 24 times more diameters.
3) Properly clean any grease or lubricant from that portion of the rope, which will be griped by the wedges.
4) Place the two wedges around the rope approximately in the position they will occupy when in capel.
5) Fit the U-shaped strip over the wedges such that the U-shaped strip & wedge top are in one line. Draw the iron clamps over the U-shaped strip.
6) Hammer the iron clamps for proper grip. The ring number one should not be hammered because it is only for the safety of the white metal block. With this capping operation is over.

✞ **Recapping**

Every rope should be re-capped at least once in every six month or if necessary at shorten intervals & also after every over wind. Before every such recapping, At least two meter of rope is cut off & examined properly so that condition of the rope can be judged. If it is found that rope can be used again, the normal capping operation should be done.

✞ Rope Splicing:-

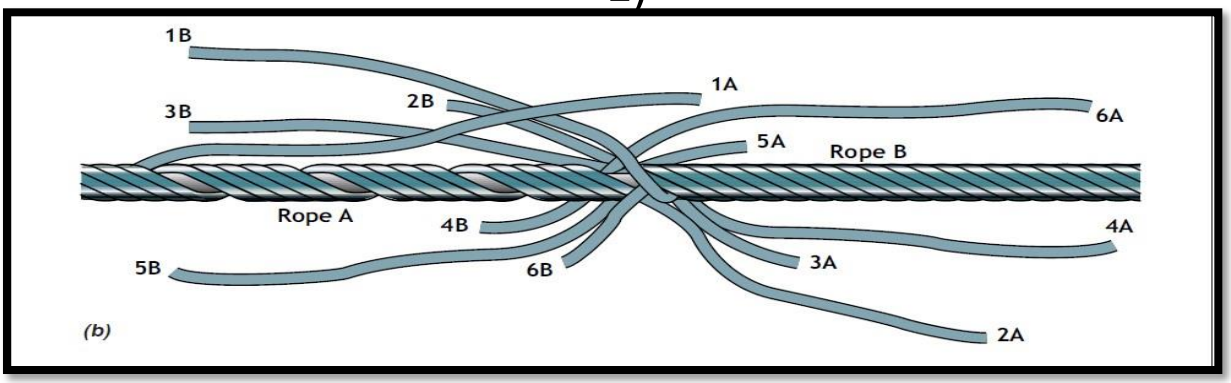


Splicing is a method of joining two wire ropes permanently without using special fittings or attachment. Splicing of winding drum is not permitted by DGMS after splicing the diameter of rope should not increase & also the joint should have almost original strength of the rope. Splicing length depends on the diameter of the rope. Let splicing length is 2X.

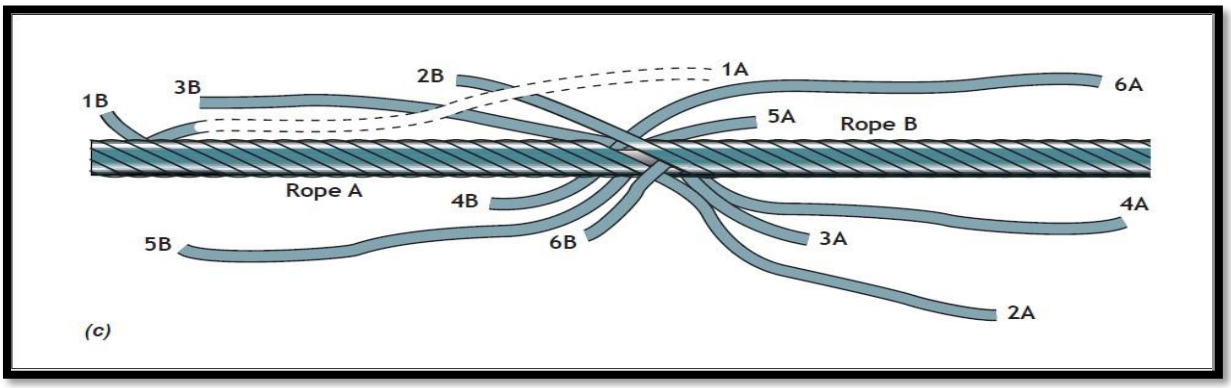
Procedure

1) Describe the length of splice let it be 2X.
2) Each rope is tied at the half of the splice length i.e. point A & B.
3) Open out strands of the rope up to A & B.
4) Cut the fibre core & remove from both ropes.
5) Bring the two ropes close to each other.
6) Strand 1' unwound from rope B up to a length approximately equal to x & the space left by strand 1' is filled by strand 1 from rope A. in a similar manner space left by 2 is replaced by 2'.
7) Next set of strands number (3 - 3' & 4 - 4') are spliced or 2/3rd length & strands 5 - 5' & 6 - 6' are spliced for 1/3rd length only.
8) Cut the strand up to the length required for tucking.
9) Bend the splice back & forth until all strands rest from the in their places.
10) Insert a tucker & needle into the rope at the point where the two strands cross, pull out the main core & cut it. The tail of strand fills the void created by fibre core.
11) Repeat the operation at all other five points & with this splicing operation is over

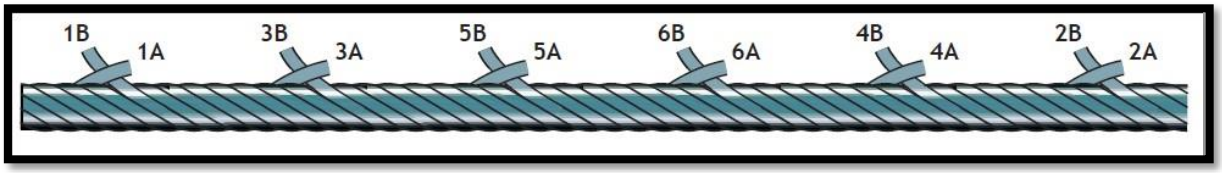
1)


1B
3B
2B
1A
6A
5A
Rope B
Rope A
4B
4A
5B
6B
3A
2A
(b)

2)


1B
3B
2B
1A
6A
5A
Rope B
Rope A
4B
4A
5B
6B
3A
2A
(c)

3)


1B
1A
3B
3A
5B
5A
6B
6A
4B
4A
2B
2A

Chapter no 4 -PUMPS

PUMP

A pump is a device used to move fluids, such as liquids, gases, or slurries. It increases the mechanical energy of the fluid. The additional energy can be used to increase :

Velocity (flow rate)

Pressure

Elevation

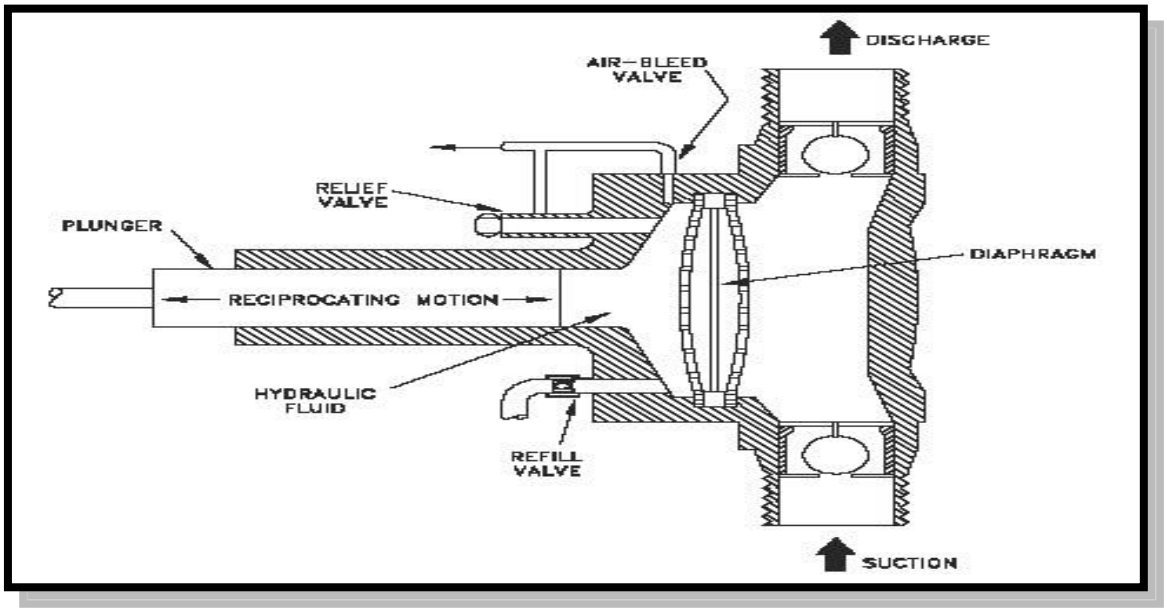
TYPES OF PUMPS:-

-RECIPROCATING PUMP

-CENTRIFUGAL PUMP

-FACE PUMP

RECIPROCATING PUMPS :-



Reciprocating pumps depends for their action on the relatively slow to and fro motion of a piston, plunger or ram within a cylinder called working barren. The reciprocating motion may be given by steam or compressed air engine, either direct or through the medium of a crank and connecting rod or by an electric motor through reducing gearing.

Reciprocating pump may be single acting or double acting with piston or ram within the pump barrel. piston pump are suitable only for pumping fairly clean water to moderate height,upto about 90m to 120m.they have the merits of being light, cheap and compact. But their cheap drawback is that there is some difficult in maintaining a closed internal fit between the piston and the working barrel, especially if the water is of gritty in nature and the delivery head is high. In such case, leakage of water from one side to the other may occur to a serious extent. Ram pumps are suitable when the pumping conditions are more arduous because of dirty water or high lift or combined. They may be designed to deal with any head up to 100 m or

even more. The special advantage of ram is that it has only to be kept water- light at the external stuffing boxes. These can be readily maintained in a good condition and lekeage,if it occurs, is at once visible.

SINGLE ACTING RAM PUMP

Pumps of this type may be arranged either vertically or horizontally, and they may have either 1,2 or 3 rams. Thus a unit of two ram pumps placed side by side and actuated by the same engine, with a common delivery are called duplex pump and three single acting pumps in similar arrangement are called triplex (or three – through).The triplex pumps have a smooth flow of water from the delivery. If the pump has four or five cylinders, it is called quadruplex or quintuplex .

VETICAL SINGLE ACTING PLUNGER OR RAM PUMP

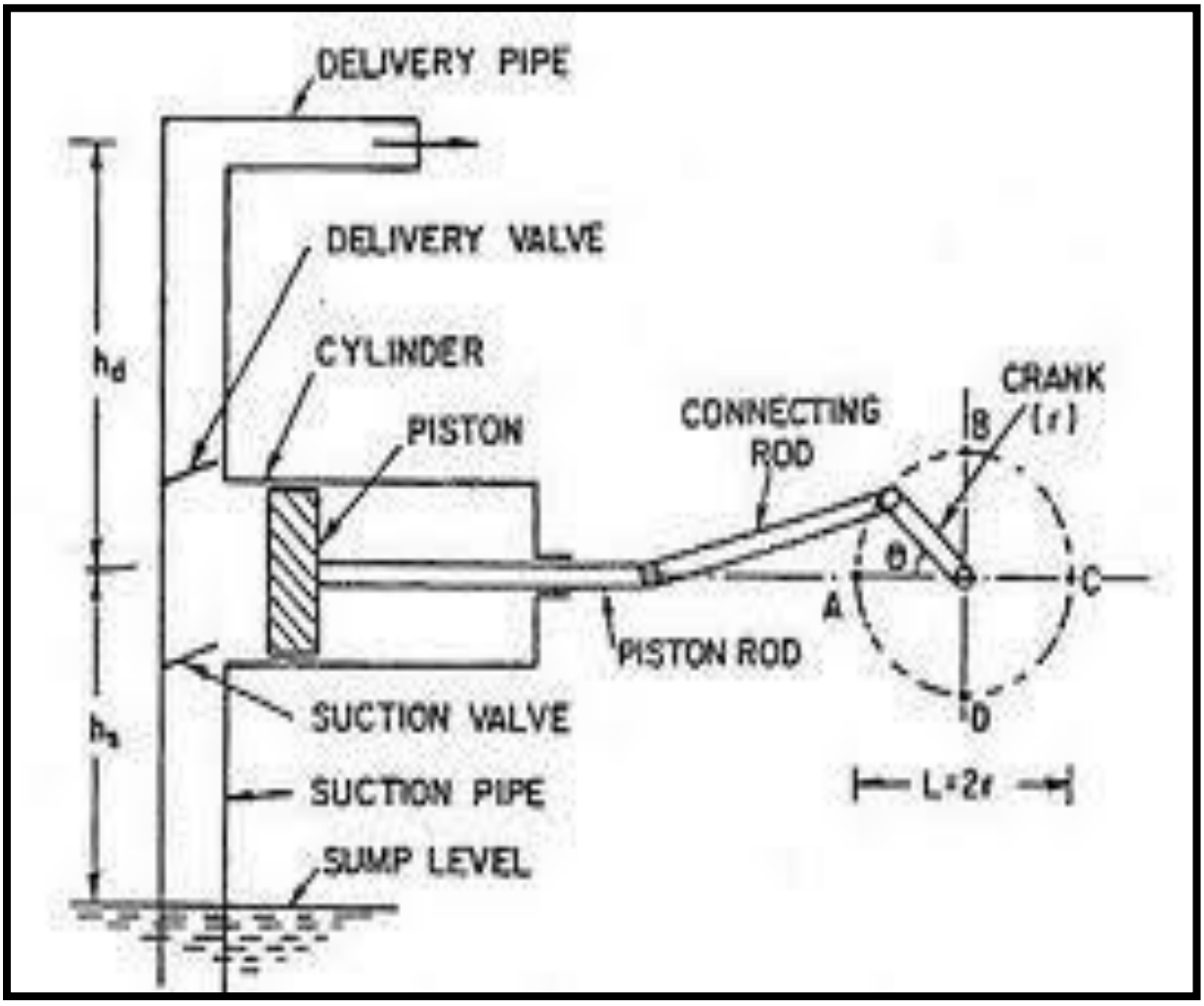
It forces the water to the delivery pipe during the down stroke. It is therefore called forced pump

The pump consists of hollow plunger or ram moved up and down within the working barrel or ram case.Lekeage of water past the ram is prevented by a stuffing box and gland. Two valves, one delivery and the other suction valve, are provided. Suction pipe, delivery pipe and air vessels are the accessories.

During the upstroke of the plunger, a low pressure is created in the cylinder as the deliver valve closes. Hence the suction valve opens and water from the suction pipes enters into the cylinder. During the downward stroke, the suction valve closes and the deliver valve opens, in order to relieve the pressure, due to compression of the water. A part of the water enters into the air vessels, and most of the water goes out through the delivery pipe. As the delivery may have hydrostatic head, water from the delivery pipe presses on the delivery valve and keeps it closed during the upward stroke. Thus the cycle is repeated, and water is drawn up, from the suction side and pushed out on the delivery side. The discharge under these conditions will be in the form of sudden spurts of water. In order to even out the flow, air vessel is added. This is generally a hollow cylindrical vessels in which some air is traped.As the water from the delivery side enters the air vessels the air in the vessel is compressed and this acts as a cushion or spring. When the ram retreats, during the suction stroke, the compressed air in the air vessels causes the water to flow out of the delivery pipe, thus producing a steady rate of flow, during the suction stroke as well.

Since atmospheric pressure can normally support a column of water 10.2 m high at mean sea level, the suction should not exceed this limiting height. But in practice only

Since atmospheric pressure can normally support a column of water 10.2 m high at mean sea level, the suction should not exceed this limiting height. But in practice only 6 m of suction is used. A foot valve and a strainer are also fitted at end of the suction pipe, and when starting a pump the suction pipe is filled with water for priming.



A brief specification of pump is as follows:

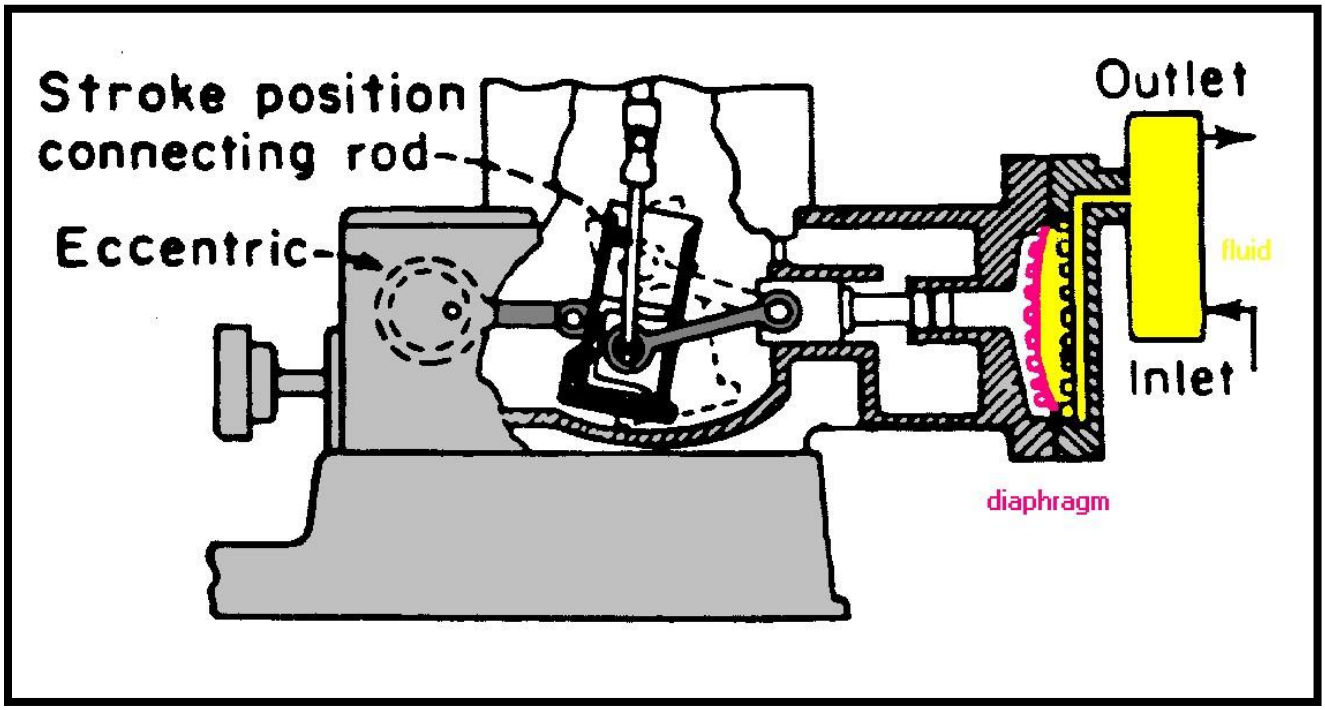
a. Ram case: Usually made of cast iron, line with brass (cu-70%,zn-30%) or gun metal (cu-88%,sn-10% and zn-2%).
b. Ram: Cast iron, may be lined similarly.
c. Ram rod: Forged mild steel.
d. Valves and seats: Brass or gun metal.

If the water is corressive,the whole pump may be made of monel metal (ni67%,cu-30%,fe1.25%,mn1.25%) to resist corrosion.

The packing for the stuffing box may consists of rings of hemp soaked in tallow, square braids of compressed cotton, but patend composite packings of asbestos, graphite and interwoven with anti friction wires ,maybe used for high pressure

HORIZONTAL SINGLE ACTING RAM PUMP:

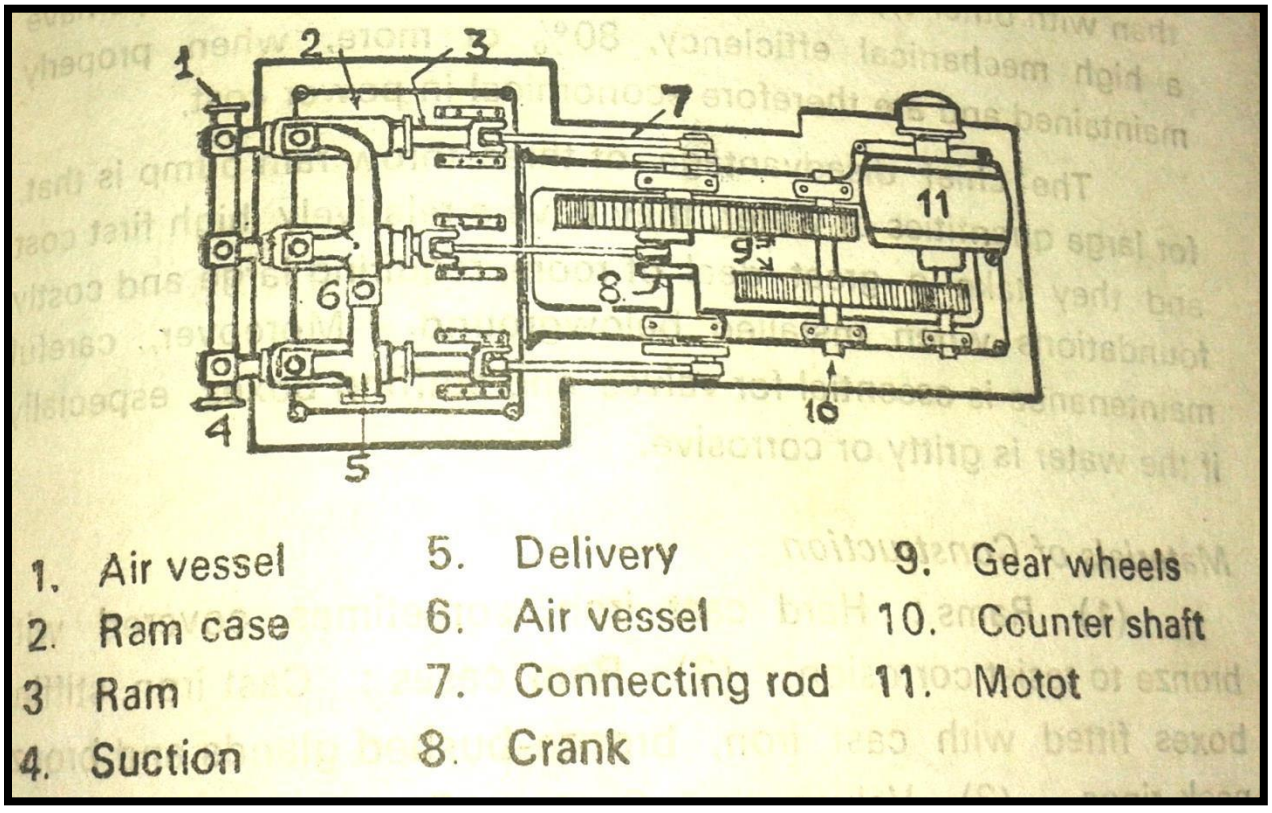
In this type of pump the ram moves horizontally within the pump barrel. when the ram moves backward, a region of low pressure is created within the barrel or ram case and water rises up the suction pipe and into the case behind the retreating ram. when the ram moves forward ,the suction valve closes and water is forced through the delivery valve into the delivery pipe.



THREE-THROW RAM PUMP:

A three throw ram pump consists of three rotative single-acting ram pumps mounted together on a same bed plate and connected to common suction and delivery pipes. All three rams are driven by one crank shaft, but the three cranks are spaced at 120 degree to each other so as to give a uniform flow of water and more uniform load on the driving motor. The whole of the pump, with its motor and gearing, is mounted on the cast iron belt plate of box section, made in parts for convenience in transit and erection.

The pump is normally driven by electrical motor. The motor is generally of three-phase A C.induction type, a squirrel cage motor is used the large sizes. It drives the pump through double-reduction spur gearing; alternatively, lower speed motor may be arrange to drive the pump through single-reduction double helical gearing with a flexible coupling between the motor and pinion wheel.



Mode of action: In the backward stroke, a region of low pressure is created within the barrel and water flows from the sump through the suction valve and into the barrel, being implied by the difference of the pressure of the barrel and the outside the atmosphere. In the forward stroke the ram advances into the ram-case and forces the water from the barrel to the delivery valve into the delivery pipe. The process continues in each of the rams. As the cranks attached to the rams are spaced at 120 degree, there are three delivery of the water for each revolution of the crank shaft. The delivery of the water is thus almost continues throughout each revolution ,the load on he driving engine or motor being therefore much more uniform than with other types of reciprocating pump. Such pump have a high mechanical effiency,80% or more, when properly maintained and are therefore economical in power cost.

The chief disadvantage of three –throw ram pump is that for large quantities of water, they have a relatively high first cost and they take a great deal of room ,requiring large and costly foundations when installed below ground.Moreover,careful maintaience is essential for valve and stuffing boxes, especially if the water is grity or corrosive.

Material of construction:

1. Rams: Hard cast iron, sometimes covered with bronze to resists corrosion.
2. Ram cases: Cast iron, stiffing boxes fitted with cast iron, bronze-bushed glands and bronze neck-rings.
3. Valves and seats: Bronze, spring –loaded removable and interchangeable.
4. Gearing: Machines- cut teeth; Motor pinion of compressed paper.
5. Shafts: Forged steel with bronze –bushed bearing.
6. Crank shaft: Fitted with cat iron discs at each end, with hard steel crankpins.

Controlling valves

1. A foot valve at lower end of the suction pipe to prevent water returning to the sump.
2. A main valve, also called a sluice or gate valve, in the delivery column.
3. A retaining valve, above the main valve. To holds the water in the delivery column if the pump stops while the main valve is open.
4. By –pass valve, short circuiting both the main valve and the retaining valve, to enable the pump to prime with water direct from the delivery column.
5. Air cock on each barrel to release the air whilst the pump is being primed.
6. Suction and delivery air-vessels.

Electrical equipments

The following electrical apparatus would be required for supplying and controlling the motor (assuming the pump is driven by a 3-phase A.C. slip –ring

induction motor with wound rotor, main supply 3300V and the pump running at 550V)-

1. Main H.T.switch to control 3300 volts supply.
2. Static transformer to step down the voltage from 3300v to 550 volts.
3. L.T. switch to control the 550 volts supply.
4. A variable starting resistance in the rotor circuiting of the motor for the starting purpose.

Other Equipments required in the pump room are –

1. A small lighting transformer to step down the voltage to 110 volts for lighting pupose.
2. A telephone.
3. Statutory notices.
4. Pails of sand to extinguish fire.
5. Flame safety lamp.

Starting of the pump

1. Prime the pump.
2. Open the main valve.
3. Start the motor.

Stopping of the pump

1. Stops the motor.
2. Close the main valve.

Advantages and Disadvantages of Three –throw Ram Pumps

Among their advantages may mentioned-

1. Simple, reliable robust and easy to work.
2. High effiency(80-85%) remaining constant for a long time .
3. High pressure developed with small capacities.

4. The delivery of water is almost continuous and the load on the driving motor is relatively constant.
5. Applicable to variable pressures without speed adjustment.
6. Self priming.
7. Can operate under adverse suction conditions.
8. Less sensitive to air leakage.
9. Able to handle air , gas viscous liquids.
10. Working parts are readily accessible, and the water is more easily seen and rectified.
11. Low power cost. **The Disadvantages Include**:-
    1. Larger floor space with heavier and comparatively expensive foundation is required.
    2. Unreliable for high speed drivers.
    3. Multiplicity of valves and stuffing boxes render carefully maintenance essential, especially if the water is gritty or corrosive.
    4. To much vibration and noise.
    5. High initial cost.
    6. Cost of packing and lubrication is higher.
    7. Water hammer is common occurrence, and excessive pressure may be developed.
    8. Fluctuating discharge adversely affecting the foundation and prime mover and increasing the friction head.
    9. Inflexible operating characteristics.

Applications:-

a) It is particularly suitable for pumping relatively small quantities of water against high head, usually at shaft bottom in deep mines and at working faces.
b) It may be used for pumping muddy, heavily mineralized or acidic water.

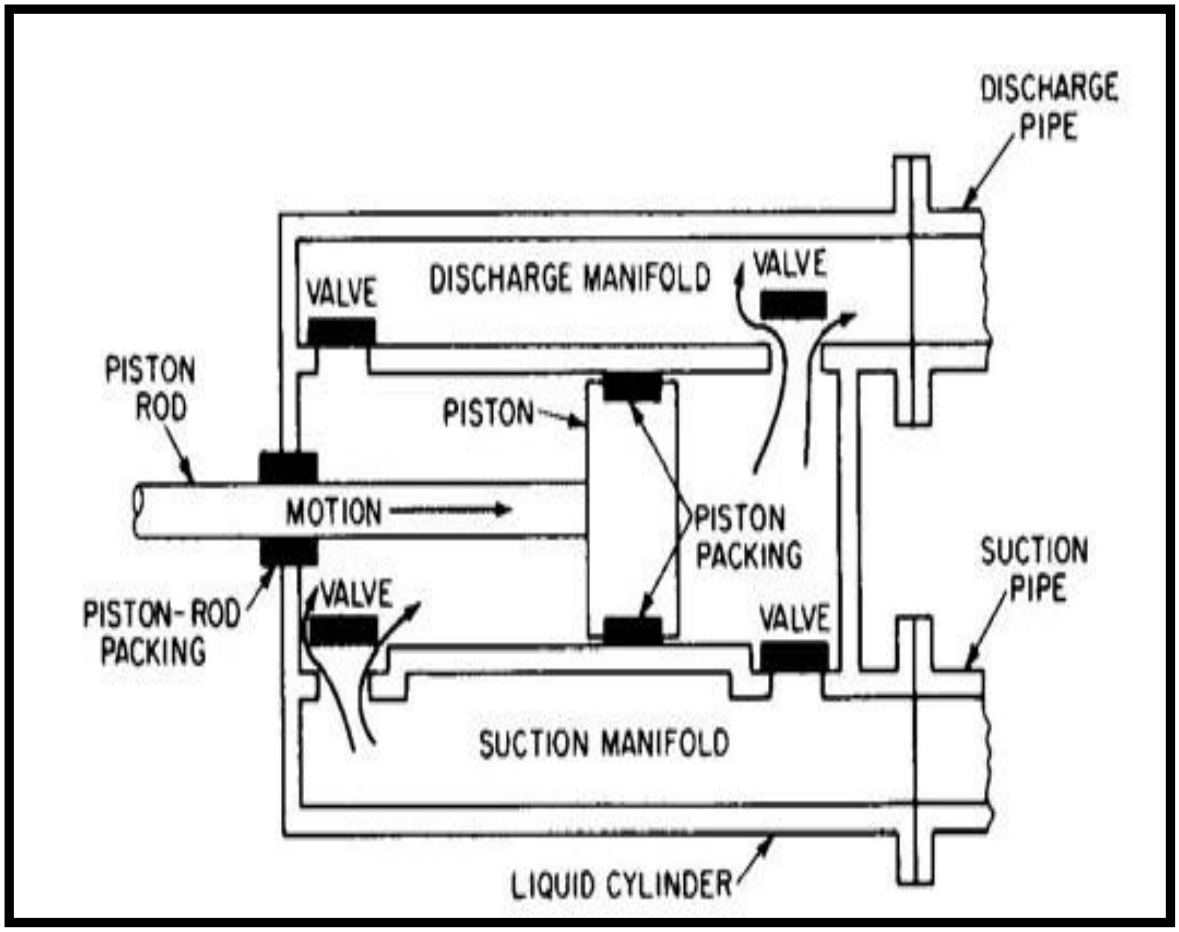
Double- Acting Pump

This type of pump is provided with two suction vavles,V1 and V2, and two delivery valve D1 and D2.During the stroke to the left, water entering through the suction valves V2,and being forced through the delivery valve D1.In the reverse stroke (for the stroke to the right in the figure),water enter at V1 and leaves through D2.Every stroke is effective to make the pump double-acting. Water is thus delivered during every stroke.

Volumes of water discharged during two strokes (left stroke and stroke to the right side) are not equal due the effect of piston or ram rod. The difference is about 3% to 4% and this is usually ignored during pump calculations. The valves may be of the rubber disc type, or single beat valves of the 'poppet' type, all metals part being of brass or gun metal. A delivery airvessel may be fitted, if desired.

The pump barrel is usually fitted with a liner of cast iron or brass which can readily be renewed when worn by gritty water. Piston pumps are suitable for pumping clean water to moderate heights up to about 120m.They have the merits of being lights, cheap and compact. The chief drawback of piston pump is that leakage of water from one side to other may occur due to some difficulty in maintaining a close internal fit between the piston and the working barrel. Ram pumps are preferred to pistons pumps when the pumping condition are more arduous because of dirty water, or high lifts, or both combined.They may be designed to deal with any head up to 1000m or even more.Such pumps have only to be kept water-tight at external stuffing boxes.

Direct-driven double-acting ram pumps are specially suitable for raising water from deep workings, or for keeping dry the advancing the faces of an incline, where the water is dirty and pumps may be frequently be working on air.



Duplex pump:-

A duplex pump is simply to direct driven double acting piston or ram pumps mounted side by side on one bed plate. Such a pump has twice the pumping capacity of a single pump and more uniform delivery.

Differential pump:-

The differential ram pump consists of a ram which has two diameters, the larger being (under root) 2 or 1.4142 times the smaller. The cross-sectional area of the plunger rod is exactly half that of ram R.

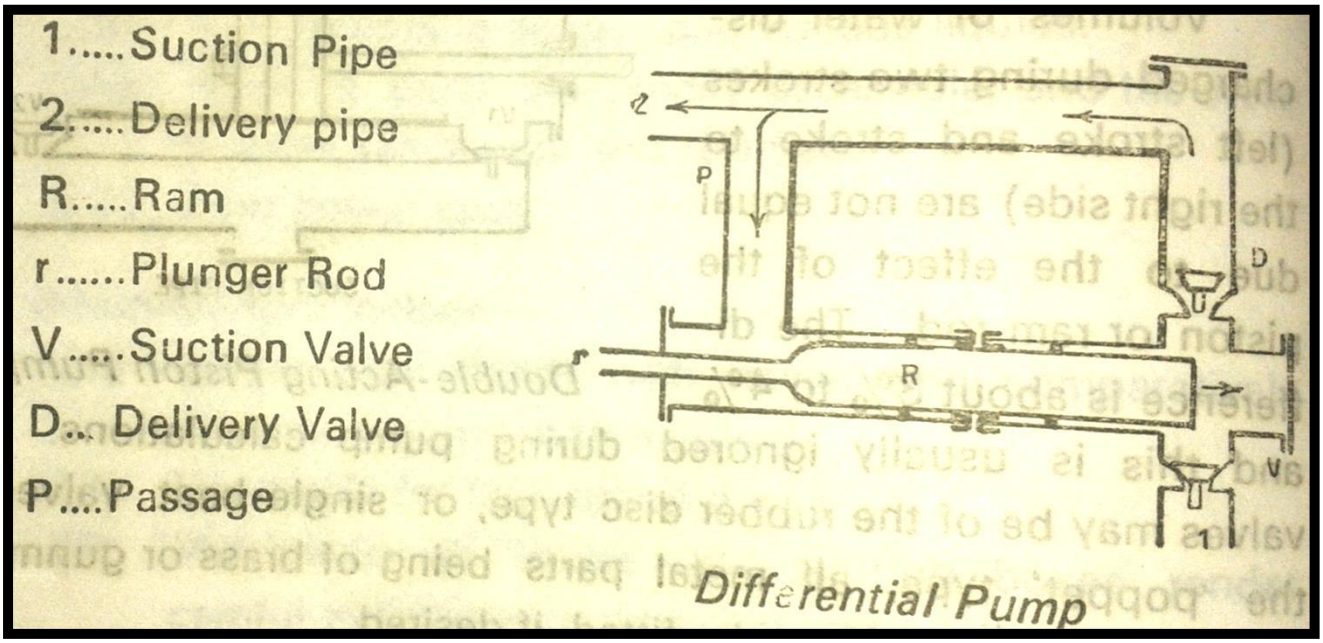
Let the ram is making its stroke to right and a volume of water, corresponding to the displacement of the ram is forced through the delivery valve D into the delivery pipe, the suction valve V is remaining closed. The delivery pipe is connected via the passage 'p' with the opposite end of the

pump barrel, and thus half the water pump by the ram passes back into the barrel, filling the space around the plunger rod ‘r’.The other half passes along delivery pipe which represents the quantity of water actually pumped by the stroke to the right.

During the stroke to the left, the pump barrel is emptied of its half volume of water. The delivery valve D remains closed and a volume of water corresponding to the ram flows through the now-open suction valve V.

Differential pump is so called because of the two different diameter of the ram – delivers same volume of water in every stroke its is ,in effect, a double acting pump, having only one suction valve and one delivery valve just like a single-acting pump.

Effective capacity may be taken as that a double-acting pump having a diameter equal to that of the smaller plunger ‘r’,or as that of a single-acting pump of diameter equal to that ram R.



Priming:-

If the pump barrel is filled with air the pump will fail to draw its water. This trouble may be overcome by filling the barrel solidly with water. The process is known as priming. Actually most reciprocating pumps are self-priming, but all pumps can be started more easily if they are first primed. Centrifugal or turbine pumps cannot create their own vaccum when the pump is empty. Before starting such pump must be primed solidly with water right from the sump-level to the main valve in the delivery column. If the pump fails to draw water, it will heat up and become damaged.

Primming may be done by hand.Alternatively,water may be drawn from the delivery column by the means of a special by pass valve and pipe fitted for the purpose.

Water hammer:-

This is a violent shock caused by a moving column of water being suddenly brought to rest. In reciprocating pumps, it is liable to occurs whenever the ram or piston returns into half empty casing and meets the still advancing water with violent shock and noise. If allowed to continue, a joint may be blown out and valves or some other parts of the pump delivery column damaged.

Causes:

The reasons for water hammer may be as follows-

1. Suction pipe being too small.
2. Suction pipe or strainer partially choked.
3. Valve being defected.
4. Valve-seat loose
5. Suction pipe is too long.
6. The pump is suddenly started or stopped.

Remedies:

The following measures should to be take to minimize water hammer-

1. Install a larger suction pipe.
2. Avoid choking of valves and strainer.
3. Check valves and valve-seats.
4. Reduce the speed of the pump so that ram and water move in synchronism.
5. Use shorter suction range.
6. Use air-vessel suction range.
7. Use air-vessel to ensure amore constant flow of water.

Air-Vessel:

Delivery Air-Vessel: Air vessel is a chamber filled with air and directly communicated with delivery pipe of the pump. Its purpose being to reduce the jar, shock and noise with which a reciprocating pupm, and especially single-ating, inevitably works when opposed by appreciable delivery head.

During the forcing stroke, the whole of the water in column is accelerated and then brought to rest. The rate of acceleration is not constant and causes pulsations or surge of water which ultimately results shocks on driving mechanism. But when an air-vessel is fitted, an certain amount is forced into it, so compressing the air therein when the rate of delivery is maximum. At the end of the forcing stroke, the compress air expands and drives out the excess water into the main delivery column. It thus helps to maintain more continuous flow of water in the delivery pipe. It acts like a spring buffer or cushion smoothing out fluctuations of delivery and prevents damage to the pipes and joints. It increase the effiency of the pump saving the power lost in the acceleration head.

The capacity of the air-vessel:

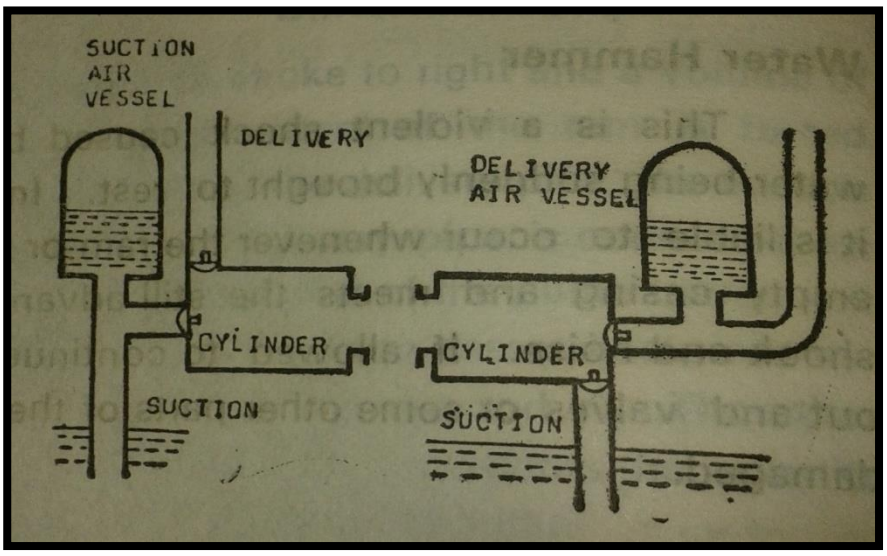
1. For a single-acting pump it should be 10 minutes the displacement of the pump per stroke.

2. For a double-acting or a three-throw pump, an air-vessel of about half this size or even less (2 to 4 times the displacement per revolution) will suffice.

   The air-vessel should be regularly re-charged via a tap at the top of the vessel either from compressed-air supply or by an air pump. A water gauge should be fitted to the side of the air-vessel to check the amount of air in vessel.

Suction Air-Vessel:

The need for a suction air-vessel arises from the fact that the water may not rise up the suction pipes as fast as the ram retreats, the result being that an empty space exists between the water and the ram. This is known as cavitation. Which is likely to arise due to high speed of the pump and longer suction pipe of small diameter.On the reverse stroke of the ram strikes the still advancing water in the barrel with a violent shock. The use of suction air-vessel ensures a constant flow of water and enables the water to keep pace with the retreating ram. Such air-vessel is fitted to the suction pipe, the top of the vessel being above the level of the suction valve.



Centrifugal pump

A centrifugal pump is one of the simplest pieces of equipment. Its purpose is to convert energy of an electric motor or engine into velocity or kinetic energy and then into pressure of a fluid that is being pumped. The energy changes occur into two main parts of the pump, the impeller and the volute. The impeller is the rotating part that converts driver energy into the kinetic energy. The volute is the stationary part that converts the kinetic energy into pressure.

Working Mechanism of a Centrifugal Pump

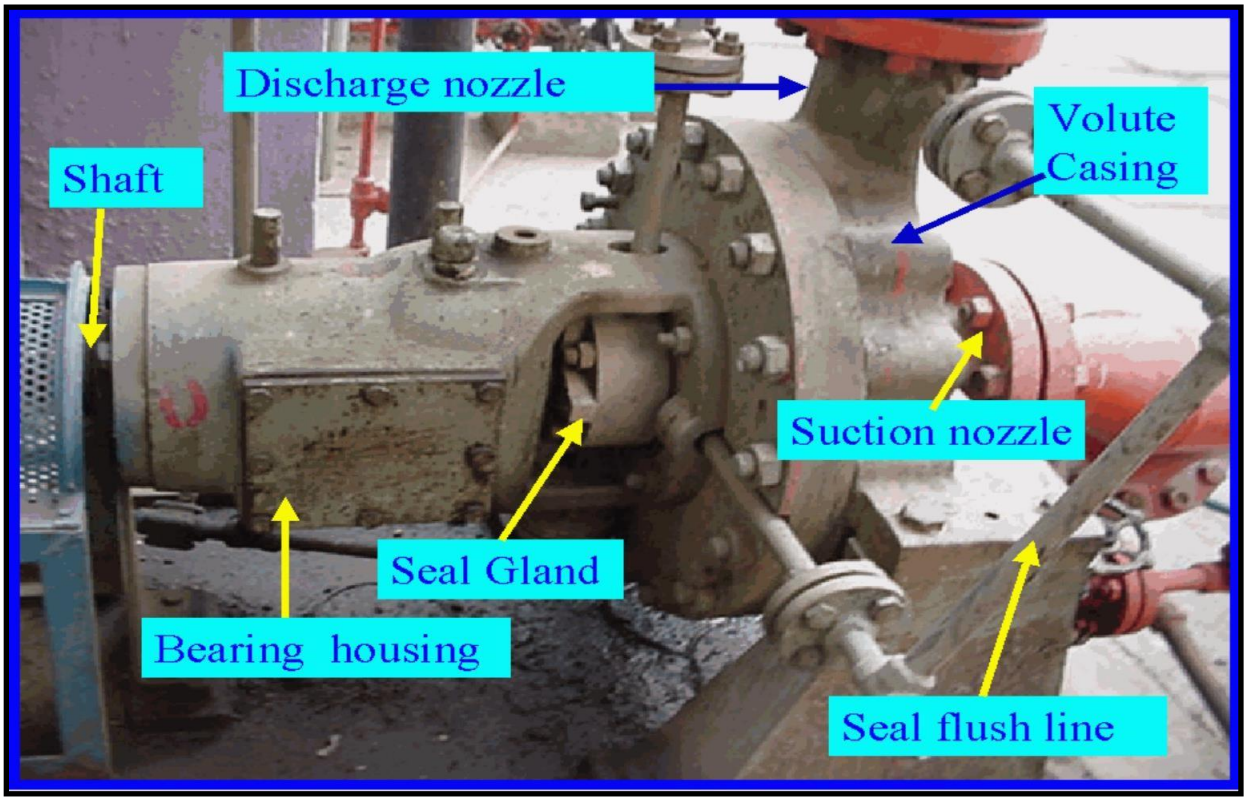
A centrifugal pump is one of the simplest pieces of equipment in any process

plant. Its purpose is to convert energy of a prime mover (a electric motor or turbine) first into velocity or kinetic energy and then into pressure energy of a fluid that is being

pumped. The energy changes occur by virtue of two main parts of the pump, the impeller

and the volute or diffuser. The impeller is the rotating part that converts driver energy into

the kinetic energy. The volute or diffuser is the stationary part that converts the kinetic energy into pressure energy.



Generation of Centrifugal Force

The process liquid enters the suction nozzle and then into eye (center) of a revolving device known as an impeller. When the impeller rotates, it spins the liquid sitting in the cavities between the vanes outward and provides centrifugal acceleration.

As liquid leaves the eye of the impeller a low-pressure area is created causing more liquid to flow toward the inlet. Because the impeller blades are curved, the fluid is pushed in a tangential and radial direction by the centrifugal force. This force acting inside the pump is the same one that keeps water inside a bucket that is rotating at the end of a string.

Figure below depicts a side cross-section of a centrifugal pump indicating the movement of the liquid.

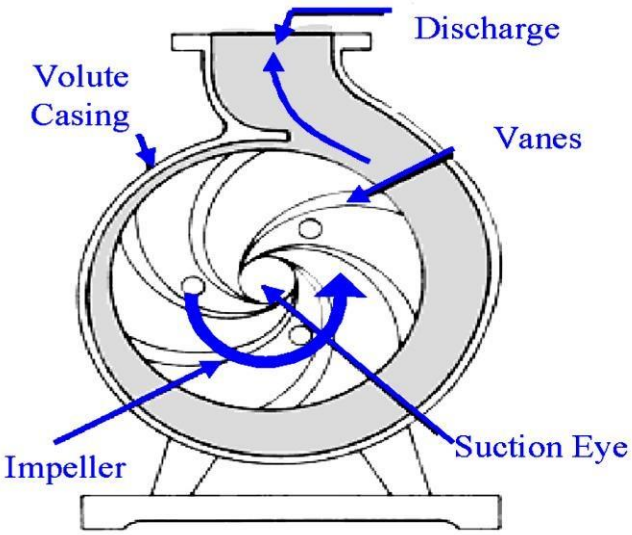
Types of Centrifugal Pumps

- Volute Pump (Centrifugal Pump)

- Turbine Pump

  <u>Volute Pump or Centrifugal Pump</u>: Main components of the volute Pump are as under:

- **<u>Impeller</u>:** It is a wheel or rotor which is provide with a series of curved blades or vanes. It is mounted on a shaft which is coupled to an external source of energy (electric motor) which supplies the required energy to impeller, thereby making it to rotate.
- **<u>Casing</u>:** The impeller is surrounded by a spiral shaped chamber, which is known as casing as shown in the figure. The shape of the casing is such that the sectional area of flow around the impeller generally increases from the point A towards the delivery pipe.



1) <u>Suction Pipe</u>: It is a pipe which is connected to its upper end to the inlet of the pump, which is known as Eye. The lower end of the suction pipe dips into the liquid which is to be pumped.

2) <u>Foot Valve & Strainer</u>: The lower end of the suction pipe is filled with a foot valve & strainer. The liquid first enters the strainer which is provided in order to keep the debris away from the pump and then water enters the foot valve. A foot valve is non-return valve and opens only in the upwards

direction as such the liquid will pass through the foot valve only upwards and it will not allow the liquid to move downward back to the sump.

3) Delivery Pipe: It is a pipe which is connected at its lower end to the outlet of the pump and it delivers the liquid to the required height.

4) Delivery Valve: Just near the outlet of the pump on the delivery pipe a delivery valve is provided. It is a regulating valve which is required to control the flow of liquid from the pump into delivery pipe.

5) Airlock: It is used for Priming.

Working of Volute Pump

The centrifugal pumps cannot be started until water is not filled in the casing. As the impeller rotates, the water particles also rotate and their Kinetic energy increases continuously. Due to which they are thrown away from the impeller tangentially towards the casing. As soon as water particles hits casing their kinetic energy are converted into the potential energy due to which the water is raised to a greater height.

Priming

It is the operation in which the suction pipe, casing of the pump and the portion of the delivery pipe up to the delivery valve are completely filled with the liquid which is to be pumped so that no air is left in the casing.

The pressure generated by the impeller is directly proportional to the density of the liquid i.e. in contact with it. Hence if an impeller is made to rotate in the presence of air, only a negligible pressure would be produced with the result that no liquid will be lifted by the pump as such it is essential to properly bring a centrifugal pump before it can be studied.

“Face Pumps”

A pump is a mechanical device which converts mechanical energy into hydraulic energy.

In mines there is presence of water it creates lot of problems.

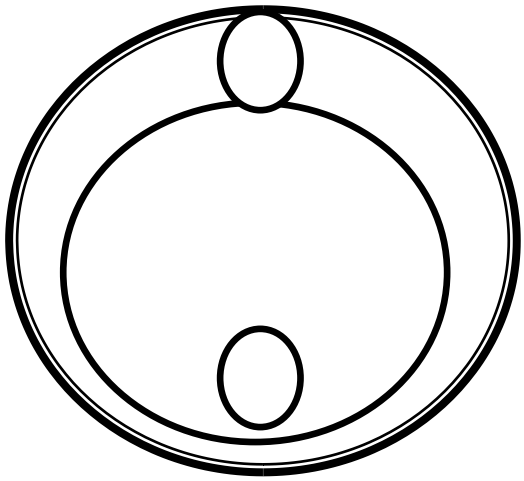
Accumulation of water maybe due to-

1) percolation of surface water
2) seepages from water bearing strata.
3) Influx from waterlogged old and abandoned. 4) Water due to stowing.

Face pumps are the pumps used in the face for drowning out the accumulated water .

MAGATOR PUMP :

The magator pump is a hybrid product between the ram pump and turbine pumps. It has the advantages of a centrifugal pump as if is direct-driven, no internal valve and gearing. It has also common features of a ramp pump, viz positive displacement and eccentrics. It works on a principle similar to that of a three three throw ram pump.



The pump consist of three rubber discs mounted eccentrically at 120® apart on a shaft to enxure smooth flow and vibration. The discs work with in a chamber with a closed it. The function of the ram is provided by a eccentrics, each sliding its rubber block to and fro by there movement. The eccentrics works as valve maintaining a continuous seal with blocks and thus effecting a positive displacement as in case of reciprocating pumps.

The pumps is normally designed for heads 45 meter or more. It is compact, light in weight, portable and directly coupled to motors. The wearing members are minimum easy to dismantle, clean, inspect and refit-all these qualities make it an ideal mining pumps for small requisted. Magator pumps is costly and used for face drainage.

DRILL PUMP :

The drill pump is a single stage centrifugal pump run by a normal electrical drill. At the bottom end of the pump there are a number of inlet opening impeller eye. The delivery outlet is a short length of pipe to which 5cm diameter pipe can be added. The pump shaft is fitted up in the drill chuck. A carbon seal is used on the shaft to prevent water going up. The speed of the electric drill is which is normally 350 to 600 RPM is stopped up by means of a sum or planet gearing to run the pump at 1450 RPM.

The drill pump is self priming and can deal with gritty water. It is handy, portable, weight about 18kg liters per minutes against 12 meter head. It is ideal for face drainage. The disadvantage of this pump are it can be used for very short period about 15 to 20 minutes & The used for longer period will heat up the motor to cause damage again. If the pump is immersed in water due to rise of water level, the motor winding will be damage.

MONO PUMPS :

Mono Pumps, also known as “Screw Pumps” or “Roto Pumps”, relate to displacement until whose operating principle differs for that of reciprocating or centrifugal pumps. It is an electrically driven rotative pump having no valve. The pump requires no priming and can on a suction life as high as 75 meter.

CONSTRUCTION :

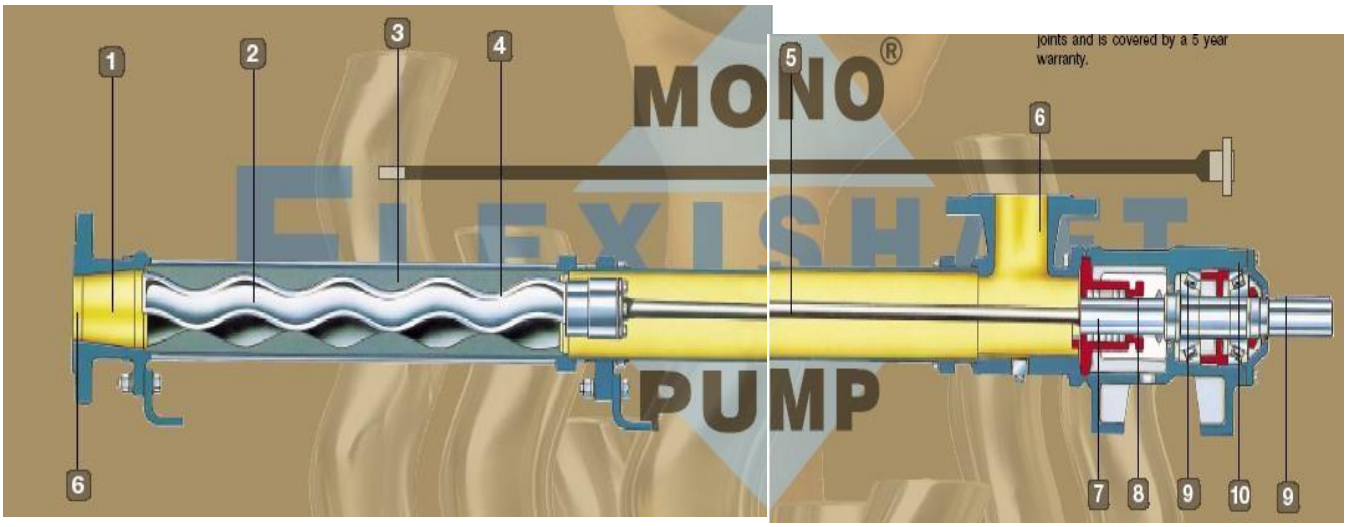
The Mono Pump consist of

1) A stator mode of natural or synthetic rubber or of other plastic material torsion free stators bonded to melelsleeve are also in use. The stator has a form of a double internal index.

2) A machined cast iron or midd steel barrel inside which the stator is push fitted.

3) A single helical rotor of special abrasion-resisting non-corrosive steel.

4) Suction and delivery branches, ringin for of 19mm to 75mm did are with the main structure of the pump.



5) A showing by-puss pipe connecting the delivery branch back to the suction to permit the recirculation of water to keep the stator lubricated during dry running.

6) A hallow driving shaft running in bell bearing and transmitting and electric motion to the roter by a coupling rod of high tensile steel.

7) A three-phase AC squirrel cage induction motor running at 580 to 1450 RPM is switched direct on to the line.

Normal capacities of the pumps rang form 30 liters per minuets up to 450 liters per minutes, at total heads (including pipe frication) ranging up to 45 for single stage pump and 90 meter for single stage pump. The pump requires no foundation, normally it is skid mounted and work on any incline. When the delivery head exceeds about 30m, a hand-controlled valve, with a pipe leading back to the sump should be provided below the non-return valve in the delivery column in order to relive the pressure developed when the pump starts up against a full delivery column.

ACTION OF PUMPS :

The radial cross section of the rotor is curculer and center are eccentric relative to it's axis of rotation. The pitch of the stator is twice that of the roter & the two engage in such a way that the roter passage maintaining a constant seal across the stator. This seal is advancing continuously through the pump giving a uniform positive displacement.

Water which enters the suction branch is thus caught up in the space between the rotor and the stator and is forced through the pump as the rotor revolves. A positive pressure developed on the delivery side and there must be a free passage for water before the pump is started up. **ADVANTAGES :**

The advantages of mono pump are as followed ;

1) The action is positive and displacement is continuous without pulsation.

2) Self priming is an in herent features since here are no valve to give rise to slip and leakage.

3) The pump can work efficiently with suction life of up to 7.5 meters.

4) The pump can really deal with grit, with out serious damage to the stator or motor.

5) It is light and portable and maintenance I cheap.

6) The works no shore, the by-pass pipe recirulates a little quantity of water through the pump when there is no water in the sump and it keeps the stator and rotor lubricated.

7) The speed of the rotor is kept low and the velocity of water inside the pump is less which helps for lowering down the vibration and noise wear in stator rotor and other moveable units.

8) Suction and discharge can be reversed by changing the direction of rotation. The diameter of delivery pipe range should be smaller than of suction pipe to combat suspension of the solid particles.

9) As the pump is inherently non-clogging and self priming a regular which saves manpower.

10) The pump is skid mounted and can be easily shifted and installed. It requires no foundation.

11) It avoids construction of deep water collecting pit's near the face but such arrangement is necessary for a centrifugal pump which requires fool valve to be always submerged in water.

DISADVANTAGES :

1) Attainable heds are limited in region of 45m and 90m for single and two stage models.

2) It the pump run dry the stator will immediately be damage. The pumps must be first be filled with water for lubrication purpose before the pipe are connected.

3) Larger sizes of solid partical present in water if entered into the helical space may cause juming the rotor and stator.

APPLICATION :

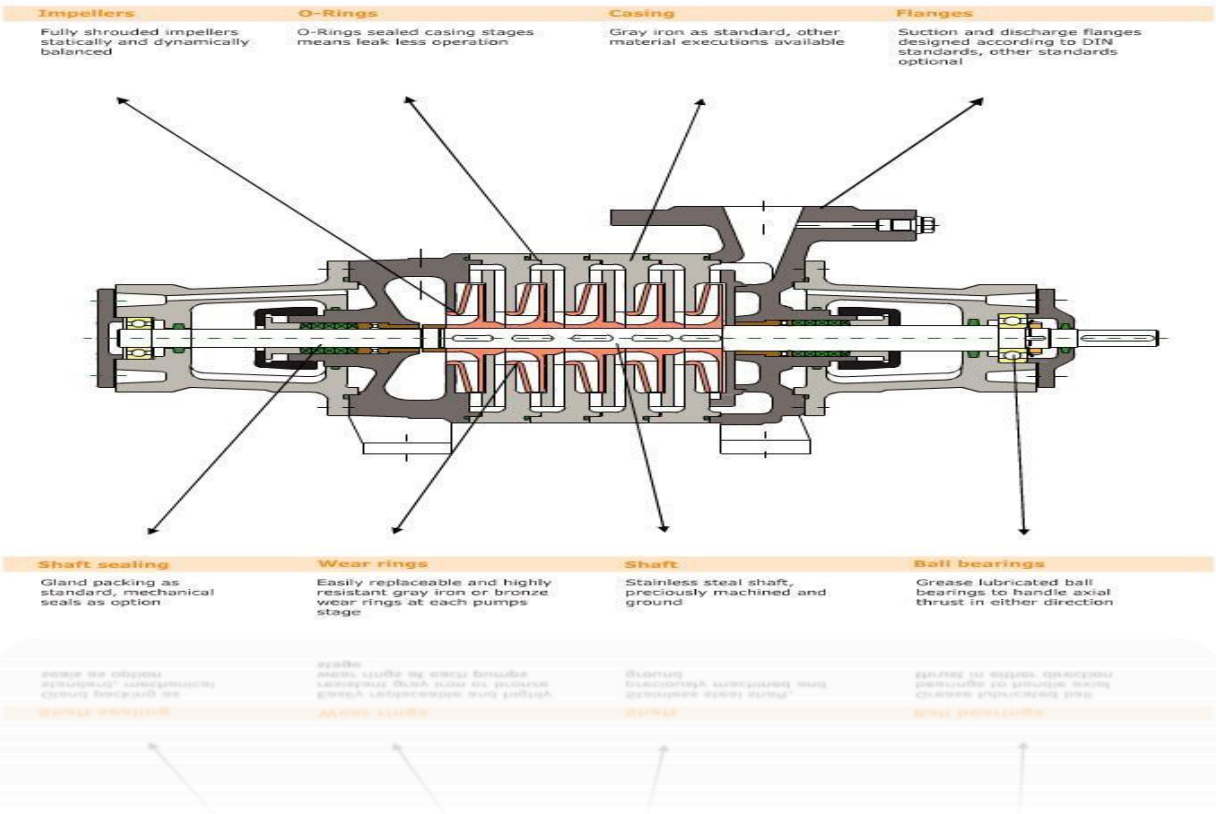
The mono pump has a wide field of use fullness for following purposes :

1) For handling coal slurry in was heries.
2) For in bye works at the face or in dip beadings, where the suction condition are difficult and variable and the pump may be have to work on shore.
3) For cleaning sump and standaeges or on new drivages, wheare water may be heavily 10 den with high abrasive solids or the water may contain fine silt or sluges.
4) It may be used for water spring, wet drilling and cutting, flusing of boreholes and infusion, blasting in coal mines.

Turbine pump or Difuser pump

Turbine pumps are essentially meant to built up pressure to cope up with high hydrostatic head.Itdiffers from a centrifugal pump in that the single volute casing is replaced by one provided with stationary diffusing channels surrounding the impeller. This has the effect of greatly increasing the efficiency of conversion of kinetic energy into pressure energy.

Multi-Stage Pump



A multi-stage turbine pump is provided with a number of impeller in series on the same shaft, with properly shaped diffusing channel leading from the periphery of one impeller to the eye of the next. Each such stage consists of two cast-iron diaphragms with an annular space between them to receive the impeller. The outer casting may consists of a number of sections held together by long bolts passing through the flanges of the two end covers which form the suction and delivery chambers respectively.The advantages of such sectionalised construction of the pump are chiefly that it facilitates transport, erection and dismantling, or an

alteration in number of stages when required, and it enables the inside of the pump to be readily inspected and clean. For very high head the casting may be a one-piece cylindrical casing with detachable end-covers. The shaft has ring-oiled bearing at each and the pump is connected to the motor through flexible bearing. As the impellers are all keyed to the shaft and impeller are normally single-end of the pump. A balance disc is keyed near the delivery end of the shaft to counteract the end-thrust.

After leaving the diffuser the water travels inward readily at low velocity through the passage communicating with the 'eye' of the next impeller, and so on, stage by stage, until the dekivery chamber is reached. The total pressure developed by the pump is the sum of the pressure of the individual stage

Principle of action : -

When the impeller of a turbine pump rotates it causes a suction effect in the pump and water enters the suction pipe as the atmospheric pressure forces the water into first impeller via the central opening or 'eye' or the impeller. In the impeller, the water is whirled around by the blades, and it leaves the periphery with an increased pressure and at high velocity, there after passing between the stationary scroll-shaped guide blades or vanes forming the diffusing channels.

The functioning of the diffusing channels is the same as the volute casing in a centrifugal pump, or as the spiral casing and evasee chimney in a fan, to convert the kinetic (or velocity) enery of the water into equivalent pressure energy by virtue of its construction causing the water to pass along the passage of gradually increasing cross-section. The total head generated by each impeller or stage in created in two ways, partly by and within the impeller itself by centrifugal action, and partly in the guide passage by conversion of velocity into pressure energy. More than half the pressure rise takes place in the impeller, and the rest in the diffusing channel.

5. COAL CUTTING MACHINE

Definition of COAL CUTTING MACHINE (CCM):

A coal cutting machine (CCM) is to make a groove or cut 2 meter to 2.5 meter in depth & 125cm to 175cm height at a coal face. The cut is across the whole width of the gallery in board & pillar system & across the whole length of face in long wall mining.

Objects of Coal Cutting Machine (CCM)

or

Advantages or Purpose of Coal Cutting Machine (CCM) are as follows:

1) It gives extra free face for efficient blasting.
2) To increase coal output per blasting 3) High rate of advance.
4) Straight & systematic advance.
5) Systematic roof support can be installed.
6) Roof is not damaged.
7) Less explosive is used.
8) More safety in gassy mines.
9) Dirt bands removed easily.

Classification of Coal Cutting Machine (CCM):

1) Depending upon the Position of Cut

a) Under cutting coal cutting machine (CCM): It gives cut at floor level only.
b) Over cutting coal cutting machine (CCM): It gives cut at roof level.
c) Middle cutting coal cutting machine (CCM): It gives cut any where between roof & floor.

2) Depending upon Design
   a) Short wall coal cutting machine (CCM)
   b) Long wall coal cutting machine (CCM)
   c) Bent jib coal cutting machine (CCM)
   d) Arc wall coal cutting machine (CCM)
   e) Arc shearing coal cutting machine (CCM)

Theory :-

Many type of coal cutting machine have been designed and the process of development is continuous. The coal cutting machine which are generally used to give either an undercut, middle cut, to cut or side cut for making a free face for efficient blasting operation are as follows:

1) Long wall coal cutters.
2) Short wall coal cutters.
3) Arc wall coal cutting.
4) Arc shearer.
5) Percussive coal cutters.

1) Long wall coal cutters :-

The chain coal cutter this machine is built in three parts. a)
The cutting unit.

b) The hauling unit.
c) The drilling unit.

a) <u>The cutting unit :-</u>

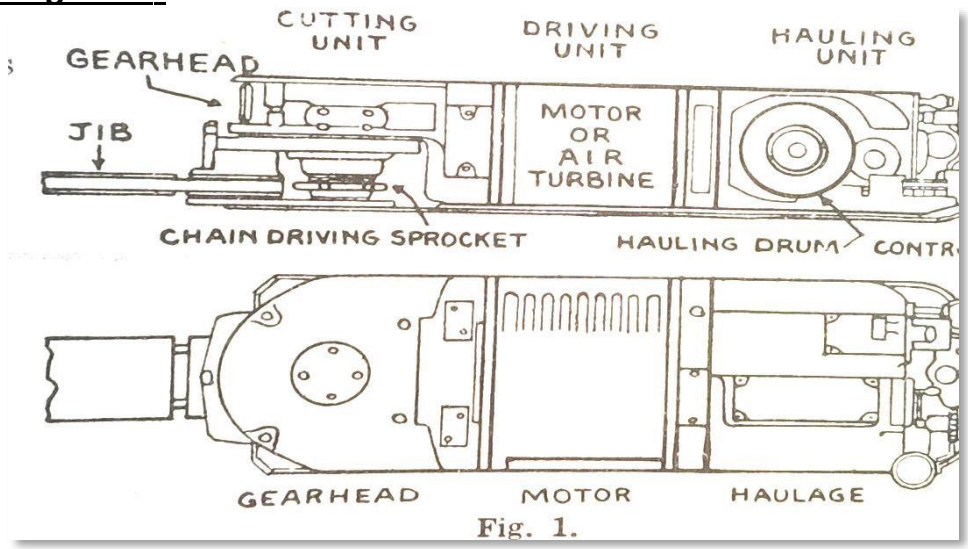


Fig. 1.

This comprises a cost steel gear head which encloses the reduction gearusually a combination of spurb and bevel gearing between the motor and the cutting chain driving socket. It serves also as a support for the cutting chain jib all shafts are carried on boll and roller bearing. Chain jib : This consist of three main components.

a) The jib head or bucket of cost steel swinging on the gear head.
b) The jib post or support bar of head treaded steel, bolted into a socket on the jib head and giving rigidity to the jib of rollered steel bar and which is supplied on to it.
c) The jib of rolled steel bar and plats security riveted together, forming the chain path and provided with renewable hardened steel wearing strips.

In some cases a sprocket is provided at the outer end of the jib so as to reduce the wear of the cutting chain and jib, especially in hard coal, otherwise a plan end jib are is used in CCM.

The jib can be locked in line with the machine for fitting or it can be swing to either side and locked (at rather less than 90° to the body of the machine) for cutting. The spring-loaded-locking pins engage automatically at the appropriate position.

The length of the jib may be anything form 0.95m-30m, depending on the desired depth on many factor including the nature of the coal and it's associated roof and floor, the thickness of the seam and facilities for clearance.

The cutting chain :-

It consist of a series of case-hardend or alloy steel pick boxes, joined together by lincks and connecting pins in such a way as to resist all twisting and bending excepted that necessary for going round the jib.

Each pick-box has forget upon it a block which carries the pick at the

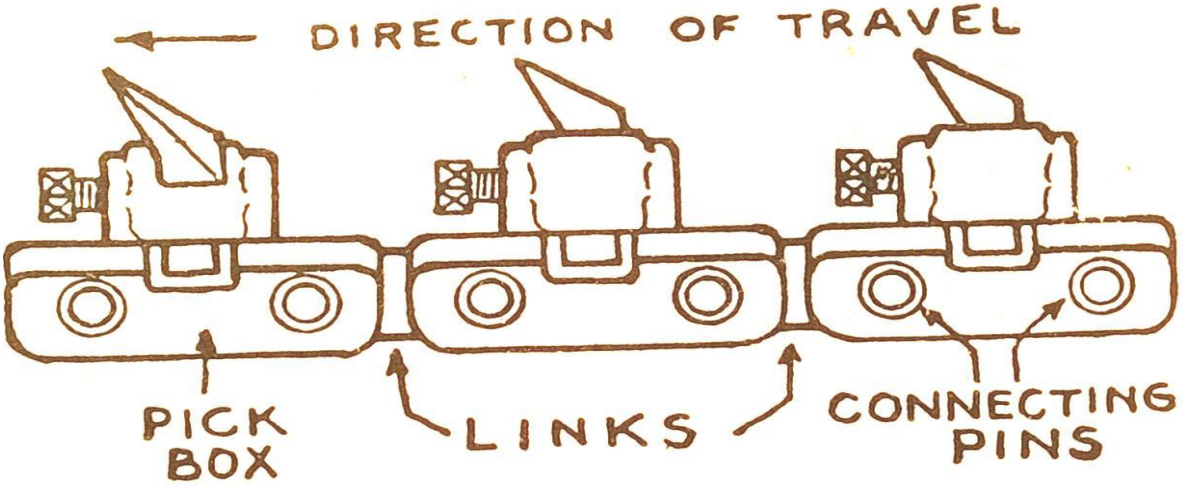


Fig. 2. Cutter Chain.

required angle, the pick itself secured by a set-screw.

In a given chain, all the picks at a given angle form a "line" of picks and the number of "lines" may be 7, 9 or 11. The angles of the picks and their

arrangement in the chain & depend on the nature of the material to be cut and the position cut in the seam and are best found by experiment, the tougher the material. The greater the number of lines of picks that are necessary.

All the picks in each line, of course, must be set to the correct gauge so that they project the some distance. If the coal is tender and apt to sit down on the jib. The clearance may be increases by increasing the projection of both top and bottom line of picks. It the jib rises in the seam and leaves coal on the floor, the projection of the bottom like of picks may be increased to counteract this tendency.

The normal "kerf" or thick of coal cut is between 16.67m – 21.67m but winder cuts upto 8 in, can be made in easy ground by using a winder set chain whilst special chains are also available to give **thinner cut of 10.55m – 13.50m.**

The picks :-

Coal cutter pick may be mode of a plain high carbon steel containing 0.60% to 0.65% carbon, about 0.50% managanese and only small traces of sulpher and phosphorous such a steel has the requisite. Streight and toughness and will take a sharp cutting edge. When forget and heat-treated. It is essential that only sharp pinks should be used forged to the correct shape.

To sharpen carbon steel picks they should be forged at a temperature of 1000°c (bright orange) down to 850°f (dark orange) and should be allow to coal slowly in air. The cutting edge should be wider that the rest of pick so as to give side clearance.

To harden and temper the cutting edge, various method are in use a good method being as follows :

1) Re-heat the nead of pick to about 80.0°c (bright red)
2) Partially coal the bit in the water until the remainder of the neat is dull red.
3) Clean the edge of the pick bright with emery or a piece of sand stone.
4) Coal by complete immersion as soon as the point assumes a straw coloure.

The shank should not be hardened, for this would make it too brittle and the pick set-screw would not bite.

Some times, alloy steels containing chromium, tungsten, etc. are used for the picks because they have longer life and require less frequent sharping, but they are much more costly and require more care full heat treatment.

For abnormal conditions, plain, carbon steel picks may have their cutting edges tipped with special non-ferous cutting material. Such as widia or satellite. These have a natural hardness approaching that of a diamond and can only be sharpened by grining with special wheels.

Type of Picks:

a) **Throw Away Type:** These picks are made of high carbon steel; they can be prepared in mine workshop & required sharpening after every shift. These picks are very cheap.
b) **Tipped Picks:** The trips of these picks are made up of tungsten carbide, they required sharpening after every 50 to 100 cuts, and these picks are costlier.
c) **Reversible Picks:** It consists of two cutting tips made of tungsten carbide. It can be used for 100 to 200 cuts, the main advantage of these picks is that they can be used in either direction, these picks are very costlier. The picks are mounted on the cutting chain on the pick boxes, these pick boxes are connected together with the help of pin & links.

The hauling unit :-

In the machine being described, the haulage gear comprises two ropes drum one at each side of the machine. Driven by the motor through a series of straight cut at the end of the machine to facility turning and jibbing in each drum carries 40 yard of (36.4m) of 1.27 cm rope or 22.75m – 27.3m of 0.625 inch rope.

When cutting only the drum next to the face is in action. The rope being secured to and anchor prop set some distance away. This arrangement of the rope together

with the face that the jib, when fixed in position for cutting forms and angle of rather less than 90° with the machine, tends to keeps the machine tight to the face and renders of use of guide rails or “fenders” normally unnecessary exept when the face is advancing to the rise cutting speeds can be adjusted to 10, 20, 30, 40, 50 or 60 inches per min.

When fitting the haulage drum is driven through a different set of gears to give a rope speed some 7.5 m/m or more in some machines.

Half the stated speed can be obtained. When describe by pussing the rope around a pullry at the anchor prop. And back to the machine to which it is then attached the arrangement being term using a “double rope”.

The Driving Unit :-

This occupies the central portion of the machine and may be either an A.C. Motor or a D.C. Motor or compressed air turbine.

In mines where it’s use is permissible electrical is nearly always preferred because of the greater efficiency. The greater cutting speed obtained, the ease with which the system may be extended and the lower running cost. In some mines however compressed air must be used for reason of safety although it is much noisier and create dustier condition at the face.

The dimensions capacity of longwall coal cutter described are : length about 2.4 meter; width about 0.78 meter; and height 0.48 meter. A smaller model is also available having a height of only 0.30 meter.

The cutting capacity depends on the nature of the coal. The condition underground and the skill of the operators, but double unit regularly been cut in one shift by one machine on a gradient of 1:3 and under and indifferent roof, a machine of the type described regularly fitted down the face and them cut up the 136.5m all with in shift.

2) <u>Short wall and cutters :</u>

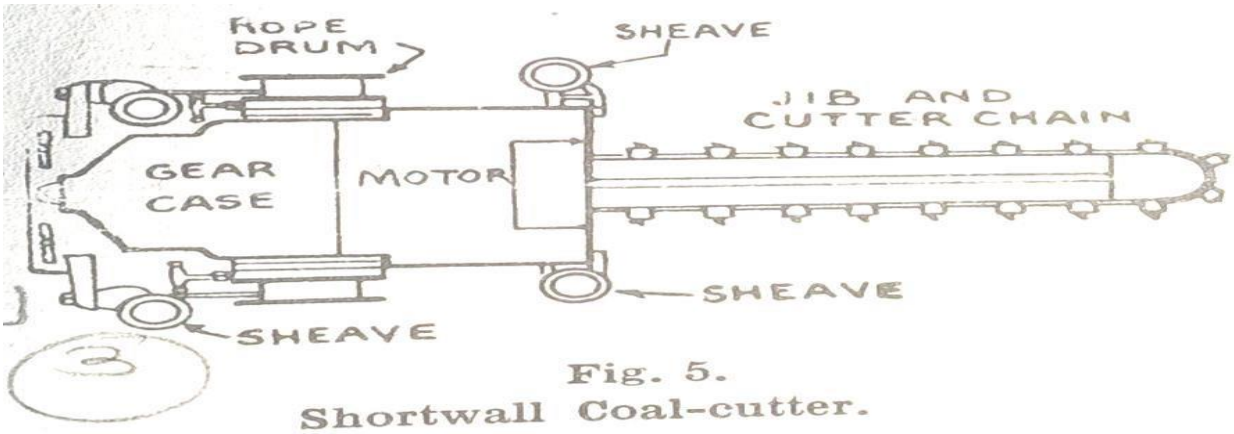


Fig. 5.
Shortwall Coal-cutter.

Short wall machines are used of cutting in the room and piller system, both in the developing rooms or heading and in pillar extraction; or where the face are too large or gradient too sleep for are wall machines; or for the rapid driving of one or two headings.

The cycle operation consist of cutting, drilling, blasting and loading & may be completed in several time in each shift in the working place to which a machine is allotted.

The short wall coal cutters differ from the long wall type in that it is specially designed to sump straight in and cut across a short face only, being then withdrawn. For such work that jib is permanently fixed in line with the machine and special arrangement are made for manoevaring it are required.

The machine is divided into two compartment :-

a) The power unit, bearing either an A.C. or a D.C.Motor and
b) The gear unit which drivers the haulage drun and cutting chain

Short Wall Coal Cutting Machine (CCM)	Long Wall Coal Cutting Machine (CCM)
1) It is used in board & pillar method.	1) It is used in long wall method.
2) The cutting jib is fixed in line with the machine.	2) The cutting jib can be moved with respect to machine in either direction at 90□.
3) The jib is longer.	3) Jib is shorter.
4) This machine is large in overall dimension because the haulage drums are mounted out side machine.	4) The machines are smaller in overall dimensions because the haulage drums are inside the machine.
5) It can be used as flight loader.	5) It can be used as flight loader.

3) <u>Arc wall coal cutter :-</u>

The arc wall machine, like the short wall machine is used for driving relatively narrow headings as in the room and pillar system, but it is mounted on wheel, or on cater piller track and cuts the face In a semicircular arc.

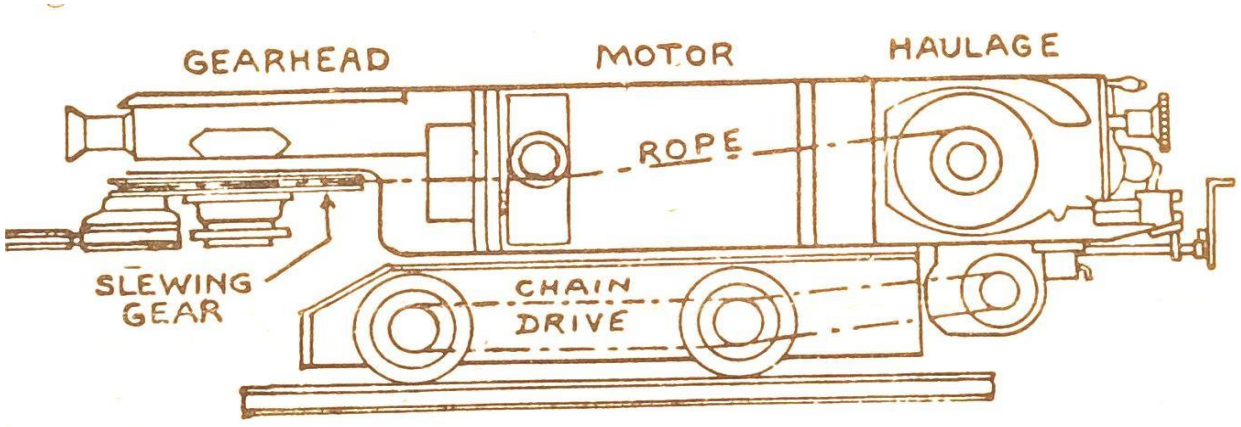


Fig. 7.

Arcwall Coal-cutter. (*M. and C. Ltd.*)

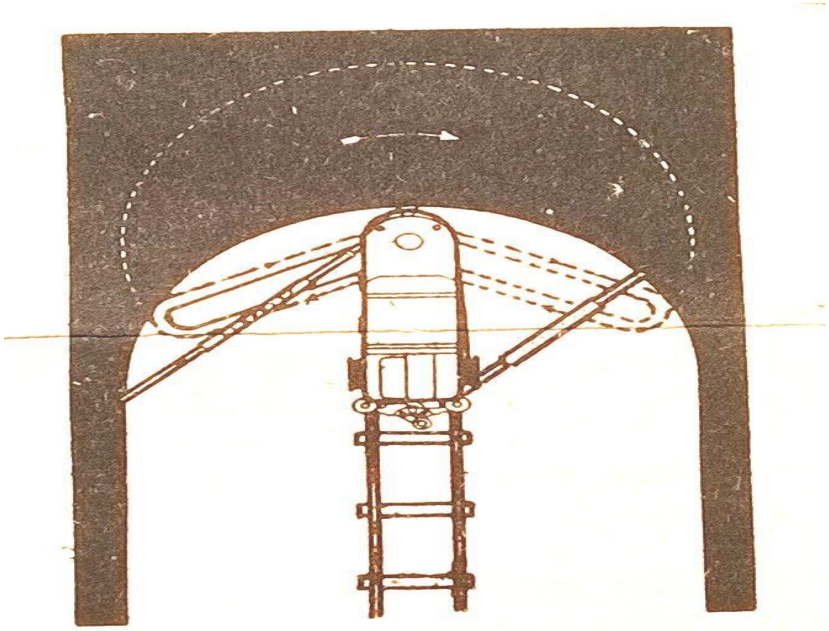


Fig. 8.
Arcwalling.

The essential difference between the arc wall caol – cutting and long wall m/c.

A) It is mounted on a boogie or chassis, with chain driven wheels, giving a fitting speed of some 24 meter per minuted. The wheels have wide trads and deep flanges to prevent derailment and are fitted with a power full screw-operated brake.

B) It is fitted with slewing gear to enable the jib to be swung by power through an arc of about 240° for this purpose. The two ropes drums project clear of the sides of the machine (as in the short wall coal cutter) and the ropes pass form each drum direct to the jib head. When required one of the ropes may be used for moving a wheel-mounted machine on gradients on which the wheels would slip, say steeper than 1:8 for fitting speed then being 6 meter per minutes.

C) The gear head is longer by 6 or 7 in them in a long wall machine to allow the jib head to be larger in diameter for-case in arc-cutting and to let the jib swing through the required angle.

D) The length of the jib, i.e. its protection beyond the frame of the machine, is usually 1.8 meter or 2.1 meter or longer is special cases a 1.8m jib sweeps a radius of 2.25m, cut a depth of 1.8m, and forms a place 4.5m wide. A 2.1m jib sweeps a radius of 2.55 meter, cut a depth of 2.1 meter and forms a places 5.1 meter wide.

4) <u>Arc – shearer :-</u>

This differs form an ordinary arc wall machine in that it is fitted with an adjustable gear head. Which enables the jib to be rotated in the vertical plane through any angle so a to cut horizontally either near that bottom or near the top of the seam or to shear the coal vertically at either side of the place. It is therefore, sometime described as an arc shearer.

An arc shearer may be mounted either on wheels or on crowlers, and it may be driven by an electric motor or a compressed air turbine. The machine is clearly more versatile that an arc wall and can therefore deal more successfully with the variable condition met with underground.

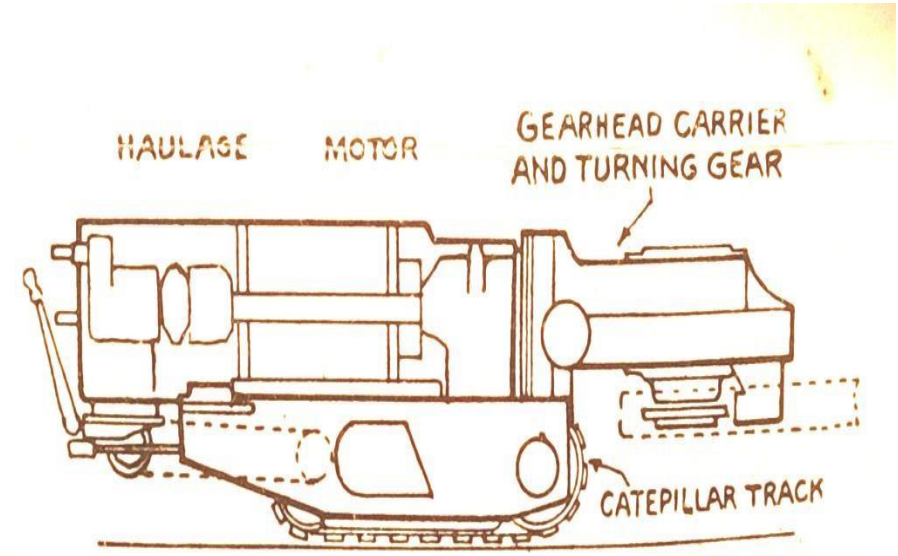


Fig. 9. Arc-Shearer.

5) <u>Percussive coal cutters :-</u>

This types of coal cutter is essentially a heading machine for use in narrow working and is adoptable to either undercutting, over cutting, shearing (nicking) or scalloping (breaking down) the coal.

Such machine is likely to be more effective than the pneumatic pick where the coal is very hard nature or the cleavage plane are not well defined and when fitted with a vertical guardant for shearing or punching (scalloping) purposes, it enables short firing to be dispensed with altogether for coal getting.

It thus provided an alternative to short wall or arc wall coal cutters in seams where blasting is undesirable although it cannot generally be regarded as an

adequate substitute for these machine under ordinary condition. A typical percussive coal –cutter driven by compressed air consist of five essential parts :-

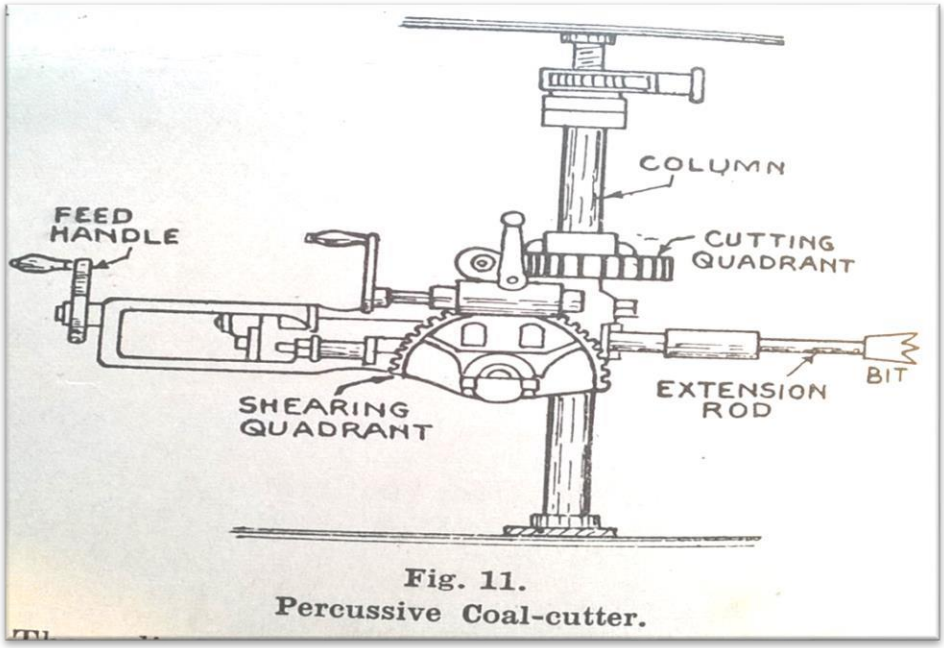


Fig. 11.
Percussive Coal-cutter.

1) Supporting column of steel tubing, with screw adjustment to suit the height of the seam.
2) Toothed quadrants or segments one vertical and one horizontal, where by the cutting tool can be revolved horizontally around the column for undercutting plane for shearing or nicking by a combination of both movement. The tools can be directed to any point on the coal face.
3) Air drill with a piston and valve mechanism where by a reciprocating or punching motion is give to the cutting tool. It's position on the steel column may be varied to any height between roof and floor the piston with it's cutting tools gives 300 to 350 blows per minutes and also rotates. The tool at about 80 to 90 rpm be feel for word as required by the handle and screw feel.
4) Extension road 0.60 meter, 1.2 meter, 1.8 meter, 2.4 meter, 3 meter long respectively and having conically shaped ends one end fits the drill chuck and the other cutting bit.

5) Cutting bit of tool steel 0.09m diameter and weighting 5 lb. they usually have five cutting prongs or edge, but may have 3 or 7 prongs in certain cases.

Haulage Gear Arrangement for Coal Cutting Machine (CCM)

In a haulage gear arrangement the speed of motor shaft is reduced by two stage speed reduction gear box. The motor shaft connected to two spur gear A & B by which the speed is reduced to $2/3^{rd}$ time. Now it is connected to worm & worm gear arrangement through which the speed is transmitted in perpendicular direction & is reduced to $1/5^{th}$ or $1/7^{th}$ times. At the upper side of worm & worm wheel is connected to another spur gear arrangement where speed is reduced to $1/4^{th}$ to $1/13^{th}$ times on the lower side & worm & worm gear. There is a spur gear with a ladder placed to transfer the speed of one wheel to another in the same direction. There is a pinion drum which may be connected to low speed by the log clutch. The drum pinion rotates the drum gear which is connected to handing drum. In this manner speed is reduced. Rotached & pull arrangement at the low speed side just to prevent the rotation of handling drum in opposite direction.

Cutting Gear Arrangement for Coal Cutting Machine (CCM)

In this CCM only one motor issued for cutting hauling. One side of more shafts is connected with the handling gear arrangement & the other side is connected with the cutting gear arrangement. The motor shaft is connected with the spur gear arrangement where speed is reduced to ½ to 1/3 times. There is a lever gear which is connected to spur gear where speed is further reduced & transmitted in perpendicular direction. The lever gear is connected with a dog clutch which may be connected to the sprocket wheel to rotate the cutting jib.

Mechanical Loaders

It is used for loading of coal or material in the driving road. It is having an apron plate to collect the blasted material from the apron plate & transport it to the discharge end. The discharge end of the loader can move in vertical & horizontal plane.

Apron plate is lowered to touch the ground & it is inserted into the blasted coal or rock. As apron plate is full & blasted material, it is lifted upward to transport the blasted material on the chain conveyor is in motion & as soon as it receives the material to the discharge end from where the material can be loaded in the tub or conveyor etc. it has crawler mounted chain.

Joy Loader

It is used for the loading of coal or rock in the drivage road. It is having an apron plate over which two gathering arms are mounted in the eccentric. There is a chain conveyor to transport the coal from apron plate to discharge end. The discharge end of ladder can move in a horizontal end vertical plane.

The apron plate is lowered to touch the ground end at the same time the two gathering arm are rotating continuously. As soon as the apron plate is inserted in the blasted material & loads on the chain conveyor this is in motion. The chain conveyor transports the blasted material to the discharge end where it is loaded in the mine tub or conveyor etc. it is crawler mounted machine.

1. **Load Haul dumper (LHD):**

   Also known as a scoop tram

   specialized loading machine manufactured for the underground mining industry.

   LHDs are used in >75 % of u/g mines throughout the world and are suitable for small and large tunnels, mines, chambers, and stopes.

   It performs loading, hauling and dumping of bulk materials

LHD is categorized into two **types**:

1. Diesel LHD
2. Electric LHD

Selection:

It depends upon the following factors:

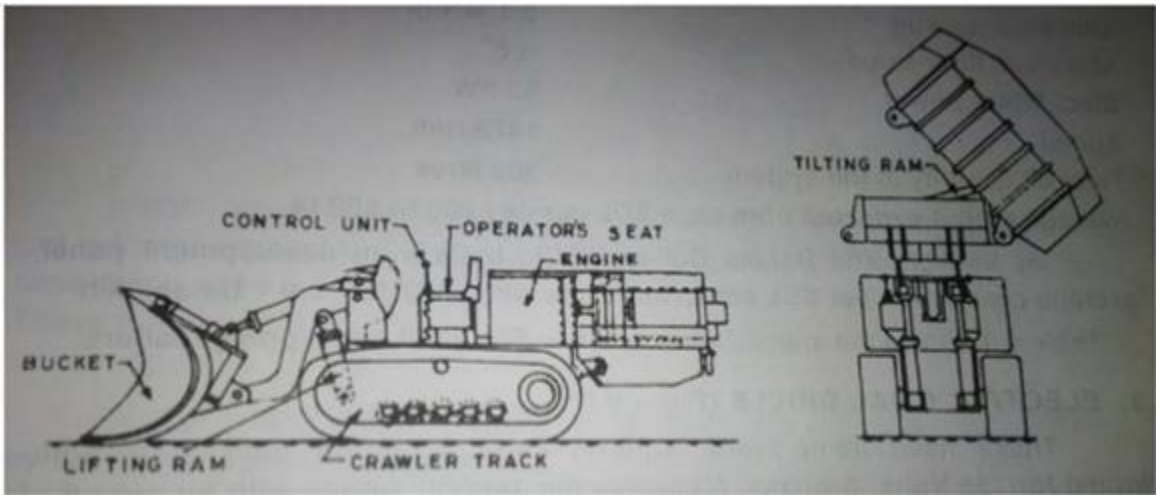
1. Size of operation
2. Length of haul
3. Height of seam
4. Operating condition
5. Local permissibilities
6. Experience

Standard bucket capacity	1.6 m^3
Breakout force at bucket blade	55kN
Lifting time	7.5 secs
Lowering time	6.5 secs
Time of roll forward	5 secs
Electrical components	Flame proof for U/G gassy mines
Travel speed	0-8 km/hr (high speed mode); 0-3 km/hr(low speed)
System pressure(max)	400 bar
Traction motors	variable axial piston type
Displacement	107 cc/revolution
Drive power(max)	45kW
Hydraulic medium	HFDU 68
Tramming radius	2300mm

. Side Discharge Loader (SDL):

1. mounted on a crawler track and is designed for loading the broken rocks onto a conveyor or into the tub in coal or stone workings.
2. The high travel speed (0.7 m/s) makes it suitable for working with the discharge point upto 10 m from the working face with no appreciable reduction in loader output.
3. The loader can be employed on gradients rising or dipping upto 18^0 (1 in 3).
4. It is totally flameproof.

5. The SDL may be adopted for discharge on the left or right side. Bucket capacity is 2.032 te (maximum).



Optional components:

1. Cable reel
2. 0.1m^3 coal bucket
3. Head light
4. Dust suppression kit
5. Dump valve with lock and key
6. Average output expected from each SDL/day is 200 to 500 te/day.
7. This equipment is used for applications in underground mining.
8. It is indigenously designed and developed by in-house R&D.
9. This equipment weighing 9 tonnes, is fitted with 1cu.m. bucket.
10. Fitted with powerful 55 KW motor operating at 525V, 50Hz,
11. this equipment ensures very high productivity.

12. It is ideally suitable for deployment in underground mines where intermediate or Semi- mechanization is used.

Standard bucket capacity	1.0/1.5m^3
Travelling speed:	2.6 kmph (max.)
Total weight	8500/9000 kgs
Ground pressure	0.9 kg/cm^2
Tractive force	5200 kgs
Break out force	3000 kgs
Electrical components	Flame proof for U/G gassy mines
Negotiable gradient for driving and loading:	1:4, cross gradient 1:6
System pressure (max)	125 bar
Traction motors:	Radial piston fixed displacement type
Payload(max):	2.0 MT
Drive power (max):	55 kW
Hydraulic medium	HFB 68

Chapter No 6 - ELECTRIC POWER SUPPLY

Definition: The current carrying conductors which are used underground are known as cables.

Types of electrical power cable used in a mine

1) Permanent cable(shaft and roadways cabel)
2) Semi-flexible(conveyors,loaders, and other semi permanent machines)
3) Flexible cable(coalcutters,drills,and other portable machines.)

1) PERMANENT CABLE

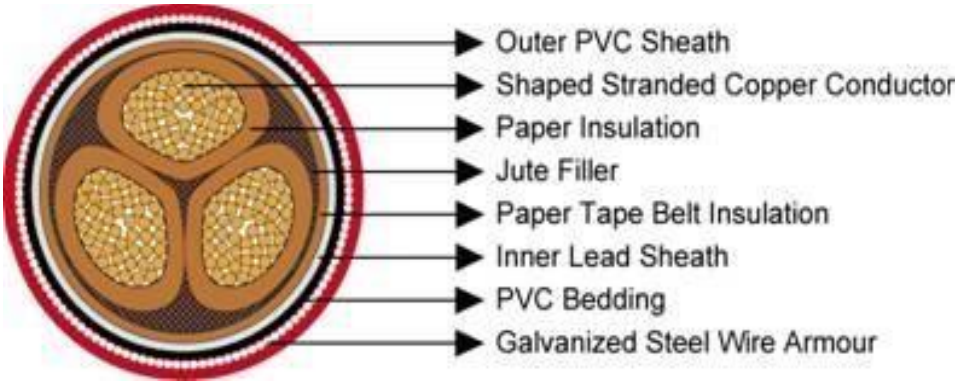
These are **armoured cabels** and may be either

(a) Paper insulated

(b)Vulcanized bitumen insulated

(c)Compound insulated

- **PILSDWA (Paper insulated level sheathed double wire armoured cable)**



It consist of three :-

1) **Copper core :-** It consist of three copper wire either made up of circular section shape. The copper cores made of thin annealed copper wires.
2) **Paper insulation** :- all three copper conductors are insulated by papers individually then all the three conductors are coiled to a give a circular cross-section. The paper which is used for circulation should be oily in nature to reduce it hydroscopic tendency. The oily layer should be within or otherwise it will have a bleeding tendency.
3) **Lead sheath :-** To protect the cable form coming in contact with water and the paper conductor it is covered with a joint less lead tube. The paper insulated cable down through molten lead path for a joint less uniform lead sheath.

1st Jute bedding :

The lead sheathing is very shoft in nature, hence it may be rasily scratched or cut by a steel wire used for armoring. Hence to protect it is covered by the 1st Jute bed. So, that it is not cut by the steel wire armoring.

2nd Jute bedding :

Around the first bed and lay of thick steel wire are wond spirally to give mechanical strength to the cable. Between the two layers of wires there is a layer of jute bedding to protect the wires form each other.

3rd Jute Bedding & White Wash:

It gives a smooth surface to the cable. It is treated with a layer of coal tar. The coal tar prevents the entry of the water inside the cable but such a cable is sticky in nature, hence it is very difficult to take out the cable out the cable from the drum. To overcome this difficulty the cable is painted by a thin layer of warmish, which is known as white wash. It makes the cable non sticky in nature.

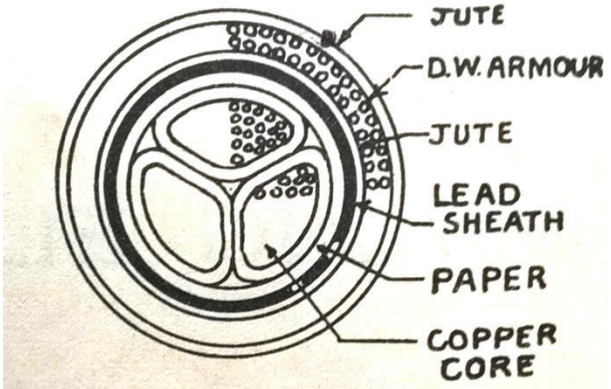


Fig. 1.
Double-wire armoured Lead-sheathed Paper-insulated Cable.

ADVANTAGES :

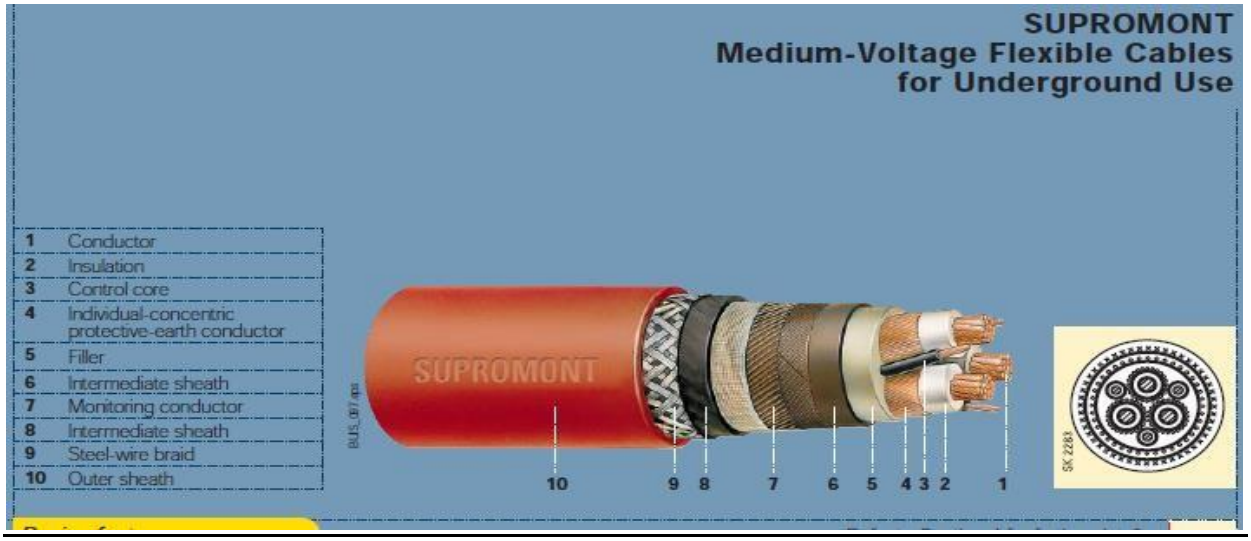
1. Armoring takes the complete weight of cable.
2. It acts as earth conductor.
3. Mechanical strength increases.
4. Crushing straight increases.

3rd Jute bedding :

It gives smooth surface to the cable. It is treated with a layer of coal tar. The coal tar prevent the entry of water inside the cable but such a cable is sticky in nature hence, it's very difficult to take out the cable form the drum. To

overcome this it is pointed by this layer of varnish, which is known as white wash which non-sticky.

- **PILSSWA (Paper insulated lead sheath single wire armored cable):-**



It's construction is same as PILSDWA but the is a sing armoring in between 1st jute bedding and 2nd jute bedding.

A) <u>Copper Core</u>: It consists of three copper cores either made of circular section or sector shape. The copper cores are made of thin armoured copper wire.

B) <u>Paper Insulation</u>: All these copper conductors are insulated by paper individually then all the three conductors are coiled together & wrapped over by the paper to give a circular cross section. The paper used for installation should be oily in nature to reduce its hydroscopic tendency. The oil layer should be thin otherwise it will have a pleading tendency.

C) <u>First Jute Bedding</u>: The load sheathing is very safe in nature hence it may be easily scratched or cut by the steel wires used for armouring, hence to protect this; it is covered by the first jute bedding so that it is not affected by steel wire armouring.

D) <u>Third Jute Bedding & White Wash</u>: It gives a smooth surface to the cable. It is treated with a layer of coal tar. The coal tar prevents the entry of the water

inside the cable but such a cable is sticky in nature, hence it is very difficult to take out the cable out the cable from the drum. To overcome this difficulty the cable is painted by a thin layer of warmish, which is known as white wash. It makes the cable non sticky in nature.

To protect the cable from coming in contact with water & to prevent the entry of water up to the paper or conductor, it is covered with a joint of lead tube. The paper insulated cable is drawn through molten load path for a joint less uniform load sheath.

- **Compound Insulated Cable**

Compound insulator: All the three copper ore are insulated by a compound which is a combination of rubber & other patent material. Then all the three copper conductors are laid around each other & insulated by the compound to give a circular cross section.

Advantages of Compound Insulated Cable

1) Impervious to moisture
2) Unaffected by low & high temperature
3) Overall diameter is less

Disadvantage of Compound Insulated Cable

1) It is costly

- **VBI (Vulcanized bitumen insulated cable)**

1) **Copper core** : It consist of 3 copper core. The copper wire used of core consist of a small amount of tin. It is required to protect the copper form the sulpher which is used in vulcanized process.
2) **Bitumen insulation** : All there copper core are insulated by sheath of vulcanized bitumen. The core are thin lead. Around each other and its is again sheathed with bitumen to give a circular cross-section.

ADVANTAGES :

1) Impervious to moisture

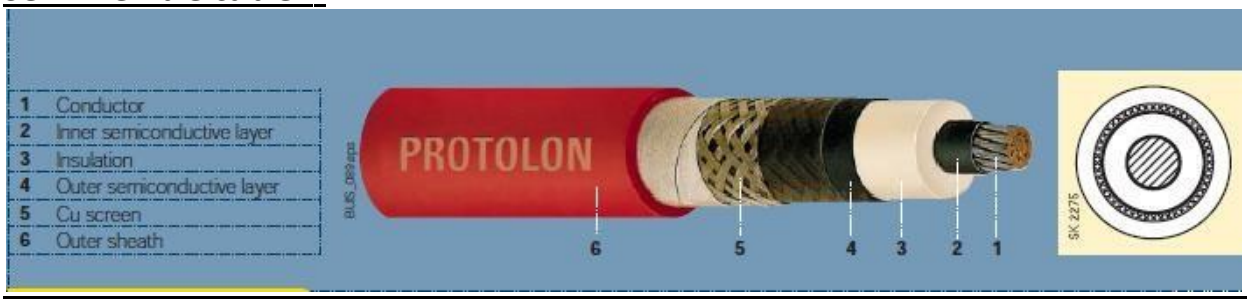
1) Unaffected by level and high temperature.
2) Overall diameter is less

DISADVANTAGES :-

1) Larger in diameter.
2) Adversely affected by high temperature.
3) Adversely affected by low temperature. **E)** Compound insulated cable : 1) Compound insulator :

All three copper are insulated a compound which is a combination of rubber and other matter then all three copper conductor are laid around each other and insulated by the compound to give a circular cross-section.

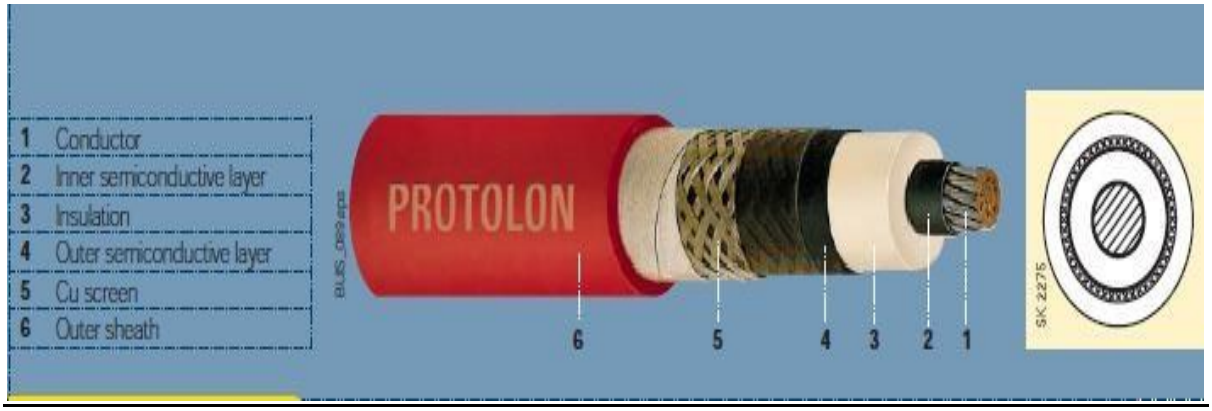
2) Semi-flexible cable :-



A three core semi flexible cable had 3 copper core, each vulcanized rubber insulated and laid around center. The whole being tough rubber sheathed to give a circular cross-section for mechanical strength, it is armored by steel wires and overall sheathed with tough rubber or P.C.P.

Alternative the cable may have four core one being used as an earth core or as a pilot core or it may have five cores one being on earth.

Flexible cable :-

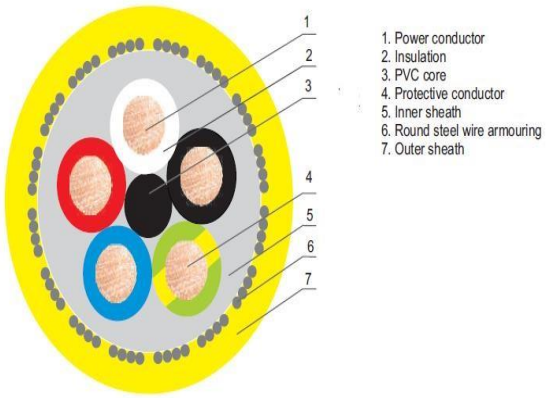


Flexible cable requirements :

1) It should be very flexible.
2) Light in weight.
3) Water proof.
4) Mechanically strong.
5) Fire resistance.

Types of flexible cable :

1) 5 core A.C. Cable :-

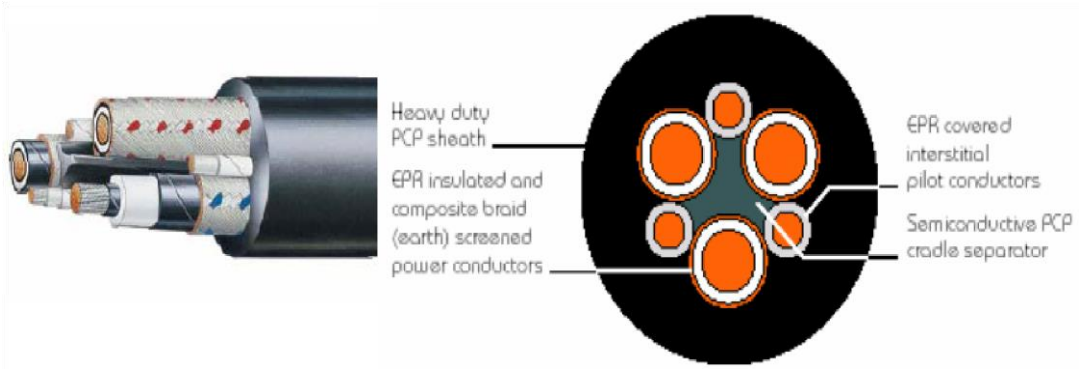


It consist of three power core one earth core and one pilot core each of them is of equal size & valcanised rubber insulated and laid around a rubber center which or it may have 4 core laid around a rubber center which consist of a pilot core. Now, it is sheathed with tough rubber screw collectively and overall sheathed with PCP compound.

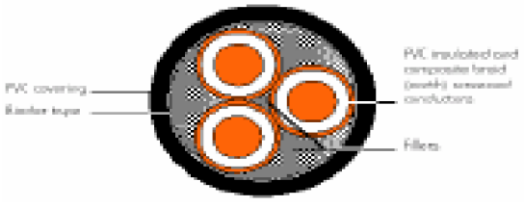
2) 3 core D.C. Cable :

It consist of 3 copper cores each vulcanized rubber insulated two core which are used for carrying current are screened and all the three cores are laid around a rubber center & over sheathed with PCP compound.

3) 5 core A.C. Cable (Individually screened) :



Individually screened



It cosist of 3 power cores one earth core and pilot core, each vulcanized rubber insulated only 3 power cores are screened and laid around a rubber center or 3 power cores and one earth core are laid around the rubber which consist of a pilot core. It is then overall sheathed with PCP compound to give the circular cross-section.

4) Drill cable :

It consist of 3 power core one pilot one earth core each of them is of equal size and unscrewed and laid around a rubber center and overall sheathed with PCP compound. It is lighter then any other cable. It is

used at 125V and the accidents at this voltage are unlikely to be serious, hence it is mode up of unscreened.

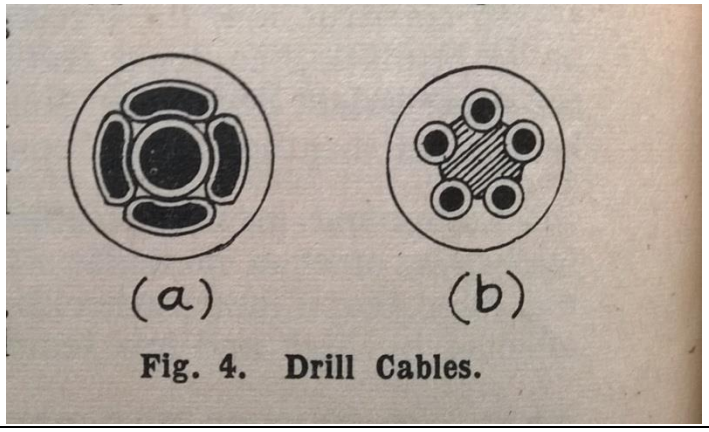


Fig. 4. Drill Cables.

Place	**Cable Used.**
1. Shaft	PILSDWA.
2. Underground levels	PILSDWA, PILSSWA, bitumen insulated or compound insulated depending on condition.
3. C. C. M.	Five core A.C. vulcanised rubber insulated (collectively screened), flexible cable.
4. Coal drill	Flexible cable, drill cable (five core A.C. cables unscreened).
5. Watery places	Permanent cable, compound insulated.
6. Belt conveyor	Semi-flexible, three, four or five core vulcanised rubber insulated & armoured cable.
7. Loader	Flexible, five core vulcanised rubber insulated collectively screened cable.

Care & Maintenance of Flexible Cable

1) The operator should handle the cable carefully so that it is not damaged by the moving machines.
2) Except when it is in use, cable should be coiled on the drum.
3) The cable should be examined & tested by an electrician when first installed & thereafter once in every 24 hours.
4) The cable should be examined by the machine operator before starting the machine.
5) If any defect is found in cable, it should be withdrawn at once.
6) The length of drilling cable in use should be kept down to a minimum.
7) Spare cable should be ready for use in mines so that a defected cable may replace immediately.

Repair of Flexible Cable

Permanent cables are not prepared by the flexible cables prepared. The procedure of cable repair is as follows:

The five copper conductors, insulators, screen & tough rubber each are open up to 15 cm length as shown. The five copper conductors are soldered with each other. Now put an insulation tape of black compound over each copper conductor & then wrap the tape over all five conductors very firmly so that these should not be any air gap between the tapes. It is immersed in molten black compound & then cooled down. The screening tape is taped & connected with the connective screen of the cable. The cable is again treated with tough rubber & P. C. P. compound to give the original design of the cable. Now the cable is again ready for the use.

Cable Joint Box:-

The permanent cables are jointed using the cable joint box. A joint box must fulfil the following conditions:

1) It must effectively protect the conductors from injury.
2) It must preserve the efficiency & continuity of the insulation & exclude moisture.
3) It must secure the cable armour & bend it in such away as to maintain the continuity of the earth in system.

4) A joint box is made of cast iron or mild steel, split longitudinally to give the access to the conductors& assembled after the work is finished. The actual joint between the conductors is made by a mechanical connector. When the joint has been completed, it is covered with several layers of insulation tape. Each core is separated by porcelain plates each end of the joint box is provided with an armoured clamp & saddling clamp which seals the cable at its entry into the joint box & effectively secure the steel wire armoured. When all collection has bear made the box is filled with a special bituminous compound through the compound filling holes which are provided in the upper half of the box. The compound is solid at normal working temperature. Finally it is most important that a copper wire is provided between the armouring to main the continuity of the earth in system.

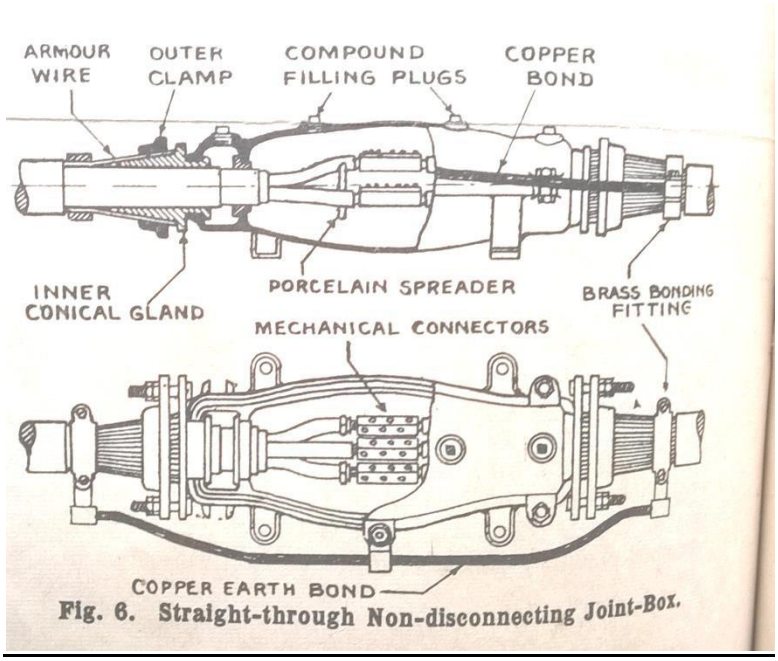


Fig. 6. Straight-through Non-disconnecting Joint-Box.

Installation of Shaft Cable

Cleat: Cleat are used to attach the cable with the bun tons in a shaft. Cleats are prepared in two halves of circular cross section & joint together with the help of bolts as shown. These are made of wood, their length varies from 0.7 to 1.0 meter & thickness is up to 0.2 meter. At the top of the cleat a conical wood is provide to shade water & to deflect material falling in the shaft. The cleats are secured to the bun tons by bolts or suspended by chains.

Types of Methods

1) Behind the bun ton
2) On the bun ton
3) Top to bottom
4) Bottom to top

1) **Behind the Bun-Ton:** When the cable is to be fixed behind the bun tons the cable drum & a rope drum mounted on a winch at the surface. A long diameter pulley is installed in the headgear as shown. The cable & wire rope are lashed & it

passes over the large diameter pulley. It is slowly lowered & also the cable & rope lashed together at certain interval. When the cable & rope reaches the shaft bottom the cable is attached to the bun tons by using cleats which are kept in the cage. As soon as the cleats are fitted the lashing is taken out. In this way cable is installed behind the bun tons.

2) **Top to Bottom:** In one of the cage resting at the shaft top, number of cleats, a winch carrying the cable drum & bolts etc. are kept in the cage. The out end of the cable is attached with the headgear with the help of cleats. The cage is lowered slowly so that cable unwound from the winch & as soon as the cage reaches the bun ton, it is stopped & the cable is attached to the bun tons with the help of cleats. In this manner the cable may be installed in the shaft on the bun tons.

Short Notes

1) **Vulcanising:** Vulcanising compound is the rubber sheet with the liner backing in the tape form. Each core of the cable is bound tightly with this tape in such a manner that no air is left between the layers. Now the cable is placed in a vulcanising bath which is steel trough. The trough is filled with wax which is heated to a temperature of about 300(F. The cable is kept in the bath for about 30 to 45 minute depending on the type & thickness of vulcanizing compound used. The cable prepared in such a way is known as vulcanizing.

2) **Bleeding of the Cable:** If a paper insulated cable is hanged vertically in a shaft it bleeds, in other words the oil which is observed by the paper tries to flow down & if oil is access the pressure developed by the oil may be sufficient to burst the lead sheet of the cable, this is known as bleeding of the cable. To prevent this oil used should be properly viscous & a proper method should be used to make the insulated paper oily in nature. PILSDWA & PILSSWA are bleeding type of cable while the bitumen insulated & compound insulated cables are known as no bleeding type of cable.
3) **Earth in:** Earth in means connection with general mass of earth in such a manner that it ensures at all times an immediate discharge of energy without danger. All metallic sheets, handles, joint boxes, lamp holes, motors

switchgears etc. should be properly earthed. There should not be any fuse or circuit breaker in the earth conductor.

4) **Flame Proof Enclosure:** It has been defined as an apparatus that can withstand without injury, an explosion of the inflammable gas that may occur within it & can prevent the transmission of flame to the atmosphere to ignite the inflammable gas which may be present in the surrounding atmosphere. In all the gassy mines, electrical motor, switchgear, control panel etc. are required to be flame proof.
5) **Intrinsically Safe Apparatus:** Intrinsically safe apparatus denotes that any sparking that may occur in normal work is incapable of causing explosion of inflammable gas. The spark coming out in the apparatus operating current is less than one ampere. It is achieved in case of low power apparatus such as telephones, signalling system, remote control & exploder etc.

Factors to be considered for Selection of Cable for Mining Use

1) Total current requirement.
2) Location.
3) Working environment.
4) A.C. or D.C.
5) Remote controlled operations.
6) Type of machines to be used.
7) Length of cable required.

Chapter No 7- GATE END BOX.

GATE END BOX :-

It is used to supply 550 volt AC to the coal cutting machine working at coal faces. The maximum distance of gate end box from the machine is 100 meter. For putting ON, OFF the switch at 550 volt on the machine itself may produce a spark which is turn may ignite firedamp or coal dust. Hence to avoid this there is pilot switch on the coal cutting machine which works at 30 volts. When this switch is operated at the CCM, it operates the main switch at gate end box to supply power to the CCM.

The gate end box is always placed in the fresh air, so that there is no danger of gas on coal dust explosion due to spark. The gate end box is used to supply the power to the CCM trough a five core cable (three power core, one pilot core & one earth in core). The main switch of the CCM which works on 550 volts is placed at the gate end box & it is operated by switch which is located at 30 volts, hence CCM is known as “Remote Control Machine”.

Theory :-

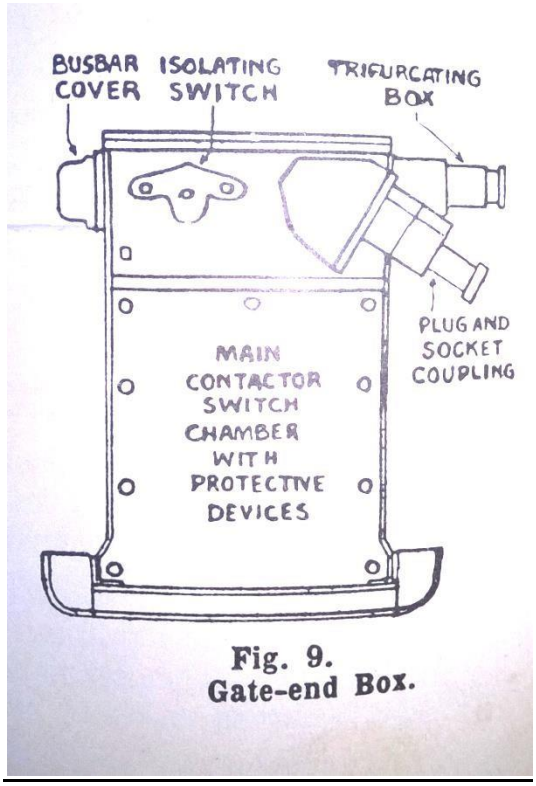


Fig. 9.
Gate-end Box.

For controlling motors near the coal face coal cutters, conveyors, loaders & drilling machines. The switchgear is usually of the ironclad flame proof air brake type, preferable equipped for remote control and all possible protective devices.

Figure gives an external outline view if one typical switch unit consisting of a welded steel case with removable tope cover and front cover, machined joints and shrouded bolt heads. The whole being mounted on skids with detachable and pieces several interconnected switches. If desired may be mounted side by side form a switch board the bus bar cover then being removed.

The incoming cable arrangement may consist of a compound filled trifurcating box with air insulated spreader chamber or a bolted play and soket coupling (flit plug). Which can be secured to either end of the bus bar chamber the outgoing arrangement consist of a 4 rpm. 100 apm standard BSI plug and socket or a lift plug as occasion requires.

That is two separate flameproof compartment. The upper compartment contains the bus bars and a three pole reversing isolating switch operated by a specially shaped key and so interlocked that the lower chamber can not be opened unless the isolator is OFF and all the apparatus and contact are dead and safe.

The tower compartment contains a three ole air brake main contractor (an electro magnetically operated switch) fitted with magnetic below out will and are shields on each poles, a single phase voltage transformer giving the pitot voltage of 25-30 voltage all the necessary protactive devices as follows :-

1) Over-current (over load) protection by means of three series over current trip coils, filled with double action time lag dashpots to enable squirrel cage motors to be switched on directly.
2) Under voltage release : this being inherent ion the action of main contractor.
3) Core-balanced leakage protection, provided by means of a core balance transformer working in conjunction with a relay which may be set to trip at a priming leakage current of 5 ampar. The relay is provided with a flagindicator and latch up and reset device.
4) Earth-continuity protection : to ensure that until a through earth connection is established the power can not be switched on and should that earth circuit be disconnected at either end or otherwise broken. (by withdrawing a live plug) the switch will immediate be opened.
5) Plot core protection, with flag indicator which operated in the event of a short-circuit fault between the pilot core and the earth core.
6) Interlocked, prevent (a) the opening of the box while the switch is ON and (b) the accidental closing of the switch while the box is open.

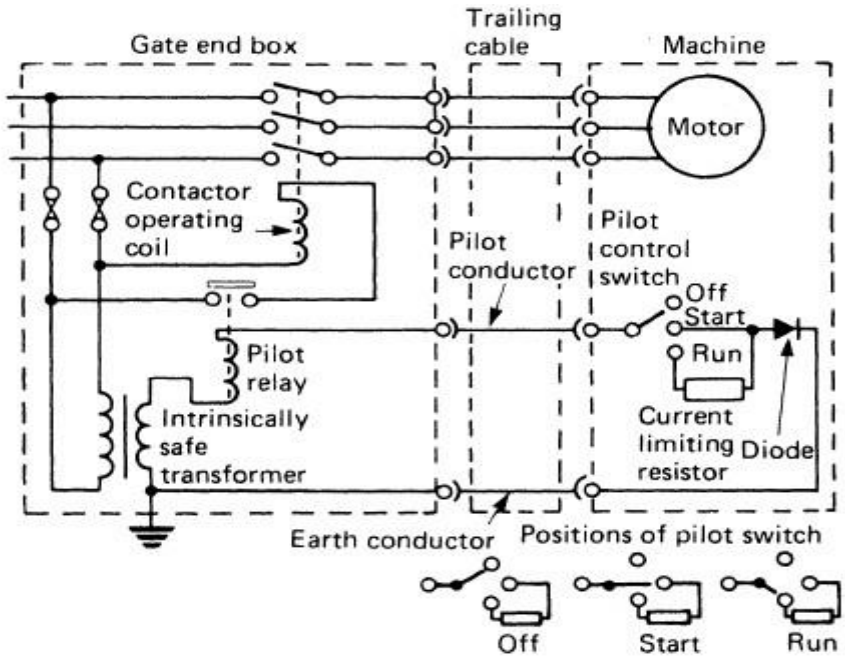
In conjunction with the foregoing, a system of remote control is incorporated where by all switch operations for stating and stopping the motor are preferment in so far as the main power circuit is concerned not at the motor but at the circuit breaker. The master control switch on the motor only operates a law-voltage auxiliary pilot circuit. When operated the contractor electro-magnetic action. The remote control system provided for –

a) Closing and opening the gate-end-contractor by a master switch on the coal cutter or converor (as already discribed)
b) Automatic tripping of the contractor if the pilot conductors are open circuit.
c) Automatic tripping if the trailing cables is damaged and so causes a short circuit between pilot and earth cores.
d) Automatic tripping if the supply fails or if either of the trailing cable plugs is removed or not fully home.
e) No re-closing of the contractor on restoration of supply unit the coa cutter master switch has been opened and re-closed.

The foregoing arrangements require a 5 core trailing cable to be used i.e. having three power cores, one earth core, and one pilot core alternatively a 4 core pliable armoured cable in which the armouring is used as the earth conductor or a 5 core cable in which both pilot core ad earth core are provided.

A complete connection diagram for a remote controlled get –end-switch is rather complex as there are so many circuits superimposed on one another. It is sufficient to note that the circuits are for over laad low voltage and core balance earth leakage protection are similar in principle to those already described and illustrated for ordinary switch gear among the other circuits. That for earth continuily is perhaps the most importend and schematic diagram of one method of searing his is shown.

- **Earth continuity protection :-**



It will be seen that the main contactor is closed magnetically by the coil a when this is emergised coal a is connected a cross two phase of the incoming feeder and it becomes energized. When the supply fails.

There is also a circuit through the pilot core, motor switch, earth coer, the secondary side of the potential transformer PI and the relay coil R. the transformer is protected by fuses F on the high-twnsion side.

When the motor switch is placed on the “start” position relay coil R is encrgised so closing the relay and completing the circuite of A the main contactor the circuite by closed and supply is given to the motor the switch is then placed in the “RUN” position.

If however, there should be some fault in the pilot core. Or in the earth circuit some times connections, they relay coil R becomes de-energised and this in its turn, opens the relay R and shuts down the equipment. The removal of a plug at either end of the trailing cable will have a similar effects.

Control of the gate-end box can be effected locally or remotely, the selection being by way of a changeover switch on the control unit. In the majority of cases the remote control facility is adopted: it utilises a pilot control core in the fivecore flexible trailing cable and a flameproof starting device at the motor end. In the past, the pilot circuit or the remote control IS circuit was designed to the NCB specification P130, based on the following principles:

(1) the circuit is energised from an intrinsically safe constant voltage transformer within the gate-end box, designed to give a constant 12 or 7.5V secondary output over a wide variation of primary inputÐone side of the
12 or 7.5V winding is earthed;

(2) a pilot relay is provided in the gate-end box which will operate on half-wave but not on full-wave a.c.; and

(3) at the far end of the trailing cable a diode is provided along with a start switch across which is connected a 30 resistor.

- **<u>Single-point sensitive earth leakage:-</u>**

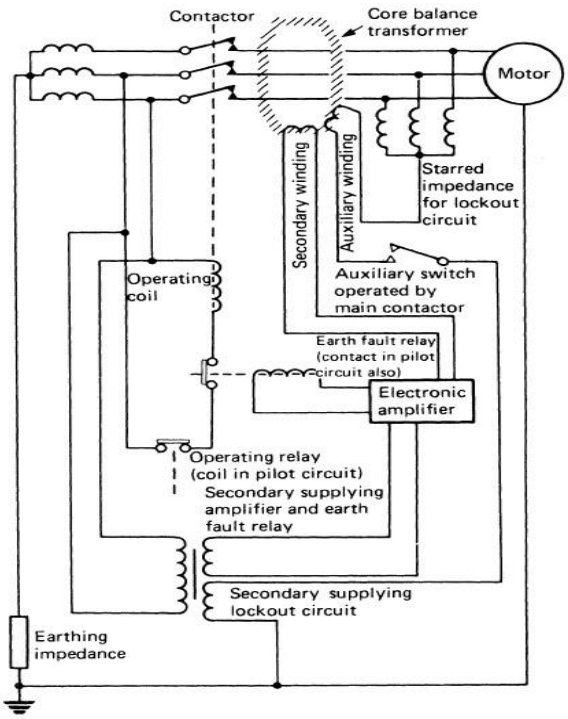


Figure 48.17 Protection unit for high-impedance single-point earthing

The basic principles of single-point earthing systems are similar to those of solidly earthed systems in that a corebalance
transformer more sensitive than used on solidly earthed systems is employed. This system is sometimes
referred to as sensitive core balance, and the main difference between the two systems is in the method of earthing the neutral point of the transformer secondary winding. In the single-point system an impedance is inserted between the neutral point and earth of such value as to limit the earth fault current to a maximum of 750mA
. Although this is the maximum earth fault current
permitted, individual earth fault trip circuits are set to trip
at between 80 and 100 mA, giving a safety factor of
approximately 7 to 1.
The core-balance transformer output under fault conditions is very small and an electronic amplifier is used to control the earth fault relay, which is energised under healthy conditions and de-energises on the occurrence of a fault. This arrangement results in a fail-safe system. The earth leakage relay contacts are inserted in the contactor coil circuit, which opens on the occurrence of a fault.

To ensure that a contactor cannot close onto a system on which an earth fault condition exists, an additional arrangement is provided which is termed the electric lockout circuit.
It consists of three impedances, one end of which is connected to the three outgoing phases; the other ends are star-connected and, in turn, are connected to an auxiliary core-balance transformer winding, a pair of contactor auxiliary contacts (closed when the contactor is open) and an intrinsically safe source of supply which has one end of its winding earthed. Should an earth fault develop while the contactor is de-energised, the earth leakage lock-out circuit would operate to prevent the contactor coil energising, a condition that would persist as long as the earth fault was in existence.

- **Multipoint sensitive earth leakage:-**

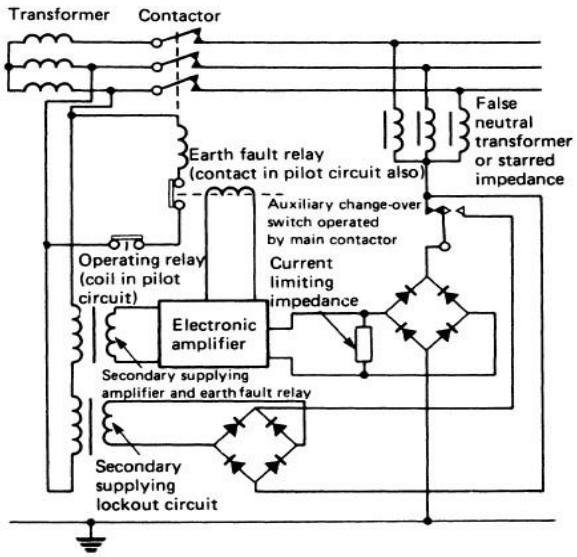


Figure 48.18 Protection unit for multipoint earthing

In the multipoint system the transformer secondary is completely insulated from the earth, i.e. it is a free neutral which, similar to the single-point system, consists of three impedances connected to the three outgoing phases. The star point is connected via a pair of contactor auxiliary
change-over contacts to either the failsafe earth leakage detection circuit or the earth leakage lock-out circuit, depending on whether the contactor is energised or not.

The earth fault current on the multipoint system is limited to 40mA on a 1100V system. Since an earth fault on a system supplied from one transformer could cause all gate-end boxes on the system to trip, and in order to keep the maximum earth fault current to 750 mA, the number of gate-end boxes on a system must be limited to 750/40 .

When a contactor trips on earth leakage on either system, that contactor locks out and displays earth leakage trip conditions, which can only be re-set by an authorised craftsman with the appropriate specialised equipment.

How Gate End Box is Made Flame Proof?

A flame proof enclosure is one which will withstand without injury & explosion of gas that may occur within it & will prevent the transmission of flame.

In fact it would be impossible to design the gas tight enclosure hence the alternative is therefore to construct it so that flame coming out from the explosion of gas will not pass outside.

The Requirements of FLP are as follows

1) At joint of enclosure, it should not have gap more than 0.5 mm.
2) IF there is any hole, it must be blocked by a screw etc.
3) It should have sufficient strength.
4) All heads of screw/bolts should be cored.
5) All external circuit conductors must not pass through the casing but must terminate in properly designed terminal box.

Advantages of Remote Control (Gate End Box)

1) Closing & opening of coal cutting machine (CCM) motor is done away from the face which is well ventilated & safe.
2) If the pilot conductors are opening circuited the main conductor automatically trips.
3) If the trailing cable is damaged causing short circuit, the main conductor automatically trips.
4) If the supply fails or flexible cable is removed or the plug are not fully inserted then again main conductor trips.
5) After the insertion of power the coal cutting machine (CCM) motor can't be started until the starter handle is put back to off position & then to on position.
6) Control on the coal cutting machine (CCM) is simple & easy to operate.
7) Power core is flexible cable is allow only when the coal cutting machine (CCM) is running.

Main Safety Provisions of Gate End Box

1) Overload or short circuit protection.
2) Lower voltage or power failure protection.
3) Earth continuity protection. 4) Earth leakage protection 5) Pilot protection.
6) Flame proof protection.
7) Mechanical protection.

1) **Overload or Short Circuit Protection:** In case of overloading or short circuiting the coal cutting machine (CCM) will draw more current hence more current flows flow in the power cable & this more current may overheat the motor of coal cutting machine (CCM) which is working at the face, hence it is required that in case of overloading the machine should be trip automatically as shown. The over current flow in the overloading coil L_1, L_2 & L_3 exert an extra force on plunger of dash peat which brakes the pilot circuit at d1 & d2.
   Hence the current flows in the coil Y & C_1 & C_2 are disconnected & again no current flow in the coil Z. hence main conductor is operated to trip the power supply to the machine.

2) **Lower Voltage or Power Failure Protection:** The pilot circuit is so designed that if the voltage falls below 60% of the normal voltage the coil Y will not generate force to close C_1 & C_2.
3) **Earth Continuity Protection:** The pilot circuit is so designed that the machine can't be started till the earth continuity is established. It is so because pilot circuit is completed through earth in wire only. If the earth in breaks it means no current flow in the pilot circuit or in coil.
4) **Earth Leakage Protection:** If the flexible cable is partially damaged then the insulation between earth in wire & power cores may get cracked through these cracks the leakage of current takes place & balance of current in the leakage

transformer is distributed. Due to this a voltage is induced in the leakage transformer & a force is exerted by the coil by on the plunger to break the pilot circuit at E_1 & E_2. (If the pilot core is breaks, no current is flown in the coil & C_1 & C_2 are disconnected & no current flow in coil Z)

5) **Flame Proof Protection:** Whole gate end box is enclosed in flame proof enclosure.

6) **Mechanical Protection:** The design of gate end box should be such that it should not be opened till the insulator is in off position & all the apparatus are dead & safe.

Why Pilot Circuits are used?

Pilot circuits are used primarily in the interest of safety. Following main considerations are,

1) The use of a pilot circuit make it possible to provide a number of specific and particular safely measured like -
    a) Pilot circuit ensures that the machine cannot self start after a powerfailure, or tripping, even if the remote control switch has been left in the run position.
    b) Makes sure that the machine will not operate if earth continuity is interrupted.
    c) The pilot circuit itself fails if it becomes faulty.
    d) If anyone inadvertently attempts to disconnect a live trailing cable, the live parts are exposed.
    e) In case of emergency the pilot switch is near at hand to switch off the circuit.
    f) When the motor is not running the trailing cable is dead.
2) When a circuit carrying heavy current is broken, arcs at the main contacts are pretty severe. It is therefore preferable that this arcing should take place in the gate end rather than at the face where an explosive mixture of fire damp

and arc is more likely to occur. Due to the pilot circuit, the circuit can be broken without causing any severe arc at the face, as the safety is ensured by causing arc to take place inside the flameproof enclosure of the gate end.

3) A pilot circuit is designed as an intrinsically safe circuit.

Pilot Circuit: Some standard pilot circuits used in the modern Gate End Box

There will be other contacts in the pilot circuit e.g. those opened by the Earth Fault Relay when there is an earth fault.

How does a Pilot Switch Operate?

To start the machine, the pilot switch is moved to the start position. By doing this the circuit is closed or completed from the secondary winding of the transformer through the operating coil, pilot conductor, pilot switch and the earth core of the trailing cable and back to the transformer. In this start position, as the circuit is closed, the cost of the operating relay is energised, and its contacts close, completing the medium voltage circuit through the contactor operating coil. This coil then closes the three phase main contactor. As soon as the motor has started, the pilot switch moves to the RUN position, bringing the current limiting resistor into circuit. The resistor limits the current flowing in the pilot circuit to a value just sufficient to hold the operating relay closed. To stop the, machine the remote control switch is moved to the stop position. The pilot circuit is then interrupted, and the coil of the operating relay is de-energised. The operating relay therefore, opens, breaking the circuit to the operating coil which allows the three phase contactor to open and then stop the motor.

Earth continuity failure protection:-

In figure seen that the earth core of the trailing provides earth continuity between the machine and the gate end panel. In fact from the figure, we see this earth core is also apart of the pilot circuit. Therefore, if the earth continuity is broken, the pilot circuit is also broken and the three phase contactor opens. Therefore it is not possible to start up the machine as long as the fault continues.

Protection against self-starting:-

Due to a fault in the distribution system or line, or if the power to the area is switched off for any reason, the supply to the transformer and thus to the pilot circuit will cease. As such the operating relay and the contactor will therefore open. The pilot switch may be left in the RUN position, but the machine will not start automatically when the supply is restored. This is because of the fact that though the circuit through the current limiting resistor and the operating relay coil again becomes live, the current passed by the resistor is not sufficient to close the operating relay. The machine in fact cam only start when the operator moves the pilot switch to the START position, as resistor is designed so that it cannot remain in the START position; if the operator releases it in the START position, it moves automatically to RUN position of the pilot switch.

Failure to Safety: Now let us look at fig. when short circuit between the pilot and earth cores in the trailing cable completes the circuit through the operating relay, and if the pilot circuit were not to fail to safety, such a fault would cause the motor to start immediately. In fact, if the motor was running, it would become impossible to stop switch.

However, failure to safety is ensured by the remote rectifier and the operating relay. When the circuit is operating normally, the rectifier at the pilot switch permits only pulses of direct current to flow in the circuit, that is, each positive half-cycle of the alternating supply. The operating relay is designed to operate only on this type of current. In the event of a short circuit between the pilot switch is bypassed and a full alternating current flows in the circuit. The operating relay, due to its higher impedance to a fault wave A.C. current, is deenergised and the contacts of this relay immediately open and break the operating coil circuit so that the motor cannot run.

Protection against disconnecting the live cable is provided by the design of the plugs and sockets used to connect the trailing cable to the machine and to the gate end panel. On each plug the pin of the pilot coil is shorter than those of the other cores. When the plug is withdrawn from the socket, the pilot pin breaks contact before the others. If the cable is live when the plug is withdrawn, the pilot circuit is broken and the main contactor opens while the power cores and the earth core are still connected. Open arcing at the plug when the power lines are broken is,

therefore, eliminated and the danger of electric shock is minimised to a very great extent.

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THE END